MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

VOLUME 114 OCTOBER–DECEMBER 2010

FIG 1. *Conocybe volviradicata* sp. nov.
(Watling, Işıloğlu & Baş Sermenli— FIG. 1, p. 147)
GÜLNUR EKŞI, *artist*

ISSN 0093-4666 MYXNAE 114: 1–522 (2010)
For subscription details and general information see back cover

MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

VOLUME 114

OCTOBER–DECEMBER, 2010

CONSISTING OF i–vi + 522 PAGES INCLUDING FIGURES

Published by
MYCOTAXON, LTD, P. O. BOX 264
Ithaca, NY 14581-0264, USA

WWW.MYCOTAXON.COM
Printed in the United States of America

MYCOTAXON

VOLUME ONE HUNDRED FOURTEEN — TABLE OF CONTENTS

PUBLICATION DATE FOR VOLUME ONE HUNDRED THIRTEEN

MYCOTAXON *for* JULY–SEPTEMBER, VOLUME 113 (I–VI + 1–526)

was issued on October 15, 2010

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.1

Volume 114, pp. 1–6 October–December 2010

Caloplaca tianshanensis (lichen-forming *Ascomycota*), a new species of subgenus *Pyrenodesmia* from China

HURNISA XAHIDIN[1,2], ABDULLA ABBAS[1] & JIANG-CHUN WEI[3*]

Hurnisa_xju@sina.com & weijc2004@126.com or weijc@im.ac.cn

[1]*College of Life Science and Technology*
[2]*College of Resource and Environment Sciences*
Xinjiang University, Urumqi 830046, P. R. China

[3]*Key Laboratory of Systematic Mycology & Lichenology,*
Institute of Microbiology, Chinese Academy of Sciences
1-3 West Beichen Road, Chaoyang District, Beijing 100101, P. R. China

Abstract — *Caloplaca tianshanensis* is described as a species new to science. It has a crustose and areolate thallus of yellowish-brown color with conspicuous cracks, bearing dark brown to black apothecia. An analysis of ITS sequences supports the affinity of the new species to subgenus *Pyrenodesmia*.

Key words — *Teloschistaceae*, peltate areoles, zeorine, isthmus

Introduction

As presently circumscribed, the subgenus *Pyrenodesmia* (A. Massal.) Boistel of the lichen-forming genus *Caloplaca* Th. Fr. (*Teloschistaceae*) contains lichens characterized by brown or black apothecia, an epihymenium that is usually K– or K+ violaceous, and a thallus that is not yellow, orange or red unlike most other *Caloplaca* spp., and lacks the K+ red reaction of the parietin complex (Tretiach & Muggia 2006).

Forty-two species of the genus *Caloplaca* were reported from China (Wei 1991). Among them 9 species belong to the subgenus *Pyrenodesmia*: *C. chrysophora* Zahlbr., *C. cupreorufa* Zahlbr. and *C. cervina* Zahlbr. from Sichuan (Zahlbruckner 1930, 1932), *C. giraldii* Jatta from Shaanxi (Jatta 1902) and Sichuan (Zahlbruckner 1930, 1931), *C. ochrotropa* Zahlbr. from Yunnan (Zahlbruckner 1930, 1932), *C. plumbeoolivacea* H. Magn., *C. circumalbata* (Delile) Wunder from Inner Mongolia (Magnusson 1944, as *C. aegyptiaca* (Müll.

*corresponding author

TABLE 1. Lichen species and sequences used to generate the phylogenetic tree.

SPECIES	GENBANK #
Caloplaca albopruinosa (Arnold) H.Olivier	EF093577
	EF093578
C. albopustulata Khods. & S. Y. Kondr.	EU192150
C. alociza (A. Massal.) Mig.	EF090933
	EF090936
C. badioreagens Tretiach & Muggia	EF081039
	EF081040
C. cerina (Ehrh.Ex Hedw.) Th.Fr.	AF353958
C. chalybaea (Fr.) Müll.Arg.	AY313970
	AY313971
C. chlorina (Flot.) Sandst.	AF353959
C. concreticola Vondrák & Khodos.	EU192153
	EU192152
C. cretensis (Zahlbr.) Wunder	EF093579
C. erodens Tretiach et al.	EF090922
	EF090921
C. obscurella (J. Lahm) Th.Fr.	AY313976
	AY313977
C. peliophylla (Tuck.) Zahlbr.	AY313965
C. tianshanensis Xahidin, A. Abbas & J.C. Wei *	GU552277
C. transcaspica.	EU192156
C. variabilis (Pers.) Müll. Arg.	EF090926
	EF090925

Arg.) Stnr; Wunder 1974), *C. transcaspica* (Nyl.) Zahlbr. from Inner Mongolia (Magnusson 1944, as *C. paulsenii*), Gansu, Qinghai (Magnusson 1940, as *C. paulsenii*) and Xinjiang (Poelt & Hinteregger 1993)., and *C. alociza* (Massal.) Mig. from Jiangsu (Wu & Xiang 1981, as *C. agardhiana* (Flot.) Flag., 1981).

During a study of the lichen genus *Caloplaca* in China numerous samples were collected by the first two authors from the Xinjiang region. Some specimens belonging to *Pyrenodesmia* attracted our special attention and were examined in detail for morphology, anatomy, chemistry and molecular systematics. As a result, one of them, *C. tianshanensis*, is described here as new to science.

Material and methods

Material

The lichen material examined for morphology, anatomy, chemistry and molecular analyses was collected from Miaoergou on Mt. Nan-shan in the Tianshan mountain chain, Xinjiang region, in 2009.

Morphological observations

Observations and photographs were made with a dissecting microscope (Leica MZ 12), a Zeiss Axioplan compound microscope and an Axiocam digital camera with associated software. Squash mounts and hand sections were routinely examined using tap water as the mounting medium. Lichen substances were detected by TLC and MCT (Culberson & Kristinsson 1970, Culberson 1972, Orange et al. 2001).

DNA extraction, amplification, and sequencing

The dried apothecia first were checked under the dissecting microscope for well-developed fruit bodies to avoid contamination of other organisms.

Total DNA was extracted from dry apothecia following the rapid one-tube genomic DNA extraction (Steiner et al. 1995) with modifications: seven dried and cleaned apothecia were transferred directly into a 2 ml Eppendorf tube. The material was grinded with a pestle in liquid nitrogen until a fine powder was obtained. Then 150 µl TE solution was added into the tube and stirred for 2 min. until the powder was well-distributed, and immediately stored at −20°C.

Primers for PCR of the nuclear ribosomal ITS region ITS1F (Gardes & Bruns 1993) and ITS4 (White et al. 1990) were used.

The phylogenetic tree was constructed with a Bayesian approach based on the nuclear ribosomal ITS sequence data of the new species and sequences of species from the same subgenus retrieved from GenBank (TABLE 1).

Taxonomy

Caloplaca tianshanensis Xahidin, A. Abbas & J.C. Wei, **sp. nov.** (FIGS 1, 2)

MYCOBANK MB 518332

Species nova similis C. peliophyllae *a qua thallo flavido-brunneo areolato cum rimis conspicuis et areolis peltatis, stipitatis in centro thalli, discis apotheciorum atris raro atrobrunneis, substantias lichenium ignotas continente differt.*

TYPE: China, Xinjiang, Mt. Nan-shan in Tianshan mountain chain, Miaoergou, on limestone, alt. 1280 m, April 10, 2009, A. Abbas & H. Xahidin 20090001 (**holotype** in XJU, **isotype** in HMAS-L).

ETYMOLOGY: The specific epithet refers to the type locality.

THALLUS crustose, 2–11 cm in diam., consisting of numerous peltate areoles of 0.7–3 mm wide and 0.4–0.6 mm thick, much thicker in central part of the thallus, yellowish brown, flat, separated by conspicuous cracks (FIG. 1a, b), with a whitish gray to light gray and very thin prothallus.

Upper cortex well developed, paraplectenchymatous, 50–175 µm thick; algal layer discontinuous (FIG. 1c).

ASCOMATA apothecia, orbicular to irregular in shape, immersed or somewhat prominent, 0.8–1 mm in diam., numerous, usually 1 per areole, sometimes 2 or occasionally more than 2, zeorine, with both a proper and a thalline margin; thalline margin raised and proper margin not visible when younger;

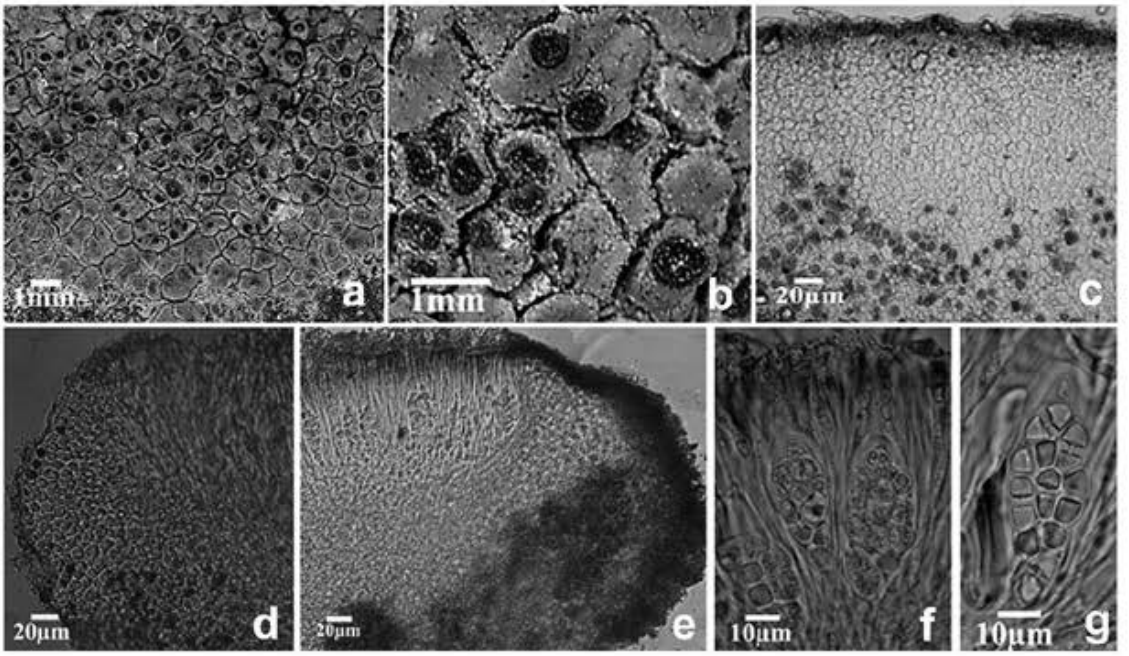


FIG. 1. *Caloplaca tianshanensis*: a, b. habit; c. cross section of a peltate areole of the thallus showing the well-developed paraplectenchyma in the upper cortex; d. cross section of an apothecium showing the well-developed paraplectenchyma in the proper exciple; e. cross section of an apothecium showing the double or zeorine margin, with both thalline and proper exciple; f. cross section of the hymenium showing asci containing spores and paraphyses with beaded apices consisting of 2–5 swollen terminal cells; g. an ascus containing 8 spores with thin septa.

proper margin raised and prominent, and thalline margin lower when mature (FIG. 1e); disc dark brown to black, concave, shiny, without or with thin whitish pruina (FIG. 1a, b); hymenium 75–115 µm thick; paraphyses septate, simple, with beaded apices consisting of 2–5 swollen cells (FIG. 1f); asci 44–62 × 12–26 µm, 8-spored; spores broadly ellipsoid, polarilocular, 12–18 × 5–9 µm (FIG. 1f, g); proper exciple paraplectenchymatous (FIG. 1d); hypothecium with gray crystals, 55–90 µm thick.

CONIDIOMATA not seen.

CHEMISTRY: upper cortex K–, C–, epihymenium K–; two unknown substances were detected by TLC: one gives a spot in R_f class 5–6 by solvent systems A, B and G, and in R_f class 6 by solvent system C, grey-brown after charring; the other gives a spot in R_f class 5 by solvent systems A and G, in R_f class 2 by B, and in R_f class 2–3 by C, green after charring.

REMARKS: The new species is similar to *C. peliophylla* in its yellowish brown thallus, but different by the areolate thallus, dark brown to black apothecium discs, the presence of two unknown lichen substances, and the Asian distribution. The latter species differs in its subsquamose thallus with shiny brown apothecia, an American distribution and the absence of lichen substances (Wetmore 1994). In addition, the new species is similar to *C. transcaspica* in its crustose and

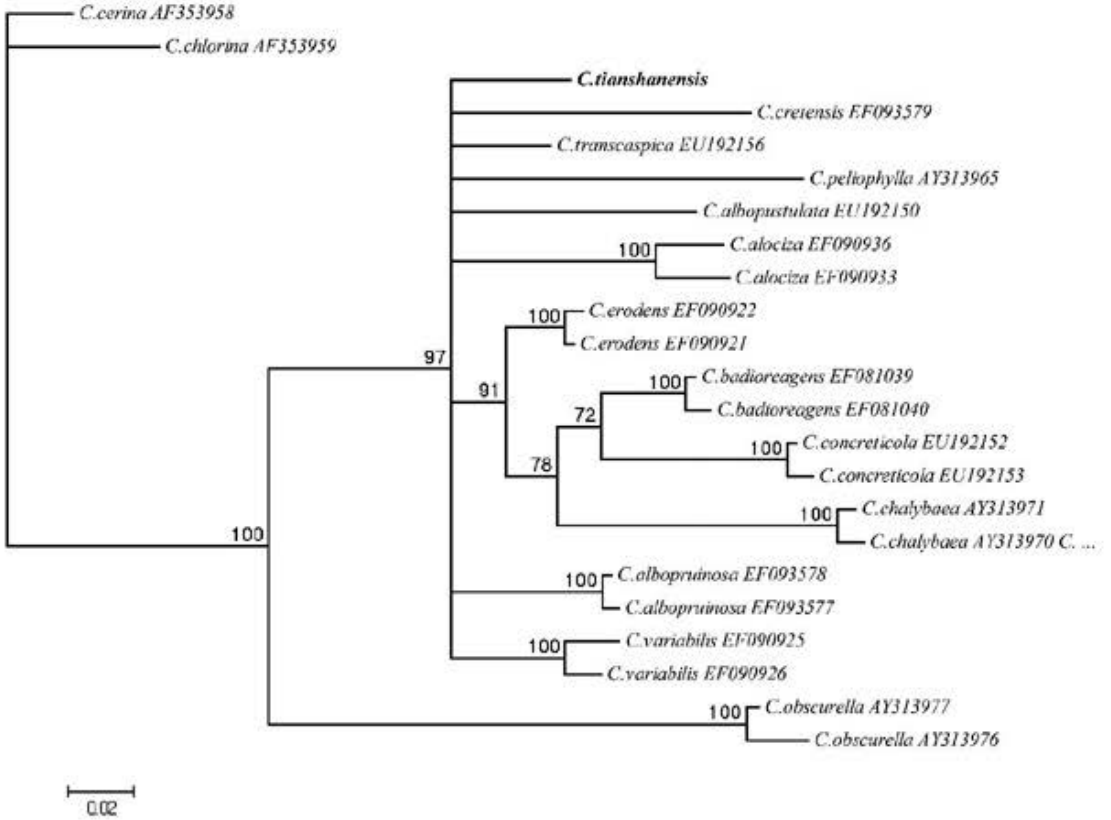


FIG. 2. Consensus tree generated by Bayesian analysis based on ITS region rDNA sequence data. *Caloplaca tianshanensis* groups with species of subgenus *Pyrenodesmia*. Bootstrap support values from 1000 replicates higher than 50% are reported at the nodes. *C. cerina* and *C. chlorina* from subgenus *Caloplaca* were selected as outgroup.

areolate thallus, but differs by its yellowish brown color, dark brown to black discs, smaller ascospores, wider isthmus in cells, and 2–5 swelling terminal cells of the paraphyses.

