Genera of phytopathogenic fungi: GOPHY 1

Y. Marin-Felix1,2*, J.Z. Groenewald1, L. Cai3, Q. Chen4, S. Marinowitz2, I. Barnes5, K. Bensch6,7, U. Braun6, E. Camporesi7,8, U. Damm10, Z.W. de Beer10, A. Dissanayake11,12, J. Edwards13, A. Giraldo1,2, M. Hernández-Restrepo1,2, K.D. Hyde1,14, R.S. Jayawardena11,12, L. Lombard6, J. Luangsard13, A.R. McTaggart16, A.Y. Rossman17, M. Sandoval-Denis1,18, M. Shen19, R.G. Shivás20, Y.P. Tan21,22, E.J. van der Linde23, M.J. Wingfield2, A.R. Wood24, J.Q. Zhang19, Y. Zhang19, and P.W. Crous2*

1Westerdijk Fungal Biodiversity Institute, P.O. Box 85167, 3508 AD Utrecht, The Netherlands; 2Department of Microbiology and Plant Pathology, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, South Africa; 3State Key Laboratory of Mycology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100101, PR China; 4Department of Genetics, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, South Africa; 5Botanische Staatsammlung München, Merzlinger Straße 67, D-80638 München, Germany; 6Martin-Luther-Universität, Institut für Biologie, Bereich Geobotanik und Botanischer Garten, Herbarium, Neuerwerk 21, D-06099 Halle (Saale), Germany; 7A.M.B. Gruppo Micologico Forlivese “Antonio Ciognotto”, Via Roma 18, Forlì, Italy; 8A.M.B. Circolo Micologico “Giovanni Carini”, C.P. 314, Brescia, Italy; 9Società per gli Studi Naturalistici della Romagna, C.P. 144, Bagnacavallo (RA), Italy; 10Senckenberg Museum of Natural History Görlitz, PF 300 154, 02806 Görlitz, Germany; 11Center of Excellence in Fungal Research, School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand; 12Department of Plant and Environment Protection, Beijing Academy of Agriculture and Forestry Sciences, Beijing 100097, PR China; 13AgRiBioCentre for AgriBiosciences, Department of Economic Development, Jobs, Transport and Resources, 5 Ring Road, LaTrobe University, Bundooma, Victoria 3083, Australia; 14School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand; 15Microbe Interaction and Ecology Laboratory, Biodiversity and Biotechnological Resource Research Unit (BBR), BIOTEC, NSTDA 113 Thailand Science Park Phahonyothin Rd., Khlong Nueng, Khlong Luang, Pathum Thani 12101, Thailand; 16Department of Plant and Soil Ecology, Forestry and Agricultural Biotechnology Institute (FABI), University of Pretoria, Pretoria, South Africa; 17Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331, USA; 18Faculty of Natural and Agricultural Sciences, Department of Plant Sciences, University of the Free State, P.O. Box 339, Bloemfontein 9300, South Africa; 19Institute of Microbiology, P.O. Box 61, Beijing Forestry University, Beijing 100083, PR China; 20Centre for Crop Health, Institute for Agriculture and the Environment, University of Southern Queensland, Toowoomba 4350, Queensland, Australia; 21Department of Agriculture & Fisheries, Biosecurity Queensland, Ecociences Precinct, Dutton Park, Queensland 4102, Australia; 22Microbiology, Department of Biology, Utrecht University, Padualaan 8, 3584 CT Utrecht, The Netherlands; 23ARC – Plant Protection Research Institute, Biosystematics Division – Mycology, P. Bag X134, Queenswood 0121, South Africa; 24ARC – Plant Protection Research Institute, P. Bag X5017, Stellenbosch 7599, South Africa

*Correspondence: Y. Marin-Felix, y.marin@westerdijkinstitute.nl; P.W. Crous, p.crous@westerdijkinstitute.nl

Abstract: Genera of Phytopathogenic Fungi (GOPHY) is introduced as a new series of publications in order to provide a stable platform for the taxonomy of phytopathogenic fungi. This first paper focuses on 21 genera of phytopathogenic fungi: Bipolaris, Boeremia, Calonectria, Ceratocystis, Cladosporium, Colletotrichum, Coniella, Curvularia, Monilinia, Neofabraea, Neovestibularia, Pcladium, Pleiochaeta, Sclerotinia, Thamnochortus, Venturia and Vistosonomyces. For each genus, a morphological description and information about its pathogenicity, distribution, hosts and disease symptoms are provided. In addition, this information is linked to primary and secondary DNA barcodes of the presently accepted species, and relevant literature. Moreover, several novelties are introduced, i.e. new genera, species and combinations, and ne-, lecto- and epitypes designated to provide a stable taxonomy. This first paper includes one new genus, 26 new species, ten new combinations, and four typifications of older names.

Keywords: DNA barcodes, Fungal systematics, Phytopathogenic fungi, Plant pathology, Taxonomy, Typifications.

TAXONOMIC NOVELTIES: New genera: Bipolaris saccharicola Y. Marin & Crous, Boeremia frachelospermi Q. Chen & L. Cai, Calonectria ecuadoriensis L. Lombard & Crous, L. Lombard & Crous, Ca. longiramosa L. Lombard & Crous, Ca. nemoralis L. Lombard & Crous, Ca. octornata L. Lombard & Crous, Ca. parvispora L. Lombard & Crous, Ca. tucurinicensis L. Lombard & Crous, Colletotrichum psammaphanthericum Bensch, U. Braun & Crous, Cl. kenpeggi Bensch, U. Braun & Crous, Cl. welwitschii Bensch, U. Braun & Crous, Colletotrichum sydowii Damm, Curvularia pistia Y. Marin & Crous, Cu. soli Y. Marin & Crous, Neovestibularia italicum Dissanayake & K.D. Hyde, Nm. pistaciicola Y. Marin & Crous, N. pruni Crous, Pcladium septatum Giraldo & Crous, Pleiochaeta carotae Hern.-Rest., van der Linde & Crous, Plenodomus deqinensisi Q. Chen & L. Cai, Prostestigia euciclica Crous, Saccharara leucospermi Crous, S. protearum Crous, Thamnomyces franserai Crous, Venturia paeonophila Z. Zhang ter & J.Q. Zhang, New species: Coniella hisbici (B. Sutton) Crous, Monilinia mumbelica (Y. Hartman, Horváth & Sandoval-Denis & Crous, M. yunnanensis (M.J. Hu & C.X. Luo) Sandoval-Denis & Crous, Pseudopyricularia bothriochiae (Crous & Chew), Y. Marin & Crous, Puccinia diianae (Dietel) McTaggart & R.G. Shivás, Pu. gelloniopsis (McAlpine) McTaggart & R.G. Shivás, Pu. memilliana (Syd. & P. Syd.) McTaggart & R.G. Shivás, Pu. rhagodae ( Cooke & Massée) McTaggart & R.G. Shivás, Venturia martianoffiana (Thüm.) Y. Zhang ter & J.Q. Zhang, Verklewomyces alíci (X. Sun et al.) Y. Marin & Crous, Typification: Epitypification: Ceratophorum setosum Kirchn., Coniella musaiensis var. hisbici B. Sutton, Helminthosporium carphophilum Šev.; Lectotypification: Ceratophorum setosum Kirchn.

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INTRODUCTION

Since the advent of molecular DNA techniques, many species of phytopathogenic fungi have been shown to represent species complexes or to be included in genera that are poly- or paraphyletic (Crous et al. 2015b). Resolving these generic and species concepts is thus of the utmost importance for plant health and global trade in food and fibre (Crous et al. 2015b, 2016a). The present project focused on genera of fungi that have members causing plant diseases (phytopathogenic), links to a larger initiative called the “The Genera of Fungi project” based on Clements & Shear (1931) (www.GeneraOfFungi.org, Crous et al. 2014a, 2015a, Giraldo et al. 2017), which aims to revise the generic names of all currently accepted fungi (Kirk et al. 2013).
Of the approximately 18,000 fungal genera that have thus far been described, only around 8,000 are in current use. However, the majority of these were described before the DNA era. To validate the application of these names, their type species need to be recollected and designated as epi- or neotypes with a MycoBank Typification (MBT) number to ensure traceability of the nomenclatural act (Robert et al. 2013). Furthermore, to move to a single nomenclature for fungi (Wingfield et al. 2012, Crous et al. 2015b), their sexual—axsexual links also need to be confirmed.

The present initiative forms part of the activities of the International Subcommission for the Taxonomy of Phytopathogenic Fungi [Pedro Crous and Amy Rossman (co-chairs), of the International Committee for the Taxonomy of Fungi (www.fungaltaxonomy.org)].

The aims of this project are to:

1. Establish a new website, www.plantpathogen.org, to host a database that will link metadata to other databases such as MycoBank, Index Fungorum, FacesofFungi, U.S. National Fungus Collections Databases, etc., and associated DNA barcodes (ITS, LSU and other loci as needed) to GenBank (Schoch et al. 2014).
2. Source type specimens and cultures of the type species of genera from fungaria and Biological Resource Centres (BRCs), and generate the required metadata as explained below.
3. Recollect fresh material of the type species if not already available, and as far as possible derive DNA barcodes and cultures from this material.
4. Designate type species, and type specimens of those species, for those genera where this has not been indicated in the original publications.
5. Fix the application of the type species of generic names by means of lecto-, neo-, or epitypification as appropriate, and at the same time deposit cultures in at least two Microbial Biological Resource Centres (M-BRCs) from which they would be widely available to the international research community.
6. Publish modern generic descriptions, and provide DNA barcodes for all accepted species, with reference to appropriate literature.

Authors with new submissions should ensure that all new species and typification events are registered in MycoBank (MB and MBT numbers), respectively. It is recommended that the following issues are addressed in each genus:

1. Modern generic description, and phylogenetic placement of the type species of the genus.
2. Higher order phylogeny.
3. New nomenclature merging asexual and sexual generic names (see Rossman et al. 2013, Johnston et al. 2014).
4. Description of novel taxa, with a reference collection (e.g. fungarium), and MycoBank and GenBank sequence accession numbers.
5. Name changes that result from the new phylogenetic placement.
6. Notes discussing the relevance and implications of the phylogeny, and importance of the genus.

Authored generic contributions will be combined into scientific papers to be published online in Studies in Mycology, and also placed in a database displayed on www.plantpathogen.org. Preference will be given to genera that include novel DNA data and/or novel species or typifications. Authors that wish to contribute to future issues of this project are encouraged to first contact Pedro Crous (p.crous@westerdijkinstitute.nl) before final submission, to ensure there is no potential overlap with activities arising from other research groups. The genera chosen in the first paper were randomly selected, based on the fact that their phylogenetic position was resolved, DNA data were available for those species known from culture, and novel species or typifications were available for inclusion.

MATERIAL AND METHODS

Isolates and morphological analysis

Descriptions of the new taxa and typifications are based on cultures obtained from the Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands (CBS), the working collection of P.W. Crous (CPC), housed at the Westerdijk Institute, Herbarium Mycologicum Academiae Sinicae (HMAS), BIOTEC Culture Collection (BCC), the Queensland Plant Pathology Herbarium (BRIP), the Chinese General Microbiological Culture Collection Center (CGMCC), the Mae Fah Luang University Culture Collection (MFLUCC), and the Victorian Plant Pathogen Herbarium (VPRI). For fresh collections, we followed the procedures previously described in Crous et al. (1991). Colonies were transferred to different media, i.e. carnation leaf agar (CLA), cornmeal agar (CMA), 2 % malt extract agar (MEA), 2 % potato-dextrose agar (PDA), synthetic nutrient-poor agar (SNA), oatmeal agar (OA), water agar (WA) (Crous et al. 2009c), autoclaved pine needles on 2 % tap water agar (PNA) (Smith et al. 1996), and incubated at different conditions depending on the taxon to induce sporulation (requirements of media and conditions of incubations specified in each genus). Reference strains and specimens are maintained at the BCC, CBS, CGMCC, HMAS and MFLUCC.

Vegetative and reproductive structures were mounted in clear lactic acid, Shear’s mounting fluid and lactophenol cotton blue, either directly from specimens or from colonies sporulating on CLA, MEA, OA, PDA, PNA, or SNA. Sections of conidiomata were made by hand for examination purposes. For cultural characterisation, isolates were grown and incubated on different culture media and temperatures as stipulated for each genus. Colour notations were rated according to the colour charts of Rayner (1970). For some taxa, NaOH pot test was carried out on MEA cultures to detect the production of metabolite E (Boerema et al. 2004). Taxonomic novelties were deposited in MycoBank (www.MycoBank.org; Crous et al. 2004b).

DNA isolation, amplification and analyses

Fungal DNA was extracted and purified directly from the colonies or host material according to the Wizard® Genomic DNA purification kit protocol (Promega, Madison, USA). Primers and protocols for the amplification and sequencing of gene loci can be found in the bibliography related to the phylogeny presented for each genus. Phylogenetic analyses consisted of Maximum-Likelihood (ML), Bayesian Inference (BI), and Maximum Parsimony (MP). The ML was carried out using methods described by Hernandez-Restrepo et al. (2016), and the MP using those
described by Crous et al. (2006b). The BI was inferred as described by Hernández-Restrepo et al. (2016), or on the CIPRES portal (www.phylo.org) using MrBayes on XSEDE v. 3.2.6. Sequence data generated in this study were deposited in GenBank and ENA databases, and the alignments and trees in TreeBASE (http://www.treebase.org).

RESULTS

Bipolaris Shoemaker, Canad. J. Bot. 37: 882. 1959. Fig. 1. Synonym: Cochliobolus Drechsler, Phytopathology 24: 973. 1934.

Classification: Dothideomycetes, Pleosporomycetidae, Pleosporales, Pleosporaceae.

Type species: Bipolaris maydis (Y. Nisik. & C. Miyake) Shoemaker. Neotype and ex-neotype culture: ATCC 48332, CBS 137271.

DNA barcodes (genus): LSU, ITS.

DNA barcodes (species): ITS, gapdh, tef1. Table 1. Fig. 2.

Ascomata pseudothecial, mostly globose to elliptoidal, sometimes flask-shaped or flattened on hard substrata, brown or black, immersed, erumpent, partially embedded or superficial, free, smooth or covered with vegetative hyphae; ostiole central, papillate or with a sub-conical, conical, paraboloid or cylindrical neck; ascomatal wall comprising pseudoparenchymatous cells of equal thickness or slightly thickened at apex of the ascoma.

Hamathecium comprising septate, filiform, branched pseudo-paraphyses. Asci bitunicate, clavate, cylindrical-clavate or broadly fusoid, straight or slightly curved, thick-walled, fissitunicate, often becoming more or less distended prior to dehiscence, short pedicellate, rounded at apex. Ascospores multiseriate, filiform or flagelliform, hyaline and sometimes pale yellow or pale brown at maturity, septate, helically coiled within ascoma, ascospore coiling moderate to strongly, often with a mucilaginous sheath. Conidiophores single, sometimes arranged in small groups, straight to flexuous or geniculate, pale to dark brown, branched, thick-walled, septate. Conidiogenous nodes smooth to slightly verruculose. Conidia cance-shaped, fusoid or obclavate, mostly curved, hyaline, pale or dark brown, reddish brown or pale to deep olivaceous, thick-walled, smooth-walled, 3–14-distoseptate, germinating by production of one or two germination tubes by polar cells; hila often slightly protruding or truncate, sometimes inconspicuous; septum ontogeny first septum median to sub-median, second septum delimits basal cell and third delimits distal cell (adapted from Manamgoda et al. 2014).

Culture characteristics: Colonies on PDA white or pale grey when young, brown or dark grey when mature, fluffy, cottony, raised or convex with papillate surface, margin lobate, undulate, entire or sometimes rhizoid.

Optimal media and cultivation conditions: Sterilised Zea mays leaves placed on 1.5 % WA or slide cultures of PDA under near-ultraviolet light (12 h light, 12 h dark) at 25 °C to induce sporulation of the asexual morph, while for the sexual morph, Sachs's agar with sterilised rice or wheat straw at 25 °C is used.

Distribution: Worldwide.

Hosts: Mainly pathogens of grasses, but some also on non-grass hosts, causing devastating diseases on cereal crops in the Poaceae, including rice, maize, wheat and sorghum and on various other host plants. Moreover, this genus can occur on at least 60 other genera in Anacardiaceae, Araceae, Euphorbiaceae, Fabaceae, Malvaceae, Rutaceae and Zingiberaceae as either saprobes or pathogens.

Disease symptoms: Leaf spots, leaf blight, melting out, root rot, and foot rot, among others.

Notes: Species delimitation based on morphology alone is limited since many species have overlapping characters. Moreover, the morphology of the sexual morph is of limited value due to difficulties to induce this morph in culture, or find it in nature. The genus is morphologically similar to Curvularia, and distinguishing these genera can be problematic. Both genera contain species with straight or curved conidia, but in Bipolaris the curvature is continuous throughout the length of the conidium, while the conidia of Curvularia have intermediate cells inordinately enlarged which contributes to their curvature. Moreover, conidia in Bipolaris are usually longer than in Curvularia. Another morphological difference is the presence of stromata in some species of Curvularia, a feature not observed in species of Bipolaris. In order to properly delineate both genera, phylogenetic studies using ITS, gapdh and tef1 sequences were recently performed (Manamgoda et al. 2014, 2015).

References: Ellis 1971, Sivanesan 1987 (morphology and pathogenicity); Manamgoda et al. 2011, Tan et al. 2016 (morphology, phylogeny and pathogenicity); Manamgoda et al. 2014 (morphology, phylogeny, pathogenicity and key of all Bipolaris spp.).

Bipolaris saccharicola Y. Marin & Crous, sp. nov. MycoBank MB820809. Fig. 3.

Etymology: Name refers to the host genus it was isolated from, Saccharum.

Hyphae hyaline to pale brown, branched, septate, thin-walled, 2.5–5.5 μm. Conidiophores arising in smalls groups, septate, straight or flexuous, smooth-walled, sometimes branched, cell walls thicker than those of vegetative hyphae, nononematous, semi- to macronematous, pale brown to brown, paler towards apex, rarely swollen at base, up to 900 μm tall. Conidiogenous cells smooth-walled, terminal or intercalary, subhyaline to pale brown or brown, subcylindrical to swollen, 10–27(–47) × 4–8 μm. Conidia verruculose, curved, rarely straight, fusiform, subhyaline to pale brown or brown, (2–9–11)-distoseptate, (30–45)–120 × 10.5–20 (–21.5) μm; hila inconspicuous, brown, slightly protuberant, flat, darkened, slightly thickened, 2–4 μm. Chlamydospores and sexual morph not observed.

Culture characteristics: Colonies on PDA reaching 41–53 mm diam after 1 wk, moderate aerial mycelium giving a cottony
appearance, margin lobate; surface olivaceous grey to olivaceous black; reverse olivaceous black.

**Material examined:** Unknown country, unknown substratum, 1926, H. Atherton (holotype CBS H-23114, culture ex-type CBS 155.26 = MUCL 9693); Unknown country, from Saccharum officinarum, unknown date, R.R. Nelson, CBS 325.64 = DSM 62597 = MUCL 9694 = NRRL 5241.

Notes: This species is closely related to Bi. maydis. However, Bi. saccharicola can easily be distinguished by the absence of a sexual morph, longer conidiophores and verruculose, more prominently curved conidia. Both species can be found on the same host, Saccharum officinarum. Other species of Bipolaris isolated from this host include Bi. cynodontis, Bi. sacchari, Bi. setariae, Bi. stenospila and Bi. yamadae (Manamgoda et al. 2014). Bipolaris saccharicola is morphologically similar to Bi.
| Species | Isolates | GenBank accession numbers | References |
|---------|----------|---------------------------|------------|
| Bipolaris austrostipae | BRIP 12490T | KX452442 KX452408 KX452459 | Tan et al. (2016) |
| Bi. axonopicola | BRIP 11740T | KX452443 KX452409 KX452460 | Tan et al. (2016) |
| Bi. bamaegensis | BRIP 13577T | KX452445 KX452411 KX452462 | Tan et al. (2016) |
| Bi. bicolor | CBS 690.96 | KJ09762 KMO42893 KMO93776 | Manamgoda et al. (2014) |
| Bi. chloridis | BRIP 10965T | KJ415523 KJ415423 KJ415472 | Tan et al. (2016) |
| Bi. clavata | BRIP 12530T | KJ415542 KJ415422 KJ415471 | Tan et al. (2016) |
| Bi. coffeana | BRIP 14845sT | KJ415525 KJ415421 KJ415470 | Tan et al. (2016) |
| Bi. cookei | AR 5185 | KJ22391 KMO34833 KMO93777 | Manamgoda et al. (2014) |
| Bi. crotonis | BRIP 14838 | KJ415526 KJ415420 KJ415479 | Tan et al. (2016) |
| Bi. cynodontis | CBS 109894 | KJ909767 KMO34843 KMO93791 | Manamgoda et al. (2014) |
| Bi. drechsleri | CBS 136207 | KF500530 KF500533 KMO93760 | Crous et al. (2013b), Manamgoda et al. (2014) |
| Bi. gossypina | BRIP 14830T | KJ415528 KJ415418 KJ415467 | Tan et al. (2016) |
| Bi. heliconiae | CBS 241.92 | KJ09763 KMO34843 KMO93791 | Manamgoda et al. (2014) |
| Bi. heveae | BRIP 17186T | KJ415530 KJ415417 KJ415465 | Tan et al. (2016) |
| Bi. heveae | CBS 241.92 | KJ09763 KMO34843 KMO93791 | Manamgoda et al. (2014) |
| Bi. luttrellii | BRIP 14643sT | AF071350 AF081402 Berbee et al. (1999) |
| Bi. maydis | CBS 137271NT | AF071325 KMO34846 KMO93794 | Berbee et al. (1999), Manamgoda et al. (2014) |
| Bi. microlaenae | CBS 280.91T | JN601032 JN600974 JN601017 | Manamgoda et al. (2011) |
| Bi. microstegii | CBS 132550T | JX089579 JX089575 KMO93756 | Crous et al. (2012a), Manamgoda et al. (2014) |
| Bi. oryzae | PBSUCC 10-0715sT | JX256416 JX276430 JX266885 | Manamgoda et al. (2012c) |
| Bi. panici-miliacei | CBS 136207 | KJ415528 KJ415418 KJ415467 | Tan et al. (2016) |
| Bi. peregianensis | CBS 128.91T | JN601034 JN600977 JN601022 | Manamgoda et al. (2011) |
| Bi. pluriseptata | BRIP 14838sT | KJ415532 KJ415414 KJ415455 | Tan et al. (2016) |
| Bi. sacchari | ICMP 6227 | KJ909767 KMO34843 KMO93791 | Manamgoda et al. (2014) |
| Bi. salviniae | BRIP 16571sT | KJ415535 KJ415411 KJ415475 | Tan et al. (2016) |
| Bi. saccharicola | CBS 155.26T | KY906574 KY905686 KY905694 | Present study |
| Bi. secalis | CBS 241.92 | KJ909767 KMO34843 KMO93791 | Manamgoda et al. (2014) |
| Bi. setariae | CBS 141.31 | EF452444 EF513206 – | Andrie et al. (2008) |
| Bi. shoemakeri | BRIP 15290T | KX452453 KX452419 KX452470 | Tan et al. (2016) |
| Bi. simmondsii | BRIP 12030T | KX452454 KX452420 KX452471 | Tan et al. (2016) |
| Bi. sivanesaniana | BRIP 15290T | KX452453 KX452419 KX452470 | Tan et al. (2016) |
| Bi. sorokiniana | CBS 110.14 | KJ922381 KMO34822 KMO93763 | Manamgoda et al. (2014) |
| Bi. subramanianii | BRIP 16226T | KX452457 KX452423 KX452474 | Tan et al. (2016) |
| Bi. urochloae | ATCC 5317 | KJ922389 KMO34822 KMO93770 | Manamgoda et al. (2014) |
| Bi. variabilis | CBS 127716T | KY905676 KY905688 KY905696 | Present study |
| Bi. victoriae | CBS 127736 | KY905676 KY905689 – | Present study |
| Bi. yamadae | CBS 202.96T | KJ909779 KMO34830 KMO93773 | Manamgoda et al. (2014) |
| Bi. yamadae (neotype of Bi. euphorbiae) | CBS 127087 | KY905673 KY905685 KY905693 | Present study |

(continued on next page)
Bipolaris variabilis

Y. Marín, Y.P. Tan & Crous, sp. nov. MycoBank MB820810. Fig. 4.

Etymology: Name refers to the highly variable conidial morphology.

Leaf spots brown to reddish, elongated, often confluent and following veins, some with central part brown, 2.5 × 1–2 mm. Hyphae subhyaline to pale brown, branched, septate, thin-walled, 3–6 μm. Conidiophores arising in groups, septate, straight or flexuous, sometimes geniculate at upper part, smooth to verruculose, branched, cells walls thicker than those of vegetative hyphae, mononematous, semi- to macro-nematous, pale brown to brown, paler towards apex, slightly swollen at base, up to 1 600 μm tall. Conidiogenous cells smooth-walled, terminal or intercalary, proliferating sympodially, subhyaline or pale brown to brown, subcylindrical to dilyally, subhyaline or pale brown to brown, subcylindrical to smooth-walled, terminal or intercalary, proliferating sympodially and exuous, sometimes geniculate at upper part, proliferating sympodially and exuous, sometimes geniculate at upper part.

Culture characteristics: Colonies on PDA reaching 90 mm diam in 1 wk, with sparse to moderate aerial mycelium giving a cottony appearance, margin lobate; surface olivaceous grey to iron-grey; reverse olivaceous black.

Material examined: Argentina, from leaf spots on Pennisetum clandestinum, 28 Jul. 1986, col. M.N. Sisterna, isol. J.L. Alcorn (holotype CBS H-23115, culture ex-type CBS 127716 = BRIP 15349). Brazil, from Pennisetum clandestinum, Apr. 1987, J.J. Muchovej, CBS 127736 = BRIP 15702 = ATCC 62423.

Notes: Bipolaris variabilis can easily be distinguished based on its highly variable conidial size, shape and septation. Hitherto, this species has only been found on Pennisetum clandestinum in South America. Other species of Bipolaris can be found on Pennisetum spp., i.e. Bi. bicolor, Bi. colocasiae, Bi. cynodontis, Bi. maydis, Bi. mediocris, Bi. sacchari, Bi. setariae, Bi. sorokiniana, Bi. stenospila, Bi. urochloae and Bi. zeae; however, only Bi. mediocris is restricted to that host (Manamgoda et al. 2014). Bipolaris mediocris and Bi. variabilis are morphologically similar, but Bi. variabilis produces smaller, verruculose conidia. Moreover, Bi. mediocris is characterised by much shorter conidiophores (up to 150 μm tall), and has only been reported in Africa (Farr & Rossman 2017). Bipolaris variabilis is closely related to Bi. zeae, but the latter is characterised by shorter conidiophores (up to 370 μm tall), and less septate conidia that are less variable in shape than those of Bi. variabilis.

Table 1. (Continued).

| Species       | Isolates¹ | GenBank accession numbers² | References |
|---------------|-----------|---------------------------|------------|
| Bi. woodii    | BRIP 12239³ | KX452458 KX452424 KX4524725 | Tan et al. (2016) |
| Bi. zeae      | BRIP 11512² | KJ415538 KJ415408 KJ415454 | Tan et al. (2014) |
| Bi. zeicola   | FIP 532³   | KM230398 KM034815 KM093752 | Manamgoda et al. (2014) |

¹ AR, FIP: Isolates housed in Systematic Mycology and Microbiology Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, Maryland, USA; Bi: Isolates housed in the Department of Plant Protection, Faculty of Agricultural Sciences and Engineering, University College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran (TUPP); ATCC: American Type Culture Collection, Virginia, USA; BRIP: Queensland Plant Pathology Herbarium, Brisbane, Australia; CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; ICMP: International Collection of Micro-organisms from Plants, Landcare Research, Private Bag 92170, Auckland, New Zealand; MFLUCC: Mae Fah Luang University Culture Collection, Chiang Ria, Thailand. T, ET, IsoT, IsoLT, IsoPT, LT and NT indicate ex-type, ex-epitype, ex-isotype, ex-lectotype, ex-isoparatype, ex-neotype and ex-neotype strains, respectively.

² ITS: Internal transcribed spacers and intervening 5.8S nrDNA; gapdh: partial glyceraldehyde-3-phosphate dehydrogenase gene; tef1: partial translation elongation factor 1-alpha gene.

³ This species has only been found on Pennisetum clandestinum

Notes: Bipolaris euphorbiae was originally described in Helminthosporium (Hansford 1943), then transferred to Drechslera (Ellis 1971), and finally placed in Bipolaris based on the bipolar germination and hilum structure (Muchovej & Carvalho 1989). In their revision of Bipolaris, Manamgoda et al. (2014) accepted this species in the genus despite the lack of molecular data. In the present study, the neotype strain of Bi. euphorbiae CBS 127087 (=BRIP 16567; see Fig. 5), which was designated by Muchovej & Carvalho (1989), clustered with the ex-epitype strain of Bi. yamadae. Both species are morphologically similar differing only in the size of the structures that are usually overlapping. Based on these data, we propose to reduce Bi. euphorbiae to synonymy under Bi. yamadae. Moreover, we emended the description of Bi. yamadae to include the morphology of its new synonym, as well as the new host and distribution records.
Bipolaris heveae
Bipolaris axonopicola
Bipolaris sacchari
Bipolaris bicolor
Bipolaris urochloae
Bipolaris yamadae
Bipolaris salviniae
Bipolaris setariae
Bipolaris heliconiae

Bipolaris bicolor
Bipolaris yamadae
Bipolaris setariae
Bipolaris heliconiae

Bipolaris salviniae
Bipolaris setariae
Bipolaris heliconiae

Bipolaris maydis
Bipolaris panici-miliacei
Bipolaris oryzae
Bipolaris sivanesaniana

Bipolaris maydis
Bipolaris panici-miliacei
Bipolaris oryzae
Bipolaris sivanesaniana

Bipolaris victoriae
Bipolaris variabilis sp. nov.

Bipolaris victoriae
Bipolaris variabilis sp. nov.

Bipolaris victoriae
Bipolaris variabilis sp. nov.

Bipolaris victoriae
Bipolaris variabilis sp. nov.

Curvularia subpapendorfii CBS 656.74T
Curvularia buchloes CBS 246.49T

2.0
Leaf spots on Panicum sp. ovoid, oblong, pale brown at margin and pale brown at centre, with an irregular concentric zone. Hyphae hyaline, branched, septate, anastomosing, thin-walled, 1.5–4.5 μm. Conidiophores arising singly or in small groups, septate, rarely branched, straight or flexuous, sometimes geniculate at upper part, smooth walled, mononematous, semi-to macronematous, olive-brown to pale brown, sometimes paler towards apex, swollen at base, 40–650 × 3–10.5 μm. Conidiogenous cells smooth-walled, sometimes slightly verruculose, terminal or intercalary, subhyaline to pale brown or dark brown, subcylindrical to slightly swollen, 7–30(–40) × 5.5–9.5 μm. Conidia smooth-walled, straight or curved, ellipsoidal, cylindrical, fusiform or obclavate, sometimes obovoid, with rounded ends, subhyaline to pale brown or olive-brown, (3–)5–7(–11)-distantseptate, 27–100(–120) × 11.5–20 μm; hila 2.5–4.5 μm, non or slightly protuberant, flat, darkened; germination at both ends.

Distribution: Brazil, Cuba, China, India, Japan, Sudan, Tanzania, USA (IA, ID, ND, WI).

Hosts: Panicum capillare, Pa. implicatum, Pa. maximum, Pa. miliaceum, Euphorbia sp., Oryza sp., Saccharum sp., Setaria plicata (Farr & Rossman 2017).

Authors: Y. Marin-Felix, P.W. Crous & Y.P. Tan

Boeremia Aveskamp et al., Stud. Mycol. 65: 36. 2010. Fig. 6.

Classification: Dothideomycetes, Pleosporomycetidae, Pleosporales, Didymellaceae.

Type species: Boeremia exigua (Desm.) Aveskamp et al. Representative strain: CBS 431.74.

DNA barcodes (genus): LSU, ITS.

DNA barcodes (species): act, cal, rpb2, tef1, tub2. Table 2. Fig. 7.
Ascomata pseudothecial, subglobose. Asci cylindrical or sub-clavate, 8-spored, biseriate. Ascospores ellipsoidal, 1-septate. Conidiomata pycnidial, variable in shape and size, mostly globose to subglobose, superficial or immersed into agar, solitary or confluent; ostiole non-papillate or papillate, lined internally with hyaline cells when mature; conidiomatal wall pseudoparenchymatous, multi-layered, outer wall brown pigmented. Conidiophores reduced to conidiogenous cells. Conidiogenous cells phialidic, hyaline, smooth, ampulliform to doliiform. Conidia variable in shape, hyaline, smooth- and thin-walled, mainly aseptate, but 1(–2)-septate larger conidia may be found (adapted from Aveskamp et al. 2010).

Fig. 4. Bipolaris variabilis (ex-type CBS 127716). A–C. Conidiophores and conidia. D–M. Conidia. Scale bars: A = 20 μm; B, C = 15 μm; H applies to D–H, M applies to I–M = 5 μm.
Culture characteristics: Colonies on OA white to dull green, grey olivaceous to olivaceous or smoke-grey, velvety, floccose to woolly, margin often regular, sometimes lobate and irregular scalloped.

Optimal media and cultivation conditions: OA or PNA at 25 °C under near-ultraviolet light (12 h light, 12 h dark) to promote sporulation.

Distribution: Worldwide.

Hosts: Seed-borne pathogens of *Phaseolus vulgaris* (Fabaceae) and noxious pathogens of *Coffea arabica* (Rubiaceae). Species on more than 200 host genera including *Amaryllidaceae*, *Apocynaceae*, *Araliaceae*, *Asteraceae*, *Caprifoliaceae*, *Chenopodiaceae*, *Crassulaceae*, *Fabaceae*, *Lamiaceae*, *Linaceae*, *Oleaceae*, *Salicaceae*, *Solanaceae*, *Ulmaceae*, *Umbelliferae*.

Disease symptoms: Leaf spots, stem lesions, black node, bulb rot, root rot, shoot dieback.

Notes: The genus *Boeremia* was established by Aveskamp et al. (2010) to accommodate phoma-like species that are morphologically similar and closely related to *Ph. exigua*. Taxa in this genus are characterised by having ostioles with a hyaline inner layer of cells and producing aseptate and septate conidia (Aveskamp et al. 2010). To date only *Bo. lycopersici* has been reported to have a sexual morph. Recently, Chen et al. (2015a) and Berner et al. (2015) further examined the phylogenetic relationships of taxa in *Boeremia* in two combined multilocus analyses, the first one based on LSU, ITS, tub2 and rpb2 sequences, and the second on ITS, act, cal, tef1 and tub2 sequences.

References: Boerema et al. 2004 (morphology and pathogenicity); Aveskamp et al. 2010, Chen et al. 2015a (morphology and phylogeny); Berner et al. 2015 (morphology, pathogenicity and phylogeny).

*Boeremia trachelospermi* Q. Chen & L. Cai, sp. nov. MycoBank MB818819. Fig. 8.

Etymology: Named for the host genus from which the holotype was collected, *Trachelospermum*.

Conidiomata pycnidial, solitary or aggregated, globose to subglobose, glabrous or with few hyphal outgrowths, superficial, with a short neck, 75–255 × 60–225 μm; ostiole single, papillate or non-papillate; conidiomatal wall pseudoparenchymatous 2–4-layered, 16.5–37 μm thick, composed of isodiametric cells. Conidiophores reduced to conidiogenous cells. Conidiogenous cells phialidic, hyaline, smooth, ampulliform to doliform, 4.5–12.5 × 4.5–6 μm. Conidia variable in shape, mostly ovoid, ellipsoidal to cylindrical, smooth- and thin-walled, hyaline, mainly aseptate, occasionally 1-
Chen et al. heteromorpha var. Boeremia exigua

Fig. 6. Boeremia spp. A. Symptoms of Boeremia ilicis (LC 8116) on Ocimun sp. B. Symptoms of Boeremia exigua var. rapontica (ex-type CBS 113651) on Rhaponticum repens. C. Symptoms of Boeremia ilicis (LC 5178) on Lonicera sp. D. Ostitole configuration of Boeremia exigua var. exigua (CBS 431.74). E. Section of young pycnidium of Boeremia exigua var. pseudolilacis (ex-type CBS 101207). F. Conidia of Boeremia exigua var. pseudolilacis (ex-type CBS 101207). G. Conidia of Boeremia exigua var. heteromorpha (ex-neotype CBS 443.94). Scale bars: D–E = 20 μm; F = 5 μm; G = 10 μm. Picture B taken from Berner et al. (2015); D–F from Aresktrap et al. (2010); G from Chen et al. (2015a).

Fig. 11. Table 3.

Lectotype: France, litter of Platanus, Autumn. Desm., Pl. Crypt. France Ed. 2 (2) # 372 (fide Rossman 1979); no culture or DNA data available.

DNA barcodes (genus): LSU, ITS.

DNA barcodes (species): cmdA, his3, tef1, tub2, and rpb2.

Ascomata perithelial, solitary or in groups, globose to sub-globose to ovoid, yellow to orange to red or red-brown to brown, turning dark red to red-brown in KOH, rough-walled; ascomatal apex consisting of flattened, thick-walled hyphal elements with rounded tips forming a papilisade, discontinuous with warty wall, gradually becoming thinner towards ostiolar canal, and merging with outer periphyses; ascomatal base consisting of dark brown-red, angular cells, merging with an erumpent stroma, cells of outer wall layer continuing into pseudoparenchymatous cells of erumpent stroma. Asci 8-spored, clavate, tapering to a long thin stalk. Ascospores aggregated in upper third of ascus, hyaline, smooth, fusoid with rounded ends, straight to sinuous, unconstricted, or constricted at septa. Macroconidiophores, if present, borne on agar surface or immersed in agar; stipe extensions mostly absent; conidiophores unbranched, terminating in 1–3 phialides, or sometimes with a single subterminal phialide; phialides straight to curved, cylindrical, seemingly producing a single conidium, pericinal thickening and an inconspicuous, divergent collarette rarely visible. Megaconidia hyaline, smooth, frequently remaining attached to phialide, multi-septate, widest in middle, bent or curved, with a truncate base and rounded apical cell. Macroconidiophores consist of a stipe, a penicillate arrangement of fertile branches, a stipe extension, and a terminal vesicle; stipe septate, hyaline or slightly pigmented at base, smooth or finely verruculose; stipe extensions septate, straight to flexuous, mostly thin-walled, terminating in a thin-walled vesicle of characteristic shape. Conidiogenous apparatus with 0–1-septate primary branches, septate large conidia, 4.5–9.5 × 2.5–4.5 μm, with 1–8 guttules. Conidial matrix cream-coloured.

Culture characteristics: Colonies on OA, reaching 47–55 mm diam after 1 wk, margin regular, floccose, white, dark grey near centre; reverse white to buff, dark grey near centre. Colonies on MEA 40–60 mm diam after 1 wk, margin regular, woolly, pale olivaceous grey; reverse concolorous. Colonies on PDA, reaching 20–25 mm diam after 1 wk, margin regular, floccose, compact, white to olivaceous; reverse white to buff, olivaceous near centre. NaOH test negative.

Material examined: USA, on seedlings of Trachelospermum jasminoides, 2014, W.J. Duan holotype HMAS 246706, culture ex-type CGMCC 3.18222 = LC 8105.

Notes: Boeremia trachelospermi represents the first report of a Boeremia species on Trachelospermum (Apocynaceae). Phylogenetically, it forms a distinct lineage separate from Bo. diversispora, the Bo. exigua varieties, Bo. noackiana and Bo. sambuci-nigrae (Fig. 7), and morphologically it often produces longer conidiogenous cells and conidia than the other taxa.

Authors: Q. Chen & L. Cai

Calonectria De Not., Comm. Soc. crittog. Ital. 2(fasc. 3): 477. 1867. Figs 9, 10.

Synonyms: Cylindrocladium Morgan, Bot. Gaz. 17: 191. 1892. Candelospora Rea & Hawley, Proc. R. Ir. Acad., Sect. B, Biol. Sci. 13: 11. 1912.

Classification: Sordariomycetes, Hypocreomycetidae, Hypocreales, Nectriaceae.

Type species: Calonectria pyrochroa (Desm.) Sacc. Holotype: Italy, leaves of Magnolia grandiflora, Daldini (as Ca. daldiniana);

Type species: Calonectria pyrochroa (Desm.) Sacc. Holotype: Italy, leaves of Magnolia grandiflora, Daldini (as Ca. daldiniana);

Lectotype: France, litter of Platanus, Autumn. Desm., Pl. Crypt. France Ed. 2 (2) # 372 (fide Rossman 1979); no culture or DNA data available.

DNA barcodes (genus): LSU, ITS.

DNA barcodes (species): cmdA, his3, tef1, tub2, and rpb2.

Ascomata perithelial, solitary or in groups, globose to sub-globose to ovoid, yellow to orange to red or red-brown to brown, turning dark red to red-brown in KOH, rough-walled; ascomatal apex consisting of flattened, thick-walled hyphal elements with rounded tips forming a papilisade, discontinuous with warty wall, gradually becoming thinner towards ostiolar canal, and merging with outer periphyses; ascomatal base consisting of dark brown-red, angular cells, merging with an erumpent stroma, cells of outer wall layer continuing into pseudoparenchymatous cells of erumpent stroma. Asci 8-spored, clavate, tapering to a long thin stalk. Ascospores aggregated in upper third of ascus, hyaline, smooth, fusoid with rounded ends, straight to sinuous, unconstricted, or constricted at septa. Macroconidiophores, if present, borne on agar surface or immersed in agar; stipe extensions mostly absent; conidiophores unbranched, terminating in 1–3 phialides, or sometimes with a single subterminal phialide; phialides straight to curved, cylindrical, seemingly producing a single conidium, pericinal thickening and an inconspicuous, divergent collarette rarely visible. Megaconidia hyaline, smooth, frequently remaining attached to phialide, multi-septate, widest in middle, bent or curved, with a truncate base and rounded apical cell. Macroconidiophores consist of a stipe, a penicillate arrangement of fertile branches, a stipe extension, and a terminal vesicle; stipe septate, hyaline or slightly pigmented at base, smooth or finely verruculose; stipe extensions septate, straight to flexuous, mostly thin-walled, terminating in a thin-walled vesicle of characteristic shape. Conidiogenous apparatus with 0–1-septate primary branches, septate large conidia, 4.5–9.5 × 2.5–4.5 μm, with 1–8 guttules. Conidial matrix cream-coloured.

