Inside Plectosphaerellaceae

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Abstract: The family Plectosphaerellaceae (Glomerellales, Sordariomycetes) includes numerous plant pathogenic genera and soil-borne fungal species. Ten genera are currently accepted, including several taxa that occupy an unresolved position within the family. To address this issue, a multilocus sequence analysis was carried out using partial gene sequences from the 28S large subunit nrRNA gene (LSU), the internal transcribed spacer (ITS) regions of the nrDNA region, including the 5.8S nrRNA gene, the translation elongation factor 1-alpha (TEF1-α), tryptophan synthase (TS), actin (ACT) and the RNA polymerase II second largest subunit (RPB2), based on a large set of isolates mainly from the CBS collection. Results of the molecular data combined with a detailed morphological study resolved 22 genera in the family, of which 12 are newly described. Additionally, 15 new species and 10 new combinations are proposed. An epi-type and neotype are also introduced for Stachylium bicolor and Plectosphaerella cucumerina, respectively.

Key words: Acremonium, New taxa, Phylogeny, Plant pathogens, Plectosphaerella, Soil fungi, Taxonomy.

Taxonomic novelties: new genera: Brunneochlamydosporium Giraldo López & Crous, Chlamydosporiella Giraldo López & Crous, Furcastergirmium Giraldo López & Crous, Fuscohypha Giraldo López & Crous, Musidium Giraldo López & Crous, Paramusciulium Giraldo López & Crous, Phialolavum Giraldo López & Crous, Summertilera Giraldo López & Crous, Sayamrella Giraldo López & Crous, Theobromium Giraldo López & Crous, Tunabrelia Giraldo López & Crous, and New species: Brunneochlamydosporium macroclavatum Giraldo López & Crous, Brunneochlamydosporium expansum Giraldo López & Crous, Gibellulopsis aquatica Giraldo López & Crous, G. catenata Giraldo López & Crous, Lectera humicola Giraldo López & Crous, L. phaseolii Giraldo López & Crous, Musidium tropicale Giraldo López & Crous, M. elettariane Giraldo López & Crous, Paramusciulium asperulatum Giraldo López & Crous, Phialolavum bifurcatum Giraldo López & Crous, Plectosphaerella humicola Giraldo López & Crous, Summertilera oligotrophica Giraldo López & Crous, Sayamreella subulate Giraldo López & Crous, Theobromium fuscom Giraldo López & Crous, and Sodiomyces alcalophilus Giraldo López & Crous.

New combinations: Brunneochlamydosporium cibotii (J.F.H. Beyma) Giraldo López & Crous, B. nepalense (W. Gams) Giraldo López & Crous, Chlamydosporiella restricta (J.F.H. Beyma) Giraldo López & Crous, Furcastergirmium furcatum (W. Gams) Giraldo López & Crous, Gibellulopsis fusca (Thirum. & Sukapure) Giraldo López & Crous, and G. serra (Maffeii) Giraldo López & Crous.

New species: Brunneochlamydosporium macroclavatum, Brunneochlamydosporium expansum, Gibellulopsis aquatica, Gibellulopsis catenata, Lectera humicola, L. phaseolii, Musidium tropicale, M. elettariane, Paramusciulium asperulatum, Phialolavum bifurcatum, Plectosphaerella humicola, Summertilera oligotrophica, Theobromium fuscom, and Sodiomyces alcalophilus.

INTRODUCTION

The family Plectosphaerellaceae was proposed by Zare et al. (2007) based on the plant pathogen Plectosphaerella cucumerina as the type species. The saprotrophic species Verticillium nigrescens and the causal agent of the cigar-end rot of bananas, Verticillium theobroma, which were demonstrated not to be congeneric with the type species of Verticillium, V. dahiae, were included in the family as members of Gibellulopsis and the new genus Musicillium, respectively (Zare et al. 2007). Additionally, Verticillium s. str., the type species of Acrostalagmus, A. luteoalbus, and other taxa were also placed in the new family. Based on DNA phylogenetic analyses published in the last decade, the genus Stachylium, and recently described genera such as Brunneonectes, Chordomyces, Lectera and Sodiomyces have been added to the family (Réblová et al. 2011, Cannon et al. 2012, Grun-Grzhimaylo et al. 2013, 2016, Giraldo et al. 2017).

Based on molecular data, Pitt et al. (2004) and Zhang et al. (2006) demonstrated the affinity between Plectosphaerella and Verticillium dahiae with Glomerella, respectively, which was placed in Glomerellaceae although with an uncertain position at the order level in Hypocreomycetidae (Zhang et al. 2006). Following these studies, Réblová et al. (2011) proposed the order Glomerellales to accommodate Glomerellaceae, and Plectosphaerellaceae was considered as sister clade of the new order. Finally, in a recent systematic revision of the families in Sordariomycetes, Maharachchikumbura et al. (2016) established the taxonomic position of Plectosphaerellaceae in the order Glomerellales.

Few sexual morphs have been reported in this family. Plectosphaerella cucumerina produces perithecial ascospores with clavate asci and hyaline, two-celled ascospores (Uecker 1993, Carlucci et al. 2012). This is in stark contrast with the cleistothecial ascomata, saccate asci and pale brown ascospores of Sodiomyces spp. (Grun-Grzhimaylo et al. 2013, 2016). However, the assexual morphs are more homogeneous, and they have simple or verticillate conidiophores with phialidic conidiogenous cells and mostly cylindrical or ellipsoidal conidia arranged in slimy heads (Zare et al. 2007).

Species of this family are mainly soil-borne saprobes or weak to virulent, facultative or obligate plant pathogens. Some are...
causal agents of important diseases in different host plants worldwide (Cannon et al. 2012, Carlucci et al. 2012, Hyde et al. 2014, Giraldo et al. 2017). A few species have also been reported as fungicolous or insecticolous, or as opportunistic pathogens of animals (Batista & Maia 1959, Domsch et al. 2007, Duc et al. 2009, Gräfenhan et al. 2011) and some members are known for their alkalitolerant properties (Okada et al. 1993, Grum-Grzhimaylo et al. 2013, 2016).

Currently, 10 genera are accepted in the family, i.e. Acrostalagnus, Brunneomyces, Chordomyces, Gibellulopsis, Lectera, Musciellum, Plectosphaerella, Sodiomyces, Stachylidium and Verticillium s. str. However, Cephalosporium serrae, Gliocladium cibotii and several Acremonium species are included in the family, but their placement remains unresolved. In order to revise this family, we thus conducted a multilocus sequence analysis combined with phenotypic data from all genera and species known in pure culture and traditionally classified as Plectosphaerellaceae.

**MATERIALS AND METHODS**

**Isolates**

Fungal strains were obtained from the CBS Culture Collection at the Westerdijk Fungal Biodiversity Institute (WI) in Utrecht, The Netherlands, the working collection of Pedro W. Crous housed at the WI (CPC), the CABI Genetic Resource Collection in the UK (IMI), the Canadian Collection of Fungal Cultures (DAOMC) and the BIOTEC Culture Collection in Thailand (BCC).

**DNA extraction, amplification and sequencing**

Total genomic DNA was extracted from fresh colonies using the Wizard® Genomic DNA Purification Kit (Promega Corporation, Madison, WI, USA), following the manufacturer’s protocol. The internal transcribed spacer (ITS) regions and the 5’ end of the 28S nrRNA gene (LSU) were amplified and sequenced with the primer pairs ITS5/ITS4 (White et al. 1990) and LR0R/LR5 (Vilgalys & Hester 1990, Vilgalys & Sun 1994), respectively. Fragments of the translation elongation factor 1-alpha (TEF1-α) and RNA polymerase II second largest subunit (RPB2) genes were amplified with the primer sets EF1-983F/EF1-2218R (Rehner & Buckley 2005) and RPB2-5F2/RPB2-7cR (Liu et al. 1999), correspondingly. In addition, fragments of actin (ACT), elongation factor (EF) and tryptophan synthase (TS) were amplified for Verticillium species with the following primer sets: VaActfl/VaActR for ACT, VEF1/VEFr for EF and VTS3fl/VTS3r for TS (Inderbitzin et al. 2011b). Polymerase chain reaction (PCR) protocols followed Zuccaro et al. (2004), Inderbitzin et al. (2011b) and Grum-Grzhimaylo et al. (2013). The program SeqMan v. 12.1.0 (DNASTAR, Madison, WI, USA) was used to obtain consensus sequences of each isolate.

**Phylogenetic analysis**

Sequences of each locus were aligned through MAFFT v. 7 (Katoh et al. 2017), using the default parameters, and were manually corrected in v. 6.06 (Tamura et al. 2013). Phylogenetic reconstructions were based on Maximum Composite Likelihood (ML) and were performed on the CIPRES Science Gateway portal (Miller et al. 2012) using RAxML v. 8.2.9. The selection of the best-fit nucleotide substitution model for each locus was calculated with MrModelTest v. 2.3 (Nylander 2004). For ML analyses, the default parameters were used, and bootstrap support (BS) was carried out using the rapid bootstrapping algorithm with the automatic halt option. A BS value >70 % was considered as statistically significant. Each partition was assessed for incongruence before being concatenated by checking individual phylogenies for conflicts between clades with significant ML support (Mason-Gamer & Kellogg 1996, Wiens 1998). All novel DNA sequences generated in this study were deposited in GenBank and the European Nucleotide Archive (ENA) (Table 1), while the alignments and the resulting trees were accessioned in TreeBASE (http://www.treebase.org) and the taxonomic novelties in MycoBank (http://www.MycoBank.org, Crous et al. 2004).

**Morphology**

Morphological features were determined on oatmeal agar (OA), potato carrot agar (PCA), 2 % potato dextrose agar (PDA) and 2 % malt extract agar (MEA) (recipes in Crous et al. 2009). In the case of alkalophilic species MEA with 5 mL KOH 2N was used as a standard medium. Cultures were incubated at 25 °C in the dark for 4 wk. Macroscopic characters and diameters were measured after 14 d of incubation, and the colony colour (surface and reverse) rated after Rayner (1970). Microscopic features were examined from slide cultures and preparations mounted in clear lactic acid or Shear’s mounting fluid from colonies sporulating on the media previously mentioned. Observations were performed with a Zeiss V20 Discovery (Zeiss, Oberkochen, Germany) and Nikon AZ100 (Nikon, Tokyo, Japan) stereo-microscopes and with a Zeiss Axio Imager 2 light microscope using differential interference contrast (DIC) optics. Photomicrographs and measurements were taken with a Nikon DS-Ri2 digital camera using the NIS-elements D software v. 4.50. The length and width of at least 30 randomly selected structures were measured, and at least 30 extreme values calculated.

**RESULTS**

The combined alignment of the LSU, ITS, TEF1-α and RPB2 loci from 330 strains, including the outgroup *Manilochaeas infuscans* (CBS 379.77 and CBS 869.96), encompassed 2 966 characters including 981 phylogenetically informative positions (197 LSU, 203 ITS, 241 TEF1-α and 340 RPB2). The best-fit evolutionary model for each dataset was GTR+I+G. The phylogenetic tree (Fig. 1) showed 12 well-supported clades and one lineage, which include the genera currently accepted in Plectosphaerellaceae, and 12 that represent putative new genera.

**Clade I** (80 % BS) was formed by the genus *Gibellulopsis*, which encompassed three main subclades and two single branches. The first subclade (94 % BS) included the ex-type strains of *Cephalosporium sarae* CBS 290.30, *Gibellulopsis piscis* CBS 892.70 and *Verticillium amaranthi* CBS 387.35, in addition to 22 isolates from different origins (soil, plants, fungi and animals). The second (100 % BS) and third (82 % BS) subclades included the neotype of *G. nigrescens* CBS 120949 and the ex-type strain of *Cephalosporium sarae* var. *fuscum* CBS 560.65, respectively. The two single branches were formed...
| Species                  | Isolate nr. | Source                                    | Locality                          | GenBank/ENA Accession No. |
|-------------------------|-------------|-------------------------------------------|------------------------------------|---------------------------|
|                         |             |                                           |                                    |                          |
| **Acrostalagmus luteoalbus** | CBS 112.16  | Unknown                                   | UK                                 | LR025797                  |
|                         | CBS 194.87  | Straw-meal-amended field soil             | Germany                            | LR025799                  |
|                         | CBS 222.60  | Well, treated with fungicides             | Germany, Geisenheim                | LR025794                  |
|                         | CBS 236.55  | Unknown                                   | Unknown                            | LR025798                  |
|                         | CBS 325.61  | Decayed wood                              | Canada, Quebec, Gatineau Park      | LR025796                  |
|                         | CBS 331.52  | Bark of Fagus sylvatica                   | UK                                 | LR025799                  |
|                         | CBS 388.65  | Decaying timber of boat                    | Netherlands                        | LR025800                  |
|                         | CBS 565.80  | Decaying leaf                              | Canada, Ontario, York Co., Toronto, High Park | LR025795 |
|                         | CBS 577.78B| On Colletotrichum lagenarium               | Russia, Astrakhan                  | LR025801                  |
|                         | CBS 121.84  | Leaf of Ananas comosus                     | Sierra Leone, Njala                | LR025802                  |
|                         | CBS 121213  | Musa sapientum                            | Brazil, Minas Gerais, Viçosa       | LR025806                  |
|                         | CBS 12114   | Musa sapientum                            | Brazil, Minas Gerais, Viçosa       | LR025791                  |
|                         | CBS 121215  | Musa sapientum                            | Brazil, Minas Gerais, Viçosa       | LR025792                  |
|                         | CBS 137628  | Soda soil                                 | Russia, Kulunda Steppe, Altai      | KJ431414                  |
|                         | CBS 137629  | Soda soil                                 | Russia, Kulunda Steppe, Altai      | KJ431415                  |
| **A. annulatus**        | CBS 121.84  | Leaf of Ananas comosus                     | Sierra Leone, Njala                | LR025802                  |
|                         | CBS 185.70  | Glycine soja                              | Mexico                             | LR025803                  |
|                         | CBS 450.85  | Wood                                      | Venezuela, Amazonas, Cerro de la Nebliña | LR025804 |
|                         | CBS 545.84  | Dead stem                                 | Japan, Okinawa Pref., Ishigaki Island, Mt. Omoto | LR025805 |
|                         | DAOMC 212126| Soil and roots                            | Brazil, Pará, near Belém            | GU180646                  |
| **Brunneochlamydosporium orbitori** | CBS 109240  | Cibotium schiedei                         | Netherlands, Delft                  | LR025807                  |
|                         | CBS 372.93  | Aphiandra sp.                             | Switzerland                        | LR025808                  |
| **B. macroclavatum**    | CBS 372.93  | Aphiandra sp.                             | Switzerland                        | LR025809                  |
|                         | CBS 823.73  | Salvinia auriculata                       | India, Bangalore                   | LR025810                  |
|                         | CBS 101249T| Pteridophyte                              | Mauritius                          | LR025811                  |
| **B. nepalense**        | CBS 277.89  | Soil                                      | Unknown                            | LR025812                  |
|                         | CBS 971.72T| Soil under Pinus sp.                      | Nepal, Northern Himalaya           | LR025813                  |
|                         | CBS 112045  | Scrub sandy soil                          | Netherlands, Kwade Hoeik           | LR025814                  |
|                         | CBS 113254  | Scrub sandy soil                          | Netherlands, Kwade Hoeik           | LR025815                  |
|                         | CBS 116720  | Scrub sandy soil                          | Netherlands, Kwade Hoeik           | LR025816                  |
|                         | CBS 116721  | Scrub sandy soil                          | Netherlands, Kwade Hoeik           | LR025817                  |
| **B. terrestre**        | CBS 112777T| Soil under Manihot                        | French Polynesia, Moorea, Vallée de Toto | LR025819 |
| **Brunneomyces brunescens** | CBS 559.73T| On dead stem of Dendrocalamus giganteus   | Sri Lanka                          | HQ231966                  |

(continued on next page)
### Table 1. (Continued).

| Species               | Isolate nr. | Source                                  | Locality                      | GenBank/ENA Accession No.                        |
|-----------------------|-------------|-----------------------------------------|--------------------------------|-------------------------------------------------|
|                       |             |                                         |                                | LSU    | ITS     | TEF1-α | RPB2 | ACT  | EF  | TS  |
| **B. europaeus**      | CBS 560.86  | Leaf of Bambusa sp.                     | France                         | LN810511 | LN810518 | LN810537 | LN810527 |      |     |     |
| CBS 652.96†           | River sediment |                                          | Spain                          | LN810512 | LN810519 | LN810538 | LN810528 |      |     |     |
| **B. hominis**        | FMR 10429†  | Sputum                                  | USA                            | LN810509 | KP131517 | LN810535 | –       |     |     |     |
| FMR 10437             | Sputum      |                                          | USA                            | LN810510 | KP131516 | LN810536 | –       |     |     |     |
| **Chlamydosporiella** | CBS 119.97  | Unknown                                 | Brazil                         | LR025820 | LR026691 | LR026393 | LR026120 | LR026120 |     |     |
| restricta             | CBS 177.40  | Packing material                        | Netherlands, Rotterdam, Unileve | LR025821 | LR026692 | LR026394 | LR026121 | LR026121 |     |     |
| CBS 176.40†           | Packing material |                                          | Netherlands, Rotterdam, Unileve | LR025822 | LR026693 | LR026395 | LR026122 | LR026122 |     |     |
| CBS 434.83            | Unknown     |                                          | Sweden                         | LR025823 | LR026694 | LR026396 | LR026123 | LR026123 |     |     |
| **CBS 443.66**        | Moist wall  | Germany, Kiel-Kitzeberg                 | –                              | LR025824 | LR026695 | LR026397 | LR026124 | LR026124 |     |     |
| **CBS 716.88**        | Human skin  | France                                   | –                              | LR025825 | LR026696 | LR026398 | LR026125 | LR026125 |     |     |
| **CBS 988.69**        | Mineral wool packing | UK, England, Newcastle on Tyne | –                              | LR025826 | LR026697 | LR026399 | –       | LR026127 |     |     |
| **Chordomycetes**     | CBS 204.70  | Dead stem of Angelica archangelica      | Germany, Kiel-Kitzeberg        | LR025827 | LR026698 | LR026400 | LR026126 | LR026126 |     |     |
| albus                 | CBS 205.70  | Rhizosphere soil of Ammophila arenaria  | –                              | LR025828 | LR026699 | LR026401 | LR026127 | LR026127 |     |     |
|                      | CBS 206.70  | Moist wall                              | Germany, Kiel, Botanical Garden | LR025829 | LR026700 | LR026402 | LR026128 | LR026128 |     |     |
|                      | CBS 299.70E | Agricultural soil                       | France, Grignon                | LR025830 | LR026701 | LR026403 | LR026129 | LR026129 |     |     |
|                      | CBS 409.70  | Dead leaf of Canna indica               | Netherlands, Baam              | LR025831 | LR026702 | –       | LR026130 | LR026130 |     |     |
|                      | CBS 508.65  | Forest humus soil                       | Netherlands, Baam              | LR025832 | LR026703 | –       | –       | LR026131 | LR026131 |     |
|                      | CBS 580.97  | On leaf litter of Viscum album          | UK, England, Egham             | LR025833 | LR026704 | LR026404 | –       | LR026132 | LR026132 |     |
|                      | CBS 741.69  | Garden soil                             | Belgium, Heverlee               | LR025834 | LR026705 | –       | –       | –       | LR026133 |     |
|                      | CBS 742.69  | Peat                                    | Ireland                        | LR025835 | LR026706 | LR026405 | LR026130 | LR026130 |     |     |
|                      | CBS 743.69  | Soil                                    | Netherlands                    | LR025836 | LR026707 | LR026406 | LR026131 | LR026131 |     |     |
|                      | CBS 987.87† | On Hypogymnia physodes                  | Luxembourg                     | JX158444 | DQ825970 | JX158466 | –       | LR026132 | LR026132 |     |
| **C. antarcticus**    | CBS 120042  | Soda soil                               | Mongolia, North Gobi           | KJ43108  | KJ43240  | KJ443196 | KJ443156 | KJ443156 |     |     |
|                      | CBS 120043  | Soda soil                               | Russia, Kulunda Steppe, Altai  | KJ43109  | KJ43241  | KJ443197 | KJ443157 | KJ443157 |     |     |
|                      | CBS 120046  | Soda soil                               | Russia, Kulunda Steppe, Altai  | KJ43110  | KJ43242  | KJ443198 | KJ443158 | KJ443158 |     |     |
|                      | CBS 120047  | Soda soil                               | Russia, Kulunda Steppe, Altai  | KJ43111  | KJ43243  | KJ443199 | KJ443159 | KJ443159 |     |     |
|                      | CBS 137606  | Soda soil                               | Russia, Kulunda Steppe, Altai  | KJ43102  | KJ43234  | KJ443190 | KJ443150 | KJ443150 |     |     |
|                      | CBS 137610  | Suada salsa                             | Kazakhstan, Aral Lake          | KJ43106  | KJ43238  | KJ443194 | KJ443154 | KJ443154 |     |     |
|                      | CBS 137630  | Soda soil                               | Russia, Kulunda Steppe, Altai  | KJ43146  | KJ43276  | KJ443233 | KJ443189 | KJ443189 |     |     |
|                      | CBS 610.69  | Cork                                    | Portugal, Lisboa               | LR025837 | LR026708 | LR026407 | LR026132 | LR026132 |     |     |
| **Furcastergium**     | CBS 122.42† | Dune sand under Calystegia soldanella   | France, Normandie, Pointe du Sêge | LR025838 | LR026709 | LR026408 | LR026133 | LR026133 |     |     |
| furcatum              | CBS 299.70A | Agricultural soil                       | Italy, Turin                   | LR025839 | LR026710 | –       | LR026134 | LR026134 |     |     |
|                      | CBS 299.70C | Loamy loess soil                        | Germany                        | LR025840 | LR026711 | –       | LR026135 | LR026135 |     |     |
|                      | CBS 299.70F | Gymnopus sp.                            | Germany, Kr. Plön, Schüttenhym | LR025841 | –       | –       | –       | LR026136 | LR026136 |     |
|                      | CBS 116548  | Endophyte in stem of Vitis vinifera     | Iran                           | LR025842 | LR026712 | LR026409 | LR026134 | LR026134 |     |     |
|                      | CBS 116550  | Moist house                             | Germany, Lübeck                | LR025843 | LR026713 | LR026410 | LR026135 | LR026135 |     |     |
| Species              | Isolate nr. | Source                  | Locality                      | GenBank/ENA Accession No. ² |
|----------------------|-------------|-------------------------|-------------------------------|-----------------------------|
|                      |             |                         |                               | LSU  | ITS | TEF1-α | RPB2 | ACT | EF | TS |
|                      |             |                         |                               |     |     |        |      |     |    |    |
| **Fuscohypha expansa** | CBS 103.95  | Soil                    | Brazil                        | LR025844 | LR026714 | LR026411 |     |    |    |    |
|                      | CBS 418.89² | Tuber of Dioscorea sp.  | Martinique                    | LR025845 | LR026715 | LR026412 | LR026136 |    |    |    |    |
| **Gibellulopsis aquatica** | CBS 11713¹ | Cloud water             | France                        | LR025850 | LR026720 | LR026414 |     |    |    |    |
|                      | CBS 113951¹ | Cervical swab of mare   | Germany                       | LR025851 | LR026721 | LR026415 | LR026137 |    |    |    |    |
| **G. fusca**         | CBS 308.38  | Apium graveolens        | Germany, Giessen              | LR025852 | LR026722 | LR026416 | LR026138 |    |    |    |    |
|                      | CBS 402.80  | On Aegopodium podagraria | Netherlands, Baarn            | LR025853 | LR026723 | LR026417 | LR026139 |    |    |    |    |
|                      | CBS 560.65⁵ | Soil                    | India, Banaras                | LR025854 | LR026724 | LR026418 | LR026140 |    |    |    |    |
|                      | CBS 747.83  | Apium graveolens        | Netherlands                   | LR025855 | LR026725 | LR026419 |    |    |    |    |
|                      | CBS 120818  | Root of Beta vulgaris    | Iran, Mashad                  | LR025856 | LR026726 | LR026420 | LR026141 |    |    |    |    |
|                      | CBS 125.79  | Wrapping material       | Netherlands, Rotterdam       | LR025857 | LR026727 | LR026421 | LR026142 |    |    |    |    |
|                      | CBS 455.51  | Solanum tuberosum       | UK                            | LR025858 | LR026728 | LR026422 | LR026143 |    |    |    |    |
|                      | CBS 469.64  | Seed of Linum usitatissimum | Denmark, Kllpinge         | LR025859 | LR026729 | LR026423 | LR026144 |    |    |    |    |
|                      | CBS 470.64  | Medicago sativa         | France                        | LR025860 | LR026730 | LR026424 | LR026145 |    |    |    |    |
|                      | CBS 577.50  | Soil under Humulus lupulus | UK                           | LR025861 | LR026731 | LR026425 | LR026146 |    |    |    |    |
|                      | CBS 100829  | Solanum tuberosum       | Israel, Kerem-Shalom         | LR025862 | LR026732 | LR026426 | LR026147 |    |    |    |    |
|                      | CBS 100832  | Soil                    | Israel, Lahav                 | LR025863 | LR026733 | LR026427 | LR026148 |    |    |    |    |
|                      | CBS 100833  | Soil                    | Israel, Lahav                 | LR025864 | LR026734 | LR026428 | LR026149 |    |    |    |    |
|                      | CBS 100844  | Solanum tuberosum       | Israel, Kerem-Shalom         | LR025865 | LR026735 | LR026429 | LR026150 |    |    |    |    |
|                      | CBS 110719  | Sandy soil              | Netherlands, Kwade Hoek       | LR025866 | LR026736 | LR026430 | LR026151 |    |    |    |    |
|                      | CBS 119666  | Nail                    | Netherlands                   | LR025867 | LR026737 | LR026431 | LR026152 |    |    |    |    |
|                      | CBS 120949⁵⁶ | Soil under lawn          | Netherlands, Baarn           | LR025868 | LR026738 | LR026432 | LR026153 |    |    |    |    |
|                      | CBS 123176  | Moisture damaged building | Finland                       | LR025869 | LR026739 | LR026433 | LR026154 |    |    |    |    |
|                      | CBS 125.79  | Soil                    | New Zealand, Havelock North   | LR025870 | LR026740 | LR026434 | LR026155 |    |    |    |    |
|                      | CBS 175.79  | Solanum tuberosum       | UK                            | LR025871 | LR026741 | LR026435 | LR026156 |    |    |    |    |
|                      | CBS 175.75  | Solanum tuberosum       | Germany                       | LR025872 | LR026742 | LR026436 | LR026157 |    |    |    |    |
|                      | CBS 199.30⁵⁵ | Human eye              | Italy                         | LR025873 | LR026743 | LR026437 | LR026158 |    |    |    |    |
|                      | CBS 345.39  | Wood pulp               | Sweden                        | LR025874 | LR026744 | LR026438 | LR026159 |    |    |    |    |
|                      | CBS 383.66  | Beta vulgaris var. allissima | Canada, Quebec              | LR025875 | LR026745 | LR026439 | LR026160 |    |    |    |    |
|                      | CBS 387.35  | Amanarthus tricolor     | Italy                         | LR025876 | LR026746 | LR026440 | LR026161 |    |    |    |    |
|                      | CBS 392.89  | Seed of Abelmoschus esculentus | Cuba, Santiago de las Vegas | LR025877 | LR026747 | LR026441 | LR026162 |    |    |    |    |
|                      | CBS 416.76  | Unknown                 | India                         | LR025878 | LR026748 | LR026442 | LR026163 |    |    |    |    |
|                      | CBS 493.82A | Soil of Glycine max     | Argentina, Misiones, Cerro Azul | LR025879 | LR026749 | LR026443 | LR026164 |    |    |    |    |
|                      | CBS 493.82B | Seed                    | Argentina, Buenos Aires, Castelar | LR025880 | LR026750 | LR026444 | LR026165 |    |    |    |    |
|                      | CBS 493.82C | Seed                    | Argentina, Chaco, Las Brenas  | LR025881 | LR026751 | LR026445 | LR026166 |    |    |    |    |
|                      | CBS 565.78A | On Oidium sp.           | Russia, Odessa                | LR025882 | LR026752 | LR026446 | LR026167 |    |    |    |    |
|                      | CBS 565.78B | On Cercospora beticola  | Moldavia                      | LR025883 | LR026753 | LR026447 | LR026168 |    |    |    |    |
|                      | CBS 565.78C | On Erysipe sp.          | Russia, Astrakhan             | LR025884 | LR026754 | LR026448 | LR026169 |    |    |    |    |
|                      | CBS 592.70⁵⁷ | Gold-fish (Carassius auratus) | Brazil, Recife              | LR025885 | LR026755 | LR026449 | LR026170 |    |    |    |    |
|                      | CBS 100826  | Solanum tuberosum       | Israel, Gili                  | LR025886 | LR026756 | LR026450 | LR026171 |    |    |    |    |
|                      | CBS 100827  | Soil in cotton field    | Israel, Ramat-David          | LR025887 | LR026757 | LR026451 | LR026172 |    |    |    |    |
| Species | Isolate nr. | Source | Locality | GenBank/ENA Accession No. |
|---------|------------|--------|----------|--------------------------|
|         |            |        |          | LSU | ITS  | TEF1-α | RPB2 | ACT | EF | TS |
| CBS 100830 | Soil | Israel, Ein-Shemer | LR025888 | LR026758 | LR026448 | LR026162 |
| CBS 100831 | Soil | Israel, Ein-Shemer | LR025889 | LR026759 | LR026449 |
| CBS 101221 | Soil in cotton field | Israel, Ein-Shemer | LR025890 | LR026760 | LR026450 | LR026163 |
| CBS 109724 | Human blood | Greece, Thessaloniki | LR025891 | LR026761 | LR026451 | LR026164 |
| CBS 120008 | Leaf of Musa sp. | India, Bangaon, W.-Bengal | LR025892 | LR026762 | LR026452 | LR026165 |
| DAOMC 226890 | Solarium tuberosum | Canada, Ontario | LR025893 | LR026763 | LR026453 |
| Lectera capsici | CBS 142534T | Capsicum annuum | LR025894 | LR026764 | LR026454 | LR026166 |
| L. colletotrichoides | IMI 303885 | Capsicum annuum | LR025895 | LR026765 | LR026455 | LR026167 |
| L. humicola | IMI 265740T | Soil | Brazil | LR025896 | LR026766 | LR026456 | LR026168 |
| L. longa | IMI 181698T | Triticum sp. | Australia | LR025897 | LR026767 | LR026457 | LR026169 |
| L. phaseoli | IMI 366179T | Phaseolus vulgaris | Ethiopia | LR025898 | LR026768 | LR026458 | LR026170 |
| Lectera sp. | CBS 144921 | Garden soil | Netherlands, Friesland, Leeuwarden | LR025899 | LR026769 | LR026459 | LR026171 |
| CBS 144922 | Garden soil | Netherlands, Güldenes, Arnhem | LR025900 | LR026770 | LR026460 | LR026172 |
| CBS 231013 | Garden soil | Netherlands, Friesland, Leeuwarden | LR025901 | LR026771 | LR026461 | LR026173 |
| Monilochaetes infuscans | CBS 379.77 | Ipomoea batatas | New Zealand, South Auckland, Mangere | LR025902 | LR026772 | LR026462 | LR026174 |
| CBS 869.66 | Ipomoea batatas | South Africa, Eastern Cape, Gamoos | LR025903 | LR026773 | LR026463 | LR026175 |
| Musicillium elettariae | CBS 252.80T | Elettaria cardomomum | Rwanda | LR025904 | LR026774 | LR026464 | LR026176 |
| CBS 110322 | Leaf of Musa acuminata | Thailand, Chiang Mai, Doi Suthep | LR025905 | LR026775 | LR026465 | LR026177 |
| CBS 140681 | Dead leaf of Carex pendula | Iran, Golestan, Forest park of Tuskestan | LR025906 | LR026776 | LR026466 | LR026178 |
| M. theobromae | CBS 122.97 | Unknown | Brazil | LR025907 | LR026777 | LR026467 | LR026179 |
| CBS 243.74 | Decaying stalk of Musa sp. | Netherlands, Baarn | LR025908 | LR026778 | LR026468 | LR026180 |
| CBS 360.76 | Unknown | Finland, Rovaniemi | LR025909 | LR026779 | LR026469 | LR026181 |
| CBS 385.32 | Unknown | Unknown | LR025910 | LR026780 | LR026470 | LR026182 |
| CBS 397.58 | Musa sp. | Jamaica | LR025911 | LR026781 | LR026471 | LR026183 |
| CBS 96.72 | Musa sp. | Egypt, Cairo | LR025912 | LR026782 | LR026472 | LR026184 |
| CBS 120527 | Musa sapientum | Iran, Chabahar | LR025913 | LR026783 | LR026473 | LR026185 |
| CBS 120528 | Musa sapientum | Iran, Chabahar | LR025914 | LR026784 | LR026474 | LR026186 |
| CBS 120529 | Musa nana | Iran, Mazandaran | LR025915 | LR026785 | LR026475 | LR026187 |
| CBS 121211 | Rotten banana | Brazil, Minas Gerais | LR025916 | LR026786 | LR026476 | LR026188 |
| CPC 29810 | Leaf of Musa sp. | Morocco, Kenitra | LR025917 | LR026787 | LR026477 | LR026189 |
| M. tropicale | CBS 395.58 | Lactarius sp. | Czech Republic, Bohemia | LR025918 | LR026788 | LR026478 | LR026190 |
| CBS 398.58 | Musa sp. | Zambia | LR025919 | LR026789 | LR026479 | LR026191 |
| CBS 458.51 | Unknown | Japan | LR025920 | LR026790 | LR026480 | LR026192 |
| CBS 100951 | Leaf litter | Cuba, Estado de Agua, Parque Nacional Henry Pittie | LR025921 | LR026791 | LR026481 | LR026193 |
| CBS 120097 | Leaf of Musa sp. | Bangladesh, Bangaon | LR025922 | LR026792 | LR026482 | LR026194 |
| CBS 121212 | Rotten banana | Brazil, Minas Gerais | LR025923 | LR026793 | LR026483 | LR026195 |
| Species              | Isolate nr. | Source                                      | Locality                                      | GenBank/ENA Accession No. |
|----------------------|-------------|---------------------------------------------|-----------------------------------------------|----------------------------|
|                      |             |                                             |                                               | LSU | ITS | TEF1-α | RPB2 | ACT | EF | TS |
| Musidium stromaticum | CBS 132.74  | Musa sp.                                    | Costa Rica, Coto valley                       | LRO25919 | LRO26785 | LRO26481 | LRO26187 |
|                      | CBS 133.74  | Musa sp.                                    | Costa Rica, Coto valley                       | LRO25920 | LRO26786 | LRO26480 | LRO26188 |
|                      | CBS 134.74  | Musa sp.                                    | Honduras, Lula Valley                         | LRO25921 | LRO26787 | LRO26482 | LRO26189 |
|                      | CBS 135.74A | Musa sp.                                    | Panama, Chiangmola                             | LRO25922 | LRO26788 | LRO26483 | LRO26190 |
|                      | CBS 135.74D | Musa sp.                                    | Colombia, Turbo                               | LRO25924 | LRO26789 | –        | –       |
|                      | CBS 135.74F | Rhizosphere of Musa sp.                     | Philippines                                   | LRO25925 | LRO26790 | LRO26484 | LRO26191 |
|                      | CBS 135.74G | Musa sp.                                    | United Kingdom, England, Kew, Royal Botanical Gardens | LRO25926 | LRO26791 | –        | –       |
|                      | CBS 135.74H | Musa sp.                                    | Tanzania                                      | LRO25927 | –        | –        | –       |
| Nigrocephalum collariferum | CBS 124585 | Toenail                                      | Panama, Chiriqui, Los Algarrobos              | LRO25928 | FJ765365 | LRO26845 | LRO26192 |
|                      | CBS 124586  | Toenail                                      | Panama, Chiriqui, Los Algarrobos              | LRO25929 | FJ765367 | LRO26846 | LRO26193 |
| Paramusciulium asperulum | CBS 120158 | Soil                                         | Democratic Republic of Sào Tomé and Principe | LRO25930 | LRO26792 | LRO26487 | LRO26194 |
| Paragibellulopsis chrysanthemi | MAFF 242621T | On rotten leaves of Garland chrysanthemum | Japan, Osaka, Kishiwada                       | KC287230 | KC287235 | KC287232 | –       |
|                      | MAFF 243429 | On rotten leaves of Garland chrysanthemum   | Japan, Osaka, Kishiwada                       | KC287229 | KC287234 | KC287231 | –       |
| Phialoparum bifurcatum | CBS 299.70B | Soil                                         | Belgium, Heverlee                             | LR025931 | LR026793 | LR026488 | LR026195 |
| Plectosphaerella alismatis | CBS 113382T | Alisma plantago-aquatica                    | Netherlands, Pijnenburg near Soest            | LR025932 | LR026794 | LR026489 | LR026196 |
| P. citriae            | CBS 131740  | Root of Cucumis melo                         | Italy, Foggia, Torre Bianca                  | LRO25933 | LR026795 | LRO26490 | –       |
|                      | CBS 131741  | Root of Citrullus lanatus                    | Italy, Foggia                                 | LRO25934 | LR026796 | LRO26491 | LRO26197 |
| P. cucumerina         | CBS 137.32NT | Nicotiana tabacum                           | England, Bristol                              | LRO25935 | LR026797 | LRO26492 | LRO26198 |
|                      | CBS 137.37T | Paper                                        | Italy                                         | LRO25836 | LR026798 | LRO26493 | LRO26199 |
|                      | CBS 139.60  | Unknown                                      | USA                                           | LRO25937 | LR026799 | LRO26494 | LRO26200 |
|                      | CBS 286.64  | Nicotiana tabacum                           | Belgium, Heverlee                             | LRO25938 | LR026800 | LRO26495 | LRO26201 |
|                      | CBS 355.36  | Root of Viola tricolor                      | Netherlands                                   | LRO25939 | LR026801 | LRO26496 | –       |
|                      | CBS 367.73  | Viola odorata                                | Egypt                                         | LRO25940 | LR026802 | LRO26497 | LRO26202 |
|                      | CBS 400.58  | Solarium esculentum                         | Canada                                        | LRO25941 | LR026803 | LRO26498 | LRO26203 |
|                      | CBS 567.78  | Unknown fungus                              | USSR                                          | LRO25942 | LR026804 | LRO26499 | LRO26204 |
|                      | CBS 619.74  | Leaf of Pyrus malus                         | Switzerland, Basel                            | LRO25943 | LR026805 | LRO26500 | LRO26205 |
|                      | CBS 632.94  | Arabidopsis sp.                              | Switzerland                                   | LRO25944 | LR026806 | LRO26501 | LRO26206 |