The ITS sequence of *C. tianshanensis* grouped with those of other 12 related species was retrieved from GenBank as a group belonging to the subgenus *Pyrenodesmia* with 100% bootstrap support. The ITS sequence of the new species *C. tianshanensis* form a distinct clade among the other 11 well recognized related species, such as *C. cretensis*, *C. transcaspica*, *C. peliophylla*, *C. albopustulata*, etc., with 97% bootstrap support. These results show that *C. tianshanensis* is clearly distinct from the above-mentioned well-recognized species (FIG. 2).

Acknowledgments

The first and second authors thank the National Natural Science Foundation of China for the financial support from the grants Nos: 30960003, 30750012. The authors are very grateful to Drs. H. Sipman and W.Y. Zhuang for reading the manuscript and giving valuable comments and suggestions.

Literature cited

Culberson CF. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. Journal of Chromatography 72: 113–125. doi:10.1016/0021-9673(72)80013-X

Culberson CF, Kristinsson H. 1970. A standardized method for the identification of lichen products. Journal of Chromatography 46: 85–93. doi:10.1016/S0021-9673(00)83967-9

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes - application for the identification of mycorrhizae and rusts. Molecular Ecology 2: 113–118. doi:10.1111/j.1365-294X.1993.tb00005.x

Magnusson HA. 1940. Lichens from Central Asia. Reports from the scientific expedition to the north-western provinces of China under the leadership of Dr. Sven Hedin. The Sino-Swedish Expedition 13.

Magnusson HA. 1944. Lichens from Central Asia. Part II. Reports from the scientific expedition to the north-western provinces of China under the leadership of Dr. Sven Hedin. The Sino-Swedish Expedition 22.

Orange A, James PW, White FJ. 2001. Microchemical methods for the identification of lichens. British Lichen Society, London. doi:10.1639/0007-2745(2003)106[0345:R]2.0.CO;2

Steiner JJ, Poklemba CJ, Fjellstrom RG, Elliott LF. 1995. A rapid one-tube genomic DNA extraction process for PCR and RAPD analyses. Nucleic Acids Research 23(13): 2569–2570. doi:10.1093/nar/23.13.2569-a

Tretiach M, Muggia L. 2006. *Caloplaca badioreagens*, a new calcicolous, endolithic lichen from Italy. The Lichenologist 38(3): 223–229. doi:10.1017/S0024282906005305

Wei JC. 1991. An Enumeration of Lichens in China. International Academic Publishers, Beijing.

Wetmore CM. 1994. The lichen genus *Caloplaca* in North and Central America with brown or black apothecia. Mycologia 86(6): 813–838. doi:10.2307/3760596

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal DNA genes for phylogenies. In: PCR protocols: a guide to methods and applications. (M. A. Innis, D H. Gelfand, J. J. Sninsky & T. J. White, eds): 315–322. San Diego: Academic Press. doi:10.1002/mrd.1080280418

Wu JN, Xiang T. 1981. A preliminary study of the lichens from Yuntai mountain in Lianyungang , Jiangsu. Journal of Nanjing Normal College (Natural Science Edition) 3:1–11.

Wunder H. 1974. Schwarzfrüchtige, Saxicole Sippen der Gattung *Caloplaca* (Lichenes, *Teloschistaceae*) in Mitteleuropa, dem Mittelmeergebiet und Vorderasien. Bibliotheca Lichenologica Band 3.

Zahlbruckner A. 1930. Lichenes, in: Handel-Mazzetti, H. (ed.), Symbolae Sinicae III. Julius Springer, Wien.

Zahlbruckner A. 1931. Catalogus Lichenum Universalis 7. Borntraeger, Leipzig.

Zahlbruckner A. 1932. Catalogus Lichenum Universalis 8. Borntraeger, Leipzig.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.7

Volume 114, pp. 7–14 *October–December 2010*

A new species of *Physarum* (*Myxomycetes*) from a boreal pine forest in Thuringia (Germany)

T. Hoppe, H. Müller & U. Kutschera

kut@uni-kassel.de
Institute of Biology, University of Kassel
Heinrich-Plett-Str. 40, D-34109 Kassel, Germany

Abstract – A new species of plasmodial slime mold, *Physarum parvicalcareum*, recorded from flowering stalks, leaves and stems of the common heather (*Calluna vulgaris*) that commonly inhabits boreal pine forests in Thuringia (Germany), is described based on morphological features of the capillitium and spores. Phylogenetic trees, reconstructed using data from elongation factor-1 alpha and small subunit ribosomal RNA gene sequence analyses, corroborate the taxonomic status of this new species. In addition, these results support the congruence of morphological and molecular data in this group of eukaryotic microorganisms.

Keywords – molecular phylogenetics, myxomycetes, species concepts

Introduction

Plasmodial slime molds (*Mycetozoa*, commonly referred to as myxomycetes) have been regarded as either "plant-like animals" or "animal-like plants," depending on whether a zoologist or a botanist investigated them. In the 19th century, taxonomists classified the myxomycetes as either fungi or protozoans (Martin & Alexopoulos 1969). However, a detailed analysis of DNA sequence data has recently shown beyond any doubt that these inhabitants of soil and other habitats containing moist, decomposing organic matter comprise a sister taxon to the *Amoebozoa* and hence are members of the Kingdom *Protoctista* (Pawlowski & Burki 2009, Hoppe & Kutschera 2010).

Physarum is the most widely known genus among the myxomycetes, due to the fact that the species *P. polycephalum* serves as a model organism for cell research.

Several years ago, Müller (2007) collected an unidentifiable myxomycete in boreal forests in the Federal State of Thuringia (Germany). Based on morphological, ultrastructural, and molecular data, we herein describe this taxon as a new species of the genus *Physarum*.

Materials and methods

During field trips in 2005 and two subsequent years to the boreal pine (*Pinus sylvestris* L.) forests in the Federal State of Thuringia (close to the towns of Rudolstadt and Mörla in eastern Germany, Central Europe), samples were collected from the leaves, stems, and flowering stalks of the common heather, *Calluna vulgaris* (L.) Hull. This cut plant material was analyzed in the laboratory, using a stereo light microscope (Photomikroskop III, Carl Zeiss, Germany) and a scanning electron microscope (REM, S-4000, Hitachi, Japan) as described by Hoppe & Kutschera (2010). Sample preparations and photographic documentation of the results were carried out as described in the reference cited above. Collections are conserved in Botanische Staatssammlung München (M) and the private collections of T. Hoppe (Germany), H. Müller (Germany), M. Meyer (France), and W. Nowotny (Austria).

Extraction of total deoxynucleic acids (DNA), DNA-amplification via polymerase chain reaction (PCR), and phylogenetic analyses were performed as described in Hoppe & Kutschera (2010). In brief, fruiting bodies were mechanically crushed, after which the homogenized samples were first treated using a FastRNA Pro Red Kit (Solon, Colorado, USA) and then incubated for 90 sec. with the Fast Prep-System FP120 (MP Biomedical) (Costa et al. 2004). In the next step, the samples were incubated for 24 h in a solution of lysozyme (5%, 35°C) and thereafter for 24 to 48 h in proteinase K (5%, 55°C) (Roth, Karlsruhe, Germany). DNA-purifications were performed using a QIAamp DNA Mini Kit (Quiagen, Hilden, Germany). The purified DNA samples were amplified with primers designed for specific elongation factor-1alpha gene sequences (Hoppe & Kutschera 2010) and primers for the small subunit of a ribosomal RNA gene (Kamono & Fukui 2006). The products were purified using NucleoSpin Extract II (Machery-Nagel, Germany) and sequenced. Phylogenetic trees, based on maximum parsimony analyses, were reconstructed as described by Hoppe & Kutschera (2010).

Taxonomy

Physarum parvicalcareum Thom. Hoppe, Holg. Müll. & Kutschera, **sp. nov.**

MycoBank MB 516617; NCBI (GenBank) FJ 558512 and GU 289193 Figs. 1–4

Sporocarpia sessilia, singula vel gregaria vel seria, globosa vel semiglobosa vel brevia plasmodiocarpia, violaceus usque ad aeneus iridescens, (0.3–)0.6–0.8 mm in diametro, usque ad 2 mm longae. Hypothallus membranaceus, translucidus. Peridium simplex, calce non incrustatum, violaceus usque ad aeneus, nonnullum clarum zonatum iridescens, lucem orientem versus visae incoloratum, dehiscentia irregularis. Capillitium reticulatum, album vel alutaceum, lucem orientem versus visae incolor, capilloides vel fasciatum, (1–)2–5(–7) µm in diametro, cum nodis calcareis parvis. Columella vel Pseudocolumella nulla. Sporae frequentes brunneus, lucem orientem versus visae cineraceo-brunneae vel brunneus, globosae, dense cum obscurus, irregulariter verrucosae, 10–11(–12) µm in diametro. Plasmodium ignotum.

Type specimens: Germany, close to Mörla, 50.43°N 11.20°E, on stems, green leaves and flowering stalks of *Calluna vulgaris* in a pine forest, 10 Oct. 2005, Holger Müller. (**Holotype**: Botanische Staatssammlung München (Germany), M 0151322; **Isotype**: private collection of H. Müller (Germany), Müll. 2238).

Etymology: from the Latin *parvus* = small; *calcareus* = calcareous.

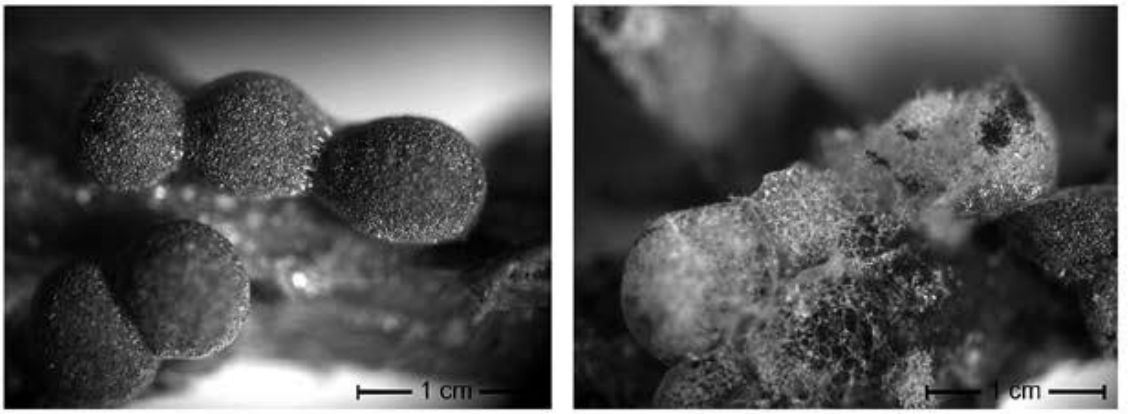


FIG. 1. Photographs of the sporocarps of *Physarum parvicalcareum* attached to a flowering stalk of *Calluna vulgaris*. A- Sporocarps with peridium still intact and spores present. B- Sporocarps after the release of the spores.

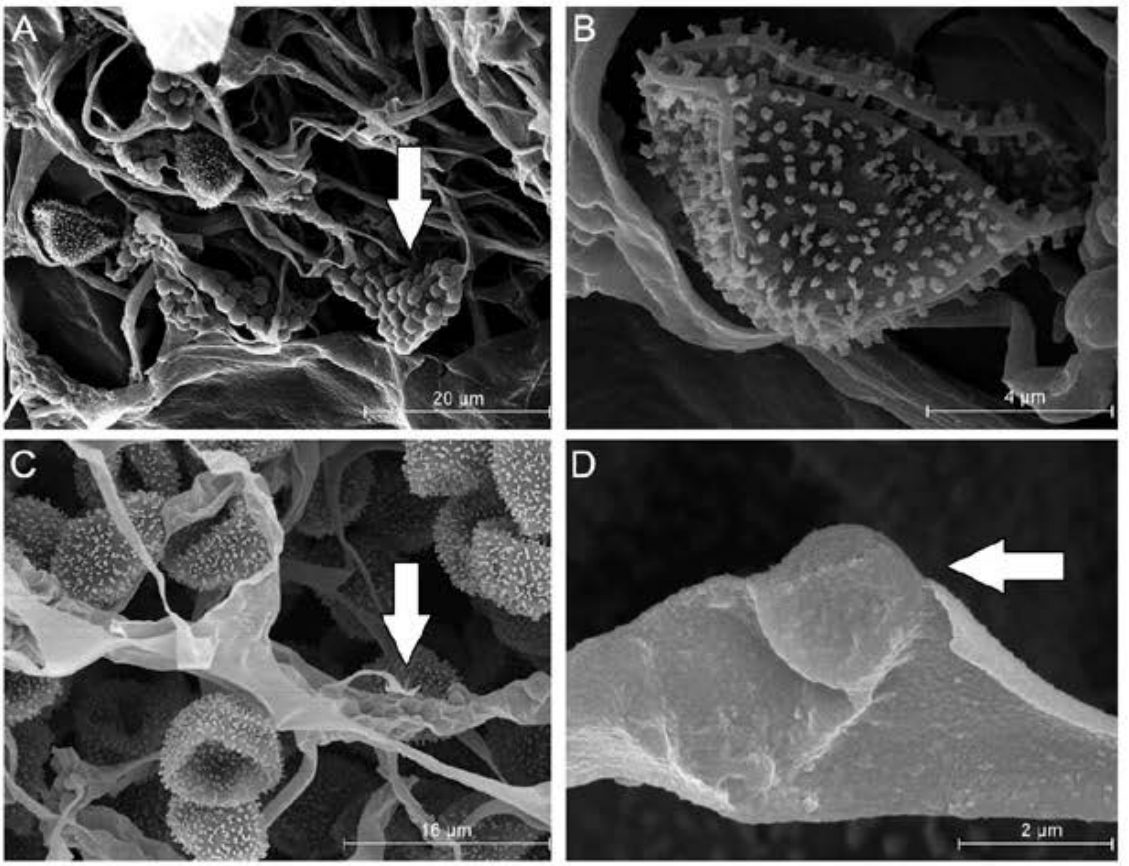


FIG. 2. Scanning electron micrographs of capillitium and spores of *Physarum parvicalcareum*. A- Capillitium with calcareous deposits (arrows). B- Single spore. C- Spores with capillitium that is free of deposits. D- Isolated portion of smooth capillitium with grain (calcareous deposit).