Culture characteristics: Colonies on OA, reaching 47–55 mm diam after 1 wk, margin regular, floccose, white, dark grey near centre; reverse white to buff, dark grey near centre. Colonies on MEA 40–60 mm diam after 1 wk, margin regular, woolly, pale olivaceous grey; reverse concolorous. Colonies on PDA, reaching 20–25 mm diam after 1 wk, margin regular, floccose, compact, white to olivaceous; reverse white to buff, olivaceous near centre. NaOH test negative.

Material examined: USA, on seedlings of Trachelospermum jasminoides, 2014, W.J. Duan holotype HMAS 246706, culture ex-type CGMCC 3.18222 = LC 8105.

Notes: Boeremia trachelospermi represents the first report of a Boeremia species on Trachelospermum (Apocynaceae). Phylogenetically, it forms a distinct lineage separate from Bo. diversispora, the Bo. exigua varieties, Bo. noackiana and Bo. sambuci-nigrae (Fig. 7), and morphologically it often produces longer conidiogenous cells and conidia than the other taxa.

Authors: Q. Chen & L. Cai

Calonectria De Not., Comm. Soc. crittog. Ital. 2(fasc. 3): 477. 1867. Figs 9, 10.

Synonyms: Cylindrocladium Morgan, Bot. Gaz. 17: 191. 1892. Candelospora Rea & Hawley, Proc. R. Ir. Acad., Sect. B, Biol. Sci. 13: 11. 1912.

Classification: Sordariomycetes, Hypocreomycetidae, Hypocreales, Nectriaceae.

Type species: Calonectria pyrochroa (Desm.) Sacc. Holotype: Italy, leaves of Magnolia grandiflora, Daldini (as Ca. daldiniana);
| Species                  | Isolates\(^1\) | GenBank accession numbers\(^2\) | References                                                                 |
|-------------------------|----------------|-------------------------------|---------------------------------------------------------------------------|
| Boeremia crinicola      | CBS 109.79     | GU237377                      | GU237489                                                                  |
| Bo. diversispora        | CBS 102.80     | GU237725                      | GU237492                                                                  |
| Bo. exigua var. coffeae | CBS 109183     | GU237748                      | GU237489                                                                  |
| Bo. exigua var. exigua  | CBS 431.74     | FJ427001                      | GU237494                                                                  |
| Bo. exigua var. forsythiae | CBS 101213    | GU237723                      | GU237494                                                                  |
| Bo. exigua var. gilvescens | CBS 101150   | GU237715                      | GU237495                                                                  |
| Bo. exigua var. heteromorpha | CBS 443.94\(^{NT}\) | GU237866                          | GU237497                                                                  |
| Bo. exigua var. linicola | CBS 116.76    | GU237754                      | GU237500                                                                  |
| Bo. exigua var. populi  | CBS 100167\(^1\) | GU237707                      | GU237501                                                                  |
| Bo. exigua var. pseudollacias | CBS 101207\(^1\) | GU237721                      | GU237503                                                                  |
| Bo. exigua var. rhapontica | CBS 113651\(^1\) | GU237721                      | GU237503                                                                  |
| Bo. exigua var. viburni | CBS 100354     | GU237711                      | GU237506                                                                  |
| Bo. foveata             | CBS 109176     | GU237742                      | GU237506                                                                  |
| Bo. hedenicola          | CBS 367.91     | GU237842                      | GU237511                                                                  |
| Bo. illicis             | CBS 569.79     | GU237892                      | GU237511                                                                  |
| Bo. lycopersici         | CBS 378.67     | GU237848                      | GU237512                                                                  |
| Bo. noackiana           | CBS 100353     | GU237710                      | GU237514                                                                  |
| Bo. sambuci-nigrae      | CBS 629.68\(^1\) | GU237897                      | GU237517                                                                  |
| Bo. strasseri           | CBS 126.93     | GU237773                      | GU237518                                                                  |
| Bo. telephit            | CBS 109175     | GU237741                      | GU237520                                                                  |
| Bo. trachelospermi     | CGMCC 3.18222\(^1\) | KY064028                      | KY064051                                                                  |

\(^1\) CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CGMCC: Chinese General Microbiological Culture Collection Center, Beijing, China. \(^1\) and \(^{NT}\) indicate ex-type and ex-neotype strains, respectively.

\(^2\) ITS: internal transcribed spacers and intervening 5.8S nrDNA; act: partial actin gene; cal: partial calmodulin gene; rpb2: partial RNA polymerase II second largest subunit gene; tef1: partial translation elongation factor 1-alpha gene; tub2: partial \(\beta\)-tubulin gene.
up to eight additional branches, mostly aseptate, each terminal branch producing 1–6 phialides; phialides cylindrical to allantoid, straight to curved, or doliform to reniform, hyaline, aseptate, apex with minute periclinal thickening and inconspicuous divergent collarette. *Macroconidia* cylindrical, rounded at both ends, straight or curved, widest at base, middle, or first basal septum, 1- to multi-septate, lacking visible abscission scars, held in parallel cylindrical clusters by colourless slime. *Microconidiophores* consist of a stipe and a penicillate or sub-verticillate arrangement of fertile branches; *primary branches* 0–1-septate, subcylindrical; *secondary branches* 0–1-septate, terminating in 1–4 phialides; phialides cylindrical, straight to slightly curved, apex with minute periclinal thickening and marginal frill. *Microconidia* cylindrical, straight to curved, rounded at apex, flattened at base, 1(–3)-septate, held in asymmetrical clusters by colourless slime.

**Culture characteristics:** Colonies on MEA white to pale brick when young, becoming pale brick to dark sepia when mature, fluffy, cottony, effuse to convex with papillate surface, margin entire, undulate, lobate, or fimbriate, sometimes with abundant chlamydospores forming microsclerotia within medium.
Optimal media and cultivation conditions: CLA to induce sporulation of the asexual morph at 25 °C, while for the sexual morph sterile toothpicks placed on SNA is used at 20 °C.

Distribution: Worldwide.

Hosts: Soil-borne pathogens of forestry, agricultural and horticultural crops representing approximately 100 plant families and 340 plant host species (Crous 2002, Lombard et al. 2010c).

Disease symptoms: Leaf spots, leaf and shoot blights, cutting rot, stem cankers, damping-off and root rot.

Notes: The genus Calonectria presently includes 151 species of which only Ca. hederae and Ca. pyrochroa are not supported by ex-type cultures and supplementary DNA barcodes. Species delimitation based on morphology alone is complicated by the large number of cryptic taxa recognised in this genus (Lombard et al. 2016). The perithecia of several Calonectria spp. are morphologically similar. The cylindrocladium-like asexual morph, the life phase most commonly found in nature, is extensively used for taxon identification, although it is complicated by the morphological overlap of some cryptic species. For accurate species delimitation, phylogenetic inference of the cmdA, tef1 and tub2 (or combinations of these) is required.

References: Crous 2002 (morphology, pathogenicity and monograph); Lombard et al. 2010a–d, 2015, 2016 (morphology, phylogeny and key of Calonectria spp.); Alfenas et al. 2015 (morphology and phylogeny).

Calonectria ecuadorensis L. Lombard & Crous, sp. nov. MycoBank MB820849. Fig. 12.

Eymology: Name refers to Ecuador, the country where this fungus was collected.

Macroconidiophores consist of a stipe bearing a penicillate arrangement of fertile branches, and a stipe extension terminating in a vesicle; stipe septate, hyaline, smooth, 55–70 × 6–10 μm; stipe extension septate, straight to flexuous, 130–280 μm long, 3–6 μm wide at apical septum, terminating in a clavate vesicle, 4–6 μm diam. Conidiogenous apparatus 45–90 μm wide, and 20–90 μm long; primary branches aseptate, 13–31 × 4–6 μm; secondary branches aseptate, 13–23 × 4–5 μm; tertiary branches aseptate, 9–15 × 3–4 μm, each terminal branch producing 2–6 phialides; phialides doliform to reniform, hyaline, aseptate, 6–11 × 2–4 μm, apex with minute periclinal thickening and inconspicuous collarette. Macroconidia cylindrical, rounded at both ends, straight, (35–)35–39(–44) × (3–3.5–4.5(–5) μm (av. 37 × 4 μm), 1-septate, lacking a visible abscission scar, held in parallel cylindrical clusters by colourless slime. Mega- and microconidia not observed.

Culture characteristics: Colonies moderately fast growing (35–55 mm diam) on MEA after 1 wk at room temperature; surface rosy-buff to cinnamon with sparse white woolly aerial mycelium and abundant sporulation on aerial mycelium and colony surface; reverse rosy-buff to cinnamon to sepia with abundant chlamydospores throughout medium, forming microsclerotia.
**Fig. 9.** Calonectria spp. A–H. Sexual morphs. A–D. Perithecia. A. Calonectria asiatica (ex-type CBS 114073). B. Calonectria braziliensis (ex-type CBS 230.51 × CBS 114257). C. Calonectria fujianensis (ex-type CBS 127201). D. Section through perithecium of Calonectria asiatica (ex-type CBS 114073). E–F. Asci. E. Calonectria croussiana (ex-type CBS 127198). F. Calonectria asiatica (ex-type CBS 114073). G–H. Ascospores. G. Calonectria fujianensis (ex-type CBS 127201). H. Calonectria acicola (ex-type CBS 114813).

I–AB. Asexual morphs. I–L. Macroconidiophores. I. Calonectria malesiana (ex-type CBS 112752). J. Calonectria macroconidialis (ex-type CBS 114880). K. Calonectria spathulata (ex-type CBS 555.92). L. Calonectria ovata (CBS 111307). M–O. Conidiogenous apparatus. M. Calonectria brachialita (ex-type CBS 123700). N. Calonectria ekuadoriae (ex-type CBS 111406). O. Calonectria hurae (CBS 114551). P. Microconidiophore of Calonectria reteaudi (ex-type CBS 112144). Q. Macroconidia of Calonectria hurae (CBS 114551). R. S. Macroconidia. R. Calonectria angustata (ex-type CBS 109065). S. Calonectria chinensis (ex-type CBS 114827). T. Macroconidia of Calonectria pteridis (ex-type CBS 111793). U–AB. Terminal vesicles of stipe extensions. U. Calonectria brasicae (ex-type CBS 111869). V. Calonectria rumohrae (CBS 109062). W. Calonectria cylindrospora (CBS 119670). X. Calonectria hongkongensis (ex-type CBS 114828). Y. Calonectria chinensis (ex-type CBS 114827). Z. Calonectria humicola (ex-type CBS 125251). AA. Calonectria mexicana (ex-type CBS 110916). AB. Calonectria spathulata (ex-type CBS 555.92). Scale bars: A–C = 500 μm; D–F = 100 μm; G, H, M–P, R–AB = 10 μm; I–L, Q = 20 μm.
Material examined: **Ecuador**, from soil, 20 Jun. 1997, M.J. Wingfield (holotype CBS H-23134, culture ex-type CBS 111706 = CPC 1636); *ibid.*, culture CBS 114164 = CPC 1634.

Notes: *Calonectria ecuadorensis* can be distinguished from *Ca. ecuadoriae* (Crous et al. 2006a) by its fewer branches in the conidiogenous apparatus. Also, the conidia of *Ca. ecuadorensis* ([34(−)35–39(−44) × (3−)3.5–4.5(−5) μm (av. 37 × 4 μm)] are smaller than those of *Ca. ecuadoriae* ([45−]48–55(−65) × (4−) 4.5(−5) μm (av. 51 × 4.5 μm); Crous et al. 2006a).

**Calonectria longiramosa** L. Lombard & Crous, sp. nov. MycoBank MB820843. Fig. 13.

**Etyymology:** Name refers to the characteristic long fertile branches of the conidiogenous apparatus in this fungus.

Macroconidiophores consist of a stipe bearing a penicillate arrangement of fertile branches, and a stipe extension terminating in a vesicle; stipe septate, hyaline, smooth, 100−245 × 6−9 μm; stipe extension septate, straight to flexuous, 155−310 μm long, 4−6 μm wide at apical septum, terminating in a clavate vesicle, 5−8 μm diam. Conidiogenous apparatus 50−85 μm wide, and 60−140 μm long; primary branches aseptate to 1-septate, 22−42 × 4−6 μm; secondary branches aseptate, 15−35 × 3−6 μm; tertiary branches aseptate, 12−30 × 3−6 μm; quaternary branches aseptate, 11−19 × 3−6 μm each terminal branch producing 2−4 phialides; phialides elongate doliiform to allantoid, hyaline, aseptate, 8−16 × 2−4 μm, apex with minute periclinal thickening and inconspicuous collarette. Macroconidia cylindrical, rounded at both ends, straight to slightly curved, (57−) 66−76(−84) × (3−)4.5−5.5(−6) μm (av. 71 × 5 μm), 1-septate, lacking a visible abscission scar, held in parallel cylindrical clusters by colourless slime. Mega- and microconidia not observed.

Culture characteristics: Colonies moderately fast growing (35−70 mm diam) on MEA after 1 wk at room temperature; surface amber with moderate white, woolly aerial mycelium and moderate sporulation on the aerial mycelium and colony surface; reverse amber with abundant chlamydospores throughout the medium, forming microsclerotia.

Material examined: **Brazil**, Amazon, from *Eucalyptus* sp., 1993, P.W. Crous & A.C. Alfenas (holotype CBS H-22759, culture ex-type CBS 116319 = CPC 3761); *ibid.*, cultures CBS 116305 = CPC 3765.

Notes: *Calonectria longiramosa* is a new species in the *Ca. pteridis* complex. This species is characterised by the long fertile branches of the conidiogenous apparatus distinguishing it from the other species in this complex (Alfenas et al. 2015).

**Calonectria nemoralis** L. Lombard & Crous, sp. nov. MycoBank MB820850. Fig. 14.

**Etyymology:** Name refers to the environment, a *Eucalyptus* plantation, from where this fungus was collected.

Macroconidiophores consist of a stipe bearing a penicillate arrangement of fertile branches, and a stipe extension terminating in a vesicle; stipe septate, hyaline, smooth, 40−165 × 6−8 μm; stipe extension septate, straight to flexuous, 140−210 μm long, 3−5 μm wide at the apical septum, terminating in a fusiform to ovoid vesicle, 7−9 μm diam. Conidiogenous apparatus 20−45 μm wide, and 40−55 μm long; primary branches aseptate, 18−24 × 3−6 μm; secondary
Table 3. DNA barcodes of accepted Calonectria spp.

| Species         | Isolates1 | GenBank accession numbers2 | References                                      |
|-----------------|-----------|----------------------------|-------------------------------------------------|
|                 | tub2      | cmdA                       | his3                                           |
| Calonectria acicola | CBS 114812T | DQ190590 GQ267359 GQ267291 | DQ190693 KY653352 GQ280547 GQ280669            |
|                 |           |                            |                                                 |
| Ca. aconidialis  | CBS 136068T | –                          | KJ463017 KJ462785 KJ463133                    |
|                 |           |                            |                                                 |
| Ca. amazonica    | CBS 116250T | KX784612 KX784555 KX784682 | – KY653355 KY653241 KY653297                    |
|                 |           |                            |                                                 |
| Ca. amazoniensis | CBS 115440T | KX784615 KX784558 KX784685 | – KY653358 KY653244 KY653300                    |
|                 |           |                            |                                                 |
| Ca. angustata    | CBS 109065T | AF207543 FJ918551 DQ190696 | KY653359 GQ280548 GQ280671                     |
|                 |           |                            |                                                 |
| Ca. arbusa       | CBS 136079T | KJ462904 KJ463018 KJ462787 | KJ463135 – –                                   |
|                 |           |                            |                                                 |
| Ca. asiatica     | CBS 114073T | AY725616 AY725741 AY725705 | AY725658 – GQ280550 GQ280672                    |
|                 |           |                            |                                                 |
| Ca. australiensis| CBS 112954T | DQ190956 GQ267363 GQ267293 | DQ190699 KY653361 GQ280552 GQ280674            |
|                 |           |                            |                                                 |
| Ca. biephilaee   | CBS 136425T | KF777246 –                  | – KF777243 – KF77141 KF77197                  |
|                 |           |                            |                                                 |
| Ca. brachtiaca   | CBS 123700T | FJ696388 GQ267368 GQ267296 | FJ696396 – GQ280555 GQ280677                    |
|                 |           |                            |                                                 |
| Ca. brasiiliana  | CBS 111484T | KX784616 KX784559 KX784686 | – KY653362 KY653245 KY653301                    |
|                 |           |                            |                                                 |
| Ca. brasiliensis | CBS 230.51T | GQ267241 GQ267421 GQ267328 | GQ267259 KY653364 GQ280624 GQ280746            |
|                 |           |                            |                                                 |
| Ca. brassicicae  | CBS 134455T | KM395969 KM396056 KM396882 | KM396139 – –                                   |
|                 |           |                            |                                                 |
| Ca. brassicolicola| CBS 112841T | KX784619 KX784561 KX784689 | – – –                                           |
|                 |           |                            |                                                 |
| Ca. brevistipitata| CBS 115671T | KX784623 KX784565 KX784693 | – KY653368 KY653248 KY653304                    |
|                 |           |                            |                                                 |
| Ca. canadania    | CBS 110817T | AF348212 AY725743 GQ267297 | AF348228 KY653369 GQ280556 GQ280678            |
|                 |           |                            |                                                 |
| Ca. candelabrum  | CPC 1675   | FJ972426 GQ267367 F.J972525 | F.J972476 – GQ280557 GQ280679                    |
|                 |           |                            |                                                 |
| Ca. cercicina    | CBS 123693T | FJ918510 GQ267369 FJ918559 | FJ918528 – GQ280559 GQ280681                    |
|                 |           |                            |                                                 |
| Ca. chinensis    | CBS 114827T | AY725619 AY725747 AY725710 | AY725661 KY653371 GQ280561 GQ280683            |
|                 |           |                            |                                                 |
| Ca. clarva       | CBS 114557T | AF333396 GQ267377 GQ267305 | DQ190623 KY653372 GQ280571 GQ280693            |
|                 |           |                            |                                                 |
| Ca. cliffordicola| CBS 111812T | KX784624 KX784566 KX784694 | – KY653374 KY653249 KY653305                    |
|                 |           |                            |                                                 |
| Ca. colhounii    | CBS 293.79T | DQ190564 GQ267373 GQ267301 | DQ190639 KY653376 GQ280565 GQ280687            |
|                 |           |                            |                                                 |
| Ca. colombiana   | CBS 115127T | FJ972423 GQ267455 F.J972492 | F.J972442 – GQ280660 GQ280782                    |
|                 |           |                            |                                                 |
| Ca. colombianis  | CBS 112220T | GQ267207 AY725748 AY725711 | AY725662 – GQ280566 GQ280688                    |
|                 |           |                            |                                                 |
| Ca. crousiana    | CBS 127198T | HQ285829 –                 | HQ285822 HQ285808 – –                          |
|                 |           |                            |                                                 |
| Ca. cylindrospora| CBS 110666 | FJ918509 GQ267423 F.J918557 | F.J918527 KY653378 GQ280626 GQ280748            |
|                 |           |                            |                                                 |
| Ca. densa        | CBS 125261T | GQ267232 GQ267444 GQ267352 | GQ267281 – GQ280647 GQ280769                    |
|                 |           |                            |                                                 |
| Ca. duoramosa    | CBS 134655T | KM395940 KM396027 KM395853 | – – –                                           |
|                 |           |                            |                                                 |
| Ca. ecuadoriae   | CBS 111406T | DQ190600 GQ267375 GQ267303 | DQ190705 KY653381 GQ280569 GQ280691            |

(continued on next page)
Table 3. (Continued).

| Species | Isolates | GenBank accession numbers | References |
|---------|----------|--------------------------|------------|
| Ca. ecuadorensis | CBS 111706<sup>T</sup> | KX784674 | KY653382 | Lombard et al. (2016), present study |
| Ca. eucalypti | CBS 125275<sup>T</sup> | GQ267218 | GQ267267 | Lombard et al. (2010c) |
| Ca. eucalypticola | CBS 134847<sup>T</sup> | KM395694 | – | Allenas et al. (2015) |
| Ca. expansa | CBS 136247<sup>T</sup> | KJ462914 | KJ463146 | Lombard et al. (2015) |
| Ca. floridana | CBS 114692<sup>T</sup> | KX784588 | – | Lombard et al. (2016) |
| Ca. folicola | CBS 136641<sup>T</sup> | KJ462916 | KJ463148 | Lombard et al. (2015) |
| Ca. fujianensis | CBS 127201<sup>T</sup> | HQ285792 | – | Chen et al. (2011) |
| Ca. giaeboicola | CBS 134852<sup>T</sup> | KM395666 | – | Allenas et al. (2015) |
| Ca. gordoniae | CBS 112142<sup>T</sup> | AF449449 | DQ190708 | Lombard et al. (2010c), present study |
| Ca. gracilipes | CBS 111141<sup>T</sup> | DQ190566 | KY653386 | Crous et al. (2004c), Lombard et al. (2010c), present study |
| Ca. gracilis | CBS 111807<sup>T</sup> | AF232858 | GQ267323 | Lombard et al. (2010c), present study |
| Ca. guangxiensis | CBS 136092<sup>T</sup> | KJ462919 | KJ463151 | Lombard et al. (2015) |
| Ca. hainanensis | CBS 136248<sup>T</sup> | KJ463036 | KJ463152 | Lombard et al. (2015) |
| Ca. hawksworthii | CBS 111870<sup>T</sup> | AF333407 | FJ191585 | Schoch et al. (2001), Lombard et al. (2010c), present study |
| Ca. hemicola | CBS 138102<sup>T</sup> | JX535308 | KF815157 | Gehesquière et al. (2016) |
| Ca. hodgei | CBS 133609<sup>T</sup> | KC491228 | KC491225 | Afanas o et al. (2015) |
| Ca. hongkongensis | CBS 114829<sup>T</sup> | AY725622 | AY725667 | Crous et al. (2004c), Lombard et al. (2010c) |
| Ca. humicola | CBS 125251<sup>T</sup> | GQ267233 | GQ267282 | Lombard et al. (2010c) |
| Ca. hurea | CBS 114551<sup>T</sup> | AF333408 | FJ191584 | Schoch et al. (2001), Lombard et al. (2010c, d) |
| Ca. iliccola | CBS 190.50<sup>T</sup> | AY725631 | AY725767 | Lombard et al. (2010c) |
| Ca. indonesiae | CBS 112823<sup>T</sup> | AY725623 | AY725718 | Lombard et al. (2010c) |
| Ca. indonesiana | CBS 112936<sup>T</sup> | KX784631 | KX784701 | Lombard et al. (2016) |
| Ca. indusiata | CBS 144.36<sup>T</sup> | GQ267239 | GQ267332 | Lombard et al. (2010c), present study |
| Ca. insulans | CBS 114558<sup>T</sup> | AF210861 | FJ191556 | Schoch et al. (1999), Lombard et al. (2010b, c), present study |
| Ca. kyotensis | CBS 114525<sup>T</sup> | AF348215 | AY725713 | Lombard et al. (2010c) |
| Ca. laevisporus | CBS 111324<sup>T</sup> | KX784632 | KX784702 | Lombard et al. (2016), present study |
| Ca. lateralis | CBS 136629<sup>T</sup> | KJ462955 | KJ463186 | Lombard et al. (2015), present study |
| Ca. laui | CBS 749.70<sup>T</sup> | GQ267210 | GQ267312 | Lombard et al. (2010c), present study |
| Ca. leguminosarum | CBS 728.68<sup>T</sup> | AF389837 | FJ191547 | Lombard et al. (2010c) |
| Ca. leucothoës | CBS 109166<sup>T</sup> | FJ191850 | FJ191853 | Lombard et al. (2010b,c), present study |
Ca. longiramosa CBS 116319T KX784635 KX784577 KX784705 – KY653406 KY653260 KY653316 Lombard et al. (2016), present study
Ca. macheaiireae CBS 123183T KX784636 – KX784706 – KY653407 KY653261 KY653317 Lombard et al. (2016), present study
Ca. madagascariensis CBS 114572T DG190572 GQ267394 GQ267314 DG190658 KY653409 GQ280592 GQ280714 Crous et al. (2006a), Lombard et al. (2010c), present study
Ca. macroconidialis CBS 114880T AF232855 GQ267393 GQ267313 DG190655 KY653410 GQ280591 GQ280713 Crous et al. (1999, 2006a), Lombard et al. (2010c), present study
Ca. magnispora CBS 136249T KJ462956 KJ463071 KJ462841 KJ463187 – KY653410 KY653262 KY653316 Lombard et al. (2015)
Ca. malesiana CBS 112752T AY725627 AY725760 AY725672 – KY653415 KY653262 KY653318 Lombard et al. (2015), present study
Ca. maranhensis CBS 136368T KJ462960 KJ463075 KJ462845 KJ463191 KY653411 KY653262 KY653316 Lombard et al. (2015), present study
Ca. monticola CBS 140645T KT964769 KT964771 KT964773 – KT964775 KT983443 Crous et al. (2015e)
Ca. mossambicensis CBS 137243T – JX570722 JX570718 JX570726 – JX570730 – JX570730 – Crous et al. (2013b)
Ca. multilateralis CBS 110932T KX784642 KX784580 KX784712 – KY653413 KY653263 KY653319 Lombard et al. (2016), present study
Ca. multinaviculata CBS 134837T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. multiphialidica CBS 136638T KJ462960 KJ463075 KJ462845 KJ463191 KY653411 KY653262 KY653316 Lombard et al. (2015), present study
Ca. multiseptata CBS 112682T GQ267397 FJ918535 DQ190659 KY653416 GQ280598 GQ280720 Crous et al. (2006a), Lombard et al. (2010c, d), present study
Ca. naviculata CBS 138824T KJ462956 KJ463071 KJ462841 KJ463187 – KY653410 KY653262 KY653316 Lombard et al. (2015), present study
Ca. nemicola CBS 111423T KX784679 KX784609 KX784752 – KY653412 KY653263 KY653319 Lombard et al. (2016), present study
Ca. nemoralis CBS 134838T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. nymphaeae CBS 110121T GQ267211 GQ267399 GQ267317 GQ267252 KM232309 GQ280600 GQ280722 Lombard et al. (2010c, 2015)
Ca. octoramosa CBS 131802T JN964864 – KC555273 – – – – – – Crous et al. (2012)
Ca. orientalis CBS 123183T AY725627 AY725760 AY725672 – KY653415 GQ280597 GQ280719 Crous et al. (2004c), Lombard et al. (2010c), present study
Ca. ovata CBS 112682T GQ267397 FJ918535 DQ190659 KY653416 GQ280598 GQ280720 Crous et al. (2006a), Lombard et al. (2010c, d), present study
Ca. paipatia CBS 112682T GQ267397 FJ918535 DQ190659 KY653416 GQ280598 GQ280720 Crous et al. (2006a), Lombard et al. (2010c, d), present study
Ca. paciifca CBS 112682T GQ267397 FJ918535 DQ190659 KY653416 GQ280598 GQ280720 Crous et al. (2006a), Lombard et al. (2010c, d), present study
Ca. papillata CBS 134838T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. paracoloonii CBS 134838T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. parakei CBS 134838T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. parvispora CBS 111423T KX784679 KX784609 KX784752 – – KY653412 KY653263 KY653319 Lombard et al. (2016), present study
Ca. pauciramosa CBS 134838T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. parvula CBS 134838T KM395979 KM396066 KM395892 KM396149 – Ky653415 KY653265 KY653321 Lombard et al. (2016), present study
Ca. peniscoloides CBS 114636T AY725627 AY725760 AY725672 – KY653415 GQ280598 GQ280720 Crous et al. (2006a), Lombard et al. (2010c, d), present study
Ca. pentaseptata CBS 133349T KJ462956 KJ463071 KJ462841 KJ463187 – KY653410 KY653262 KY653316 Lombard et al. (2016), present study
Ca. piauiensis CBS 134838T KM395979 KM396066 KM395886 KM396143 – – – – – – Crous et al. (2012a)

(continued on next page)
| Species | Isolates | GenBank accession numbers | References |
|---------|----------|--------------------------|------------|
| Ca. pini | CBS 123698<sup>T</sup> | GQ267224 GQ267436 GQ267344 GQ267273 | Lombard et al. (2015) |
| Ca. polizzi | CBS 123402<sup>T</sup> | FJ972419 | Lombard et al. (2016b, d) |
| Ca. plurilateralis | CBS 111401<sup>T</sup> | KX784648 KX784586 KX783759 | Lombard et al. (2016), present study |
| Ca. pluriramosa | CBS 136976<sup>T</sup> | KJ462995 KJ460122 KJ462682 KJ463228 | Lombard et al. (2015), present study |
| Ca. propagicola | CBS 134815<sup>T</sup> | KM395953 KM395604 KM395866 KM396123 | Alfenas et al. (2015) |
| Ca. pseudobrassicae | CBS 134662<sup>T</sup> | KM395936 KM395623 KM395849 KM396106 | Alfenas et al. (2015) |
| Ca. pseudocercicana | CBS 134824<sup>T</sup> | KM395962 KM395604 KM395875 KM396132 | Alfenas et al. (2015) |
| Ca. pseudocolhounii | CBS 127195<sup>T</sup> | HX285788 – HX285756 HG85802 – | Chen et al. (2011) |
| Ca. pseudocucuadiaria | CBS 111402<sup>T</sup> | KX784652 KX784589 KX783759 | Lombard et al. (2016), present study |
| Ca. pseudohodgesii | CBS 134818<sup>T</sup> | KM395905 KM395991 KM395871 KM396079 | Alfenas et al. (2015) |
| Ca. pseudolaptotensis | CBS 137332<sup>T</sup> | KJ462994 KJ463111 KJ462861 KJ463227 | Lombard et al. (2015) |
| Ca. pseudometrosidi | CBS 134845<sup>T</sup> | KM395909 KM395995 KM395821 KM396083 | Alfenas et al. (2015) |
| Ca. pseudomexicana | CBS 130354<sup>T</sup> | JN607496 – JN607266 | Lombard et al. (2011) |
| Ca. pseudoximalensis | CBS 110924<sup>T</sup> | KX784654 – KX784726 – | Lombard et al. (2016), present study |
| Ca. pseudonaviculata | CBS 114417<sup>T</sup> | GQ267214 GQ267409 GQ267325 GQ267258 | Lombard et al. (2015c), present study |
| Ca. pseudopteridis | CBS 163.28<sup>T</sup> | – KM395076 KM395902 – – | Alfenas et al. (2015) |
| Ca. pseudoreteaudi | CBS 123694<sup>T</sup> | FJ918504 GQ267411 FJ918541 FJ918519 – | Lombard et al. (2010c, d) |
| Ca. pseudoscloparia | CBS 125257<sup>T</sup> | GQ267229 GQ267441 GQ267349 GQ267278 – | Lombard et al. (2010c) |
| Ca. pseudospathiphylly | CBS 109165<sup>T</sup> | FJ918513 GQ267412 FJ918562 AF348241 | Kang et al. (2001), Lombard et al. (2010c, d), present study |
| Ca. pseudospathiphyllyl | CBS 134841<sup>T</sup> | KM395983 KM395907 KM395896 KM396153 – – | Alfenas et al. (2015) |
| Ca. pseudovata | CBS 134675<sup>T</sup> | KM395896 KM396033 KM395859 KM396116 – – | Alfenas et al. (2015) |
| Ca. pteridis | CBS 111793<sup>T</sup> | DQ190678 GQ267413 FJ918563 DQ190679 | Lombard et al. (2016), present study |
| Ca. putamamosa | CBS 111449<sup>T</sup> | KX784656 KX784591 KX784726 – | Lombard et al. (2016), present study |
| Ca. queenslandica | CBS 112146<sup>T</sup> | AF389835 GQ267415 FJ918543 FJ918521 – | Lombard et al. (2001), Lombard et al. (2010c, d) |
| Ca. quinqueramosa | CBS 134654<sup>T</sup> | KM395942 KM396029 KM395855 KM396112 – – | Alfenas et al. (2015) |
| Ca. reteaudi | CBS 112144<sup>T</sup> | AF389833 GQ267417 FJ918537 DQ190661 | Lombard et al. (2010c, d), present study |
| Ca. robigopila | CBS 134652<sup>T</sup> | KM395937 KM395924 KM395850 KM396107 – – | Alfenas et al. (2015) |
| Ca. rumohrae | CBS 111431<sup>T</sup> | AF232871 GQ267419 FJ918549 DQ190675 | Lombard et al. (2010c) |
| Ca. seminaria | CBS 136632<sup>T</sup> | KJ462998 KJ463115 KJ462885 KJ463231 | Lombard et al. (2015), present study |
| Ca. silvicola | CBS 135237<sup>T</sup> | KM395978 KM396065 KM395891 KM396148 – – | Alfenas et al. (2015) |
| Ca. spathulata | CBS 555.92<sup>T</sup> | GQ267215 GQ267426 FJ918554 GQ267261 | Lombard et al. (2010c, d), present study |
| Ca. spathiphyll | CBS 114540 | AF348214 GQ267424 GQ267330 AF348230 | Lombard et al. (2010c), present study |
| Genus                        | CBS | GenBank Accessions                                                                 | Authors                      |
|-----------------------------|-----|------------------------------------------------------------------------------------|------------------------------|
| Ca. sphaeropendunculata     | 113801<sup>T</sup> | KJ463003, KJ463120, KJ462890, KJ463236                                             | Lombard et al. (2015)       |
| Ca. stipitata               | 112513<sup>T</sup> | KX784661, KX784596, KX784734, –, KY653450, KY655320, KY653336                     | Lombard et al. (2016), present study |
| Ca. sulawesiensis           | 125277<sup>T</sup> | GQ267222, GQ267344, GQ267271, –, GQ280637, GQ280759                             | Lombard et al. (2010c)      |
| Ca. sumatrensis             | 112829<sup>T</sup> | AY725649, AY725771, AY725696, –, GQ280654, GQ280776                            | Lombard et al. (2016)       |
| Ca. syzygitica              | 112831<sup>T</sup> | KM395930, KM396017, KM395843, KM396100, –, –                                    | Lombard et al. (2016)       |
| Ca. teffricola              | 134664<sup>T</sup> | GQ280654, GQ280776                                                              | Lombard et al. (2016)       |
| Ca. tereticornis            | 111301<sup>T</sup> | KX784664, –, KX784737, –, –                                                     | Lombard et al. (2016)       |
| Ca. terrae-reginae          | 112151<sup>T</sup> | FJ918506, GQ267451, FJ918545, FJ918522, –, GQ280656, GQ280778                  | Lombard et al. (2016)       |
| Ca. terrestris              | 136642<sup>T</sup> | KJ463004, KJ463121, KJ462891, KJ463237, –, –                                    | Lombard et al. (2015)       |
| Ca. terricola               | 116247<sup>T</sup> | KX784665, –, KX784738, –, –                                                     | Lombard et al. (2016)       |
| Ca. tetraramosa             | 136635<sup>T</sup> | KJ463011, KJ463128, KJ462898, KJ463244, KY653453, KY655328, KY653338           | Lombard et al. (2015), present study |
| Ca. trifurcata              | 112753<sup>T</sup> | KX784667, KX784598, KX784740, –, KY653464, KY653292, KY653348                  | Lombard et al. (2016), present study |
| Ca. tropicalis              | 116271<sup>T</sup> | KX784669, KX784599, KX784742, –, KY653455, KY653284, KY653340                  | Lombard et al. (2016), present study |
| Ca. turanicola              | 136077<sup>T</sup> | KJ463013, –, KJ462900, KJ463246, –, KY653287, KY653343                       | Lombard et al. (2015)       |
| Ca. tucuniensis             | 114755<sup>T</sup> | KX784670, KX784600, KX784743, –, KY653456, KY653285, KY653341                  | Lombard et al. (2016), present study |
| Ca. tunisiana               | 116265<sup>T</sup> | KX784680, KX784610, KX784753, –, KY653457, KY653286, KY653342                  | Lombard et al. (2016), present study |
| Ca. uniseptata              | 130357<sup>T</sup> | JN607276, JN607291, JN607261, –, –                                             | Lombard et al. (2011)       |
| Ca. uxmalensis              | 413.06<sup>T</sup>  | GQ267208, GQ267379, GQ267307, GQ267248, –, GQ280573, GQ280695                  | Lombard et al. (2010c)      |
| Ca. variabilis              | 110925<sup>T</sup> | KX784638, –, KX784708, –, KY653461, KY653288, KY653350                       | Lombard et al. (2016), present study |
| Ca. venezuelana             | 111052<sup>T</sup> | KX784671, KX784601, KX784744, –, –                                             | Lombard et al. (2016), present study |
| Ca. vietnamensis            | 112152<sup>T</sup> | KX784672, KX784602, KX784745, –, KY653483, KY653291, KY653347                  | Lombard et al. (2016), present study |
| Ca. zuluensis               | 125268<sup>T</sup> | FJ972414, GQ267459, FJ972483, FJ972433, –, GQ280664, GQ280786                  | Lombard et al. (2010b, c)   |

1 CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CPC: Culture collection of Pedro Crous, housed at Westerdijk Fungal Biodiversity Institute. <sup>T</sup> indicates ex-type strains.  
2 <sup>tub2</sup>: partial β-tubulin gene; <sup>cmdA</sup>: partial calmodulin gene; <sup>tef1</sup>: partial translation elongation factor 1-alpha gene; <sup>his3</sup>: partial histone H3 gene; <sup>rpb2</sup>: RNA polymerase II second largest subunit; ITS: internal transcribed spacers and intervening 5.8S nrDNA; LSU: 28S large subunit RNA gene.
branches aseptate, 11–19 × 3–5 μm, each terminal branch producing 2–4 phialides; phialides elongate doliform to reniform, hyaline, aseptate, 6–14 × 2–4 μm, apex with minute periclinal thickening and inconspicuous collarette. Macroconidia cylindrical, rounded at both ends, straight, (44–)47–59(–71) × (3–)3.5–4.5(–6) μm (av. 53 × 4 μm), 1-septate, lacking a visible abscession scar, held in parallel cylindrical clusters by colourless slime. Mega- and microconidia not observed.

Culture characteristics: Colonies moderately fast growing (35–55 mm diam) on MEA after 1 wk at room temperature; surface sienna with sparse buff to white, woolly aerial mycelium with moderate sporulation on the aerial mycelium and colony surface; reverse sienna with abundant chlamydospores throughout the medium, forming microsclerotia.

Material examined: Brazil, from soil in Eucalyptus plantation, 1996, P.W. Crous (holotype CBS H-23135, culture ex-type CBS 116249 = CPC 3533).

Notes: Calonectria nemoralis is closely related to Ca. pseudovata. The macroconidia of Ca. nemoralis [(44–)47–59(–71) × (3–)3.5–4.5(–6) μm (av. 53 × 4 μm)] are smaller than those of Ca. pseudovata [(55–)67–70(–80) × (4–)5(–7) μm (av. 69 × 5 μm); Alfenas et al. 2015]. Furthermore, no microconidiophores and microconidia were observed in Ca. nemoralis, although they are readily produced by Ca. pseudovata (Alfenas et al. 2015).

Calonectria octoramosa L. Lombard & Crous, sp. nov. MycoBank MB820851. Fig. 15.

Etymology: Name refers to the eight levels of branching of the conidiogenous apparatus.

Macroconidiophores consist of a stipe bearing a penicillate arrangement of fertile branches, and a stipe extension terminating in a vesicle; stipe septate, hyaline, smooth, 36–152 × 7–9 μm; stipe extension septate, straight to flexuous, 137–277 μm long, 3–6 μm wide at the apical septum, terminating in a clavate vesicle, 4–8 μm diam. Conidiogenous apparatus 56–92 μm wide, and 50–70 μm long; primary branches aseptate, 16–34 × 4–7 μm; secondary branches aseptate, 11–20 × 4–6 μm; tertiary branches aseptate, 7–15 × 3–5 μm; quaternary branches and additional branches (–6) aseptate, 8–16 × 3–5 μm, each terminal branch producing 2–6 phialides; phialides doliform to reniform, hyaline, aseptate, 7–12 × 3–5 μm, apex with minute periclinal thickening and inconspicuous collarette. Macroconidia cylindrical, rounded at both ends, straight, (24–)26–32(–36) × (3–)3.5–4.5(–5) μm (av. 29 × 4 μm), 1-septate, lacking a visible abscession scar, held in parallel cylindrical clusters by colourless slime. Mega- and microconidia not observed.

Culture characteristics: Colonies fast growing (50–75 mm diam) on MEA after 1 wk at room temperature; surface umber to sepia with abundant buff to white, woolly aerial mycelium and abundant sporulation on the aerial mycelium and colony surface; reverse amber to sepia with abundant chlamydospores throughout the medium, forming microsclerotia.

Material examined: Brazil, from soil, Jun. 1998, A.C. Alfenas (holotype CBS H-22765, culture ex-type CBS 111465 = CPC 1902). Colombia, La Paz, Rodal Seuiller, from soil, Jan. 1994, P.W. Crous, CBS 116108 = CPC 726.