(continued on next page)
| Species | Isolate nr.¹ | Source | Locality | GenBank/ENA Accession No.² |
|---------|--------------|--------|----------|---------------------------|
|         |              |        |          | LSU | ITS | TEF1-α | RPB2 | ACT | EF | TS |
| Arabidopsis thaliana | CBS 101014 | Switzerland | LR025945 | LR026807 | LR026502 | LR026207 |      |     |     |
| Endophyte in leaf and stem of Galium spumum | CBS 101958 | Canada, Alberta | LR025946 | LR026808 | LR026503 | LR026208 |      |     |     |
| P. delsorboi | CBS 131739⁵ | Italy, Foggia, Borgo Cervaro | LR025947 | LR026809 | LR026504 |      |     |     |     |
| P. humicola | CBS 423.66T | Soil Zaire, Katanga | LR025948 | LR026811 | LR026506 | LR026210 |      |     |     |
| P. melonis | CBS 489.96T | Root of Cucurbita melo | LR025949 | LR026812 | LR026507 |      |     |     |     |
| P. oligotrophica | CBS 440.90T | Soil | LR025950 | LR026813 | LR026508 |      |     |     |     |
| P. oratosquillae | CBS 489.97T | Oratosquilla oratoria | LR025951 | LR026814 | LR026509 | LR026211 |      |     |     |
| P. pauciseptata | CBS 131744 | Collar of Cucumis melo | LR025952 | LR026815 | LR026510 | LR026212 |      |     |     |
| P. plurivora | CBS 101.87 | Soil Netherlands, Oostelijk Flevoland, De Schreef | LR025953 | LR026816 | LR026511 | LR026213 |      |     |     |
| P. populi | CBS 139623T | Branch of Populus nigra | LR025954 | LR026817 | LR026512 | LR026213 |      |     |     |
| P. ramiseptata | CBS 139624 | Populus nigra | LR025955 | LR026818 | LR026513 | LR026214 |      |     |     |
| P. sinensis | CBS 131860 | Stem of Solanum esculentum | LR025956 | LR026819 | LR026514 | LR026215 |      |     |     |
| Sayamraella subulata | CBS 78964T | Soil around Hopea odorata | LR025957 | LR026820 | LR026515 | LR026216 |      |     |     |

¹ Isolate number.
² Accession numbers correspond to the GenBank or ENA databases.
Table 1. (Continued).

| Species                  | Isolate nr. | Source                                      | Locality                      | GenBank/ENA Accession No. |
|--------------------------|-------------|---------------------------------------------|-------------------------------|---------------------------|
|                          |             |                                             |                               | LSU    | ITS    | TEF1-α | RPB2  | ACT   | EF    | TS    |
| S. calcalophilus         | CBS 114.92  | Sludge of pig faeces compost                | Japan, Kanagawa Pref., Tsukui-gun | JX158443 | JX158421 | JX158399 | JX158465 |       |       |       |       |
| S. alkalinus             | CBS 110278  | Soda soils                                  | Mongolia, Choibalsan area     | JX158427 | NR_145378 | JX158383 | JX158449 |       |       |       |       |
|                          | CBS 13729   | Soda soils                                  | Russia, Chita area, Kunkur Steppe | JX158423 | JX158401  | JX158379 | JX158445 |       |       |       |       |
|                          | CBS 13860   | Soda soils                                  | Russia, Chita area, Kunkur Steppe | JX158424 | JX158402  | JX158380 | JX158446 |       |       |       |       |
|                          | CBS 137619  | Soda soils                                  | Kenya, Magadi Lake            | KJ443148 | KJ443278  |          |          |       |       |       |       |
|                          | CBS 137618  | Soda soils                                  | Kenya, Magadi Lake            | KJ443147 | KJ443277  |          |          |       |       |       |       |
|                          | CBS 13419   | Soda soils                                  | Kenya, Magadi Lake            | KJ443149 | KJ443279  |          |          |       |       |       |       |
| Stachylidium bicolor     | CBS 121802  | Plant debris                                | Spain, Asturias, Picos de Europa, Sotres | LR025972 | LR026834  | LR026532 |          |       |       |       |       |
| S. pallidum              | BCC 79031   | Soil                                        | Thailand                      | LR025973 | LR026835  | LR026533 | LR026227 |       |       |       |       |
|                          | CBS 292.72  | Soil, under Abies sp. and Rhododendron sp.  | Nepal                         | LR025974 | LR026836  |          |          |       |       |       |       |
|                          | CBS 449.88  | Soil                                        | Turkey                        | LR025975 | LR026837  |          |          |       |       |       |       |
| Summerbellia             | CBS 299.70  | Grapefruit juice can                        | USA, Florida                  | LR025846 | LR026716  | LR026413 |          |       |       |       |       |
| oligotrophica            | CBS 299.70H | Bath towel                                  | USA, Florida                  | LR025847 | LR026717  |          |          |       |       |       |       |
|                          | CBS 620.76  | Unknown                                     | Australia, New South Wales    | LR025848 | LR026718  |          |          |       |       |       |       |
|                          | CBS 657.94  | Alkaline soil                               | Indonesia                     | LR025849 | LR026719  |          |          |       |       |       |       |
| Theobromia fuscum        | CBS 112271  | Theobroma sp.                               | Ecuador, Pichincha Province, Vicente Maldonado | LR025976 | LR026839  | LR026535 | LR026229 |       |       |       |       |
| Verticillium albo-atrum  | CBS 385.82  | Morchella esculenta                         | Netherlands, Vogelenzang      | LR025977 | LR026840  | LR026536 | LR026230 |       |       |       |       |
|                          | CBS 386.82  | Dung of carnivore                           | Germany, Holzdorf             | LR025978 | LR026841  | LR026537 | LR026231 | LR026286 | LR026322 |       |       |
|                          | CBS 582.88  | Solanum tuberosum                           | Netherlands                   | LR025979 | LR026842  | LR026536 | LR026231 | LR026286 | LR026322 |       |       |
|                          | CBS 745.83  | Dead stem of Urtica dioica                  | UK, Scotland, Kinkgof Field Centre | LR025980 | LR026843  | LR026539 | LR026231 | LR026286 | LR026322 |       |       |
|                          | CBS 101242  | Solanum tuberosum                           | United Kingdom                | LR025981 | LR026844  | LR026540 | LR026231 | LR026286 | LR026322 |       |       |
|                          | CBS 102464  | Cynara scolymus                             | Italy                         | LR025982 | LR026845  | LR026541 | LR026231 | LR026286 | LR026322 |       |       |
|                          | CBS 120947  | Leaf of Humulus lupulus                     | Denmark                       | LR025983 | LR026846  | LR026542 | LR026232 | LR026286 | LR026324 |       |       |
|                          | CBS 130340  | Soil from potato field                      | Canada, Prince Edward Island  | LR025984 | LR026847  | LR026543 | LR026233 | JN188144 | JN188272 | JN188080 |       |
| V. alfae                 | CBS 241.82  | Catalpa bignonioides                        | Italy                         | LR025985 | LR026848  | LR026544 | LR026234 | LR026286 | LR026322 |       |       |
|                          | CBS 453.51  | Catalpa bignonioides                        | United Kingdom                | LR025986 | LR026849  | LR026545 | LR026234 | LR026286 | LR026322 |       |       |
|                          | CBS 67169   | Medicago sativa                             | USA, Pennsylvania             | LR025987 | LR026850  | LR026546 | LR026235 | LR026286 | LR026324 |       |       |
|                          | CBS 130603  | Medicago sativa                             | USA                           | LR025988 | LR026851  | LR026547 | LR026236 | JN188097 | JN188225 | JN188033 |       |
| V. dahiae                | CBS 127.79B | Nicotiana tabacum                           | New Zealand, Motueka          | LR025989 | LR026852  | LR026548 | LR026237 | LR026286 | LR026324 |       |       |
|                          | CBS 177.66  | Solanum lycopersicon                        | Netherlands, Wageningen       | LR025990 | LR026853  | LR026549 | LR026237 | LR026286 | LR026324 |       |       |
|                          | CBS 178.66  | Solanum lycopersicon                        | Netherlands, Wageningen       | LR025991 | LR026854  | LR026549 | LR026237 | LR026286 | LR026324 |       |       |
|                          | CBS 179.66  | Solanum lycopersicon                        | Netherlands, Wageningen       | LR025992 | LR026855  | LR026549 | LR026237 | LR026286 | LR026324 |       |       |

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| Species                  | Isolate nr. | Source                          | Locality          | GenBank/ENA Accession No. |
|-------------------------|-------------|---------------------------------|-------------------|---------------------------|
|                         |             |                                 |                   | LSU | ITS | TEFl-α | RPB2 | ACT | EF | TS |
| CBS 204.26              | Rubus idaeus | Unknown                         |                   |     |     |        |      |     |    |    |
| CBS 205.26              | Rubus idaeus | Unknown                         |                   |     |     |        |      |     |    |    |
| CBS 222.72A             | Unknown     | Russia                          |                   |     |     |        |      |     |    |    |
| CBS 222.72C             | Unknown     | Russia                          |                   |     |     |        |      |     |    |    |
| CBS 380.49              | Humulus lupulus | United Kingdom                 |                   |     |     |        |      |     |    |    |
| CBS 381.86              | Solanum lycopersicon | Canada, Quebec             |                   |     |     |        |      |     |    |    |
| CBS 383.49              | Xanthium italicum | Italy                      |                   |     |     |        |      |     |    |    |
| CBS 384.19              | Solanum tuberosum | Netherlands                 |                   |     |     |        |      |     |    |    |
| CBS 385.49              | Rosa rugosa  | Netherlands                     |                   |     |     |        |      |     |    |    |
| CBS 386.49              | Solanum melongena | Netherlands                 |                   |     |     |        |      |     |    |    |
| CBS 388.49              | Antirrhinum majus | Unknown                     |                   |     |     |        |      |     |    |    |
| CBS 389.49              | Humulus lupulus | Unknown                       |                   |     |     |        |      |     |    |    |
| CBS 390.49              | Fragaria sp. | Unknown                        |                   |     |     |        |      |     |    |    |
| CBS 391.49              | Solanum tuberosum | Unknown                    |                   |     |     |        |      |     |    |    |
| CBS 392.49              | Rubus idaeus  | Unknown                        |                   |     |     |        |      |     |    |    |
| CBS 425.52              | Solanum lycopersicon | Netherlands, Naaldwijk     |                   |     |     |        |      |     |    |    |
| CBS 717.96              | Root of Solanum tuberosum | Netherlands, Drente    |                   |     |     |        |      |     |    |    |
| CBS 718.96              | Root of Vicia faba | Netherlands, Oost-Flevoland |                   |     |     |        |      |     |    |    |
| CBS 800.97              | Soil        | Netherlands, Wageningen        |                   |     |     |        |      |     |    |    |
| CBS 801.97              | Soil        | Netherlands, Wageningen        |                   |     |     |        |      |     |    |    |
| CBS 802.97              | Vessel in stem of Phlox sp. | Netherlands               |                   |     |     |        |      |     |    |    |
| CBS 806.97              | Vessel in stem of Ribes rubrum | Netherlands             |                   |     |     |        |      |     |    |    |
| CBS 807.97              | Vessel in stem of Fragaria sp. | Netherlands            |                   |     |     |        |      |     |    |    |
| CBS 809.97              | Vessel in stem of Rosa sp.  | Netherlands             |                   |     |     |        |      |     |    |    |
| CBS 810.97              | Stem of Rubus fruticosus | Unknown                   |                   |     |     |        |      |     |    |    |
| CBS 811.97              | Stem of Acer sp. | Unknown                   |                   |     |     |        |      |     |    |    |
| CBS 812.97              | Soil        | Netherlands, Lelystad          |                   |     |     |        |      |     |    |    |
| CBS 814.97              | Forsythia sp. | Netherlands                    |                   |     |     |        |      |     |    |    |
| CBS 110223              | Helianthus annus | Argentina               |                   |     |     |        |      |     |    |    |
| CBS 110224              | Helianthus annus | Argentina               |                   |     |     |        |      |     |    |    |
| CBS 110225              | Helianthus annus | Argentina               |                   |     |     |        |      |     |    |    |
| CBS 110274              | Trifolium pratense | Germany             |                   |     |     |        |      |     |    |    |
| CBS 111500              | Caerola frutescens var. sericea | USA, Hawaii       |                   |     |     |        |      |     |    |    |
| CBS 127170              | Lactuca sativa | USA, California, Watsonville |                   |     |     |        |      |     |    |    |
| CBS 128315              | Capsicum annuum | USA, California, Salinas          |                   |     |     |        |      |     |    |    |
| CBS 130341†             | Lactuca sativa | USA, California, Watsonville |                   |     |     |        |      |     |    |    |
| V. isaaci                | Lactuca sativa | Netherlands, Wageningen        |                   |     |     |        |      |     |    |    |
| CBS 373.75              | Lactuca sativa | Netherlands, Groningen        |                   |     |     |        |      |     |    |    |
| CBS 378.75              | Lactuca sativa | Netherlands, Groningen        |                   |     |     |        |      |     |    |    |
| CBS 504.97              | Stem of Limonium sp. | Netherlands             |                   |     |     |        |      |     |    |    |
| CBS 100839              | Soil from potato field | Israel, Re'm                |                   |     |     |        |      |     |    |    |
| Species | Isolate nr. | Source | Locality | LSU Accession Number | ITS Accession Number | TEF1-α Accession Number | RPB2 Accession Number | ACT Accession Number | EF Accession Number | TS Accession Number |
|---------|-------------|--------|----------|----------------------|----------------------|-------------------------|-----------------------|----------------------|----------------------|---------------------|
| CBS 100840 | Soil from potato field | Israel, Re'im | | LR026035 | LR026896 | | | | | |
| CBS 100843 | Solanum sp. | Israel, Kerem-Shalom | | LR026036 | LR026897 | | | | | |
| CBS 101220 | Brassica sp. | Israel, Nir-Izhak | | LR026037 | LR026898 | LR026576 | | LR026299 | LR026340 | LR026624 |
| CBS 130343 | Lactuca sativa | USA, California | | LR026038 | LR026899 | LR026577 | | HG206985 | HG414688 | HG414973 |
| V. klebahnii | Lactuca sativa | USA, Watsonville | | LR026039 | LR026900 | LR026578 | | | | |
| V. longisporum | CBS 124.64 | Root of Armoracia rusticana | Germany, Niedersachsen, Altes Land | LR026040 | LR026901 | | | LR026259 | | |
| CBS 649.85 | Stem of Brassica rapa | Sweden | | LR026041 | LR026902 | | | | | |
| CBS 110218 | Brassica napus | Sweden | | LR026043 | LR026904 | LR026579 | | LR026259 | | |
| CBS 110219 | Brassica napus | Sweden | | LR026044 | LR026905 | LR026260 | | LR026260 | | |
| CBS 110220 | Brassica napus | Sweden | | LR026045 | LR026906 | LR026261 | | LR026261 | | |
| CBS 110221 | Brassica napus | Sweden | | LR026046 | LR026907 | LR026262 | | LR026262 | | |
| CBS 110227 | Brassica napus | Sweden | | LR026047 | LR026908 | LR026263 | | LR026263 | | |
| CBS 110228 | Brassica napus | Sweden | | LR026048 | LR026909 | LR026264 | | LR026264 | | |
| CBS 11029 | Brassica napus | Sweden | | LR026049 | LR026910 | LR026265 | | LR026265 | | |
| CBS 110230 | Brassica napus | Sweden | | LR026050 | LR026911 | LR026266 | | LR026266 | | |
| CBS 110231 | Brassica napus | Sweden | | LR026051 | LR026912 | LR026267 | | LR026267 | | |
| CBS 110232 | Brassica napus | Germany | | LR026052 | LR026913 | LR026268 | | LR026268 | | |
| CBS 110233 | Brassica napus | Germany | | LR026053 | LR026914 | LR026269 | | LR026269 | | |
| CBS 110272 | Brassica napus | Sweden | | LR026054 | LR026915 | LR026270 | | LR026270 | | |
| CBS 110273 | Brassica napus | Sweden | | LR026055 | LR026916 | LR026271 | | LR026271 | | |
| CBS 110275 | Brassica napus | Sweden | | LR026056 | LR026917 | LR026272 | | LR026272 | | |
| CBS 110276 | Brassica napus | Sweden | | LR026057 | LR026918 | LR026273 | | LR026273 | | |
| CBS 110277 | Brassica napus | Sweden | | LR026058 | LR026919 | LR026274 | | LR026274 | | |
| CBS 128316 | Armoracia rusticana | USA, Illinois | | LR026059 | LR026920 | LR026275 | | LR026275 | | |
| CBS 128317 | Brassica oleracea var. botrytis | USA, California, Salinas | | LR026060 | LR026921 | LR026276 | | LR026276 | | |
| V. ronalfiae | CBS 321.91 | Solanum lycopersicon | Netherlands, Naaldwijk | LR026061 | LR026922 | LR026579 | LR026274 | LR026300 | LR026341 | LR026625 |
| CBS 322.91 | Solanum lycopersicon | Netherlands, Naaldwijk | | LR026062 | LR026923 | LR026580 | LR026275 | LR026301 | LR026342 | LR026626 |
| CBS 381.49 | Humulus lupulus | UK | | LR026063 | LR026924 | LR026581 | | LR026301 | LR026342 | LR026626 |
| CBS 382.49 | Fragaria sp. | UK | | LR026064 | LR026925 | LR026582 | LR026276 | LR026302 | LR026343 | LR026627 |
| CBS 382.68 | On Verticillium albo-atrum | Canada | | LR026065 | LR026926 | LR026303 | LR026344 | LR026345 | LR026346 | LR026628 |
| CBS 385.91 | Solanum esculentum | Netherlands, Loenen | | LR026066 | LR026927 | LR026277 | | LR026304 | LR026345 | LR026629 |
| CBS 395.91 | Humulus lupulus | Belgium, Poperinge | | LR026067 | LR026928 | LR026583 | LR026278 | LR026305 | LR026346 | LR026629 |
| CBS 451.88 | Unknown | Belgium | | LR026068 | LR026929 | LR026584 | LR026279 | LR026305 | LR026346 | LR026629 |
| CBS 452.51 | Antirrhinum sp. | UK | | LR026069 | LR026930 | LR026585 | LR026280 | LR026306 | LR026347 | LR026630 |
| CBS 454.51 | Solanum tuberosum | UK | | LR026070 | LR026931 | LR026586 | LR026279 | LR026307 | LR026348 | LR026631 |
| CBS 113707 | Citrus sinensis | Portugal | | LR026071 | LR026932 | LR026587 | LR026280 | LR026308 | LR026349 | LR026632 |
| CBS 121305 | Humulus lupulus | Slovenia, Savinja valley | | LR026072 | LR026933 | LR026588 | LR026281 | LR026309 | LR026350 | LR026633 |
| CBS 121306 | Humulus lupulus | Slovenia, Savinja valley | | LR026073 | LR026934 | LR026589 | LR026282 | LR026310 | LR026351 | LR026634 |
| CBS 130339 | Solanum tuberosum | Japan, Hokkaido | | LR026074 | LR026935 | LR026590 | | | | |