Sporocarps sessile, single, in groups or in lines, globose or sub-globose or short plasmodiocarps, violet to bronze, iridescence in white light, (0.3–)0.6–0.8 mm in diameter, up to 2 mm long (FIG. 1A,B). Hypothallus membranous, transparent, continuous within a group of fruiting bodies. Peridium single,

TABLE 1: Morphological features of *Physarum parvicalcareum*, *P. nudum*, and *P. cinereum*, based on newly collected and herbarium materials

CHARACTER	*P. parvicalcareum*	*P. nudum*	*P. cinereum*
Mature fruiting body	sporocarp or plasmodiocarp	sporocarp or plasmodiocarp	sporocarp or plasmodiocarp
– colour	violet to bronze	white to faint violet	white
– diameter (mm)	0.6–0.8	0.4–1.0	0.3–0.6
– length (mm)	up to 2.0	up to 1.2	up to 0.8
Capillitium surface	smooth or rough	rugged	rugged
– pili length (nm)	up to 300	up to 300	up to 250
Calcareous deposits within fruiting bodies	greatly reduced or absent	present	present

limeless, violet to bronze, some individuals conspicuously iridescent, colourless in transmitted light, dehiscence irregular. Columella or pseudo-columella absent. Capillitium consists of a three-dimensional net with small meshes, white to pale-yellow, colourless in transmitted light, filamentous, with few swellings, covered with small lime granules (FIG. 2A–D), sometimes with a band-like widened appearance, (1–)2–5(–7) µm in diameter. Spores dark-brown, grey-brown or dark-brown in transmitted light, globose, 10–11(–12) µm in diam., densely covered with dark, coarse, more or less irregular warts. Plasmodium not observed.

ECOLOGY AND HABITAT – Living stems, leaves, and flowering stalks of *Calluna vulgaris*; no fruiting bodies were found on nearby plants in the same area.

EXPANDED DESCRIPTION – A phylogenetic analysis, based on novel elongation factor-1 alpha gene sequences supplemented by published data, is depicted in FIG. 3. In addition, a partial (123 bp) sequence of the small subunit of a ribosomal RNA gene was investigated (GenBank-Numbers provided above the lines in FIGS. 3, 4) and aligned with morphologically similar species. These data show that *Physarum parvicalcareum* is closely related to the species *P. cinereum* and *P. nudum*, but differs from these taxa in several morphological features (TABLE 1). Hence, our evolutionary trees (FIGS. 3, 4), in tandem with our morphological data (FIGS. 1, 2) document *P. parvicalcareum* as a new species and not a morphological variant (variety) of *P. nudum* or one of the other taxa that were analyzed as part of the present study.

ADDITIONAL SPECIMENS EXAMINED: **GERMANY**, close to Mörla, 50.43°N 11.20°E, on stems, green leaves and flowering stalks of *Calluna vulgaris* in a pine forest, 15 Oct. 2005, Holger Müller (Distributed among private collections of H. Müller (Germany: Müll. 2632); M. Meyer (France: 29759, 29760, 30078, 30077); T. Hoppe (Germany: Myx 90); and W. Nowotny (Austria: Now. 13507).

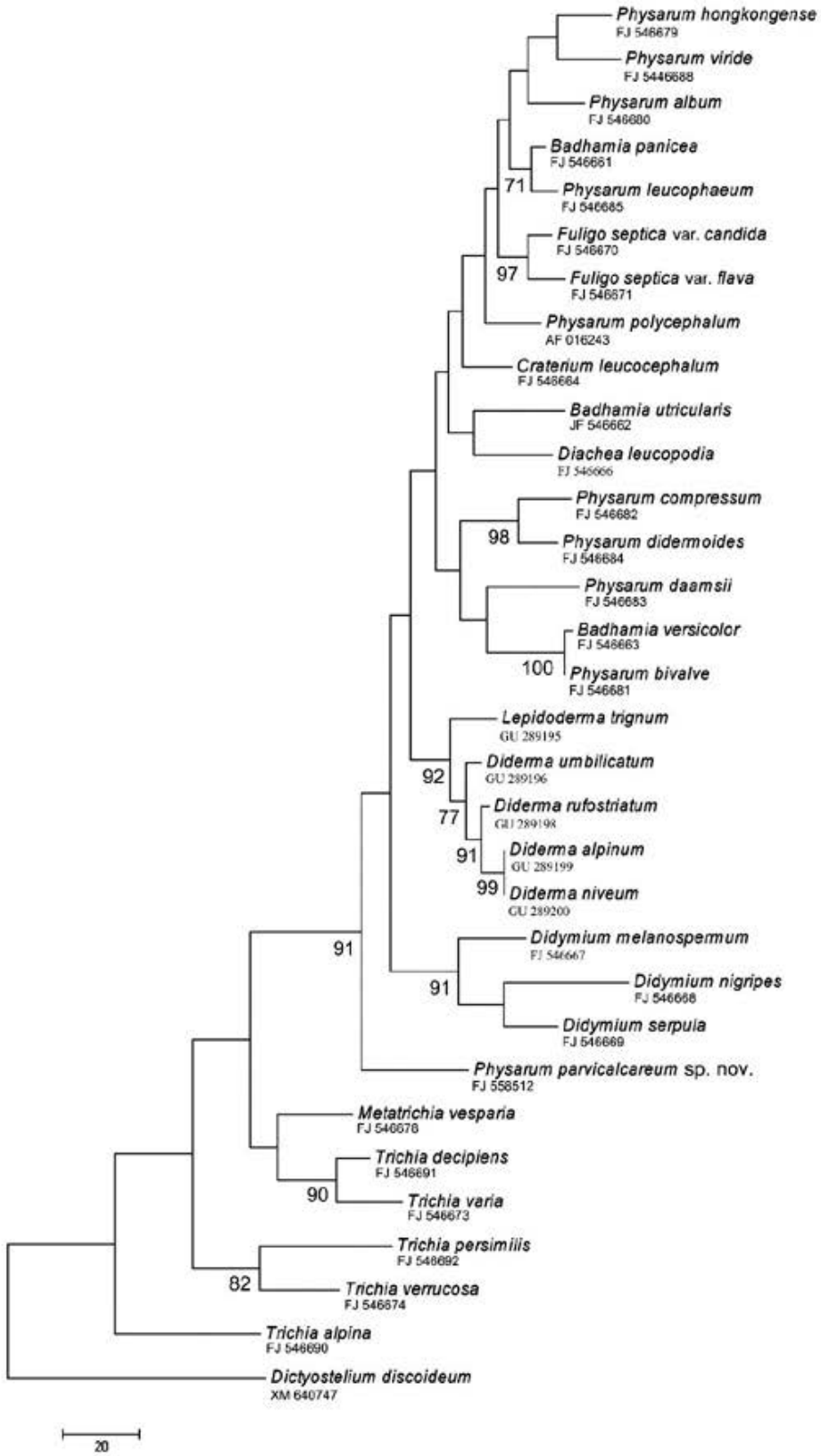


FIG. 3. Phylogenetic tree based on elongation factor-1 alpha gene sequences of 31 myxomycetes, with *Dictyostelium discoideum* as outgroup. The bootstrap values of this maximum parsimony analysis and the GenBank accession numbers are included.

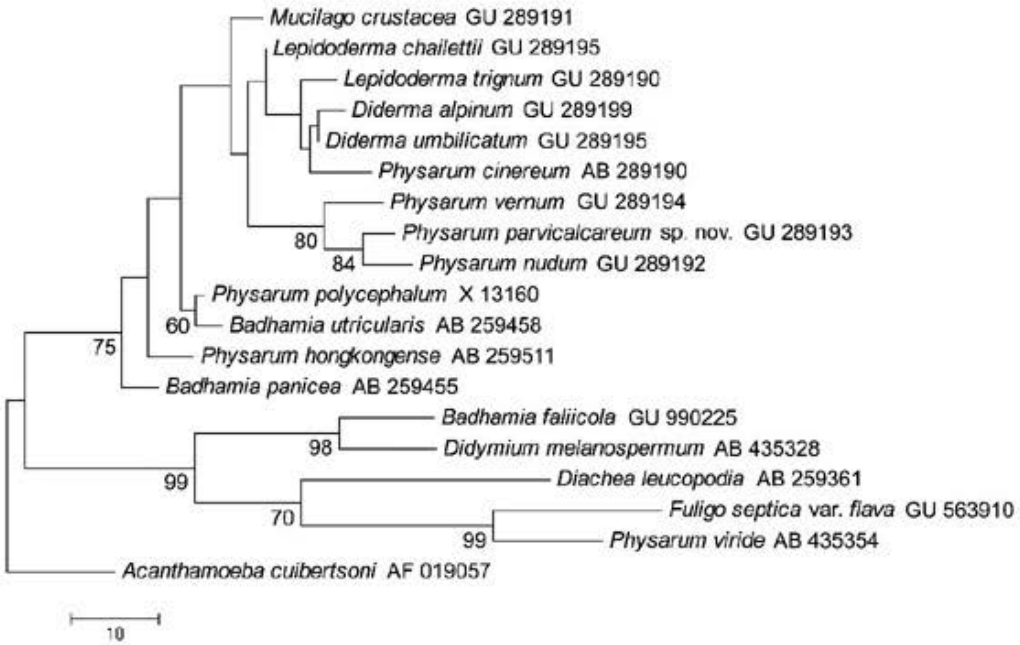


FIG. 4. Phylogenetic tree based on a fragment (123 bp) of the small subunit of a ribosomal RNA gene of 18 morphologically distinct species, with *Acanthamoeba cuibertsoni* as outgroup. The bootstrap values of this maximum parsimony analysis and the GenBank accession numbers are included.

COMMENTS – As pointed out by Neubert et al. (1993, 1995, 2000) and Clark (2000, 2004), myxomycete taxonomy is currently based on the classical morphological species concept. Hence, myxomycetologists have described numerous taxa ("species") that were found in a single habitat or a restricted area, often in low numbers, or even based on a single individual (Lado 2001).

As a result of his survey of recent biosystematic studies in the myxomycetes, Clark (2004) suggested that many commonly accepted morphospecies might, in reality, be species complexes. Moreover, the author suggested that many of the accepted morphospecies might represent morphological variants of one and the same "true" species and therefore should be assigned to the same taxon. In conclusion, Clark (2004) recommended that new species be described only on the basis of numerous collected specimens from different localities so that the problems outlined above could be circumvented.

In this report we describe a new species of myxomycete that was assigned to the genus *Physarum*. The question to be discussed here is whether or not we have met the standards proposed by Clark (2004). In other words, is *P. parvicalcareum* (FIG. 1, 2) only a "variant" of a closely related taxon or does it in fact represent a truly new species?

Our arguments in support of the second conclusion can be summarized as follows. First, the requirement that a new species should be based on an

extensive collection of individuals made on different occasions and (if possible) localities has been met. As documented in a previous report (Müller 2007), numerous samples were collected on several different occasions in Thuringia, and over the past year we found additional specimens of *P. parvicalcareum* in forests in close proximity to the type locality described above (unpublished observations). Second, there is sufficient morphological evidence to separate our new species from all other taxa assigned to the genus *Physarum*, particularly the most closely related species (TABLE 1). Finally, we analyzed the phylogenetic relationships among 30 myxomycete species within the genera *Trichia, Hemitrichia,* and *Metatrichia* in the order *Trichiales* and within the genera *Badhamia, Fuligo, Craterium, Diachea, Didymium,* and *Physarum* in the order *Physarales.* These analyses were based on elongation factor-1 alpha gene sequences. In addition, 14 relevant species of the *Physarales* belonging to the genera *Badhamia, Diachea, Didymium, Lepidoderma, Physarum* (8 different species), and *Mucilago,* based on a partial sequence of the small subunit of a ribosomal RNA gene, were also investigated. Our quantitative maximum parsimony analyses (FIGS. 3, 4) led to the conclusion that *P. parvicalcareum* represents a distinctly new species and not a "morphological variant" of another taxon assigned to the genus *Physarum.*

In summary, our results document that on the above-ground portions (leaves, stems, and flowering stalks) of the common heather (*Calluna vulgaris*) there occurs a myxomycete species that is described here as *P. parvicalcareum.* However, we do not yet know whether or not this new *Physarum* species inhabits its host organism as a commensal or an endophytic parasite (Stephenson & Studlar 1985). It should be noted that we are currently unaware of any other plant species in the boreal pine forest where our new myxomycete was discovered that is inhabited (or infected) by *P. parvicalcareum.* However, more fieldwork is required to further elucidate the entire habitat of this new plant-associated species of the genus *Physarum.*

Acknowledgements

We thank Mr. H. Rühling (Dept. of Cell Biology, University of Kassel, Germany) for help with the scanning electron microscopy, and Prof. S.L. Stephenson (University of Arkansas, USA), Dr. C. Lado (Real Jardin Botánico, Spain), and Dr. S.R. Pennycook (Nomenclature Editor, MYCOTAXON) for helpful comments on earlier versions of the manuscript.

Literature cited

Clark J. 2000. The species problem in the myxomycetes. Stapfia 73: 39–53.

Clark J. 2004. Reproductive systems and taxonomy of the myxomycetes. Syst. Geogr. Pl. 74: 209–216.

Costa R, Gomes NCM, Milling A, Smalla K. 2004. An optimized protocol for simultaneous extraction of DNA and RNA from soils. Brazilian Journal of Microbiology 35: 230–234. doi:10.1590/S1517-83822004000200011

Hoppe T, Kutschera U. 2010. In the shadow of Darwin: Anton de Bary's origin of myxomycetology and a molecular phylogeny of the plasmodial slime molds. Theory in Biosciences 129: 15–23. doi:10.1007/s12064-009-0079-7

Kamono A, Fukui M. 2006. Rapid PCR-based method for detection and differentiation of *Didymiaceae* and *Physaraceae* (myxomycetes) in environmental samples. Journal of Microbiological Methods 67: 496–506. doi:10.1016/j.mimet.2006.05.003

Lado C. 2001. Nomenmyx. A nomenclatural taxabase of myxomycetes. Cuaderos de Trabajo de Flora Micológica Ibérica 16: 1–221.

Martin GW, Alexopoulos C J. 1969. The myxomycetes. University of Iowa Press, Iowa.

Müller H. 2007. Myxomyceten an *Calluna vulgaris*. Zeitschrift für Mykologie 73: 245–250.

Neubert H, Nowotny W, Baumann K. 1993. Die Myxomyceten Deutschlands und des angrenzenden Alpenraumes unter besonderer Berücksichtigung Österreichs. Vol. 1. *Ceratiomyxales*, *Echinosteliales*, *Liceales* und *Trichiales*. Verlag Karlheinz Baumann, Gomaringen.