Notes: Calonectria parvispora is a new species in the Ca. brassicae complex (Lombard et al. 2009, Alfenas et al. 2015). The macroconidia of Ca. parvispora [(24–)26–32(–36) × (3–)3.5–4.5(–5) μm (av. 29 × 4 μm)] are smaller than those of Ca. clavata [(44–)50–70(–80) × (4–)5(–6) μm (av. 65 × 5 μm); Crous 2002]. Ca. brachiatica [(37–)40–48(–50) × 4–6 μm (av. 44 × 5 μm); Lombard et al. 2009]. Ca. brassicae [(38–)40–55(–65) × (3.5–)4–5(–6) μm (av. 53 × 4.5 μm); Crous 2002]. Ca. ecuadoriae [(45–)48–55(–65) × (4–)4.5(–5) μm (av. 51 × 4.5 μm); Crous et al. 2006a]. Ca. gracilipes [(35–)40–48(–60) × 4–5(–6) μm (av. 45 × 4.5 μm); Crous 2002] and Ca. gracilis [(40–)53–58(–65) × (3.5–)4–5 μm (av. 56 × 4.5 μm); Crous 2002].
Fig. 11. The Maximum Likelihood (ML) consensus tree inferred from the combined cmdA, tef1 and tub2 sequence alignments. Thickened lines indicate branches present in the ML, Maximum parsimony (MP) and Bayesian consensus trees. Branches with ML-bootstrap (BS) & MP-BS = 100 % and posterior probabilities (PP) = 1.00 are in blue. Branches with ML-BS & MP-BS ≥ 75 % and PP ≥ 0.95 are in green. The scale bar indicates 0.02 expected changes per site. The tree is rooted to Calonectria brasiliensis (CBS 230.51). Ex-type strains are indicated in bold. GenBank accession numbers are indicated in Lombard et al. (2010a, 2015, 2016) and Alfenas et al. (2015). TreeBASE: S20877.
Calonectria ecuadorensis (ex-type CBS 111706). A, B. Macroconidiophores. C–E. Conidiogenous apparatus with conidiophore branches and doliiform to reniform phialides. F–I. Clavate vesicles. J. Macroconidia. Scale bars: A, B = 50 μm; C–J = 10 μm.
Calonectria tucuruiensis L. Lombard & Crous, sp. nov. MycoBank MB820845. Fig. 17.

Etymology: Name refers to Tucuruí, the region in Brazil from which this fungus was collected.

Macroconidiophores consist of a stipe bearing a penicillate arrangement of fertile branches, and a stipe extension terminating in a vesicle; stipe septate, hyaline, smooth, 35–105 × 6–9 μm; stipe extension septate, straight to flexuous, 165–290 μm long, 4–6 μm wide at the apical septum.

Fig. 13. Calonectria longiramosa (ex-type CBS 116319). A–C. Macroconidiophores. D–F. Conidiogenous apparatus with conidiophore branches and elongate doliiform to allantoid phialides. G–J. Clavate vesicles. K. Macroconidia. Scale bars: A–C = 50 μm; D–K = 10 μm.
terminating in a fusiform to ovoid to ellipsoid vesicle, 9–12 μm diam. 
Conidiogenous apparatus 40–95 μm wide, and 40–90 μm long; primary branches aseptate, 19–32 × 4–7 μm; secondary branches aseptate, 10–28 × 3–5 μm; tertiary branches aseptate, 11–16 × 3–6 μm; quaternary branches aseptate, 8–14 × 3–4 μm each terminal branch producing 2–4 phialides; phialides elongate doliiform to reniform, hyaline, aseptate, 8–17 × 3–5 μm, apex with minute periclinal thickening and inconspicuous collarette. Macroconidia
cylindrical, rounded at both ends, straight, (51–) 57–69(–71) × (4–)4.5–5.5(–6) μm (av. 63 × 5 μm), 1-septate, lacking a visible abscission scar, held in parallel cylindrical clusters by colourless slime. *Mega-* and *micro-conidia* not observed.

**Culture characteristics.** Colonies fast growing (55–75 mm diam) on MEA after 1 wk at room temperature; surface cinnamon to amber with sparse, buff to white, woolly aerial mycelium and abundant sporulation on the aerial mycelium and colony surface;
reverse sienna to amber with abundant chlamydospores throughout the medium, forming microsclerotia.

**Material examined:** Brazil, Tucurui, from leaves of *Eucalyptus tereticornis*, 8 Aug. 1996, P.W. Crous (holotype CBS H-22777, culture ex-type CBS 114755 = CPC 1403); *ibid.*, CBS 116265 = CPC 3552.

**Notes:** *Calonectria tucuruiensis* is closely related to *Ca. terricola* (Fig. 11). The macroconidia of *Ca. tucuruiensis* [(51–)57–69(–71) × (4–)4.5–5.5(–6) μm (av. 63 × 5 μm)] are larger than those of *Ca. terricola* [(40–)43–49(–53) × (3–)4–5(–6) μm (av. 46 × 4.5 μm); Lombard et al. (2016)].

**Authors:** L. Lombard & P.W. Crous

*Calonectria* Ellis & Halst., New Jersey Agric. Coll. Exp. Sta. Bull. 76: 14. 1890. Fig. 18.

**Synonym:** *Rostrella* Zimm., Meded. Lands Plantentuin 37: 24, 1900.

**Classification:** Sordariomycetes, Hypocreomycetidae, Microascales, Ceratocystidaceae.

**Type species:** *Ceratocystis fimbriata* Ellis & Halst. Neotype: BPI 595863.

**DNA barcodes (genus):** 60S, LSU, mcm7.

**DNA barcodes (species):** ITS, bt1, tef1, rpb2, ms204. Table 4.

Ascomata perithecial, scattered or gregarious, immersed, partially embedded or superficial on the substrate; bases subglobose to globose or obpyriform, brown to black, covered with undifferentiated hyphae; ostiolar necks central, long, tapering towards apex; ascovatal apex straight or undulate, unbranched or branched, brown to black and becoming paler; ostiolar hyphae divergent or convergent, non-septate, straight, tapering towards apex, hyaline to light brown. Asci evanescent. Ascospores hyaline, 1-celled, ellipsoidal with gelatinous sheath which gives hat-shaped impression, accumulating in white, creamy to yellow masses at tips of necks. Conidiophores branched, straight or flexuous, hyaline to pale brown. Conidiogenous cells endophialdic, flask-shaped (lageniform) producing various shapes of cylindrical conidia or tubular-form producing barrel-shaped (doliiform) conidia, either lageniform alone or both forms present. Conidia hyaline, 1-celled, doliiform to cylindrical.
Aleuroconidia (in some literature as chlamydospores) absent or present, pale brown to dark brown, pyriform, ellipsoidal to globose, singly or in chains.

Culture characteristics: Colonies showing circular growth with undulate margins, mycelium submerged to aerial, colour ranging from moderate yellowish brown to greyish or brownish olive when mature, releasing sweet fruity aroma. No growth on cycloheximide.

Optimal media and cultivation conditions: 2 % MEA incubated at 25 °C. Addition of thiamin stimulates the development of sexual morph.

Distribution: Worldwide.

Hosts: Herbaceous root crops, Ipomea batatas (sweet potato), wounds or larval tunnels of woody angiosperms, Acacia, Annona, Caryota, Citrus, Coffea, Colocasia, Colophospermum, Combretum, Corymbia, Cunninghamia, Dalbergia, Eucalyptus, Coffea, Mangifera, Platanus, Populus, Purina, Quercus, Raphanea, Saccharum, Schizolobium, Schotia, Syrax, Syzygium, Terminalia, Theobroma. Some known to be vectored by flies (Diptera), non-specific ambrosia beetles (Scolytinae), or nitidulid beetles (Nitidulidae), but without specific insect associates.

Disease symptoms: Root rot, cankers and vascular stain.

Notes: Ceratocystis sensu lato included a heterogeneous group of fungi classified under this generic name due to similar morphology resulting from convergent evolution, despite their diverse ecological and biological features (Upadhyay 1981). The group has recently been divided into seven more narrowly defined homogeneous genera, supported by multigene phylogenies, morphological similarities and ecological commonality (Wingfield et al. 2013a, De Beer et al. 2014). The family Ceratocystidaceae includes nine genera, namely Ambrosiella, Ceratocystis, Chalaropsis, Davidsoniella, Endoconidiophora, Huntiella, Thielaviopsis, Meredithiella and Phialophoropsis (De Beer et al. 2014, Mayers et al. 2015). Ceratocystis sensu stricto is now restricted to those species producing ascomata with smooth bases, ascospores with hat-shaped sheaths, and thielaviopsis-like asexual morphs, which differentiate them from other genera (De Beer et al. 2014). Within Ceratocystis, morphological differences between species are insignificant and phylogenies based on multiple gene regions are used to distinguish them from each other (Fourie et al. 2015). The ITS region has been widely used for delimiting species of Ceratocystis (Schoch et al. 2012). However, discovery of multiple ITS types within single species in the genus (Al Adawi et al. 2013, Naidoo et al. 2013, Harrington et al. 2014) raised an awareness that the ITS region alone should not be applied to delimit species in Ceratocystis, and that additional gene regions should also be considered. Loci such as bt1 and tef1 do not provide good species resolution on their own, but provide strong support in combination with ITS (Fourie et al. 2015).
Fig. 18. A. Sweet potatoes (Ipomea batatas) infected with Ceratocystis fimbriata. B−O. Microscopic features of Ceratocystis fimbriata (CBS 114723 = CMW 14799) on 2 % MEA. B. Ascomata with yellowish droplets of ascospores at tips of necks, with asexual state (white background). C. Young ascoma. D. Mature ascoma. E. Ostiolar hyphae. F, G. Ascospores. H, I. Aleurioconidia. J. Conidiogenous cells producing aleurioconidia (black arrow) and cylindrical-shape conidia (white arrow). K−O. Conidia of various shapes in chains. Scale bars: B = 500 μm; C = 100 μm; E = 50 μm; F, G, K−O = 10 μm; H = 50 μm; I, J = 25 μm.
| Species              | Isolates  | ITS GenBank accession numbers | Reference(s)                                      |
|----------------------|-----------|------------------------------|--------------------------------------------------|
| **Ceratocystis adepha** | CBS 115169T | DQ520637, KJ601509 | Van Wyk et al. (2006), Fourie et al. (2015) |
| Ce. albifundus        | CBS 128992 | DQ520638, KJ601516 | Van Wyk et al. (2006, 2007) |
| Ce. atrox            | CBS 120518T | NR_136981; EF070415, KJ601509 | Fourie et al. (2015) |
| Ce. cacaofunesta      | CBS 115172T | AY157953, KJ601519 | Baker et al. (2003), Fourie et al. (2015) |
| Ce. caryae           | CBS 114716T | NR_119550; AY907035, EF070424, KJ601509 | Johnson et al. (2005, 2007) |
| Ce. cercafabiensis    | CBS 139654T | KP727592, KP727593, KP727594, KJ601509 | Liu et al. (2015a) |
| Ce. collisensis       | CBS 139679T | KP727578, KP727579, KJ601509 | Liu et al. (2015a) |
| Ce. colombiana        | CBS 121792T | NR_119483, AY177233 | Van Wyk et al. (2007) |
| Ce. corymbiicola      | CBS 127215T | NR_119830; HMO71902, KJ601509 | Kamga Nkwuen et al. (2012) |
| Ce. curvata           | CBS 122603T | NR_137018; FJ515143, KJ601509 | Van Wyk et al. (2011b), Fourie et al. (2015) |
| Ce. diversacionidia   | CBS 123013T | FJ151440, KJ601509 | Van Wyk et al. (2011b), Fourie et al. (2015) |
| Ce. ecuadoriana       | CBS 124020T | FJ151432, KJ601509 | Van Wyk et al. (2011b), Fourie et al. (2015) |
| Ce. eucalypticola     | CBS 124016T | FJ236723, KJ601509 | Van Wyk et al. (2011b), Fourie et al. (2015) |
| Ce. ficiola           | MAFF 625119 | NR_119410, KJ601509 | Kajitani & Masuya (2011) |
| Ce. fimбриata         | CBS 114723T | KC493160, KJ601509 | Luchi et al. (2013, 2015), Fourie et al. (2015) |
| Ce. fimбриatomima     | CBS 121786T | EF190963, KJ601509 | Van Wyk et al. (2009b, 2015), Fourie et al. (2015) |
| Ce. harringtonii      | CBS 119.78 | EF070418, KJ601509 | Van Wyk et al. (2007) |
| Ce. larium            | CBS 122512T | NR_137016; EU881906, KJ601509 | Van Wyk et al. (2009a) |
| Ce. mangicola         | CBS 114721T | AY953382, KJ601509 | Van Wyk et al. (2005, 2011a), Fourie et al. (2015) |
| Ce. manginicans       | CBS 121659T | NR_119532; AY953383, KJ601509 | Van Wyk et al. (2005, 2007), Fourie et al. (2015) |
| Ce. mangivora         | CBS 128340T | FJ200262, KJ601509 | Van Wyk et al. (2011a, 2015), Fourie et al. (2015) |
| Ce. neglecta          | CBS 121789T | NR_137552; EF127990, KJ601509 | Rodas et al. (2008, 2009a), Fourie et al. (2015) |
| Ce. obpyriformis      | CBS 122511T | NR_137016, EU881906, KJ601509 | Heath et al. (2009) |
| Ce. papillata         | CBS 121793T | NR_119486; EU881906, KJ601509 | Van Wyk et al. (2010, 2015), Fourie et al. (2015) |
| Ce. piniformis        | CBS 118128T | NR_119452; AF427105, KJ601509 | Barnes et al. (2003), Van Wyk et al. (2004, 2006), Fourie et al. (2015) |
| Ce. platani           | CBS 114724T | NR_119529; AY907030, KJ601509 | Heath et al. (2009) |
| Ce. polychora         | CBS 115162T | DQ520630, KJ601509 | Van Wyk et al. (2006, 2007), Fourie et al. (2015) |
| Ce. polyconidia       | CBS 115778T | AY528970, KJ601509 | Van Wyk et al. (2004) |
| Ce. smalleyi          | CBS 122289T | EU244906, KJ601509 | Heath et al. (2009) |
The loci rpb2 and ms204 give stronger resolution than tef1 and bt1, but also need to be used in combination with ITS (Fourie et al. 2015).

References: Hunt 1956, Upadhyay 1981 (morphology); Nag Raj & Kendrick 1975, Paulin-Mahady et al. 2002 (asexual morphs and species); Kile 1993, Van Wyk et al. 2013 (pathogenicity); De Beer et al. 2013a (higher classification); De Beer et al. 2013b (nomenclator); Wilken et al. 2013, Van der Nest et al. 2014a, b, Wingfield et al. 2015, 2016a, b (genomes); Wingfield et al. 2013a, De Beer et al. 2014 (generic definitions and phylogenetic relationships); Wingfield et al. 2013b (international spread).

Authors: I. Barnes, S. Marincowitz, Z.W. de Beer, & M.J. Wingfield

Cladosporium Link, Mag. Gesell. naturf. Freunde, Berlin 7: 37. 1816 (1815). Fig. 19.
For synonyms see Bensch et al. (2012).

Classification: Dothideomycetes, Dothideomycetidae, Capnodiales, Cladosporiaceae.

Type species: Cladosporium herbarum (Pers.: Fr.) Link. Lectotype: L 910.225-733. Epitype and ex-epitype culture: CBS H-19853, CPC 12100 = CBS 121621.

DNA barcodes (genus): LSU.

DNA barcodes (species): act and tef1; in a few cases tub2. Table 5. Fig. 20.

Ascomata pseudothecial, black to red-brown, globose, inconspicuous and immersed beneath stomata to superficial, situated on a reduced stroma, with 1–3 short, periphysate ostiolar necks; periphysoids frequently growing down into cavity; ascomatal wall consisting of 3–6 layers of textura angularis. Pseudoparaphyses frequently present in mature ascomata, hyaline, septate, subcylindrical. Asci fasciculate, short-stalked or not, subsessile, bitunicate, obovoid to broad ellipsoid or subcylindrical, straight to slightly curved, 8-spored. Ascospores bi- to multiseriate, hyaline, obovoid to ellipsoid-fusiform, with irregular luminar inclusions, mostly thick-walled, straight to slightly curved, frequently becoming brown and verruculose in asci, at times covered in mucoid sheath. Dematiaceous hyphomycetes. In vivo: Mycelium internal or external, superficial; hyphae branched, septiculate, subhyaline to usually pigmented, smooth, sometimes slightly rough-walled to verruculose. Stromata absent to sometimes well-developed. Conidiophores mononematous, usually macronematous, solitary, fasciculate, in small to large fascicles, loosely to densely caesipitose, usually erect, occasionally subdecumbent, decumbent or repent, straight to flexuous, unbranched or branched, continuous to septeate, subhyaline to usually distinctly pigmented, smooth to verruculose, proliferation holoblastic, occasionally enteroblastic (after a period when growth has stopped and then resumed), usually sympodial, rarely monopodial (sometimes leaving coarse annellations from repeated enteroblastic proliferation). Conidiogenous cells integrated, terminal or intercalary, monoblastic or usually polyblastic, mostly sympodially proliferating, more or less cylindrical, geniculate-sinuous
or nodulose, sometimes with unilateral swellings; conidiogenous loci usually conspicuous, protuberant, composed of a central convex dome surrounded by a more or less raised periclinal rim (coronate), thickened, refractive or barely to distinctly darkened; conidial formation holoblastic.

Conidia solitary or catenate, in unbranched or branched acropetal chains, amero- to phragmosporous, shape and septation variable, usually subglobose, ovoid, obovoid, ellipsoid, fusiform, limoniform to cylindrical, asperate or with several transverse eusepta, rarely with a single longitudinal septum, subhyaline to usually pigmented, smooth, verruculose, verrucose, echinulate, cristate; hila protuberant, coronate, with a central convex dome and raised periclinal rim, thickened, refractive to darkened; microcyclic conidiogenesis often occurring. In vitro: Stromata usually lacking. Conidiophores usually solitary, arising terminally or laterally from plagiotropic or ascending hyphae, often longer than in vivo. Micronematous conidiophores, lacking in vivo, are often formed in culture. Conidial chains often longer than in vivo (species with solitary conidia are often capable of forming conidial chains in culture).
| Species               | Isolates | GenBank accession numbers | References |
|-----------------------|----------|---------------------------|------------|
| Cladosporium acalyphae | CBS 125982T | HM147994, HM148481, HM148235 | Bensch et al. (2010) |
| Cl. aciculare         | CBS 140488T | KT600411, KT600607, KT600509 | Bensch et al. (2015) |
| Cl. aggregatocricatatum | CBS 140493T | KT600448, KT600645, KT600547 | Bensch et al. (2015) |
| Cl. albiflavezens     | CBS 140690T | LN334420, LN334604, LN334516 | Sandoval-Denis et al. (2016) |
| Cl. alicicinum        | CBS 121624NT | EF769350, EF769502, EF769425 | Schubert et al. (2007) |
| Cl. allii             | CBS 101.81T | JN906977, JN906996, JN906983 | Bensch et al. (2012) |
| Cl. angulocom         | CBS 140692T | LN334425, LN334609, LN334521 | Sandoval-Denis et al. (2016) |
| Cl. angustiterbarum   | CBS 140479T | KT600379, KT600575, KT600476 | Bensch et al. (2015) |
| Cl. angustisporum     | CBS 125983T | HM147995, HM148482, HM148236 | Bensch et al. (2010) |
| Cl. angustiterbarum   | CBS 140480T | KT600379, KT600575, KT600476 | Bensch et al. (2015) |
| Cl. antarcticum       | CBS 690.92T | EF769334, EF769484, EF769405 | Schubert et al. (2007) |
| Cl. antropophilum     | CBS 140685T | LN334437, LN334621, LN334533 | Sandoval-Denis et al. (2016) |
| Cl. aphidis           | CBS 132182ET | JN906978, JN906998, JN906985 | Bensch et al. (2012) |
| Cl. arthropodi        | CBS 124043ET | JN906979, JN906998, JN906985 | Bensch et al. (2012) |
| Cl. asperula          | CBS 126340T | HM147998, HM148485, HM148239 | Bensch et al. (2010) |
| Cl. australiense      | CBS 125984T | HM147999, HM148486, HM148240 | Bensch et al. (2010) |
| Cl. austroafricanum   | CBS 140481T | KT600381, KT600577, KT600478 | Bensch et al. (2015) |
| Cl. austrohemisphaericum | CBS 140482T | KT600382, KT600578, KT600479 | Bensch et al. (2015) |
| Cl. basiinflatum      | CBS 822.84T | HM148000, HM148487, HM148241 | Bensch et al. (2010) |
| Cl. chalastosporoides | CBS 125985T | HM148001, HM148488, HM148242 | Bensch et al. (2010) |
| Cl. chasmanthicola    | CBS 142612ET | KY646221, KY646224, KY646227 | Present study |
| Cl. chubutense        | CBS 124457T | FJ936158, FJ936165, FJ936163 | Schubert et al. (2009) |
| Cl. cladosporoides    | CBS 112388NT | HM148003, HM148490, HM148244 | Bensch et al. (2010) |
| Cl. colombiae         | CBS 274.80BT | DQ780388, EF101372, JN906988 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. crousii           | CBS 140686T | LN334431, LN334615, LN334527 | Sandoval-Denis et al. (2016) |
| Cl. cucumerinum       | CBS 171.52ET | HM148072, HM148561, HM148316 | Bensch et al. (2010) |
| Cl. cycadicola        | CPC 17251T | KJ896122, KJ869227, KJ869236 | Crous et al. (2014b) |
| Cl. delicatatum       | CBS 126344T | HM148081, HM148570, HM148325 | Bensch et al. (2010) |
| Cl. dominicanum       | CBS 119415T | DQ780353, EF101368, JN906986 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. echinulatum       | CBS 125987T | HM148090, HM148580, HM148334 | Bensch et al. (2010) |
| Cl. exasperatum       | CBS 125986T | HM148091, HM148580, HM148335 | Bensch et al. (2010) |
| Cl. exile             | CBS 125987T | HM148092, HM148581, HM148336 | Bensch et al. (2010) |
| Cl. flaviforme        | CBS 126345T | HM148092, HM148581, HM148336 | Bensch et al. (2010) |
| Cl. flavovirens       | CBS 140462T | LN334440, LN334624, LN334536 | Sandoval-Denis et al. (2016) |
| Cl. flavococum        | CBS 140463T | LN334416, LN334600, LN334512 | Sandoval-Denis et al. (2016) |
| Cl. funiculosum       | CBS 122129T | HM148094, HM148583, HM148339 | Bensch et al. (2010) |
| Cl. fusiforme         | CBS 119414T | DQ780388, EF101372, JN906986 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. gamsianum         | CBS 125989T | HM148095, HM148584, HM148339 | Bensch et al. (2010) |
| Cl. globisporum       | CBS 812.96T | HM148096, HM148585, HM148340 | Bensch et al. (2010) |
| Cl. grevilleae        | CBS 114271T | JF770450, JF770473, JF770472 | Crous et al. (2011b) |
| Cl. halotolerans      | CBS 119416T | DQ780364, EF101397, JN906989 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. herbaroides       | CBS 121626T | EF769357, EF769509, EF769432 | Schubert et al. (2007) |
| Cl. herbarum          | CBS 121621ET | EF769363, EF769516, EF769440 | Schubert et al. (2007) |
| Cl. hillianum         | CBS 125988T | HM148097, HM148586, HM148341 | Bensch et al. (2010) |
| Cl. inversicolor      | CBS 401.80T | HM148101, HM148590, HM148345 | Bensch et al. (2010) |
| Cl. ipereniae         | CBS 140483T | KT600394, KT600589, KT600491 | Bensch et al. (2015) |
| Cl. iranicum          | CBS 126346T | HM148110, HM148599, HM148354 | Bensch et al. (2010) |
Table 5. (Continued).

| Species                      | Isolates | GenBank accession numbers | References       |
|------------------------------|----------|---------------------------|------------------|
| Cl. iridis                   | CBS 138.40TT | EF679370 EF679523 EF679447 | Schubert et al. (2007) |
| Cl. keneggi                  | CBS 142613T | KY646222 KY646225 KY646228 | Present study     |
| Cl. langeronii               | CBS 189.54TT | DQ780379 EF101357 JN906990 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. licheniphilum            | CBS 129900TT | HM148111 HM148600 HM148355 | Bensch et al. (2010) |
| Cl. limoniforme              | CBS 140484T | KT600397 KT600592 KT600494 | Bensch et al. (2015) |
| Cl. longicanatum             | CBS 140485T | KT600403 KT600598 KT600500 | Bensch et al. (2015) |
| Cl. longissimum              | CBS 140485T | DQ780352 EF101385 EU570259 | Zalar et al. (2007), Dugan et al. (2008) |
| Cl. lycoperdinum             | CBS 574.78CRS | HM148604 HM148359 | Bensch et al. (2010) |
| Cl. macrocarpum              | CBS 121623TT | EF679375 EF679529 EF679453 | Schubert et al. (2007) |
| Cl. montecellularum          | CBS 140486T | KT600406 KT600504 | Bensch et al. (2015) |
| Cl. myrtacearum              | CBS 126350TT | HM148117 HM148606 HM148361 | Bensch et al. (2010) |
| Cl. ossifragi                | CBS 842.91TT | EF679381 EF679535 EF679459 | Schubert et al. (2007) |
| Cl. oxyssporum               | CBS 129991TT | HM148118 HM148607 HM148362 | Bensch et al. (2010) |
| Cl. paraocladosporoides      | CBS 171.54TT | HM148120 HM148609 HM148364 | Bensch et al. (2010) |
| Cl. parapenidielloides       | CBS 140487T | KT600412 KT600508 | Bensch et al. (2015) |
| Cl. perangustum              | CBS 126596T | HM148121 HM148610 HM148365 | Bensch et al. (2010) |
| Cl. pheanococmae             | CBS 128769T | JF499837 JF499881 JF499875 | Crous & Groenewald (2011) |
| Cl. phlei                    | CBS 358.60TT | JN906981 JN907000 JN906991 | Bensch et al. (2012) |
| Cl. phlyctinicola            | CBS 126352T | HM148150 HM148639 HM148394 | Bensch et al. (2010) |
| Cl. phlyophillum             | CBS 129992TT | HM148154 HM148643 HM148398 | Bensch et al. (2010) |
| Cl. pini-ponderosae          | CBS 124456T | FJ936160 FJ936167 FJ936164 | Schubert et al. (2009) |
| Cl. pseudiridis              | CBS 116463T | EF679383 EF679537 EF679461 | Schubert et al. (2007) |
| Cl. pseudochalastosporoides  | CBS 140490T | KT600415 KT600513 | Bensch et al. (2015) |
| Cl. pseudocladosporoides     | CBS 125993T | HM148158 HM148647 HM148402 | Bensch et al. (2010) |
| Cl. psychrotolerans          | CBS 119412T | DQ780386 EF101365 JN906992 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. puyae                    | CBS 274.80AT | KT600418 KT600516 | Bensch et al. (2015) |
| Cl. ramotenellum             | CBS 126126T | EF679384 EF679538 EF679462 | Schubert et al. (2007) |
| Cl. rectoides                | CBS 125994T | HM148193 HM148683 HM148388 | Bensch et al. (2010) |
| Cl. rhusicola                | CBS 140492T | KT600440 KT600539 | Bensch et al. (2015) |
| Cl. ruguloflabelliforme      | CBS 140494T | KT600458 KT600565 KT600557 | Bensch et al. (2015) |
| Cl. rugulovarians            | CBS 140495T | KT600459 KT600558 | Bensch et al. (2015) |
| Cl. salinae                  | CBS 119413T | DQ780374 EF101390 JN906993 | Zalar et al. (2007), Bensch et al. (2012) |
| Cl. scabrellum               | CBS 126358T | HM148195 HM148685 HM148440 | Bensch et al. (2010) |
| Cl. silenes                  | CBS 100682T | EF679354 EF679506 EF679429 | Schubert et al. (2007) |
| Cl. sinuosum                 | CBS 126129T | EF679386 EF679540 EF679464 | Schubert et al. (2007) |
| Cl. solidaneae               | CBS 132186TT | JN906982 JN907001 JN906994 | Bensch et al. (2012) |
| Cl. sphaerorespermum         | CBS 193.54TT | DQ780343 EF101380 EU570261 | Zalar et al. (2007), Dugan et al. (2008) |
| Cl. spinulosum               | CBS 119907T | EF679388 EF679542 EF679466 | Schubert et al. (2007) |
| Cl. subcinereum              | CBS 140465T | LN834433 LN834529 LN834617 | Sandoval-Denis et al. (2016) |
| Cl. subinflatum              | CBS 126130T | EF679389 EF679543 EF679467 | Schubert et al. (2007) |
| Cl. sublittisimum            | CBS 113754T | EF679397 EF679551 EF679475 | Schubert et al. (2007) |
| Cl. subuliforme              | CBS 126500T | HM148196 HM148686 HM148441 | Bensch et al. (2010) |
| Cl. succulentum              | CBS 140466T | LN834434 LN834618 LN834530 | Sandoval-Denis et al. (2016) |
| Cl. tenellum                 | CBS 126134T | EF679401 EF679555 EF679479 | Schubert et al. (2007) |
| Cl. tenuissimum              | CBS 125995TT | HM148197 HM148687 HM148442 | Bensch et al. (2010) |
| Cl. tuberosum                | CBS 140693T | LN834417 LN834601 LN834513 | Sandoval-Denis et al. (2016) |
| Cl. uredinicola              | ATCC 46649 | AY251071 HM148712 | Braun et al. (2003), Bensch et al. (2010) |
| Cl. varieable                | CBS 121635TT | EF679402 EF679556 EF679480 | Schubert et al. (2007) |

(continued on next page)
### Culture characteristics:
Colonies on SNA often grey olivaceous or olivaceous grey, reverse leaden-grey or black, flat, velvety with fluffy or cottony patches, margin irregular or undulate, aerial mycelium loose diffuse or more abundantly formed, often with abundant submerged mycelium.

### Optimal media and cultivation conditions:
For morphological examinations SNA incubated under continuous near-ultraviolet light at 25 °C proved to be best suited to promote sporulation. The sexual morph can be induced by inoculating plates of 2% WA onto which autoclaved stem pieces of *Urtica dioica*.

### Table 5. (Continued).

| Species                        | Isolates | GenBank accession numbers | References |
|-------------------------------|----------|---------------------------|------------|
| *Cl. varians*                  | CBS 126362<sup>T</sup> | HM148224, HM148715, HM148470 | Bensch et al. (2010) |
| *Cl. velox*                    | CBS 119417<sup>T</sup> | DQ708031, EF101388, JN906995 | Zalar et al. (2007), Bensch et al. (2012) |
| *Cl. verrucocladosporioides*   | CBS 126363<sup>T</sup> | HM148226, HM148717, HM148472 | Bensch et al. (2010) |
| *Cl. versiforme*               | CBS 140491<sup>T</sup> | KT600417, KT600613, KT600515 | Bensch et al. (2015) |
| *Cl. welwitschiicola*          | CBS 142614<sup>T</sup> | KY646223, KY646226, KY646229 | Present study |
| *Cl. xanthochromaticum*        | CBS 140691<sup>T</sup> | LN834415, LN834599, LN834511 | Sandoval-Denis et al. (2016) |
| *Cl. xylophilum*               | CBS 125997<sup>T</sup> | HM148720, HM148721, HM148476 | Bensch et al. (2010) |

1 ATCC: American Type Culture Collection, Virginia, USA; CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CPC: Culture collection of Pedro Crous, housed at Westerdijk Fungal Biodiversity Institute. T, ET, NT and RS indicate ex-type, ex-epitype, ex-neotype and reference strains, respectively.

2 ITS: internal transcribed spacers and intervening 5.8S nrDNA; act: partial actin gene; tef1: partial translation elongation factor 1-alpha gene.

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**Fig. 20.** The first of two equally most parsimonious trees obtained from a heuristic search of the combined ITS/tef1/actA alignment. The tree was rooted to *Cladosporium allicinum* CBS 121624 and the novel species described in this study are shown in bold. Bootstrap support values from 1000 replicates are shown at the nodes and the scale bar represents the number of changes. GenBank accession numbers are indicated in superscript (ITS/tef1/actA). TreeBASE: S20877.
(European stinging nettle) are placed. Inoculated plates have to be incubated on the laboratory bench for 1 wk, after that period they have to be further incubated at 10 °C in the dark for 1–2 mo to stimulate sexual morph development.

**Distribution:** Worldwide.

**Hosts:** Asparagaceae, Asteraceae, Fabaceae, Myrtaceae, Orchidaceae, Poaceae and many other hosts, including fungi and insects.

**Disease symptoms:** Leaf spots, leaf blight, discolourations, necrosis, or shot-hole symptoms, on stems and fruits, but also saprobic, endophytic or isolated from numerous substrates and environments, e.g. indoor environments, salterns and human and animal infections.

**Notes:** The monophyletic genus *Cladosporium* is well characterised by the coronate structure of its conidiogenous loci and conidial hila, consisting of a central convex dome surrounded by a raised periclinal rim (David 1997, Braun et al. 2003). At the moment it comprises about 200 species. *Cladosporium* was previously extremely heterogeneous and encompassed 772 names assigned to this genus (Dugan et al. 2004). Heuchert et al. (2005) examined *Cladosporium* spp. dwelling on other fungi, and Schubert (2005) provided a comprehensive treatment of foliicolous species. Crous et al. (2007a) encompassed a series of papers dealing with a reassessment and new circumscription of *Cladosporium s. str.* and treatments of several cladosporioid genera. Bensch et al. (2012) published a phylogicoporphorous monograph of the genus *Cladosporium* which can be consulted for further information on the history and many other aspects of this genus.

Species delimitation in *Cladosporium* based on morphology alone is limited since many species have overlapping characters. Some key differential features have been identified and detailed in a series of monographic papers (Schubert et al. 2007, Zalar et al. 2007, Bensch et al. 2010, 2012). The most relevant differential morphological traits are the shape, width and complexity of conidiophores, the presence of ramosocinidia, and the formation and ornamentation of conidia. However, given the overlapping of these features, and the need for standardisation using special culture media and scanning electron microscopy procedures, the use of a molecular approach should be mandatory for correct identification of the species in this complex fungal group (Sandoval-Denis et al. 2016).

Three different species complexes are recognised within the genus, mainly based on morphology, and used for practical purposes. The *Cl. cladosporioides* species complex is characterised by mainly narrowly cylindrical or cylindrical-oblong, non-nodulose, mostly non-geniculate conidiophores and conidia with a quite variable surface ornamentation ranging from smooth to irregularly verrucose-rugose or rough-walled (reticulate or embossed stripes under SEM); the *Cl. herbarum* species complex includes species mainly having nodulose conidiophores, with conidiogenesis confined to swellings, and verruculose, verrucose or echinulate conidia; and the *Cl. sphaerospermum* complex is most remarkable due to forming numerous globose or subglobose terminal and intercalary conidia with variable surface ornamentation and often poorly differentiated conidiophores in most of the species (Bensch et al. 2012, 2015). Morphologically similar genera have been treated in Crous et al. (2007b).

Members of *Cladosporiaceae: Cladosporium, Graphiopsis, Neocladosporium, Rachicladosporium, Toxicocladosporium, Verrucocladosporium.*

**References:** Braun et al. 2003 (sexual morph); Crous et al. 2007a, b (cladosporioid-like genera); Schubert et al. 2007 (morphology, phylogeny *Cl. herbarum* complex); Zalar et al. 2007 (morphology, phylogeny *Cl. sphaerospermum* complex); Bensch et al. 2010 (morphology, phylogeny *Cl. cladosporioides* complex); Bensch et al. 2012 (morphology, phylogeny and key of all *Cladosporium* species); Bensch et al. 2015 (morphology, additions to the three species complexes); Sandoval-Denis et al. 2016 (morphology, phylogeny of clinical samples).

*Cladosporium chasmanthicola* Bensch, U. Braun & Crous, sp. nov. MycoBank MB819978. Fig. 21.

**Etymology:** Epithet composed of the name of the host genus, Chasmanthe, and -cola, dweller.

Leaf spots solitary, distributed over leaf surface, amphiogenous, ellipsoid, 1–2 mm diam, pale brown with dark brown margin, some spots also associated with uredinia of *Uromyces kentianii*. On SNA: *Myceum* loosely branched, filiform, narrowly cylindrical-oblong or irregular in outline due to swellings and constrictions, 0.5–4 μm wide, septeate, subhyaline or pale olivaceous or olivaceous brown, almost smooth, verruculose, distinctly verrucose or irregularly rough-walled. **Conidiophores** solitary, formed terminally or laterally by hyphae, straight or somewhat flexuous, macro- and micronematous; *macro-nematous conidiophores* cylindrical, sometimes geniculate, often irregular in outline due to lateral outgrowths, swellings and constrictions (not connected with conidiogenesis), mostly unbranched, 20–100 (–140) × 3.5–5–6 μm, up to 6 μm wide at the base, 1–6-septate, septa sometimes in short succession, not constricted at septa, pale olivaceous or pale to medium olivaceous brown, smooth, walls slightly thickened; *micronematous conidiophores* shorter, narrower and paler than macronematous ones, 15–30 (–80) × 2–3 μm, 0–2-septate, subhyaline or pale olivaceous. **Conidigenous cells** integrated, terminal and intercalary, 8–24 μm long, short cylindrical or often irregular in outline due to lateral prolongations and shoulders and numerous conidiogenous loci often crowded at or towards the apex, up to eight loci in terminal cells, 1–3 loci in intercalary cells, loci conspicuous, subdenticulate, 1–2 μm diam. **Ramoconidia** commonly formed, subcylindrical or irregular due to numerous loci at the distal end, 15–33 × 3–4.5 μm, 0–1(–3)-septate, base broadly truncate, 2.5(–3.5) μm wide. **Conidia** numerous, especially small terminal and intercalary conidia, in branched chains, branching in all directions with 1–3 conidia in the terminal unbranched part of the chain; **terminal conidia** very small, ovoid or obovoid, very pale, subhyaline or pale olivaceous brown, 2.5–4.5 × 2–2.5(–3) μm (av. ± SD: 3.4 ± 0.6 × 2.2 ± 0.3), apex rounded; **intercalary conidia** ovoid, limoniform, ellipsoid or irregular due to lateral outgrowths, 4–10.5 × (2)–3–3.5(–4) μm (av. ± SD: 7.2 ± 2.0 × 3.1 ± 0.5), asperate, with 1–4 distal hila; **secondary ramoconidia** ellipsoid, subcylindrical or irregular in
outline due to numerous hila crowded at or towards the distal end, sometimes located on lateral shoulders or lateral prolongations, those formed on micronematous conidiophores shorter and narrower, (5–)8–23 × (2.5–)3–4.5 μm (av. ± SD: 13.3 ± 5.4 × 3.5 ± 0.6), 0–1(–3)-septate, very pale olivaceous or pale olivaceous brown, smooth, walls unthickened, with (2–)3–6(–7) distal scars; hila conspicuous, 0.5–2 μm diam, darkened-refractive and somewhat thickened; conidia sometimes germinating.

Culture characteristics: Colonies on PDA reaching 28–35 mm diam after 2 wk, olivaceous grey, grey olivaceous with several smoke-grey patches of dense, felty aerial mycelium, reverse leaden-grey to olivaceous grey, powdery, margin white, broad, glabrous, colony centre somewhat folded and wrinkled, growth flat. Colonies on MEA attaining 29–35 mm diam, whitish, smoke-grey to pale olivaceous grey, reverse greyish sepia or olivaceous grey, velvety; margin glabrous, to somewhat feathery, radially furrowed, colony centre elevated, wrinkled and folded; aerial mycelium abundant, covering large parts of the colony surface, dense, fluffy. Colonies on OA reaching 20–28 mm diam, olivaceous grey with patches of smoke-grey, grey olivaceous or glaucous-grey towards margins, reverse leaden-grey to iron-grey, fluffy-felty; margin glabrous, undulate, colony centre somewhat elevated; aerial mycelium loose, diffuse to dense and fluffy in a few spots. On all media without prominent exudates, sporulation profuse.

Material examined: South Africa, Western Cape Province, Cape Town, Brackenfell, Bracken Nature Reserve, isol. from leaf spots on Chasmanthe aethiopica, 25 Sep. 2012, A.R. Wood (holotype CBS H-23117, culture ex-type CBS 142612 = CPC 21300).

Note: Cladosporium chasmanthicola is closely related to Cl. acalyphae, but the latter species has much longer and narrower conidiophores (150–430 × 3–4 μm) and smooth to loosely verruculose, irregularly verruculose-rugose or rough-walled conidia (Bensch et al. 2010).

Cladosporium kenpeggii Bensch, U. Braun & Crous, sp. nov. MycoBank MB819979. Fig. 22.

Etymology: Named after Dr Ken Pegg (Agri-Science and Biosecurity Queensland, Australia), the collector of the species, who celebrates his 80th birthday this year.

On SNA: Superficial mycelium sparingly formed, unbranched, occasionally branched, 2.5–3.5 μm wide, septate, without swellings and constrictions, pale olivaceous brown, almost smooth to verruculose. Conidiophores macronematous, solitary, arising mostly terminally, rarely laterally from hyphae, narrowly cylindrical-oblong, usually unbranched, non-nodulose, sometimes slightly geniculate towards the apex, 15–100(–150) × 2.5–4 μm, 0–2(–5)-septate, pale to medium olivaceous brown, smooth or minutely verruculose, walls unthickened or slightly thickened. Conidiogenous cells integrated, mainly terminally, narrowly cylindrical-oblong, 16–60 μm long, with (1–)2–3(–4) distal conidiogenous loci, crowded at or towards the apex, sometimes slightly geniculate due to sympodial proliferation, conidiogenous loci conspicuous, 1–2 μm diam,
Fig. 22. Cladosporium kenpeggi (ex-type CBS 142613). A. Part of the colony on SNA. B–H. Conidiophores and conidial chains. Note the microcyclic conidiogenesis in C, forming a secondary conidiophore at a still attached conidium with giving rise to secondary conidia and the germinating conidia in C and G. Scale bars = 10 μm; C applies to C, D; E applies to E–G.