(continued on next page)
| Species               | Isolate nr. | Source                     | Locality                                          | GenBank/ENA Accession No. | LSU | ITS | TEF1-α | RPB2 | ACT | EF | TS |
|----------------------|-------------|----------------------------|---------------------------------------------------|----------------------------|-----|-----|--------|------|-----|----|----|
| V. nubilum           | CBS 578.50  | Soil                       | UK, England, East Malling Res. Sta.                | LR026075 LR026036         |     |     |        |      |     |    |    |
|                      | CBS 457.51† | Soil                       | UK                                                | LR026076 LR026037 LR026591 LR026282 |     | JN188139 | JN188267 | JN180075 |
|                      | CBS 456.51  | Solanum tuberosum          | UK                                                | LR026077 LR026038         |     |     |        |      |     |    |    |
|                      | CBS 126.79  | Soil                       | New Zealand, Havelock North                       | LR026076 LR026039 LR026592 |     |     |        |      |     |    |    |
| V. tricorpus         | CBS 127.79A | Solanum lycopersicon       | New Zealand, Roxborough                           | LR026077 LR026040 LR026593 LR026283 LR026308 LR026349 LR026632 |     |     |        |      |     |    |    |
|                      | CBS 227.84  | Solanum tuberosum          | Netherlands, Oostelijk Flevoland, De Schreef       | LR026080 LR026041 LR026594 |     | LR026309 | LR026350 | LR026633 |
|                      | CBS 255.57  | Solanum lycopersicon       | UK, England, Cambridgeshire                       | LR026081 LR026042 LR026595 |     | LR026310 | LR026351 | LR026634 |
|                      | CBS 280.75  | Lactuca sativa             | Netherlands, Vleuten                              | LR026082 LR026043 LR026596 |     | LR026311 | LR026352 | LR026635 |
|                      | CBS 447.54† | Solanum lycopersicon       | UK, England, Fareham, Hants                       | LR026083 LR026044         |     |     |        |      |     |    |    |
|                      | CBS 545.79  | Solanum lycopersicon       | New Zealand                                       | LR026084 LR026045 LR026597 LR026284 LR026312 LR026636 |     |     |        |      |     |    |    |
|                      | CBS 603.97  | Root of Alstroemeria sp.   | Netherlands                                       | LR026085 LR026046 LR026598 LR026285 |     | LR026353 | LR026354 | LR026637 |
|                      | CBS 608.97  | Stem of Solanum lycopersicon | Netherlands                                    | LR026086 LR026047 LR026599 |     |     |        |      |     |    |    |
|                      | CBS 100834  | Solanum sp.                | Israel, Gilat                                    | LR026087 LR026048 LR026600 |     | LR026313 | LR026355 | LR026639 |
|                      | CBS 100835  | Soil from potato field     | Israel, Gilat                                    | LR026088 LR026049 LR026601 |     | LR026314 | LR026355 | LR026640 |
|                      | CBS 100836  | Solanum sp.                | Israel, Gilat                                    | LR026089 LR026050 LR026602 |     | LR026315 | LR026356 | LR026641 |
|                      | CBS 100867  | Solanum sp.                | Israel, Gilat                                    | LR026090 LR026051 LR026603 |     | LR026316 | LR026357 | LR026642 |
|                      | CBS 100868  | Senecio sp.                | Israel, Ein-Hashlosha                             | LR026091 LR026052         |     | LR026317 | LR026358 | LR026643 |
|                      | CBS 101218  | Soil from potato field     | Israel, Re‘im                                    | LR026092 LR026053 LR026604 |     | LR026318 | LR026359 | LR026644 |
|                      | CBS 102465  | Cynara scolymus            | Italy                                             | LR026093 LR026054 LR026605 |     | LR026319 | LR026360 | LR026645 |
| V. zaregamsianum      | CBS 100837  | Solanum sp.                | Israel, Sde-Boker                                 | LR026094 LR026055 LR026606 |     | LR026361 | LR026646 |
|                      | CBS 100838  | Solanum sp.                | Israel, Kerem-Shalom                              | LR026095 LR026056 LR026607 |     | LR026320 | LR026362 | LR026647 |
|                      | CBS 100841  | Solanum sp.                | Israel, Kerem-Shalom                              | LR026096 LR026057 LR026608 |     | LR026321 | LR026363 | LR026648 |
|                      | CBS 100842  | Solanum sp.                | Israel, Kerem-Shalom                              | LR026097 LR026058 LR026609 |     |     |        |      |     |    |    |
|                      | CBS 130342† | Lactuca sativa             | Japan, Chiba                                      | LR026098 LR026059 LR026610 |     | JN188133 | JN188261 | JN180069 |

1 Ex-type, 2 Ex-epitype, 3 Ex-isotype, 4 Ex-neotype

1 ACCC: Agricultural Culture Collection of China, Beijing, China; BCC: BIOTEC Culture Collection, Pathumthani, Thailand; CBS: Culture Collection of the Westerdijk Fungal Biodiversity Institute, Utrecht, The Netherlands; CPC: Collection of Pedro W. Crous, Utrecht, The Netherlands; DAOMC Canadian Collection of Fungal Cultures; FMR: Faculty of Medicine of Reus, Reus, Spain; IMI: International Mycological Institute, CABI-Bioscience, Egham, Bisham Lane, UK; JW: Johanna Westerdijk Collection, Utrecht, The Netherlands; MAFF: Ministry of Agriculture, Forestry and Fisheries, Ibaraki, Japan; NJM: Nippon Veterinary and Life Science University, Tokyo, Japan.

2 ENA, European Nucleotide Archive; LSU, large subunit of the nrDNA; ITS, internal transcribed spacer regions of the nrDNA and intervening 5.8S nrRNA gene; TEF1-α, translation elongation factor 1-alpha; RPB2, RNA polymerase II second largest subunit; ACT, actin; EF, elongation factor 1-alpha fragment amplified in Inderbitzin et al. (2011b); TS, tryptophan synthase. Accession numbers of sequences generated in this study are in bold.
Fig. 1. Maximum composite likelihood tree constructed with partial sequences from the LSU, ITS, TEF1-α and RPB2 regions from genera of Plectosphaerellaceae. Bootstrap support values above 70 % are shown at the nodes. Ex-type, Ex-epitype, Ex-isotype, Ex-neotype.
Fig. 1. (Continued).
Fig. 1. (Continued).
Verticillium

CBS 383.49 Xanthium italicum, Italy
CBS 425.52 Solanum esculentum, Netherlands
CBS 127.798 Nicotiana tabacum, New Zealand
CBS 381.66 Solanum esculentum, Canada
CBS 110225 Helianthus annuus, Argentina
CBS 110224 Trifolium pratense, Germany
CBS 110223 Helianthus annuus, Argentina
CBS 124.64* Armoracia rusticana, Germany
CBS 386.49 Solanum melongena, Netherlands
CBS 204.26 Rubus idaeus, Unknown
CBS 388.49 Antirrhinum majus, Netherlands
CBS 205.26 Rubus idaeus, Unknown
CBS 806.97 Ribes rubrum, Netherlands
CBS 130341* Lactuca sativa USA
CBS 809.97 Rosa sp., Netherlands
CBS 177.66 Solanum lycopersicon, Netherlands
CBS 380.49 Unknown, Unknown
CBS 807.97 Fragaria sp., Unknown
CBS 717.98 Solanum tuberosum, Netherlands
CBS 385.49 Rosa rugosa, Netherlands
CBS 384.49 Solanum tuberosum, Netherlands
CBS 801.97 Soil, Netherlands
CBS 389.49 Humulus lupulus, Unknown
CBS 812.97 Soil, Netherlands
CBS 800.97 Soil, Netherlands
CBS 391.49 Solanum tuberosum, Unknown
CBS 222.72C Unknown, Russia
CBS 179.66 Solanum lycopersicon, Netherlands
CBS 128315 Capsicum annuum, USA
CBS 811.97 Acer sp., Unknown
CBS 178.66 Solanum lycopersicon, Netherlands
CBS 802.97 Phlox sp., Netherlands
CBS 111590 Caerula frutescens var. sericea, USA
CBS 222.72A Unknown, Russia
CBS 127170 Unknown, Unknown
CBS 392.49 Rubus idaeus, Unknown
CBS 810.97 Rubus fruticosus, Unknown
CBS 718.96 Vicia faba, Netherlands
CBS 814.97 Forsythia sp., Netherlands
CBS 390.49 Fragaria sp., Unknown
CBS 110274 Trifolium pratense, Germany
CBS 113707 Citrus sinensis, Portugal
CBS 121305 Humulus lupulus, Slovenia
CBS 322.91 Solanum lycopersicon, Netherlands
CBS 366.91 Humulus lupulus, Belgium
CBS 121306 Humulus lupulus, Slovenia
CBS 452.51 Antirrhinum sp., UK
CBS 130339* Solanum tuberosum, Japan
CBS 451.88 Unknown, Belgium
CBS 454.51 Solanum tuberosum, UK
CBS 382.49 Unknown, Unknown
CBS 381.49 Unknown, Unknown
CBS 385.91 Solanum lycopersicon, Netherlands
CBS 382.66 Verticillium albo-atrum, Canada
CBS 321.91 Solanum lycopersicon, Netherlands
CBS 127169 Medicago sativa, USA
CBS 130603* Medicago sativa, USA
CBS 241.82 Catalpa bignonioides, Italy
CBS 453.51 Catalpa bignonioides, UK
CBS 578.50 Soil, England
CBS 457.51* Sol, UK
CBS 456.51 Solanum tuberosum, UK
CBS 130340* Sol, Canada
CBS 101242 Solanum tuberosum, UK
CBS 682.88 Solanum tuberosum, Netherlands
CBS 388.82 Dung, Germany
CBS 120947 Humulus lupulus, Denmark

Fig. 1. (Continued).
Fig. 1. (Continued).
by the isolates CBS 117131 and CBS 113951. **Clade II** (82 % BS) encompassed one subclade representing *Acremonium stromaticum* (99 % BS), a second subclade (100 % BS) formed by four unnamed isolates CBS 299.70G, CBS 299.70H, CBS 620.76 and CBS 657.94, and a third subclade (100 % BS) representing *Acremonium furcatum*. The isolates BCC 79864 and CBS 112271 from soil and *Theobroma sp.*, respectively were distributed in two single lineages within the clade II. The genus *Chordomyces* was placed in **clade III** (100 % BS), which was divided in two terminal subclades. The first one (100 % BS) included the ex-type strain of *C. albus* CBS 987.87 and 10 European isolates from different sources, and the second one (96 % BS) harboured the ex-type strain of *C. antarcticus* CBS 120045 and seven Asian isolates mainly from soil. **Clade IV** (100 % BS) encompassed three well-supported subclades. The first one (95 % BS) was represented by 13 accepted species of *Plectosphaerella*, which were distributed in well-separated lineages. An unnamed isolate CBS 423.66 was placed in a single branch, phylogenetically related (100 % BS) with the clade containing *P. plurivora* and *P. paucisepeta*. The second subclade (100 % BS) included the ex-isotype strain of *Acremonium nepalense* CBS 971.72, the isotype of *Gliocladium cibotii* CBS 109240, and five isolates mainly from ferns belonging to two unnamed species. The third terminal subclade (100 % BS) was represented by two unidentified isolates, CBS 103.95 and CBS 418.89 from soil and *Dioscorea sp.*, respectively. **Clade V** (100 % BS) encompassed three Japanese isolates of *Gibellulopsis chrysanthemi*, including the ex-type MAFF 242621. Basal but unrelated with this clade, the isolate CBS 299.70B was placed in a single lineage (L1). **Clade VI** (100 % BS) comprised the genus *Musicillium*, with the ex-neotype strain of *Musicillium theobromae* CBS 968.72 located in a terminal subclade (83 % BS) together with 10 isolates mainly from *Musa*, and nine isolates distributed in two subclades representing two putative new species. The soil isolate CBS 120158 was located in a single branch, basal to *Musicillium* clade. **Clade VII** (98 % BS) clustered two separate monophyletic lineages, one of them included the ex-type strain of *Acremonium restrictum* CBS 178.40 and six isolates from different origins, and the other one contained two isolates of *A. collariferum* including the ex-type CBS 124586. **Clade VIII, IX** and X represented the genera *Stachyphilum*, *Brunneomyces* and *Lectera*, respectively, each one fully supported (100 % BS). **Clade XI** was the biggest clade, representing the genus *Verticillium* with 10 accepted species. Most of the species were placed in independent and well-supported clades. However, the ex-type strains of *V. dahliae* CBS 130341 and *V. longisporum* CBS 124.64 grouped together in a highly supported (93 % BS) terminal clade, phylogenetically related (100 % BS) with *V. nonalfalfae* and *V. alfalfae*. Similarly, the ex-type strains of *V. klebahnii* CBS 13034A and *V. isaccii* CBS 130343 clustered together, but in a poorly supported clade, which was phylogenetically related (98 % BS) with *V. zaregmansianum* and *V. tricorpus*. The ex-type strain of *V. tricorpus* CBS 447.54 clustered with a pool of isolates mainly from *Solanum lyco-persicum* and *S. tuberosum*, in a poorly supported clade. **Clade XII** (100 % BS) encompassed the genera *Acrostalagmus* and *Sodiomyces*. The former was represented by 14 isolates of *A. luteoalbus* and five isolates of *A. annulatus*, distributed in two main subclades. The subclade containing *Sodiomyces* (100 % BS) clustered the three accepted species, *S. alkalinus*, *S. tronii* and *S. magadai*, and the ex-isotype strain of *Acremonium alcalophilum* CBS 114.92.

In order to resolve the species delimitation in *Verticillium*, a second phylogenetic analysis was carried out with a subset of isolates and the ex-type strain of each species from this genus. The combined dataset of ITS, ACT, EF and TS loci included 54 ingroup taxa, with *Gibellulopsis nigrescens* PD709 as the outgroup. The final alignment encompassed 2 960 characters including 805 phylogenetically informative positions (135 ITS, 151 EF, 158 TS and 361 ACT). The best-fit nucleotide substitution model for ML analysis was GTR+I+G. The phylogenetic tree (Fig. 2) resolved the 10 accepted species in *Verticillium*, placing the ex-epitype strain of *V. dahliae* CBS 130341 in a well-supported clade (92 % BS) with nine more isolates, and separated from the two alleles of *V. longisporum* A1 and D3 (Inderbitzin et al. 2011a). Those species together with *V. alfaffae* and *V. nonalfalfae* were accommodated in a main clade (95 % BS) called Flavnonexudans according to Inderbitzin (2011a). In the case of *V. klebahnii*, it was placed on a single branch phylogenetically related (100 % BS) but separate from the clade containing the *V. isaccii* isolates. The ex-type strain of *V. tricorpus* was distant, located in a fully supported clade (100 % BS) with 14 isolates mainly obtained from tomato and potato. The last three species, plus *V. albo-atrum* and *V. zaregmansianum* were nested in a main clade (89 % BS) named Flavexudans, following the nomenclature of Inderbitzin et al. (2011a).

According to the phylogenetic results and the morphological features, 12 new genera and 15 new species are proposed in this study, in addition to 10 new combinations. Generic and species descriptions and illustrations are provided here for the new taxa and for some species previously described by other authors, but included in this revision. Genera and species are alphabetically arranged following the clade number shown in Fig. 1.

**TAXONOMY**

**Plectosphaerellaceae** W. Gams et al., Nova Hedwigia 85: 476. 2007. Emended.

Type genus: *Plectosphaerella* Kleb.

Ascomata perithecial or cleistothecial, solitary or gregarious, superficial, subglobose, globose or pyriform, brown to dark brown, with paler and elongate neck, with or without setae around the base of the neck. *Peridium* multi-layered, with *textura angularis*. Paraphyses conspicuous in young stages or absent. Ascii uniloculate, cylindrical, clavate or saccate, thin-walled, lacking an apical differentiation, 8-spored. Ascospores ellipsoidal or ovoid, 1- or 2-celled, hyaline or pale brown, smooth to slightly warted. *Conidiomata* when present, synnematous, sporodochial or acervular. *Conidiophores* simple or branched. *Conidiogenous cells* enteroblastic, mono- or polyphialidic. *Conidia* variable in shape, 1- or 2-celled, hyaline or pigmented, arranged in slimy heads or chains. Clamydospores and pigmented microsclerotia usually formed by some species (modified from Zare et al. 2007, Maharachchikumbura et al. 2016).

Notes: The family concept was based in the holomorph species *Plectosphaerella cucumerina*, which produces perithecia with elongate necks. The asexual morphs were described as phialidic with mononematous conidiophores (Zare et al. 2007). However, since the introduction of *Sodiomyces*, which forms cleistothecial
ascomata (Grum-Grzhimaylo et al. 2013), and *Lectera* and *Acrostalagnus annulatus* which produce conidiomata (Rébllová et al. 2011; Cannon et al. 2012), the diagnosis of the family had to be broadened.

**Clade I**

### Gibellulopsis

*G. serrae* single branch which is sister to the clade (90 % BS) harbouring *G. nigrescens*. Although *G. aquatica* produces branched chains of chlamydospores as does *G. catenata*, the production of these structures remained scarce after 14 d, becoming profuse after 21 d. Only 1-celled conidia were observed in all media tested.

*Gibellulopsis catenata* Giraldo López & Crous, sp. nov. MycoBank MB828035. Fig. 4.

**Etymology:** Named after the production of chlamydospores in chains.

*Gibellulopsis* consisting of branched, septate, smooth, hyaline and thin-walled hyphae, up to 2 μm wide. *Conidiophores* arising from submerged or superficial hyphae, (sub-)erect, simple or poorly branched, bearing 1–2 levels with 2–3 phialides per node, ca. up to 96 μm long, 1.5–2.5 μm wide at the base, hyaline, smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. *Phialides* terminal, lateral, cylindrical or acicular, hyaline, thick- and smooth-walled, 29–61 μm long, 1.5–2 μm wide at the base, with inconspicuous collarette and periclinal thickening at the conidiogenous locus, occasionally with a percurrent proliferation. *Conidia* cylindrical with rounded ends, 1- or 2-celled, hyaline- and smooth-walled, 4.1–12.9 × 1.5–2.8 μm, arranged in slimy heads. *Chlamydo-spores* terminal, lateral or intercalary, mostly in single or branched chains, subglobose or ellipsoidal, pale brown, smooth- and thick-walled, 5.3–9 × 3.9–6.9 μm. *Sexual morph* not observed.

Specimen examined: Germany, from cloud water of mare, unknown date and collector (*holotype* CBS H-23650, culture ex-type CBS 113951).

Notes: *Gibellulopsis catenata* is represented by a single isolate, which is placed in a single branch basal to the main clade (86 % BS) containing *G. serrae*, *G. aquatica* and *G. nigrescens*. *Gibellulopsis catenata* can be morphologically distinguished from the other species of the genus by the production of long branched chains of chlamydospores and by formation of 2-celled conidia.

### Gibellulopsis aquatica

*G. fusca*: After 14 d at ca. 25 °C: On PDA reaching 48 mm diam, flat, woolly, entire margin, fuscous black at centre and white at periphery, reverse fuscous black. On OA reaching 44–45 mm diam, flat, dusty, entire margin, white, reverse uncoloured.

Specimen examined: Germany, from cloud water of mare, unknown date and collector (*holotype* CBS H-23650, culture ex-type CBS 113951).

Notes: *Gibellulopsis fusca* is represented by a single isolate, which is placed in a single branch basal to the main clade (86 % BS) containing *G. serrae*, *G. aquatica* and *G. nigrescens*. *Gibellulopsis fusca* can be morphologically distinguished from the other species of the genus by the production of long branched chains of chlamydospores and by formation of 2-celled conidia.

### Gibellulopsis catenata

*G. catenata* Giraldo López & Crous, sp. nov. MycoBank MB828038. Fig. 5.

**Basionym:** *Cephalosporium serrae* var. *fuscum* *Thurim.* & Sukapure, Mycologia 58: 360. 1966.

**Synonyms:** *? Cephalosporium apii* M.A. Smith & Ramsey, Bot. Gaz.112: 399. 1951.

*Accrementum apii* (M.A. Smith & Ramsey) W. Gams, Cephalosporium-artige Schimmelpilze 136. 1971.

*Myceium* consisting of branched, septate, smooth, hyaline and thin-walled hyphae, 1.5–2.5 μm wide. *Conidiophores* arising from submerged or superficial hyphae, erect or slightly curved, simple or poorly branched, up to 65 μm long, 1.5–2 μm wide at the base, hyaline, smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. *Phialides* lateral, cylindrical or subulate, hyaline, thick- and smooth-walled, occasionally borne on short cylindrical subteluting cells; 32–65 μm long, 1.5–2 μm wide at the base, with inconspicuous collarette and periclinal thickening at the conidiogenous locus, occasionally with a percurrent proliferation. *Conidia* cylindrical with rounded ends, 1- or 2-celled, hyaline, thin- and smooth-walled,
Fig. 2. Maximum composite likelihood tree based on partial sequences from ITS, ACT, TEF1-α and TS regions from \textit{Verticillium} species. Bootstrap support values above 70% are shown at the nodes. \textsuperscript{T} Ex-type, \textsuperscript{ET} Ex-epitype.
6.9–13.7 \times 2.5–4 \mu m, arranged in slimy heads. *Chlamydospores* lateral or intercalary, single or in pairs, with or without intermittent hyaline cells, subglobose, ellipsoidal or obpyriform, brown, smooth- and thick-walled, 6.5–10 × 4.7–6.7 \mu m. *Sexual morph* not observed.

*Culture characteristics*: After 14 d at ca. 25 °C: On PDA reaching 40–42 mm diam, flat, velvety, white, reverse becoming grey to black with age. On OA reaching 57–59 mm diam, flat, felty, white, reverse becoming grey with age. On PCA reaching 34–38 mm diam, flat, scarce aerial mycelium, white, reverse uncoloured. On MEA reaching 51–53 mm diam, raised, cottony, white, reverse dark brown to black.

*Specimens examined*: Germany, Giessen, from *Apium graveolens*, unknown date and collector, CBS 308.38. India, Banaras, from soil, Dec. 1962, M.J. Thirumalachar (holotype CBS H-19291, culture ex-type CBS 560.65 = ATCC 16090 = HACC 149 = IMI 112791). Iran, Mashad, from *Beta vulgaris*, unknown date and collector, CBS 120818. Netherlands, Baam, from *Aegopodium podagraria*, unknown date, H.A. van der Aa, CBS 402.80; from *Apium graveolens*, unknown date and collector, CBS 747.83.

*Notes*: This clade contains two isolates from *Apium graveolens* (CBS 308.38 and CBS 747.83), one from *Beta vulgaris* (CBS 120818), one from *Aegopodium podagraria* (CBS 402.80) and one from plant debris (CBS 560.65); which form a basal clade (82 % BS) to the remaining species from the genus. Since this clade includes the ex-type strain of *Cephalosporium serrae* var. *fuscum* (CBS 560.65, Sukapure & Thirumalachar 1966), which we have demonstrated is a different species from *C. serrae* (treated here as *Gibellulopsis serrae*), the new combination *Gibellulopsis fusca* is proposed. Strains CBS 560.65 and CBS 120818 were also studied by Zare et al. (2007), who
Fig. 3. Gibellulopsis aquatica (ex-type CBS 117131). A. Colony on PDA after 14 d at 25 °C. B–F. Conidiophores. G, H. Chlamydospores. I. Conidia. Scale bars: B, C = 20 μm; D–H = 10 μm; I = 5 μm.

Fig. 4. Gibellulopsis catenata (ex-type CBS 113951). A. Colony on PDA after 14 d at 25 °C. B–D. Conidiophores. E, F. Chlamydospores. G. Conidia. Scale bars = 10 μm.
demonstrated their genetic differences from *G. nigrescens* and *G. piscis* (treated here as *G. serrae*) in ITS and TEF1-α sequences, as well as their different growth patterns at 27 °C and 33 °C.

*Cephalosporium apii* (currently *Acremonium apii*) was described from *Apium graveolens* based on the strain CBS 130.51 (= ATCC 10837 = IMI 92629), as the causal agent of brown spot of celery (Smith & Ramsey 1951). The species is morphologically similar to *G. fusca* in the chlamydospore’s shape and colour, and in the production of cylindrical septate conidia, which was also noticed by Gams (2017). According to Zare et al. (2007) and Summerbell et al. (2011) the LSU and ITS sequences derived from CBS 130.51 falls with *Verticillium albo-atrum*, being considered as synonym of this species.

We have sequenced three different batches of CBS 130.51 from the culture collection, obtaining the same molecular results as Zare et al. (2007) and Summerbell et al. (2011). However, the examination of the culture led us to conclude that the strain was swapped at some point before or after it was deposited, since the micromorphology does not match that what was originally described and illustrated as *Acremonium apii* (Gams 1971).

**Gibellulopsis nigrescens** (Pethybr.) Zare et al., Nova Hedwigia 85: 477. 2007. Fig. 6.

*Basionym:* *Verticillium nigrescens* Pethybr., Trans. Brit. Mycol. Soc. 6: 177. 1919.

*Synonym:* *Verticillium dahiae f. zonatum* J.F.H. Beyma, Antonie van Leeuwenhoek 6: 43. 1940.

*Mycelium* consisting of branched, septate, smooth, hyaline and thin-walled hyphae, up to 2 μm wide. *Conidiophores* arising from submerged or superficial hyphae, (sub-)erect, mostly irregularly branched, bearing 1–4 levels with 1–3 phialides per node, ca. up to 100 μm long, 1.5–2.5 μm wide at the base, hyaline, smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. *Phialides* terminal, lateral, aculeate, hyaline, thick- and smooth-walled, 21–44 μm long, 1–2 μm wide at the base, with conspicuous collarette and a distinct periclinal wall thickening at the conidiogenous locus. *Conidia* cylindrical with rounded ends, sometimes with a slightly protuberant basal end, 1-celled, hyaline, becoming pale brown with age, thin- and smooth-walled, 4.1–5.6 × 1.6–2.3 μm, arranged in slimy heads. *Chlamydospores* terminal, lateral or intercalary, mostly single, globose to subglobose, olivaceous brown, smooth- and thick-walled, 4.1–6.1 × 3.7–4.6 μm.