Neubert H, Nowotny W, Baumann K. 1995. Die Myxomyceten Deutschlands und des angrenzenden Alpenraumes unter besonderer Berücksichtigung Österreichs. Vol. 2. *Physarales*. Verlag Karlheinz Baumann, Gomaringen.

Neubert H, Nowotny W, Baumann K. 2000. Die Myxomyceten Deutschlands und des angrenzenden Alpenraumes unter besonderer Berücksichtigung Österreichs. Vol. 3. *Stemonitales*. Verlag Karlheinz Baumann, Gomaringen.

Pawlowski I, Burki F. 2009. Untangling the phylogeny of amoeboid protists. Journal of Eukaryotic Microbiology 56: 16–25. doi:10.1111/j.1550-7408.2008.00379.x

Stephenson SL, Studlar S. 1985. Myxomycetes fruiting upon bryophytes: coincidence or preference? Journal of Bryology 13: 537–548.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.15

Volume 114, pp. 15–23 October–December 2010

Muscodor cinnamomi, a new endophytic species from *Cinnamomum bejolghota*

NAKARIN SUWANNARACH[1], BOONSOM BUSSABAN[1], KEVIN D. HYDE[2] & SAISAMORN LUMYONG[1*]

*scboi009@chiangmai.ac.th

[1]*Department of Biology, Faculty of Science, Chiang Mai University Chiang Mai 50200, Thailand*

[2]*School of Science, Mae Fah Luang University Chiang Rai 57100, Thailand*

Abstract — *Muscodor cinnamomi* is described as a new species, endophytic within leaf tissues of *Cinnamomum bejolghota* (*Lauraceae*) in Doi Suthep-Pui National Park, Northern Thailand. Molecular analysis indicated differences from the five previously described *Muscodor* spp. Volatile organic compounds analysis showed that *M. cinnamomi* produced azulene (differentiating it from *M. crispans*) but did not produce naphthalene (differentiating it from *M. albus*, *M. roseus*, and *M. vitigenus*).

Key words — sterile ascomycete, cinnamon, endophytes, volatile compounds

Introduction

Plants are reservoirs of untold numbers of endophytic organisms (Bacon & White 2000). By definition, these microorganisms (mostly fungi and bacteria) reside in the tissues beneath the epidermal cell layer and cause no apparent harm to the host (Azevedo et al. 2000, Hyde & Soytong 2008). Endophytes from rainforest and medicinal plants have been studied for their volatile antibiotic and other medicinal characteristics (Strobel et al. 2003, Huang et al. 2008, 2009, Mitchell et al. 2008, Tejesvi et al. 2009, Aly et al. 2010). Five endophytes characterized by sterile mycelium that have recently been described as novel fungi are *Muscodor albus* isolated from *Cinnamomum zeylanicum* (*Lauraceae*) in Honduras (Worapong et al. 2001), *M. roseus* from *Grevillea pteridifolia* (*Proteaceae*) in the Northern Territory of Australia (Worapong et al. 2002), *M. vitigenus* from *Paullinia paullinioides* (*Sapindaceae*) in Lake Sandoval (Daisy et al. 2002), *M. crispans* from *Ananas ananassoides* (*Bromeliaceae*) in the Bolivian Amazon (Mitchell et al. 2008), and *M. yucatanensis* from *Bursera*

simaruba (*Burseraceae*) in the Northeastern Yucatan Peninsula of Mexico (González et al. 2009). All *Muscodor* species grow slowly, have felt-like mycelia, and produce a distinctive odor. Gas chromatography and mass spectrometry (GC/MS) can be used to identify *Muscodor* species based on differences in the volatile compounds that they produce (Strobel et al. 2001).

In the present study an endophyte (CMU-Cib 461) was recovered from leaf tissue of a wild cinnamon tree (*Cinnamomum bejolghota*) growing in Doi Suthep-Pui National Park, Thailand. The strain produced a mixture of volatile compounds including propanoic acid and alcohol; these have antagonistic activities and can be used to identify the particular *Muscodor* species. CMU-Cib 461 possesses cultural, chemical, and molecular characteristics that differ from *M. albus*, *M. crispans*, *M. roseus*, *M. vitigenus*, and *M. yucatanensis*. We conclude that CMU-Cib 461, based on its unique features, represents a new species of *Muscodor*, for which we propose the name *Muscodor cinnamomi*.

Materials and methods

Fungal isolation

Ten healthy leaves of *Cinnamomum bejolghota* were collected from plants growing in Doi Suthep-Pui National Park, Northern Thailand (alt. 950 m) during May 2008. Totally, 250 tissue squares (5 × 5 mm) were cut from the leaf samples. All leaf tissues squares were surface sterilized in 75% ethanol for 30 s, 2% sodium hypochlorite for 3 min and 95% ethanol for 30 s under a laminar flow hood (Nuangmek et al. 2008). The sterilized samples were placed in Petri dishes containing 2% malt extract agar, 0.05% streptomycin sulfate and 0.03% rose bengal (Bussaban et al. 2001). Petri dishes were sealed with Parafilm and incubated at room temperature (25±2°C) for one week. The fungi growing out from the samples were aseptically transferred to two culture media, potato dextrose agar (PDA) and malt extract agar (MA); pure isolates were maintained in corn meal agar (CMA) slants. Various methods were tried to stimulate spore production (Guo et al. 1998).

Scanning electron microscopy

Scanning electron microscopy was preformed on isolate CMU-Cib 461 following procedures described by Castillo et al. (2005). A piece of agar with fungus was placed in a filter paper packet and then placed in 2% glutaraldehyde vapor, a wetting agent, and aspirated over night. Samples were then dehydrated in an ethanol series (15 mins at 5, 10, 15, 20, 40, 50, 70, 80, 95 and 100%) and in an acetone series (10 mins at 10, 15, 20, 40, 50, 70, 80, 95 and 100%). The fungal material was critically point dried, gold sputter coated, and images observed under a JEOL JSM-5910LV SEM using a high vacuum mode.

Qualitative analysis of CMU-Cib 461 volatiles

CMU-Cib 461 was grown in 5 ml Aglelent® clear glass vials containing PDA for 10 days at room temperature (25±2°C). Volatile compounds produced by the fungus were analyzed on an automatic Agilent Technologis GC 7890 gas chromatograph column

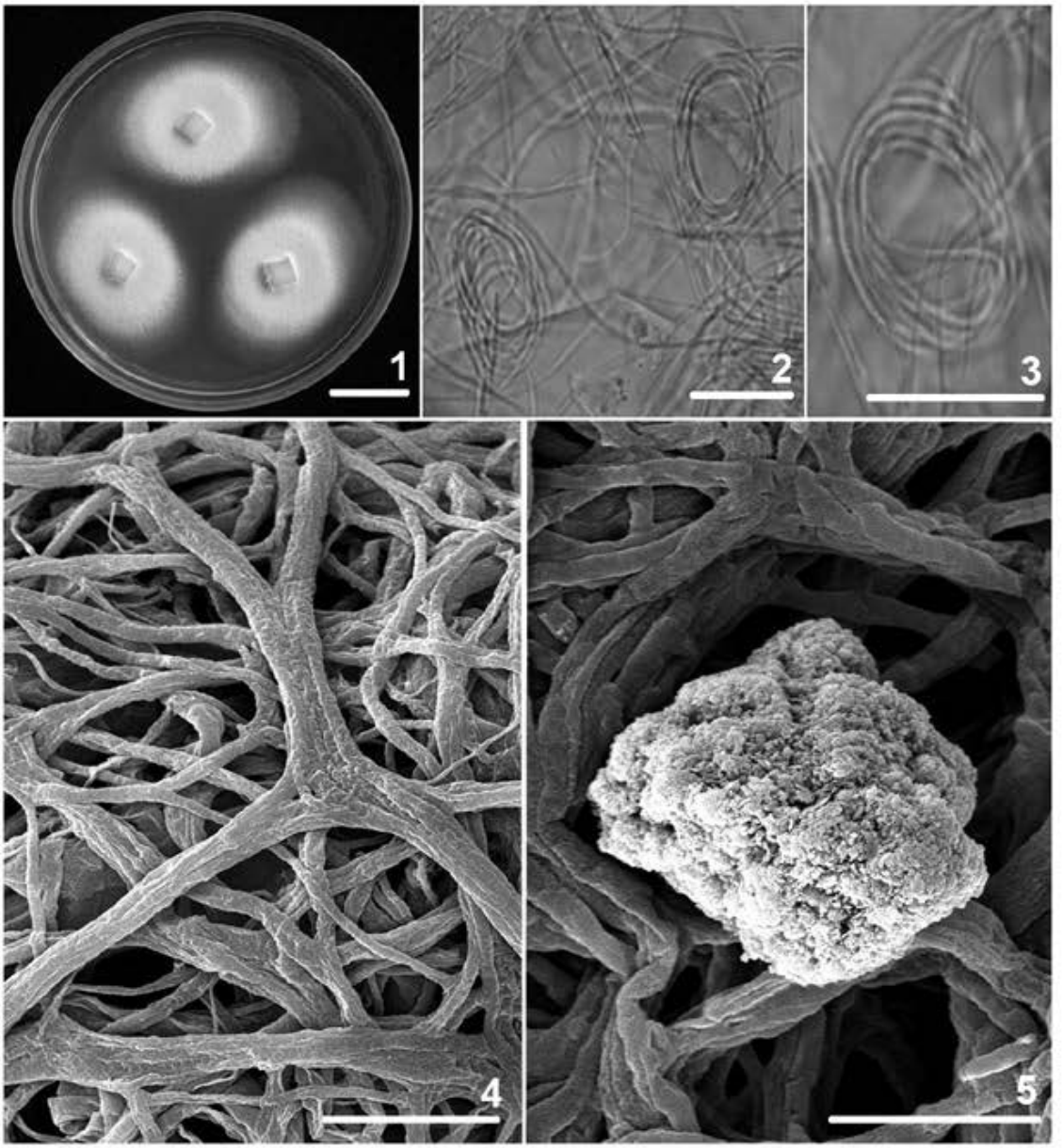
containing a HP-5MS 30 m × 0.25 mm I.D. × 0.25 µm. The column was temperature programmed as follows: 32°C for 2 min followed to 220°C at a rate of 5°C/min. The carrier gas was ultra high purity helium released at a rate of 1.5 mL/min. Prior to trapping the volatiles, the fiber was conditioned at 250°C for 39.6 min under a flow of helium gas. The gas chromatograph was interfaced to a MSD 5973 (EI) mass selective detector (mass spectrometer) operating at unit resolution. Acquisition and processing data were performed on the MSD 5973 (EI) software system. Initial identification of the volatile compounds produced by CMU-Cib 461 was made through library comparison using the NIST database, and compared with the original isolates, *M. albus* strain 620 (Strobel 2006) and strain E-6 (Strobel et al. 2007).

Fungal cultures and DNA extraction

Genomic DNA was extracted by a modified SDS-CTAB method (Bussaban et al. 2005). Strain CMU-Cib 461, isolated from *C. bejolghota* leaves, was subcultured onto PDA and incubated for 10 days. Mycelium was harvested, freeze dried, and ground into a fine powder with a pestle and mortar. About 15 mg of powdered mycelium was suspended in 1 mL of ice-cold lysis buffer (150 mM NaCl, 50 mM EDTA, 10 mM Tris-HCl, pH 7.4, 20 mg/mL proteinase K), transferred into 1.5 mL Eppendorf tube and kept at 4°C to prevent endonuclease activity during rehydration of the sample. SDS was added to a final concentration of 2%, vortexed and incubated 30 min at 65°C. After centrifugation for 15 min at 14,000 rpm, the supernatant was transferred to a new sterile 1.5 mL Eppendorf tube. The volume of supernatant was measured and the NaCl concentration was adjusted to 1.4 M, and one-tenth volume of 10% CTAB buffer (10% CTAB, 500 mM Tris-HCl, 100 mM EDTA, pH 8.0) was added. The solution was thoroughly mixed and incubated for 10 min at 65°C. After cooling for 2 min at 15°C, an equal volume of chloroform: isoamyl alcohol (24:1 v/v) was added, thoroughly mixed and the tube was centrifuged 15 min at 14,000 rpm. The extraction was repeated until the interface was clear. The supernatant was removed to a new Eppendorf tube, containing 2 volumes of cold 100% ethanol. After DNA precipitation, the pellet was centrifuged for 15 min at 14,000 rpm and 4°C. The pellet was washed with 70% ethanol and dried at room temperature. It was resuspended in 100 mL of 0.002% RNase (5 mg/mL) in TE buffer and incubated for 1 h at 37°C. The suspension was stored at -20°C pending use for PCR amplification.

Fungal ITS regions sequencing and phylogenetic analysis

The internal transcribed spacer (ITS) regions 1 and 2, including 5.8S rDNA were separately amplified in a 25 mL reaction on a GeneAmp 9700 thermal cycler (Applied Biosystems) under these reaction conditions: 1 mL of template DNA extraction, 0.2 mM dNTP, 0.2 mL of FastTaq (Applied Biosystems), 0.2 mM each of primers, 2.5 mL of the supplied 103 PCR buffer with $MgCl_2$, and sterile water to bring the volume to 25 mL. The ITS regions were amplified by using ITS4 and ITS5 primers. Amplification of ITS regions was for 30 cycles (initial denaturation at 95°C for 2 min, denaturation at 95°C for 30 s, annealing at 50°C for 30 s, and extension at 72°C for 1 min, with a final extension at 72°C for 10 min). PCR products were analyzed by electrophoresis in 1% agarose gels in TAE buffer (20 mM Tris-Acetate, 1 mM EDTA, pH 8.0) and viewed by staining with ethidium bromide. PCR products were purified using PCR clean up Gel extraction



Figs. 1–5. *Muscodor cinnamomi* 1. A culture of *Muscodor cinnamomi* CMU-Cib 461 growing on PDA, bar = 2 cm. 2–3. Light microscope micrographs of coiling formation of fungal hyphae, bars = 5 µm. 4–5. Scanning electron micrographs. 4. Hyphal cells from the colony edge showing fused, rope-like hyphal cells, bar = 10 µm. 5. Fused hyphal cells and a cauliflower-like structure, bar = 5 µm.

NucleoSpin® Extract II purification Kit (Macherey-Nagel, Germany) following the manufacturer's protocol. The purified PCR products were directly sequenced. Sequencing reactions were performed and sequences determined automatically in a genetic analyzer (1ST Base, Malaysia) using the PCR primers mentioned above. Sequences obtained in this study were compared to those from GenBank database using the BLAST software on the NCBI website: (http://www.ncbi.nlm.nih.gov/BLAST/). After multiple alignment of selected sequencher with Clustal X. Phylogenetic trees were constructed using the PUAP beta 10 software version 4.0 (Swofford 2002).