Fig. 23. Cladosporium welwitschicola (ex-type CBS 142614). A–G. Conidiophores and conidial chains. H. Conidial chain. Scale bars = 10 μm; A applies to A–C; E applies to E, F.
thickened and darkened-refractive, sometimes cells germinating. **Ramoconidia** frequently formed, (17–)25–55 × 3–4(–5) μm, 0–1(–2)–septate, base broadly truncate, 2–4 μm wide, unthickened, somewhat darkened-refractive. **Conidia** numerous, formed in branched chains, branching in all directions, up to eight conidia in the terminal unbranched part of the chain; **small terminal conidia** obvoid or ellipsoid, 4.5–6 × (2–)2.5–3(–3.5) μm (av. ± SD: 5.0 ± 0.5 × 2.7 ± 0.5), apex rounded; **intercalary conidia** ovoid or ellipsoid, 5.5–15 × (2–)2.5–3.5 μm (av. ± SD: 8.3 ± 3.2 × 3.0 ± 0.4), aseptate, with 1–2 distal hila, attenuated towards apex and base; **secondary ramos conidia** subcylindrical or cylindrical, 14.5–35 × 3–4(–5) μm (av. ± SD: 22.4 ± 5.8 × 3.8 ± 0.6), 0–1(–2)–septate, with 2–3 distal hila, pale olivaceous or pale olivaceous brown, smooth, walls slightly thickened; **hila** conspicuous, subdenticulate, 1–2 μm diam, somewhat thickened and darkened-refractive; **microcyclic conidiogenesis** occurring, conidia often germinating, often with more than one germination tube, tubes sometimes even branched, filiform or irregular in outline.

**Culture characteristics:** Colonies on PDA attaining 35–47 mm diam after 2 wk, olivaceous to olivaceous grey, dull green towards margins, reverse iron-grey, greyish blue towards margins, growth when sporulating profusely, whitish or smoke-grey due to aerial mycelium forming high strains, growth reaching 39–48 mm diam, grey olivaceous to olivaceous grey, dull green towards apex, conspicuous, subdenticulate, 1–2 μm diam, somewhat thickened and darkened-refractive; **microcyclic conidiogenesis** occurring, conidia often germinating, often with more than one germination tube, tubes sometimes even branched, filiform or irregular in outline.

**Material examined:** **Australia**, New South Wales, Upper Dungay, 28°15′S 153°21′E, **culture ex-type CBS 142613** = **CPC 19248** = **BRIP 26701a**.

**Notes:** The smooth conidia formed in long branched chains and the frequently formed ramos conidia remind one of **Cl. cladosporioides** and **C. iranicum**. However, compared with **Cl. cladosporioides**, **C. kenpeggi** possesses much shorter macroconidiospores, macroconidiospores are not formed and the conidia are very often germinating and forming secondary conidiophores. In **C. iranicum** the conidia also germinate quite often, but the conidiophores are longer, macroconidia are shorter and somewhat wider with a narrower base and intercalary conidia are shorter and narrower (Bensch et al. 2012).

**Cladosporium maracuja**, described from *Passiflora* in Brazil in 1935, is morphologically quite similar in having smooth, catenate, 0–1–septate conidia and short conidiophores but since it is only known from the type specimen it is kept separate. The conidia of this species are shorter and wider and the conidiophores wider in vivo.

**Cladosporium welwitschicola** Bensch, U. Braun & Crous, sp. nov. MycoBank MB819980. **Fig. 23.**

**Etymology:** Epithet composed of the name of the host genus, **Welwitschia**, and -cola, dweller.

On SNA: **Superficial mycelium** abundantly formed, filiform to cylindrical-oblong, unbranched or loosely branched, (0.5–)1–4 μm wide, sometimes slightly swollen or constricted, septate, subhyaline, pale olivaceous or pale olivaceous brown, surface ornamentation variable, smooth or almost so, asperulate, verru- culose or sometimes even verrucose, walls unthickened, sometimes forming ropes of several hyphae. Conidiophores macronematous, solitary, erect, straight or slightly flexuous, terminally or laterally formed from hyphae, narrowly cylindrical-oblong, non-nodulose, occasionally once geniculate towards the apex due to sympodial proliferation, 25–90 × (2.5–)3–4.5(–5) μm, 0–3(–4)–septate, not constricted at septa, pale to medium olivaceous brown, smooth, sometimes verrucose or irregularly rough-walled towards the base, walls thickened. **Conidiogenous cells** integrated, usually terminal, cylindrical, 12.5–42 μm long, with 2–4 conidiogenous loci crowded at the apex, conspicuous, subdenticulate, 1–2 μm diam, somewhat thickened and darkened-refractive. **Ramoconidia** not observed. **Conidia** catenate, in branched chains, branching in all directions, (1–)2–5–(–6) conidia in the terminal unbranched part of the chain; **small terminal conidia** obvoid, ellipsoid, 4–5 × 2.5–3.5 μm (av. ± SD: 4.6 ± 0.6 × 3.0 ± 0.4), rugulose, broadly rounded at the apex; **intercalary conidia** ellipsoid, limoniform or fusiform, sometimes irregular in outline due to surface ornamentation, slightly to distinctly attenuated towards apex and base, 5–11 × (2.5–)3–3.5(–4) μm (av. ± SD: 7.4 ± 1.9 × 3.2 ± 0.4), 0–1–septate, with 1–3 distal hila, rugulose to distinctly rugose; secondary **ramoconidia** ellipsoid or subcylindrical, often 3–4 formed at the apex of conidiophores, 8.5–21 × 3–4(–4.5) μm (av. ± SD: 14.6 ± 3.6 × 3.5 ± 0.4), 0–2(–3)–septate, mostly 1-septate, septum median or somewhat in the lower half, pale to medium olivaceous brown or dingy brown, smooth or almost so to rugu- lose, walls somewhat thickened; **hila** conspicuous, 0.5–2 μm diam; **microcyclic conidiogenesis** not occurring.

**Fig. 24.** Colletotrichum spp. A–AA. Assexual morphs. A–C. Conidiomata. A. *Colletotrichum acutatum* (ex-type CBS 112996). B. *Colletotrichum destructivum* (ex-type CBS 136228). C. *Colletotrichum cymbidioideum* (ex-type IMI 347923). D. **Seta** of *Colletotrichum turutusum* (ex-type CBS 128544). E. **Tip** of a seta of *Colletotrichum gloeosporioides* (ex-type CBS 112999). F. Basis of a seta of *Colletotrichum gloeosporioides* (ex-type CBS 112999). G–K. Conidiogenous cells. G. *Colletotrichum brasilense* (ex-type CBS 128501). H. *Colletotrichum scovelli* (ex-type CBS 136529). I. *Colletotrichum tosakii* (CBS 485.85). J. *Colletotrichum petchi* (ex-type CBS 378.94). K. *Colletotrichum gloeosporioides* (ex-type CBS 112999). L–R. Appressoria. L. *Colletotrichum americae-bonaisii* (CBS 136855). M. *Colletotrichum graminicola* (ex-epitype CBS 130836). N. *Colletotrichum gloeosporioides* (ex-type CBS 112999). O. *Colletotrichum latiplicitum* (ex-type CBS 112989). P. *Colletotrichum phormii* (ex-type CBS 118194). Q. *Colletotrichum pinicola* (ex-type CBS 119444). R. *Colletotrichum truncatum* (ex-type CBS 151.35). S–AA. Conidia of the ex-type strains of the name-giving species of nine *Colletotrichum* species complexes. S. **Colletotrichum dematium** (ex-type CBS 125.25). T. *Colletotrichum acutatum* (ex-type CBS 112996). U. *Colletotrichum truncatum* (ex-type CBS 151.35). V. *Colletotrichum gloeosporioides* (ex-type CBS 112999). W. *Colletotrichum graminicola* (ex-epitype CBS 130836). X. *Colletotrichum boninense* (ex-type CBS 122755). Y. *Colletotrichum destructivum* (ex-type CBS 136228). Z. *Colletotrichum orbiculare* (ex-type CBS 570.97). AA. *Colletotrichum gigasporum* (ex-type CBS 133266). –A–E. –H. K. from **Antithusisc stamina. D. I, J, L–AA. from SNA. Scale bars: A = 200 μm; B applies to B, C = 100 μm; G applies to D–AA = 10 μm. A–AA Pictures taken by U. Damm, A, H, O–P, T from Damm et al. (2012b); B, L, Y from Damm et al. (2014); C, D, G, J, X from Damm et al. (2012a); I, O–S, U from Damm et al. (2009); Z from Damm et al. (2013).
Culture characteristics: Colonies on PDA reaching up to 78 mm diam after 2 wk, olivaceous grey, fawn at margins, reverse mouse-grey, viscid-buff at margins, fluffy; margins feathery, growth low convex. Colonies on MEA reaching up to 80 mm diam, smoke-grey, pale olivaceous grey to olivaceous grey, reverse iron-grey, fluffy; margin feathery. Colonies on OA reaching up to 72 mm diam, smoke-grey and pale olivaceous grey, reverse iron-grey, fluffy. On all three media aerial mycelium abundantly formed covering large parts of the colony, loose to dense, high, fluffy; without prominent exudates, sporulation profuse.

Material examined: Namibia, isol. from dead leaf of Welwitschia mirabilis, 1 Oct. 2010, M.J. Wingfield (holotype CBS H-23119, culture ex-type CBS 142614 = CPC 18648).

Notes: With its rugose or distinctly rugose conidia and relatively short conidiophores, Cl. welwitschiola reminds one of Cl. exasperatum and Cl. verruculodiasporioides, but the latter two species differ in forming ramoconidia and in having longer and slightly wider small, intercalary and secondary ramoconidia. Phylogenetically, it is closest to Cl. gamsianum and Cl. pseudoocladosporioides, but these species are easily distinguishable in having smooth and narrower conidia (Bensch et al. 2012).

Authors: K. Bensch, U. Braun, J.Z. Groenewald & P.W. Crous

Colletotrichum Corda, in Sturm, Deutschl. Fl., 3 Abt. (Pilze Deutschl.) 3: 41, tab. 21. 1831. Figs 24, 25.

Synonyms: Glomerella Spauld. & H. Schrenk, Science, N.Y. 17: 1903.

For additional synonyms see Sutton (1980).

Classification: Sordariomycetes, Hypocreomycetidae, Glomerellales, Glomerellaceae.

Type species: Colletotrichum lineola Corda. Holotype: PRM 155463. Epitype and ex-epitype culture: CBS H-20362, CBS 125337.

DNA barcodes (genus): ITS.

DNA barcodes (species): act, ApMat, apn2, cal, chs-1, gapdh, gs, his3, sod2, tub2. Tables 6, 7. Fig. 26.

Ascomata solitary or gregarious, globose to subglobose, dark brown to black, ostiole periphetysae; ascomatal wall composed of pale to medium brown flattened cells of textura angularis. Hamathecium composed of hyaline, septate paraphyses, branched at the bases, rounded at the tips. Asci 8-spored, uniseriate, cylindrical to subfusoid, short pedicellate, with an inamyloid, refractive ring at the apex. Ascospores uniseriate, asperate, hyaline, smooth-walled, cylindrical, oval, fusiform or rhomboid, straight or curved, one end ± acute and one end rounded or both ends rounded. Conidiomata acervular, conidiophores and setae formed on cushions of pale to medium brown, roundish to angular cells, but very variable in culture, ranging from sporodochia-like aggregations of conidiophores directly on hyphae to closed conidiomata that open by rupture. Setae may or may not be present, straight, pale to dark brown, sometimes hyaline towards the tip, smooth-walled, verruculose to verrucose, 1–8-septate, base cylindrical, conical or slightly inflated, tip ± rounded to ± acute. Conidiophores hyaline to pale brown, simple or septate, branched or unbranched, smooth-walled, sometimes verruculose. Conidiogenous cells enteroblastic, hyaline to pale brown, smooth-walled, discrete, cylindrical, ellipsoid, doliform or ampulliform, collarette usually distinct, periclinal thickening visible to conspicuous, sometimes extending to form new conidigenous loci (percurrent) or surrounded by a gelatinous coating. Conidia hyaline, smooth-walled, asperate, cylindrical, clavate, fusiform, sometimes ellipsoid to ovoid, straight or curved, apex rounded to acute, sometimes with a filiform appendage, base rounded to truncate, sometimes with a prominent hilum. Appressoria single or in small groups, pale to dark brown, with a globose, elliptical, clavate, navicular or irregular outline and an entire, undulate or lobate edge.

Culture characteristics: Colonies on PDA flat, with an entire to irregular margin, grey to dark in centre, aerial mycelium, if present, sparse to cottony, white, buff or pale olivaceous green in colour. Reverse first white, with age turning grey to black, olivaceous green or smoke-grey, concentric rings can be observed. Conidia in mass orange, salmon, pink, white or pale grey. Colonies on SNA flat, with an entire, erose, dentate or undulate margin, aerial mycelium, if present, hyaline, white, honey colour, iron-grey, greenish black or dark olivaceous. Reverse hyaline, honey, pale olivaceous grey to iron-grey. Colonies on OA flat, with an entire to umbonate margin, aerial mycelium, if present, white, buff, rosy-buff, very pale glaucous, hyaline or honey coloured. Reverse buff, rosy-buff, flesh, pale luteous, honey coloured, smoke-grey or olivaceous grey. Conidia in mass salmon, saffron, orange, white or rosy-buff.

Optimal media and cultivation conditions: For morphological examinations of the asexual morphs SNA amended with double autoclaved stems of Antriscus sylvestris (wild chervil) and autoclaved filter paper placed onto the agar surface and incubated under near-ultraviolet light with a 12 h photoperiod at 20 °C for 10 d proved to be best suited to promote sporulation of most of the species, while for other species, culturing on OA or PDA incubated under the same conditions is more suitable.
| Species                     | Isolates | GenBank accession numbers | References                                                                 |
|-----------------------------|----------|---------------------------|-----------------------------------------------------------------------------|
| Colletotrichum abscissum    | COAD 1877 | KP843126                  | Crous et al. (2015d)                                                        |
| Col. acerbum                | CBS 12850 | JQ948459                  | Damm et al. (2012b)                                                         |
| Col. acutatum               | CBS 112996| JQ948461                  | Damm et al. (2012b)                                                         |
| Col. aenigma                | ICMP 18968| JX010244                  | Weir et al. (2012)                                                          |
| Col. aescynomenes           | ICMP 17673| JX010176                  | Weir et al. (2012)                                                          |
| Col. agaves                 | CBS 11819| DQ286221                  | Damm et al. (2006)                                                          |
| Col. alatae                 | ICMP 17919| JX010190                  | Damm et al. (2012a)                                                         |
| Col. alienum                | ICMP 12071| JX010251                  | Damm et al. (2014)                                                          |
| Col. americae-borealis       | CBS 136232| KM105224                  | Damm et al. (2014)                                                          |
| Col. anellatum              | CBS 129826| JQ005222                  | Damm et al. (2009)                                                          |
| Col. anthrisci              | CBS 125334| GU228335                  | Damm et al. (2009)                                                          |
| Col. antirrhinicola         | CBS 102189| KM105180                  | Damm et al. (2014)                                                          |
| Col. aotearoa               | ICMP 18537| JX010205                  | Weir et al. (2012), Sharma et al. (2015)                                    |
| Col. aracearum              | CGMCC 3.14983| KX853167               | Hou et al. (2016)                                                           |
| Col. axii                   | CBS 132511| KF687843                  | Liu et al. (2014)                                                           |
| Col. asianum                | ICMP 18580| JX010053                  | Prhastuti et al. (2009), Silva et al. (2012), Weir et al. (2012)          |
| Col. australiae             | CBS 118478| JQ948455                  | Damm et al. (2012b)                                                         |
| Col. beeveri                | CBS 128527| JQ005258                  | Damm et al. (2012a)                                                         |
| Col. bidentis               | COAD 1020 | KF178506                  | Damm et al. (2013)                                                          |
| Col. bletillum              | CGMCC 3.15117| JX625178              | Tao et al. (2013)                                                           |
| Col. boninense              | CBS 123755| JQ005153                  | Damm et al. (2012a)                                                         |
| Col. brasiliense            | CBS 128501| JQ005235                  | Damm et al. (2012a)                                                         |
| Col. brassicola             | CBS 101059| JQ005259                  | Damm et al. (2012a)                                                         |
| Col. brevisporum            | BCC 38876 | JN050238                  | Noireung et al. (2012)                                                      |
| Col. brisbanense            | CBS 292.67 | JQ948291                  | Damm et al. (2012b)                                                         |
| Col. bryoniicola            | CBS 108949| KM105181                  | Damm et al. (2014)                                                          |
| Col. cairnsense             | CBS 116478| JQ948456                  | Damm et al. (2012b)                                                         |
| Col. camelliae              | CGMCC 3.14925| KJ954783              | Liu et al. (2015b)                                                          |
| Col. camelliae-japonicae    | CGMCC 3.18118| KX853165              | Hou et al. (2016)                                                           |
| Col. cathami                | SAPA100011| AB696998                  | Damm et al. (2012b), Uematsu et al. (2012)                                  |
| Species                  | Accession Numbers                                      | Authors                  |
|-------------------------|--------------------------------------------------------|--------------------------|
| Col. changpingense      | KP683152, KP852469, KP852449, KP683093, KP852490     | Jayawardena et al. (2016a) |
| Col. chlorophyti       | GU228286, GU228384, GU2282090, GU227992, GU228188    | Damm et al. (2009)       |
| Col. chrysanthemi     | AB696999                                               | Umematsu et al. (2012), Damm et al. (2012b) |
| Col. circinans         | GU228247, GU228345, GU2282051, GU227953, GU228149    | Damm et al. (2009)       |
| Col. citri             | KC293741, KC293621, KC293661, KC293701, KC293781    | Huang et al. (2013)      |
| Col. citricoa          | KC293736, KC293616, KC293656, KC293696, KC293776    | Yang et al. (2009), et al. (2012) |
| Col. clydermiae        | JX009989, JX009877, JX009537, JX104038, JX009645, JX010129, JX010356 | Weir et al. (2012) |
| Col. clivae            | GQ485607, GQ856756, GQ856722, JX560963, GQ856777, GQ849440 | Yang et al. (2009), Cannon et al. (2012) |
| Col. coccodes          | HM171679, JX546681, JX546779, JX546873                | Liu et al. (2011, 2013a) |
| Col. colombiense       | JQ005261, JQ005435, JQ005522, JQ005608, JQ005695     | Damm et al. (2012a)      |
| Col. conoides          | KP890168, KP890156, KP890144, KP890174, KP890150    | Diao et al. (2017)       |
| Col. constrictum       | JQ005238, JQ005412, JQ005586, JQ005672, JQ005759     | Damm et al. (2012a)      |
| Col. cordylinicola     | JX010226, JX009975, JX009864, HM470235, JX010440     | HM470238, JX010122, JX010361, JQ899274 | Chaudhry et al. (2012b) |
| Col. cosmi             | JQ494804, JQ494895, JQ494925, JQ494955, JQ494925     | Damm et al. (2012b)      |
| Col. costaricense      | JQ494810, JQ494841, JQ494917, JQ494950, JQ494931     | Damm et al. (2012b)      |
| Col. curcumaes         | GU227893, GU228285, GU228383, GU228089, GU227991, GU228187 | Damm et al. (2009)       |
| Col. cuscata          | JQ048425, JQ494856, JQ494916, JQ494964, JQ494964     | Damm et al. (2012b)      |
| Col. cymbidicola       | JQ005253, JQ005430, JQ005427, JQ005514, JQ005600, JQ005687 | Damm et al. (2012a)      |
| Col. dacyrcarpis       | JQ005323, JQ005410, JQ005584, JQ005670, JQ005757     | Damm et al. (2012a)      |
| Col. dematiaceae       | GU228211, GU228309, GU228015, GU227917, GU228113     | Damm et al. (2009)       |
| Col. destructivum      | KM105207, KM105561, KM105277, KM105347, KM105417, KM105487, KM105487 | Damm et al. (2014)       |
| Col. dracaenophilum    | DQ286209, JX546707, JX519230, JX546756, JX519238, JX519247 | Cannon et al. (2012), Farr et al. (2006) |
| Col. endophytica       | KC338354, KP382854, KP382834, KP306258, KP381008     | Manamgoda et al. (2013)  |
| Col. euphorbiae        | KF777131, KF777128, KF777134, KF777125, KF777247    | Crous et al. (2013b)     |
| Col. excelsum-altitudum| KC843502, KC843548, JX562511                           | Tao et al. (2013)        |
| Col. fiorinia          | JQ948392, JQ948353, JQ949934, JQ949943                | Damm et al. (2012b)      |
| Col. freudii          | GU228236, GU228334, GU228040, GU227942, GU228138     | Damm et al. (2009)       |
| Col. fructicola        | JX101065, JX010033, JX009866, JX010405, FJ917508, JX010095, JX010327, JQ807838 | Weir et al. (2012) |
| Col. fructivorum       | JX145145, JX145196, JX145300                           | Doyle et al. (2013)      |
| Col. fuscin            | KM105524, KM105524, KM105344, KM105344, KM105454     | Damm et al. (2014)       |
| Col. fusiforme         | MFLUCC 12–043T, KT290266, KT290253, KT290251, KT290256 | Aryawanisa et al. (2015a) |
| Col. gigasporum        | AM982797, KF687715, KF687822, KF687761, KF687844, FNS57442, KF687866 | Rakotoniariaina et al. (2013), Liu et al. (2014) | (continued on next page)
| Species                  | Isolates | GenBank accession numbers | References               |
|-------------------------|----------|--------------------------|--------------------------|
| **Col. gloeosporioides** | CBS 1129997 | JQ005152 JQ005239 JQ005326 JQ005413 JQ005500 JQ005587 JQ005673 JX010085 JX010365 JQ087843 | Weir et al. (2012) |
| **Col. godetiae**       | CBS 133.447 | JQ948402 JQ948733 JQ949063 JQ949393 JQ949723 JQ950053 – – – | Damm et al. (2012b) |
| **Col. gnirrata**       | CBS 1328797 | KC297078 KC297010 KC296987 KC297056 KC296941 KC297022 KC296963 KC297033 – – | Liu et al. (2013b) |
| **Col. grossum**        | CGMCC3.176147 | KP890165 KP890159 KP890153 KP890141 KP890171 KP890147 | Diao et al. (2017) |
| **Col. guajava**        | IMI 3508397 | JQ948270 JQ948600 JQ948931 JQ949261 JQ949591 JQ949921 – – – | Damm et al. (2012b) |
| **Col. guizhouensis**   | CGMCC 3.151127 | JX625158 KC843507 – – KC843536 JX825185 – – – | Tao et al. (2013) |
| **Col. hebeiense**      | MFLUCC13–07267 | KP136863 KP377495 KP289008 – KP377532 KP288975 | Yan et al. (2015) |
| **Col. hemicoccidioides** | CBS 1306427 | JQ400005 JQ400012 JQ399998 JQ400025 JQ400019 KJ781319 – – | Yang et al. (2012) |
| **Col. henanense**      | CGMCC 3.173547 | KJ954109 – – KM023257 KJ955257 KJ954662 KJ954960 – KJ954524 | Liu et al. (2015b) |
| **Col. higginssianum**  | IMI 3496017 | KM105614 KM105455 KM105452 KM105451 KM105450 KM105449 – – | Damm et al. (2014) |
| **Col. hippocastri**    | CBS 1253767 | JQ005231 JQ005318 JQ005405 JQ005492 JQ005579 JQ005665 JQ005752 – – – | Damm et al. (2012a) |
| **Col. horii**          | ICMP 104927 | GQ392690 GQ392681 GQ392682 GQ392683 GQ392684 GQ392685 GQ392686 GQ392687 | – – – – | Sato et al. (2012) |
| **Col. hsienchen**      | MAFF 243051 | AB738855 – AB738846 AB738847 AB738848 – – – | KJ954672 KJ955051 – KJ954567 | Liu et al. (2015b) |
| **Col. hymenoaulicidica** | MFLUCC 12–05317 | K290263 K290262 – K290260 K290261 – – – | Arijawansa et al. (2015a) |
| **Col. incanum**        | ATCC 646827 | KC110879 KC110870 – KC110825 KC110821 KC110816 | Yang et al. (2014) |
| **Col. indonesiensis**  | CBS 1275517 | JQ948288 JQ948618 JQ949849 JQ949279 JQ949609 JQ949939 – – – | Damm et al. (2012b) |
| **Col. inserta**        | MFLU 15–18957 | KX618686 KX618684 KX618683 KX618682 KX618681 – – – | Hyde et al. (2016) |
| **Col. jiangxiense**    | CGMCC 3.173867 | KJ952521 KJ954902 – KJ954741 KJ954534 – KJ954752 KJ955051 – KJ954567 | Liu et al. (2015b) |
| **Col. johnstonii**     | CBS 1285237 | JQ948444 JQ948775 JQ949105 JQ949435 JQ949095 – – – | Damm et al. (2012b) |
| **Col. kahawae subsp. kahawae** | ICMP 178167 | JX010231 JX010230 JX009966 JX009800 JX009523 JX009435 JX009635 JX010132 JX010346 JX010350 | Weir et al. (2012) |
| **Col. kahawae subsp. cigrasso** | ICMP 185397 | JX010230 JX009966 JX009800 JX009523 JX009435 JX009635 JX010132 JX010346 | Weir et al. (2012) |
| **Col. karstii**        | CBS 1321347 | HM585409 HM585391 HM582023 HM581995 HM585428 HM582013 – – | Yang et al. (2009) |
| **Col. kinghornii**     | CBS 198.357 | JQ948454 JQ948785 JQ949111 JQ949445 JQ949775 JQ950105 – – – | Damm et al. (2012b) |
| **Col. lacticiphilum**  | CBS 1129897 | JQ948289 JQ948619 JQ948950 JQ949280 JQ949610 JQ949940 – – – | Damm et al. (2012b) |
| **Col. lednbouriae**    | CBS 1412847 | KX228054 – – KX228054 KX228054 – – | Cros et al. (2016c) |
| **Col. lentis**         | CBS 1276047 | JQ005766 KM105597 JQ005787 JQ005808 JQ005829 JQ005850 – – – | Damm et al. (2014) |
| **Col. liasoningense**  | CGMCC 3.176167 | KP890104 KP890135 KP890127 KP890097 KP890111 KP890119 – – – | Diao et al. (2017) |
| **Col. lili**           | CBS 109214 | GU227810 GU228202 GU228300 GU228006 GU227908 GU228104 – – – – | Damm et al. (2009) |
| **Col. lilicicola**     | CBS 114.47 | JQ948193 JQ948523 JQ948854 JQ949184 JQ949514 JQ949844 – – – – | Damm et al. (2012b) |
| **Col. lindemuthianum** | CBS 144.317 | JQ005779 JX546712 JQ005800 JQ005821 JQ005842 JQ005863 – KF178643 – – | Damm et al. (2013), Liu et al. (2013a) |
| **Col. lineola**        | CBS 1253377 | GU227829 GU228319 GU228025 GU227927 GU228123 – – – – | Damm et al. (2009) |
| Genus                  | Species                | Accession Numbers                                                                 | Authors                              |
|-----------------------|------------------------|----------------------------------------------------------------------------------|--------------------------------------|
| Col. lini              | CBS 172.51T            | JQ005765 JQ005786 JQ005807 JQ005828 JQ005849                                   | Damm et al. (2014)                   |
| Col. linopes           | CBS 119444T            | GU22704 JQ948155 JQ948185 JQ949146 JQ949476 JQ949806                               | Damm et al. (2009)                   |
| Col. lupini            | CBS 109225T            | JQ005765 JQ005786 JQ005807 JQ005828 JQ005849                                   | Damm et al. (2012b)                  |
| Col. magnisporum       | CBS 398.84T            | KF687718 KF687782 KF687865 KF687803 KF687882                                   | Liu et al. (2014)                    |
| Col. malvarum          | CBS 521.97T            | KF178480 KF178504 KF178529 KF178553 KF178577 KF178601 KF178628                 | Damm et al. (2013)                   |
| Col. melonis           | CBS 159.84T            | JQ948194 JQ948524 JQ948855 JQ949155 JQ949845                                   | Damm et al. (2012b)                  |
| Col. menisepini        | MFLU 14–0626T          | KU242357 KU242356                                                               | Li et al. (2016)                     |
| Col. metake            | MAFF 24409T            | AB738959                                                                        | Sato et al. (2012)                   |
| Col. musae             | ICMP 19119T            | JX010146 JX009586 – JX009433 HO596280 JX009742 JX010103 JX010335 K888926       | Weir et al. (2012)                   |
| Col. neoaseniiaviae    | CBS 139918T            | KR746747 KR476791 – KR476790 KR476797                                        | Crous et al. (2015d)                 |
| Col. nigrum            | CBS 169.49T            | JX546838 JX546793 JX546693 JX546464 JX546885                                    | Liu et al. (2013a)                   |
| Col. novae-zelandiae   | CBS 128505T            | JQ005228 JQ005315 JQ005402 JQ005489 JQ005576 JQ005662 JQ005749 –                | Damm et al. (2012a)                  |
| Col. nupharicola       | ICMP 18187T            | JX010187 JX009972 JX009835 – JX009437 JX010398 JX009663 JX010088 JX145319       | Weir et al. (2012), Doyle et al. (2013) |
| Col. nymphaeae         | CBS 515.78T            | JQ948197 JQ948527 JQ948858 JQ949188 JQ949518 JQ949848 –                        | Damm et al. (2012b)                  |
| Col. ocimi             | CBS 298.94T            | KM105222 KM105577 KM105362 KM105432 KM105502                                    | Damm et al. (2014)                   |
| Col. oncidii           | CBS 129828T            | JQ005169 JQ005256 JQ005343 JQ005430 JQ005517 JQ005603 JQ005690                 | Damm et al. (2012a)                  |
| Col. orbiculare        | CBS 570.97T            | KF178466 KF178490 KF178515 KF178539 KF178563 KF178587 – KF178611 –            | Damm et al. (2013)                   |
| Col. orchidophillum    | CBS 632.80T            | JQ004815 JQ94881 JQ948812 JQ949142 JQ949472 JQ949802                           | Damm et al. (2012b)                  |
| Col. panaccola         | C00848                 | GU535867 – GU944587 – GU944757 – GU935807                                       | Choi et al. (2011)                   |
| Col. paranaense        | CBS 134729T            | KC204992 KC205026 KC205043 KC205077 KC205060                                  | Bragança et al. (2016)               |
| Col. parsonsiæ         | CBS 128525T            | JQ005233 JQ005320 JQ005407 JQ005494 JQ005581 JQ005667 JQ005754                 | Damm et al. (2012a)                  |
| Col. paxtonii          | IMI 165753T            | JQ948285 JQ948615 JQ948964 JQ949276 JQ949606 JQ949936                          | Damm et al. (2012b)                  |
| Col. petchii           | CBS 378.94T            | JQ005223 JQ005310 JQ005397 JQ005484 JQ005571 JQ005657 JQ005744                 | Damm et al. (2012a)                  |
| Col. phormii           | CBS 118194T            | JQ948446 JQ948777 JQ949107 JQ949437 JQ949767 JQ950977                         | Damm et al. (2012b)                  |
| Col. phyllanthi        | CBS 175.67T            | JQ005221 JQ005308 JQ005395 JQ005482 JQ005569 JQ005655 JQ005742                 | Damm et al. (2012a)                  |
| Col. pisciola          | CBS 724.97T            | KM105172 KM105222 KM105242 KM105312 KM105382 KM105452                        | Damm et al. (2014)                   |
| Col. proteae           | CBS 132882T            | KC297097 KC296986 KC297045 KC296940 KC297101 KC296960 –                     | Liu et al. (2013b)                   |
| Col. pseudoacutatum    | CBS 436.77T            | JQ948480 JQ948811 JQ949141 JQ949471 JQ949801 JQ501131                     | Damm et al. (2012b)                  |
| Col. pseudomajus       | CBS 571.88T            | KF687722 KF687826 KF687779 KF687864 KF687891 KF687833 KF687807 KF687744     | Liu et al. (2014)                    |
| Col. paidii            | ICMP 19120             | JX010219 JX009667 JX009901 – JX009515 JX010443 JX009743 JX010133 JX010366     | Weir et al. (2012)                   |
| Col. pyrcicolae        | CBS 128531T            | JQ948445 JQ948776 JQ949106 JQ949436 JQ949766 JQ950906                         | Damm et al. (2012b)                  |
| Col. queenslandicum    | ICMP 1778T             | JX010276 JX009934 JX009899 – JX009447 JX010414 JX009691 JX010104 JX010336     | Weir et al. (2012)                   |
| Col. quinquelobaiae    | MFLU 14–0626T          | KU242357 KU242356 – KU236389 KU236392                                        | Li et al. (2016)                     |
| Col. radicis           | CBS 529.93T            | KF687719 KF687825 KF687762 KF687847 KF687785 KF687869 KF687806 KF687743     | Liu et al. (2014)                    |

*(continued on next page)*
| Species | Isolates | GenBank accession numbers | References |
|---------|----------|--------------------------|------------|
| Col. rhexiae | CBS 133134^T | JX145128 – – – JX145179 – – – JX145290 | Doyle et al. (2013) |
| Col. rhombifome | CBS 129953^T | JQ948457 JQ948788 JQ949118 JQ949448 JQ949778 JQ950108 – – – – | Damm et al. (2012b) |
| Col. riograndense | ICMP 20083^T | KM655299 KM655298 KM655297 – KM655296 KM655300 KM655296 – – – – | Macedo et al. (2016) |
| Col. rusci | CBS 119206^T | GU227818 GU228210 GU228308 GU228014 GU227916 GU228112 – – – – | Damm et al. (2009) |
| Col. salicis | CBS 607.94T | JQ948460 JQ948791 JQ949121 JQ949451 JQ949781 JQ950111 – – – – | Damm et al. (2012b) |
| Col. salsolea | ICMP 19051T | JX009916 JX009863 – JX009562 JX010403 JX009696 JX010093 JX010325 KC888925 | Weir et al. (2012) |
| Col. sansevieriae | MAFF 239721T | (Sequences available at http://www.gene.affrc.go.jp/databases-micro_search_en.php) | Nakamura et al. (2006) |
| Col. scovillei | CBS 126529^T | JQ948267 JQ948597 JQ949258 JQ949988 JQ949298 JQ949918 – – – – | Damm et al. (2012b) |
| Col. sedi | MFLUCC 14–1002T | KM974758; KM974755 KM974754 – KM974752 KM974753 – – – – | Liu et al. (2015c) |
| Col. siamense | ICMP 18578T | JX010171 JX009924 JX009865 – JX009474 JX010403 JX009694 JX010094 JX010326 JQ992897 | Phoulivong et al. (2009), Weir et al. (2012) |
| Col. sidae | CBS 504.97T | KF178472 KF178497 KF178521 KF178545 KF178569 KF178593 – KF178618 – – | Damm et al. (2013) |
| Col. simmondsii | CBS 122122^T | JQ948267 JQ948606 JQ948397 JQ949267 JQ949957 JQ949927 – FJ917510 FJ972591 – – | Damm et al. (2012b), Prihastuti et al. (2009) |
| Col. sloanei | IMI 364297T | JQ948287 JQ948617 JQ949258 JQ949688 JQ949928 JQ949938 – – – – | Damm et al. (2009) |
| Col. spaethianum | CBS 167.49T | GU227807 GU228599 GU228203 GU227905 GU228105 GU228411 – – – – | Damm et al. (2009) |
| Col. spinacea | CBS 133122^T | JQ948267 JQ948606 JQ948397 JQ949267 JQ949957 JQ949927 – FJ917510 FJ972591 – – | Damm et al. (2012b), Prihastuti et al. (2009) |
| Col. spinosum | CBS 128.57 GU227847 GU228239 GU228237 GU228043 GU227945 GU228141 – – – – | Damm et al. (2013) |
| Col. sydowii | CBS 135819^T | KY263783 KY263787 KY263789 KY263791 KY263793 – | Present study |
| Col. syzygicola | MFLUCC 10–0624T | KF242094 KF242156 – – KF157801 KF254880 KF254859 KF242125 – – | Udayanga et al. (2013) |
| Col. tabacum | CPC 18945T | KM105204 KM105274 KM105344 KM105414 KM105484 – – – – | Damm et al. (2009) |
| Col. tebeestii | CBS 522.97T | KF178472 KF178505 KF178522 KF178546 KF178570 KF178594 – KF178620 – – | Damm et al. (2013) |
| Col. temperatum | CBS 133122^T | JX145159 – – – – JX145211 – – – – | Doyle et al. (2013) |
| Col. theobromicola | ICMP 18649^T | JQ948184 JQ948985 JQ949175 JQ949950 JQ949835 – – – – | Damm et al. (2012b) |
| Col. tofleidiae | CBS 1005.64 | GU227801 GU228219 GU228291 GU227997 GU227899 GU228095 – – – – | Damm et al. (2009) |
| Col. torulosum | CBS 128544^T | JQ005164 JQ005251 JQ005338 JQ005425 JQ005512 JQ005512 – JQ005512 – – – – | Damm et al. (2012a) |
| Col. brichellum | CBS 217.64 | GU227812 GU228204 GU228302 GU228009 GU227910 GU228106 – – – – | Damm et al. (2009) |
| Genus       | Accession Numbers                                                                 | Authors and Year(s)          |
|------------|------------------------------------------------------------------------------------|------------------------------|
| Col. trifolii | CBS 158.83^T KF178478 KF178502 KF178527 KF178551 KF178575 KF178599 – KF178624  | Damm et al. (2014)          |
| Col. tropicale | ICMP 19653^T JX010264 JX010007 JX009870 – JX009489 JX010407 JX009719 JX010097 JX010329 KC790728 | Rojas et al. (2010), Weir et al. (2012) |
| Col. tropicola | BCC 38877^T JN050240 JN050229 – JN050218 JN050246 – – – – – – | Noireung et al. (2012) |
| Col. truncatum | CBS 151.35^T GU227862 GU228254 GU228352 GU228058 GU227960 GU228156 – – – – – – | Damm et al. (2009) |
| Col. utrechtense | CBS 130243^T KM105501 KM105554 KM105271 KM105341 KM105411 KM105481 – – – – – – | Damm et al. (2014) |
| Col. verruculosum | IMI 45525^T GU227806 GU228198 GU228296 GU228002 GU227904 GU228100 – – – – – – | Damm et al. (2009) |
| Col. vietnamense | CBS 125478^T KF687721 KF687832 KF687769 KF687855 KF687792 KF687877 KF687816 KF687753 – – – – | Liu et al. (2014) |
| Col. vignae | CBS 501.97^T KM105183 KM105534 KM105253 KM105323 KM105393 KM105463 – – – – – – | Damm et al. (2014) |
| Col. viniferum | GZAAS 5.0860^T JN141280 JN141278 – – JN141279 JN141281 JQ309639 JN141278 – – – – – | Peng et al. (2013), Hyde et al. (2014) |
| Col. walleri | CBS 125472^T JQ948275 JQ948605 JQ948936 JQ949266 JQ949596 JQ949926 – – – – – – | Damm et al. (2012b) |
| Col. wuxiense | CGMCC 3.17894^T KU251591 KU252045 KU251939 – KU251672 KU252200 KU251833 KU252101 KU251722 | Wang et al. (2016) |
| Col. xanthorrhoeae | ICMP 17903^T JX010261 JX009927 JX009823 – JX009478 JX010448 JX009653 JX010138 JX010369 KC790689 | Shivas et al. (1998), Weir et al. (2012) |
| Col. yunnanense | CBS 132135^T EF369490, JX546706 JX519231 JX546755 JX519239 JX519248 – – – – – – | Liu et al. (2007), Cannon et al. (2012) |

ATCC: American Type Culture Collection, Virginia, USA; BCC: BIOTEC Culture Collection, National Center for Genetic Engineering and Biotechnology (BIOTEC), Khlong Luang, Pathumthani, Thailand; BRIP: Queensland Plant Pathology Herbarium, Brisbane, Australia; CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CGMCC: Chinese General Microbiological Culture Collection Center, Beijing, China; COAD: Coleção Octávio Almeida Drummond, Universidade Federal de Viçosa, Viçosa, Brazil; CPC: Culture collection of Pedro Crous, housed at Westerdijk Fungal Biodiversity Institute, GZAAS: Guizhou Academy of Agricultural Sciences, Guizhou Province, China. ICMP: International Collection of Micro-organisms from Plants, Landcare Research, Private Bag 92170, Auckland, New Zealand; IMI: International Mycological Institute, Kew, UK; MAFF: Ministry of Agriculture, Forestry and Fisheries, Tsukuba, Ibaraki, Japan; MFLU: Herbarium of Mae Fah Luang University, Chiang Rai, Thailand; MFLUCC: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand. "^T" and "^T" indicate holotype specimens and ex-type strains, respectively.