**Culture characteristics:** After 14 d at ca. 25 °C: On PDA reaching 47–53 mm diam, flat, finely floccose, olivaceous black with a smoke-grey mycelium at centre and white towards the periphery, reverse olivaceous grey to black. On OA reaching 38–40 mm diam, flat, membranous, surface and reverse greenish black. On PCA reaching 18–19 mm diam, flat, glabrous, surface and reverse greenish black. On MEA reaching 30–33 mm diam, radially folded, felly, with white, buff and grey concentric rings, reverse iron grey.

Specimens examined: Denmark, Klippinge, from *Linum usitatissimum*, 1964, A. Jensen CBS 469.64. Finland, from moisture damaged building insulator wool, unknown date, VTT, CBS 123176. France, from *Medicago sativa*, idem., A. Jensen CBS 470.64. Israel, Kerem-Shalom, from *Solanium tuberosum*, 1994–1996, N. Korolev, CBS 100829, CBS 100844; Lahav, from soil, idem., CBS 100832, CBS 10833. Netherlands, Baarn, from soil under lawn, Feb. 2007, W. Gams (neotype of *Verticillium nigrescens* CBS-H 19845, culture ex-neotype CBS 120949, designated in Zare et al. 2007); Kwade Hoek, from sandy soil, 2002, F.X.
Prenafeta-Boldú, CBS 110719; Rotterdam, from wrapping material, unknown date and collector (holotype of Verticillium dahliae f. zonatum CBS 179.40 culture permanently preserved in a metabolically inactive state) culture ex-type CBS 179.40 = MUCL 9783; from nail, unknown date, A. van Duin, CBS 119666.

UK, soil under Humulus lupulus, idem., I. Isaac, CBS 577.50; from Solanum tuberosum, idem., I. Isaac, CBS 455.51 = MUCL 9790.

Notes: This species was originally described as Verticillium nigrescens from potato tubers in England (Pethybridge 1919) and later on, neotypified with a soil isolate (CBS 120949) from the Netherlands (Zare et al. 2007). However, Zare et al. (2007) demonstrated that it is not congeneric with Verticillium s. str., being conspecific with the type species of Gibellulopsis, G. piscis. As a consequence, the new combination Gibellulopsis nigrescens, was introduced. The isolates studied by Zare et al. (2007) were phenotypically and genetically variable, clustering in different subclades according to partial TEF1-α sequences. One of them comprised the ex-types of Cephalosporium serrae CBS 290.30 and G. piscis CBS 892.70, and other one held the neotype of G. nigrescens. The authors did not consider those differences significant enough to justify renaming those clades and they treated all isolates as G. nigrescens. According to our multilocus phylogenetic analyses and morphological examination, these subclades correspond to G. serrae and G. nigrescens, respectively (Fig. 1).

Gibellulopsis serrae (Maffei) Giraldo López & Crous, comb. nov. MycoBank MB828040. Fig. 7.
Basionym: Cephalosporium serrae Maffei, Atti Ist. Bot. Pavia. Ser. 4: 196. 1930.

Synonyms: Verticillium serrae (Maffei) F.H. Beyma, Antonie van Leeuwenhoek 6: 40. 1939.

Hyalopus serrae (Maffei) Barbosa, Subsidios para o Estudo parasitologico do Genero Hyalopus. Thesis, Recife: 19. 1941.
Verticillium amaranthi Verona & Ceccar., Phytopathol. Z. 8: 373. 1935 (as ‘amaranti’).
Gibellulopsis piscis Bat. & H. Maia, Anais. Soc. Biol. Pernambuco 16: 156. 1959.

Mycelium consisting of branched, septate, hyaline, smooth- and thin-walled hyphae, up to 2 μm wide. Conidiophores arising from submerged or superficial hyphae, (sub-)erect, simple or branched, bearing 1–2 levels with 2–3 phialides per node, ca. up to 300 μm long, 2.5–3 μm wide at the base, hyaline, smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. Phialides terminal, lateral, cylindrical or aculeate, hyaline, thick- and smooth-walled, 23–72 μm long, 1.5–2 μm wide at the base, with inconspicuous collarette and a distinct periclinal thickening at the conidiogenous locus. Conidia ellipsoidal to cylindrical with rounded ends, 1-celled, hyaline, thin- and smooth-walled, 3.5–7.4 × 1.7–2.3 μm, arranged in slimy heads. Chlamydospores mostly intercalary, singly or in pairs, globose to subglobose with a truncate base, pale brown, smooth- and thick-walled, 5–5.5(–7) × 2(–2.5)–5 μm. Sexual morph not observed.

Culture characteristics: After 14 d at ca. 25 °C: On PDA reaching 50–65 mm diam, flat, felty or floccose, completely white or pale mouse grey at centre and colourless to the periphery, reverse uncoloured or dark mouse grey. On OA reaching 42–50 mm diam, flat, felty at centre, glabrous or membranous at periphery, slightly zonate, entire margin, white, reverse uncoloured. On PCA reaching 30–42 mm diam, flat, glabrous or membranous to
finely floccose, entire margin white, reverse uncoloured. On MEA reaching 28–30 mm diam, raised, feltly to downy, entire margin, white, reverse uncoloured. In cultures older than 20 d the reverse becomes more or less dark grey due to formation of chlamydospores.

**Specimens examined.** Argentina, Buenos Aires, from seed, unknown date and collector, CBS 493.82B, CBS 493.82C, Misiones, from soil, unknown date and collector, CBS 493.82A. Brazil, Recife, from granuloma in goldfish (Carassius auratus), 28 Jul. 1957, Batista (holotype of Gibellulopsis piscis I.M.U.R. 891, culture ex-type CBS 892.70 = ATCC 16168 = IFO 6653). Canada, Quebec, from Beta vulgaris var. altissima, unknown date and collector, CBS 383.66. Cuba, Santiago de Las Vegas, from seed of Abelmoschus esculentus, unknown date, R.F. Castaneda, CBS 392.89 = INIFAT C88-362. Germany, from Solanum tuberosum, idem., K.H. Schramm, CBS 175.75 = BBA 12362. Greece, Thessaloniki, from human blood, idem., E. Rolides, CBS 109724. India, Bangaon, from leaf of Musa sp., unknown date and collector, CBS 120008; unknown, substrate, date and collector, CBS 416.76. Israel, Ein-Sherem, from soil, 1994–1996, N. Korolev, CBS 100830; from soil in cotton field, idem., CBS 101221; Gilat, from Solanum tuberosum, idem., CBS 100826; Ramat-David, from soil in cotton field, idem., CBS 100827. Italy, from human eye, unknown date, G.M. Serrà (holotype of Cephalosporium serrae CBS 290.30 culture permanently preserved in a metabolically inactive state) culture ex-type CBS 290.30 = MUCL 7973; from Amanthus tricolor, unknown date, O. Verona (holotype of Verticillium amaranthi CBS H-19312, culture ex-type CBS 387.35 = MUCL 9784). Japan, from Solanum tuberosum, unknown date and collector, CBS 101277 = NSRC 32001. Moldavia, from Cercospora beticola, idem., CBS 565.78B = VKM F-481. New Zealand, Havelock North, from soil, idem., CBS 125.79. Russia, Astrakhan, from Erysiphe sp., idem., CBS 565.78C = VKM F-241; Odessa, from Oldium sp., idem., CBS 565.78A = VKM F-53. Sweden, from wood pulp, idem., CBS 345.39.

**Notes:** Most of the isolates in this clade were previously identified as Gibellulopsis nigrescens. However, the neotype of that species falls in a different clade, and therefore, these isolates represent a species distinct from G. nigrescens. This clade harbours the ex-types of Cephalosporium serrae CBS 290.30, G. piscis CBS 892.70 and Verticillium amaranthi CBS 387.35, which were previously considered as synonyms of G. nigrescens (Zare et al. 2007). Since C. serrae is the oldest epithet, we propose G. serrae comb. nov. for the isolates included in this clade. Although the isolates in this clade are genetically heterogeneous we were not able to separate them and we prefer to keep them as a single species until more studies are performed.

**Clade II**

**Furcasterigmium** Giraldo López & Crous gen. nov. MycoBank MB828041.

**Etymology:** From the Latin *furcatus*, meaning fork, and modern Latin, from Greek *stigma*, meaning support. In reference to the forked-like appearance of the conidiogenous cell characteristically formed by these fungi.

**Mycelium** consisting of branched, septate, hyaline and thick-walled hyphae. **Conidiophores** erect, unbranched or poorly branched, often proliferating sympodially, showing conidiogenous cells as short lateral and cylindrical asymmetrical projections. **Conidiogenous cells** enteroblastic, mono- and pol-yphialidal, terminal, lateral, subulate, hyaline, with conspicuous collarette and periclinal thickening at the conidiogenous locus. **Conidia** ellipsoidal, 1-celled, hyaline, smooth-walled, arranged in slimy heads. **Sexual morph** unknown.

**Type species:** Furcasterigmium furcatum (W. Gams) Giraldo López & Crous.

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Fig. 7. Gibellulopsis serrae. B, D. CBS 892.70. A, C, E, F. CBS 101221. H. CBS 565.78C. A. Colony on OA after 14 d at 25 °C. B–D. Conidiophores. E, F. Chlamydospores. G, H. Conidia. Scale bars = 10 μm.
**Furcasterigmium furcatum** (W. Gams) Giraldo López & Crous, comb. nov. MycoBank MB828042. Fig. 8.

**Basionym:** *Acremonium furcatum* W. Gams, Nova Hedwigia 18: 3. 1969.

**Synonym:** *Cephalosporium furcatum* Moreau & R. Moreau, Rev. Mycol. 6: 65. 1941. Nom. inval., Art. 39.1 (Melbourne).

Mycelium consisting of branched, septate, hyaline and thick-walled hyphae, 2–2.5 μm wide. Conidiophores erect, unbranched or proliferating sympodially, showing conidiogenous cells as short lateral and cylindrical asymmetrical projections, up to 36 μm long, 2.5 μm wide at the base, hyaline, smooth-walled. Phialides lateral, terminal, subulate, hyaline, thick- and smooth-walled, 18–36 μm long, 2–2.5 μm wide at the base, with cylindrical collarette and conspicuous periclinal thickening at the conidiogenous locus, polyphialides with up to three conidiogenous loci commonly present. Conidia ellipsoidal, sometimes with a slightly apiculate base, 1-celled, hyaline, thick- and smooth-walled, 2.7–3.8 × 1.5–2.1 μm, arranged in slimy heads. Sexual morph unknown.

**Culture characteristics:** After 14 d at ca. 25 °C: On OA reaching 35–41 mm diam, flat, dusty, dirty white, reverse uncoloured. On MEA reaching 26–35 mm diam, radially folded, hairy at the centre, floccose at periphery, entire margin, dirty white, reverse uncoloured.

**Specimens examined:** France, Normandie, Pointe du Siège, from young dunes under *Calystegia soldanella*, unknown date and collector (holotype of *Cephalosporium furcatum* CBS 122.42 culture permanently preserved in a metabolically inactive state) culture ex-type CBS 122.42 = IAM 14647 = MUCL 9745. Germany, from Loamy löss soil, unknown date, A. von Klopotek, CBS 299.70C; Kr. Plön, Schüttbrehm, from *Gymnopilus* sp., unknown date and collector CBS 299.70F; Lübeck, from moist house, unknown date, R.A. Samson, CBS 116550. Iran, from *Vitis vinifera*, Aug. 2004, T. Gräfenhan & R. Zare, CBS 116548. Italy, Turin, from agricultural soil, unknown date and collector, CBS 299.70A.

Notes: Twenty isolates labelled as *Acremonium furcatum* were included in this study. They were genetically heterogenous and were distributed in different clades along the tree (Fig 1). Six of them, including the ex-type CBS 122.42, formed a monophyletic lineage (100 % BS) within clade II which is proposed here as the new monotypic genus, *Furcasterigmium*. The remaining isolates were placed in the clades representing the genera *Chordomyces*, *Theobrium* and *Phialoparvum*, which will be discussed below.

*Furcasterigmium furcatum* was originally described as *Cephalosporium furcatum* from young dunes in France (Moreau & Moreau 1941), but invalidly published because of the lack of a Latin diagnosis. The species was validated by Gams (Gams & Domsch 1969) and transferred to the genus *Acremonium* as one of the species from the section Nectrioidea (Gams 1971). Among the species in that section, *A. furcatum* resembles *A. hyalinulum* in the production of schizophialides, but the conidia of the latter species are arranged in chains. According to Gams (1971), *A. furcatum* sometimes produces synnemata in culture, linking the species with *Tilachlidium*. However, no synnemata were observed by us among the representative isolates of *Furcasterigmium*.

**Summerbellia** Giraldo López & Crous, gen. nov. MycoBank MB828043.

**Etymology:** In honour of Richard Summerbell, who made a huge contribution towards the modern taxonomy of *Acremonium* species.
Mycelium consisting of branched, septate, hyaline and thick-walled hyphae. Conidiophores erect or (sub-)erect, unbranched or poorly branched. Conidiogenous cells enteroblastic, monophialidic, terminal, lateral, sub-cylindrical, hyaline, with minute cylindrical collarette, and an inconspicuous periclinal thickening at the conidiogenous locus. Conidia ellipsoidal or cylindrical, 1-celled, hyaline, smooth-walled, arranged in slimy heads. Chlamydospores terminal or intercalary, mostly in chains, pale to dark brown, smooth- and thick-walled. Sexual morph unknown.

**Types species:** *Summerbellia oligotrophica* Giraldo López & Crous.

**Summerbellia oligotrophica** Giraldo López & Crous, sp. nov. MycoBank MB828044. Fig. 9.

*Etymology:* Referring to the oligotrophic nature of the fungus.

**Mycelium** consisting of branched, septate, hyaline and thick-walled hyphae, up to 2 μm wide. Conidiophores erect or (sub-)erect, simple or poorly branched, up to 50 μm long, 2 μm wide at the base, hyaline, smooth-walled. Phialides terminal, lateral, sub-cylindrical, hyaline, thin- and smooth-walled, often borne on short cylindrical subtending cells; 13–50 μm long, 1.5–2 μm wide at the base, with minute cylindrical collarette, and an inconspicuous periclinal thickening at the conidiogenous locus. Conidia ellipsoidal or cylindrical, 1-celled, hyaline, thin- and smooth-walled, 2.3–4.3 × 1.2–2 μm, arranged in slimy heads. Chlamydospores, terminal or intercalary, mostly in chains, subglobose, light to dark brown, smooth- and thick-walled, 3–4 × 3–4 μm.

**Culture characteristics:** After 14 d at ca. 22 °C: On OA attaining 40–44 mm diam, flat, dusty, dirty white, reverse slightly buff. On MEA attaining 35–38 mm diam, raised, radially folded, hairy, diffuse margin, buff, uncoloured reverse.

**Specimens examined:** Australia, New South Wales, unknown substratum, date and collector, CBS 620.76. Indonesia, from alkaline soil, unknown date, K. Nagai (holotype CBS-H-23648, culture ex-type CBS 657.94). USA, Florida, from grapefruit juice can, unknown date and collector, CBS 299.70G = QM 2995; from bath towel, idem., CBS 299.70H = QM 3222.

**Notes:** The genus *Summerbellia* is proposed here for a group of isolates clustering in a well-supported monophyletic lineage in clade II (Fig. 1). All isolates were previously identified as *Gliocladium cibotii* based on morphological characters. However, the ex-type strain of this species falls in a phylogenetically distant clade (named here *Brunneochlamydosporium*). In addition, *G. cibotii* differs by having a faster growth rate on OA and MEA, frequently branched conidiophores, and larger conidia and chlamydospores than those of *S. oligotrophica*.

Among the isolates included in *Summerbellia*, CBS 657.94 and CBS 299.70H were also treated by Zare et al. (2007), who found them to be genetically different from the ex-type strain of *G. cibotii*. However, the authors could not correlate the molecular difference with any phenotypic feature.

**Musidium** Giraldo López & Crous gen. nov. MycoBank MB828045.

*Etymology:* From Latin *Musa*, meaning banana, the most frequent host.

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**Fig. 9.** *Summerbellia oligotrophica* (ex-type CBS 657.94). A. Colony on MEA after 14 d at 25 °C. B–D. Conidiophores. E. Chlamydospores. F, G. Conidia. Scale bars: B–D, F, G = 10 μm; E = 5 μm.
Mycelium consisting of branched, septate, hyaline and thin-walled hyphae. Conidiophores erect, unbranched or poorly branched. Conidiogenous cells enteroblastic, monophialidic, terminal, lateral, subulate, hyaline, with short cylindrical collarette, and with a distinct periclinal thickening at the conidiogenous locus. Conidia cylindrical or ellipsoidal, 1-celled, hyaline, smooth-walled, arranged in slimy heads. Stromatic hyphae branched or unbranched, dark olivaceous, incrusted or smooth and thick-walled, produced on the bottom of plate cultures or at the edge of agar slants. Sexual morph unknown.

Type species: Musidium stromaticum (W. Gams & R.H. Stover) Giraldo López & Crous.

Musidium stromaticum (W. Gams & R.H. Stover) Giraldo López & Crous, comb. nov. MycoBank MB828046. Fig. 10. Basionym: Acremonium stromaticum W. Gams & R.H. Stover, Trans. Brit. Mycol. Soc. 64: 400. 1975.

Mycelium consisting of branched, septate, hyaline and thin-walled hyphae, 2–2.5 μm wide. Conidiophores erect, lateral, unbranched or basitonously branched, up to 59 μm long, 2.5 μm wide at the base, hyaline, smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. Conidiogenous cells lateral, subulate, hyaline, thick- and smooth-walled, 23–55 μm long, 2–2.5 μm wide at the base, with cylindrical collarette, and with a distinct periclinal thickening at the conidiogenous locus, commonly with a percurrent proliferation. Conidia cylindrical with rounded ends or ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 4.2–6.2 × 1.4–2.3 μm, arranged in slimy heads. Stromatic hyphae branched, dark olivaceous, smooth- and thick-walled, produced on the bottom of plate cultures or at the edge of agar slants. Sexual morph unknown (Adapted from Gams 1975).

Culture characteristics: After 14 d at ca. 25 °C: On PDA reaching 70–71 mm diam, flat, felty, fimbriate margin, dirty white, reverse uncoloured. On OA reaching 69–72 mm diam, flat, membranous with scarce aerial mycelium, dirty white, reverse uncoloured. On MEA reaching 28–42 mm diam, flat, wrinkled, woolly to cotty, filiform margin, dirty white, reverse gradually becoming dark grey by the stromatic tissue.

Specimens examined: Colombia, Turbo, from Musa sp., unknown date, R.H. Stover, CBS 135.74D. Costa Rica, Coto valley, idem., CBS 132.74, CBS 133.74. Honduras, Lula valley, idem., unknown date, R.H. Stover, CBS 134.74, CBS 135.74C; from Musa sapientum root lesions, Dec. 1962, R.H. Stover (isotype IMI 185381, culture ex-type CBS 863.73 = ATCC 32187). Panama, Changumola, from Musa sp., unknown date, R.H. Stover, CBS 135.74A. Philippines, Mindanao, from rhizosphere of Musa sp., idem., R.H. Stover, CBS 135.74F. Tanzania, from Musa sp., 1953, G.B. Wallace, CBS 135.74H. UK, England, Kew, Royal Botanical Gardens, from leaf of Musa sp. (in a greenhouse), 1969, W. Gams, CBS 135.74G.

Notes: The monotypic genus Musidium is established here to accommodate a group of isolates previously classified as Acremonium stromaticum, which was described based on isolates from Musa sp. in Honduras (Gams 1975). The genus formed a well-supported clade (99 % BS), closely related (Fig. 1) to Sayamraella, Summerbellia and Theobromium (94 % BS), but morphologically differentiable by the production of branched stromatic hyphae. All the isolates in this clade are from root and rhizome lesions from banana growing in the tropics, specially from Central America, except CBS 135.74G which comes from

Fig. 10. Musidium stromaticum (ex-type CBS 863.73). A. Colony on PDA after 14 d at 25 °C. B–D. Poorly branched conidiophores with percurrent proliferations. E, F. Stromatic hyphae. G. Conidia. Scale bars = 10 μm.
Europe and is placed in a separate branch, basal to the clade containing the tropical isolates. All the isolates included in *Musidium stromaticum* were studied by Stover (1966), who treated them as *Cephalosporium* sp. Stover (1966) commonly recorded the isolates in lesions produced by the nematode *Rodopholus similis*, and stated that they can constitute up to 50% of the isolates in such lesions in some areas. Attempts to grow the species are not always successful, since the host material (roots and rhizomes) must to be macerated before plating (Gams 1975).

**Sayamraella** Giraldo López & Crous, *gen. nov*. MycoBank MB828047.

*Etymology*: Name derived from the combination of Sayam and Ra; in Thai meaning Thailand and fungus, respectively; where this fungus was first discovered.

*Mycelium* consisting of branched, septate, hyaline and thick-walled hyphae. *Conidiophores* erect, unbranched or poorly branched, often proliferating sympodially, showing conidiogenous cells as short lateral and cylindrical asymmetrical projections. *Conidiogenous cells* enteroblastic, mono- and polyphialidic, terminal, lateral, subulate, hyaline, with minute cylindrical collarette, and an inconspicuous periclinal thickening at the conidiogenous locus. *Conidia* ellipsoidal, 1-celled, hyaline, smooth-walled, arranged in slimy heads. *Sexual morph* unknown.

*Type species*: *Sayamraella subulata* Giraldo López & Crous.

**Sayamraella subulata** Giraldo López & Crous, *sp. nov*. MycoBank MB828048. Fig. 11.

*Etymology*: Referring to the subulate shape of its phialides.

*Mycelium* consisting of branched, septate, hyaline and thick-walled hyphae, 2–2.5 μm wide. *Conidiophores* erect, unbranched or poorly branched, often proliferating sympodially, showing conidiogenous cells as short lateral and cylindrical asymmetrical projections, up to 74 μm long, 3 μm wide at the base, hyaline, smooth-walled. *Phialides* terminal, lateral, subulate, hyaline, thin- and smooth-walled, 20.3–73.7 μm long, 2.1–3 μm wide at the base, with minute cylindrical collarette, and an inconspicuous periclinal thickening at the conidiogenous locus, polyphialides with up to two conidiogenous loci commonly present. *Conidia* ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 3.6–4.7 × 1.7–2.4 μm, arranged in slimy heads. *Sexual morph* unknown.

*Culture characteristics*: After 14 d at ca. 25 °C: On PDA reaching 60–64 mm diam, flat, floccose to woolly, dirty white, reverse uncoloured, strong geosmin odour. On OA reaching 49–50 mm diam, flat, floccose at centre with concentric rings at periphery, dirty white, reverse uncoloured.

*Specimen examined*: Thailand, Lopburi province, Wang Kan Lueang waterfall, from soil around *Hopea odorata*, 14 Jul. 2015, A. Giraldo (holotype BCC 78964 culture permanently preserved in a metabolically inactive state) culture ex-type BCC 78964.

*Notes*: *Sayamraella subulata* is introduced as a monotypic genus for a fungus isolated from soil collected around roots of *Hopea odorata* in Thailand. The isolate clustered in a single branch within clade II, separated from, but related to, *Summerbellia, Musidium* and *Theobromium* (Fig. 1).

![Fig. 11. Sayamraella subulata (ex-type BCC 78964). A. Colony on PDA after 14 d at 25 °C. B–D. Simple conidiophores. E, F. Phialides. G. Phialide with minute collarette. H. Conidia. Scale bars = 10 μm.](www.studiesinmycology.org)
**Theobromium** Giraldo López & Crous, gen. nov. MycoBank MB828049.

*Etymology:* From Latin *Theobroma*, meaning cacao, the source of isolation of the ex-type strain.

*Mycelium* consisting of branched, septate, hyaline and thin-walled hyphae, becoming light brown and thick-walled with age. *Conidiophores* erect, unbranched or poorly branched, often proliferating sympodially, showing conidiogenous cells as short lateral and cylindrical asymmetrical projections. *Conidiogenous cells* enteroblastic, mono- and polyphialidic, lateral, subulate, hyaline, with minute cylindrical collarette, and an inconspicuous periclinal thickening at the conidiogenous locus. *Conidia* cylindrical or ellipsoidal, 1-celled, hyaline, smooth-walled, arranged in slimy heads. *Sexual morph* unknown.

*Type species:* *Theobromium fuscum* Giraldo López & Crous.

**Theobromium fuscum** Giraldo López & Crous, sp. nov. MycoBank MB828050. Fig. 12.

*Etymology:* From Latin *fuscus*, meaning brownish. Referring to the production of brownish pigmented hyphae.

*Mycelium* consisting of branched, septate, hyaline and thin-walled hyphae, 2–2.5 μm wide, becoming pale brown (especially at the septa) and thick-walled with age, 2.4–4 μm wide. *Conidiophores* erect, unbranched or basitonously branched, bearing up to two phialides, commonly proliferating sympodially, showing conidiogenous cells as short lateral and cylindrical asymmetrical projections, up to 57 μm long, 3 μm wide at the base, hyaline, smooth-walled. *Phialides* lateral, subulate, hyaline, thin- and smooth-walled, 23–38 μm long, 2–3 μm wide at the base, with minute cylindrical collarette, and an inconspicuous periclinal thickening at the conidiogenous locus, commonly with a percurrent proliferation, polyphialides with up to two conidiogenus loci. *Conidia* cylindrical or ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 2.7–4.1 × 1.3–2 μm, arranged in slimy heads. *Sexual morph* unknown.

*Culture characteristics:* After 14 d at ca. 25 °C: On PDA reaching 38–44 mm diam, flat, floccose at centre, diffuse margin, dirty white, reverse uncoloured. On OA reaching 38–40 mm diam, flat, felty at the inoculation point, membranous at the periphery, dirty white, reverse uncoloured. On MEA reaching 31–34 mm diam, raised, radially folded, felty to powdered, dirty white to pale luteous, with an amber exudate and strong geosmin odour.

*Specimen examined:* **Ecuador**, Pichincha province, Vicente Maldonado, from *Theobroma* sp., unknown date, H.C. Evans & K.A. Holmes (holotype CBS H-23657, culture ex-type CBS 112271).

*Notes:* The monotypic genus *Theobromium* is proposed here to accommodate a single strain, isolated from *Theobroma* sp., that is phylogenetically related (94 % BS) with *Summerbellia*, *Musiodium* and *Sayamaella*. *Theobromium fuscum* resembles *Sayamaella subulata* in the production of polyphialides and conidial morphology. However, the former species has phialides with percurrent proliferation, shorter conidiophores and conidia, and a slower growth rate than *Sayamaella subulata*.

**Clade III**

*Chordomyces* Bilanenko et al., Fungal Diversity 76: 55. 2016.

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*Fig. 12. Theobromium fuscum (ex-type CBS 112271). A. Colony on MEA after 14 d at 25 °C. B. Simple conidiophore. C. Conidiophores with percurrent proliferation. D. Polyphialides. E, F. Hyphae. G. Conidia. Scale bars = 10 μm.*
Mycelium consisting of septate, hyaline, thin- and smooth-walled hyphae. Conidiophores erect, solitary or forming synnema, unbranched or branched. Synnema when present sometimes branched, indeterminate, fimbriate, hyaline. Conidiogenous cells enteroblastic, mono- or polyphialidic, tapering towards the apex, hyaline, often proliferating sympodially. Conidia subglobose, limoniform to cylindrical, rounded at the apex, sometimes with protuberant hilum, 1—2—celled, hyaline, smooth-walled, arranged in slimy heads. Sexual morph unknown. Description adapted from that of Giraldo et al. 2017.

Type species: Chordomyces antarcticus Bilanenko et al.

Chordomyces albus Giraldo et al., Mycol. Progr. 16: 359. 2017.

Specimens examined. Belgium, Hoeverlee, from garden soil, 1964, G.L. Hennebert, CBS 299.70E. Germany, Kiel, Botanical Garden, from moist wall, 1965, W. Gams, CBS 206.70; Bottsand, from rhizosphere soil of Aphanthella arenaria, idem., CBS 205.70; Kitzeberg, from dead stem of Angelica archangelica, idem., CBS 204.70. Ireland, from peat, unknown date, C.H. Dickinson, CBS 742.69. Luxembourg, Hautecharage, on Hypogymnia physodes, Dec. 1987, G. Marson (holotype CBS H-8083, culture ex-type CBS 987.67 = MFR 10866). Netherlands, Baarn, on dead leaf of Canna indica, 21 May 1969, W. Gams, CBS 409.70; from forest humus soil, 1964, G.L. Hennebert, CBS 508.65; Wageningen, from soil, unknown date, J.H. van Emden, CBS 743.69. UK, England, Egham, on leaf litter of Viscum album, unknown date, T. Grøenhaug & W. Gams, CBS 580.97.