Results

Taxonomic description

Muscodor cinnamomi Suwannarach, K.D. Hyde & Lumyong, **sp. nov.** FIGS 1–5

MYCOBANK # MB518008, GENBANK # GQ848369

Fungus in natura cum Cinnamomi bejolghota *consociatus et est deuteromycete myceliis sterilibus pertinens. Coloniae fungales est luteus in vitro examinati in loco cum sol lux. Sporae velcorpora fructificantia substatibus ullis non observata. Hyphae (0.9–5.2 µm) vulgo ramificantes et convolventes, fila stripformia et spiras perfectas (4.5–12 µm) formantes. In vitro examiniter corpores colifloriform (6.3–14 µm) e repletus forma hyphae.*

ETYMOLOGY: *cinnamomi*, from the name of the host plant.

HOLOTYPE: Thailand, Doi Suthep-Pui National Park; from a leaf of *Cinnamomum bejolghota* (*Lauraceae*), May 2008, Nakarin Suwannarach; **holotype** – dried culture, SDBR CMU-Cib 461. (Living culture, BCC38842).

TELEOMORPH: Unknown.

In nature, the fungus is associated with *Cinnamomum bejolghota* and it is an ascomycete with sterile mycelium. Fungal colonies whitish on all media (PDA, MA and CMA) when grown in darkness (FIG. 1), pale orange when grown in natural light. Hyphae (0.9–5.2 µm thick) commonly appearing as fused rope-like strands, branching (FIG. 4); with coils (4.5–12 µm diam.; FIGS 2, 3) and cauliflower-like bodies (6.3–14 µm; FIG. 5). Mycelium on PDA reaching 9 cm in 2–3 weeks and producing a fruity odor. Spores and other fruiting bodies did not develop under any conditions tested.

Molecular phylogeny of *Muscodor cinnamomi* CMU-Cib 461

Partial ITS1 5.8 ITS2 rDNA sequences of *M. cinnamomi* were obtained and compared with GenBank database. After searching the ITS-5.8S rDNA sequences, 635 bp of *M. cinnamomi* (GQ848369) was subjected to an advanced BLAST search. The ITS1 5.8S ITS2 rDNA sequences of *M. cinnamomi* blasted five type strains of *Muscodor* species. The result showed that there was a 99, 99, 99, 98 and 90% similarity with *M. albus* (AF324336), *M. roseus* (AY034665), *M. crispans* (EU195297), *M. vitigenus* (AY100022) and *M. yucatanensis* (FJ917287), respectively.

Parsimony analysis of the alignment yielded 100 most parsimonious trees with total length of 873 steps (CI = 0.705, RI = 0.746, RC = 0.526, HI = 0.294), one of which is shown in FIG. 6. *Muscodor cinnamomi* and *Muscodor* species from GenBank formed a monophyletic clade (clade I) with a high bootstrap support (99%), and formed a sister group to *Anthostomella* (clade II) with 83% bootstrap support. *Muscodor* species are more closely related to the *Xylariaceae* than *Amphisphaeriaceae* with 100% bootstrap support.

Volatile compounds from *M. cinnamomi* (CMU-Cib 461)

Muscodor cinnamomi (CMU-Cib 461) produced at least 11 volatile compounds. These could be positively identified on the basis of a GC/MS

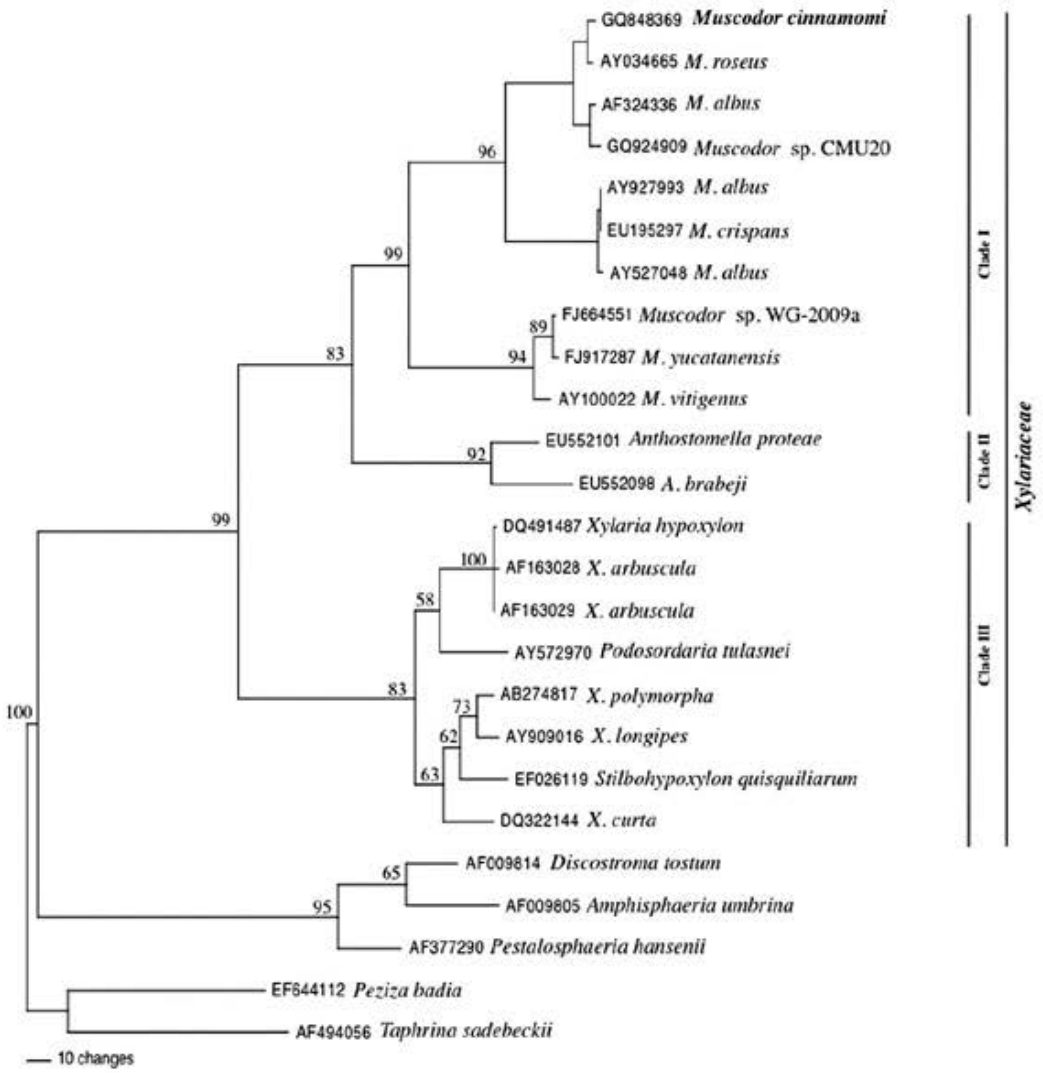


FIG 6. One of 100 most parsimonious trees inferred from a heuristic search of the ITS1-5.8S-ITS2 rDNA sequence alignment of 25 isolates of *Muscodor* and related genera. *Peziza badia* and *Taphrina sadebeckii* were used to root the tree. The size of the branches is indicated with a scale bar. Branches with bootstrap values ≥ 50% are shown at each branch.

comparison with authentic standards obtained from commercial sources as well as organic synthesis. The compounds were identified primarily on the basis of their mass spectral properties when compared to the NIST database. Of the compounds produced by this organism the most abundant were propanoic acid, 2-methyl, methyl ester, butanoic acid, 2-methyl, methyl ester and cis-2,4-dimethylthiane,S,S-dioxide with total area higher than 10% (TABLE 1). A number of other volatiles appeared that were unique to this isolate, including cis-2,4-dimethylthiane,S,S-dioxide; β-humolene; cyclopentane; eudesma4(14),11-diene and 1,1,1,5,7,7,7-heptamethyl-3,3-bis(trimethylsiloxy) tetrasiloxane compounds. In addition, the fungus produced azulene, but no naphthalene compounds.

TABLE 1. GC/MS analysis of the volatile compounds produced by *Muscodor cinnamomi* (CMU-Cib 461) culture in 5.0 mL clear glass vial Aglelent® for 10 days.

RT (min:s)	TOTAL AREA (%)	ANALYSIS COMPOUND	*M/z*
3:15	1.10	(S)-(+)-5-methyl-1-heptanol	130
3:32	5.49	ethyl acetate	88
4:35	32.26	propanoic acid,2-methyl,methyl ester	102
5:38	11.35	cis-2,4-dimethylthiane,S,S-dioxide*	162
5:41	7.69	cyclopentane*	70
6:38	14.90	butanoic acid,2-methyl,methyl ester	116
9:29	3.12	1-butanol,3-methyl,acetate	130
27:42	3.23	β-humulene*	204
30:89	8.58	azulene, 1,2,3,5,6,7,8,8a-octahydro-1,4-dimethyl-7-(1-methylethenyl)-,[1S-(1.α., 7.α., 8a.β)]	204
30:90	7.32	Eudosma-4(14),11-diene*	107
34:48	2.66	1,1,1,5,7,7,7-heptamethyl-3,3-bis (trimethylsiloxy) tetrasiloxane	444

Abbreviations: * = compounds found in *M. cinnamomi* but not in other *Muscodor* species; RT = retention time; *M/z* = mass to charge ratio.

Discussion

Muscodor cinnamomi is introduced as a new species based on differences in colony characteristics, growth rate, ITS sequence data and volatile compounds produced. *Muscodor cinnamomi* (CMU-Cib 461) produced a white mycelium on a PDA. Spores or fruiting structures did not develop on any media including ones containing the host plant material, cinnamon leaves. In this respect it is similar to other *Muscodor* species. The hyphae tend to intertwine to form rope-like strands. Other species of *Muscodor* also have this tendency (Worapong et al. 2001, 2002). The fungus also produces cauliflower-like structures, which is similar to *M. crispans*. The features of *M. cinnamomi* (CMU-Cib 461) are similar to *M. albus, M. crispans, M. vitigenus* and *M. yucatanensis* which produce whitish mycelium on all media tested in artificial light (Worapong et al. 2001, Daisy et al. 2002, Mitchell et al. 2008, González et al. 2009). *Muscodor cinnamomi* developed a pale orange coloured mycelium in natural light, while *M. crispans* produces a pale pink mycelium in natural light (Mitchell et al. 2008). Phylogenetic analysis of the sequences of ITS1, 5.8S, and ITS2 showed that *M. cinnamomi* was closely related the other *Muscodor* species, which are related to family *Xylariaceae* (Worapong et al. 2001, 2002).

When measured by GC/MS, the fungus consistently produced alcohols, esters and small molecular weight acids, in the gas phase, when grown on PDA. *Muscodor cinnamomi* produces propanoic acid,2-methyl,methyl ester, which is similar to other *Muscodor* species. However, there are differences in other

TABLE 2. Synopsis of azulene and naphthalene production* by *Muscodor* species.

SPECIES	AZULENE	NAPHTHALENE	DATA SOURCE
M. albus	+	+	Worapong et al. 2001
M. cinnamomi	+	–	This paper
M. crispans	–	–	Mitchell et al. 2008
M. roseus	+	+	Worapong et al. 2002
M. vitigenus	+	+	Daisy et al. 2002
M. yucatanensis	n	–	González et al. 2009

* (+) = production; (–) = non-production; (n) = unreported.

compounds produced by the different *Muscodor* species (TABLE 2). The volatile compounds showed inhibition ability and lethal activity against a number of plant and human pathogens (Strobel et al. 2001, Worapong & Strobel 2009). Details on the bioactivities of this interesting genus appear elsewhere (Worapong et al. 2001, 2002, Daisy et al. 2002, Ezra et al. 2004, Strobel 2006, Strobel et al. 2007, Mitchell et al. 2008). The strain CMU-Cib 461 shared all of the common features of previously described *Muscodor* species but there were a number of different aspects to the taxon that distinguished it from other *Muscodor* species.

Acknowledgments

This work was supported by grants from Graduate School of Chiang Mai University and The Higher Education Commission, Thailand under National Research University (A1) program. We grateful to Dr. Eric H.C. McKenzie and Prof. Dr. E.B. Gareth Jones for presubmission reviews.

Literature cited

Aly AH, Debbab A, Kjer A, Proksch P. 2010. Fungal endophytes from higher plants: a prolific source of phytochemicals and other bioactive natural products. Fungal Divers (In press).

Azevedo JL, Maccheroni W Jr, Pereira JO, Araujo WL. 2000. Endophytic microorganisms: a review on insect control a recent advances on tropical plant. Electron J Biotechnol 3: 40–65. doi:10.2225/vol3-issue1-fulltext-4

Bacon CW, White JF. 2000. Microbial Endophytes. Marcel Dekker, New York.

Bussaban B, Lumyong S, Lumyong P, McKenzie EHC, Hyde KD. 2001. Endophytic fungi from *Amomum siamense*. Can J Microbiol 47: 943–948. doi:10.1139/cjm-47-10-943

Bussaban B, Lumyong S, Lumyong P, Seelanan T, Park DC, McKenzie EHC, Hyde KD. 2005. Molecular and morphological characterization of *Pyricularia* and allied genera. Mycologia 97: 1002–1011. doi:10.3852/mycologia.97.5.1002

Castillo U, Myers S, Browne L, Strobel G, Hess WM, Hanks J, Reay D. 2005. Scanning electron microscopy of some endophytic streptomycetes in snake vine–*Kennedia nigricans*. Scanning 27: 305–311.

Daisy B, Strobel G, Ezra D, Castillo U, Bairn G, Hess WM. 2002 *Muscodor vitigenus* anam. sp. nov., an endophyte from *Paullinia paullinioides*. Mycotaxon 81: 463–475.

Ezra D, Hess WM, Strobel GA. 2004. New endophytic isolates of *Muscodor albus*, a volatile antibiotic producing fungus. Microbiology 150: 4023–4031. doi: 0.1099/mic.0.27334-0

González MC, Anaya AL, Glenn AE, Macías-Rubalcava ML, Hernández-Bautista BE, Hanlin RT. 2009. *Muscodor yucatanensis* a new endophytic ascomycete from Mexican chakah, *Bursera simaruba*. Mycotaxon. 110: 363–372.

Guo LD, Hyde KD, Liew ECY. 1998. A method to promote sporulation in palm endophytic fungi. Fungal Divers 1: 109–113.

Huang WY, Cai YZ, Hyde KD, Corke H, Sun M. 2008. Biodiversity of endophytic fungi associated with 29 traditional Chinese medicinal plants. Fungal Divers 33: 61–75.

Huang WY, Cai YZ, Surveswaran S, Hyde KD, Corke H, Sun M. 2009. Molecular phylogenetic identification of endophytic fungi isolated from three *Artemisia* species. Fungal Divers 36: 69–88.

Hyde KD, Soytong K. 2008. The fungal endophyte dilemma. Fungal Divers 33: 163–173.

Mitchell AM, Strobel GA, Hess WM, Vargas PN, Ezra D. 2008. *Muscodor crispans*, a novel endophyte from *Ananas ananassoides* in the Bolivian Amazon. Fungal Divers 31: 37–43.