1 ITS: internal transcribed spacers and intervening 5.8S nrDNA; gapdh: partial glyceraldehyde-3-phosphate dehydrogenase gene; chs-1: partial chitin synthase-1 gene; his: partial histone H3 gene; act: partial actin gene; tub2: partial beta-tubulin gene; cal: partial calmodulin gene; gs: partial glutamine synthetase gene; sod2: partial manganese superoxide dismutase gene; ApMat: partial Apn2-Mat1-2 intergenic spacer and partial mating type (Mat1-2) gene.
### Table 7. DNA barcodes of accepted *Colletotrichum* spp. in the *Col. graminicola* and *caudatum* complexes.

| Species       | Isolates                | GenBank accession numbers | References                                                                 |
|---------------|-------------------------|---------------------------|---------------------------------------------------------------------------|
| *C. alcorni*  | IMI 176619<sup>T</sup>  | EU554079, JX076858        | Crouch et al. (2009c), Crouch (2014)                                       |
| *C. baltimorense* | BPI 892771<sup>T</sup> | JX076866                  | Crouch (2014)                                                              |
| *C. caudasporum* | CGMCC 3.15106<sup>T</sup> | JX625162, KC843512        | Tao et al. (2013)                                                          |
| *C. caudatum*   | BPI 423339<sup>T</sup>  | JX076915                  | Crouch (2014)                                                              |
| *C. cereale*    | BPI 892771<sup>T</sup>  | JX076860                  | Crouch et al. (2009c), Crouch (2014)                                       |
| *C. chenii*     | CGMCC 3.15105<sup>T</sup> | JX625180                  | Tao et al. (2013)                                                          |
| *C. echinochloae* | MAFF 511473<sup>T</sup> | AB439811                  | Moriwaki & Tsukiboshi (2009), Crouch & Tomaso-Peterson (2012)              |
| *C. elodes*     | CGMCC 3.15108<sup>T</sup> | JX625177                  | Cannon et al. (2012), Crouch et al. (2009b, c), O’Connell et al. (2012)  |
| *C. endophytum* | CBS 129661<sup>T</sup>  | JQ478447                  | Cannon et al. (2012), Crouch & Tomaso-Peterson (2012)                      |
| *C. falcatum*   | CBS 147945<sup>T</sup>  | HM171877                  | Prihastuti et al. (2010), O’Connell et al. (2012)                         |
| *C. graminicola* | CBS 130836<sup>T</sup>  | JQ005788                  | Crouch et al. (2009a, c), Du et al. (2005), Cannon et al. (2012)           |
| *C. hanaii*     | MAFF 305402<sup>T</sup> | JQ005788                  | Crouch et al. (2009b, c), Cannon et al. (2012)                            |
| *C. jacksonii*  | MAFF 305408<sup>T</sup> | JQ005788                  | Crouch et al. (2009b, c), Cannon et al. (2012)                            |
| *C. kelleyi*    | MAFF 51155<sup>T</sup>  | JX519226                  | Cannon & Tomaso-Peterson (2012)                                           |
| *C. melocarpi*  | CGMCC 3.15107<sup>T</sup> | JX625180                  | Cannon et al. (2012), Crouch et al. (2009b, c), O’Connell et al. (2012)  |
| *C. ochracea*   | CGMCC 3.15104<sup>T</sup> | JX625188                  | Tao et al. (2013)                                                          |
| *C. paspali*    | MAFF 305403<sup>T</sup> | JX519225                  | Crouch et al. (2009b, c), Cannon et al. (2012)                            |
| *C. somersetense* | CBS 131599<sup>T</sup> | JX076882                  | Crouch (2014)                                                              |
| *C. sublineola* | CBS 131301<sup>T</sup>  | JX076882                  | Crouch et al. (2006), Crouch & Tomaso-Peterson (2012), O’Connell et al. (2012) |
| *C. zoysia*     | MAFF 238575<sup>T</sup> | JX076871                  | Crouch et al. (2014)                                                       |

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1 BPI: US National Fungus Collections, Beltsville, Maryland, USA; CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CGMCC: Chinese General Microbiological Culture Collection Center, Beijing, China; IMI: International Mycological Institute, Kew, UK; MAFF: Ministry of Agriculture, Forestry and Fisheries, Tsukuba, Ibaraki, Japan. <sup>T</sup> indicates lectotype specimen and ex-epitype and ex-type strains, respectively.  
2 ITS: internal transcribed spacers and intervening 5.8S nrDNA; gapdh: partial glyceraldehyde-3-phosphate dehydrogenase gene; chs-1: partial chitin synthase-1 gene; his3: partial histone H3 gene; act: partial actin gene; tub2: partial beta-tubulin gene; apn2: partial DNA lyase gene; ApMat: partial Apn2-Mat1-2 intergenic spacer and partial mating type (Mat1-2) gene; sod2: partial manganese superoxide dismutase gene.
Plates sometimes need to be incubated for 1–2 mo to allow development of the sexual morph.

**Distribution**: Worldwide.

**Hosts**: Occurs on a wide range of plant families.

**Disease symptoms**: Anthracnose disease symptoms include defined, often sunken necrotic spots on leaves, stems, flowers or fruits. Additionally, crown and stem rots, ripe rot, seedling blights and brown blotch are caused by species of this genus.

**Notes**: Due to the overlapping morphological characters, species delimitation based on morphology alone is hardly possible in *Colletotrichum*. Multilocus sequence analyses combined with a polyphasic approach, including the analysis of geographical, ecological and morphological data, is generally suggested for...
species differentiation within the genus Colletotrichum (Cai et al. 2009). This approach resulted in the differentiation of almost 200 species, most of them belonging to species complexes. Due to simultaneous studies in the genus by different researchers, the sets of loci used for differentiating species vary among the different species complexes. ITS, gapdh, chs-1, act, his3 and tub2 (with some also gs or cal) gene regions have been used for studying species within the Col. acutatum, boninense, dematium, destructivum, gigasporum, orbiculare, spathianum and truncatum species complexes (Cannon et al. 2012, Damm et al. 2012a, b, 2013, 2014, Liu et al. 2014, Jayawardena et al. 2016b), while gs, cal and sod2 were additionally applied for the species differentiation within the Col. gloeosporioides species complex (Weir et al. 2012) (Table 6). In contrast, Crouch et al. (2009b) and Crouch (2014) applied ITS, sod2, apn2 and Mat1/apn2 (= ApMat), to study the Col. graminicola and Col. caudatum species complexes (Table 7). Silva et al. (2012) and Sharma et al. (2015) emphasised the use of ApMat in Colletotrichum species delimitation because of its high resolution within the Col. gloeosporioides species complex compared to previously used loci. Liu et al. (2015b, 2016) applied different sets of loci and different phylogenetic methods on a large set of closely related Colletotrichum strains/species belonging to this complex and revealed that ApMat should be combined with other loci to achieve
satisfactory species delimitation in the Col. gloeosporioides complex.

Because different sets of loci are used in different species complexes and the resolution of species differs depending on both locus and species, there is no agreement among the mycologists on the locus or loci to use for species identification/barcoding. For example, most species in the Col. acutatum complex can be separated by tub2 sequences (Damm et al. 2012b), while species in the Col. gloeosporioides complex can be identified with a combination of ApMat and gs sequences (Liu
et al. 2015b). Research to select better genetic markers and the best secondary barcoding gene(s) is still ongoing.

References: Cannon et al. 2012 (species complexes); Crouch et al. 2009b, Crouch 2014 (phylogeny); Damm et al. 2009, 2012a, b, 2013, 2014, Weir et al. 2012, Liu et al. 2014 (morphology, phylogeny).

**Colletotrichum sydowii** Damm, sp. nov. MycoBank MB820688. Fig. 27.

**Etyymology:** The species epithet is derived from Hans Sydow (1879–1946), a German mycologist who described several **Colletotrichum** species including one on *Sambucus*, host from which this fungus was isolated.

**Sexual morph not observed. Asexual morph on SNA:** Vegetative hyphae 1.5–9.5 μm diam, hyaline to pale brown, smooth-walled, septate, branched. *Chlamydospores* not observed. *Conidiomata* absent, conidiophores and setae formed directly on hyphae. *Setae* medium brown, smooth-walled, upper part verrucose, 60–115 μm long, 2–4-septate, base cylindrical, 4–6 μm diam, tip ± acute to ± rounded. *Conidiophores* hyaline to pale brown, smooth-walled to verrucose, cylindrical to clavate, 13–28 × 4–5 μm, with a gelatinous coating, opening 1–2 μm diam, collarette ≤ 0.5 μm long, periclinal thickening visible. *Conidia* hyaline, smooth-walled, aseptate, straight, slightly clavate to cylindrical, with one end round and the other truncate, (17–)17.5–19.5(–21) × 5–5.5 μm, mean ± SD = 18.3 ± 0.9 × 5.2 ± 0.2 μm, L/W ratio = 3.5. *Appressoria* single, medium brown, smooth-walled, subglobose, elliptical or irregular in outline, with a strongly lobate margin, (7.5–)9–14(–17.5) × (5.5–)7–10.5(–12) μm, mean ± SD = 11.4 ± 2.4 × 8.6 ± 1.8 μm, L/W ratio = 1.3. *Appressoria* of strain CBS 132889 shorter, measuring (7.5–)8.5–12.5(–14) × (6.5–)7.5–11(–13) μm, mean ± SD = 10.6 ± 1.9 × 9.1 ± 1.8 μm, L/W ratio = 1.2. **Asexual morph on Anthriscus species:** *Conidiomata*, conidiophores and setae formed on pale brown, angular cells, 3.5–8 μm diam. *Setae* medium brown, verruculose to verrucose, 30–80 μm long, (1–2)–3–septate, base conical to ± inflated, 4.5–7.5 μm diam, tip ± acute to ± rounded. *Conidiophores* pale brown, smooth-walled, septate, branched, to 20 μm long. *Conidiogenous cells* pale brown, smooth-walled, cylindrical to doliform, 6.5–18 × 5–6.5 μm, opening 1.5–2 μm diam, collarette 0.5–1 μm long, periclinal thickening distinct. *Conidia* hyaline, smooth-walled, aseptate, straight, cylindrical, with one end round and the other truncate, (14–)15.5–18.5(–20.5) × 5–6 μm, mean ± SD = 17.0 ± 1.6 × 5.5 ± 0.3 μm, L/W ratio = 3.1, conidia of strain CBS 132889 larger, measuring (15.5–)17–20(–20.5) × (4.5–)5–5.5(–6) μm, mean ± SD = 18.6 ± 1.4 × 5.4 ± 0.3 μm, L/W ratio = 3.5.

**Culture characteristics:** Colonies on SNA flat with entire margin, hyaline to honey, filter paper and *Anthriscus* stem partly pale to dark grey, agar medium partly covered with short feltly whitish aerial mycelium, reverse similar; growth 27.5–29.5 mm diam in 1 wk (≥ 40 mm diam in 10 d). Colonies on OA flat with entire margin; olivaceous buff to greenish olivaceous, partly covered with short feltly whitish aerial mycelium and grey conidiomata, saffron to salmon conidial masses in the centre, reverse primrose, rosy-buff to grey olivaceous, growth 26–28 mm diam in 1 wk (≥ 40 mm in 10 d). Conidia in mass saffron to salmon.

**Material examined:** Taiwan, from leaves of *Sambucus* sp., 18 Dec. 2011, P.W. Crous (holotype CBS H-21509, culture ex-type CBS 135819 = CPC 20071); ibid., CBS 132889 = CPC 20070.

Notes: *Colletotrichum sydowii* is to date only known from *Sambucus* leaves in Taiwan. The conidia of this species resemble those of several species, e.g. *Col. clidemiae*, *Col. australae* and *Col. parsonsiarum* belonging to the *Col. gloeosporioides*, *acutatum* and *boninense* species complexes (Damm et al. 2012a, b, Weir et al. 2012). Based on DNA sequences, *Col. sydowii* does not belong to any known *Colletotrichum* species complex; the closest matches in blastn searches of the ex-holotype strain in GenBank with sequences of the different loci resulted in sequences of strains from different species complexes. The ITS sequence is 99 % (1–2 nucleotide difference) identical to those of “*Col. gloeosporioides*” strain EECC-453 from *Ensete ventricosum* (GenBank KP942898, from an unpublished study in Ethiopia by Y. Mulugeta et al.) and “Fungal sp.” strain TCPR 106 from a photosynthetically root of *Tinospora cordifolia* in India (GenBank JX951175, R.N. Kharwar et al., unpubl. data), as well as 93–94 % identical to the ITS sequences of several species of the *Col. gigasporum* and *gloeosporioides* complexes and *Col. coccodes*. The tub2 sequence is 83 % (> 130 nucleotides difference) identical to those of *Col. vietnamense* strain CBS 125477 (GenBank KF687876), *Col. gigasporum* strain CBS 109355 (GenBank KF687870), both belonging to the *Col. gigasporum* complex (Liu et al. 2014), and *Col. dracaenophilum* isolate DMM 170 (GenBank KJ653227, Macedo & Barreto 2016). The his3 sequence is 90–91 % identical with species from different complexes, including *Col. constrictum* strain CBS 128503 (GenBank JQ005498, *Col. boninense* complex, Damm et al. 2012a) and *Col. vietnamense* strain CBS 125477 (GenBank KF687854, *Col. gigasporum* complex, Liu et al. 2014) as well as *Col. yunnanense* strain CBS 132135 (GenBank JX546755, Liu et al. 2014). The chs-1 sequence is 89–91 % identical with e.g. *Col. dacyrcarp* strain CBS 130241 (GenBank JQ005410, *Col. boninense* complex, Damm et al. 2012a) and *Col. guillierei* strain CBS 132879 (GenBank KC296987, *Col. gloeosporioides* complex, Liu et al. 2013b). Closest match with the act sequence is *Col. magnisporum* strain CBS 398.84 with 82 % identity (GenBank KF687803, *Col. gigasporum* complex, Liu et al. 2014). There is no species with more than 52 % query cover to the gapdh of *Col. sydowii*.

There is one *Colletotrichum* species that was previously described from *Sambucus*, *Col. sambuci* Sydow. 1942, that caused fruit anthracnose of *Sa. nigra* in Germany. *Sydow* (1942) regarded *Gloeosporium fructigenum* f. *sambuci* Mül.-Thur. 1922, described from *Sa. nigra* in Switzerland, as a synonym of *Col. sambuci*. Conidia of *Col. sambuci* are cylindrical, elongate ellipsoidal to clavate with one end rounded tapering to the other slightly acute end, measuring 13–20 × 4.5–6 μm. They have similar dimensions as those of *Col. sydowii*, however it is unlikely that the fungus collected from *Sambucus* leaves in Taiwan is identical with the fruit anthracnose pathogen of black elderberry in Europe, as the morphological characters apply to many *Colletotrichum* species and all molecular data suggest a species in the
Col. acutatum species complex. Based on ITS sequences, Benduhn et al. (2011) and Michel et al. (2013) identified Col. acutatum (s. lat.) as causal agent of the fruit anthracnose of Sa. nigra in Germany and Switzerland, respectively. As part of the multilocus alignment of the Col. acutatum complex, Col. godetiae was identified from fruits of Sa. nigra in the Netherlands (Damm et al. 2012b). The ITS sequences of "Col. cf. gloeosporioides" strain BBA 67435 (GenBank AJ301931) from Sa. nigra in Germany and of strain BBA 71332 (GenBank AJ301972) also from Sambucus (Nirenberg et al. 2002) are identical with that of strain CBS 862.70; these isolates are probably also Col. godetiae. Conidia of the Col. godetiae strain from the Netherlands (CBS 862.70) measure (8–14) × (4–5.5) μm on SNA. The shape of this species can be either fusiform or clavate with only one acute end, depending on the strain (Damm et al. 2012b) and there were no setae observed. Strain BBA 67435 also had conidia pointed only at one end (Nirenberg et al. 2002), which agrees with the shape of Col. sambuci. It is possible that Col. sambuci is an older name of Col. godetiae, however, we cannot confirm this here as we could not locate the type material.

Another species was described from Sambucus in Canada, Vermicularia sambucina (Ellis & Dearness 1897), which however has curved conidia with different dimensions (24 × 3–3.5 μm, Saccardo & Sydow 1899). In contrast, Col. fructicola, a species with considerably shorter conidia belonging to the Col. gloeosporioides complex, was isolated from leaves with anthracnose leaf spot symptoms on Sa. ebulus in Iran (Arzanlou et al. 2015).

Authors: U. Damm, R.S. Jayawardena, L. Cai

Coniella Höhn. Ber. Deutsch. Bot. Ges. 36: 316. 1918. Fig. 28. Synonyms: Schizoparme Shear, Mycologia 15: 120. 1923. Baeumleria Petr. & Syd., Repert. Spec. Nov. Regni Veg. Beih. 42: 268. 1927. Pilidiella Petr. & Syd., Repert. Spec. Nov. Regni Veg. Beih. 42: 462. 1927. Anthasthoopa Subram. & K. Ramakr., Proc. Indian Acad. Sci., Sect. B 43: 173. 1956. Cyclodomella Mathur et al., Sydowia 13: 144. 1959. Embolidium Bat., Bot. Mag. N.S. 33(3–4): 194. 1964 non Sacc. 1978.
Fig. 28. Coniella spp. A–D. Disease symptoms. A, B. Coniella eucalyptorum on Eucalyptus sp. C. Coniella tibouchinae on Tibouchina granulosa. D. Coniella granati on Punica granatum (pictures taken by M. Mirabolfathy). E–I. Sexual morph of Coniella eucalyptigena (ex-type CBS 139893). E. Ascomata forming on OA. F. Ostiolar area. G, H. Asci. I. Ascospores. J–R. Asexual morphs. J. Conidiomata forming on OA of Coniella diplodiella (ex-epitype CBS 111858). K. Transverse section through a conidioma of Coniella eucalyptorum (ex-type CBS 112640). L. Conidiogenous cells giving rise to conidia. M. Coniella diplodiopsis (ex-type CBS 590.84). N. Coniella obovata (CBS 111025). O–R. Conidia. O. Coniella africana (ex-type CBS 114133). P. Coniella diplodiella (ex-epitype CBS 111858). Q. Coniella fusiformis (ex-type CBS 141596). R. Coniella limoniformis (ex-type CBS 111021). S. Coniella obovata (CBS 111025). Scale bars: E = 250 μm, others = 10 μm. Pictures taken from Alvarez et al. (2016).
**Distribution:** Worldwide.

**Hosts:** Wide variety of hosts, e.g. *Eucalyptus* (Myrtaceae), *Fragaria* (Rosaceae), *Hibiscus* (Malvaceae), *Psidium* (Myrtaceae), *Punica* (Lythraceae), *Terminalia* (Combretaceae) and *Vitis* (Vitaceae).

**Disease symptoms:** Foliar, fruit, stem and root lesions, white rot and crown rot.

**Notes:** In the most recent revision of the members of *Schizoparmaceae*, *Pilidiella* and its sexual morph *Schizoparme* were synonymised under *Coniella* because the type species of the three genera clustered in a single well-supported clade in a phylogenetic analysis based on four different loci (LSU, ITS, *rpb2* and *tef1*) (Alvarez et al. 2016). *Coniella* and *Pilidiella* were initially distinguished by von Arx (1981) based on their conidial pigmentation, being hyaline to pale brown in *Pilidiella* and dark brown in *Coniella*. However, Alvarez et al. (2016) demonstrated that conidial colour evolved multiple times throughout the clade representing *Coniella*, and therefore rejected it as a character for generic delimitation in *Schizoparmaceae*. Sutton (1980) and Nag Raj (1993) also considered *Coniella* and *Pilidiella* synonymous since both genera presented identical conidiomata, conidigenesis and orientation of conidiophores. However, Castlebury et al. (2002) demonstrated a separation of both genera in a phylogenetic study based on LSU sequences. This was further supported by van Nierkerk et al. (2004b) based on their LSU, ITS and *tef1* sequence data. Based on these molecular studies, together with the difference in conidial pigmentation reported by von Arx (1981), Wijayawardene et al. (2016) regarded *Coniella* and *Pilidiella* as two separate genera in a recent study of dematiaceous coelomycetes. By adding more loci and expanding the number of isolates studied, Alvarez et al. (2016) resolved the conflict that lasted a few decades regarding the classification of these genera.

**References:** Van Nierkerk et al. 2004b, Crous et al. 2014a, Alvarez et al. 2016 (morphology and phylogeny).

*Coniella duckerae* H.Y. Yip, Trans. Brit. Mycol. Soc. 89: 587. 1987. Fig. 29.

**Description and illustration:** Yip (1987).

**Material examined:** Australia, Victoria, Wilson's Promontory, Five Mile Road, on rhizosphere of *Lepidospermum concavum*, unknown collector and date (holotype DAR 55703, isotype VPRI 13689, culture ex-type VPRI 13689 = CBS 142045).

**Notes:** *Coniella duckerae* was excluded from the study of Alvarez et al. (2016), as no ex-type culture was available. However, the original culture was recently revived, and DNA barcodes could thus be generated for inclusion in this study.

*Coniella hibisci* (B. Sutton) Crous, comb. nov. MycoBank MB820811. Fig. 30. Basionym: *Coniella musaiaensis* var. *hibisci* B. Sutton, The Coelomycetes (Kew): 420. 1980.

**Notes:** The generic delimitation of *Coniella* and *Pilidiella* presented identical conidiomata, conidigenesis and orientation of conidiophores. However, Castlebury et al. (2002) demonstrated a separation of both genera in a phylogenetic study based on LSU sequences. This was further supported by van Nierkerk et al. (2004b) based on their LSU, ITS and *tef1* sequence data. Based on these molecular studies, together with the difference in conidial pigmentation reported by von Arx (1981), Wijayawardene et al. (2016) regarded *Coniella* and *Pilidiella* as two separate genera in a recent study of dematiaceous coelomycetes. By adding more loci and expanding the number of isolates studied, Alvarez et al. (2016) resolved the conflict that lasted a few decades regarding the classification of these genera.

**References:** Van Nierkerk et al. 2004b, Crous et al. 2014a, Alvarez et al. 2016 (morphology and phylogeny).
slightly truncate base, smooth-walled, mono- to multiguttulate, germ slits absent, (10–)11–13(–15) × (3–)3.5–4(–5) μm (L/W = 3.4), with a mucoid appendage alongside conidium.

_Culture characteristics:_ Colonies on MEA surface dirty white, with profuse black conidial masses spreading from centre. On OA and PDA surface dirty white with profuse black conidiomata and sparse aerial mycelium.

_Material examined:_ **Africa**, from _Hibiscus sp._, unknown date, A.R. Rossman (epitype designated here BPI 748426, MBT376042, culture ex-epitype CBS 109757 = ARS 3534). **Nigeria**, on leaves of _Hibiscus esculentus_, 25 Jul. 1967, Arny (holotype IMI 129200). **Notes:** The morphology of the present African ex-epitype strain from _Hibiscus_. (CBS 109757 = ARS 3534) compares well with that of the holotype of _Coniella musaiaensis_ var. _hibisci_, which was described from _Hibiscus esculentus_ collected in Nigeria. A new combination is therefore proposed, elevating it to species rank. Presently there are still no cultures available of _Coniella musaiaensis_, which was described from _Bauhinia reticulata_ (Sierra Leone) need to be made to resolve its phylogeny. _Coniella hibisci_ is also morphologically similar to _Coniella javanaensis_ (on _Hibiscus sabdariffa_, Indonesia), although they are phylogenetically divergent (Alvarez et al. 2016).

**Authors:** Y. Marin-Felix, J. Edwards, A.Y. Rossman & P.W. Crous

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Table 8. DNA barcodes of accepted _Coniella_ spp.

| Species                  | Isolates | GenBank accession numbers | References |
|--------------------------|----------|---------------------------|------------|
| _Coniella africana_      | CBS 114133\(^T\) | KY833444 / KX833421 / KX933600 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella crousi_        | NFFCI 2213 | HG264189 / – / – | Rajeshkumar et al. (2011) |
| _Coniella diplodiella_   | CBS 111586\(^TT\) | AY339323 / KX833423 / KX933603 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella diplodiopsis_  | CBS 590.84\(^T\) | AY339334 / – / – | Van Niekerk et al. (2004b) |
| _Coniella diplodiopsis_  | CBS 109.23 | AY339332 / KX833440 / KX933624 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella duckerae_      | VPR1 13689 = CBS 142045\(^T\) | KY924929 / – / – | Present study |
| _Coniella erumpens_      | CBS 523.78\(^T\) | KX833535 / KX833446 / KX933630 | Alvarez et al. (2016) |
| _Coniella eucalyptigena_ | CBS 139893 | KX833505 / KX833507 / KX933697 | Alvarez et al. (2016) |
| _Coniella eucalyptorum_  | CBS 112640\(^T\) | AY339338 / KX833452 / KX933637 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella fraganiae_     | CBS 172.49\(^TT\) | AY339317 / KX833472 / KX933663 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella fusiformis_    | CBS 141596\(^T\) | KX833576 / KX833481 / KX933674 | Alvarez et al. (2016) |
| _Coniella granati_       | CBS 252.38 | KX833581 / KX833488 / KX933681 | Alvarez et al. (2016) |
| _Coniella hibisci_       | CBS 109757\(^TT\) | KX833589 / – / KX933689 | Present study |
| _Coniella javanica_      | CBS 455.68\(^T\) | KX833583 / KX833489 / KX933683 | Alvarez et al. (2016) |
| _Coniella koreana_       | CBS 143.97\(^T\) | KX833584 / KX833490 / KX933684 | Alvarez et al. (2016) |
| _Coniella lanneesii_     | CBS 141597\(^T\) | KX833585 / KX833491 / KX933685 | Alvarez et al. (2016) |
| _Coniella limoniformis_  | CBS 111021\(^T\) | KX833586 / KX833492 / KX933686 | Alvarez et al. (2016) |
| _Coniella macrospora_    | CBS 524.73\(^T\) | KX833587 / KX833493 / KX933687 | Alvarez et al. (2016) |
| _Coniella malaysiana_    | CBS 141596\(^T\) | KX833588 / KX833494 / KX933688 | Alvarez et al. (2016) |
| _Coniella nicotianae_    | CBS 875.72\(^T\) | KX833590 / KX833495 / KX933690 | Alvarez et al. (2016) |
| _Coniella nigra_         | CBS 165.60\(^T\) | AY339319 / KX833496 / KX933691 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella obovata_       | CBS 111025 | AY339313 / KX833497 / KX933692 | Van Niekerk et al. (2004b), Alvarez et al. (2016) |
| _Coniella paracastaneicola_ | CBS 141292\(^T\) | KX833591 / KX833498 / KX933693 | Alvarez et al. (2016) |
| _Coniella peruesiens_    | CBS 110394\(^T\) | KJ710463 / KX833499 / KX933695 | Crous et al. (2015c), Alvarez et al. (2016) |
| _Coniella pseudogranati_ | CBS 137980\(^T\) | KJ869132 / – / – | Crous et al. (2014b) |
| _Coniella pseudodermatina_ | CBS 112624 | KX833593 / KX833500 / KX933696 | Alvarez et al. (2016) |
| _Coniella quercicola_    | CBS 904.69\(^T\) | KX833595 / KX833502 / KX933698 | Alvarez et al. (2016) |
| _Coniella solanum_       | CBS 766.71\(^T\) | KX833597 / KX833505 / KX933701 | Alvarez et al. (2016) |
| _Coniella straminea_     | CBS 132530\(^T\) | JX068873 / KX833509 / KX933705 | Crous et al. (2012b), Alvarez et al. (2016) |

CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; NFCCI: National Fungal Culture Collection of India, Agrahark Research Institute, Pune, India; VPR1: Victorian Plant Pathogen Herbarium, Bundoora, Australia. \(^T\), \(^TT\) and \(^TT\) indicate ex-type, ex-epitype and ex-neotype strains, respectively. 2 ITS: internal transcribed spacers and intervening 5.8S nrDNA; rpb2: partial RNA polymerase II second largest subunit gene; tef1: partial translation elongation factor 1-alpha gene.
**Curvularia** Boedijn, Bull. Jard. Bot. Buitenzorg, 3 Sér. 13: 123. 1933. Fig. 31.

*Synonyms*:
- *Malustela* Bat. & J.A. Lima, Publ. Inst. Micol. Recife 263: 5. 1960.
- *Curvosporium* Corbetta as “Curvosporium”, Riso 12: 28, 30. 1963.
- *Pseudocochliobolus* Tsuda, et al., Mycologia 69: 1117. 1978.

*Classification*:
- Dothideomycetes, Pleosporomycetidae, Pleosporales, Pleosporaceae.

*Type species*: *Curvularia lunata* (Wakker) Boedijn. Ex-neotype culture: CBS 730.96.

*DNA barcodes (genus)*: LSU, ITS.

*DNA barcodes (species)*: ITS, gapdh, tef1. Table 9. Fig. 32.

Ascomata pseudothecial, mostly globose to ellipsoidal, sometimes flask-shaped or flattened on hard substrata, brown or black, immersed, erumpent, partially embedded or superficial, free or developing on a basal columnar or flat stroma, smooth or covered with vegetative filaments; *ostiolar* central, papillate or with a sub-conical, conical, paraboloid or cylindrical neck; *ascomatal wall* comprising pseudoparenchymatous cells of equal thickness or slightly thickened at apex of the ascoma. *Hama-theicum* comprising septate, filiform, branched pseudoparaphyses. *Asci* bitunicate, clavate, cylindrical-clavate or broadly fusoid, straight or slightly curved, thin-walled, fissitunicate, often becoming more or less distended prior to dehiscence, short pedicellate, rounded at the apex. Ascospores multiseriate, filiform or flagelliform, hyaline or sometimes pale yellow or pale brown at maturity, septate, helically coiled within ascus, degree of ascospore coiling moderate to very strongly coiled, often with a mucilaginous sheath. *Conidiophores* straight to flexuous, often geniculate, multiseptate, usually simple, sometimes branched, smooth to verruculose, macronematous, mononematous, sometimes nodose, cylindrical. *Conidiogenous nodes* cylindrical, integrated, terminal and intercalary, proliferating sympodially, ocatrised. *Conidia* solitary, often curved, acroleurogenous, broadly fusoid, elliptical, obvoid or obpyriform, mostly smooth, sometimes verruculose, echinulate or tuberculate, 3 or more distoseptate, with or without an unequally swollen cell which is more pigmented than the other cells, septa sometimes accentuated with a dark band in some or all the cells, germinating mainly from one or both polar cells with the basal germ tube.
growing semiaxially, hilum in a slightly protruding truncate basal section of the conidial wall and often visible as two dark lenticular spots in optical section arranged close together with a small obscure narrow separating canal between them or distinctly protuberant, first conidial septum median or submedian, second septum often delimiting the basal cell of the mature conidium, third septum then distal. Microconidiation not common, producing conidia 1–2-celled, pale brown, globose to subglobose (adapted from Sivanesan 1987).

Culture characteristics: Colonies on PDA white or pale grey when young, orange to brown or different shades of grey (mainly dark olivaceous grey) when mature, fluffy, cottony, raised or convex with papillate surface, margin lobate, undulate, entire or sometimes rhizoid.

Optimal media and cultivation conditions: Sterilised Zea mays leaves placed on 1.5 % WA or slide cultures of half-strength PDA under near-ultraviolet light (12 h light, 12 h dark) to induce sporulation of the asexual morph, while for the sexual morph Sach's agar with sterilised rice or wheat straw at 25 °C is used.

Distribution: Worldwide.

Hosts: Wide host range, occurring as pathogens or saprobes. Mainly found on members of the Poaceae, being pathogens of...
Table 9. DNA barcodes of accepted *Curvularia* spp.

| Species              | Isolates | GenBank accession numbers | References       |
|----------------------|----------|---------------------------|------------------|
|                      |          | ITS | gapdh | tef1  |                                |
| *Curvularia aeria*   | CBS 294.81T | HE861850 | HF565450 | –     | da Cunha et al. (2013)         |
| *Cu. affinis*        | CBS 154.344T | KJ909780 | KM230401 | KM196566 | Manamgoda et al. (2015)       |
| *Cu. akaii*          | CBS 317.86 | KJ909782 | KM230402 | KM196569 | Manamgoda et al. (2015)       |
| *Cu. akiakensis*     | BRIP 16060T | KJ415539 | KJ415407 | KJ415453 | Tan et al. (2014)             |
| *Cu. alcalinae*      | MFLUCC 10-0703T | JX256420 | JX276433 | JX285698 | Manamgoda et al. (2012a)      |
| *Cu. americana*      | UTHSC 08-3414T | HE861833 | HF565488 | –     | Madrid et al. (2014)          |
| *Cu. asiatica*       | MFLUCC 10-0711T | JX256424 | JX276436 | JX285693 | Manamgoda et al. (2012a)      |
| *Cu. australiensis*  | BRIP 12044T | KJ415540 | KJ415406 | KJ415452 | Tan et al. (2014)             |
| *Cu. australis*      | BRIP 12521T | KJ415541 | KJ415405 | KJ415451 | Tan et al. (2014)             |
| *Cu. bannonii*       | BRIP 167324T | KJ415542 | KJ415404 | KJ415450 | Tan et al. (2014)             |
| *Cu. borteriæ*       | CBS 859.73 | HE861848 | HF565455 | –     | da Cunha et al. (2013)        |
| *Cu. bothriochloae*  | BRIP 12522T | KJ415543 | KJ415403 | KJ415449 | Tan et al. (2014)             |
| *Cu. brachyspora*    | CBS 186.50 | KJ922372 | KM061784 | KM230405 | Manamgoda et al. (2014)       |
| *Cu. bucheiba*       | CBS 246.49T | KJ909765 | KM061789 | KM196588 | Manamgoda et al. (2014)       |
| *Cu. carica-papayae* | CBS 135941T | HG778984 | HG779146 | –     | Madrid et al. (2014)          |
| *Cu. chlamydoïsopora*| UTHSC 07-2764T | HG779021 | HG779151 | –     | Madrid et al. (2014)          |
| *Cu. clavata*        | BRIP 61680b | KU552205 | KU552167 | KU552159 | Khemmu et al. (2016)          |
| *Cu. coicis*         | CBS 192.294T | JN192373 | JN600962 | JN601006 | Manamgoda et al. (2015)       |
| *Cu. crustacea*      | BRIP 135244T | KJ415544 | KJ415402 | KJ415448 | Tan et al. (2014)             |
| *Cu. cymbopogonis*   | CBS 419.78 | HG778985 | HG779129 | HG779163 | Madrid et al. (2014)          |
| *Cu. dactylotoenii*  | BRIP 12846T | KJ415545 | KJ415401 | KJ415447 | Tan et al. (2014)             |
| *Cu. ellisi*         | CBS 193.62T | JN192375 | JN600963 | JN601007 | Manamgoda et al. (2011)       |
| *Cu. eragrostidis*   | CBS 189.48 | HG778986 | HG779154 | HG779164 | Madrid et al. (2014)          |
| *Cu. geniculata*     | CBS 187.50 | KJ909781 | KM083609 | KM230410 | Manamgoda et al. (2015)       |
| *Cu. gladoli*        | CBS 210.79 | HG778987 | HG779123 | –     | Madrid et al. (2014)          |
| *Cu. graminicola*    | BRIP 23186T | JN192376 | JN600964 | JN601008 | Manamgoda et al. (2012b)      |
| *Cu. gudauskasi*     | DAOM 165085 | AF071338 | –     | –     | Berbee et al. (1999)          |
| *Cu. harveyi*        | BRIP 574124T | KJ415546 | KJ415400 | KJ415446 | Tan et al. (2014)             |
| *Cu. hawaiiensis*    | BRIP 1158744T | KJ415547 | KJ415399 | KJ415445 | Tan et al. (2014)             |
| *Cu. heteropogoniconcola* | BRIP 145794T | KJ415548 | KJ415398 | KJ415444 | Tan et al. (2014)             |
| *Cu. heteropogonis*  | CBS 284.91T | JN192379 | JN600969 | JN601013 | Manamgoda et al. (2012b)      |
| *Cu. hominisin*      | CBS 136985T | HG779011 | HG779106 | –     | Madrid et al. (2014)          |
| *Cu. homomorpha*     | CBS 156.60T | JN192380 | JN600970 | JN601014 | Manamgoda et al. (2014)       |
| *Cu. inaequalis*     | CBS 102.42T | KJ922375 | KM061787 | KM196574 | Manamgoda et al. (2014)       |
| *Cu. intermedia*     | CBS 334.64 | HG778991 | HG779155 | HG779169 | Madrid et al. (2014)          |
| *Cu. ischaeii*       | CBS 137.62T | JX256428 | JX276440 | –     | Manamgoda et al. (2012b)      |
| *Cu. kusanoii*       | CBS 137.29 | JN192381 | –     | JN601016 | Manamgoda et al. (2015)       |
| *Cu. lunata*         | CBS 730.96T | JX256429 | JX276441 | JX285696 | Manamgoda et al. (2012b)      |
| *Cu. malina*         | CBS 131274T | JF812154 | KP153179 | KR493095 | Tomaso-Peterson et al. (2016) |
| *Cu. miyakeii*       | CBS 197.294T | KJ909770 | KM083611 | KM196584 | Manamgoda et al. (2014)       |
| *Cu. muehlenbeckia*  | CBS 144.83T | HG779002 | HG779108 | –     | Madrid et al. (2014)          |
| *Cu. neergaardii*    | BRIP 129194T | KJ415550 | KJ415397 | KJ415443 | Tan et al. (2014)             |
| *Cu. neoindica*      | BRIP 17439 | AF081449 | AF081406 | –     | Berbee et al. (1999)          |
| *Cu. nicotiae*       | CBS 655.744T = BRIP 11983 | KJ415551 | KJ415396 | KJ415442 | Tan et al. (2014)             |
| *Cu. nodulosa*       | CBS 160.58 | JN601033 | JN600975 | JN601019 | Manamgoda et al. (2015)       |
| *Cu. oryzae*         | CBS 169.534T | KP400650 | KP645344 | KM196590 | Manamgoda et al. (2015)       |
| *Cu. ovanicolata*    | CBS 470.90T | JN192384 | JN600976 | JN601020 | Manamgoda et al. (2012b)      |
| *Cu. papendorffi*    | CBS 308.6T | JN192384 | JN600976 | JN601020 | Manamgoda et al. (2012b)      |

(continued on next page)
grass and staple crops, including rice, maize, wheat and sorghum. This genus also occurs on genera belonging to Actinidiaceae, Alisoaceae, Caricaceae, Convolvulaceae, Fabaceae, Iridaceae, Lamaceae, Lythraceae, Oleaceae, Polygonaceae and Rubiaceae.

Disease symptoms: Leaf spots, leaf blight, melting out, root rot, foot rot, among others.

Notes: Species delimitation in Curvularia based on morphology only is difficult due to the morphological complexity within this genus, as also observed in Bipolaris. Furthermore, the differentiation of both genera based on morphology alone is sometimes complicated (see Bipolaris notes for morphological differences between Bipolaris and Curvularia). Therefore, molecular data are essential for an accurate identification of species within these genera, ITS, gapdh and tef1 being the loci selected for this purpose (Manamgoda et al. 2014, 2015).

Curvularia is a rich genus in host range and geographic distribution compared to Bipolaris. Apart from phytopathogenic species, this genus comprises species that are pathogens of humans and other animals, causing respiratory tract, cutaneous, cerebral and corneal infections, mainly in immunocompromised patients (Carter & Boudreaux 2004). Some species can be found in association with both humans and plants, such as Cu. hawaiensis, Cu. lunata and Cu. spicifera (Manamgoda et al. 2015).

References: Sivanesan 1987 (morphology and pathogenicity); Manamgoda et al. 2011 (pathogenicity), Manamgoda et al. 2015 (morphology, pathogenicity and phylogeny).

Curvularia pisi Y. Marin & Crous, sp. nov. MycoBank MB820814. Fig. 33.

Etymology: Name refers to the host genus from which it was isolated, Pisum.
Curvularia inaequalis

Curvularia soli

Curvularia spicifera

Hyphae hyaline to pale brown, branched, septate, thin-walled, 1.5–5 μm. Conidiophores arising in groups, septate, straight or flexuous, geniculate at upper part, verruculose, tapering towards apex, sometimes branched, cells walls thicker than those of vegetative hyphae, mononematous, semi- to macronematous, pale brown to brown, paler towards apex, not swollen at the base, (35–)50–210 × 2.5–5 μm. Conidigenous cells verruculose, terminal or intercalary, proliferating sympodially, pale brown to brown, subcylindrical to swollen, (2.5–)5–15.5 × 3–7.5 μm. Conidia verruculose, curved, rarely straight, middle cells unequally enlarged, reniform, rarely ellipsoidal, pale brown to brown, apical and basal cells wider than the middle cells being subhyaline to pale brown, (2–)3-distoseptate, 16–35 × 9–15.5 μm; hila slightly protuberant, flat, darkened, slightly thickened, 1.5–4 μm. Chlamydospores, microconidiation and sexual morph not observed.

Culture characteristics: Colonies on PDA reaching 90 mm diam within 1 wk, with sparse to moderate aerial mycelium giving a slightly cottony appearance, margin lobate; surface apricot to chestnut; reverse umber to chestnut.

Material examined: Canada, Ontario, Renfrew, on Pisum sativum seeds, 15 Feb. 1943, J.W. Groves (holotype CBS H-11405, culture ex-type CBS 190.48).

Notes: Curvularia pisi is closely related to Cu. muehlenbeckiae and Cu. hominis. Morphologically, these species are similar but Cu. pisi produces smaller conidiophores. Moreover, Cu. muehlenbeckiae produces smaller conidia than Cu. pisi, and Cu. hominis is characterised by 3–4-distoseptate conidia while the conidia in the other two species are 3-distoseptate.

Curvularia inaequalis is known to occur on Pisum sativum, which is also host to two other species of Curvularia, Cu. inaequalis and Cu. spicifera. Curvularia spicifera produces a sexual morph, while no sexual morph has been observed in the other two species. Moreover, Cu. spicifera differs from Cu. pisi in having smooth-walled conidia. Curvularia inaequalis can be distinguished from Cu. pisi by its longer conidia, which are predominantly 4-distoseptate.

Curvularia soli Y. Marin & Crous, sp. nov. MycoBank MB820816. Fig. 34.

Etymology: Named after its ecology, occurring in soil, “soli”.

Hyphae subhyaline to pale brown, branched, septate, thin-walled, 2.5–5.5 μm. Conidiophores arising in groups, septate, straight or flexuous, geniculate at upper part, smooth to verruculose, unbranched, cells walls thicker than those of vegetative hyphae, mononematous, semi- to macronematous, pale brown to brown, slightly paler towards apex, not swollen at the base, (65–)90–270–(390) × 2.5–5(–6) μm. Conidigenous cells smooth-walled to finely verruculose, terminal or intercalary, proliferating sympodially, pale brown to brown, subcylindrical to swollen, 4–13 × 2.5–5 μm. Conidia verruculose, curved, rarely straight, middle cells unequally enlarged, reniform, rarely ellipsoidal, pale brown to brown, apical and basal cells paler than middle cells being subhyaline to pale brown, 3–(4–5)-distoseptate, (13.5–)18–28 × 7.5–11 μm; hila protuberant, flat, darkened, thickened, 1.3–3.5 μm. Chlamydospores, microconidiation and sexual morph not observed.