Notes: Chordomyces albus is the second species described in the genus, from a lichen in Luxembourg (Giraldo et al. 2017). In our study, all the isolates placed in C. albus clade (CBS 204.70, CBS 205.70, CBS 206.70, CBS 299.70E, CBS 409.70, CBS 508.65, CBS 580.97, CBS 741.69, CBS 742.69 and CBS 743.69) were formerly identified as Acremonium furcatum, which is treated here as Furcasteringium furcatum. Both species share the conidial morphology and the production of polyphialides. However, in C. albus the polyphialides have up to two conidiogenous loci, while in F. furcatum they have maximum three conidiogenous loci.

The distribution of C. albus seems to be restricted to Europe and the USA, commonly being isolated from soil, but also found in Canna indica (Cannaceae), Viscum album (Santalaceae) and Angelica archangelica (Apiaceae). Only one isolate is presently known from human sources; it was isolated from sputum in the USA (Giraldo et al. 2017).

Chordomyces antarcticus Bilanenko et al., Fungal Diversity 76: 57. 2016.

Description and illustrations: Grum-Grzhimaylo et al. (2016).

Specimens examined. Kazakhstan, from Suaeda salsa on the coast of the Aral lake, Dec. 2003, F.V. Sapozhnikov, CBS 137610 = A141. Mongolia, North Gobi, Bayan-Zag area, from soil under soda soil, Aug. 2003, I.A. Yamnova, CBS 120042 = M10 = VKM F-156. Portugal, Lisboa, from cork, unknown date and collector, CBS 610.69. Russia, Altai, Kulunda steppe, from soil near the edge of Berdabay lake, Aug. 2005, D.Y. Sorokin, CBS 137607 = A135; at the edge of Bezymiany lake, Aug. 2002, D.Y. Sorokin, CBS 137630 = V21; at the edge of Karakul lake, Nov. 2002, M. Georgieva (holotype CBS H-2196, culture ex-type CBS 120045 = VKM FW-3039); at the edge of Petuchovskoe lake, Aug. 2002, D.Y. Sorokin, CBS 137606 = A134; at the edge of Solyonoe lake, idem., CBS 120047 = M31 = VKM FW-3906; at the edge of Uzkoje lake, idem., CBS 120046 = M30 = VKM FW3042.

Notes: The genus Chordomyces was introduced by Grum-Grzhimaylo et al. (2016) based on C. antarcticus as type species, isolated from soda soils of Russia. The genus was recently emended by Giraldo et al. (2017) to include species with subglobose to limoniform conidia. The majority of isolates of C. antarcticus were recovered from soils with a pH ranging from 8.9 to 10.1, and were alkali-tolerant according to Grum-Grzhimaylo et al. (2016).

Clade IV

Plectosphaerella Kleb., Phytopathol. Z. 1: 43. 1930.

Ascomata perithecial, solitary or gregarious, superficial, subglobose to pyriform, dark-brown in the basal part, paler at the neck, with or without sparse setae around the base of the neck, surface with textura angularis. Setae cylindrical with wider base, rounded to pointed ends, golden brown, thick- and smooth-walled. Asci uniseriate, cylindrical, clavate, thin-walled, lacking an apical differentiation, 8-spored. Ascospores ellipsoidal, 2—celled, hyaline, smooth to slightly warted. Conidiophores simple and poorly branched, hyaline, smooth, thin-walled. Conidiogenous cells enteroblastic, mono- and polyphialidic, terminal, lateral, cylindrical, tapering gradually towards the apex, hyaline, with cylindrical collarette and conspicuous periclinal thickening at the conidiogenous locus. Conidia cylindrical 1- or 2-celled, hyaline, smooth-walled, arranged in slimy heads (adapted from Uecker 1993, Domsch et al. 2007 and Zare et al. 2007).

Type species: Plectosphaerella cucumerina (Lindf.) W. Gams.

Plectosphaerella cucumerina (Lindf.) W. Gams, Persoonia 5: 179. 1968. Fig. 13.

Basionym: Venturia cucumerina Lindf., Medd. CentAnst. För Svås. JordbrOrmad., Stockholm 193: 17. 1919.

Synonyms: Monographella cucumerina (Lindf.) Arx, Trans. Brit. Mycol. Soc. 83: 374. 1984.

Plectosphaerella cucumerina Kleb., Phytopathol. Z. 1: 43. 1930.

Micronectriella cucumeris (Kleb.) C. Booth, The genus Fusarium: 39. 1971.

Cephalosporium tabacinum J.F.H. Beyma, Zentralbl. Bakteriol., 2 Abt. 89: 240. 1933.

Fusarium tabacinum (J.F.H. Beyma) W. Gams, Persoonia 5: 179. 1968.

Microdochium tabacinum (J.F.H. Beyma) Arx, Trans. Brit. Mycol. Soc. 83: 374. 1984.

Plectosporium tabacinum (J.F.H. Beyma) M.E. Palm, W. Gams & Nirenberg, Mycologia 87: 399. 1995.

Cephalosporium ciferrii Verona, Studio sulle cause microbiche che dannegiano la carte ed I libri, Roma: 30. 1939.

Cephalosporiosis imperfecta Moreau & R. Moreau, Rev. Mycol. 6: 67. 1921. Nom. inval., Art. 39.1 (Melbourne).

Descriptions and illustrations: Domsch et al. (2007), Carlucci et al. (2012).

Specimens examined. Belgium, Hoeverlee, from Nicolita tabacum rootlet in greenhouse, unknown date and collector, CBS 286.64. Canada, from Solanum lycopersicum, unknown date and collector, CBS 400.58; Alberta, from leaf and stem of Galium spumum, unknown date, W. Zhang, CBS 101958. Egypt, from Viola odorata, unknown date and collector, CBS 367.73 = IMI 151458. Italy, Foggia, Borgo Cervaro, from collar of Cucumis melo, 2004, A. Carlucci (neotype of Venturia cucumerina designated here CBS H-20898, MBR38650, culture ex-neotype CBS 137139 = Plect 11); unknown locality, from paper, unknown date, O. Verona, (holotype of Cephalosporium ciferrii CBS 137.37 culture permanently preserved in a metabolically inactive state) culture ex-type CBS 137.37 = MUCJ 9704. Netherlands, from root of Viola tricolor, idem., T. van Eek, CBS 355.36.

Switzerland, Basel, from leaf of Pyrus malus, 3 Oct 1974, F. Stadelmann, CBS 619.74; unknown locality, from Arabidopsis sp., unknown date, B. Mauch-Mani, CBS 632.94; from Arabidopsis thaliana, idem., CBS 101014. USA, unknown origin and date, M.A. Pisano, CBS 139.60. USSR, from unknown fungus, unknown date and collector, CBS 567.78 = VKM F-156. UK, England, Bristol, from...
Nicotiana tabacum, unknown date, Jollyman (neotype of Cephalosporium tabacinum CBS H-7656, culture ex-neotype CBS 137.33, designated in Palm et al. 1995).

Notes: Plectosphaerella cucumerina, the type species of Plectosphaerella was originally described as Venturia cucumerina from Cucumis sativus (Cucumeris sativae, in the protologue) in Sweden, based on the sexual morph (Lindfors 1919). The genus Plectosphaerella was established 10 yr later by Klebahn (1929), based on P. cucumeris, also obtained from Cucumis sativus in Germany. Elbakyan (1970) regarded both species as conspecific, but the formal combination, Plectosphaerella cucumerina was only later introduced by Gams (Domsch & Gams 1972). A detailed development study of P. cucumerina was carried out by Uecker (1993), based on isolate CBS 101607 (= ATCC 96328 = G.J.S. 84-531), recovered from Nicotiana tabacum in New Zealand. This isolate was then designated as neotype for both Plectosphaerella cucumeris and Venturia cucumerina (Rossman et al. 1999).

The asexual morph was described as Cephalosporium tabacinum from Nicotiana tabacum (van Beyma 1933), and was then transferred to Fusarium and Microdochium as F. tabacinum (Gams & Gerlagh 1968) and M. tabacinum (von Arx 1984), respectively. Finally, Palm et al. (1995) introduced the genus Plectosporium, based on P. tabacinum with the ex-neotype CBS 137.33. After the abolishment of dual nomenclature, the name Plectosphaerella took priority over Plectosporium.

In our phylogeny, the isolates of P. cucumerina clustered in a single clade (95 % BS), including the ex-type of Plectosporium tabacinum CBS 137.33 and Cephalosporium ciferri CBS 137.37; while the neotype of Venturia cucumerina CBS 101607 falls in the P. plurivora clade (Fig. 1). In order to stabilize the species epithet, which is very important to the plant pathology community, the

Fig. 13. Plectosphaerella cucumerina. A–E. Sexual morph (ex-neotype CBS 131739). F–K. Asexual morph (CBS 137.37). A–C, Sporulating ascomata on OA. D, E, Details of the ostiolar region and peridium, respectively. F–H, Monophialides (note the microcyclic conidiation on F). I, Polyphialide. J, K, Septate and aseptate conidia. Scale bars = 10 μm.
selection of a new neotype that correctly represents the species is necessary. Among the isolates included in the *P. cucumerina* clade, CBS 131739 was able to produce the sexual morph in culture (Fig. 13), morphologically matching the protologue of *V. cucumerina*. Thus, we have selected CBS 131739, from *Cucumis melon*, grown in Italy, as the neotype of this taxon.

**Plectosphaerella humicola** Giraldo López & Crous, sp. nov. MycoBank MB828052. Fig. 14.

**Etymology**: Name refers to the substrate from which this fungus was isolated, soil.

Mycelium consisting of branched, seporate, hyaline and thin-walled hyphae. 1.5–2 μm wide. Conidiophores solitary, unbranched or rarely branched, hyaline, smooth, thin-walled, sometimes radiating out from sterile coils formed by the mycelium. Phialides terminal, lateral, cylindrical, sub-cylindrical or ampulliform, hyaline, thick- and smooth-walled, 11–41 μm long, 2.3–3.3 μm wide at the base, with cylindrical collarette and conspicuous periclinal thickening at the conidiogenous locus, adelophialides 2.8–13.7 × 1.5–4 μm, polyphialides with up to two conidiogenous loci commonly present. Septate conidia cylindrical or ellipsoidal, with obtuse apices and apiculate bases, 2-celled, hyaline, thick- and smooth-walled, 7.5–11 × 2.5–3.5 μm, arranged in slimy heads. Aseptate conidia cylindrical or ellipsoidal, acute at apex and base, 1-celled hyaline, thick- and smooth-walled, 5–8 × 2.1–3.3 μm, arranged in slimy heads.

**Culture characteristics**: After 14 d at ca. 25 °C: On PDA attaining 74–75 mm diam, flat, floccose at centre, membranous at periphery, surface and reverse dirty white. On OA attaining 56–70 mm diam, flat, glabrous, entire margin, pale luteous with ochraceous shades.

**Specimen examined**: Zaire, Katanga, from soil, unknown date, M. Lanneau (holotype CBS H-23655, culture ex-type CBS 423.66 = DSM 62443 = NRRL 20448.)

**Notes**: The isolate CBS 423.66 is nestled in the same clade (100 % BS) as *P. pauciseptata* and *P. plurivora*. The species can be morphologically distinguished by the colony colour on PDA being buff or pink in *P. pauciseptata* and *P. plurivora*, and dirty white in *P. humicola*. This strain was examined by Gams & Gerlagh (1968), being one of the isolates of *P. cucumerina* able to produce perithecia in culture. However, the sexual morph was not observed in our study.

**Plectosphaerella plurivora** A.J.L. Phillips et al., Persoonia 28: 44. 2012. Fig. 15.

**Synonym**: *Plectosphaerella niemeijerarum* L. Lombard, Persoonia 39: 459. 2017.

The description of the sexual morph complements the previous species concept based on the asexual morph (Carlucci et al. 2012), thus providing a holomorphic species concept.

Ascomata perithecial solitary or gregarious, superficial, sub-globose to pyriform, dark brown in the basal part, paler at the neck, 100.3–209 × 86–156 μm, without setae around the neck, textura angularis. Asci unitunicate, clavate, thin-walled, lacking iodine reaction, 8-spored, 31.4–43 × 6.2–8.2 μm. Ascospores biseriate, ellipsoidal, 1- or 2-celled hyaline, smooth-walled, 6.1–13.2 × 2.4–3.7 μm. Descriptions and illustrations of the asexual morph: Carlucci et al. (2012).

![Fig. 14. Plectosphaerella humicola (ex-type CBS 423.66). A. Colony on PDA after 14 d at 25 °C. B–D. Monophialides. E–H. Adelophialides. I, J. Polyphialides. K, L. Septate and aseptate conidia, respectively. Scale bars = 10 μm.](https://www.studiesinmycology.org)
Specimens examined: 

**Australia**, New South Wales, from *Lolium perenne*, unknown date, M. Priest, CBS 101.87. 

**Belgium**, from soil, unknown date and collector, CBS 642.63. 

**Germany**, from soil, unknown date, H. Nirenberg, CBS 260.89; idem., CBS 261.89. 

**Italy**, Apulia, Borgo Cervaro, on asparagus turion, 2006, A. Carlucci (holotype CBS H-20899, culture ex-type CBS 131742); Rignano Garganico, from *Solanum lycopersicum*, unknown date, A. Carlucci, CBS 131860. 

**Netherlands**, Haren, from *Solanum tuberosum*, unknown date and collector, CBS 406.85; Nieuwegein, from garden soil, Feb. 2017, F. & R. Niemeijer, CBS 143233 = JW 5012 (ex-type of *Plectosphaerella niemeijerarum*); Oostelijk Flevoland, from agricultural soil, unknown date and collector, CBS 215.84; from wheat field soil, May 1966, W. Gams, CBS 386.68; from soil, 1966, M. Gerlagh, CBS 757.68; from soil, unknown date, G.J. Bollen, CBS 757.68. 

**New Zealand**, Auckland, from *Nicotiana tabacum*, Oct. 1984, G.J. Samuels, CBS 101607 = ATCC 96328 = G.J.S. 84–531. 

**UK**, Scotland, Lona, from *Solanum tuberosum*, unknown date and collector, CBS 417.81. 

**USA**, Tennessee, from *Solanum tuberosum*, unknown date, Wollenweber, CBS 291.38 = ATCC 13425. 

**Notes:** *Plectosphaerella plurivora* was described from *Asparagus* by Carlucci et al. (2012), based on the production of the asexual morph. In our study, among the isolates examined, only CBS 101607 from *Nicotiana tabacum* and CBS 101.87 from *Lolium perenne* were able to produce the sexual morph in culture. This finding makes *P. plurivora* the second holomorphic species described in the genus. Strain CBS 101607 was designated by Rossman et al. (1999) as neotype of *P. cucumerina*, a placement that is rejected by us based on our phylogenetic results (Art. 9.18 Shenzhen Code, see notes under *P. cucumerina*). Morphologically, the ascomata of *Plectosphaerella plurivora* are wider, have a darker peridium and a shorter neck than those of *P. cucumerina*. Although we have not seen setae in these isolates, according to the observations of Uecker (1993) and Palm et al. (1995) a few golden-brown setae were present at the base of the neck of some ascomata formed by those strains. At the same time Palm et al. (1995) stated that the production of setae did not appear to be a stable character.

According to our phylogeny the isolates CBS 101.87, CBS 215.84, CBS 260.89, CBS 261.89, CBS 291.38, CBS 292.66, CBS 386.68, CBS 406.85, CBS 417.81, CBS 642.63, CBS 757.68 and CBS 101607, previously identified as *P. cucumerina*, are re-identified here as *P. plurivora*. Among these isolates, CBS 292.66 and CBS 386.68 were examined by Gams & Gerlagh (1968), who found that they were able to produce perithecia in culture at that time.

*Plectosphaerella niemeijerarum* was recently described from soil in the Netherlands, based on ITS, LSU, TEF1-α and beta-tubulin sequences (Crous et al. 2017). However, the multilocus sequence analysis performed in this study shows this species falls within the range of variation accepted for *P. plurivora* (Fig. 1).

**Brunneochlamydosporium** Giraldo López & Crous, gen. nov. MycoBank MB828053. 

**Etymology:** From Latin *brunneus* = brown, referring to the brownish chlamydospores produced by species in this genus. 

**Mycelium** consisting of branched, septate, hyaline and thin-walled hyphae, often becoming pigmented and thick-walled with age. *Conidiophores* erect, lateral, simple or poorly branched. *Conidiogenous cells* enteroblastic, monophialidic, sometimes polyphialidic, terminal, lateral, (sub)cylindrical to subulate, hyaline, with conspicuous collarette and a periclinal thickening at the conidiogenous locus. *Conidia* ellipsoidal, cylindrical, 1-celled, hyaline, smooth-walled, arranged in siliny heads. *Chlamydospores* lateral, terminal, intercalary, solitary, in giu. 

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**Fig. 15.** *Plectosphaerella plurivora* sexual morph (CBS 101607). A, B. Sporulating ascomata on OA. C. Ascoma releasing the asci. D. Details of the ostiolar region and peridium. E, F. Asci. G. Ascospores. Scale bars: C, D = 20 μm; E–I= 10 μm.
pairs or short chains, 1–2-celled, pale to dark brown, smooth- and thick-walled. Sexual morph unknown.

**Type species:** *Brunneochlamydosporium nepalense* (W. Gams) Giraldo López & Crous

**Brunneochlamydosporium cibotii** (J.F.H. Beyma) Giraldo López & Crous, **comb. nov.** MycoBank **MB828054.** Fig. 16.

_Basionym:_ *Gliocladium cibotii* J.F.H. Beyma, _Antonie van Leeuwenhoek_ 10: 47. 1944.

*Mycelium* consisting of branched, septe, hyaline and thin-walled hyphae, becoming green-brown to brown-black and thick-walled with age, up to 2 μm wide, forming bundles. _Conidiophores_ arising from submerged, erect, simple or poorly branched hyphae, bearing 2–3 phialides at the middle, up to 84 μm long, 2–2.5 μm wide at the base, hyaline, smooth-walled. _Phialides_ terminal, lateral, cylindrical, hyaline, thick- and smooth-walled, 13–58 μm long, 2 μm wide at the base, with cylindrical to flared collarette and a distinct periclinal thickening at the conidiogenous locus, adelophialides commonly present, up to 7.5 μm long. _Conidia_ ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 2.9–4.5 × 1.6–2.2 μm, containing two guttules, arranged in slimy heads. _Chlamydospores_ mostly terminal, intercalary, solitary, rarely in pairs, subglobose or obovoid, sometimes 2-celled, pale brown, smooth- and thick-walled, 3.9–6.2 × 2.6–4.3 μm.

_Culture characteristics:_ After 14 d at ca. 25 °C: On OA reaching 60–65 mm diam, flat, dusty, with concentric rings, buff, reverse isabelline. On MEA reaching 59–62 mm diam, wrinkled, radially folded, membranous, isabelline at centre and buff at periphery, becoming fuscous black with age, reverse uncoloured. Strong geosmin odour in both media.

**Specimen examined:** Netherlands, Delft, from _Cibotium schiedei_ (Mexican tree fern) in the Netherlands. However, this species is not congeneric with the type species of _Gliocladium,_ _G. penicillioides_ (currently _Sphaerostilbella,_ Lombard _et al._ 2015), which belongs to _Hypocreaceae_ (_Hypocreales, Sordariomycetes_). According to our phylogenetic inference the ex-type of _G. cibotii_ CBS 109240 falls in a fully supported clade (100 % BS) together with the ex-isotype of _Acremonium nepalense_ CBS 971.72, and therefore the new genus _Brunneochlamydosporium_ is proposed here to accommodate these taxa. Both species are easily distinguished by their colony colour on OA at 14 d, which is dark grey to almost black with the reverse becoming dark grey in _B. nepalense_ and buff in _B. cibotii_. In addition, the conidiophores and phialides of _B. cibotii_ are longer than those of _B. nepalense._

In the protologue of _G. cibotii,_ van Beyma (1944) described and illustrated the conidiophores as dichotomously bifurcated, arising from pigmented hyphae grouped in bundles, just as we observed here. However, no mention was made of the production of chlamydospores. These structures were observed in the present study after 14 d in all media tested.

**Brunneochlamydosporium macroclavatum** Giraldo López & Crous, **sp. nov.** MycoBank **MB828055.** Fig. 17.

**Notes:** _Brunneochlamydosporium cibotii_ was originally described as _Gliocladium cibotii_ by van Beyma (1944) from _Cibotium schiedei_ (Mexican tree fern) in the Netherlands. However, this species is not congeneric with the type species of _Gliocladium,_ _G. penicillioides_ (currently _Sphaerostilbella,_ Lombard _et al._ 2015), which belongs to _Hypocreaceae_ (_Hypocreales, Sordariomycetes_). According to our phylogenetic inference the ex-type of _G. cibotii_ CBS 109240 falls in a fully supported clade (100 % BS) together with the ex-isotype of _Acremonium nepalense_ CBS 971.72, and therefore the new genus _Brunneochlamydosporium_ is proposed here to accommodate these taxa. Both species are easily distinguished by their colony colour on OA at 14 d, which is dark grey to almost black with the reverse becoming dark grey in _B. nepalense_ and buff in _B. cibotii._ In addition, the conidiophores and phialides of _B. cibotii_ are longer than those of _B. nepalense._

In the protologue of _G. cibotii,_ van Beyma (1944) described and illustrated the conidiophores as dichotomously bifurcated, arising from pigmented hyphae grouped in bundles, just as we observed here. However, no mention was made of the production of chlamydospores. These structures were observed in the present study after 14 d in all media tested.

**Brunneochlamydosporium macroclavatum** Giraldo López & Crous, **sp. nov.** MycoBank **MB828055.** Fig. 17.

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**Fig. 16.** _Brunneochlamydosporium cibotii_ (ex-isotype CBS 109240). **A.** Colony on OA after 14 d at 25 °C. **B–C.** Conidiophores. **D.** Adelophialide. **E.** Hyphae. **F.** Chlamydospores. **G.** Conid. Scale bars = 10 μm.
**Etymology:** From Latin *macro*, meaning large, and *clavatus* meaning clavate, i.e., club-shaped. Referring to the large and clavate chlamydospores produced by this fungus.

**Mycelium** consisting of branched, septate, hyaline and thin-walled hyphae, becoming dark brown and thick-walled with age, up to 2 μm wide, forming bundles. **Conidiophores** arising from submerged, erect, simple or poorly branched hyphae, bearing 2–3 phialides at the middle, up to 113 μm long, 2–2.5 μm wide at the base, hyaline, smooth-walled. **Phialides** terminal, lateral, (sub)cylindrical to subulate, hyaline, thick- and smooth-walled, 27–66 μm long, 2–2.5 μm wide at the base, with cylindrical to flared collarette and a distinct periclinal thickening at the conidiogenous locus, adelophialides up to 3 μm long, polyphialides with up to two conidiogenous loci sometimes present. **Conidia** ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 4–5.2 × 2–2.5 μm, containing one or two guttules, arranged in slimy heads. **Chlamydospores** terminal, intercalary, solitary, in pairs or in short chains, subglobose, clavate or pyriform, 1-celled, pale to dark brown, smooth- and thick-walled, 4.6–10 × 3.3–6 μm.

**Culture characteristics:** After 14 d at ca. 25 °C: On PDA reaching 78–80 mm diam, flat, floccose to woolly, dirty white with fuscous black shades, reverse fuscous black. On OA reaching 75–77 mm diam, flat, woolly at centre, floccose at periphery, pale luteous with pale mouse grey shades, reverse mouse grey to fuscous black. On MEA reaching 57–58 mm diam, flat, wrinkled, radially folded, downy, buff, reverse with fuscous black shades. Strong geosmin odour in all media.

**Specimens examined:** India, Bangalore, from *Salvinia auriculata*, unknown date, T. Sankaran, CBS 823.73. Mauritius, from a Pteridophyte, S.P.B. Madhu (holotype CBS H-23658, culture ex-type CBS 101249 = IMI 296138). Switzerland, from *Aphelandra* sp., unknown date, P. Petrini, CBS 372.93; idem., CBS 373.93.

**Notes:** The four isolates included in this species were previously identified as *Gliocladium cibotii* (CBS 823.73) and *Verticillium* sp. (CBS 372.93, CBS 373.93 and CBS 101249). The tropical strains CBS 823.73 and CBS 101249 were isolated from fern, while the European ones (CBS 372.93 and CBS 373.93) come from a flowering plant in the family Acanthaceae, which is native to tropical regions of the Americas.

**Morphologically,** *B. macroclavatum* resembles *B. nepalense* in conidial morphology and in the production of chlamydospores in short chains along with pigmented ropes of hyphae. However, in *B. macroclavatum* the conidia are longer (4–5.2 μm vs. 3.2–4.7 μm), and the chamydospores are larger (4.6–10 × 3.3–6 μm vs. 4.4–5 × 3.5–3.6 μm) than those of *B. nepalense.*

**Brunneochlamydosporium nepalense** (W. Gams) Giraldo López & Crous, **comb. nov.** MycoBank MB828056. Fig. 18.

**Basionym:** *Acremonium nepalense* W. Gams, Trans. Brit. Mycol. Soc. 64: 400. 1975.

Mycelium consisting of branched, septate, hyaline and thin-walled hyphae, becoming brown and thick-walled with age, up to 2 μm wide, forming bundles. Conidiophores arising from submerged or superficial hyphae, erect, simple or poorly branched, up to 55 μm long, 2–2.5 μm wide at the base, hyaline, smooth-walled. Phialides terminal, lateral, cylindrical or subulate,
hyaline, thick- and smooth-walled, 25–55 μm long, 2–2.5 μm wide at the base, with minute cylindrical collarette and a distinct periclinal thickening at the conidiogenous locus, adelophialides up to 6 μm long, polyphialides with up to two conidiogenous loci sometimes present. Conidia cylindrical with rounded ends to ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 3.2–4.7 × 1.9–2.4 μm, containing two guttules, arranged in slimy heads. Chlamydospores lateral, terminal, solitary, in pairs, rarely in short chains, subglobose or irregularly shaped, sometimes 2-celled, light brown, smooth- and thick-walled, 4.4–5 × 3.5–3.6 μm (adapted from Gams 1975).

Culture characteristics: After 14 d at ca. 20 °C: On PDA reaching 49–53 mm diam, flat, floccose, whitish to cream, turning grey-brown in patches. On OA reaching 60–63 mm diam, flat, dusty, zonate, with mouse grey and fuscous black shades, reverse fawn to dark grey. On MEA reaching 50–52 mm diam, raised, hairy at centre, floccose at periphery, dirty white with dark brown shades, reverse dark brown to black. Strong geosmin odour in all media.

Specimens examined: Nepal, Himalaya septentrional, from soil under Pinus sp., unknown date, G. Franz (isotype CBS H-8260, culture ex-isotype CBS 971.72 = ATCC 185380), Netherlands, Kwade Hoek, from sandy soil, 22 May 2002, F.X. Prenafeta-Boldú, CBS 112045, CBS 113254, CBS 116720, CBS 116721, CBS 116722. Unknown locality, date and collector, from soil, CBS 277.89.

Notes: Brunneochlamydosporium nepalense was originally described as Acremonium nepalense by Gams (1975) from soil in Nepal, as a tropical species of Acremonium section Necctrioidea. In its original description the chlamydospores were described as scarce, terminal, solitary or in pairs and no mention was made of the hyphal colour or the production of adelophialides or polyphialides. However, we have observed that the chlamydospores were abundantly produced, in terminal and lateral position, and sometimes they formed short chains. In addition, the hyphal colour become brown with age, and short adelophialides and polyphialides were produced. This species as well as B. cibotii and B. catenatum produces a strong geosmin odour in all media.