Nuangmek W, McKenzie EHC, Lumyong S. 2008. Endophytic fungi from wild banana (*Musa acuminata* Colla) works against anthracnose disease caused by *Colletotrichum musae*. Res J Microbiol 3: 368–374.

Strobel GA. 2006. *Muscodor albus* and its biological promise. J Ind Microbiol Biotechnol 33: 514–522. doi:10.1007/s10295-006-0090-7

Strobel GA, Dirske E, Sears J, Markworth C. 2001. Volatile antimicrobials from *Muscodor albus*, a novel endophytic fungus. Microbiology 147: 2943–2950. doi: 10.1099/mic.0.27334-0

Strobel GA, Kluck K, Hess WM, Sears J, Ezra D, Vargas PN. 2007. *Muscodor albus* E-6, an endophytic of *Guazuma ulmifolia* making volatile antibiotics: isolation, characterization and experimental establishment in the host plant. Microbiology 153: 2613–2620. doi: 0.1099/mic.0.2007/008912-0

Swofford DL. 2002. PAUP*: Phylogenetic analysis using parsimony (*and other methods), beta version 4.0b10. Sinauer Associates, Sunderland, Massachusetts.

Tejesvi MV, Tamhankar SA, Kini KR, Rao VS, Prakash HS. 2009. Phylogenetic analysis of endophytic *Pestalotiopsis* species from ethnopharmaceutically important medicinal trees. Fungal Divers 38: 167–183.

Worapong J, Strobel GA. 2009. Biocontrol of root rot of kale by *Muscodor albus* strain MFC2. Biocontrol 54: 301–306. doi:10.1007/s10526-008-9175-8

Worapong J, Strobel GA, Daisy BH, Castillo U, Baird G, Hess WM. 2002. *Muscodor roseus* sp. nov., an endophyte from *Grevillea pteridifolia*. Mycotaxon 81: 463–475.

Worapong J, Strobel GA, Ford E, Li JY, Baird G, Hess WM. 2001. *Muscodor albus* anam. gen. et sp. nov., an endophyte from *Cinnamomum zeylanicum*. Mycotaxon 79: 67–79.

ISSN (print) 0093-4666 © 2010. Mycotaxon, Ltd. ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.25

Volume 114, pp. 25–32 *October–December 2010*

Paecilomyces echinosporus sp. nov., a species isolated from soil in China

MINGJUN CHEN[1], NA ZHOU[1], ZENGZHI LI[1], GI-HO SUNG[2*] & BO HUANG[1*]

chenmingjun2007@yahoo.cn zhouna0116@yahoo.com.cn
zzli@ahau.edu.cn bhuang@ahau.edu.cn
[1] *Anhui Provincial Key Laboratory of Microbial Control*
Anhui Agricultural University, Hefei 230036, P. R. China

sung97330@korea.kr
[2] *Mushroom Research Division, Dept of Herbal Crop Research*
National Institute of Horticultural and Herbal Science
Suwon 404-707, Republic of Korea

Abstract — During a survey of entomopathogenic fungi in China, a new species of *Paecilomyces* was isolated from a soil sample collected from Anhui province in China. It is differentiated from previously described species based on the morphology of its minutely echinulate conidia and conidiophores that possess penicillate phialides. Phylogenetic analyses with ITS region indicate that it is distantly related to *Isaria* and a close relative of *P. carneus*. The new species, *Paecilomyces echinosporus*, is presented with its Latin diagnosis, English description, and illustration. The type isolate and holotype are deposited in the Research Center for Entomogenous Fungi of Anhui Agricultural University (RCEF).

Key words — taxonomy, morphological characteristics, molecular identification

Introduction

The genus *Paecilomyces* was established by Bainier in 1907 and differentiated from the genus *Penicillium* Link by its colony that lacks green color, cylindrical conidiogenous cells, and the slime mass of spores (Samson 1974). The generic concept of *Paecilomyces* was later expanded to include species of genera *Isaria* and *Spicaria* that possess a conidiogenous structure similar to that of *P. variotii*, the type species of *Paecilomyces* (Brown & Smith 1957). The most comprehensive monographic work (Samson 1974) divides *Paecilomyces* species into two sections (i.e., *P.* sect. *Paecilomyces* and *P.* sect. *Isarioidea*) based on their teleomorphic affinities, colony color, odor, and growth temperature.

* Corresponding authors: Bo Huang, Gi-Ho Sung

Conducting phylogenetic analyses based on the small rDNA subunit to arrive at a natural classification of *Paecilomyces*, Luangsa-ard et al. (2004) showed that *Paecilomyces* is polyphyletic and represents two distantly related classes (i.e., *Sordariomycetes* and *Eurotiomycetes*). As a result, *P.* sect. *Isarioidea* was revised taxonomically with the lectotypification and formal conservation of the generic name, *Isaria* (Gams et al. 2005, Hodge et al. 2005). Following phylogenetic analyses of *P.* sect. *Isarioidea* using the β-tubulin gene and ITS region, ten species of *P.* sect. *Isarioidea* were transferred to *Isaria*.

Liang et al. (2005) reviewed 32 known species of *Paecilomyces* in China, where 12 novel *Paecilomyces* species were reported based on the survey of soil-borne filamentous fungi from 2003–06 (Liang et al. 2009). Of these, six monophialidic species were transferred to a new genus, *Taifanglania*, based on their morphological characteristics and molecular analyses. In this study, we report a new species of *Paecilomyces* that was found during a survey of entomopathogenic fungi in soil in Anhui province, China. The morphological examination and phylogenetic analysis revealed a species with features that differed from previously described *Paecilomyces* species and was distantly related to some *Isaria* taxa. This new species is described below as *Paecilomyces echinosporus*.

Materials and methods

Sample collection and strain isolation

Strain RCEF4111 was isolated from soil samples collected from Qimen, Anhui province, China. A 5 g sample of soil was mixed with 100 ml of sterile distilled water containing 0.05% (v/v) Tween 80. The soil suspension was diluted to a concentration of 10^{-2} after shaking for approximately four hours. A 200 µl of the soil suspension was plated on one plate with the D0C2 selective medium (Shimazu & Sato 1996), and incubated at 25°C for approximately 5 days until the colonies were formed. Colonies that formed conidiogenous structures were transferred to SDAY (Sabouraud's dextrose agar with yeast) slants.

Strain identification

Strain RCEF4111 was transplanted onto Czapek agar, potato dextrose agar (PDA), and Sabouraud's agar according to Brown & Smith (1957) and Samson (1974), and then was incubated at 25°C for 14 days. The isolated fungus was examined using classical mycological techniques based on growth rate, as well as macroscopic and microscopic characteristics. The strain was also tested to investigate its ability to grow on PDA at 35°C. The type strain, RCEF4111 (dried RCEF4111-DPC1, holotype), has been deposited in the Research Center for Entomogenous Fungi (RCEF), Anhui Agriculture University, China.

DNA extraction

For DNA extraction, spores were inoculated to Petri dish containing SDAY medium overlaid with a disc of sterilized cellophane. After incubating at 25°C for approximately

TABLE 1. Accession numbers, strain numbers, and origins of *Paecilomyces* spp. and other taxa used for phylogenetic analysis.

GENBANK #	NAME	STRAIN #	REFERENCES
AJ786573	*Cordyceps militaris* (L.) Link	3856.H.	Stensrud et al. (2005)
AY624168	*Isaria amoenerosea* Henn.	CBS 107.73 T	Luangsa-ard et al. (2005)
AY624172	*I. cateniannulata* (Z.Q. Liang) Samson & Hywel-Jones	CBS 152.83	Luangsa-ard et al. (2005)
AY624175	*I. cicadae* Miq.	BCC 2574	Luangsa-ard et al. (2005)
AY624176	*I. coleopterorum* (Samson & H.C. Evans) Samson & Hywel-Jones	CBS 102.73	Luangsa-ard et al. (2005)
AY624181	*I. farinosa* (Holmsk.) Fr.	CBS 111113	Luangsa-ard et al. (2005)
AY624184	*I. fumosorosea* Wize	CBS 107.10	Luangsa-ard et al. (2005)
AY624186	*I. javanica* (Frieder. & Bally) Samson & Hywel-Jones	CBS 134.22	Luangsa-ard et al. (2005)
AY624196	*I. tenuipes* Peck	ARSEF 5135	Luangsa-ard et al. (2005)
AY624202	*Mariannaea camptospora* Samson	CBS 209.73	Luangsa-ard et al. (2005)
AF135210	*Metarhizium anisopliae* (Metschn.) Sorokin var. *anisopliae*	FI1029	Driver et al. (2000)
AF368270	*M. cylindrosporum* Q.T. Chen & H.L. Guo	ACCC 30114 T	Huang et al. (2004)
AF138270	*M. flavoviride* W. Gams & Rozsypal var. *flavoviride*	FI 38	Driver et al. (2000)
AF368501	*Nomuraea rileyi* (Farl.) Samson	RCEF 0292	Huang et al. (2004)
AY624170	*Paecilomyces carneus* (Duché & R. Heim) A.H.S. Br. & G. Sm.	CBS 399.59	Luangsa-ard et al. (2005)
AY624174	*P. cinnamomeus* (Petch) Samson & W. Gams	CBS 398.86	Luangsa-ard et al. (2005)
GU108582	*P. echinosporus* Ming J. Chen, G.H. Sung & B. Huang	RCEF 4111	In this study
AJ536552	*P. gunnii* Z.Q. Liang	ZSU 20872	Unpublished
AY624189	*P. lilacinus* (Thom) Samson	CBS 284.36 T	Luangsa-ard et al. (2005)
AY624193	*P. marquandii* (Massee) S. Hughes	CBS 182.27 T	Luangsa-ard et al. (2005)
AY624192	*P. niphetodes* Samson	CBS 364.76	Luangsa-ard et al. (2005)
AY624194	*P. penicillatus* (Höhn.) Samson	CBS 448.69	Luangsa-ard et al. (2005)
AY624197	*P. viridis* Segretain et al. ex Samson	CBS 348.65	Luangsa-ard et al. (2005)
EU004811	*Taifanglania curticatenata* (Z.Q. Liang & Y.F. Han) Z.Q. Liang et al.	HC 125-2 T	Liang et al. (2009)

7 days, genomic DNA was extracted from the mycelia scraped from the cellophane using benzyl chloride (Zhu et al. 1994). The extracted DNA was stored in 100 μL TE buffer (10mM Tris-HCl, PH8.0; 1mM EDTA) at 4°C, and was diluted 10-fold with TE buffer for the following PCR reactions.

PCR amplification and determination of ITS sequencing

The PCR amplification of ITS region was performed using the primers of ITS5 and ITS4 (White et al. 1990). The PCR conditions are as follows: 94°C for 5 mins, 35 cycles of 94°C for 1 min, 52°C for 1 min, 72°C for 2 mins and 72°C for 10 mins. The PCR reaction

was conducted in 25 µL volume with the following components: 2.5 µL of 10 × reaction buffer, 0.5 µL of each dNTP, 1 µL of each primer, and 2 units of Taq DNA polymerase, 2 µL of the diluted DNA and 16.8 µL of ddH_2O. The resulting PCR product was examined on 1.2% TBE agarose gel stained with ethidium bromide. After purifying PCR product using EasyPure quick gel extraction kit (TransGen Biotech), DNA sequencing was carried out at Sangon Company (Shanghai, China) and the resulting ITS sequence of RCEF 4111 was submitted to GenBank with accession number GU108582.

Sequence alignment and phylogenetic analysis

DNA sequences that are generated in this study and downloaded form GenBank were aligned using Clustal X 1.81 (Thompson et al. 1997). The alignment was manually adjusted to maximize homology. Maximum parsimony analyses were conducted using PAUP* 4.0b10 (Swofford 2002) with 1,000 replicates of heuristic search of random sequence additions, branch swapping by tree bisection-reconnection (TBR) and MulTrees in effect. In the parsimony analyses, unambiguously aligned gaps were treated as a new state and all characters were equally weighted. Branch support was estimated by bootstrapping using 1,000 replicates of 10 replicates of heuristic search with the same option (Felsenstein 1985). We also performed a BLAST search with the obtained sequence of the new taxon as a query to find the close relatives in GenBank database.

Results

Taxonomy

Paecilomyces echinosporus Ming J. Chen, G.H. Sung & B. Huang, **sp. nov.** FIG. 1

MycoBank 518113; GenBank GU108582

Coloniae in agaro Czapekii ad 30–37 mm diam post 14 dies 25°C, in medio modice sulcatae, albae, pulverulentae, margine regulari; reversum luteolum; 35°C haud crescit. Hyphae vegetativae hyalinae, septatae, ramosae, leves, 2.0–3.5 µm latae. Apparatus conidialis elongatus vel compactus, seu phialides singulae seu capitula verticillos ramorum et phialidum ferentia; stipites ex hyphis aeriis orientes, vulgo 45–95 × 2.5 µm. Phialides ad quinae verticillatae, 9.5–15.5 × 2.0–3.0 µm, e basi cylindrica et collulo angusto minus quam 0.5 µm lato composita. Conidia unicellularia, minute echinulata, subglobosa vel elllipsoidea, 2.7–5.0 × 2.0–3.0 µm. Chlamydosporae absentes.

HOLOTYPE — RCEF4111 was isolated by B. Huang & N. Zhou from soil of Qimen, Anhui province, China, in March, 2008, deposited in the Research Center for Entomogenous Fungi (RCEF).

Colony on Czapek agar attaining a diameter of 30 to 37 mm within 14 days at 25°C, slightly ridged at the center, white, powdery, regular in the margin; reverse yellowish. Colony growth not observed at 35°C. Vegetative hyphae hyaline, septate, branched, smooth-walled, 2.0–3.5 µm wide. Conidial structures elongated to compact, varying in complexity from single detached phialides to heads with a terminal whorl of phialides and whorl of branches, conidiophores arising from aerial hyphae, normally 45–95 × 2.5 µm. Phialides up to 5 in a whorl, 9.5–15.5 × 2.0–3.0 µm, consisting of a cylindrical basal portion, tapering into a thin neck, less than 0.5 µm wide. Conidia one-celled, minutely echinulate, subglobose to ellipsoidal, 2.7–5.0 × 2.0–3.0 µm. Chlamydospores absent.