Culture characteristics: Colonies on PDA reaching 75–79 mm diam after 1 wk, velvety to slightly powdery; surface and reverse grey olivaceous to olivaceous black.

Material examined: Papua New Guinea, Madang, Jais Aben, isolated from soil along coral reef coast, Nov. 1995, collected by A. Aptroot, isol. by A. van Iperen (holotype CBS H-23116, culture ex-type CBS 222.96).

Notes: Curvularia soli is closely related to Cu. asiaticensis, Cu. geniculata and Cu. senegalensis. All three species are characterised by conidia that are predominantly 4-distoseptate. Curvularia geniculata is the only species that produces a sexual morph and has the longest conidia among these taxa (26–48 μm). Curvularia asiatica can be distinguished from Cu. soli by its much longer conidiophores ([75–]100–700(–708) μm) and shorter conidia ([11–]15–23(–23.5) μm). Curvularia senegalensis is characterised by having shorter conidiophores (up to 150 μm) and wider conidia (10–14 μm) than Cu. soli.

Authors: Y. Marin-Felix, P.W. Crous & Y.P. Tan

Monilinia Honey, Mycologia 20: 153. 1928. Fig. 35. Symonym: Monilinia Bonord., Handb. Mykol.: 7. 1851.

Classification: Leotiomycetes, Leotiomycetidae, Helotiales, Sclerotiniaceae.

Type species: Monilinia fructicola (G. Winter) Honey. Holotype: BPI 1109031.

DNA barcode (genus): ITS.

DNA barcode (species): tef1. Table 10. Fig. 36.

Ascomata apothecial, cup- or funnel-shaped, long stipitate, pale brown, formed solitary or in groups from pseudosclerotia in aborted or mummified fruits and debris partially or completely buried in soil; stipe cylindrical, flexuous, pale brown, often darker near the base; hymenium comprising fiform, septate, unbranched and hyaline paraphyses. Asci unitunicate, inoperculate, with amyloid apical apparatus, cylindrical to clavate, flattened or rounded at the apex, thin-walled, 8-spored. Ascospores ellipsoid, often with tapered ends, 1-celled, hyaline, sometimes covered with a gelatinous sheath. Conidiophores single or aggregated forming sporodochia, straight or flexuous, hyaline to subhyaline, branched, thin-walled, septate. Macroconidia blastic-acropetal, oval, lemon-shaped or broadly ellipsoidal, rarely doliform, hyaline to subhyaline, thin and smooth-walled, 1-celled, sometimes presenting distinct axial connections (disjunctors), formed in chains, simple or dichotomously branched; microconidia (spermata) sometimes present in old cultures, globose to pyriform, hyaline, smooth- and thin-walled, borne on lageniform, often asymmetric phialides. Arthric conidia occasionally formed, ovoid to ellipsoid, smooth- and thin-walled.
Culture characteristics: Colonies on PDA white, yellow-grey, brown-grey or olive-grey, often zonate or forming concentric rings, felty to velvety, flat or concave, margin entire or lobed giving a rosette-like appearance, brown to black stromata can be present in old cultures.

Optimal media and cultivation conditions: PDA and WA, incubated under near-ultraviolet light (12 h light, 12 h dark) at 22–25 °C to determine growth rates, colour and shape of the colony, and induce sporulation of the asexual morph. The sexual morph is not formed under in vitro culture conditions but can be induced by inoculation on natural substrata and incubated several months partially buried in sterilised soil.

Distribution: Worldwide.

Hosts: Mostly found as crop pathogens or causing post-harvest losses on stone fruits, most commonly on members of Rosaceae, predominantly on Cydonia spp., Malus spp., Prunus spp. and Pyrus spp., but have been reported in at least 11 other genera on this family, linked to some kind of host specialisation. Other known hosts include members of Actinidiaceae, Berberidaceae, Betulaceae, Ebenaceae, Ericaceae, Euphorbiaceae, Moraceae, Myricaceae, Myrtaceae, Solanaceae and Vitaceae.

Disease symptoms: Leaf spots, blossom and twig blight, twig and stem canker, fruit rot.

Notes: Generic identification in vivo or in vitro is easy considering the characteristic monilioid hyphae and sexual-morphs. Monilinia is morphologically similar and closely related to the genus Sclerotinia, from which it can be differentiated by the absence of asexual reproduction and formation of true sclerotia in Sclerotinia. However, species identification in Monilinia is rather difficult by means of morphology alone. A combination of cultural features, physiology and host range is often necessary, including macro and micromorphology, growth rates, conidial dimension and characteristics of the germ tube during sporulation. Other employed techniques include AFLP and RFLP (Gril et al. 2010, Vasić et al. 2016), specific PCR amplification for the three major brown rot pathogens.
M. fructigena, M. fructicola and M. laxa (Cote et al. 2004, Gell et al. 2007) and amplification of specific introns for rapid identification of M. fructicola (Fulton & Brown 1997). A species delimitation based on molecular phylogeny is currently lacking and no ex-type material is known to exist for most taxa. However, several reference ITS and tef1 sequences are available from a set of curated isolates in Q-bank (http://www.q-bank.eu/Fungi/).

A proposal to protect the generic name Monilinia over Monilia has been recently published based on the complex and often conflicting taxonomic history of the latter name (Johnston et al. 2014). Following this proposal, two new combinations are proposed below.

References: Batra 1988, 1991, Honey 1928, 1936, van Leeuwen et al. 2002 (morphology and pathogenicity); van Leeuwen 2000 (morphology, pathogenicity and epidemiology); OEPP/EPPO 2009, Martini & Mari 2014 (morphology, pathogenicity and biology).

Monilinia mumeicola (Y. Harada et al.) Sandoval-Denis & Crous, comb. nov. MycoBank MB819176. Basionym: Monilia mumeicola [as ‘mumecola’] Y. Harada et al., J. Gen. Plant Pathol. 70: 305. 2004.

Notes: This species is only known from its asexual morph. It was described as a pathogen on Japanese apricot (Prunus mume) in Japan (Harada et al. 2004), and later reported causing brown rot of Prunus armeniaca (Yin et al. 2014) and Prunus salicina (Yin et al. 2015) in China. Our phylogeny (Fig. 36) included sequences of two authentic isolates of Monilia numeicola and supported its location in the genus Monilinia, being closely related to the common agents of brown rot M. fructicola, M. fructigena and M. laxa.

Monilinia yunnanensis (M.J. Hu & C.X. Luo) Sandoval-Denis & Crous, comb. nov. MycoBank MB819177. Basionym: Monilia yunnanensis M.J. Hu & C.X. Luo, PloS ONE 6: 11. 2011.

Notes: This taxon was described as a pathogen of peach (Prunus persica) in China and has subsequently been isolated as the most prevalent pathogen of apple and pear in the southern, northern and western regions of that country (Zhu et al. 2016). Its phylogenetic placement in Monilinia was supported in our phylogeny (Fig. 36) based on sequences from two authentic isolates, showing that it forms a clade basal to the main cluster grouping the most economically relevant species of the genus.

Authors: M. Sandoval-Denis & P.W. Crous

Neofabraea H.S. Jacks., Rep. Oregon Exp. Sta. 1911–1912: 187. 1913. Fig. 37.
**Classification:** Leotiomycetes, Leotiomycetidae, Helotiales, Dermateaceae.

**Type species:** Neofabraea malicorticis H.S. Jacks. Neotype and ex-neotype culture: CBS H-22219, CBS 122030 = OSC 100036.

**DNA barcodes (genus):** LSU.

**DNA barcodes (species):** ITS, tub2, rpb2. Table 11. Fig. 38.

**Ascomata** apothecial, erumpent from bark, sessile to short-stalked, solitary or in clusters on a basal stroma; disc often not well-delimited, circular, elliptical, or irregular and merged, greyish, flesh-coloured to pale reddish or brownish, drying darker, 0.5–2.0 mm diam. **Paraphyses** numerous, filiform, septate, obtuse, simple or branched, hyaline, smooth-walled, apical cells mostly slightly swollen. Asci inoperculate, cylindrical-clavate, apex rounded or truncate-rounded, attenuated into a stalk of variable length, crozier present, 8-spored; apical apparatus with a well-developed apical thickening, Lugo's + or −, blue in herbarium material, Melzer's + or −. Ascospores inequilateral, elongated ellipsoid, ends rounded, straight or curved, aseptate, thin-walled, smooth, hyaline, with granular contents or small oil droplets; later septate, sometimes germinating or forming conidia from minute openings or phialidic apertures, hyaline, acrogenous or acropleurogenous. **Conidiogenous cells** discrete or integrated, determinate, phialidic, cylindrical to narrowly ampulliform, giving rise to macro- and/or microconidia. **Conidiomata** cylindrical-fusiform, allantoid to ellipsoid, straight or curved, rounded or somewhat pointed at apex, rounded or attenuated and with an indistinct, barely or non-protruding scar at base, smooth, aseptate, hyaline, and thin-walled when liberated, mostly filled with numerous oil droplets; later becoming sepa- tate and brown. **Microconidia** present or absent, cylindrical, rounded at apex, narrowly truncate at base, aseptate, hyaline, thin- and smooth-walled, with minute granular contents (adapted from Chen et al. 2016).

**Culture characteristics:** Colonies on OA white, cottony. Colonies on PDA orange or red, slimy.

**Optimal media and cultivation conditions:** OA at 25 °C under near-ultraviolet light (12 h light, 12 h dark); OA supplemented with sterile nettle stems (Anthriscus sylvestris) or direct inoculation into apple fruit (Malus domestica) can be used to induce sporulation.

**Distribution:** Worldwide.

**Hosts:** Pathogens or harmless saprobes of apples and pears, but also of several other hosts such as species of Prunus and Populus.

**Disease symptoms:** Anthracnose canker, perennial canker and bull’s-eye rot.

**Notes:** Neofabraea was introduced by Jackson (1913) to accommodate the sexual morph Gloeosporium malicorticis. Subsequently, Nannfeldt (1932) synonymised this genus with Pezicula. However, Verkley (1999) revalidated it and observed that species of Neofabraea are more explicitly pathogenic than those of Pezicula. Neofabraea further differs from Pezicula in that Neofabraea produces ascomata with excipular tissues less differentiated and macroconidia more strongly curved with the basal scar less distinct than in Pezicula. Moreover, Pezicula comprises species that have two types of conidiogenesis: conidigenous cells are determinate and phialidic, or indeterminate and proliferating percurrently, while Neofabraea spp. only produces phialidic conidiogenous cells (Chen et al. 2016). Recently, Chen et al. (2016) carried out a revision of the genus by performing a phylogenetic study based on LSU, ITS, tub2 and rpb2 sequences of Neofabraea, Pezicula and related genera. Consequently, the genus Phlyctena was re-established to accommodate Neofabraea alba, which is the main pathogen causing bull’s eye rot in continental Europe. Moreover, the new genera Parafabraea and Pseudofabraea were introduced in order to accommodate Neofabraea eucalypti and Neofabraea citriceara, respectively (Chen et al. 2016).

**References:** Verkley 1999 (morphology and pathogenicity), Wang et al. 2015 (morphology and key of Neofabraea spp.), Chen et al. 2016 (phylogeny).

**Verkleomyces** Y. Marín & Crous, gen. nov. MycoBank MB820818.

**Etymology:** Named after Gerard J.M. Verkley, in recognition for his contributions to the understanding of Neofabraea and related genera.

**Mycelium** hyaline to pale brown, branched, septate. **Ascomata** apothecial, partly immersed, erumpent, sessile, solitary, sometimes gregarious; medullary excipulum weakly developed, composed of hyaline textura prismatica; ectal excipulum composed of brown to olivaceous brown textura prismatica at the base, and pale brown textura intricata towards the margin; subhyphenum hyaline, composed of interwoven hyphae. **Paraphyses** cylindrical, slender, septate, apex rounded, hyaline, flexuous, numerous. Asci unilunulate, clavate to cylindrical-clavate, base truncate, short pedicellate, with an apical appara- ratus stained blue or purplish blue in Melzer’s reagent, 8- spored, ascospores discharging through apical pore. Ascospores fusoid to ellipsoid, hyaline, ends rounded or somewhat pointed, straight or slightly curved, thin-walled, guttulate or eguttulate, initially aseptate, or later becoming 1-septate. Conidiomata acervular or cupulate, semi-immersed, dark, separate, formed of olivaceous brown textura intricata, dehiscence by irregular fissures, sometimes by a central ostiole. Conidiophores simple, hyaline, smooth, thin-walled, septate at the base, unbranched, discrete, or rarely integrated beneath the aged conidiogenous cell. Conidiogenous cells enteroblastic, phialidic, cylindrical, hyaline, smooth, thin-walled, sometimes with proliferation, pericidal thickening present. Conidia cylindrical, straight, apex obtuse, base abruptly tapered to a distinct scar, hyaline, smooth, thin-walled, aseptate, eguttulate to biguttulate.

**Culture characteristics:** Colonies on PDA glaucous to sky-grey, with irregular white margin; reverse olivaceous black.

**Type species:** Verkleomyces ilicic (X. Sun et al.) Y. Marín & Crous. Holotype and ex-type culture: HMAS244704, ASH 3-6-2-5b.
Monilinia laxa (CBS H-14556) leaf spot on

Notes

1 ARO: Ascomycete Systematics Research Group, University of Oslo, Norway; ATCC: American Type Culture Collection, Virginia, USA; CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; HHUF: Hirosaki University, Japan; KY: Strain code as stated in GenBank, Hirosaki University Culture Collection, Japan.

2 ITS: internal transcribed spacers and intervening 5.8S nrDNA; indicates ex-type strain. A Accession number corresponding to the NITE Biological Resource Center, Japan.

Species Isolates Genbank accession number References

Monilinia amelanchieris ATCC 58538 ZT3769 – Holst-Jensen et al. (1997)

M. aucupariae ARO 885.2 ZT3771 – Holst-Jensen et al. (1997)

M. azaleae ATCC 58539 AB182266 – Takahashi et al. (2005)

M. baccarum CBS 388.93 KX982694 LT632532 Present study

M. cassiosperae ARO 1459.S ZT3776 – Holst-Jensen et al. (1997)

M. fructicola CBS 329.35 KX982695 LT632533 Present study

M. fructigena CBS 348.72 KX982697 LT632535 Present study

M. gaylussaciae ATCC 64508 ZT3782 – Holst-Jensen et al. (1997)

M. jasioensis 4222* AB182265 – Takahashi et al. (2005)

M. johnsonii ATCC 58542 ZT3783 – Holst-Jensen et al. (1997)

M. kusanoi NBRC 9725 00972502 A Harada et al. (2004)

M. laxa CBS 132.21 KX982699 LT632537 Present study

M. linhartiana CBS 150.22 KX982701 LT632539 Present study

M. megalospora ARO 619.2 ZT3788 – Holst-Jensen et al. (1997)

M. mali 2769* AB125619 – Harada et al. (2004)

M. mespili CBS 139.23 KX982702 LT632540 Present study

M. mumeicola 3231 01-01* AB125613 – Harada et al. (2004)

M. oxyccoci ARO 1087.P ZT3789 – Holst-Jensen et al. (1997)

M. padi ARO 923.K ZT3791 – Holst-Jensen et al. (1997)

M. polycodei ATCC 58546 ZT3792 – Holst-Jensen et al. (1997)

M. polystrona CBS 102688* KX982704 LT632542 Present study

M. seaveri CBS 170.24 KX982705 – Present study

M. ssiori HHUF 19771* AB220062 – Harada et al. (2005)

M. umula ARO 476.1 ZT3794 – Holst-Jensen et al. (1997)

M. vaccinii-corymbosi CBS 172.24 KX982706 LT632543 Present study

M. yunnanensis KY-1 H0208788 – Hu et al. (2011)

Notes: Verkleyomyces is introduced to accommodate Neofabraea illicii, the most recently published species of Neofabraea (Wang et al. 2015). In the phylogenetic analysis based on ITS sequences (Fig. 38), this species was located in a clade separate from the rest of the species belonging to Neofabraea. Verkleyomyces is mainly differentiated by its endophytic habit. Morphologically both genera are comparable, but Verkleyomyces produces 1-septate ascospores and asceptate conidia, while Neofabraea is characterised by asceptate ascospores and predominately septate conidia. Parafabraea, which is more closely related, also produces asceptate conidia, but this can be differentiated from Verkleyomyces by the production of asceptate ascospores. Other similar genera are Pezicula and Dermea, but these can easily be distinguished by the production of ascospores that are initially hyaline, and then become coloured or contain coloured oil droplets.

Verkleyomyces illicii (X. Sun et al.) Y. Marin & Crous, comb. nov. MycoBank MB820819. Basionym: Neofabraea illicii X. Sun et al., Mycoscience 56: 334. 2015.

Description and illustration: Wang et al. (2015).

Note: Verkleyomyces illicii is an endophytic fungus isolated from Illicium verum, cultivated in a plantation in southern China.

Authors: Y. Marin-Felix & P.W. Crous

Neofusicoccum Crous et al., Stud. Mycol. 55: 247. 2006. Fig. 39.
**Classification:** Dothideomycetes, Incertae sedis, Botryosphaeriales, Botryosphaeriaceae.

**Type species:** Neofusicoccum parvum (Pennycook & Samuels) Crous et al. Holotype and ex-type culture: PDD 45438 (Herbarium of Plant Diseases Division), ATCC 58191 = CBS 138823 = PDDCC 8003 = ICMP 8003 = CMW 9081.

**DNA barcodes (genus):** LSU, rpb2.

**DNA barcodes (species):** ITS, tef1, tub2, rpb2. Table 12. Fig. 40.

**Ascomata:** forming botryose clusters, each comprising many ascomata, erumpent through the bark, globose, with a short, conical papilla, dark brown to black, smooth, thick-walled; **ascomatal wall** composed of dark brown thick-walled cells of textura angularis, lined with thin-walled hyaline cells of textura angularis. **Asci** clavate, 8-spored, bitunicate. **Ascospores** broadly ellipsoidal to fusoid, hyaline, smooth, aseptate, occasionally becoming 1-septate.

**Conidiomata:** globose and non-papillate, entire locule lined with conidiogenous cells. **Conidiogenous cells** holoblastic, hyaline, subcylindrical, 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.

**Culture characteristics:** Colonies initially white to buff turning olivaceous grey becoming black with age, moderately dense, appressed mycelial mat with irregular very dense aerial aggregations, some conidioma covered by mycelium, immersed-erumpent, conidia and spermatia present. **Reverse** white to olivaceous black. Reaching 90 mm diam on half strength MEA in 3–4 d.

**Optimal media and cultivation conditions:** Half strength MEA at 25–30 °C.

**Distribution:** Worldwide.

**Hosts:** Plurivorous, mainly pathogenic on Anacardiaceae, Cupressaceae, Ebenaceae, Fagaceae, Juglandaceae, Lauraceae, Moraceae, Myrtaceae, Oleaceae, Pinaceae, Proteaceae.
Rosaceae, Rutaceae, Vitaceae, families belonging to Lamiales and various other host plants.

Disease symptoms: Fruit rot, wood canker, leaf spots.

Notes: Neofusicoccum was introduced by Crous et al. (2006b) to accommodate species morphologically similar to, but phylogenetically divergent from Botryosphaeria (= Fusicoccum).

To separate Neofusicoccum from Botryosphaeria based solely on morphology can be difficult due to similar morphological characteristics. Therefore, molecular data are required to achieve accurate identification. One morphological difference between both genera is the presence of a Dichomera synasexual morph in Neofusicoccum. However, this synasexual morph is not produced by all Neofusicoccum species, nor even all isolates of any given species. Moreover, dichomera-like conidia...
were reported in some isolates of *Bot. dothidea* (Barber et al. 2005, Phillips et al. 2005). Other morphological differences are the absence of paraphyses in the conidiomata of *Neofusicoccum* spp., while these have been seen in most of the currently accepted *Botryosphaeria* species, and the conidal L/W ratios being less than 4 in *Neofusicoccum*. Furthermore, the conidia of *Neofusicoccum* are more ellipsoidal than the fusiform ones of *Fusicoccum* s. str.

Species in *Neofusicoccum* are morphologically similar and hard to differentiate from one another. *Neofusicoccum* species are currently defined on the basis of conidial dimensions and pigmentation, pigment production in culture media and ITS sequence data. Taxa in some of the species complexes are defined exclusively on DNA sequence data (ITS, often together with *tef1*, *tub2* and *rpb2*). In some cases, multigene sequence data are essential for species identification.

**References:** Crous et al. 2006b, Berraf-Tebbal et al. (2014), Yang et al. 2017 (morphology and phylogeny); Pavlic et al. 2009a (phylogeny); Pavlic et al. 2009b (morphology, pathogenicity and phylogeny), Phillips et al. 2013 (morphology, phylogeny and dichotomous key).

**Neofusicoccum italicum** Dissanayake & K.D. Hyde, sp. nov. MycoBank MB820799, Facesoffungi number FO02963, Fig. 41.

**Etymology:** Based on the country where the type specimen was collected, Italy.

**Sexual morph** not observed. *Conidiomata* 0.5 – 1.5 × 1.5 – 2.5 mm, black, scattered, uniloculate, globose; *conidiomatal wall* composed of dark brown *textura angularis*, becoming hyaline towards conidigenous region. *Conidiophores* reduced to conidiogenous cells. *Conidiogenous cells* 9 – 16.5 × 2.5 – 3.5 μm, lining inner wall of pycnidium, holoblastic, cylindrical to sub-oblanceolate, hyaline, discrete, determinate, occasionally indeterminate and proliferating percurrently with indistinct annellations. *Conidia* 13 – 18.5 × 3.5 – 6 μm, obovoid, fusiform, base truncate, apex obtuse to subobtuse, hyaline, guttulate, non-septate, older
conidia may become brownish and septate before germination. *Dichomera synasexual morph* not reported.

**Culture characteristics:** Colonies white with abundant aerial mycelium reaching 90 mm diam within 1 wk on PDA at 28 °C. Aerial mycelium becoming smoke-grey to olivaceous grey at the surface and dull green to brown-vinaceous at the reverse after 2 wk in the dark at 28 °C.

**Materials examined:** *Italy*, on a dead branch of *Vitis vinifera*, 22 Nov. 2014, E. Camporesi (*holotype* MFLU 16-2872, culture ex-type MFLUCC 15-0900). *New Zealand*, on *Malus × domestica*, unknown date, H.J. Boesewinkel, CBS 719.85.

**Notes:** According to the phylogenetic analysis *Neofusicoccum italicum* clustered close to *Nm. algeriense*, which has larger conidia (17.6 × 5.6 μm) than those of *Nm. italicum* (15.8 × 5.2 μm). Both species are pathogens of *Vitis vinifera*, but *Nm. algeriense* is restricted to this host while *Nm. italicum* was also isolated from *Malus × domestica*. Other species of *Neofusicoccum* associated with *Vitis vinifera* are *Nm. austrole*, *Nm. luteum*, *Nm. mediterraneum*, *Nm. parvum*, *Nm. stellenboschiana*, *Nm. vitifusiforme* (*Van Niekerk et al. 2004a, Phillips et al. 2013, Yang et al. 2017*). *Neofusicoccum* and other related genera belonging to *Botryosphaeriaceae* are widely distributed pathogens of grapevines that cause bud mortality, dieback, brown streaking inside the wood, internal necrotic lesions and in some cases bunch rot (*Phillips et al. 2013*).

**Neofusicoccum pistacicolica** Crous, sp. nov. MycoBank MB820820. Fig. 42.

**Etymology:** Named after the host genus from which it was collected, *Pistacia*.

**Sexual morph** not observed. *Conidiomata* stromatic, solitary, globose, up to 300 μm diam; *conidiomatal wall* 6–10 cell layers thick, of brown *textura angularis*, becoming hyaline toward inner region. *Conidiophores* 0–2-septate, branched, hyaline, smooth, subcylindrical, 15–25 × 4–5 μm. *Conidiogenous cells* holoblastic, hyaline, smooth, subcylindrical, proliferating percurrently, 12–17 × 2.5–3.5 μm. *Conidia* hyaline, smooth, thin-walled, granular, asetate, subcylindrical to fusoid-ellipsoid, apex subcylindrical, base truncate, 1.5–2.5 μm, straight to irregularly curved, (15–)18–24(–27) × (4–)4.5(–5) μm. *Spermatia* or *Dichomera synasexual morph* not observed.

**Culture characteristics:** Colonies on MEA reaching 90 mm diam within 1 wk, with fluffy moderate aerial mycelium; surface pale mouse-grey, reverse mouse-grey to dark mouse-grey.

**Material examined:** *USA*, California, Glenn County, on *Pistacia vera*, 12 Apr. 2002, T.J. Michailides (*holotype* CBS H-23108, culture ex-type CBS 113089).

**Notes:** *Neofusicoccum pistacicolica* is morphologically similar to *Nm. helenium*, which *Chen et al.* (2015b) recently described from *Pistacia vera* in the USA. However, compared with *Nm. helenium*, *Nm. pistacicolica* possesses smaller conidiomata and narrower conidia. The same features are used to distinguish it from *Nm. pistacianum*, which is the closest phylogenetic species, and also a pathogen of *Pistacia vera*. Other species of *Neofusicoccum* associated to this host are *Nm. austrole*, *Nm. mediterraneum*, *Nm. nonquaestum*, *Nm. parvum* and *Nm. pistaciae* (*Inderbitzin et al. 2010, Phillips et al. 2013, Yang et al. 2017*).

**Neofusicoccum pruni** Crous, sp. nov. MycoBank MB820821. Fig. 43.

**Etymology:** Named after the host genus from which it was collected, *Prunus*.

**Sexual morph** not observed. *Conidiomata* stromatic, solitary, globose to obpyriform, up to 300 μm diam; *conidiomatal wall* 6–10 cell layers thick, of brown *textura angularis*, becoming hyaline toward inner region. *Conidiophores* 0–1-septate, hyaline, subcylindrical, 10–20 × 2.5–4 μm. *Conidiogenous cells* holoblastic, hyaline, subcylindrical, 10–15 × 2.5–3.5 μm, proliferating percurrently with numerous proliferations, or proliferating at the same level (phialidic) with minute periclinal thickening. *Conidia* hyaline, granular, asetate, fusoid to ellipsoid, widest in the middle or upper third with an obtuse apex and flattened, subtruncated base, (18–)20–23(–25) × (6.5–)7–7.5(–8.5) μm. *Spermatia* or *Dichomera synasexual morph* not observed.

**Culture characteristics:** Colonies on MEA reaching 90 mm diam within 1 wk, with fluffy moderate aerial mycelium; surface and reverse greenish black.

**Material examined:** *South Africa*, Limpopo, Mookgopong, from branches of *Prunus salicina*, Aug. 2004, U. Damm (*holotype* CBS H-23109, culture ex-type CBS 121112 = CPC 5912).

**Notes:** *Neofusicoccum vitifusiforme* was initially described from *Vitis vinifera* in South Africa by *van Niekerk et al.* (2004a), *Damm et al.* (2007) was the first to report this fungus as a pathogen from *Prunus salicina* in South Africa, although their phylogenetic tree showed this isolate (CBS 121112) to cluster basal to the grapevine strains based on ITS and tef1 sequence data. A recent study by *Yang et al.* (2017), which incorporated all *Neofusicoccum* isolates available in the CBS culture collection, as well as additional genes (*rpb2* and *tub2*) showed the *Prunus* isolate to represent a distinct species. This isolate (formerly sterile) has subsequently been induced to sporulate, and is therefore named in the present study.

**Authors:** Y. Marin-Felix, E. Camporesi, A. Dissanayake, K.D. Hyde & P.W. Crous

**Phildium** Kunze, Mykol. Hefte 2: 92. 1823. Fig. 44.

**Synonyms:** *Sclerotiosis* Speg., *Anl. Soc. Cient. Argent. 13: 14. 1882.

**Hainesia** Ellis & Sacc., in Saccardo, *Syll. fung.* (Abellini) 3: 698. 1884.

**Dischoainesia** Nannf., *Nova Acta Regiae Soc. Sci. Upsal.*, Ser. 4 8: 88. 1932.
Fig. 39. Neofusicoccum spp. A–D. Disease symptoms. A. Leaf blight on Protea sp. B. Canker on Vitis vinifera. C, D. Cankers on Eucalyptus sp. E–J. Sexual morphs. E. Neofusicoccum parvum (ex-type ATCC 58191). F. Neofusicoccum luteum (ex-type ATCC 58193). G, H. Asci. G. Neofusicoccum luteum (ex-type ATCC 58193). H. Neofusicoccum australe (ex-type CMW 6837). I. Detail of ascus apex of Neofusicoccum parvum (ex-type ATCC 58191). J. Ascospores of Neofusicoccum parvum (ex-type
### Table 12. DNA barcodes of accepted Neofusicoccum spp.

| Species                        | Isolates ¹  | GenBank accession numbers ² | References |
|-------------------------------|-------------|----------------------------|------------|
| Neofusicoccum algerense       | CBS 137504 ⁴ | KJ657702 – KJ657715         | Berral-Tebball et al. (2014) |
| Nm. andinum                   | CBS 117453 ⁴ | AY693976 KX464002           | Mohali et al. (2006), Yang et al. (2017) |
| Nm. arbuti                     | CBS 116131 ⁴ | AY819720 KX464003           | Farr et al. (2005), Phillips et al. (2013), Yang et al. (2017) |
| Nm. australiae                 | CMW 6837 ⁷  | AY339262 EU339573          | Slippers et al. (2004b), Burgess & Sakalidis (unpubl. data) |
| Nm. batangarum                 | CBS 124924 ⁴ | FJ900607 FJ900615          | Begoude et al. (2010) |
| Nm. brasiliense                | CMW 128574 ⁷ | JX513628                  | Marques et al. (2013) |
| Nm. buxi                       | CBS 116.75 ⁷ | KX464165 KX464010           | Yang et al. (2017) |
| Nm. cordaticola               | CBS 123634 ⁷ | EU821989 EU821928 EU821868 | Pavlic et al. (2009a) |
| Nm. corticosae                 | CBS 120081 ⁷ | DQ923533 KX464013          | Summerrell et al. (2006), Yang et al. (2017) |
| Nm. cryptaustrale              | CBS 23785 ⁷  | FJ752742 KX464014           | Crous et al. (2013b), Yang et al. (2017) |
| Nm. eucalypticola              | CBS 115679 ⁷ | AY615141                   | Slippers et al. (2004c) |
| Nm. euclayptorum               | CBS 115791 ⁷ | AF283686                   | Smith et al. (2001), Slippers et al. (2004a) |
| Nm. grevilleae                 | CBS 129518 ⁷ | JF51137                    |                          |
| Nm. hellenicum                 | CERC1947 ⁷  | KP217053                   | Chen et al. (2015b) |
| Nm. italicum                   | MFLUCC 15-0900 ⁷ | KY856755 – KY856754       | Present study |
| Nm. kwambonambiense            | CBS 123639 ⁷ | EU821900 EU821930          | Pavlic et al. (2009a) |
| Nm. luteum                     | CBS 562.92 ⁷  | KX464170 KX464020           | Yang et al. (2017) |
| Nm. macroclavatum              | CBS 118223 ⁷ | DQ939169 KX464022           | Burgess et al. (2005), Yang et al. (2017) |
| Nm. mangiferae                 | CBS 118532 ⁷ | AY615185 KX464023           | Slippers et al. (2005), Burgess et al. (2005), Yang et al. (2017) |
| Nm. mediterraneum              | CBS 121718 ⁷ | EU040221 KX464024           | Crous et al. (2007c), Yang et al. (2017) |
| Nm. nonguaisetum               | CBS 126655 ⁷ | GU251163 GU254025           | Inderbitzin et al. (2010), Yang et al. (2017) |
| Nm. notatum                    | CBS 128008 ⁷ | EU301030 EU339588 EU339509 EU339472 | Sakalidis et al. (2011) |
| Nm. parvum                     | CBS 138823 ⁷ | AY236943 EU821963           | Pavlic et al. (2009a), Slippers et al. (2004a), |
| Nm. pennatiporus               | MUCU 510 ⁷ | EF591925 – EF591967         | Taylor et al. (2009) |
| Nm. pistaciae                  | CBS 595.76 ⁷  | KX464163 KX464008           | Yang et al. (2017) |
| Nm. pistaciaeri                | CBS 113083 ⁷ | KX464186 KX464027           | Yang et al. (2017) |
| Nm. pistaciicola               | CBS 113089 ⁷ | KX464199 KX464033           | Yang et al. (2017) |
| Nm. protearum                  | CBS 114176 ⁷ | AF452539 KX464029           | Denman et al. (2003), Yang et al. (2017) |
| Nm. pruni                      | CBS 121112 ⁷ | EF445349 KX464034           | Damm et al. (2007), Yang et al. (2017) |
| Nm. ribis                      | CBS 115475 ⁷ | AY236935 EU339584 AY236877 AY236906 | Slippers et al. (2004a), Sakalidis et al. (2011) |
| Nm. stelliferiscusina          | CBS 110864 ⁷ | AY343407 KX464042           | van Niekerk et al. (2004a), Yang et al. (2017) |
| Nm. umdonicolica               | CBS 123645 ⁷ | EU821904 EU821934 EU821874 EU821844 | Pavlic et al. (2009a) |
| Nm. ursonum                    | CMW 244807 ⁷ | FJ752746 KX464047           | Crous et al. (2013b), Yang et al. (2017) |
| Nm. vitescavatum               | CBS 112878 ⁷ | AY343381 KX464048           | Pavlic et al. (2009a) |
| Nm. viticispora                | CBS 110887 ⁷ | AY343383 KX464049           | van Niekerk et al. (2004a), Yang et al. (2017) |

¹ CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CERC: China Eucalypt Research Centre (CERC), Chinese Academy of Forestry (CAF), China; CMM: Culture collection of Phytopathogenic Fungi “Prof. Maria Menezes”, Universidade Federal Rural de Pernambuco, Recife, Brazil; CMW: Tree Pathology Co-operative Program, Forestry and Agricultural Biotechnology Institute, University of Pretoria, South Africa; MFLUCC: Mae Fah Luang University Culture Collection, Chiang Rai, Thailand; MUCC: Murdoch University, Perth, Western Australia.

² ITS: internal transcribed spacers and intervening 5.8S nrDNA; rpb2: partial RNA polymerase II second largest subunit gene; tef1: partial translation elongation factor 1-alpha gene; tub2: partial β-tubulin gene.

ATCC 58191, K–S, Asexual morph. K. Conidiomata on pine needles in culture of Neofusicoccum australiae (CMW 6837). L, M. Conidiogenous cells. L. Neofusicoccum mediterraneum (ex-type CBS 121718). M. Neofusicoccum parvum (ex-type ATCC 58191). N–P. Conidia. N. Neofusicoccum arbuti (ex-type CBS 118131). O. Neofusicoccum australiae (ex-type CMW 6837). P. Neofusicoccum vitisforma (ex-type CBS 110887). Q. Coloured, 1- and 2-septate conidia of Neofusicoccum parvum (ex-type ATCC 58191). R. Spermatogenous cells of Neofusicoccum mediterraneum (ex-type CBS 121718). S. Spermatia of Neofusicoccum mediterraneum (ex-type CBS 121718). Scale bar: E–G = 50 μm; H, J, L–P = 10 μm; I, Q, S = 5 μm; K = 1 mm. Pictures taken from Phillips et al. (2013).
Classification: Leotiomycetes, Leotiomycetidae, Helotiales, Chaetomellaceae.

Type species: Pilidium acerinum (Alb. & Schwein.) Kunze. Iconotype in Kunze & Schmidt (1817), table 2, fig. 5. Epitype and ex-epitype culture: BPI 843555, CBS 736.68.

DNA barcode (genus): LSU.

DNA barcode (species): ITS. Table 13. Fig. 45.

Ascomata apothecial, flat to funnel-shaped, short stipitate, white, pale brown to amber in the basal portion, wall pseudoparenchymatous (plectenchymatous). Paraphyses narrow, simple or branched, asceptate. Asci unitunicate, cylindrical, clavate, rounded or truncate at the apex, deliquescent. Ascospores ellipsoidal, somewhat enlarged at one side, straight to slightly curved, asceptate, smooth-walled. Conidiomata pycnidal or sporodochial; pycnidia globose, subglobose, obpyriform or oblong, sessile, pale brown when young, dark brown to black at maturity, superficial, solitary or gregarious, uniloculate, smooth; conidiomatal wall with two regions: outer region dark brown, inner region hyaline; opening by a stellate slit, rupturing irregularly, or lacking. Conidiophores hyaline, smooth, branched, cylindrical or filiform. Conidiogenous cells enteroblastic, phialidic, acropleurogenous, hyaline, smooth. Conidia mostly non-septate, hyaline, smooth, fusiform to falcate or cymbiform, with ends slightly pointed, straight to curved. Sporodochia globose becoming cupulate, discoid, with irregularly wavy margin, slimy, pale luteous, superficial, solitary, stalk pale brown near base, becoming dark brown at apex. Conidiophores hyaline, smooth, branched, cylindrical or filiform. Conidiogenous cells enteroblastic, phialidic, acropleurogenous, determinate, integrated, filiform or subcylindrical, hyaline, smooth, with minute collarate. Conidia asceptate, hyaline, smooth, fusiform to falcate or cymbiform to allantoid, with acute ends, straight to curved.

Culture characteristics: Colonies on PDA surface and reverse white to cinnamon, buff, honey, sepia or isabelline, slimy with production of fruiting bodies; margin smooth and lobate.

Optimal media and cultivation conditions: PDA, OA and MEA incubated at 25 °C for 1 wk at 25 °C under alternating fluorescent (12 h) and near ultraviolet (12 h) light are suitable to determine cultural characteristics and induce sporulation of the

Fig. 40. RAxML phylogram obtained from the combined ITS (541 bp), tef1 (302 bp), rpb2 (594 bp) and tub2 (463 bp) sequences of Neofusicoccum spp. The tree was rooted to Botryosphaeria dothidea CBS 100564. The novel species described in this study are shown in bold. RAxML bootstrap support (BS) values above 70 % and Bayesian posterior probability scores > 0.95 are shown at the nodes. GenBank accession numbers were listed in Berraf-Tebbal et al. (2014), Chen et al. (2015b), and Yang et al. (2017). * and ** indicate ex-type and ex-neotype strains, respectively. TreeBASE: S20877.

Fig. 41. Neofusicoccum italicum (ex-type MFLUCC 15-0900). A. Conidiomata on host substrate. B, C. Cross section of conidiomata. D, E. Immature and mature conidia attached to conidigenous cells. F. Mature conidia. Scale bars: B, C = 100 µm. D–F = 20 µm.
asexual morph. The sexual morph is not formed in vitro, and is relatively uncommon and inconspicuous.

**Distribution:** Worldwide.

**Hosts:** Species of this genus are mainly found on different hosts of Anacardiaceae, Hippocastanaceae, Myrtaceae and Rosaceae, and also in several other families such as Betulaceae, Ebenaceae, Fabaceae, Geraniaceae, Oleaceae, Paeoniaceae, Pinaceae, Polygonaceae, Salicaceae, Sapindaceae, Saxifragaceae and Vitaceae.

**Disease symptoms:** Leaf spots, root lesions and tan-brown rot of fruits.

**Notes:** Species of *Pilidium* are commonly found as plant-associated fungi or isolated from soil (Sutton 1980), and they are known to produce two kinds of conidiomata. *Pilidium lythri* (formerly known as *Pi. concavum*) and *Pi. pseudoconcavum* form sporodochia in culture. Although, the former species also produces the pycnidial morph, both species can be distinguished based on conidial shape (fusiform vs. cymbiform), sporodochial size (300–1000 μm diam vs. up to 300 μm diam) and DNA sequences (Crous et al. 2013b). Both *Pi. acerinum* and *Pi. eucalyptorum* produce brown pycnidia in vitro and they are closely related (Fig. 45). However, they differ in pycnidial size (200–1000 μm diam vs. up to 300 μm diam), conidiophore shape (cylindrical vs. filiform) and in the production of guttulate conidia, which are absent in *Pi. acerinum* and present in *Pi. eucalyptorum* (Rossman et al. 2004, Crous et al. 2015e).

Discohainesia oenotherae and Hainesia lythri were considered the sexual and synasexual morphs of *Pi. lythri* (Rossman et al. 2004). However, after the one fungus = one name initiative the generic name *Pilidium* was proposed for conservation over *Hainesia* and *Discohainesia* (Johnston et al. 2014).

**References:** Sutton 1980, Shear & Dodge 1921, Palm 1991 (morphology); Sutton & Gibson 1977 (morphology and pathogenicity); Rossman et al. 2004 (morphology, pathogenicity and ecology).

**Pilidium septatum** Giraldo & Crous, sp. nov. MycoBank MB820871. Fig. 46

**Etymology:** Refers to the presence of septate conidia.

*Conidiotoma* pycnidial, superficial, solitary or gregarious, brown to black, smooth, uniloculate, subglobose to obpyriform, 97–260 × 127–230 μm; outer conidiomatal wall 11–27 μm thick, with textura angularis, formed by thick-walled, brown cells; inner conidiomatal wall 13–20 μm thick, with textura angularis or globulosa, formed by 4–5 layers of thick-walled, hyaline cells. Conidiophores branched, cylindrical, septate, hyaline, smooth, up to 24 μm long, 1.5–2 μm diam. Conidiogenous cells acroplerigenous, monophialidic, cylindrical, slightly curved, smooth, hyaline, delineating the inner part from the pycnidium, 7–11 × 1.5–2 μm. Conidia 1-septate, hyaline, falcate with ends slightly pointed, thin- and smooth-walled, (8.1–) 9–11(–12.5) × (1–)1.5(–2) μm.
Culture characteristics: Colonies on OA and PDA reaching 30–40 mm in 2 wk. Colonies flat, granulose due to production of pycnidia, with scarce aerial mycelium, surface honey to isabelline.