Brunneochlamydosporium terrestre Giraldo López & Crous, sp. nov. MycoBank MB828057. Fig. 19.

Etymology: Name refers to the substrate from which this fungus was isolated, soil.

Mycelium consisting of branched, septate, hyaline and thin-walled hyphae, up to 2 μm wide. Conidiophores arising from submerged, erect, simple or poorly branched hyphae, bearing 2–3 phialides at the middle, up to 96 μm long, 2–2.5 μm wide at the base, hyaline, smooth-walled. Phialides terminal, lateral, (sub) cylindrical to subulate, hyaline, thick- and smooth-walled, 26–61 μm long, 2–2.5 μm wide at the base, with cylindrical collarette and a distinct periclinal thickening at the conidiogenous locus. Conidia ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 3–6 × 1.7–2.4 μm, arranged in slimy heads. Chlamydospores lateral, terminal, intercalary, solitary or in pairs, subglobose or clavate, sometimes 2-celled, pale to dark brown, smooth- and thick-walled, 2.6–5.5 × 2.3–4 μm.

Culture characteristics: After 14 d at ca. 25 °C: On OA reaching 70–72 mm diam, flat, woolly, dirty white, reverse isabelline. On MEA reaching 57–58 mm in 14 d, flat, slightly...
hairy at centre, floccose toward the periphery, dirty white, reverse dark mouse grey.

Specimen examined: French Polynesia, Moorea, Vallée de Toto, soil under Manihot, 22 Jan 2003, T. Grafenhan (holotype CBS H-23659, culture ex-type CBS 112777).

Notes: Brunneochlamydosporium terrestre is placed on a single branch, basal to B. nepalense. Both species come from the same substratum and are morphologically similar in colony aspect on OA and conidial morphology. Unlike B. nepalense, B. terrestre lacks of the strong smell of geosmin, and also lacks adelophialides and polyphialides; its hyphae remain hyaline with age, and its conidiophores are longer than those of B. nepalense.

Fuscohypha Giraldo Lopez & Crous, gen. nov. MycoBank MB828058.

Etymology: Referring to the production of brown hyphae.

Mycelium consisting of branched, septate, hyaline and thin-walled hyphae often becoming dark brown and thick-walled with age, 1.8–2 μm wide. Conidiophores erect, simple or branching once or twice, bearing whorls of 3–4 phialides per branch, up to 67 μm long, 2 μm wide at the base, hyaline, smooth-walled. Phialides simple or in whorls of 3–4, terminal, lateral, cylindrical to subulate, hyaline, thin- and smooth-walled, 18–34 μm long, 1.5–2 μm wide at the base, with cylindrical collarette and a conspicuous periclinal thickening at the conidiogenous locus. Conidia subglobose or ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 1.9–3.7 × 1.5–2.1 μm, arranged in slimy heads. Sexual morph unknown.

Culture characteristics: After 7 d at ca. 25 °C: On PDA reaching 50–51 mm diam, flat, felty, fimbriate margin, mouse grey at the centre and olivaceous black to the border, reverse black. On OA reaching 40–41 mm diam, flat dusty, entire margin, vinaceous buff to greyish sepia at centre and honey at periphery, reverse fawn. On MEA reaching 48–50 mm diam, flat, dusty, entire margin, mouse grey with white shades, reverse black.

Specimens examined: Brazil, from soil, unknown date, L. Pfenning, CBS 103.95 = CCT 3987; Martinique, from tuber of Dioscorea sp., idem., B. Hostachy (holotype CBS H-5073, culture ex-type CBS 418.89).

Notes: Fuscohypha is proposed here to accommodate a single species, F. expansa. The phylogenetic inference used in this study places the ex-type strain of F. expansa (CBS 418.89) basal

Fuscohypha expansa Giraldo Lopez & Crous, sp. nov. MycoBank MB828059. Fig. 20.
to the clade containing *Plectosphaerella* and *Brunneo-chlamydosporium* (100 % BS).

*Fuscohypha* has some morphological similarities with *Verticillium*, especially in the production of verticillate conidiophores and melanised resting structures. Its conidiophores branch only once or twice and they are shorter (up to 67 μm long) than those of *Verticillium* species, which range from 480 to 800 μm long (Inderbitzin et al. 2011a). In addition, the melanised resting structures produced by *Fuscohypha* are restricted to dark brown hyphae, while *Verticillium* species also produce dark brown chlamydospores and microsclerotia.

**Clade V**

*Paragibellulopsis* Giraldo López & Crous, *gen. nov.* MycoBank MB828060.

*Etymology:* Referring to its morphological similarity with *Gibellulopsis*.

*Mycelium* consisting of branched, septate, hyaline and smooth-walled hyphae. *Conidiophores* arising from submerged or superficial hyphae, erect or slanted, simple or poorly branched. *Conidiogenous cells* monophaialdic, terminal, lateral, cylindrical to aculeate, hyaline, with funnel-shaped collarette and a distinct periclinal thickening at the conidiogenous locus. *Conidia* cylindrical with tapering ends, straight or slightly curved, 2-celled, hyaline, smooth-walled, produced in slimy heads. *Chlamydospores* intercalary, single or in short in chains, becoming grey-brown, smooth-walled. *Sexual morph* unknown.

Type species: *Paragibellulopsis chrysanthemi* (Hirooka et al.) Giraldo López & Crous

*Paragibellulopsis chrysanthemi* (Hirooka et al.) Giraldo López & Crous, *comb. nov.* MycoBank MB828062.

*Basionym:* *Gibellulopsis chrysanthemi* Hirooka et al., Mycol. Progr. 13: 16. 2014.

*Description and illustrations:* Hirooka et al. (2014).

*Type details:* Japan, Osaka, Kishiwada, on rotten leaves of *Chrysanthemum coronarium* var. *spatiosum*, 5 Nov. 2009, M. Kawaradani (*holotype* TFM FPH-8116; *isotype* BPI 884204; culture ex-type MAFF 242621 = Y.H. 11 – 88).

*Notes:* In our study, the ex-type strain of *Gibellulopsis chrysanthemi* (MAFF 242621) falls in a separate clade from *Gibellulopsis* s. str., demonstrating that they are not congeneric. Therefore, a new genus is proposed here to accommodate this taxon.

*Paragibellulopsis chrysanthemi* differs from *Gibellulopsis* by the production of less branched conidiophores, longer phialides with a funnel-shaped collarette, and larger conidia [(10.8 –) 12.5 – 15.5 (–17) × (1.9 –) 2.7 – 3.7 (–4.2) μm] and chlamydospores [(7.8 –) 10.2 – 11.6 (–13.2) × (6.1 –) 7.1 – 9.1 (–9.7) μm] (Hirooka et al. 2014).

**Lineage I**

*Phialoparvum* Giraldo López & Crous, *gen. nov.* MycoBank MB828063.
**Etymology**: From Latin *parvus*, meaning small. Name reflects the small-sized phialides in this genus.

*Mycelium* consisting of branched, septate, hyaline and thick-walled hyphae. *Conidiophores* erect, arising directly from vegetative hyphae or ropes of hyphae, unbranched or poorly branched. *Conidiogenous cells* enteroblastic, monophialidic, terminal, lateral, subulate to ampulliform, hyaline, with conspicuous collarette and periclinal thickening at the conidiogenous locus. *Conidia* cylindrical, 1-celled, hyaline, smooth-walled, arranged in slimy heads. *Sexual morph* unknown.

**Type species**: *Phialoparvum bifurcatum* Giraldo López & Crous.

**Phialoparvum bifurcatum** Giraldo López & Crous, sp. nov. MycoBank MB828064. Fig. 21.

Etymology: Referring to the production of phialides with a bifurcate apex.

*Mycelium* consisting of branched, septate, hyaline and thick-walled hyphae. 1.5–2 μm wide. *Conidiophores* erect, arising directly from vegetative hyphae or ropes of hyphae, unbranched or poorly branched, up to 15 μm long, 2.7 μm wide at the base, hyaline, smooth-walled. *Phialides* lateral, terminal, subulate to ampulliform, hyaline, thick- and smooth-walled, 8–15 μm long, 1.5–2.7 μm wide at the base, with cylindrical collarette and conspicuous periclinal thickening at the conidiogenous locus, adelophialides sometimes present, up to 4 μm long; polyphialides with up to two symmetrical conidiogenous loci are commonly present. *Conidia* cylindrical, 1-celled, hyaline, thick- and smooth-walled, 2.8–4.4 × 1.2–1.8 μm, occasionally with one or two guttules, arranged in slimy heads. *Sexual morph* unknown.

**Culture characteristics**: After 14 d at ca. 20 °C: On PDA reaching 16–17 mm diam, flat, membranous, rhizoid margin, dirty white, reverse uncoloured. On OA reaching 29–30 mm diam, flat, glabrous, dirty white, reverse uncoloured, with brown irregular accumulations of melanin. On MEA reaching 25–28 mm diam, raised and radially folded with a mycelium tufts at centre, membranous at periphery, buff, reverse uncoloured.

**Specimen examined**: Belgium, Heverlee, from soil, unknown date, J. Meyer (holotype CBS H-8167, culture ex-type CBS 299.70B)

Notes: The only isolate representing *Phialoparvum bifurcatum* was formerly identified as *A. furcatum*. However, it falls in a single lineage, phylogenetically distant from the type strain of that species (Fig. 1). In addition, the polyphialides in *A. furcatum* are produced as short lateral and cylindrical asymmetrical projections, while in *P. bifurcatum* they are dichotomously and symmetrically distributed at the apex of the conidiogenous cells. CBS 299.70B was stated by Gams (1971) to deviate from the type of *Acremonium furcatum*, CBS 122.42, by its longer conidia. This morphological feature was also observed here and correlates with the molecular differences shown in Fig. 1.

**Clade VI**

*Musicillium* Zare & W. Gams, Nova Hedwigia 85: 482. 2007.

*Mycelium* consisting of branched, septate, hyaline or centrally pale brown and thin-walled hyphae. *Conidiophores* arising from submerged hyphae, erect, septate, repeatedly verticillate towards the apex, distinctly brown pigmented throughout (slightly pale only near the tip). *Conidiogenous cells* enteroblastic, monophialidic,
solitary or in whorls, terminal, lateral, subulate, hyaline to (sub)hyaline, with minute collarette and a distinct periclinal thickening at the conidiogenous locus. *Conidia* ellipsoidal to cylindrical, 1-celled, hyaline, smooth-walled, produced in slimy heads. *Chlamydospores* absent, but moniliform hyphae, initially subhyaline, later turning brown, commonly formed after 2 wk and longer. Sexual morph unknown (modified from Zare et al. 2007).

**Type species:** *Musicillium theobromae* (Turconi) Zare & W. Gams.

*Musicillium elettariae* Giraldo López & Crous, sp. nov. Myco-Bank MB828065. Fig. 22.

**Etymology:** Refers to *Elettaria*, the host genus from which the type culture of this fungus was isolated.

**Mycelium** consisting of branched septate, smooth, pale brown with age, thin-walled hyphae, 2–3.5 μm wide. Moniliform hyphae formed after 2 wk, subhyaline, turning brown, 8–10 μm diam, and commonly aggregating into microsclerotium-like structures. **Conidiophores** arising from submerged hyphae, erect, with 4–10 septa in the lower part, simple or verticillate towards the apex, bearing up to 4 whors of 2–5 phialides, sometimes with lateral branches, up to 640 μm long, 3–4 μm wide at the base, brown almost up to the first whorl, often tuberculate at base, with cell walls usually thicker than those of the vegetative hyphae. **Phialides** usually in divergent whors of 2–5 (rarely solitary), terminal, lateral, (sub)cylindrical to subulate, hyaline, thick- and smooth-walled, 13.7–33.5 μm long, 1.8–2.8 μm wide at the base, with inconspicuous collarette and periclinal wall thickening at the conidiogenous locus. **Conidia** cylindrical with rounded ends, 1-celled, hyaline, thin- and smooth-walled, 3.1–10.7 × 1.8–2.8 μm, arranged in slimy heads.

**Culture characteristics:** After 14 d at ca. 25 °C: On OA reaching 62–67 mm diam, flat, slightly woolly at the centre, powdery to granulose at periphery, entire margin, mouse grey to olivaceous grey, reverse dark mouse grey. On MEA reaching 65–70 mm, flat, slightly folded, feltly to woolly, entire margin, with a cottony smoke grey mass at the centre, pale mouse grey at periphery, reverse dark mouse grey.

Specimens examined: Iran, Golestan, Forest park of Tuskestan, from dead leaf of *Carex pendula*, unknown date, W. Gams & R. Zare, CBS 140681. Rwanda, from *Elettaria cardomomum*, Dec. 1979, unknown collector (holotype CBS H-19316, culture ex-type CBS 252.80). Thailand, Chiang Mai, Doi Suthep Pui National Park, from leaf of *Musa acuminata*, unknown date and collector, CBS 110322.

Notes: These isolates were previously treated as *Musicillium theobromae* by Zare et al. (2007). However, according to our phylogenetic inference they fall into a separate clade from that holding the type species (98 % BS). Morphologically, *M. elettariae* has tuberculate conidiophores and conidia, longer (640 μm long; 3.1–10.7 × 1.8–2.8 μm) than those of *M. theobromae* (up to 220 μm long; 3.4–5.3 × 1.7–2.6 μm).

The isolates included in the *M. elettariae* clade are diverse in host range, having been obtained from *Carex pendula*, *Elettaria cardomomum* and *Musa acuminata*. In comparison, two related species, *M. theobromae* and *M. tropicale*, have mostly been isolated from *Musa* spp.

*Musicillium theobromae* (Turconi) Zare & W. Gams, Nova Hedwigia 85: 482. 2007. Fig. 23.
**Basionym: Stachylidium theobromae** Turconi, Atti Ist. bot. R. Univ. Pavia 17: 7. 1920.

**Synonym:** *Verticillium theobromae* (Turconi) E.W. Mason & S. Hughes, Mycol. Pap. 45: 10. 1951.

*Mycelium* consisting of branched, septate, smooth, pale brown with age, thin-walled hyphae, 2–3.5 μm wide. *Moniliiform hyphae* formed after 2 wk, subhyaline, turning brown, 8–10 μm diam, and sometimes aggregating into microsclerotium-like structures. *Conidiophores* arising from submerged hyphae, erect, with 2–12 septa in the lower part, simple or verticillate towards the apex, bearing up to 7 whorls of 3–6 phialides, up to 732 μm long, 2–3 μm wide at the base, brown almost up to the first whorl, often smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. *Phialides* solitary and in divergent whorls of 3–6, terminal, lateral, subulate, (sub)hyaline, thick- and smooth-walled, 15.8–35.4 μm long, 2.2–3.4 μm wide at the base, with minute collarette and inconspicuous periclinal wall thickening at the conidiogenous locus. *Conidia* cylindrical with rounded ends or ellipsoidal, 1-celled, hyaline, thin- and smooth-walled, 3.4–5.3 × 1.7–2.6 μm, arranged in slimy heads.

**Culture characteristics:** After 14 d at ca. 25 °C: On OA reaching 45–65 mm diam, flat, scarce aerial mycelium at centre, glabrous at periphery, surface with greenish olivaceous and iron grey shades, reverse iron grey. On MEA reaching 48–50 mm diam, flat, cottony, entire margin, white, reverse uncoloured, but becoming fuscous black with age (after 20 d).

**Specimens examined:** Brazil, Minas Gerais, from *Musa sapientum*, 10 Oct. 2006, O.L. Pereira, CBS 121211; unknown origin and date, L. Pfenning, CBS 122.97.

**Egypt,** Cairo, from *Musa* sp., unknown date, I. Jamal El-Din (*neotype* of *Stachylidium theobromae* CBS H-19317, culture ex-neotype CBS 968.72, designated in Zare *et al.* 2007). **Finland,** Rovaniemi, unknown origin, date and collector, CBS 360.76. **Iran,** Chabahar, from *Musa* sapientum, 2005, R. Zare, CBS 120527; idem., CBS 120528; Mazandaran, from *Musa* nana, 2004, R. Zare, CBS 120528. **Jamaica,** from *Musa* sp., 1948, E.B. Martyn, CBS 397.58 = IMI 031432A. **Morocco,** Kenitra, from *Musa* sp., 1 Dec. 2015, J. Carlier, CPC 29810. **Netherlands,** Baarn, from decaying stalk of *Musa* sp., (in greenhouse), Nov. 1967, W. Gams, CBS 243.74. **Unknown** location, origin, date and collector, CBS 365.32 = ATCC 12474 = DSM 2202 = MUCL 9779.

**Notes:** *Musicillium* was introduced to accomodate *Verticillium theobromae*, an old synonym of *Stachylidium theobromae* (Zare *et al.* 2007). Although this species was originally described by Turconi (1920) from leaves of *Theobroma cacao*, most of the recent collections have been recovered from *Musa*, including isolates identified as *M. nana* and *M. sapientum*. *Musicillium theobromae* was neotyped by Zare *et al.* (2007) with the strain CBS 968.72, isolated from *Musa* sp. in Egypt.

**Musicillium tropicale** Giraldo López & Crous, sp. nov. MycoBank MB828066. Fig. 24.

**Etymology:** Refers to the tropical distribution of this fungus.
subulate or acicular, hyaline, thick- and smooth-walled, 13.3–26.6 μm long, 1.3–2.8 μm wide at the base, with minute collarette and inconspicuous periclinal wall thickening at the conidiogenous locus. Conidia ellipsoidal, 1-celled, hyaline, thick- and smooth-walled, 2.5–5.3 × 1.4–2 μm, arranged in slimy heads.

Culture characteristics: After 14 d at ca. 25 °C: On OA reaching 66–78 mm diam, flat, dusty to granulose, dirty white, reverse iron grey. On MEA reaching 70–75 mm diam, flat, sometimes radially folded, cottony, diffuse margin, white, reverse uncoloured at the beginning, becoming mouse grey to dark mouse grey with age.

Specimens examined: Bangladesh, Bangan, from leaf of Musa sp., unknown date, I. Buddenhagen (holotype CBS H-23653, culture ex-type CBS 120009). Brazil, Minas Gerais, from rotten banana, 3 Nov. 2006, O.L. Pereira, CBS 121212. Cuba, Estado de Agua, Parque Nacional Henry Pittie, from leaf litter, unknown date and collector, CBS 100951. Czech Republic, Bohemia, from Lactarius sp., idem., CBS 395.58. Japan, unknown origin, date and collector, CBS 398.58. Zambia, from Musa sp., unknown date and collector, CBS 398.58.

Notes: Musicillium tropicale is closely related with *M. elettariae* (86 % BS). However, the former species has smaller conidia (2.5–5.3 × 1.4–2 μm vs. 3.1–10.7 × 1.8–2.8 μm) and lacks production of moniliform hyphae or microsclerotium-like structures in culture.

This species seems to have a mostly tropical distribution, having been isolated from Musa trees in tropical countries (Bangladesh, Brazil, Cuba, and Zambia). In contrast, however, the strains CBS 395.58 and CBS 458.51, were recovered from Lactarius sp. mushrooms in the Czech Republic and Japan.

**Paramusicillium** Giraldo López & Crous, gen. nov. MycoBank MB828067.

Etymology: Referring to morphological similarity to the genus *Musicillium*, along with the close phylogenetic relationship.

*Mycelium* consisting of branched, septate, hyaline to dark brown, thick-walled hyphae. *Conidiophores* arising from submerged hyphae, erect, septate, repeatedly verticillate towards the apex, distinctly brown pigmented throughout (slightly paler near the tip), roughe ned. *Conidiogenous cells* enteroblastic, monophialidic, solitary or in whorls, terminal, lateral, cylindrical or subulate, hyaline to (sub)hyaline, with minute collarettes and a distinct periclinal thickening at the conidiogenous locus. *Conidia* ellipsoidal or cylindrical, 1-celled, pale brown in mass, smooth-walled, produced in slimy heads. *Chlamydospores* absent, but moniliform hyphae, initially subhyaline, later turning brown, commonly formed at the base of the conidiophore after 2 wk and more. *Sexual morph* unknown.

**Type species:** Paramusicillium asperulatum Giraldo López & Crous.

**Paramusicillium asperulatum** Giraldo López & Crous, sp. nov. MycoBank MB828068. Fig. 25.

Etymology: Referring to the rough wall of the conidiophores.

*Mycelium* consisting of branched, septate, (sub)hyaline to dark brown, thick- and rough to verrucose-walled hyphae, 2–3 μm wide. *Moniliform hyphae* formed after 2 wk, subhyaline, turning brown, 7–9 μm diam, usually aggregating into microsclerotium-like structures and formed at the base of the conidiophore. *Conidiophores* arising from submerged hyphae, erect, with 10–30 septa in the lower part, simple or repeatedly verticillate towards
the apex, bearing up to 4 whors of 2–6 phialides, up to 1245 μm long, 2.7–3.7 μm wide at the base, brown almost up to the first whorl, rough-walled in the axis including the terminal phialide, with cell walls usually thicker than those of the vegetative hyphae. Phialides solitary and in divergent whors of 2–6, terminal, lateral, cylindrical or subulate, hyaline to (sub)hyaline, thick- and smooth-walled, 17.4–43 μm long, 2–2.9 μm wide at the base, with minute collarette and inconspicuous periclinal wall thickening at the conidiogenous locus. Conidia ellipsoidal to cylindrical, sometimes with slightly truncate base, 1-celled, pale brown in mass, smooth-walled, 4.3–5.6 × 1.5–2.1 μm, produced in slimy heads.

Culture characteristics: After 14 d at ca. 25 °C: On OA reaching 40–41 mm diam, flat, slightly dusty at the centre, granulose at periphery, with concentric rings at periphery, entire margin, surface olivaceous grey, reverse dark mouse grey. On MEA reaching 65–68 mm, flat, slightly folded, felty to woolly, entire margin, with a cottony smoke grey mass at the centre, pale mouse grey at periphery, reverse dark mouse grey.

Specimen examined: Democratic Republic of São Tomé and Príncipe, São Tomé, Carretera as Pontes, Neves, from soil, unknown date and collector (holotype CBS H-23654, culture ex-type CBS 120158).

Notes: Paramusicillium asperulatum was previously identified as Musicillium theobromae. However, the distinctive morphological features, especially the length and rough walls of the conidiophores, plus the remarkable phylogenetic distance from the type species of Musicillium, led us to propose a new genus.

Clade VII

Chlamydosporiella Giraldo López & Crous, gen. nov. MycoBank MB828069.

Etymology: Referring to the production of chlamydospores.

Mycelium consisting of branched, septate, hyaline and thin-walled hyphae. Conidiophores bent, unbranched or basitously branched. Conidiogenous cells enteroblastic, monophialidic terminal, lateral, cylindrical, hyaline, with short collarette and inconspicuous periclinal thickening at the conidiogenous locus. Conidia obvoid, widely ellipsoidal, 1-celled, hyaline, smooth-walled, arranged in slimy heads. Chlamydospores, terminal or intercalary, mostly chains, dark olive green, thick-walled. Sexual morph unknown.

Types species: Chlamydosporiella restricta (J.F.H. Beyma) Giraldo López & Crous.

Chlamydosporiella restricta (J.F.H. Beyma) Giraldo López & Crous, comb. nov. MycoBank MB828070. Fig. 26.

Basionym: Verticillium dahliae f. restrictum J.F.H. Beyma, Antonie van Leeuwenhoek 7: 45. 1939.

Synonyms: Acremonium restrictum (J.F.H. Beyma) W. Gams, Cephalosporium-artige Schimmelpilze: 138. 1971.

Verticillium dahliae f. cerebriforme J.F.H. Beyma, Antonie van Leeuwenhoek 6: 43. 1939.

Mycelium consisting of branched, septate, hyaline and thin-walled hyphae, 1.5–2 μm wide. Conidiophores bent, arising directly from vegetative hyphae, unbranched or basitously
branched, up to 45 μm long, 2.5 μm wide at the base, hyaline, slightly rough in the lower part. Phialides terminal, lateral, cylindrical, slightly wavy at the apex, hyaline, thick- and smooth-walled, 22.7–45 μm long, 1.5–2 μm wide at the base, with short collarette and inconspicuous periclinal thickening at the conidiogenous locus. Conidia obovoid, widely ellipsoidal with apiculate base, 1-celled, hyaline, thick- and smooth-walled, 2.2–4.7 × 1.5–2.3 μm, arranged in slimy heads. Chlamydo- spores, terminal or intercalary, mostly in single or branched chains, sometimes clustered in coils resembling microsclerotia, subglobose, dark olive green, smooth- and thick-walled, 3–5.6 × 2.3–5.6 μm, scarce in OA and moderate to abundant in MEA. Sexual morph unknown.

Culture characteristics: After 14 d at ca. 25 °C: On OA reaching 8–13 mm diam, flat, felty or granulose, irregular margin, ranging from white, olivaceous grey to olivaceous black, reverse olive grey to black. On MEA reaching 4.5–10 mm diam, raised, felty to downy, lobulated margin, surface white to olivaceous grey, reverse uncoloured to greenish grey.

Specimens examined: Brazil, unknown origin, date and collector, CBS 119.97. France, from human skin, unknown date and collector, CBS 716.88. Germany, Kiel-Kitzeberg, from moist wall, idem., CBS 443.66. Netherlands, Rotterdam, Unilever, from packing material, unknown date, J.F.H. van Beyma (holotype of Verticillium dahliae f. restrictum CBS H-6685, culture ex-type CBS 178.40 = MUCL 9801); idem., (holotype of Verticillium dahliae f. cerebriforme CBS 177.40 culture permanently preserved in a metabolically inactive state) culture ex-type CBS 177.40 = MUCL 9791. Sweden, unknown origin, date and collector, CBS 434.83. UK, England, Newcastle on Tyne, from mineral wool packing (mainly asbestos), unknown date, H.M. Oixon, CBS 988.69 = IMI 59790.

Notes: This species was originally described by van Beyma (1940) as Verticillium dahliae f. restrictum based on the ex-type culture CBS 178.40. It was subsequently considered by Gams (1971) as heterotypic synonym of Verticillium dahliae f. cerebriforme (with ex-type strain CBS 177.40) and transferred to Acremonium. According to Gams (1971) both forms can be differentiated from V. dahliae by the scarce branching of the conidiophores and the more pronounced production of dark olive-green chlamydospores.

We have included the original material studied by Gams (1971), i.e., CBS 177.40, CBS 178.40, CBS 443.66 and CBS 988.69 and some additional specimens. Despite the genetic similarity, some morphological variation was observed. The conidial morphology of the ex-strain CBS 178.40 was variable, being obovoid to ellipsoidal, and the production of chlamydospores and branching of conidiophores was scarce on OA and profuse on MEA. While CBS 443.66 showed subglobose conidia and abundant chlamydospores, the colony colour was darker with a growth rate slower than that of the type.

Nigrocephalum Giraldo López & Crous, gen. nov. MycoBank MB828071.

Etymology: From the Latin niger, meaning black, and ancient Greek κεφαλή (kephalē), meaning head. Referring to the black heads of conidia produced in culture.

Mycelium consisting of branched, septate, pigmented, ornamented and thick-walled hyphae. Conidiophores erect, slightly bent, simple or basitonously branched. Conidiogenous cells enteroblastic, monopodial terminal, lateral, sub-cylindrical to subulate, pigmented, with conspicuous funnel-shaped collarette and periclinal thickening at the conidiogenous locus. Conidia

Fig. 26. Chlamydosporiella restricta. A, F–H. CBS 443.66. B–E, I. CBS 178.40 (culture ex-type). A. Colony on OA after 14 d at 25 °C. B–E. Conidiophores. F, G. Chlamydospores in chains and forming clumps. H, I. Conidia. Scale bars = 10 μm.
ellipsoidal, concave in lateral view, 1-celled, pigmented, smooth-walled, arranged in slimy heads. Sexual morph unknown.

Types species: *Nigrocephalum collariferum* (Weisenb. & R. Kirschner) Giraldo & Crous.

*Nigrocephalum collariferum* (Weisenb. & R. Kirschner) Giraldo López & Crous, *comb. nov.* MycoBank MB828072. Fig. 27. Basionym: *Acremonium collariferum* Weisenb. & R. Kirschner, Nova Hedwigia 90: 460. 2010.