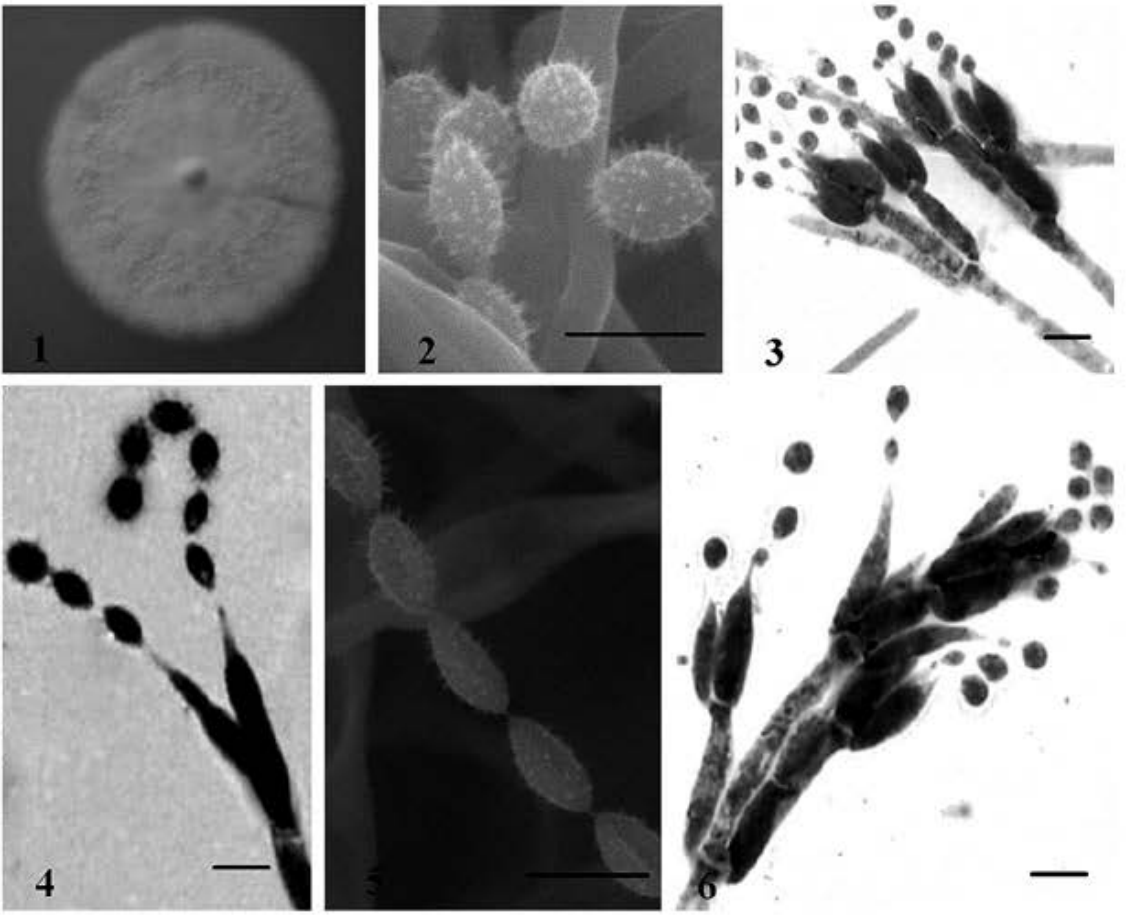


FIG. 1. Colony and conidiogenous structure of *Paecilomyces echinosporus* (Bars = 5μm). 1—Colony on Czapek agar; 2, 5—echinulate conidia; 3,4, 6—phialides and echinulate conidia.

Molecular Characteristics of *Paecilomyces echinosporus*

The ITS (ITS1, 5.8S rDNA, and ITS2) region is 538 bp long. ITS dataset with 23 strains contains 732 characters including 259 parsimony-informative characters. The single tree generated from maximum parsimony (TL= 1078, CI= 0.5965, HI = 0.4035, RI = 0.6432, RC = 0.3836) is shown in FIG. 2. The phylogenetic tree inferred from the ITS sequence data clusters isolate RCEF4111 with *P. carneus* with 95% bootstrap support. In addition to the phylogenetic analysis, we performed a BLAST search with ITS sequence of *P. echinosporus* as a query. Search results imply that *P. echinosporus* is most comparable to *P. marquandii* (ARSEF 3047, EU553322, 97%), *P. lilacinus* (CG 348, EU553317, 97%), and *P. carneus* (CBS 399.59, AY624170, 90%). A NCBI BLAST search yielded a sequence max identity of the *P. echinosporus* ITS sequence of 100% with Malian strain ARSEF 3047 and Brazilian strain CG 348 and showed the closest relative of these two isolates as *P. carneus* (GC 525, EU553292, 91%). Therefore, ARSEF 3047 and CG 348 appear either closely related to or conspecific with *P. echinosporus,* indicating the presence of the species in Brazil and Mali.

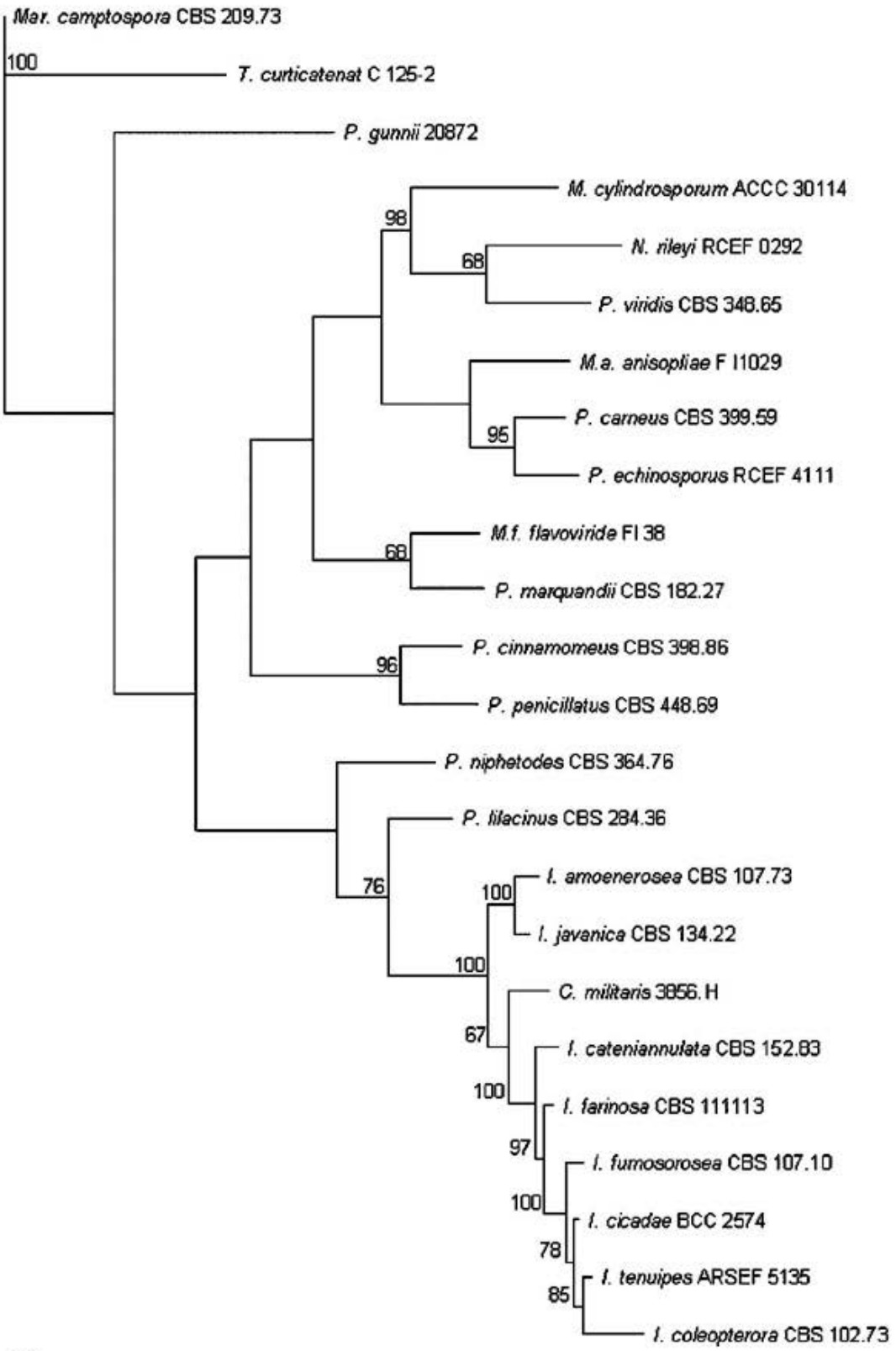


Fig. 2. Phylogenetic tree generated from parsimony analysis based on ITS rDNA sequences. Numbers at the nodes give bootstrap support derived from 1000 replicates. *Mariannaea camptospora* was used as outgroup.

Discussion

In *Paecilomyces*, based on the morphological characters, species that produce echinulate or rough conidia include *P. carneus*, *P. gunnii*, *P. marquandii*, and *P. lilacinus* (Samson 1974, Liang 1985, Han et al. 2005). Although the conidia are echinulate in both *P. carneus* and *P. gunnii*, they can be differentiated by the color of the reverse side of the colony in culture; *P. carneus* is dark green, while *P. gunnii* produces a dark brown colony and chlamydospores. Meanwhile, conidia are rough in *P. marquandii* and *P. lilacinus* but possess purple or vinaceous conidial heads. In addition, Chlamydospore-like cells are usually present in *P. marquandii* and *P. lilacinus* conidiophores are pigmented and rough-walled, while *P. echinosporus* does not produce chlamydospores and possesses white and smooth conidiophores.

Our phylogenetic analysis of *Paecilomyces* species clusters *P. echinosporus* and *P. carneus* together in a clade and distinctly related to the other four species that produce echinulate or rough conidia (Fig. 2). Although the new species resembles *P. carneus* in the echinulate conidia, *P. echinosporus* and *P. carneus* share only 91% sequence similarity. In morphological comparison, *P. echinosporus* produces conidiophores with penicillate branches and short-necked phialides and a white colony with a yellow reverse. In contrast, *P. carneus* produces conidiophores with verticillate branches and phialides that taper into a thin long neck and a pink (after sporulation) colony with a mostly green to dark green reverse. Our combined traditional morphological study and molecular analyses identify strain RCEF4111 isolated from soil sample as a new species of *Paecilomyces, P. echinosporus*.

Acknowledgements

We are grateful to Prof. Z.Q. Liang and Dr. L. Wang for reviewing the manuscript. We also thank Dr. Walter Gams for his assistance with the Latin diagnosis. This project was supported by the National Natural Science Foundation of China (No. 30770008), the Anhui Provincial Science Foundation for Excellent Youth and Program for "NCET" (No. 08040106902), and the Key Science Research Project of Anhui Province (No. TD200708).

Literature cited

Brown AHS, Smith G. 1957. The genus *Paecilomyces* Bainier and its perfect stage *Byssochlamys* Westling. Transactions of the British Mycological Society 40(1): 17–89. doi:10.1016/S0007-1536(57)80066-7

Driver F, Milner RJ, Trueman WH. 2000. A taxonomic revision of *Metarhizium* based on a phylogenetic analysis of rDNA sequence data. Mycological Research 104: 134–150. doi:10.1017/S0953756299001756

Felsenstein J. 1985. Confidence limits on phylogenies: An approach using the bootstrap. Evolution 39: 783–791. doi:10.2307/2408678

Gams W, Hodge KT, Samson RA, Korf RP, Seifert KA. 2005. Proposal to conserve the name *Isaria* (anamorphic fungi) with a conserved type. Taxon 52(12): 537. doi:10.2307/25065390

Han YF, Chu HL, Liang ZQ 2005. Two new species of the genus *Paecilomyces* in China. Mycosystema 92: 311–316.

Huang B, Li SG, Li CR, Fan MZ, Li ZZ. 2004. Studies on the taxonomic status of *Metarhizium cylindrospora* and *Nomuraea viridula*. Mycosystema 23: 33–37.

Hodge KT, Gams W, Samson RA, Korf RP, Seifert KA. 2005. Lectotypification and status of *Isaria* Pers. : Fr. Taxon 52: 485–489. doi:10.2307/25065379

Liang ZQ. 1985. Isolation and identification of the conidial stage of *Cordyceps gunnii*. Acta Mycologia Sinica 4(3): 162–166.

Liang ZQ, Han YF, Chu HL, Liu AY. 2005. Studies on the genus *Paecilomyces* in China I. Fungal Diversity 20: 83–101.

Liang ZQ, Han YF, Chu HL, Fox RTV. 2009. Studies on the genus *Paecilomyces* in China V. *Taifanglania* gen. nov. for some monophialidic species. Fungal Diversity 34: 69–77.

Luangsa-ard JJ, Hywel-Jones NL, Manoch L, Samson RA. 2005. On the relationships of *Paecilomyces* sect. *Isarioidea* species. Mycological Research 109: 581–589. doi:10.1017/S0953756205002741

Luangsa-ard JJ, Hywel-Jones NL, Samson RA. 2004. The polyphyletic nature of *Paecilomyces* sensu lato based on 18S-generated rDNA phylogeny. Mycologia 96: 773–780. doi:10.2307/3762111

Samson RA. 1974. *Paecilomyces* and some allied hyphomycetes. Studies in Mycology 6: 1–119. doi:10.1016/S0007-1536(75)80098-2

Shimazu M, Sato H. 1996. Media for selective isolation of an entomogenous fungus, *Beauveria bassiana* (*Deuteromycotina: Hyphomycetes*). Applied Entomology and Zoology 31: 291–298.

Swofford D. 2002. PAUP*: Phylogenetic analysis using parsimony (*and other methods), version 4. Sunderland, Massachusetts: Sinauer Associates.

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The Clustal X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acid Research 24: 4876–4882. doi:10.1093/nar/25.24.4876

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis MA, Gelfand DH, Sninsky JJ, White TJ, eds. PCR protocols: a guide to methods and applications. San Diego, California: Academic Press Inc. pp 315–322.

Zhu H, Qu F, Zhu LH. 1994. Isolation of genomic DNAs from fungi using benzyl chloride. Acta Mycologia Sinica 13: 41–47.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.33

Volume 114, pp. 33–42 October–December 2010

Lolia aquatica gen. et sp. nov. (*Lindgomycetaceae, Pleosporales*), a new coelomycete from freshwater habitats in Egypt

FATEN A. ABDEL-AZIZ[1] & MOHAMED A. ABDEL-WAHAB[1,2,*]

mohamed700906@gmail.com

[1]*Department of Botany, Faculty of Science, Sohag University Sohag 82524, Egypt*

[2]*Extremobiosphere Research Center Japan Agency for Marine-Earth Science and Technology (JAMSTEC) 2-15 Natsushima-cho, Yokosuka, Kanagawa 237-0061, Japan*

Abstract — An unknown coelomycete that was collected from the River Nile and associated irrigation canals in Egypt is described. The fungus is characterized by gelatinous pearl white acervuli, a peridium that forms textura intricata, holoblastic conidia that have one basal excentric cellular appendage, and up to 3–5 sub-apical cellular attenuating appendages. Based on morphology, no described genus can accommodate this new fungus, so it is described herein as new genus and species. Phylogenetic analyses of the 28S ribosomal large subunit (LSU) rDNA sequence placed the new fungus in the family *Lindgomycetaceae, Pleosporales, Dothideomycetes*.