Materials examined: Thailand, Nakhon Nayok province, Mueang Nakhon Nayok district, Wang Takhrai waterfall, N14.330023° E101.307168°, 64 m above sea level, from soil, 22 Jul. 2015, A. Giraldo (holotype metabolically inactive, culture ex-type BCC 79016); Nan province, Bo Kluea district, N19.14833333° E101.1566667, from soil, 8 Aug. 2015, A. Giraldo (BCC 79037).

Notes: Presently the genus includes only species with aseptate conidia, and thus *Pi. septatum*, with septate conidia, expands the generic concept of *Pilidium*. In addition to the phylogenetic relationship revealed through the analysis of LSU and ITS regions (Fig. 45), morphological characteristics such as the
morphology of the pycnidia, the production of acropleurogenous conidiogenous cells and conidial shape, support the inclusion of this species within the genus.

Authors: A. Giraldo, J. Luangsa-ard & P.W. Crous

Pleiochaeta (Sacc.) S. Hughes, Mycol. Pap. 36: 39. 1951. Figs 47, 48.

Synonym: Ceratophorum subgen. Pleiochaeta Sacc., Syll. fung. (Abellini) 11: 622. 1895.

Classification: Dothideomycetes, Pleosporomycetidae, Pleosporales, Dothidotthiaceae.

Type species: Pleiochaeta setosa (Kirchner) S. Hughes. Epitype and ex-epitype culture designated here: CBS H-23058, CBS 496.63 = MUCL 8091).

DNA barcode (genus): LSU.

DNA barcode (species): ITS. Table 14. Figs 49, 50.

Sexual morph unknown. Conidiophores macronematous, mononematous or grouped in fascicles, simple, erect, straight to flexuous, or geniculate, hyaline to pale olivaceous, smooth.

Conidiogenous cells mono- and polyblastic, integrated, terminal and intercalary, cylindrical. Conidia solitary, dry, subcylindrical to fusoid, mostly curved, narrowed to obtuse at the apex, truncate at the base, pale to dark brown, smooth, multisepitate; apical cell bears several long, hyaline, subulate appendages which are sometimes branched. Chlamydospores present or absent, brown to dark brown in chains or in groups.

Culture characteristics: Colonies on PDA grey to olivaceous black with aerial mycelium white, cottony, margin fimbriate, effuse; reverse black.

Optimal media and cultivation conditions: MEA, OA, PDA or SNA with sterilised twigs, incubated at 25 °C. Not all strains sporulate well in culture.

Distribution: Worldwide.

Hosts: Mainly pathogens of legumes, with one species reported from carrots.

Disease symptoms: Brown leaf spots, lesions are circular and zonate. It also can attack stems, pods and roots, and destroy whole plants.

Table 13. DNA barcodes of accepted Pilidium spp.

| Species          | Isolates† | GenBank accession numbers‡ | References               |
|------------------|-----------|----------------------------|--------------------------|
| Pilidium acerinum| CBS 736.68T | AY487091 AY487092          | Rossman et al. (2004)    |
| Pi. lythri       | CBS 114293 | AY487094 AY487095          | Rossman et al. (2004)    |
| Pi. eucalyptorum | CBS 140662T | KT950854 KT950868          | Crous et al. (2015e)     |
| Pi. pseudoconcavum| CBS 136433T | KF777184 KF777236         | Crous et al. (2013b)     |
| Pi. septatum     | BCC 79016T | KY922832 KY922833         | Present study             |

† BCC: BIOTEC Culture Collection, National Center for Genetic Engineering and Biotechnology (BIOTEC), Klong Luang, Pathumthani, Thailand; CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands. ‡ ITS: internal transcribed spacers and intervening 5.8S nrDNA; LSU: partial 28S large subunit RNA gene.

Fig. 45. Maximum likelihood (ML) tree based on partial sequences of LSU (792 bp) and ITS (477 bp) regions from reference and ex-type strains of Pilidium species. Bootstrap support values and posterior probabilities above 70 % and 0.95, respectively are shown at the nodes. Chaetomella raphigera and Chaetomella oblonga (Chaetomellaceae, Helotiales) were used as outgroup taxa. Numbers within parentheses correspond to GenBank accession numbers of LSU and ITS sequences, respectively. † and ‡ indicate ex-type and ex-epitype strains, respectively. TreeBASE: S20877.
Notes: Pleiochaeta was established by Hughes (1951) to accommodate two species previously included in Ceratophorum, namely Plei. setosa and Plei. albizziae. Currently this genus comprises six species, including pathogens and saprobes. Pleiochaeta setosa, the generic type, is the most important species from a phytopathogenic point of view, causing serious damage in Lupinus spp. and other legumes members of Fabaceae. Sequences available to date for the genus are scant. After the analysis of LSU and ITS sequences of the isolates studied with members of Pleosporales (Dothideomycetes), we support the phylogenetic position of Plei. setosa and Plei. ghindensis in the Dothidotthiaceae. Furthermore, our results allow us to describe a new species from South Africa, Plei. carotae, causing a disease on carrot leaves. Cultures of Plei. albizziae, Plei. amazonensis, Plei. cassiae and Plei. stellaris were not available for this study, and their phylogenetic position remains unknown. Further studies with additional molecular data of isolates from different origins and substrates, as well as pathogenicity tests, need to be conducted.

References: Hughes 1951 (taxonomy and morphology); Pirozynski 1974 (morphology and distribution); Bateman 1997 (pathogenicity); Yang & Sweetingham 2002 (morphology and pathogenicity).

Pleiochaeta carotae Hern.-Restr., van der Linde & Crous, sp. nov. MycoBank MB820795. Fig. 47.

Etymology: Named after the host genus from which it was isolated, Daucus carota.

Mycelium partly immersed, partly superficial, composed of branched, septate, hyaline to dark brown, smooth, 3–9 μm wide, hyphae. Conidiophores macronematous, mononematous, usually unbranched, flexuous, frequently geniculate, hyaline or pale olivaceous, smooth. Conidiogenous cells mono- and polyblastic, integrated, terminal and intercalary, sympodial, cylindrical to geniculate. Conidia solitary, dry, subcylindrical ellipsoid to fusoid, mostly curved, narrowed at apex, truncate at the base, at first colourless becoming orange-brown to olivaceous brown, smooth, 92–137 × 16–22 μm, 6–10-septate, usually constricted at the septa; basal cell conical, truncate, subhyaline to pale brown, 8–11 μm wide; apical cell obtuse, arising 2–3 hyaline appendages, with one appendage arising apically which are usually branched 2–4 times, and another two laterally on the sides which are usually branched 1–2(–3) times, appendages 70–114 μm long, 4.5–7 μm wide at the point of origin and pointed at their apices. Chlamydospores not observed.

Culture characteristics: Colonies reaching 40–55 mm diam after 1 wk at 25 °C on OA, PDA and MEA olivaceous black, cottony, with white aerial mycelium in the centre, exudate hyaline, margin fimbriate, effuse, colourless; reverse black.

Material examined: South Africa, Gauteng, Pretoria, on carrot leaf, Mar. 2015, M. Truter (holotype CBS H-23057, culture ex-type CPC 27452 = CBS 142644).

Notes: This is the first species of Pleiochaeta described from carrots, a non-legume host plant. Conidia of this species resemble those of Plei. ghindensis, having branched apical
appendages, usually more than twice branched. In *Plei. ghindensis* conidiogenous cells are monoblastic, terminal and cylindrical with percurrent proliferations. However, in *Plei. carotae*, conidiogenous cells are mono- and polyblastic, terminal and intercalary and geniculate with sympodial proliferations. Furthermore, conidia in *Plei. carotae* are larger (92–137 μm vs. 85–115 μm in *Plei. ghindensis*) and with a larger number of septa (6–10 vs. 6–7 in *Plei. ghindensis*). Finally, the basal conidial cells are usually paler than the other cells (in *Plei. ghindensis* conidia are concolourous).

**Pleiochaeta setosa** (Kirchn.) S. Hughes. Mycol. Pap. 36: 34. 1951. Figs 48, 51. **Basionym:** *Ceratophorum setosum* Kirchn. Z. Pflanzenschutz 2: 324. 1892. **Synonyms:** *Pestalotia lupini* Sorauer, Z. Pflanzenschutz 8: 269. 1898. *Mastigosporium lupini* (Sorauer) Cavara, Riv. Patol. Veg. 14: 13. 1924.

**Mycelium** partly immersed, partly superficial, composed of branched, septate, hyaline to brown, smooth, 4–7.5 μm wide, hyphae. **Conidiophores** macronematous, mononematous, usually unbranched, flexuous, frequently geniculate, hyaline or pale olivaceous, smooth, 34–138 × 5–11 μm. **Conidiogenous cells** mono-, usually polyblastic, integrated, terminal and intercalary, sympodial, cylindrical, geniculate, hyaline to pale olivaceous, 25–68 × 8–11.5 μm. **Conidia** solitary, dry, subcylindrical to fusoid, mostly curved, narrowed at the apex, truncate at the base, colourless or with the cell at each end hyaline or subhyaline and intermediate cells straw-coloured to golden brown, smooth, 68–88.5 × 11–25 μm, 8.5–11 μm wide at the base, 4–7-septate; **apical cell** bears 3–4 hyaline, subulate appendages, 89–150 × 2.5–5.5 μm, apical appendage at first simple later becoming branched, lateral appendages simple. **Chlamydospores** pale brown to dark brown, terminal and intercalary, in chains or in groups (observed in CBS 142.51 and 502.80, but not in the epitype).

**Culture characteristics:** Colonies reaching 25–50 mm diam after 1 wk at 25 °C on OA, PDA and MEA, cottony to glabrous, smoke-grey to olivaceous black, with aerial mycelium in the centre white, margin effuse, fimbriate; reverse black. On OA sometimes with hyaline exudate and apricot diffusible pigment.

**Material examined:** **Lectotype designated here:** figs 1–6 in Kirchner O. 1892. Über das Absterben junger Cytisus-Pflanzen. Z. Pflanzenschutz 2: 324–327, MBT376013.
Fig. 48. Pleiochaeta setosa (ex-epitype CBS 496.63, CBS 502.80). A–D, Conidiophores with conidia (ex-epitype CBS 496.63). E, F, Conidiogenous cells (ex-epitype CBS 496.63). G–L, Conidia (ex-epitype CBS 496.63). M–O, Chlamydospores (CBS 502.80). Scale bars: 10 μm.
Austria, Wallersberg, near Völkermarkt, on living stem and leaf of *Genista sagittale*, Aug. 1980, W. Gams, CBS 502.80. Germany, Berlin, on leaf of *Cytisus racemosus*, unknown date, R. Schneider (epitype designated here CBS H-23058, MBT376012, culture ex-epitype = CBS 496.63 = MUC 8091). The Netherlands, Boskoop, on spot on stem of *Cytisus* sp., unknown date, I. de Boer, CBS 142.51. Unknown country, on leaf of *Laburnum* sp., unknown date, dep. C.M. Doyer, CBS 118.25.

Notes: *Pleiochaeta setosa* was introduced by Kirchner (1892) as *Ceratophorum setosum* for a fungus that infects *Cytisus* in Germany and later was transferred to *Pleiochaeta* by Hughes (1951). Since type material for *Plei. setosa* is inexistent, the illustrations included in the protologue reproduced here (Fig. 51) serve as lectotype. In addition, to fix the use of the name the strain CBS 496.63 is designated here as ex-epitype. This isolate was collected, from the same locality and host genus where it was found the first time (Kirchner 1892) and fits well with the description of the protologue. This species has a worldwide distribution and it is frequently reported as pathogen of *Lupinus* (Hughes 1951, Pirozynski 1974). Nevertheless, *Crotalaria, Genista, Laburnum* and *Ornitopus* can also be hosts of this species (Pirozynski 1974, Yang & Sweetingham 2002). Unfortunately, host specificity studies are not available for this species, even though Yang & Sweetingham (2002) reported morphological and pathogenicity differences among isolates from *Lupinus* spp. and *Ornitopus* spp.

Authors: M. Hernández-Restrepo, E.J. van der Linde & P.W. Crous

**Plenodomus** Preuss, Linnaea 24: 145. 1851. Fig. 52. Synonyms: Phoma sect. **Plenodomus** (Preuss) Boerema, Kesteren & Loer., Trans. Brit. Mycol. Soc. 77: 61. 1981. **Diploplenodomus** Diedicke, Ann. Mycol. 10: 140. 1912. **Plectophomella** Moesz, Magyar Bot. Lapok 21: 13. 1922. **Apocytospora** Höhn., Mitt. Bot. Lab. TH Wien 1: 43. 1924. **Deuterophoma** Petri, Boll. R. Staz. Patolog. Veget. Roma 9: 396. 1929.

For Additional synonyms of the asexual morph and sexual morph genera listed below see Boerema et al. (1994) and Khashnobish et al. (1995), respectively.

Classification: **Dothideomycetes**, Pleosporomycetidae, Pleosporales, Leptosphaeriaceae.

**Type species**: *Plenodomus lingam* (Tode: Fr.) Höhn. Representative strains: CBS 532.66 and CBS 475.81.

**DNA barcodes (genus)**: LSU, ITS.

**DNA barcodes (species)**: tub2, rpb2. Table 15. Fig. 53.

Ascomata solitary, scattered or in small groups, erumpent to superficial, subglobose, broadly or narrowly conical, small- to medium sized, dark brown to black, smooth, ostiolate; ostiole apex with a conical, well developed papilla; ascomatal wall composed of two to several layers of scleroplectenchymatous cells. *Hamathecium* comprising long, septate, pseudoparaphyses. Ascii 8-spored, bitunicate, fissitunicate, cylindrical, rounded at the apex, with an ocular chamber, short pedicel. Ascospores cylindrical to ellipsoidal, yellowish brown, sepalate, not or slightly constricted at septa, guttulate and lacking a mucilaginous sheath, cell above central septum slightly wider. *Conidiomata*. Type 1: solitary, scattered or in small groups, erumpent to superficial, subglobose or flask shaped with a broad base, mostly black, ostiolate; ostiole with a long neck and well developed poroid papilla in the apex. Type 2: solitary, scattered or in small groups, erumpent to superficial, mostly subglobose, ostiolate; ostiole slightly papillate with a narrow pore or opening via a rupture. *Conidiomatal wall* composed of several layers with thick-walled cells of *textura angularis*, surface heavily pigmented. *Conidiophores* reduced to conidigenous cells. *Conidigenous cells* phialic, hyaline, smooth, ampulliform. *Conidia* hyaline, aseptate, ellipsoidal to subcylindrical (adapted from Ariyawansa et al. 2015b).

Culture characteristics: Colonies on OA yellow/green to olivaceous grey, dull green, or translucent, aerial mycelium tenuous, margin irregular and whitish, compact, floccose.

Optimal media and cultivation conditions: OA or PNA near-ultraviolet light (12 h light, 12 h dark) to promote sporulation at 25 °C.

**Distribution**: Worldwide.

**Hosts**: As pathogens of herbaceous plants in different families, most records refer to *Asteraceae*, and on leaves, branches, bark, wood and dead stems of various trees and shrubs of *Brassicaceae*, *Lamiaceae*, *Rutaceae*, *Salicaceae* and *Vitaceae*. In addition, some *Plenodomus* species are found as opportunistic or pathogenic fungi on *Apiaceae*, *Bignoniacaeae*, *Capprilociaceae*, *Fabaceae*, *Rosaceae*, *Ulmaceae* and *Umbelliferae*.

Disease symptoms: Leaf spots, stem lesions, slow wilt, bark canker, root rot, shoot dieback.
Fig. 49. RAxML phylogram obtained from LSU (883 bp) sequences of Dothideomycetes. RAxML bootstrap support (BS) values above 70% and Bayesian posterior probability scores ≥ 0.95 are shown at the nodes. The tree was rooted to Botryosphaeria dothidea CBS 115476, Neofusicoccum parvum CBS 124491 and Saccharata proteae CBS 115206. Numbers between parentheses correspond to GenBank accession numbers. T, ET, NT and PT indicate ex-type, ex-epitype, ex-neotype and ex-paratype, respectively. TreeBASE: S20877.
Fig. 50. Phylogenetic tree resulting from a Bayesian analysis of the combined LSU and ITS sequences alignment of Pleiochaeta species. Bayesian posterior probabilities >0.95 are indicated at the nodes. The tree was rooted to Thyrostroma compactum and Thyrostroma cornicola. Numbers between parentheses correspond to GenBank accession numbers of ITS and LSU, respectively. † and ET indicate ex-type and ex-epitype strains, respectively. *, ITS and LSU sequences. TreeBASE: S20877.

Fig. 51. Reproduction of the original drawings by Kirchner (1892) illustrating Ceratophorum setosum (original numbers are maintained to indicate the different structures). A. fig. 1. Symptoms in Cytisus capitatus. B. fig. 2. Young conidia. C. fig. 3. Conidiophores and conidia. D, E. figs 4, 5. Conidia. F. fig. 6. Germinating conidia.
Notes: The genus Plenodomus was first established by Preuss (1851), and recently re-introduced and placed in the family Leptosphaeriaceae by de Gruyter et al. (2013). The genus mainly consists of species that formerly belonged to Phoma section Plenodomus and the sexual morph Leptosphaeria. Plenodomus includes several well-known important plant pathogens, such as Plen. biglobosus, Plen. lindquistii, Plen. tracheiphilus, and Plen. wasabiae.

References: Boerema et al. 2004 (morphology and pathogenicity); de Gruyter et al. 2013, Ariyawansa et al. 2015b (morphology and phylogeny).

Plenodomus deqinensis Q. Chen & L. Cai. sp. nov. MycoBank MB818821. Fig. 54.

Etymology: Named after the location where the holotype was collected, Deqin, Yunnan Province in China.

Conidiomata pycnidial, solitary, globose to subglobose, glabrous, superficial, (150–)165–355 × (105–)125–305 μm; ostiole single, slightly papillate with a narrow pore or opening via a rupture; conidiomatal wall pseudoparenchymatous, 3–6-layered, 16–28 μm thick, composed of isodiametric to oblong cells, outer layer brown. Conidiophores reduced to conidiogenous cells. Conidiogenous cells phialidic, hyaline, smooth, ampulliform, 5–7 × 4–6.5 μm. Conidia ellipsoidal-cylindrical, smooth- and thin-walled, aseptate, 3.5–5.5 × 1.5–2.5 μm, with 2 minute polar guttules. Conidial exudates not recorded. Sexual morph not observed.

Culture characteristics: Colonies on OA 35 mm diam after 1 wk, margin regular, floccose, white, pale grey near the centre; reverse buff to amber. NaOH test negative.

Material examined: China, Yunnan, Deqin, isolated from soil, Apr. 2011, M.M. Wang (holotype MFLU 15-1876; culture ex-type CGMCC 3.18221 = LC 5189).

Notes: Plenodomus deqinensis was collected from soil on a snow mountain in China, and proved able to grow at a low temperature (15 °C). This species clustered with Plen. agnitus, Plen. fallaciosus and Plen. lupini in the phylogenetic tree (Fig. 53). The NaOH test of Plen. deqinensis proved negative, while in Plen. agnitus it was positive (Boerema et al. 1994). Morphologically, Plen. deqinensis differs from Plen. lupini in the slightly wider conidiogenous cells (5–7 × 4–6.5 μm vs. 3–8 × 3–6 μm), and being conspicuously biguttulate (de Gruyter et al. 1993). Plenodomus fallaciosus has hitherto only been observed as a sexual morph.

Authors: Q. Chen & L. Cai

Protostegia Cooke, Grevillea 9: 19. 1880. Fig. 55.

Classification: Dothideomycetes, Dothideomycetidae, Capnodiales, Mycosphaerellaceae.

Type species: Protostegia eucleae Kalchbr. & Cooke. Slide holotype: IMI 230771. Epitype and ex-epitype cultures: PREM 60879, CPC 23549 = CBS 137232.

DNA barcode (genus): LSU.

DNA barcode (species): ITS. Table 16.

Sexual morph unknown. Conidiomata pycnidial, immersed, becoming somewhat erumpent, solitary, exuding a mucoid
Table 15. DNA barcodes of accepted Plenodomus spp.

| Species                  | GenBank accession numbers | References                          |
|--------------------------|---------------------------|-------------------------------------|
| Plenodomus agnitus       | CBS 121.89 JK740194 KY064036 KY064053 | de Gruyter et al. (2013), present study |
| Plen. biglobosus         | CBS 119951 JK740198 KY064037 KY064054 | de Gruyter et al. (2013), present study |
| Plen. chrysanthemi       | CBS 539.63 JK740253 KY064038 KY064055 | de Gruyter et al. (2013), present study |
| Plen. collinsoniae       | CBS 120227 JK740200 KY064039 KY064056 | de Gruyter et al. (2013), present study |
| Plen. confertus          | CBS 375.64 AF439459 KY064040 KY064057 | Câmara et al. (2002), present study |
| Plen. congestus          | CBS 244.64 AF439460 KY064041 KY064058 | Câmara et al. (2002), present study |
| Plen. degenensis         | CGMCC 3.18221 KY064027 KY064034 KY064052 | Present study |
| Plen. enterolocus        | CBS 142.84ET JK740214 KY064042 KT266266 | de Gruyter et al. (2013), present study |
| Plen. fallaciocus        | CBS 414.62 JK740222 KY064043 KT266271 | de Gruyter et al. (2013), present study |
| Plen. guttulatus         | MFLUCC 151876 KT454721 – – | Anyawansa et al. (2015b) |
| Plen. hedericola         | CBS 113702 JK740225 KY064044 KT266271 | de Gruyter et al. (2013), present study |
| Plen. infuloescens       | CBS 143.84ET JK740228 KY064045 KT266267 | de Gruyter et al. (2013), present study |
| Plen. libanotidis        | CBS 113795 JK740231 KY064046 KY064059 | de Gruyter et al. (2013), present study |
| Plen. loquastii          | CBS 381.67 JK740233 – – | AY749028 Voigt et al. (2005), de Gruyter et al. (2013) |
| Plen. lingam             | CBS 260.94 JK740235 KY064047 KY064060 | de Gruyter et al. (2013), present study |
| Plen. lupini             | CBS 246.92 JK740236 KY064048 KY064061 | de Gruyter et al. (2013), present study |
| Plen. pimpinellae        | CBS 101637ET JK740240 – KY064062 | de Gruyter et al. (2013), present study |
| Plen. salvaje            | MFLUCC 130219 KT454725 – – | Anyawansa et al. (2015b) |
| Plen. trachiphipus       | CBS 551.93 JK740249 KY064049 KT266269 | de Gruyter et al. (2013), present study |
| Plen. visco              | CBS 122783ET JK740256 KY064050 KY064063 | de Gruyter et al. (2013), present study |
| Plen. wassiae            | CBS 120119 JK740257 – KT266272 | de Gruyter et al. (2013), present study |

Notes: The genus Protostegia is thus far only known from South Africa, where it has been reported from leaves of various Euclea spp. However, Euclea is widespread throughout Africa, and therefore Protostegia may be more widespread than currently known. Protostegia was introduced by Kalchbrenner & Cooke (1880) in order to accommodate Stegia magnoliae and the new species Pr. eucleae, and then four more species were allocated in this genus. However, Dyko et al. (1979) transferred three of these species to other genera and another two species were rejected as doubtful. Therefore, only the type species Pr. eucleae was retained and until now this genus has remained monotypic. Protostegia is characterised by immersed conidiomata with walls of textura intricata, splitting the epidermis and appearing acervular, but having a well-developed ostiole (Dyko et al. 1979). Recently Pr. eucleae was placed in the Mycosphaerellaceae together with Cystostagonospora martiniana and Phaeophleospora spp. on the basis of phylogenetic analysis of ITS and LSU sequences (Crous et al. 2015a). Cystostagonospora martiniana can be distinguished from Protostegia by having percurrent and polyphyalidic conidiogenous cells, and solitary to aggregated conidiomata embedded in stromatic tissue (Quaedvlieg et al. 2013). Phaeophleospora differs by the production of pigmented conidiogenous cells and conidia (Crous et al. 2009b).
**Etymology:** Name refers to the host genus it was isolated from, *Euclea*.

*Conidiomata* epiphyllous on living leaves, erumpent, solitary, not associated with leaf spots, exuding a mucoid conidial cirrhus that dries to a hard, dark brown crystalline droplet on the leaf surface, up to 250 μm diam, immersed, pale brown, splitting the leaf surface, with central ostiole, 10–30 μm diam; *conidiomatal wall brown, textura intricata. Conidiophores* reduced to conidiogenous cells. *Conidiogenous cells* hyaline, smooth, lining the inner cavity, lageniform to subcylindrical, 8–10 × 4–5 μm, proliferating percurrently at apex. *Conidia* hyaline, smooth, curved, guttulate, apices subacutely rounded, basal cell tapering to a truncate hilum, 1.5–2 μm diam, 3–7-septate, (40–) 50–70(–75) × (2.5–)3–4 μm.

**Culture characteristics:** Colonies erumpent, slow growing, with lobate, feathery margins and sparse aerial mycelium; on MEA surface and reverse greyish sepia; on OA surface mouse-grey; on PDA surface greyish sepia, reverse mouse-grey.

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**Fig. 53.** Phylogenetic tree generated from a maximum parsimony analysis based on the combined LSU, ITS, tub2 and rpb2 sequences. Values above the branches represent parsimony bootstrap support values (> 50 %). Novel species are shown in **bold**. The tree is rooted with *Leptosphaeria doliolum* CBS 505.75. GenBank accession numbers are listed in Table 15. *T* and *ET* indicate ex-type and ex-epitype strains, respectively. TreeBASE: S21048.
Material examined: South Africa, Western Cape Province, Porcupine Hills wine farm, between Botrivier and Villiersdorp, on Euclea racemosa, 29 Dec. 2014, A.R. Wood (holotype CBS H-23110, culture ex-type CPC 27224 = CBS 142615).

Notes: With the description of Pr. eucleicola, the genus is presently known from only two species. Protostegia eucleae [conidia (40–)50–75(–80) × (2–)2.5–3 μm] is morphologically similar to Pr. eucleicola [conidia (40–)50–70(–75) × (2.5–)3–4 μm], although the conidia are slightly wider in the latter. The two species are best distinguished based on their DNA data. It is possible that many collections originally reported as Pr. eucleae, actually represent Pr. eucleicola.

Authors: Y. Marin-Felix, A.R. Wood & P.W. Crous

Pseudopyricularia Klaubauf et al., Stud. Mycol. 79: 109. 2014. Fig. 56.

Classification: Sordariomycetes, Sordariomycetidae, Magnapor-thales, Pyriculariaceae.

Type species: Pseudopyricularia kyllingae Klaubauf et al. Holotype and ex-type culture: CBS H-21841, CBS 133597.

DNA barcodes (genus): LSU, rpb1.

DNA barcodes (species): ITS, rpb1, act, cal. Table 17. Fig. 57.

Sexual morph unknown. Conidiophores solitary, erect, straight or curved, branched or not, medium brown, smooth or finely rough-ened, septate. Conidiogenous cells integrated, terminal, rarely intercalary, medium brown, smooth or finely roughened, forming a rachis with several protruding denticles usually flat-tipped. Conidia solitary, obclavate, pale to medium brown, smooth or/to finely roughened, guttulate, 1–2-septate; hila truncate, slightly protrud-ing, unthickened, not darkened (adapted from Klaubauf et al. 2014).
Culture characteristics: Colonies smooth with sparse to moderate aerial mycelium. On MEA transparent, buff, honey to isabelline or white with patches of greyish sepia. On OA transparent sometimes with patches of olivaceous grey or greyish sepia. On PDA transparent, white, greyish sepia or olivaceous black.

Optimal media and cultivation conditions: Sterile barley seed on SNA at 25 °C under continuous near-ultraviolet light to promote sporulation.

Distribution: Mainly found in Asia, but also in North America, Africa and New Zealand.

Hosts: Pathogens of Cyperaceae, but also found on Bothriochloa bladhii (Poaceae) and Typha orientalis (Typhaceae).

Disease symptoms: Leaf spots.

Notes: Pseudopyricularia was one of the genera introduced recently in order to resolve the polyphyletic nature of...
Pseudopyricularia bothriochloae (Crous & Cheew.) Y. Marín & Crous, comb. nov. MycoBank MB819002. Basionym: Pyricularia bothriochloae Crous & Cheew., Persoonia 31: 229. 2013.

Notes: This fungus was initially described as a new species of Pyricularia (Crous et al. 2013b) before Klaubauf et al. (2014) introduced the new genus Pseudopyricularia. In the latter study, this species was incorporated in the phylogenetic analysis based on LSU sequence data, but not in the combined analysis, since only ITS and LSU sequences were available. Although the ex-type strain of Py. bothriochloae grouped in the Pseudopyricularia clade, a new combination was not proposed, as it could not be incorporated in the combined analysis. However, in the phylogenetic tree based on ITS and LSU sequences (Fig. 57), Py. bothriochloae was located in the Pseudopyricularia clade (100 % bootstrap support / 1 Posterior Probability) and accordingly the new combination, Py. bothriochloae, is made here. This species produces conidiophores with apical rachis with flat-tipped denticles.

Authors: Y. Marín-Felix & P.W. Crous

Puccinia Pers., Neues Mag. Bot. 1: 118. 1794. Fig. 58. For synonyms see Cunningham (1931).

Classification: Basidiomycota, Pucciniomycotina, Pucciniomycetes, Pucciniales, Puccinaceae.

Type species: Puccinia graminis Pers. Designated as type species of Puccinia by Cunningham (1931) on cultivated Triticum; lectotypified by Jørstad (1958).

DNA barcode (species): ITS (evidence for intraspecific and intrasubspecies diversity), LSU.

Spermogonia dark brown to black, often on adaxial leaf surface, subepidermal, concave hymenium with well-developed periphyses at ostiole [Group V, type 4 sensu Hiratsuka & Hiratsuka (1980)]. Spermata exuded in droplets, small, aseptate, hyaline. Aecia erumpent, usually abaxial, cup-shaped, with well-developed peridium; peridial cells irregular and verrucose. Aeciospores catenate, globose to subglobose, verruculose. Uredinia subepidermal or erumpent, on both leaf surfaces and stems, without peridium, pale yellow to brown. Paraphyses either absent, peripheral or within the sorus. Urediniospores borne singly on pedicels, mostly echinulate, usually globose, subglobose, ellipsoid to obovoid, germ pores absent or conspicuous. Telia subepidermal or erumpent, mostly dark brown to black, on both leaf surfaces and stems. Teliospores typically 2-celled by transverse or oblique septa (but may have variations of 1–4 cells in some species), borne singly on pedicels, mostly pale to dark brown, cell walls smooth or ornamented. Basidiospores formed singly from each basidial cell on a sterigma, sometimes ballistosporic.

Distribution: Worldwide.

Hosts: Species of Puccinia are obligate plant pathogens that occur on host species in many families, especially Asteraceae, Cyperaceae, Fabaceae, Lamiaceae, Liliaceae s. lat., Malvaceae and Poaceae. Heteroecious species of Puccinia, e.g. Pu. graminis, require two host plant species to complete their life cycle. The spermogonia and aecia of heteroecious species occur on one host species, while the uredinia and telia occur on another, often unrelated, host species. Autoecious species complete their life cycle on one host species. There are many variations in the life cycles of species of Puccinia. For example, some species, e.g. Pu. lagenophorae, do not form spermogonia or uredinia.

DNA barcodes (genus): ITS, LSU.
stage of *P. graminis*. There is little possibility that *Aecidium* and *Uredo* (asexual genera) will displace *Puccinia* (sexual genus) under Art. 57.2 of the ICN (McNeill et al. 2012). Whether *Uredo* is a synonym of *Puccinia* depends on the phylogenetic placement of *Uromyces beticola*, the lectotype of *Uredo* (Laundon 1970). A taxonomic working group on the Basidiomycota in 2011 recommended the use of *Uredo* for uredinial species that could not be assigned to a monophyletic sexual

Table 17. DNA barcodes of accepted *Pseudopyricularia* spp.

| Species                  | Isolates | GenBank accession numbers | References                           |
|--------------------------|----------|---------------------------|---------------------------------------|
| *Pseudopyricularia*       |          |                           |                                       |
| bothriochloae             | CBS 136427<sup>1</sup> | KF777186 KY905701 KY905700 – | Crous et al. (2013b), present study   |
| *Py. cyperi*              | CBS 133595<sup>1</sup> | KM484872 AB818013 AB274453 AB274485 | Klaubauf et al. (2014), Murata et al. (2014), Hirata et al. (2014) |
| *Py. hagahagae*           | CPC 25635<sup>1</sup> | KT950851 KT950877 KT950873 – | Crous et al. (2015e)                  |
| *Py. higginsii*           | CBS 121934 | KM484875 KM485095 KM485180 KM485250 | Klaubauf et al. (2014)               |
| *Py. kyllingae*           | CBS 133597<sup>1</sup> | KM484876 KM485096 AB274451 AB274484 | Klaubauf et al. (2014), Hirata et al. (2014) |

<sup>1</sup> CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands; CPC: Culture collection of Pedro Crous, housed at Westerdijk Fungal Biodiversity Institute. <sup>2</sup> Indicates ex-type strains.

<sup>2</sup> ITS: internal transcribed spacers and intervening 5.8S nrDNA; *rpb1*: partial RNA polymerase II largest subunit gene; *act*: partial actin gene; *cal*: partial calmodulin gene.
Many species of *Aecidium* and *Uredo* will need to be transferred to *Puccinia*, or other monophyletic genera, in order to preserve the one name equals one fungus principle (Hawksworth et al. 2011).

There are about 4,000 described species of *Puccinia* (Kirk et al. 2008), which have mostly been delimited by host taxon. Many of these species have diversified in the last 50 million years as a result of host jumps (McTaggart et al. 2016b), with the aecial host serving as a pathway for further speciation (van der Merwe et al. 2008). The morphology of teliospores and urediniospores is often sufficient to distinguish species of *Puccinia* that occur on the same host. Molecular approaches have uncovered cryptic diversity in some species of *Puccinia* (Liu & Hambleton 2013) as well as linking aecial to telial morphs in the life cycles of heteroecious rusts (Jin et al. 2010).

Other studies have shown there is less species biodiversity in some rusts than previously thought, e.g. *P. lagenophorae* and closely related species (Scholler et al. 2011, McTaggart et al. 2014). Intraspecific and intra-isolate diversity of the ITS region was found in *Pu. horiana* and *Pu. kuehnii* (Scholler et al. 2011, McTaggart et al. 2014). Multiple haplotypes and paralogous copies of the ITS region within species of rust must be considered for phylogenetic and molecular barcode studies.

Phylogenetic studies have identified several sexual genera as potentially congeneric with *Puccinia*. *Puccinia* is either paraphyletic or polyphyletic with respect to *Ceratocoma* (McTaggart et al. 2016b), *Cumminsiella* (Maier et al. 2003), *Dietelia* (Wingfield et al. 2004), *Diorchidium* (Beenken & Wood 2015), *Endophyllum* (Maier et al. 2003), *Macruropyxis* (Beenken & Wood 2015), *Miyagia* (Wingfield et al. 2004), *Sphenospora* (Aime 2006) and *Uromyces* (Maier et al. 2003). Three major clades that contained *Puccinia* and related genera were identified in molecular phylogenetic studies (van der Merwe et al. 2008, Dixon et al. 2010). One clade diversified on *Cyperaceae, Juncaceae* and orders of plants in the asterids and rosids (The Angiosperm Phylogeny 2016), and the other on *Poaceae* and *Ranunculaceae* (van der Merwe et al. 2008). A third clade included species of *Puccinia* on *Poaceae* (Dixon et al. 2010).
Fig 58. Puccinia spp. **A, D.** Aecia and aeciospores of *Puccinia paederiae* (BRIP 58338). **B, E.** Aecia and aeciospores of *Puccinia loranthicola* (BRIP 59685). **C, F.** Uredinia and urediniospores of *Puccinia oxalidis* (BRIP 58379). **G, J.** Uredinia and urediniospores of *Puccinia philippinensis* (BRIP 57418). **H, K.** Telia and teliospores of *Puccinia malvacearum* (BRIP 60128). **I, L.** Telia and teliospores of *Puccinia thwaitesii* (BRIP 58354). Scale bars = 10 μm.
Table 18. DNA barcodes of accepted *Puccinia* spp.

| Species                        | Isolates   | GenBank accession numbers | References                        |
|--------------------------------|------------|--------------------------|-----------------------------------|
|                                |            | ITS                      | LSU                               |
| *Puccinia abrupta var. partheniicola* | BRIP 59295 | –                        | KX999864                          | Present study                  |
| *Pu. acropilii*                 | BPI 863523 | JN204187                 | JN204187                          | Bruckart et al. (2012)          |
| *Pu. arthroconmi*              | BRIP 57772 | –                        | KX999865                          | Present study                  |
| *Pu. aucta*                    | BRIP 60028 | –                        | KX999866                          | Present study                  |
| *Pu. bassiae*                  | BRIP 57788 | –                        | KX999876                          | Present study                  |
| *Pu. brachypodii*              | BRIP 59466 | –                        | KX999878                          | Present study                  |
| *Pu. caricina*                 | BRIP 57951 | –                        | KX999870                          | Present study                  |
| *Pu. carissae*                 | BRIP 53242 | –                        | KX999871                          | Present study                  |
| *Pu. chrysanthemi*             | NA         | EU816926                 | EU816926                          | Pedley (2009)                  |
| *Pu. convolvuli*               | BPI 871465 | DQ354512                 |                                   | Aime (2006)                     |
| *Pu. coronata var. avenae*     | PUR 22125  | HM131256                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronata var. avenae f. graminicola* | PRM 155608 | HM131309                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronati-agrostis*        | PUR N114   | HM131235                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronati-brevispora*      | PUR N652   | HM131235                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronati-calamagrostidis* | PUR 22155  | HM131304                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronati-hordei*          | PUR 89857  | HM131225                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronati-japonica*        | PUR F16131 | HM131317                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. coronati-longispora*      | PRC 196    | HM131232                 | –                                 | Liu & Hambleton (2013)          |
| *Pu. cygnorum*                 | NA         | EF490601                 | –                                 | Langrell et al. (2008)          |
| *Pu. dianellae*                | BRIP 57433 | –                        | KM249859*                         | McTaggart et al. (2016a)        |
| *Pu. dichondrae*               | BRIP 60027 | –                        | KX999874                          | Present study                  |
| *Pu. diocae*                   | BPI 879279 | –                        | GU058019*                         | Dixon et al. (2010)            |
| *Pu. duthiei*                  | BRIP 61025 | –                        | KX999875                          | Present study                  |
| *Pu. flavenescens*             | BRIP 57992 | –                        | KX999876                          | Present study                  |
| *Pu. gastrolobii*              | BRIP 57375 | –                        | KX999877                          | Present study                  |
| *Pu. geitonoplesii*             | BRIP 55679 | KM249860                 | KM249860                          | McTaggart et al. (2016a)        |
| *Pu. gigiana*                  | BRIP 57723 | KF690673                 | KF690690                          | McTaggart et al. (2014)         |
| *Pu. graminis f. sp. tritici*  | CDL 75-36-700-3 | NW_003526581.1*       |                                   | Duplessis et al. (2011)        |
| *Pu. grevilleae*               | BRIP 55600 | –                        | KX999878                          | Present study                  |
| *Pu. haemodori*                | BRIP 57777 | KF690676                 | KF690694                          | McTaggart et al. (2014)         |
| *Pu. hemerocallidis*           | BRIP 53476 | KM249855                 | KM249855                          | McTaggart et al. (2016a)        |
| *Pu. horiana*                  | NA         | HQ201326                 | HQ201326                          | Aalaei et al. (2009)           |
| *Pu. hypochaeridis*            | BRIP 57771 | –                        | KX999879                          | Present study                  |
| *Pu. kuehnii*                  | BPI 879137 | GQ283007                 |                                   | Flores et al. (2009)           |
| *Pu. lagophorae*               | BRIP 57563 | KF690677                 | KF690696                          | McTaggart et al. (2014)         |
| *Pu. levis var. tricholaenae*  | BRIP 56867 | –                        | KX999880                          | Present study                  |
| *Pu. liberta*                  | BRIP 59686 | –                        | KX999881                          | Present study                  |
| *Pu. loranthica*               | BRIP 59685 | –                        | KX999882                          | Present study                  |
| *Pu. ludwigii*                 | BRIP 60129 | –                        | KX999883                          | Present study                  |
| *Pu. magnusiana*               | BPI 879281 | –                        | GU058000*                         | Dixon et al. (2010)            |
| *Pu. malvacearum*              | PBM 2572   | –                        | EF561641*                         | Matheny & Hibbett (unpubl. data) |
| *Pu. melanocephala*            | BPI 878929 | –                        | GU058001*                         | Dixon et al. (2010)            |
| *Pu. menthae*                  | BPI 871110 | –                        | DQ354513*                         | Aime (2006)                     |
| *Pu. mixta*                    | BRIP 61576 | KU296893                 | KU296893                          | McTaggart et al. (2016a)        |
| *Pu. muehlenbeckiae*           | BRIP 57718 | –                        | KX999884                          | Present study                  |
| *Pu. myrsiphylli*              | BRIP 57782 | –                        | KM249854*                         | McTaggart et al. (2016a)        |
| *Pu. naikanshiki*              | BPI 879283 | –                        | GU058002*                         | Dixon et al. (2010)            |
| *Pu. nemiliana*                | BRIP 56913 | –                        | KX999885                          | Present study                  |
relationships between the major clades in *Puccinia* can be observed in our phylogenetic analysis (Fig. 59).