*Mycelium* consisting of branched, septate, pale olive to brown, finely to roughly warty and thick-walled hyphae, 2–3 μm wide. *Conidiophores* erect, slightly bent, arising directly from vegetative and aerial hyphae, simple or basistomously branched, up to 52 μm long. 3 μm wide at the base, pale olive brown to dark brown, smooth-walled, with cell walls usually thicker than those of the vegetative hyphae. *Phialides* mostly lateral, sub-cylindrical to subulate, slightly wavy at the apex, hyaline, becoming pale olive brown to dark-brown with age, thick- and smooth-walled, often borne on short cylindrical subtending cells, 17–51.5 μm long, 1.5–2.5 μm wide at the base, with conspicuous funnel-shaped collarette and periclinal thickening at the conidiogenous locus, commonly with a percurrent proliferation. *Conidia* widely ellipsoidal, concave in lateral view, 1-celled, pale olive-brown to dark-brown, black in masses, thick- and smooth-walled, 2.9–5 × 2.1–2.7 μm, arranged in slimy heads. Sexual morph unknown.

**Culture characteristics:** After 14 d at ca. 20 °C: On OA reaching 19–20 mm diam, flat, membranous at centre, dusty at periphery, with dark exudate droplets, diffuse margin, surface and reverse olive black. On MEA reaching 6–7 mm diam, flat, velvety, cer- ebriform, diffuse margin, surface and reverse olive black.

Specimens examined: Panama, Chiriquí, Los Algarrobos, from a human toenail with onychomycosis, 1 Dec. 2007, J.L.F. Weisenborn [holotype JW016P:1 (FR, dried culture), culture ex-type CBS 124586 = JW016P:1; idem., CBS 124585 = JW013P:4.

Notes: The monotypic genus *Nigrocephalum* is proposed here to accommodate two isolates formerly described as *Acremonium collariferum*. This species was isolated from human skin and nail lesions and showed in *vitro* abilities to grow at 33 °C and to degrade keratin. The original protologue describes and illustrates conidia initially formed in chains aggregating into slimy heads (Weisenborn *et al.* 2010). Intercalary and terminal chlamydospores were also seen. According to our observations, however, the conidia were exclusively produced in heads and no chlamydospores were seen at all after 20 d of incubation in OA, MEA and SNA.

**Clade VIII**

*Stachylidium* Link: Fr., Mag. Ges. Naturf. Freunde. Berlin 3: 15. 1809: Fries, Syst. Mycol. 3: 391. 1832.

*Mycelium* consisting of branched, septate, brown, thick-walled hyphae. *Conidiophores* arising from submerged hyphae, erect, septate, verticillate, pale brown to brown at the base, sometimes paler to hyaline towards the apex, roughened, singly or in groups, sometimes forming lax synnemata. *Conidiogenous cells* enteroblastic, monophialidic, in whorls, terminal, lateral, cylindric, ellipsoidal, hyaline or pale brown. *Conidia* ellipsoidal or...
cylindrical, 1-celled, pale brown to brown, smooth-walled, produced in slimy heads. Sexual morph unknown.

Type species: *Stachylidium bicolor* Link. [= *S. verticillatum* (Hoffm.) S. Hughes].

*Stachylidium bicolor* Link: Fr., Mag. Ges. Naturf. Freunde. Berlin 3: 15. 1809; Fries, Syst. Mycol. 3: 391. 1832. Fig. 28.

**Synonyms:**
- *Botrytis bicolor* (Link: Fr.) Pers., Mycol. eur. 1: 37. 1822.
- *Acremonium bicolor* (Link: Fr.) Bonord., Handb. allg. Mykol: p. 92. 1851.

For additional synonyms see Index Fungorum and MycoBank.

On natural substratum. Mycelium consisting of branched, septate, initially hyaline but brown with age, thick- and smooth-walled hyphae, 2–6 μm wide. Conidiophores arising from submerged hyphae, erect, roughened, sometimes distinctly swollen at the base, with 4–14 septa in the lower part, verticillate, bearing up to 7 whorls of 3–4 phialides, often with additional verticillate axes emerging from the main stipe, ca. up to 700 μm long, 3.3–4.9 μm wide at the base, olive to brown at the base, hyaline to pale olive above the middle, rough-walled in the axis including the terminal phialide, with cell walls usually thicker than those of the vegetative hyphae, singly but usually in groups. Phialides in divergent whorls of 3–4, cylindrical to ellipsoidal, rounded at the apex, pale brown, thick- and rough-walled, 9.4–14.8 μm long, 3.5–5.3 μm wide at the base, with minute collarette. Conidia cylindrical with rounded ends, 1-celled, pale brown, smooth- and thick walled, 4.6–8.5 × 1.7–3.1 μm, arranged in slimy heads. On artificial media: Mycelium consisting of branched, septate, hyaline to light brown, thick- and smooth-walled hyphae 1–3 μm wide. Conidiophores arising from submerged hyphae, erect, roughened, sometimes distinctly swollen at the base, with 7–16 septa in the lower part, verticillate, bearing up to 9 whorls of 3–5 phialides, often with additional verticillate axes emerging from the main stipe, up to 557 μm long, 2.5–4 μm wide at the base, olive to brown at the base, hyaline to pale olive above the middle, completely brown with age, rough-walled in the axis including the terminal phialide, with cell walls usually thicker than those of the vegetative hyphae, usually in groups. Phialides arising in divergent whorls of 3–4, cylindrical to ellipsoidal, tapering strongly.

Fig. 28. *Stachylidium bicolor.* A–G. B700016303 (lectotype). H–N. CBS 121802 (ex-epitype culture). A. Envelope of the herbarium material B700016303. B. Detail of the lectotype. C. Conidiophore. D, E. Conidiogenous cells. F, G. Conidia. H, I. Colonies on MEA and OA after 14 d at 25 °C, respectively. J–L. Conidiophores. M. Details of the collarette from the conidiogenous cells. N. Conidia. Scale bars = 10 μm.
near the tip, light brown, thick- and rough-walled, 8.9–16.6 μm long, 2.3–4.8 μm wide at the base, with minute collarette. 
Conidia cylindrical with rounded ends, 1-celled, light brown, smooth- and thick walled, 3.7–5.1 × 1.9–2.5 μm, arranged in slimy heads.

Culture characteristics: After 14 d at ca. 25 °C: On OA reaching 4–5 mm diam, flat, granulose, surface iron-grey with black exudate, reverse uncoloured. On MEA reaching 8–10 mm diam, raised, cerebriform, incrusted in the agar, velvety, surface iron-grey, reverse uncoloured. On MEA+KOH reaching 20–22 mm diam, velvety, dark grey to black, with reddish diffusible pigment and strong smell of geosmin.

Specimens examined: Unknown origin and substratum, unknown date, Link, (lectotype designated here herbarium B B700016303, MBT383651), idem., B700016301, B700016302, B700016304; Unknown origin, substratum, date, and collector, herbarium L 910.264-771 (Barcode L 0113657). Spain, Asturias, Picos de Europa National park, from plant debris, Oct. 2006, A. Mercado & C. Silvera (epitype designated here CBS H-23656, MBT383652, ex-epitype culture CBS 121602 = FMR 9486).

Notes: When the genus was proposed by Link (1809), based on S. bicolor and S. terrestre, no type species was designated. Hughes (1951) lectotypified the genus with S. bicolor, and commented about the synonymy with the older species Dematium verticillatum (Hoffmann 1795), mentioning “Modern ruling, however, would be against the taking up of Hoffmann’s earlier epithet for S. bicolor”. Despite that, Hughes (1958) proposed the combination Stachylidium verticillatum [which has been followed by other authors, e.g. Whitten et al. (2012)] even though the species S. bicolor had been previously sanctioned by Fries (1832).

Holubová-Jechová (1988) described S. bicolor var. caespitosum from a dead petiole of Calyptragnye in Cuba, which differs from S. bicolor in having narrower and longer conidia and conidiophores arising mostly in tufts. However, Index Fungorum and MycoBank list this variety as synonym of S. bicolor. In addition to the type, around 15 species and varieties assigned to Stachylidium are listed in these databases, including the more recently described taxa, i.e., S. cubense from dead branch of Trichostigma octandrum in Cuba (Mena-Portales & Mercado-Sierra 1984), and S. pallidum from Dendrocalamus giganteus in Indonesia (Dewi 2006).

Gams (2017) designated the lectotype of S. bicolor as L 2923. However, this accession number does not correspond with the format used by the L herbarium (Roxxall Bijmoer, Senior Collections Manager, Personal communication, 7 Mar. 2018). To propose a lectotype for this species, we examined authentic material of Link deposited in B (B700016301, B700016302, B700016303, and B700016304) and one specimen from herb. Persoon deposited in L (910.264-771). Although Hughes (1951) considered the L specimen to be “typical” and authentic for the name, he did not designate it as the lectotype. Of the Link specimens in B, we considered B700016303 to be the most suitable lectotype, noting that the label for B700016304 was labelled as “typus” by S. Hughes in March 1955, but without any subsequent formal publication that would validate this status.

Species of this genus have a worldwide distribution (Whitten et al. 2012), and are usually found on herbaceous and woody substrata and are more rarely reported from soil, with S. bicolor being the most common species (Hughes 1951, Barron 1968).

Stachylidium pallidum Dewi, Reinwardtia 12: 215. 2006. Fig. 29.

Description and illustration: Dewi (2006).

Culture characteristics: After 14 d at ca. 25 °C: On OA reaching 8–10 mm diam, flat, membranous, surface dirty white, reverse uncoloured. On MEA reaching 9–10 mm diam, raised, cerebriform, incrusted in the agar, membranous with scarce aerial mycelium, surface dirty white, reverse uncoloured.

Type details: Indonesia, Java, West Java, Bogor Botanical Garden, on dead leaf of Dendrocalamus giganteus, 15 Feb. 2006, Dewi 168 (holotype BO22541).

Specimens examined: India, from Oryza sativa, unknown date, G.P. White, DAOMC 226658. Nepal, near Goropani, from soil under Abies sp. and Rhododendron sp., unknown date, G. Franz, CBS 292.72. Thailand, Nakhon Nayok province, Mueang Nakhon Nayok district, Wang Trakhrai waterfall, from soil, 22 Jul. 2015, A. Giraldo, BCC 79031. Turkey, from soil, unknown date, G. Turhan, CBS 449.88.

Notes: Stachylidium pallidum was described by Dewi (2006) from a dead leaf of Dendrocalamus giganteus in Indonesia. Among the living cultures examined here, the strains BCC 79031, CBS 292.72 and CBS 449.88 are genetically and morphologically different from the ex-epitype strain CBS 121802. They produced whitish and slow growing colonies on OA and MEA, strongly branched conidiophores with pale apices, cylindrical phialides with pointed apices and ellipsoidal to subovoidal conidia (Fig. 29). These isolates fit the description of S. pallidum rather than S. bicolor, except that they produce phialides that have echinulate rather than smooth walls. However, no authentic cultures are presently known for S. pallidum, and the holotype BO22541 was not available for comparison.

Fig. 29. Stachylidium aff. pallidum (CBS 449.88). A, B. Colonies on MEA and OA after 14 d at 25 °C, respectively. C, D. Conidiophores. E. Conidia. Scale bars = 10.
Clade IX

**Brunneomyces** Giraldo et al., Mycol. Progr. 16: 357. 2017.

Mycelium consisting of branched, septate, dark brown hyphae, verrucose and thick-walled with age. Conidiophores erect, unbranched or poorly branched, often proliferating sympodially. Conidiogenous cells enteroblastic, mono- and polyphialidic, hyaline, terminal, lateral or intercalary, subulate, lageniform or cylindrical, subhyaline or pale brown, with short cylindrical collarette and periclinal thickening at the conidiogenous locus. Conidia ovoid to ellipsoidal, 1-celled, hyaline or brown, smooth-walled, arranged in chains. Sexual morph unknown (adapted from Giraldo et al. 2017).

Type species: Brunneomyces brunnescens (W. Gams) Giraldo, Gené & Guarro

**Brunneomyces brunnescens** (W. Gams) Giraldo et al., Mycol. Prog. 16: 357. 2017.

Basionym: Acremonium brunnescens W. Gams, Trans. Br. Mycol. Soc. 64: 398. 1975.

Description and illustration: Gams 1975, Giraldo et al. (2017).

Specimen examined: Sri Lanka, on dead stem of Dendrocalamus giganteus, Jan. 1973, W. Gams (holotype CBS H-6641, isotype IMI 185378, culture ex-type CBS 559.73).

Notes: Brunneomyces was recently proposed by Giraldo et al. (2017) to accommodate Acremonium brunnescens as the type species, along with two new species: B. hominis and B. europaeus. Species in this genus are unique in the family in producing conidial chains in culture. According to our phylogenetic inference, they are placed in a distinct, well-supported clade (Clade IX, BS = 100 %).

Clade X

**Lectera** P.F. Cannon, MycoKeys 3: 28. 2012.

Conidiomata sporodochial or acervular, erumpent through host tissues and without a clear upper wall, globose to subglobose, pink or flesh coloured, with few marginal, erect setae. Setae dark brown, septate, tapering towards the apex. Conidiophores reduced to the conidiogenous cell. Conidiogenous cells monophialidic, hyaline, proliferating percurrently at the apex. Conidia navicular or fusiform with pointed ends, slightly curved, 1-celled, hyaline, smooth-walled. Appressoria formed after conidial germination, dark brown, round to ovate with smooth margins. Sexual morph unknown (Adapted from Cannon et al. 2012)

Type species: Lectera colletotrichoides (Chilton) P.F. Cannon.

**Lectera colletotrichoides** (Chilton) P.F. Cannon, MycoKeys 3: 28. 2012. Fig. 30 (A–E).

Basionym: Volutella colletotrichoides Chilton, Mycologia 46: 801. 1954.

Synonym: Volutella colletotrichoides var. setosa Chilton, Mycologia 46: 801. 1954

Description and illustrations: Chilton (1954) and Cannon et al. (2012).

Culture characteristics: After 14 d at ca. 25 °C: On PDA reaching 14–15 mm diam, flat, slightly granulose, encrusted on the agar, surface and reverse orange.

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Fig. 30. Lectera species. A–E. Lectera colletotrichoides (IMI 332702). F–J. Lectera longa (ex-type IMI 181698). A. Colony on PDA after 14 d at 25 °C. B–D. Conidiogenous cells. E. Conidia. F. Sporulating conidiomata on PDA. G, H. Conidiogenous cells. I. Setae. J. Conidia. Scale bars = 10 μm. B (applies to C, D); G (applies to H).
Type details: USA: Iowa, Ames, on stems of Medicago sativa, Oct. 1954, J. Chilton [ISC 217496, lectotype K(M) 176269, isolectotype of Volutella colletotrichoides; ISC 217482, lectotype K(M) 176270, isolectotype of Volutella colletotrichoides var. setosa].

Specimens examined: Egypt, on Cicer arietinum, unknown date, M.M. Askar, IMI 333702. Morocco, Capsicum annuum, Feb. 1986, S.B. Mathur, IMI 303685.

Notes: The genus was proposed to accommodate the plant pathogen Lectera colletotrichoides as the type species, along with L. longa. Lectera colletotrichoides has been associated with diseases mainly of Fabaceae, but also of Asteraceae, Lamiaceae, Poaceae, Solanaceae and Violaceae (Cannon et al. 2012). In addition, it is also commonly isolated from soil and plant litter. Recently, Lectera capsici, recovered from leaf spots on Capsicum annuum in Malaysia, was described by Crous et al. (2017).

The type species was lectotypified by Cannon et al. (2012) with a specimen from Medicago sativa, but the publication lacked an illustration clarifying the morphological features of the organism. In order to permit morphological comparison of this species, we examined and illustrated IMI 303685 and IMI 333702 (Fig. 30 A–E). Based on our observations on PDA, conidiomata and setae were absent. The conidiogenous cells were cylindrical or slightly tapering, hyaline, smooth-walled, growing directly on the vegetative hyphae or on short stipes bearing 2–3 phialides, 6.4–12 μm long, proliferating percurrently with conspicuous periclinal thickening and sometimes a minute collarette. The conidia were navicular, with acute ends, inequilateral, with inner plane flat and outer plane convex, 1-celled, hyaline, smooth-walled, 5.1–7.5 × 2.1–2.7 μm.

**Lectera humicola** Giraldo López & Crous, sp. nov. MycoBank MB828073. Fig. 31.

Etymology: Refers to the substratum from which this fungus was isolated, soil.

Conidiomata sporodochial subglobose, slimy, bright orange, solitary or gregarious, formed abundantly on the surface of PDA. Setae dark brown, scarcely produced, 2–3-septate, flexuous, tapering to acutely rounded apices, thick- and smooth-walled, 56–57 μm long, 3.5 μm wide at the base. Phialides sub-cylindrical to subulate, hyaline, smooth-walled, proliferating percurrently at the apex, 5.1–16.3 μm long, 2.2–2.9 μm wide at the base, with conspicuous periclinal thickening at the conidiogenous locus. Conidia ellipsoidal-fusiform to navicular, acute at the ends, inequilateral, with inner plane flat, and outer plane convex, slightly curved, 1-celled, hyaline, olive brown in mass, thick- and smooth-walled, 5.6–8 × 2–2.7 μm.

Culture characteristics: After 14 d at ca. 25 °C: On PDA reaching 20–22 mm diam, flat, dry, encrusted on the agar, fimbriate on the margin, surface and reverse orange. On OA reaching 53–54 mm diam, in 14d, flat, granulose, entire margin, surface and reverse dark mouse grey.

Specimen examined: Brazil, from soil, 18 Feb. 1982, J. Diehl & E. Reis 46/81 (holotype CBS H-23651, culture ex-type IMI 265740).

Notes: Lectera humicola was previously treated as L. colletotrichoides (Cannon et al. 2012), but it is genetically different from the strains isolated from Cicer arietinum (IMI 333702) and Capsicum annuum (IMI 303685) (Fig. 1). In

![Fig. 31. Lectera humicola (ex-type IMI 265740). A. Colony on OA after 14 d at 25 °C. B. Sporulating conidiomata on PDA. C, D. Conidiogenous cells. E. Seta. F. Conidia. Scale bars = 10 μm.](image-url)
addition, it differs morphologically by having relatively long conidiogenous cells without stipe and brown conidia in mass.

**Lectera longa** P.F. Cannon, MycoKeys 3: 30. 2012. Fig. 30 (F–J).

**Description:** Cannon et al. (2012).

**Culture characteristics:** After 14 d at ca. 25 °C: On PDA reaching 8–9 mm diam, flat, smooth, encrusted on the agar, fimbriate margin, surface and reverse peach.

Specimen examined: Australia, Western Australia, Nedlands, from *Triticum* sp., 25 Jan 1974, K. Sivasithamparam 530 [holotype of Lectera longa IMI 181698 (dried specimen), culture ex-type IMI 181698].

**Notes:** No conidiomata, setae or conidiogenous cells were shown in the original description (Cannon et al. 2012), and therefore we provided a complete illustration of this species in culture (Fig. 30 F–J). After 14 d on PDA the sporodochia were subglobose, cerebriform, bright orange, solitary or gregarious, surrounded by abundant setae. Setae dark brown, 2–4-septate, flexuous, tapering to acutely rounded at the apices, thick- and smooth-walled, intermingled among the conidiogenous cells, 36–38 μm long, 3–5 μm wide at the base. Phialides subcylindrical to doliform, hyaline, smooth-walled, often borne on short cylindrical subtending cells, proliferating percurrently at apex, 5.2–8.5 μm long, 2–3 μm wide at the base, with conspicuous periclinal thickening at the conidiogenous locus. Conidia ellipsoid-fusiform to navicular, acute at the ends, inequilateral, with inner plane flat, and outer plane convex, slightly curved, 1-celled, hyaline, becoming olivaceous in mass, thick- and smooth-walled, 5–6.5 × 1.8–2.7 μm.

Culture characteristics: After 14 d at ca. 25 °C: On PDA reaching 20–26 mm diam, flat, moist, slightly granulose, encrusted on the agar, fimbriate margin, surface and reverse orange. On OA reaching 43–44 mm diam, flat, smooth, moist, entire margin, surface and reverse olivaceous black.

Specimen examined: Ethiopia, on seed of *Phaseolus vulgaris*, 1995, H. Wolfthechel (holotype CBS H-23652, culture ex-type IMI 366179).

**Notes:** Lectera phaseoli was formerly identified as *L. coleto-trichoides* (Cannon et al. 2012), however differs morphologically in the production of abundant sporodochia and setae in vitro, and by producing shorter phialides and conidia.

**Etymology:** Refers to *Phaseolus*, the host genus from which this fungus was isolated.

**Conidiomata** sporodochial, subglobose, bright orange, solitary or gregarious, formed abundantly on the surface of PDA, surrounded by abundant setae. Setae dark brown, 2–4-septate, flexuous, tapering to acutely rounded at the apices, thick- and smooth-walled, intermingled among the conidiogenous cells, 36–38 μm long, 3–5 μm wide at the base. Phialides subcylindrical to doliform, hyaline, smooth-walled, often borne on short cylindrical subtending cells, proliferating percurrently at apex, 5.2–8.5 μm long, 2–3 μm wide at the base, with conspicuous periclinal thickening at the conidiogenous locus. Conidia ellipsoid-fusiform to navicular, acute at the ends, inequilateral, with inner plane flat, and outer plane convex, slightly curved, 1-celled, hyaline, becoming olivaceous in mass, thick- and smooth-walled, 5–6.5 × 1.8–2.7 μm.

**Culture characteristics:** After 14 d at ca. 25 °C: On PDA reaching 20–26 mm diam, flat, moist, slightly granulose, encrusted on the agar, fimbriate margin, surface and reverse orange. On OA reaching 43–44 mm diam, flat, smooth, moist, entire margin, surface and reverse olivaceous black.

Specimen examined: Ethiopia, on seed of *Phaseolus vulgaris*, 1995, H. Wolfthechel (holotype CBS H-23652, culture ex-type IMI 366179).

**Notes:** Lectera phaseoli was formerly identified as *L. coleto-trichoides* (Cannon et al. 2012), however differs morphologically in the production of abundant sporodochia and setae in vitro, and by producing shorter phialides and conidia.

**Etymology:** Refers to *Phaseolus*, the host genus from which this fungus was isolated.

**Conidiomata** sporodochial, subglobose, bright orange, solitary or gregarious, formed abundantly on the surface of PDA, surrounded by abundant setae. Setae dark brown, 2–4-septate, flexuous, tapering to acutely rounded at the apices, thick- and smooth-walled, intermingled among the conidiogenous cells, 36–38 μm long, 3–5 μm wide at the base. Phialides subcylindrical to doliform, hyaline, smooth-walled, often borne on short cylindrical subtending cells, proliferating percurrently at apex, 5.2–8.5 μm long, 2–3 μm wide at the base, with conspicuous periclinal thickening at the conidiogenous locus. Conidia ellipsoid-fusiform to navicular, acute at the ends, inequilateral, with inner plane flat, and outer plane convex, slightly curved, 1-celled, hyaline, becoming olivaceous in mass, thick- and smooth-walled, 5–6.5 × 1.8–2.7 μm.

**Culture characteristics:** After 14 d at ca. 25 °C: On PDA reaching 20–26 mm diam, flat, moist, slightly granulose, encrusted on the agar, fimbriate margin, surface and reverse orange. On OA reaching 43–44 mm diam, flat, smooth, moist, entire margin, surface and reverse olivaceous black.

Specimen examined: Ethiopia, on seed of *Phaseolus vulgaris*, 1995, H. Wolfthechel (holotype CBS H-23652, culture ex-type IMI 366179).

**Notes:** Lectera phaseoli was formerly identified as *L. coleto-trichoides* (Cannon et al. 2012), however differs morphologically in the production of abundant sporodochia and setae in vitro, and by producing shorter phialides and conidia.

**Etymology:** Refers to *Phaseolus*, the host genus from which this fungus was isolated.
Verticillium Nees, Syst. Pilze Schw 57. 1816.

Mycelium consisting of branched, septate, hyaline, thick-walled hyphae. Conidiofaphores arising from submerged hyphae or aerial mycelium, erect, mostly verticillate, septate, hyaline to subhyaline, sometimes turning brown at the base. Conidigenous cells enteroblastic, monophialidic, inserted in a mesotomous to acrotonous position, terminal, lateral, flask-shaped or aculeate, hyaline, with inconspicuous collarettes. Conidia ellipsoidal or cylindrical with rounded ends, 1-celled, rarely 2-celled, hyaline, sometimes turning brown with age, smooth-walled, produced in slimy heads. Resting structures including pigmented resting mycelium, chlamydospores in short chains, and/or microsclerotia. Sexual morph unknown.

Type species: Verticillium dahliae Kleb.

Verticillium alfalfae Inderb. et al., PloS ONE 6: 7. 2011.

Description and illustration Inderbitzin et al. (2011a).

Materials examined: Italy, from Catalpa bignonioides, unknown date and collector, CBS 241.82. UK, from Catalpa bignonioides, unknown date and collector, CBS 453.51. USA, from Medicago sativa, unknown date and collector (holotype UC 1953895, culture ex-type CBS 130603 = NRRL 54790 = PD489); Pennsylvania, USA, CBS 127169 = ATCC MYA-4576 = FGSC 10136.

Notes: The isolates placed in the V. alfalfae clade were previously identified as V. albo-atrum, which is commonly confused with V. alfalfae or V. nonalfalfae. All of them produce resting mycelium in culture. However, V. albo-atrum differs by producing microsclerotia, and more rarely 2-celled, brown-pigmented conidia, and microcyclic conidiation. Microsclerotia are only observed on water agar (WA) or prune lactose yeast agar (PLYA) and not in commonly used media such as PDA (Inderbitzin et al. 2011a).

At present, Verticillium alfalfae is only known as a causal agent of disease in Medicago sativa in Canada, China, Japan and the USA (Inderbitzin et al. 2011a, Xu et al. 2016). According to our results it can be also found on Catalpa bignonioides (Bignoniaceae) in Italy and the UK.

Verticillium dahliae Kleb., Mycol. Centbl. 3: 66. 1913. Fig. 33. Synonyms: Verticillium albo-atrum var. dahliae (Kleb.) R. Nelson, Tech. Bull. Michigan Agric. Exp. Sta. 221. 1950. Verticillium albo-atrum f. dahliae (Kleb.) Shmotina, Nauch. Dokl. Vysh. Shkoly, Biol. Nauki 8: 64. 1971.

For additional synonyms see Index Fungorum and MycoBank.

Materials examined: Argentina, from Helianthus annuus, unknown date and collector, CBS 110223, CBS 110224, CBS 110225. Canada, Quebec, from Solanum lycopersicon, idem., CBS 381.66. Germany, from Trifolium pratense, idem., CBS 110274. Italy, from Xanthium italicum, idem., CBS 383.49. Netherlands, from Solanum tuberosum, idem., CBS 384.49; from Rosa rugosa, idem., CBS 385.49; from S. melongena, idem., CBS 386.49; from Antirrhinum majus, idem., CBS 388.49; from Phlox sp., idem., CBS 802.97; from Ribes rubrum, idem., CBS 806.97; from Fragaria sp., idem., CBS 807.97; from Rosa sp., idem., CBS 809.97; from Forsythia sp., idem., CBS 814.97; Lelystad, from soil, idem., CBS 812.97; Drente, from root of Solanum tuberosum, idem., CBS 717.96; Naaldwijk, from S. lycopersicon, idem., CBS 425.52; Oost-Flevoland, from root of Vicia faba, idem., CBS 719.96; Wageningen, from S. lycopersicon, idem., CBS 177.66, CBS 178.66, CBS 179.66, from soil, idem., CBS 806.97, CBS 807.97, CBS 808.97, New Zealand, Motueka, from Nicotiana tabacum, idem., CBS 127.79B. Russia, from unknown substratum, date and collector, CBS 222.72A, CBS 222.72C. UK, from Humulus lupulus, unknown date and collector, CBS 380.49. Unknown origin, date and collector, from Rubus idaeus, CBS 204.26, CBS 205.26; idem., from Humulus lupulus, CBS 389.49; idem., from Fragaria sp., CBS 390.49; idem., from Solanum tuberosum, CBS 391.49; idem., from Rubus idaeus, CBS 392.49; idem., from stem of R. fruticosus, CBS 810.97; idem., from stem of Acer sp., CBS 811.97. USA, California, Salinas, from Capsicum annuum, unknown date, K.V. Subbarao, CBS 128315; Watsonville, from Lactuca sativa, unknown date and collector (epitype UC 1953893, designated by Inderbitzin et al. 2011a, a dried culture of PD322, culture ex-epitype CBS 130341 = NRRL 54785 = PD322), idem., CBS 127170; Hawaii, from Caesalpa frutescens var. sericea, unknown date, WH. Ko, CBS 111950.