*Uromyces* requires particular consideration as it has long been thought an aseptate variant of *Puccinia* (Sydow & Sydow 1904, Savile 1978). Morphology alone does not reliably separate *Puccinia* and *Uromyces*, because puccinoid (2-celled) and 1-celled spores and characteristics of the pedicel are homoplasious in the *Pucciniaceae* (Maier et al. 2007, Minnis et al. 2007, van der Merwe et al. 2010). Several studies have shown that *Puccinia* and *Uromyces* are polyphyletic, and furthermore that *Puccinia* is paraphyletic with respect to the type of *Uromyces* (*U. appendiculatus*) and other species of *Uromyces* on *Fabaceae* (Maier et al. 2007, van der Merwe et al. 2008). Consequently, either a taxonomy that accepts *Puccinia* as a paraphyletic group must be adopted or *Uromyces* must be synonymised under *Puccinia*. In the latter case, many important species of *Uromyces* will require name changes. The traditional use of *Uromyces* for species with aseptate teliospores has been replaced by a phylogenetic approach; for example, Demers et al. (2017) used a phylogenetic approach to describe two species of *Puccinia* with aseptate teliospores, which would have been described as *Uromyces* based on morphology.

The future of *Puccinia* depends on whether it can be divided into monophyletic genera or sub-genera that reflect synapomorphies or ecological relationships on which a natural classification can be based. A broad concept of *Puccinia* that accepts species with puccinoid spores that are recovered in closely related clades as defined by van der Merwe et al. (2008) and Dixon et al. (2010) is adopted here. Based on this molecular phylogenetic taxonomic concept, we have transferred four species of *Uredo* from the Australasian region to *Puccinia*. Further examples of taxa recovered in *Puccinia*, include Aecidium kalianchiae (Hernández et al. 2004) and *Uredo guerichiani* (Maier et al. 2007). We have chosen not to make new combinations of these species without examination of a specimen. Molecular phylogenetic support must be an essential requirement for the description of new species or new combinations in *Puccinia* because several species known from an anamorphic stage have an affinity with other genera of rust fungi, e.g. *Uredo rolliniae* (now Phakopsora rolliniae) (Beeken 2014).

ITS and LSU sequences are available for approximately 200 species of *Puccinia* on GenBank (accessed 5 Sep. 2016). These two gene regions are generally reliable as a molecular barcode for identification of species of *Puccinia*. GenBank numbers for some of the most important species of *Puccinia* that are associated with a herbarium specimen, reference genome sequence, or peer reviewed study, are provided in Table 18.

**References:**
Sydow & Sydow 1904 (morphology); Cummins & Hiratsuka 2003 (biology, morphology and taxonomy).

**Puccinia dianellae** (Dietel) McTaggart & R.G. Shivis, comb. nov. MycoBank MB819750. *Basionym:* *Uredo dianellae* Dietel, Hedwigia 37: 213. 1898.

**Material examined:** *Philippines,* Benguet, Tuba, Mount Santo Tomas, on *Dianella javanica,* 26 Jun. 2012, K.L. Lancetta, V.A.
Chenopodium candolleanum

76): 99. 1887.
Basionym
comb. nov. Shivas, (2008).
recovered in Puccinia
Puccinia rhagodiae
Ivanhoe Crossing turnoff, on leaf of O. turpethum
rust on Pu. merrilliana
U. operculinae
transfer of from the Philippines (Sydow & Sydow 1913). The
turpethum nom. nov.
Rust Fungi of Australia Lucid Key
the Morphological identi
group with species of Puccinia
Aug. 2012, C. Doungsa-ard & A.R. McTaggart (BRIP 57603).
Material examined: Australia, Queensland, Coochiemudlo Island, Victoria Parade, on leaf of Geotropis cymosa, 25 Aug. 2012, C. Doungsa-ard & A.R. McTaggart (BRIP 57603).
Notes: Puccinia geitonoplesii was recovered in a monophyletic group with species of Puccinia on Hemerocallidaceae (McTaggart et al. 2016a). Telia have not been reported.
Puccinia geitonoplesii (McAlpine) McTaggart & R.G. Shivas, comb. nov. MycoBank MB819751.
Basionym: Uredo geitonoplesii McAlpine, The Rusts of Australia, Their Structure, Nature and Classification: 203. 1906.

Puccinia merrilliana (Syd. & P. Syd.) McTaggart & R.G. Shivas, nom. nov. MycoBank MB819752.
Basionym: Uredo operculinae Syd. & P. Syd., Philipp. J. Sci., C, Bot. 8: 476. 1913.
Material examined: Australia, Western Australia, Kununurra, Ivanhoe Crossing turnoff, on leaf of Olerculina aequispala, 16 Apr. 2012, M. Butt, C. Doungsa-ard, A.R. McTaggart, R. Berndt, V. Faust-Berndt, M.D.E. Shivas & R.G. Shivas (BRIP 56913).
Notes: Uredo operculinae was first described on Olerculina turpethum from the Philippines (Sydow & Sydow 1913). The transfer of U. operculinae to Puccinia requires a new name, Pu. merrilliana, as Pu. operculinae is already occupied for a rust on O. turpethum in the Malabar region in southern India (Ramakrishnan & Sundaram 1953). The new name honours Elmer Drew Merrill (1876–1956), an American botanist, who collected this fungus while living in the Philippines, where he became an expert on the flora of the Asia-Pacific region. Puccinia merrilliana has fewer (1–2) germ pores than Pu. operculinae, which has 3–4 germ pores. Telia have not been reported for Pu. merrilliana. The specimens examined from Australia are morphologically identical to the type description by Sydow & Sydow (p. 425, 1924). Morphological identification of Pu. merrilliana can be assisted by the Rust Fungi of Australia Lucid Key (Shivas et al. 2014) (http://collections.daff.qld.gov.au/web/key/rustfungi/). Puccinia merrilliana was recovered in Puccinia in Group I sensu van der Merwe et al. (2008).

Puccinia rhagodiae (Cooke & Masssee) McTaggart & R.G. Shivas, comb. nov. MycoBank MB819756.
Basionym: Uredo rhagodiae Cooke & Masssee, Grevillea 15 (no. 76): 99. 1887.
Material examined: Australia, Tasmanin, Lilloo Beach, on leaf of Chenopodium candelaceum, 15 Dec. 2013, A.R. McTaggart, L.S. Shuey, M.D.E. Shivas & R.G. Shivas (BRIP 60078).
Notes: Puccinia rhagodiae was recovered in Puccinia group I sensu van der Merwe et al. (2008). Telia have not been reported. Several other species of Puccinia on Amaranthaceae were shown to be closely related, including Pu. arthrocnemi, Pu. bassiae and Pu. tetragoniae, although they did not form a monophyletic group. Morphological identification of Pu. rhagodiae can be assisted by the Rust Fungi of Australia Lucid Key (Shivas et al. 2014) (http://collections.daff.qld.gov.au/web/key/rustfungi/).

Authors: A.R. McTaggart & R.G. Shivas

Saccharata Denman & Crous, CBS Biodiversity Ser. (Utrecht) 2: 104. 2004. Fig. 60.
Classification: Dothideomycetes, Incertae sedis, Botryosphaeriales, Saccharataceae.
Type species: Saccharata proteae (Wakef.) Denman & Crous. Holotype and ex-type culture: PREM 32915, STE-U 1694.
DNA barcode (genus): LSU.
DNA barcodes (species): ITS, rpb2, tef1, tub2. Table 19.

Ascomata epiphyllous, separate, becoming aggregated, unilocular, immersed, substomal, with a central, flattened ostiole, surrounded by a continuous, clypeus-like apical thickening of the wall, obovoid, slightly depressed; ascomata wall consisting of 8–11 layers of brown pseudoparenchymatous textura angularis. Pseudoparaphyses hyaline, septe, branched, frequently attached to the top and base of the pseudothecial cavity. Ascii clavate to cylindrical, stipitate, bitunicate, fissitunicate; apical chamber visible as a notch-like indentation at the apex. Ascospores uni- to biseriate, hyaline, guttulate, smooth, ellipsoidal, clavate to fusiform, frequently widest in the upper third of the ascospore, tapering to obtuse ends. Conidiomata pycnidial, black, opening by a single, central ostiole, infrequently embedded in stromatic tissue with thickened, darkened upper layer; conidiomatal wall consisting of 2–3 layers of brown textura angularis. Conidiophores hyaline, smooth, subcyllindrical, branched, or reduced to conidiogenous cells, lining the inner layer of the cavity, 1–3-septate. Paraphyses intermingled among conidiophores, hyaline, smooth, subcylindrical, unbranched or branched above, with obtuse ends, 0–3-septate, extending above conidiophores or slightly above the conidia. Conidiogenous cells hyaline, smooth, phialidic, proliferating via periclinal thickening or percurrent proliferation, with or without collarettes. Conidia hyaline, smooth, thin-walled, aseptate, granular, fusiform to narrowly ellipsoid or fusoid-ellipsoid, apex subobtuse, base truncate or truncate with minute marginal frill, widest in the middle of the conidium. Synasexual morph formed in separate conidiomata, or in same conidiomata with asexual morph. Synasexual conidia pigmented, thick-walled, finely verruculose, ellipsoid or oval, aseptate. Spermatogonia similar to conidiomata in anatomy. Spermatogenous cells ampulliform to lageniform or subcylindrical, hyaline smooth, phialidic. Spermatozoid developing in conidiomata or spermatogonia, hyaline, smooth, granular, subcyllindrical or dumbbell-shaped, with rounded ends (adapted from Crous et al. 2004a and Slippers et al. 2013).
Culture characteristics: Colonies on PDA, OA and MEA spreading, with moderate aerial mycelium, usually erumpent, less frequent flat, margins irregular; surface and reverse show different shades of grey.

Optimal media and cultivation conditions: On OA or PNA at 25 °C under continuous near-ultraviolet light to promote sporulation.

Distribution: Commonly found in South Africa, but also Australia, North America (incl. Hawaii) and Europe.

Hosts: Members of Proteaceae, especially in species of Banksia, Hakea, Isopogon, Lambertia, Leucospermum, Petrophile and Protea. Also found on Daviesia (Fabaceae), Encephalartos (Zamiaceae), and Eucalyptus (Myrtaceae) (see Crous et al. 2016b).

Disease symptoms: Leaf tip die-back and leaf spots.

Notes: Saccharata is the only genus located in the family Saccharataceae, which was recently introduced by Slippers et al. (2013). This genus was described by Crous et al. (2004a) in order to accommodate “Botryosphaeria” proteae, and subsequently several additional species were added to the genus from South Africa. All the species were found on Proteaceae expect Saccharata kirstenboschensis, which was isolated from Encephalartos princeps (Crous et al. 2008). South African Saccharata spp. that occur on Proteaceae can be distinguished from other members of Botryosphaeriales by their asexual morphology, which includes a hyaline, fusicoccum-like and a pigmented diplodia-like asexual morph (Crous et al. 2013a). However, Crous et al. (2016b) introduced eight species from a range of hosts (Myrtaceae and Proteaceae) in Australia, and also widened the generic concept to include the genus Neoseptorioides (3-septate, cylindrical conidia; Crous et al. 2015e). In spite of the range of variation observed in the asexual morphs, morphology of the sexual morphs of Australian and South African species appear remarkably conserved.

References: Crous et al. 2008, 2013a, 2016b (morphology and phylogeny).

Saccharata leucospermi Crous, sp. nov. MycoBank MB820823. Fig. 61.

Etymology: Named for the host genus from which it was collected, Leucospermum.

Conidiomata on PDA pycnidial, black, up to 300 μm diam, with a single, central ostiole; conidiomatal wall consisting of 2–3 layers of brown textura angularis. Conidiophores subcylindrical, hyaline, smooth, frequently reduced to conidiogenous cells or branched in apical part, 1–2-septate, 7–20 × 2–3.5 μm. Paraphyses rarely observed, intermingled among conidiophores, unbranched hyaline, smooth, 0–1-septate, 2–3 μm wide, extending above conidiophores. Conidiogenous cells terminal, subcylindrical, hyaline, 7–10 × 2–3 μm, with periclinal thickening, rarely with percurrent proliferations. Conidia hyaline, smooth, fusiform to narrowly ellipsoid, apex subobtuse, base truncate with minute marginal frill, minutely guttulate, thin-walled, (13–) 14–16(–19) × (4–)4.5(–5) μm.

Culture characteristics: Colonies on MEA at 25 °C in the dark after 1 wk: spreading, erumpent, surface crumpled, irregular, with uneven, feathery margin and moderate aerial mycelium; surface pale mouse-grey, reverse mouse-grey.

Material examined: South Africa, Western Cape Province, Kogelberg Nature Reserve, on leaf litter of Leucospermum conocarpodendron subsp. vindum, 11 Jul. 2000, S. Marincowitz (holotype CBS H-20078, culture ex-type CBS 122694 = CPC 13698 = CMW 22197).

Notes: In the treatment of microfungi occurring on leaf litter of Proteaceae, Marincowitz et al. (2008a) listed CBS 122694 as a Saccharata sp., acknowledging the fact that it appeared to be different. Three other species are known from Protea leaves in South Africa, namely S. proteae (conidia 20–30 × 4.5–6 μm; Denman et al. 1999), S. intermedia [conidia (17–) 18–20(–22) × (3.5–)5–6 μm; Crous et al. 2009a], and S. hawaiensis [conidia (17–)24–30(–38) × (4–)5–7(–8) μm; Yang et al. 2017]. Saccharata leucospermi can readily be distinguished from these three species by having smaller conidia.

Saccharata protearum Crous, sp. nov. MycoBank MB820824. Fig. 62.

Etymology: Named after the host genus from which it was collected, Protea.

Conidiomata pycnidial, eustromatic, to 400 μm diam, immersed, subepidermal, erumpent in culture, separate, or aggregated, linked by a stroma, dark brown, uni- to multi-locular, walls consisting of dark brown textura angularis, ostiolate. Fusicoccum-like asexual morph: Conidiophores hyaline, smooth, branched, subcylindrical, 1–3-septate, formed from the inner layer of the locule, 10–30 × 2.5–3.5 μm, intermingled with hyaline, septate paraphyses. Conidiogenous cells phialidic, discrete or integrated, hyaline, smooth, cylindrical, enteroblastic, proliferating percurrently with 1–2 annellations, 9–15 × 2.5–3.5 μm. Conidia hyaline, thin-walled, asperate, smooth, fusoid, widest in the middle or upper third of the conidium, with a subobtuse apex, and a truncate base, (17–)20–25(–27) × (4–)4.5–5(–6) μm. Microconidial morph occurring in separate or the same conidiomata as the fusicoccum-like asexual morph. Microconidiophores hyaline, smooth, branched, cylindrical, 1–3-septate, formed from the inner layers of the locule, 20–30 × 2.5–3 μm. Microconidiogenous cells phialidic, discrete or integrated, hyaline, smooth, cylindrical, determinate, with prominent periclinal thickening, 5–11 × 2–2.5 μm. Microconidia medium brown, thin-walled, finely verruculose, guttulate, aseptate, subcylindrical to narrowly ellipsoid with rounded ends, (7–)10–15(–17) × (2.5–)3(–4) μm.

Culture characteristics: Colonies on MEA at 25 °C in the dark after 1 wk: flat, spreading, with moderate aerial mycelium; surface pale mouse-grey with patches of dirty white, reverse mouse-grey.
Phylogram obtained from a maximum likelihood search of LSU and cytochrome c oxidase subunit 3 of mitochondrial DNA (co3), partitioned as two separate genes in RAxML. Bootstrap values (≥ 70 %) from 1 000 replicates in a maximum likelihood search shown above nodes. Posterior probabilities (≥0.95) summarised from 30 000 trees on:

Sphaerophragmiaceae

Puccinia Clade I sensu van der Mew et al. (2008) & Dixon et al. (2010)
Telia on:
Amaranthaceae
Apocynaceae
Asparagusaceae
Asteraceae
Campanulaceae
Fabaceae
Poaceae
Rutaceae

Puccinia Clade II sensu van der Mew et al. (2008)
& Dixon et al. (2010)
Telia on:
Amaranthaceae
Apocynaceae
Asparagusaceae
Asteraceae
Campanulaceae
Fabaceae
Poaceae
Rutaceae

Puccinia Clade III sensu Dixon et al. (2010) on Poaceae

Fig 59. Phylogram obtained from a maximum likelihood search of LSU and cytochrome c oxidase subunit 3 of mitochondrial DNA (co3), partitioned as two separate genes in RAxML. Bootstrap values (≥ 70 %) from 1 000 replicates in a maximum likelihood search shown above nodes. Posterior probabilities (≥0.95) summarised from 30 000 trees obtained by Bayesian inference in MrBayes are shown below nodes. General time-reversible (GTR) with GAMMA distribution was used as a model of evolution for both
Fig. 60. Saccharata spp. A. On Banksia sp. B. Symptomatic leaves of Saccharata proteae (CBS 121406). C. Close-up of subepidermal conidiomata of Saccharata proteae. D–E. Sexual morph of Saccharata proteae (CBS 121406). D. Asci, paraphyses and ascospores. E. Asexual morphs. F–N. Asexual morphs. F. Colony sporulating on OA of Saccharata capensis (ex-type CBS 122693). G. Pycnidial conidioma of Saccharata capensis (ex-type CBS 122693). H–J. Conidiogenous cells and conidia. H. Saccharata proteae (CBS 121406). I. J. Saccharata capensis (ex-type CBS 122693). K–M. Conidia. K. Saccharata intermedia (ex-type CBS 125546). L. Saccharata kirstenboschensis (ex-type CBS 123537). M. Saccharata proteae (CBS 121406). N. Spermatia of Saccharata capensis (ex-type CBS 122693). Scale bars: G = 100 μm, others = 10 μm; I applies to I, J. Pictures B–K, J–N taken from Crous et al. (2013a); L from Crous et al. (2008).
**Material examined:** USA, Hawaii, Maui, on leaf of Protea sp., 16 Dec. 1998, P.W. Crous & M.E. Palm, (holotype CBS H-23111, culture ex-type CPC 2169 = CBS 114569).

**Notes:** In the reassessment of Botryosphaeriaceae and allied taxa published by Marincowitz et al. (2008b), the ITS DNA data could not distinguish CBS 114569 from isolates of *S. proteae*. However, in the recent study of Yang et al. (2017), the combined sequence dataset (ITS, rpb2 and tef1), showed CBS 114569 to cluster basal to *S. hawaiiensis*. Morphologically, conidia of isolates of CBS 114569 [(17–)20–25(–27) × (4–)4.5–5(–6) μm] are also smaller than those of *S. hawaiiensis* [(17–)24–30(–38) × (4–)5–7(–8) μm; Yang et al. 2017], and thus this isolate is herewith introduced as a new species, *S. proteae*.

**Authors:** Y. Marin-Felix, S. Marincowitz & P.W. Crous

**Thyrostroma** Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Cl., Abt. 1 120: 472 (94 repr.). 1911. Fig. 63.

**Classification:** Dothideomycetes, Pleosporomycetidae, Pleosporales, Dothidotthiaceae.

**Type species:** *Thyrostroma compactum* (Sacc.) Höhn. Holotype could not be located, and a neotype from Europe is required.

**DNA barcode (genus):** LSU.

**DNA barcodes (species):** ITS, tef1. Table 20. Fig. 64.

**Sexual morph unknown. Conidiomata sporodochial, plectiform, dark brown or black. Stroma immersed to superficial, brown. Conidiophores brown, finely roughened, cylindrical to subcylindrical, 1–3-septate. Conidiogenous cells brown, subcylindrical, finely roughened, proliferating percurrently at apex. Conidia cylindrical, clavate, or ellipsoid to fusoid, pale to medium brown, smooth-walled, with (1–)4 transverse septa, and 0–3 oblique or longitudinal septa, rounded at the apex, base truncate.

**Culture characteristics:** Colonies reaching 90 mm diam after 2 wk, with sparse or fluffy aerial mycelium. Colonies on MEA, PDA and OA showing different shades of grey or chestnut to umber.

**Optimal media and cultivation conditions:** MEA, PDA and OA at 25 °C.

**Distribution:** Asia, Europe and North America.

**Hosts:** Pathogens of *Ulmus spp.*, *Sambucus caerulea*, *Styphnolobium japonicum*, *Tilia spp.*, and *Cornus officinalis*.

**Disease symptoms:** Thyrostroma canker, dieback and leaf spots.

**Notes:** Thyrostroma was introduced in 1911 in order to accommodate *T. compactum* (von Höhnel 1911). Despite being described more than 100 years ago, the phylogenetic position of Thyrostroma remains unresolved. Thyrostroma was considered the asexual morph of Dothidotthia by Phillips et al. (2008). Subsequently, Slippers et al. (2013) placed Thyrostroma in the Botryosphaeriaceae based on morphology, since molecular data of Thyrostroma spp. were lacking. In the phylogenetic trees based on LSU sequences (Fig. 49), the type species of Thyrostroma, *T. compactum*, does not cluster with Dothidotthia (Dothidotthiaceae), demonstrating that these genera are not...
congeneric, as was recently mentioned by Crous et al. (2016c). However, Thyrostroma did cluster in the Dothidotthiaceae clade, as originally proposed by Phillips et al. (2008).

References: Ellis 1959, 1971, Crous et al. 2016c (morphology).

**Thyrostroma franseriae** Crous, sp. nov. MycoBank MB820825. Fig. 63.

**Etymology:** Named after the host genus from which it was collected, Franseria.

Sporodochia dark brown, punctiform, up to 250 μm diam. Stromata brown, superficial, 100–150 μm diam. Conidiophores brown, finely roughened, subcylindrical, 0–1-septate, 10–18 × 6–11 μm. Conidiogenous cells brown, subcylindrical, finely roughened, proliferating percurrently at apex, 5–10 × 6–11 μm. Conidia brown, ellipsoid to fusoid, with 2–4 oblique or longitudinal septa, 1–3 transverse septa, apex broadly obtuse, base truncate, 8–9 μm diam, (25–)28–33(–35) × (18–)20–25 μm.

**Culture characteristics:** Colonies flat, spreading, with sparse aerial mycelium and feathery margins, reaching 60 mm diam after 2 wk on MEA, PDA and OA; surface and reverse iron-grey.

**Material examined:** USA, Nevada, Death Valley, on dead leaf of Franseria sp., 7 Jul. 1970, F.W. Went (holotype CBS H-23112, culture ex-type CBS 487.71); Nevada, north end of Death Valley, on green, living leaf of Franseria sp., Jul. 1970, F.W. Went, CBS H-18568, culture CBS 700.70.

**Notes:** Thyrostroma franseriae is known from two isolates, both of which were collected from leaves of Franseria sp. in Death Valley, Nevada (USA) in 1970. Morphologically, isolate CBS 700.70 differs from CBS 487.71 in having larger conidia that are more cylindrical, clavate to ellipsoid, with 2–4 transverse septa, 2–8 oblique or longitudinal septa, 40–65 × 18–25 μm. However, the two isolates are phylogenetically indistinguishable (Fig. 64).

**Thyrostroma compactum** is a European species originally described from Ulmus in Italy. One such isolate was available for study, namely CBS 335.37, collected by J.C. Carter (a US-based researcher), but the origin of this strain remains unknown, and it proved to be sterile in culture. Phylogenetically, however, CBS 335.37 is distinct from *T. franseriae* (Fig. 64), although we could not confirm that CBS 335.37 is authentic for the name it was deposited under by J.C. Carter.

**Authors:** Y. Marin-Felix & P.W. Crous
Venturia Sacc., Syll. fung. (Abellini) 1: 586. 1882. Fig. 65.

Synonyms: Fusicladium Bonord., Handb. Mykol.: 80. 1851.
Apiosporina Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturw. Cl., Abt. 1, 119: 439. 1910.
Metacoleroa Petr., Ann. Mycol. 25: 332. 1927.
Caproventuria U. Braun, A Monograph of Cercosporella, Ramularia and Allied Genera (Phytopathogenic Hyphomycetes) 2: 396. 1998.
Pseudocladosporium U. Braun, A Monograph of Cercosporella, Ramularia and Allied Genera (Phytopathogenic Hyphomycetes) 2: 392. 1998.

Classification: Dothideomycetes, Pleosporomycetidae, Venturiales, Venturiaeae.

Type species: Venturia inaequalis (Cooke) G. Winter. Type material in Kew: IMI 47413.

DNA barcode (genus): LSU.

DNA barcodes (species): ITS, tef1, tub2. Table 21. Fig. 66.

Ascomata pseudothecial, globose, subglobose, black, initially immersed, becoming erumpent, solitary, scattered or gregarious,
**Covered with setae; ostiole central, papillate; ascovatal wall composed of a few layers of pigmented cells of *textura angularis*, which is of equal thickness or slightly thickened at apex. **Hamathecium** comprising sepal, filiform pseudoparaphyses, evanescent in mature ascomata. Asci bitunicate, oblong to obclavate, fissitunicate dehiscence unknown, with or without a short, thick pedicel, rounded at the apex with an inconspicuous ocular chamber. Ascospores obliquely uniseriate, partially overlapping to biserate, especially at the base, ellipsoidal, with broadly rounded ends, pale brown, 1-septate, slightly constricted at the septum, the upper cell shorter than the lower one, smooth-to verruculose. **Conidiophores** single, sometimes arranged in small groups, straight to flexuous, pale olivaceous to dark brown, unbranched or occasionally branched, thin- to slightly thick-walled, conidiophores often reduced to conidiogenous cells or composed of several cells. **Conidiogenous nodes** smooth to verruculose. **Conidia** in simple or branched acropetal chains, ellipsoid-ovoid, obovoid, fusoid, obclavate-subcylindrical, canoeshaped, straight to curved, subhyaline to medium brown, but mostly olivaceous, thin- to thick-walled, smooth to verruculose, 0–3(–4)-eseuate, germinating by production of germination tubes from middle or polar cells; **hila** often denticlle-like, somewhat protuberant, unthickened or almost so, occasionally somewhat darkened-refractive; **septum ontogeny**; first septum median to sub-median.

**Culture characteristics**: Colonies on PDA fuscous black, and reverse dark fuscous-black, with moderate aerial mycelium and regular, but feathery margins. Colonies normally reaching not more than 15 mm diam after 1 mo on PDA at 25 °C in the dark.

**Optimal media and cultivation conditions**: PDA, MEA and CMA. Optimal growing temperature is 24–28 °C. Sometimes grows faster after cold-shock under 10 °C for 1 wk.

**Distribution**: Worldwide.

**Hosts**: Mainly on woody dicotyledonous plants. Twenty-four families of plants have been reported hosting venturiaceous fungi, i.e. Aceraceae, Amaryllidaceae, Asteraceae, Betulaceae, Caprifoliaceae, Comaceae, Dipsaceae, Ericaceae, Fagaceae, Gentianaceae, Geraniaceae, Iridaceae, Juncaginaceae, Liliaceae, Onagraceae, Oleaceae, Polygonaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Rubiaceae, Salicaceae, Sapindaceae and Ulmaceae (Barr 1968, 1989, Sivanesan 1977). After studying a large number of type materials of *Venturia* species, many have been found to be representative of other genera (Shen et al. in prep.).

**Disease symptoms**: Leaf spots, flower and fruit canker.

**Notes**: Species of *Venturia* are widely distributed in the northern temperate region of the world, and are saprobic or parasitic on a large variety of dicotyledonous plants. *Venturia* comprises 198 species according to Index Fungorum. Based on the morphology of type specimens studied, the diagnostic characteristics of...
**Venturia** are as follows: Ascomata immersed, semi-immersed or superficial, scattered or gregarious, often papillate and ostiolate with setae. Hamathecium narrowly cellular, hyaline, evanescent in mature ascomata. Asci 8-spored, bitunicate, fissitunicate, broadly cylindrical to obclavate, usually lacking a pedicel. Ascospores pale olivaceous to brown, 1-septate, usually asymmetrical. Morphological discrimination of the sexual morph is limited, and the asexual morph is more informative (Sivanesan 1977). The genus is morphologically comparable to the *Mycosphaerella* morph of *Ramularia* in having bitunicate, oblong to obclavate asci with a short, thick pedicel or pedicel lacking, ellipsoidal, 1-septate ascospores which are slightly constricted at the septum. However, **Venturia** can be distinguished from the sexual morph of *Ramularia* by its setose ascomata, pale olivaceous to brown and asymmetrical ascospores. In addition, pseudoparaphyses are lacking in the sexual morph of *Ramularia.*
Although several studies have been conducted on the phylogeny of Venturia, they mostly relied on rDNA sequences of the ITS and LSU, which proved insufficient in distinguishing some species (Crous et al. 2007d, Zhang et al. 2011). More genes, especially protein coding genes are required to provide a better resolution at the species level.

**References:** Menon 1956, Nüesch 1960, Barr 1968, Sivasenan 1977 (morphology); Schubert et al. 2003 (morphology of asexual stage); Crous et al. 2007d, Zhang et al. 2011, 2016 (morphology and phylogeny).

**Venturia martianoffiana** (Thüm.) Y. Zhang ter & J.Q. Zhang, comb. nov. Mycobank MB821418. Basionym: *Cladosporium martianoffianum* Thüm., Byull. Moskovsk. Obschh. Issp. Prir., Otd. Biol. 55: 74. 1880.

**Venturia pheaeoeperta** Y. Zhang ter & J.Q. Zhang, sp. nov. MycoBank MB817355. Fig. 67.

**Etymology:** Latin “phaeo-”, in reference to “dark” septum.

On *Populus*: Leaf spots amphigenous, subcircular to angular, 1.5–13 mm wide, often confluent, diffuse, mostly spread along leaf veins, dark brown to black, with an irregular margin. *Colonies* amphigenous, caespitose, greenish brown to blackish. *Mycelium* mainly subcircular. *Stromata* variable in size, composed of pale olivaceous to brown, angular to rounded, thick-walled, pseudoparenchymatous cells, 4–8 μm diam. *Conidiophores* solitary or loosely fasciculate, arising mostly from stromata or from hyphae, erect, straight, sometimes flexuous at the apex, unbranched or apically branched, 12–29 × 5–8 μm, 0–1-septate, pale to medium brown, smooth, with somewhat thickened walls, sometimes conidiophores reduced to conidigenous cells. *Conidigenous cells* integrated, terminal, 15–27 × 5–8 μm, with a 1–2(–3) denticle-like conidigenous loci, proliferation sympodial, loci unthickened, not or only somewhat darkened-refractive, 2–3 μm wide. *Conidia* in simple or branched chains, clavate, subcylindrical, ellipsoid or rarely fusiform, (12–) 16–29 × 4–7 μm, pale olivaceous brown, 0–1(–3)-septate, smooth, tapering towards both ends, apex mostly truncate, occasionally rounded or pointed, base truncate; *hila* often somewhat thickened and darkened-refractive, 1.5–3 μm wide. *Sexual morph* not observed. On MEA: *Mycelium* consisting of pale olivaceous, smooth, branched, 1.5–3 μm wide hyphae. *Conidiophores* integrated, produced in the middle of the mycelium, 3–6-septate, visible as small, protruding, denticle-like loci, up to 92 μm long, 5–6 μm wide. *Conidigenous cells* subcylindrical, 15–25 × 5–7 μm, pale to medium olivaceous, smooth, tapering to 1–2 apical truncate loci, 2–4 μm wide. *Conidia* pale olivaceous, smooth, subcylindrical to narrowly ellipsoid, occurring in simple or branched chains, 0–1(–2)-septate, tapering towards subtruncate ends, ends 2–4 μm wide, aseptate conidia 12–21.5 × 5–7 μm, septate conidia up to 28 μm long and 5–7 μm wide; *basal hila* usually thickened and darkened-refractive; *microcyclic conidiation* common in older cultures. *Sexual morph* not observed.

**Culture characteristics:** Colonies reaching 43 mm diam after 1 mo on PDA at 25 °C in the dark. Colonies sporulated, erumpent, spreading, with abundant aerial mycelium and feathery to
smooth margins; grey olivaceous (surface), reverse dark olivaceous.

Habitat and distribution: China (Henan, Shannxi), on leaves of *Populus* spp.

Material examined: China, Henan, Puyang City Academy Experimental Farm, on leaves of *Populus × euramerica* cv. 74/76 (sects. Aigeiros), 20 May 2015, W. He (holotype, HMAS 246998, culture ex-type CGMCC3.18368); on leaves of *Populus × euramerica* cv. 74/76 (sects. Aigeiros), Y.F. Zhang, 20 Jun. 2015 (paratype, HMAS 246999, CGMCC3.18371); on leaves of *Populus × euramerica* cv. 74/76 (sects. Aigeiros), Y.F. Zhang, 6 Aug. 2015 (paratype, HMAS 247000, CGMCC3.18373); on leaves of *Populus × euramerica* cv. 74/76 (sects. Aigeiros), Y.F. Zhang, 7 Aug. 2015 (paratype, HMAS 247002, CGMCC3.18374); on leaves of *Populus × euramerica* cv. 74/76 (sects. Aigeiros), Y.F. Zhang, 8 Aug. 2015 (paratype, HMAS 247001, CGMCC3.18375); Shanxi, Yangling, on leaves of *Populus* sp. (sects. Aigeiros), 4 Sep. 2015, Y.F. Zhang (paratype, HMAS 247004, CGMCC3.18378); ibid. (paratype, HMAS 247005, CGMCC3.18379).

Notes: Among the reported venturiaceous species occurring on *Populus*, the asexual morph of *Venturia phaeosepta* is more comparable with *Venturia martianoffiana* and *F. romellianum* in the morphology of the conidiophore and mode of conidia production (Schubert et al. 2003). *Venturia phaeosepta*, however, can readily be distinguished from *V. martianoffiana* by its 1–2(-3) apical denticle-like conidiogenous loci (vs. a single or several (>3) conidiogenous loci of *V. martianoffiana*). *Venturia phaeosepta* differs from *F. romellianum* by its septate (vs. chieffy asceptate) conidia (Schubert et al. 2003).

Fig. 66. Maximum likelihood tree generated from a sequence analysis of the ITS rDNA dataset. The outgroup is *Fusicladium africanum* CPC 12829. Maximum likelihood bootstrap support values above 50% are shown at the nodes and based on 1 000 replicates. Bayesian posterior probability values above 0.70 are shown at the nodes. The species from *Populus* are in bold. Numbers between parentheses correspond to GenBank accession numbers. T indicates ex-type strain. TreeBASE: S21068.
Wilsonomyces Asdak. et al., Mycotaxon 37: 283. 1990. Fig. 68.

Classification: Dothideomycetes, Pleosporomycetidae, Pleosporales, Dothidotthiaceae.

Type species: Wilsonomyces carpophilus (Lév.) Asdak. et al. Lectotype: plate 7, fig. 5 in Léveillé JH. 1843. Ann. Sci. Nat., Bot., sér. 2 19: 215. Epitype and ex-epitype culture designated here: CBS H-23113, CBS 231.89.

DNA barcode (genus): LSU.

DNA barcode (species): ITS, tef1. Table 22. Fig. 64.

Sexual morph unknown. Conidiomata sporodochial, usually punctiform, tan to olivaceous brown, finally becoming black. Stroma present in host tissue, compact, immersed, erumpent, discoid on leaves, fusoid on twigs. Conidiophores macro-nematous, mononematous, densely compacted, straight or flexuous, branched or not, subcylindrical, geniculate, smooth, subhyaline to pale brown, cicatrised, 1–4-septate. Conidiogenous cells terminal and intercalary, subcylindrical, subhyaline, smooth, proliferating sympodially at apex, scars unthickened. Conidia holoblastic, solitary, dry, acrogenous, simple, thick-walled, cylindrical, clavate, ellipsoid or fusiform, occasionally forked, rounded to acute at the apex, truncate at the base, generally (2–)3–5(–10) transverse with occasionally 1–2 oblique septa, rarely with 1 longitudinal septum, subhyaline, becoming medium brown to golden-brown, dark olivaceous to black in mass, conidia in vivo are larger (adapted from Adaskaveg et al. 1990).

Culture characteristics: Growth moderate, PDA plates covered in 4 wk, mostly consisting of submerged hyphae with sparse aerial mycelium. In cultures grown in the dark, aerial mycelium sub-feltly to feltly, initially white becoming pale olive-grey to greyish olive, occasionally olive-ochre. In cultures grown exposed to light, submersed light brownish olive to olive-brown hyphae radiate outward from mycelial mat; aerial hyphae buffy-brown; olivaceous black to black conidia produced in mass (more details in Adaskaveg et al. 1990).

Optimal media and cultivation conditions: PDA at 20 °C on the laboratory bench.

Distribution: Worldwide.

Hosts: Pathogens mainly of Prunus spp., particularly peaches and apricots, but also of other members of the family Rosaceae, i.e. Pyrus communis, Malus domestica, Sorbus aucuparia and Cleonia oblonga. Also reported in Cleome sp. (Cleomaceae) and Quercus ilex (Fagaceae).

Disease symptoms: Wilsonomyces causes a disease known as shot-hole disease because of the symptoms on the host leaves: small circular purple lesions with pale centres that gradually enlarge and become necrotic in the centre until the centre falls out. This genus also produces necrotic spots on the twigs and necrotic lesions on fruit.

Notes: Wilsonomyces is a monotypic genus. Wilsonomyces carpophilus was initially described as a new species of Hel-minthosporium, and was subsequently transferred to different genera until Adaskaveg et al. (1990) introduced Wilsonomyces to accommodate it. The taxonomy of the genus was controversial, and Sutton (1997) regarded it as synonym of Thyrostroma. However, all the strains of Wilsonomyces carpophilus included in the phylogenetic analysis based on LSU, ITS and tef1 (Figs 49, 64) sequences were located in a clade separate from the rest of the taxa incorporated in the tree including the type species of Thyrostroma, T. compactum. Therefore, it is herewith supported that Wilsonomyces represents a distinct genus. Finally, its location in the Dothidotthiaceae is also supported.

References: Ellis 1959, Adaskaveg et al. 1990 (morphology); Ahmadpour et al. 2012a (morphology and pathogenicity).

Wilsonomyces carpophilus (Lév.) Asdak. et al., Mycotaxon 37: 283. 1990. Fig. 68. Basionym: Helminthosporium carpophilum Lév., Annls Sci. Nat., Bot., sér. 2 19: 215. 1843. Synonyms: Clasterosporium carpophilum (Lév.) Aderh., Landw. Jahrb. 30: 815. 1901. Coryneum carpophilum (Lév.) Jauch, Int. Bull. Pl. Protect. 14: 99. 1940. Stigmina carpophila (Lév.) M.B. Ellis, Mycol. Pap. 72: 56. 1959. Sciniatosporium carpophilum (Lév.) Morgan-Jones, Canad. J. Bot. 49: 995. 1971. Sporocadus carpophilus (Lév.) Arx, Gen. Fungi Sporul. Cult., Edn 3 (Vaduz): 224. 1981. Thyrostroma carpophilum (Lév.) B. Sutton, Arnoldia 14: 34. 1997. For additional synonyms see Adaskaveg et al. (1990).

Conidiomata sporodochial, brown, with immersed to erumpent stromata, 30–200 μm diam. Conidiophores subcylindrical, branched or not, geniculate, 10–70 × 5–7 μm, subhyaline to pale brown, smooth, 1–4-septate. Conidiogenous cells terminal and intercalary, subcylindrical, subhyaline, smooth, 10–30 × 5–7 μm, proliferating sympodially, scars unthickened, 3.5–5 μm diam. Conidia narrowly ellipsoid to subcylindrical or fusoid, subhyaline, becoming medium brown to golden-brown, smooth, with (2–)3–7(–11) dark, transverse septa, rarely with any oblique septum, (27–)32–45(–55) × (12–)13–14(–16) μm, base truncate, 4–6 μm diam in vitro. Conidia in vivo are larger, namely 20–90 × 7–16 μm (adapted from Adaskaveg et al. 1990).

Culture characteristics: Colonies flat, spreading, with moderate aerial mycelium, and feathery margins, reaching 40 mm diam after 2 wk. On MEA, PDA and OA surface umber, reverse isabelline.

Material examined: Lectotype: plate 7, fig. 5 in Léveillé JH. 1843. Ann. Sci. Nat., Bot., sér. 2 19: 215. Unknown country, on petiole of Prunus subhirtella, 1889, J.W. Veenbaas-Rijks (epitype designated here CBS H-23113, MBT376057, culture ex-epitype CBS 231.89).
Fig. 67. Venturia phaeosepta (ex-type CGMCC3.18368). A–F. On MEA. A. Colony on MEA. B. Conidial chains. C–D. Ramoconidia and conidia. E. Germinating conidium. F. Conidium. G–M. On leaves. G. Leaves infected by Venturia phaeosepta. H. Conidiophores and conidia. I. Conidiogenous cells giving rise conidia. J. Conidiogenous cell. K. Conidial chains. L. Conidia. M. Germinating conidium. Scale bars: B–D = 20 μm; E, F = 10 μm; G = 0.5 cm; H–M = 10 μm.
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Rhizoctonia solani

Fig. 68. Wilsonomyces carpophilus (ex-epitype CBS 231.89). A. Conidiomata. B–G. Conidiogenous cells giving rise to conidia. E. Conidia. Scale bars: 10 μm.

Table 22. DNA barcodes of accepted Wilsonomyces sp.

| Species            | Isolates | GenBank accession numbers | References numbers |
|--------------------|----------|---------------------------|--------------------|
| Wilsonomyces       | CBS 231.89 T | KY905672 KY905684        | Present study      |
| carpophilus        |          |                           |                    |

1 CBS: Westerdijk Fungal Biodiversity Institute, Utrecht, the Netherlands. T indicates ex-epitype strain.
2 ITS: internal transcribed spacers and intervening 5.8S nrDNA; tef1: partial translation elongation factor 1-alpha gene.

Notes: The holotype of W. carpophilus was not located by Adaskaveg et al. (1990) when they introduced the genus Wilsonomyces to accommodate Helminthosporium carpophilum, although they searched in several herbaria in Europe. The holotype was probably lost when Léveillé’s collection was destroyed in the Franco-Prussian War in 1870–1871. Therefore, Adaskaveg et al. (1990) selected the drawings of Léveillé present in the original description of this taxon as lectotype (Ann. Sci. Nat., Bot., sér. 2 19: 215, plate 7, fig. 5). To fix the application of the generic name, an epitype for this species is therefore designated here.

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