Notes: Verticillium was introduced by Nees (1816) as a monotypic genus based on V. tenuer. Numerous synonyms were later proposed for this species including Sporotrichum luteolobum (Link 1809) and Acrostalagmus cinnabarinus (Corda 1838).
Additional species were subsequently added to the genus, including the important plant pathogens *V. albo-atrum* (Reinke & Berthold 1879) and *V. dahliae* (Klebahn 1913). Molecular studies later demonstrated that the last two species were not congeneric with *V. tenerum*, even though they belonged to the same family (Zare et al. 2004). To avoid undesirable name changes for the important plant pathogenic species, Gams et al. (2005) proposed to conserve the generic name Verticillium with a conserved type *V. dahliae*. *Verticillium tenerum* was subsequently accommodated in *Acrostalagmus* as *A. luteoalbus*.

Numerous species previously assigned to *Verticillium* have been shown to be phylogenetically unrelated, and spread out among different families within the Hypocreales, including Clavicipitaceae, Cordycipitaceae and Ophiocordycipitaceae. *Verticillium* s. str. is now restricted to a monophyletic clade in the Plectosphaerellaceae, embracing 10 species, viz., *V. albo-atrum*, *V. alfalfae*, *V. dahliae*, *V. isaacii*, *V. klebahnii*, *V. longisporum*, *V. nonalfalvae*, *V. nubilum*, *V. tricorpus* and *V. zaregamsianum* (Zare et al. 2007, Inderbitzin et al. 2011a). This clade includes soil-borne and root-inhabiting fungi, some of them plant pathogens producing vascular wilt in various agricultural crops worldwide (Domsch et al. 2007). The non-Plectosphaerellaceous species previously described in *Verticillium* have been reassigned to Lecanicillium (currently Akanthomyces) and Simplicillium (both Cordycipitaceae) for insect and fungal pathogens (Gams & Zare 2001, Zare & Gams 2001a, b, 2008); Haplocillium (now Drechsleria, Ophiocordycipitaceae), Pochonia and Rotiferophthora (Clavicipitaceae s. str.) for nematode parasites (Zare & Gams 2001b, Zare et al. 2001); and more recently Ovニックillium (Bio-neocystaceae), Leptobacillium (Cordycipitaceae), Chlamydocillium and Chlorocillium (incertae sedis) (Zare & Gams 2016) for species with diverse ecologies.

All the specimens examined here were morphologically identified as *V. dahliae*, except CBS 380.49 and CBS 127.79B, which were formerly identified as *V. albo-atrum* and *V. tricorpus*, respectively.

**Verticillium isaacii** Inderb. et al., PLoS ONE 6: 9. 2011.

Description and illustrations: Inderbitzin et al. (2011a).

Materials examined: Israel, Kerem-Shalom, from *Solanum* sp., 1994–1996, N. Korolev, CBS 100843; Nir-Itzhak, from *Brassica* sp., CBS 101220; Re’m, from soil in potato field, CBS 100839; idem., CBS 100840. Netherlands, Groningen, from *Lactuca* sativa, unknown date and collector, CBS 238.75; Wageningen, CBS 237.75; from stem of *Limonium* sp., idem., CBS 804.97, CBS 813.97; from *Chrysanthemum* sp., idem., CBS 805.97. USA, California, idem., from *Lactuca* sativa (holotype UC 1953896, culture ex-type CBS 130343 = NRRL 54792).

Notes: *Verticillium isaacii* was described by Inderbitzin et al. (2011a) from *Lactuca* sativa in the USA. It is phylogenetically related to *V. tricorpus* and *V. klebahnii*. All three species are morphologically indistinguishable, producing resting mycelium, abundant chlamydospores, microsclerotia and yellow pigmented hyphae. However, they differ in pathogenicity. *Verticillium klebahnii* and *V. tricorpus* are demonstrated pathogens of lettuce and tomato, respectively. In contrast, *V. isaacii* is known from many hosts, and is non-pathogenic (Isaac 1953, Vallad et al. 2006, Qin et al. 2008).

Inderbitzin et al. (2011a) reported *Verticillium isaacii* on *Cynara scolymus*, *Lactuca* sativa, *Solanum lycopersicum* var. *lycopersicum*, *Spinacia oleracea* and soil from Canada, UK and the USA. According to our results this species can be also found on *Brassica*, *Chrysanthemum* and *Limonium*. New distribution data includes the Netherlands and Israel.

This clade includes nine isolates formerly identified as *V. albo-atrum*, which are molecularly reidentified here as *V. isaacii*. In Fig. 1 the ex-type strain of *V. klebahnii* CBS 130344 nestled together with the *V. isaacii* isolates, including the ex-type CBS 130343; however, it fell in a separate clade in Fig. 2.

**Verticillium longisporum** (C. Stark) Karapapa et al., Mycol. Res. 101: 1281. 1997, Fig. 34. Basionym: *Verticillium dahliae* var. *longisporum* C. Stark, Gartenbauwissenschaft 26: 508. 1961.

Description and illustration: Inderbitzin et al. (2011a).

![Fig. 34. Verticillium longisporum (ex-type CBS 124.64). A. Conidiophore. B. Phialide and conidia. C. Microsclerotia directly on PCA. D, E. Microsclerotia. Scale bars = 10 μm.](https://www.studiesinmycology.org)
Examined materials: Germany, Niedersachsen, Altes Land, from root of Armoracia rusticana, unknown date, C. Stark (holotype CBS H-19247, culture ex-type CBS 124.64 = PD687 = NRRL 54793); from Brassica napus, unknown date and collector, CBS 110232, CBS 110233. Sweden, from stem of Brassica rapa, unknown date, Dep. Microbial Ecol., Lund., CBS 649.85; from Brassica napus, unknown date and collector, CBS 110218, CBS 110219, CBS 110220, CBS 110221, CBS 110226, CBS 110227, CBS 110228, CBS 110229, CBS 110230, CBS 110231, CBS 110272, CBS 110273, CBS 110275, CBS 110276, CBS 110277. USA, California, Salinas, from Brassica oleracea var. botrytis, unknown date, S.T. Koike, CBS 128317 = PD348; Illinois, East Saint Louis, from Armoracia rusticana, unknown date, D.M. Eastburn, CBS 128316 = PD356.

Notes: Verticillium longisporum is the causal agent of the Verticillium wilt of oil seed rape. This wilt is an important disease in crucifer crops (Brassicaceae) in Europe. Verticillium longisporum is known to be a diploid hybrid species, with relatively long conidia (compared with the other species from the genus) and almost double the quantity of nuclear DNA (Inderbitzin et al. 2011a, b). This polyphyletic species originated at least three parental species, i.e., V. dahiae, Species A1 and Species D1. To date, V. dahiae is the only named parent of V. longisporum, while Species A1 and D1 have never been collected (Inderbitzin et al. 2011a, b).

In this study, we have included 20 isolates of V. longisporum, which were indistinguishable from the parental species V. dahiae based on their LSU and ITS sequences. Although, the TEF1-a showed a good resolution to resolve species boundaries, these isolates have different alleles for that locus, making the sequences unsuitable for multilocus sequence analysis. The same isolates possessed a unique allele for RPBe2, but its low rate of amplification prevented obtaining an amplicon from some of them.

According to Inderbitzin et al. (2011a) the ex-type culture of Verticillium longisporum CBS 124.64 (PD687) probably lost the ability to form microsclerotia in culture. However, the examination of this strain on PDA and PCA, showed that these structures were produced after 10 d of incubation at room temperature (Fig. 34). They were similar to those produced by CBS 128316 (PD356), another isolate studied by Inderbitzin et al. (2011a).

Verticillium nonalfalvae Inderb. et al., PloS ONE 6: 12. 2011.

Description and illustration: Inderbitzin et al. (2011a).

Materials examined: Belgium, unknown substratum and date, M. Cavaleri, CBS 451.88; Poperinge, from Humulus lupulus, unknown date, De Korte, CBS 390.91 = IPO 1435. Canada, growing on Verticillium albo-atrum, unknown date and collecter, CBS 382.66 = ATCC 16534 = IMI 118378. Japan, Hokkaido, from Solanum tuberosum, idem. (holotype UC 1953898, culture ex-type CBS 130339 = NRRL 54791 = PDB92). Netherlands, Loenen, from Lycopersicon esculentum, idem., CBS 385.91; Naaldwijk, idem., CBS 321.91; idem., CBS 322.91. Portugal, from Citrus sinensis, idem., CBS 113707 = UPSGC 2001. Slovenia, Savinja valley, from Humulus lupulus, unknown date, S. Radisek, CBS 121306, idem., CBS 121308. UK, from Humulus lupulus, unknown date and collector, CBS 381.49; from Fragaria sp., idem., CBS 382.49; from Antirrhinum sp., idem., CBS 452.51; from Solanum tuberosum, idem., CBS 454.51 = IHEM 3916.

Notes: As mentioned before, isolates of V. nonalfalvae and V. alfaeae are commonly misidentified as V. albo-atrum. This clade includes 13 isolates which were deposited in the CBS collection as V. albo-atrum, but are molecularly reidentified here as V. nonalfalvae. Similarly, several ITS sequences from V. nonalfalvae available in GenBank are wrongly labeled as V. albo-atrum.

Verticillium nonalfalvae and V. alfaeae are morphologically indistinguishable, but are different in DNA sequences and pathogenicity (Inderbitzin et al. 2011a). Verticillium nonalfalvae affects different kinds of hosts, including Solanum tuberosum and Humulus lupulus, while V. alfaeae causes disease mainly on Medicago sativa (Alfalfa or Lucerne). Within Europe, V. nonalfalvae has been reported from Austria, Germany, Slovenia and the UK (Inderbitzin et al. 2011a, Jelen et al. 2016, Maschek & Halschlag 2018). We have also found it in Belgium, the Netherlands and Portugal growing on Antirrhinum sp., Citrus sinensis, Fragaria sp. and Solanum lycopersicum.

Verticillium nonalfalvae is considered to be a potential biocontrol agent for the invasive tree species Allantis altissima (tree-of-heaven) in the eastern USA, including Ohio, Pennsylvania and Virginia (Kasson et al. 2015). Similar use has been considered in Austria (Maschek & Halschlag 2018).

Verticillium zaregamsianum Inderb. et al., PloS ONE 6: 15. 2011.

Description and illustrations: Inderbitzin et al. (2011a) and Grzhimaylo et al. (2016).

Materials examined: Israel, Kerem-Shalom, from Solanum sp., 1994–1996, N. Korolev, CBS 100838, CBS 100841, CBS 100842, Sde-Boker, idem., CBS 100837. Japan, Chiba, idem., from Lactuca sativa (holotype UC 1953898, culture ex-type CBS 130342 = PDB73 6 = NRRL 54795).

Notes: Verticillium zaregamsianum was recently described by Inderbitzin et al. (2011a) to accommodate isolates previously treated as V. tricorpus, which were pathogens of lettuce (Lactuca sativa) in Japan. According to our results and those of Grzhimaylo et al. (2016) this species can be also found in potato and in alkalophilic soils. Verticillium zaregamsianum can be morphologically distinguished from its relatives by the production of both microsclerotia and yellow-pigmented hyphae.

Clade XII

Acrostalagmus Corda, Icones fungorum hucusque cognitorum 2: 15. 1838.

Mycelium consisting of branched, septate, (sub)hyaline, thick-walled hyphae. Conidiophores mononematous or synnematous, arising from submerged hyphae, erect, branched, distinctly bright orange to reddish pigmented throughout. Conidiogenous cells enteroblastic, monophialidic, in pairs or whorls, terminal, lateral, flask-shaped, subulate or cylindrical, (sub)hyaline to pale orange, with a distinct periclinal thickening at the conidiogenous locus. Conidia oval, ellipsoidal to oblong-ellipsoidal, 1-celled, bright orange to reddish, smooth-walled, arranged in slimy heads. Sexual morph unknown.

Type species: Acrostalagmus luteobalbus (Link) Zare, W. Gams & Schroers.

Acrostalagmus luteobalbus (Link : Fr.) Zare et al., Mycol. Res. 108: 581. 2004. Fig. 35.

Basionym: Sporotrichum luteo-album Link: Fr., Mag. Ges. Naturf. Freunde Berlin 3: 13. 1809; Fries, Syst. mycol. 3: 424. 1832.

Synonym: Verticillium luteobalbus (Link : Fr.) Subram., Hypocytaceae: 649. 1971.

Additional synonyms in Zare et al. (2004).

Mycelium consisting of branched, septate, (sub)hyaline, thick- and smooth-walled hyphae, 2–3 μm wide. Conidiophores arising from submerged hyphae, usually densely crowded, erect, more or less straight, with main axis repeatedly branched, bearing up
to 5 nodes of phialides, usually ending in a particularly long phialide, around which three to five shorter phialides are grouped forming a verticil; up to 400 μm long, 4–5 μm wide at the base, distinctly bright orange to reddish throughout, with cell walls usually thicker than those of the vegetative hyphae. Phialides arising in whorls of 2–5(–7) along the main stipe and its branches, terminal, lateral, flask-shaped, tapering strongly near the middle into a narrow neck, (sub)hyaline to light orange, thick-and smooth-walled, 10–14 μm long, 2–3.1 μm wide at the base, with an inconspicuous collar and distinct periclinal thickening at the conidiogenous locus. Conidia oval, 1-celled, bright orange to reddish brown, smooth- and thick-walled, 3–4 × 1.8–2.3 μm, arranged in slimy heads (adapted from Domsch et al. 2007).

Culture characteristics: After 14 d at ca. 20 °C: On PDA, filling the plate; flat, floccose, dull orange to orange-brown due to the pigmented conidiophores and conidia. On OA, reaching 74–75 mm diam, flat, hairy at centre, granulose at periphery, orange with sienna shades.

Type details: Unknown location, substratum, date and collector, herbarium B (holotype of Sporotrichum luteo-album, slide 2423). According to Zare et al. (2004) and Gams (2017).

Specimens examined: Brazil, Minas Gerais, Vioasa, from Musa sapientum, 17 Nov. 2006, O.L. Pereira, CBS 121213 = IRAN 1110C = OLP 308; 25 Nov. 2006, idem., CBS 121214 = IRAN 1111C = OLP 307; 27 Nov. 2006, idem., CBS 121215 = IRAN 1112C = OLP 308. Canada, Ontario, York Co., Toronto, High Park, from decaying leaf, unknown date and collector, CBS 565.80; Quebec, Gatineau Park, from decayed wood, 31 Oct. 1960, G.L. Hennebert, CBS 325.61 = DAOMC 71555 = MUCL 1601. Germany, from straw-meal-amended field soil, unknown date and collector, CBS 194.87; Geisenheim, from wall treated with fungicides, idem., CBS 222.50. Netherlands, decaying timber of boat, idem., CBS 388.65 = IAM 14705. Russia, Astrakhan, growing on Colletotrichum lagenanum, idem., CBS 577.78B = VKM Mf-55; Kulunda steppe, Altai, Bezinate, from alkaline soil, Aug. 2002, D.Y. Sorokin, CBS 137628 = V208; Glauberovoe lake, idem., CBS 137629 = V209. UK, from bark of Fagus sylvatica, unknown date, W.R. Day, CBS 331.52; unknown substrate, 1916, G.H. Pethybridge, CBS 112.16. Unknown origin, substrate, date and collector, CBS 236.55.

Notes: In 1809, Link introduced the species Sporotrichum luteoalbum, which was later considered by Subramanian (1971) to be a synonym of the type species of Verticillium, V. tenerum; therefore the combination Verticillium luteoalbum was made. For a long time, this species was treated as the asexual morph of Nectria inventa (Pethybridge 1919). Zare et al. (2004), however, demonstrated that this asexual-sexual connection was erroneous, and the re-examination of conserved material of the latter fungus suggested its probable identity with Stephanonectria keithii (Bioenectriaceae, Hypocreales). Separately, Corda (1838) had established the genus Acrostalagmus based on A. cinnabarinus as the type species, and this species turned out to be morphologically identical with V. luteoalbum (Hughes 1958, Subramanian 1971). The combination A. luteoalbum was therefore proposed.

Fifty-four records are listed in Index Fungorum and MycoBank under the name Acrostalagmus, including records for 29 accepted species, six forms and eight varieties. Most of these were recently reviewed by Gams (2017) and were considered as probable synonyms of A. luteoalbum, including A. lateritius, A. ochraceus, A. parasitans and A. persistens. Acrostalagmus albus, A. albus f. minor, A. aphidum, A. cephalosporioides, A. cylindrosporus, A. niveus, A. nodosus, A. penicillioides, and A. spicarioides were treated as nomina dubia. Acrostalagmus caulocephalus and A. nigripes were considered probable synonyms of Verticillium albo-atrum; A. albus var. minor and
A. coccidicola were possibly Gibellulopsis nigrescens and Leptobacillum leptobactrum, respectively. Several other species were synonymized with other genera i.e., Acrostalagmus fragrans with Syzygites megalocarpus, A. galeoides with Calcarisporium arbuscula, A. herbarum with Verticillium distans and A. olivaceous with Stachylidium bicolor; while A. murinus and A. tetracladus were included in Phaeostalagmus and the Lecanicipitum fungicola species complex, correspondingly. Acrostalagmus characeus, A. fulvus and A. roseus were not included in Gams (2017) and are labelled in Index Fungorum and MycoBank as members of the Hypocreaceae.

According to Gams (2017) the holotype of Sporotrichum luteoalbum is deposited in B herbarium as the slide “2423”. Although we have not examined this slide, we have examined 14 isolates that match the morphological features described for this species. However, more isolates should be collected in order to propose an epitype for this species.

Acrostalagmus luteoalbus is a cosmopolitan fungus reported from various soil types, including alkaline soils, in Europe, Russia, Turkey, Sri Lanka, Nepal, Japan, Australia, Hawaii, Canada and the USA. Additionally, it can be isolated from a great variety of types of plant debris, as well as dung. It is known as a mycoparasite on Alternaria brassicae, Cronartium comandrae, Daldinia concentrica and Flammulina velutipes (Zare et al. 2004, Domsch et al. 2007, Seifert et al. 2011, Zhang & Tang 2015, Grum-Grzhimaylo et al. 2016).

Acrostalagmus annulatus (Berk. & Broome) Seifert, Stud. Mycol. 68: 186. 2011. Fig. 36.

**Basionym:** Stilbum annulatum Berk. & Broome, Grevillea 3: 63. 1874.

**Synonym:** Stilbella annulata (Berk. & Broome) Seifert, Stud. Mycol. 27: 58. 1985.

Additional synonyms in Seifert (1985).

Synnemata scattered, gregarious or caespitose, cylindrical-capitate, clavate or cylindrical, straight or slightly bent, unbranched or branched, often proliferating percurrently, smooth or villose at the base, with stipes white to pale orange brown, and capitula orange-brown, 250–2 000 μm tall, (25–)50–200(–500) μm wide. *Hyphae of stipe* smooth-walled, sometimes with scattered verrucose hyphae, 1.5–2.5(–3) μm wide. *Marginal hyphae* lobed, abundant, concentrated in and near the capitulum, thick- and smooth-walled, with individual lobes up to 2 μm wide. *Conidiophore* branching once or twice monochasial, 1.5–2 μm wide, metulae 11–20 × 1.5–3 μm. *Phialides* solitary or rarely in whorls of 3, terminal, lateral, cylindrical or subulate, straight or sinuous, orange in mass, thick- and smooth-walled, (8.5–) 15–30(–35) μm long, 1.5–2 μm wide at the base, with a conspicuous flared collarette and periclinal thickening at the conidiogenous locus. *Conidial mass* globose, hemisphaerical, initially yellow, becoming orange, then dark red to red-brown when mature, *Conidia* ellipsoid to oblong-ellipsoidal, 1-celled, light orange, smooth- and thick-walled, 4.3–6.3 × 2.2–3 μm, arranged in slimy heads. Adapted from Seifert (1985).

**Culture characteristics:** After 14 d at ca. 25 °C: On PDA reaching 22–30 mm diam, flat, floccose to hairy, dirty white to saffron or

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**Fig. 36.** Acrostalagmus annulatus (CBS 185.70). A. Colony on OA after 20 d at 25 °C. B, C. Synnemata. D. Apical portion of a synnema. E, F. Conidiogenous cells. G. Conidia. Scale bars: C, D = 25 μm; E–G = 10 μm.
orange. On OA reaching 22–23 mm diam, flat, granulose, white to amber, with drops of orange exudate.

**Type details:** Unknown location, on Brassica sp., Herbarium K (holotype of Stilbum annulatum: no. 6045, Car. Inf., herb. Berk., 1879). According to Seifert (1985).

Specimens examined: Brazil, Pará, near Belém, from soil and roots, unknown date, L. Pfenning, DAOMC 212126. Mexico, from Glycine max, Jan. 1970, J. Dunleavey, CBS 185.70 = JCM 9305. Japan, Okinawa Prefecture, Ishigaki island, mount. Oomo, from dead stem, 2 Jun. 1984, G. Okada, CBS 545.84 = CM 9306 = OFC 1487. Sierra Leone, Njala, from leaf of Ananas comosus, unknown date, K.A. Seifert, CBS 121.84 = IMI 056086. Venezuela, Amazonas, Cerro de la Nebina, base of Pico Phelps, from wood, idem., G.J. Samuels, CBS 450.85 = GJS 1253.

**Notes:** Acrostalagmus annulatus is reported as saprophytic on wood, bark, leaves and herbaceous stems, and it is occasionally isolated from soil. It has a cosmopolitan distribution, being specially isolated from the tropics and subtropics (Seifert 1985).

This species was treated and illustrated by Seifert (1985) as Stibella annulata, but transferred to Acrostalagmus by Réblová et al. (2011), based on a phylogeny inferred from SSU and RPB2 sequences. The synnematous construction of the conidiophores is distinct from the mononematous structures seen in the generic type, Acrostalagmus luteoalbus; however, the orange pigmentation in the conidiophores and conidia produced by the two species is a shared character that reflects their strong phylogenetic relationship (98 % BS).

In this study, we have included four isolates deposited in the CBS collection as Stibella annulata; some of them (CBS 185.70 and CBS 545.84) revised by Seifert (1985). All of them were nestled in the same clade as the strain DAOMC 212126 from soil and roots sampled in Brazil, which was included in the study of Réblová et al. (2011).

**Sodiomyces** A.A. Grum-Grzhim. et al., Persoonia 31: 154. 2013.

Ascomata cleistothecial, superficial, globose, dark-brown. Peridium multi-layered, pseudoparenchymatous, surface with textura angularis. Asci unilunate, saccate, thin-walled, without apical apparatus, scattered irregularly in the ascoma. Ascospores released by dissolution of the ascus wall before maturity, accumulating within the asccarp, released in a slimy mass, liberated by pressure within the asccarp. Ascospores ellipsoidal or ovoid, 2-celled, not constricted at the septum, pale brown, thick- and smooth-walled. Asexual morph. Conidiophores simple, weakly branched or penicillate, hyaline, smooth, thin-walled. Conidiogenous cells entero- or subulate, hyaline, thin-walled. Conidia subglobose, cylindrical or subulate, hyaline, smooth-walled, arranged in slimy heads.

**Types species:** Sodiomyces alcalophilus (G. Okada) Giraldo López & Crous, comb. nov. MycoBank MB828075. Fig. 37.

Basionym: Acremonium alcalophilum G. Okada, Trans. Mycol. Soc. Japan 34: 173. 1993.

**Description and illustrations:** Okada et al. (1993).

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**Fig. 37.** Sodiomyces alcalophilus (ex-isotype CBS 114.92). A. Colony on MEA+KOH after 14 d at 25 °C. B–D. Conidiogenous cells. E. Chlamydospore-like hyphae. F. Conidia. Scale bars = 10 μm.
Specimen examined: Japan, Kanagawa Pref., Tsukui-gun, near Tsukui Lake, from sludge of pig faeces compost, 9 Dec. 1984, A. Yoneda (holotype TNS-F-176428, ex-isolate culture CBS 114.92 = JCM 7366).

Notes: Acremonium alcalophilum was described by Okada et al. (1993) and isolated from sludge of pig manure compost, collected near the Tsukui Lake in Japan. The fungus was physiologically characterised by its alkalophilic (optimal growth at pH 9.0–9.2) and cellulytic properties, and morphologically by its pleomorphic conidiogenesis, featuring mainly phialidic structures, but also sympodial, arthric, elastic and retrogressive modes. This pleomorphism in conidial ontogeny was specially produced on alkaline glucose agar (Okada et al. 1993). Recently the genome of the ex-type strain of Acremonium alcalophilum has been sequenced, revealing a large number of genes encoding biomass-degrading enzymes, specially lipases, which have an important application in the production of biofuels and detergents, as well as in food processing, textile industries and other processes requiring an alkaline environment (Grigoriev et al. 2012, Nordberg et al. 2014).

Based in our phylogeny, the ex-type strain of Acremonium alcalophilum is nested with full support (100 % BS) in the same clade as the known Sodiomyces species, and therefore the new combination Sodiomyces alcalophilus is introduced here. This result is supported by the previous phylogeny showed in Grum-Grzhimaylo et al. (2013). Species of this genus are known to be alkaliphilic, a physiological feature also reported in S. alcalophilus (Okada et al. 1993). Sodiomyces alcalophilus can be morphologically distinguished from the other species of the genus by the absence of the sexual morph in culture.

The older genus Zodiomyces, based on Z. vorticellarius (Laboulbeniales, Laboulbeniomyctes, Ascornycota) was proposed by Thaxter (1891) for a fungus growing on the beetle Cymbiodyta lacustris (Coleoptera). The generic name comes from the Greek zodio, meaning a small animal, while Zodiomyces is based on English soda. Since they have a different eotomyology both names should not be confused.

Sodiomyces alkalinus Grum-Grzhim., Debets & Bilanenko, sp. nov. MycoBank MB828148.

Synonyms: Heleococcum alkalium Bilanenko & M. Ivanova, Mycotaxon 91: 501 (2005), Nom. inv., Art. 40.7 (Melbourne). Sodiomyces alkalins (Bilanenko & M. Ivanova) AA. Grum-Grzhim. et al., Persoonia 31: 157. 2013. Nom. inv., Art. 40.7 (Melbourne).

Description and illustrations: Bilanenko et al. (2005) and Grum-Grzhimaylo et al. (2013, 2016).

Species examined: Mongolia, Choibalsan area, the soda soil (pH 10.7) on the edge of Shar-Burdyn lake, 1999, D. Sorokin (holotype designated here CBS 110278 culture permanently preserved in a metabolically inactive state) culture ex-type CBS 110278 = F11 = VKM F-3762.

Notes: The genus Sodiomyces was proposed by Grum-Grzhimaylo et al. (2013) to accommodate the alkaliphilic species Heleococcum alkalium, which was demonstrated to be not congeneric with the type species H. aurantiacum (Bionectriaceae, Hyphocreales). The name Sodiomyces alkalins was, however, invalid, as the basionym was not validly published. It is validated above. Recently two more species have been added to the genus from soda soils, Sodiomyces magadis and S. tronis. The three species form cleistotheial ascomata in culture, but can be morphologically distinguished by aseual state morphology. While Sodiomyces magadis lacks asexual sporulation, S. alkalinus produces an acremonium-like state and S. tronis produces a gliocladium-like state (Grum-Grzhimaylo et al. 2013, 2016).

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