Key words — aquatic fungi, anamorphic fungi, subtropical, appendaged conidia

Introduction

Over 7000 coelomycetes in 1000 genera (+ 500 syn.) have been described (Kirk et al. 2008) from a wide range of substrates and geographical locations (Sutton 1980, Nag Raj 1993). A small number of coelomycetes have been linked to their teleomorphs, with affinities to ascomycetes, while a few are basidiomycetes (Nag Raj 1978, 1980, Dyko & Sutton 1979, Cole & Samson 1979, Nag Raj et al. 1989, Rungjindamai et al. 2008). Coelomycetes are a major group of the aquatic mycota of *Phragmites australis* (Van Ryckegem & Verbeken 2005a,b, 2007; Abdel-Aziz 2008). During an investigation of aquatic fungi in Egypt an unknown coelomycete with gelatinous pearl white acervuli was recorded from different localities at the River Nile and irrigation canals in Upper Egypt. This fungus is unique in that it possesses one excentric basal and three to five sub-apical un-branched cellular appendages of type A (Nag Raj 1993). This newly

discovered taxon is described, illustrated, and compared to other appendaged coelomycetes. In addition, we used phylogenetic analyses of the LSU gene to determine its phylogenetic relationship.

Materials and methods

Collection of the fungi

Submerged decayed wood was collected from the River Nile and irrigation canals from Sohag, Qena, and Aswan governorates. Samples were kept in clean plastic bags and returned to the laboratory, examined immediately under stereomicroscope for fungal fruiting structures and subsequently incubated on moist filter paper in sterile plastic boxes. Material was examined periodically over three month's incubation. Single spore isolates of the new fungus were obtained. Photographs were taken using an Olympus BX51 differential interference contrast light microscope and Olympus DP12 digital imaging system (Olympus Corporation, Tokyo, Japan). Herbarium material was dried at 60°C for 24 h and deposited along with the isolated fungal cultures in the authors' culture collection, Department of Botany, Faculty of Science, Sohag University, Egypt. Voucher slides and type material of the new fungus were deposited at International Mycological Institute (IMI).

DNA extraction, sequencing, and phylogenetic analysis

Single-spore isolate of the fungus was grown in YMG broth (4 g yeast extract, 10 g glucose, 10 g malt extract in 1 liter distilled water) until sufficient mycelium had formed to allow DNA extraction. DNA extraction for polymerase chain reaction (PCR) was performed using the Microbial DNA Extraction Kit (MOBIO; Mo Bio Laboratories, Carlsbad, CA, USA) according to the manufacturer's instructions. Partial LSU ribosomal DNA was amplified using primers LR0R and LR7 (Bunyard et al. 1994). PCR reactions, cycling parameters and sequencing were carried out as described by Abdel-Wahab et al. (2009). Sequences were assembled using Sequencher 4.2.2 (Gene Codes Corporation). Sequences were aligned with others retrieved from GenBank using ClustalX (Thompson et al. 1997) and optimized manually. The positions where one or more species contained a length mutation and ambiguously aligned regions were not included in the subsequent phylogenetic analysis. Nucleotide sequence phylogenies were constructed using PAUP* 4.0b10 (Swofford 2002). Maximum-likelihood (ML) analyses (Felsenstein 1981) were performed using heuristic searches with the random stepwise addition of 100 replicates and tree bisection-reconnection (TBR) rearrangements. The optimal model of nucleotide substitution for the ML analyses was determined using hierarchical likelihood ratio tests as implemented in Modeltest 3.7 (Posada and Crandall 1998). The model selected as the best fit for LSU rDNA data set was TrN+I+G. For the bootstrap analyses (Felsenstein 1985), 100 replicates were generated with 5 random additions and TBR. Maximum-parsimony (MP) trees were obtained by 100 random addition heuristic search replicates using PAUP, and 1000 bootstrap replicates were performed employing 5 random addition heuristic searches. Posteriori probability values were obtained by using the MrBayes 3.1.2 (Huelsenbeck & Ronquist 2001, Ronquist & Huelsenbeck 2003) with the SYM+I+G model that was determined using MrModeltest 2.2 (Nylander 2004). Five million generations were run in four chains with sampling every 100 generations,

yielding 50 000 trees, of which the first 12 500 were discarded as "burn in." The numbers on the branches are estimates of a posteriori probabilities. The LSU sequence of *Lolia aquatica* isolate used in this study was deposited at GenBank under the accession number "HM367732"; ex-type: MF 644 (JAMSTEC, Japan).

Results

Phylogenetic analyses

The partial LSU rDNA sequence of *Lolia aquatica* is aligned with representatives of the family *Lindgomycetaceae* along with representatives of the families belong to orders *Pleosporales* and *Jahnulales*. In total, the LSU rDNA dataset include 39 taxa of which 2 belong to the class *Pezizomycetes* that

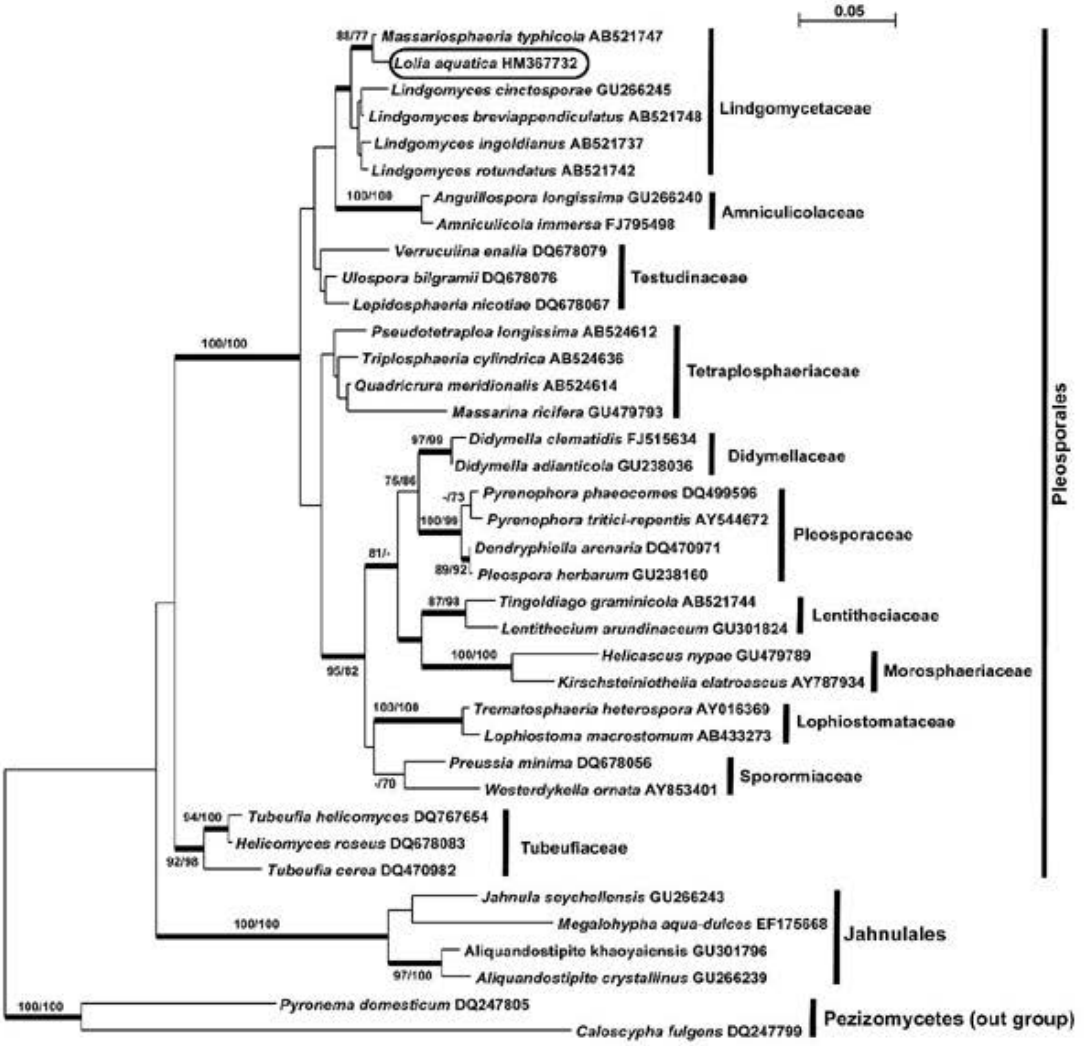


FIG. 1: Phylogenetic relationships of *Lolia aquatica* and closely similar fungi, based on the nucleotide sequences of the large subunit (LSU) rDNA. The maximum likelihood tree (ML) (–ln likelihood = 4978.2339) was constructed as described in the text. The numbers indicate pp values ≥ 95% (in bold), ML bootstrap and MP bootstrap values ≥ 70%. The new species, *Lolia aquatica*, is highlighted in a box.

was used as outgroup. The dataset consisted of 795 total characters, of which 42 gaps are excluded, 477 characters were constant, 69 variable characters were parsimony-uninformative and 207 were parsimony informative characters. Five most parsimonious trees were produced using heuristic search, the five trees have equal length of 817 steps, a consistency index of 0.5141, a retention index of 0.6953 and a rescaled consistency index of 0.3574. Maximum likelihood analysis produced one tree with -ln likelihood score of 4,978.2339 (Fig. 1). Most parsimonious (MP), and Neighbor-Joining (NJ) and Bayesian analyses produced similar trees to the one shown in Fig. 1.

Lolia aquatica is a sister taxon to *Massariosphaeria typhicola* (P. Karst.) Leuchtm. and forms a well supported clade (100/88/77 for Bayesian/ML/MP respectively) within the recently published freshwater ascomycete family, *Lindgomycetaceae* K. Hiray et al. (Schoch et al. 2009, Shearer et al. 2009, Hirayama et al. 2010).

Taxonomy

Lolia Abdel-Aziz & Abdel-Wahab, **anam. gen. nov.**

MycoBank MB 518528

Conidiomata acervularia, margariticoloria, in gelatina immerse, superficialia, solitaria vel gregaria. Peridium ex textura intricata formatum, hyalinum, in matrice gelatinosa immersum. Conidiogenesis holoblastica. Conidia aseptata, clavata, cylindrica vel ellipsoidea, hyalina, levia, tenuitunicata, ad apicem 3–5 appendicibus, ad basim appendice singulari excentrica (typi A).

Type species: *Lolia aquatica* Abdel-Aziz & Abdel-Wahab

Etymology: From the Arabic word, *Loli* = pearl, in reference to the color of the conidiomata.

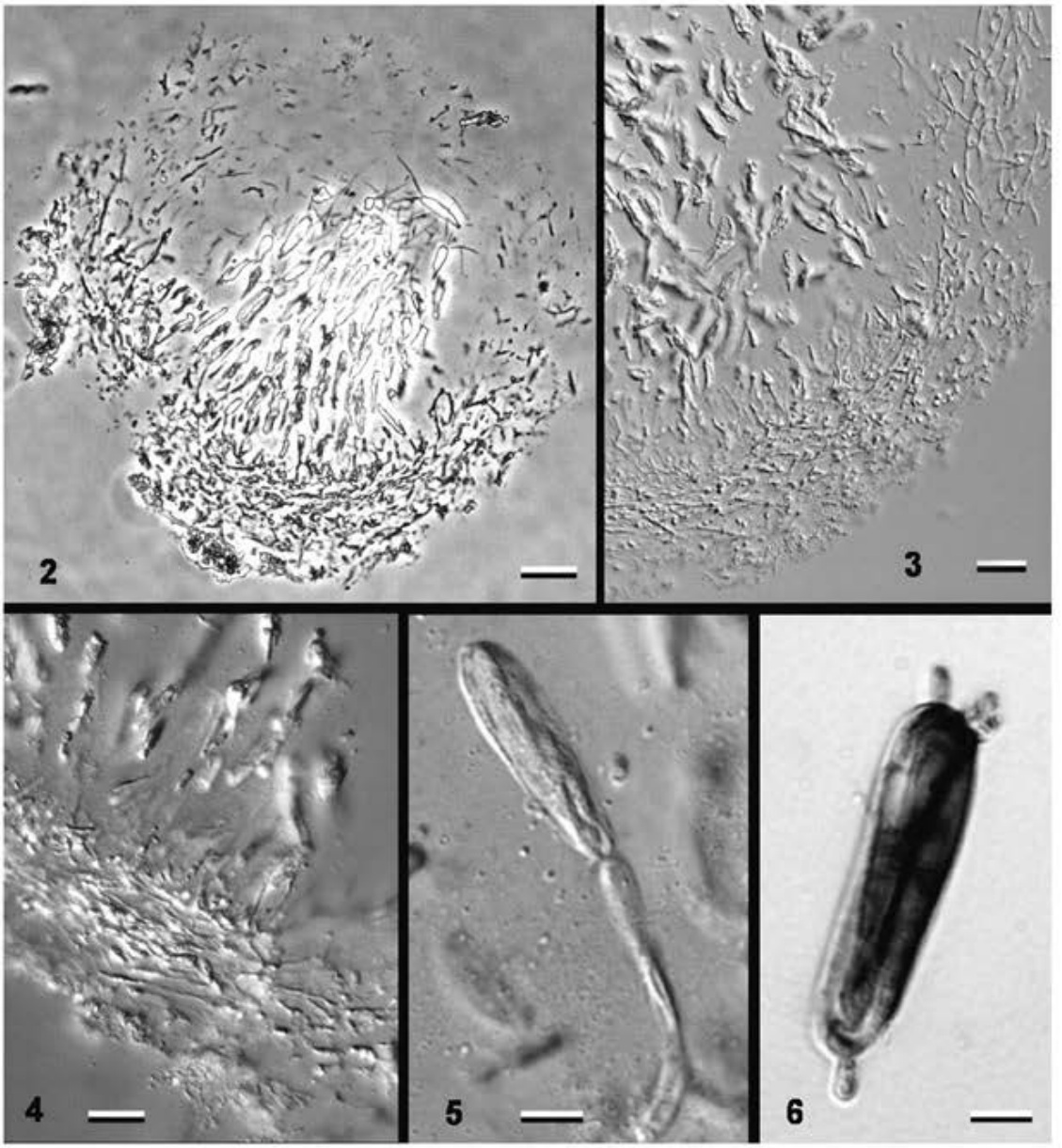
Conidiomata acervular, superficial, pearl white, embedded in gel, single or aggregated. Peridium forming textura intricata, hyaline, embedded in gel. Conidiogenesis holoblastic. Conidia unicellular, clavate, cylindrical, ellipsoidal, hyaline, smooth, thin-walled, with basal and apical cellular, tapering, attenuating appendages of type A.

Lolia aquatica Abdel-Aziz & Abdel-Wahab, **sp. nov.** Figs 2–10

MycoBank MB518529

Conidiomata acervularia, 400–480 µm alta, 380–540 µm diam., margariticoloria, superficialia, solitaria vel gregaria. Peridium 57–80 µm crassum, ex textura intricata formatum, hyalinum, in matrice gelatinosa immersum. Conidiogenesis holoblastica. Conidia 31–45 × 7–10 µm, aseptata, hyalina, clavata, ellipsoidea vel cylindrical, 3–5 appendicibus apicalibus, 55–90 × 1.5–3 µm, et appendice basali singulari, simplici, excentrica, 10–85 × 1.5–3 µm.

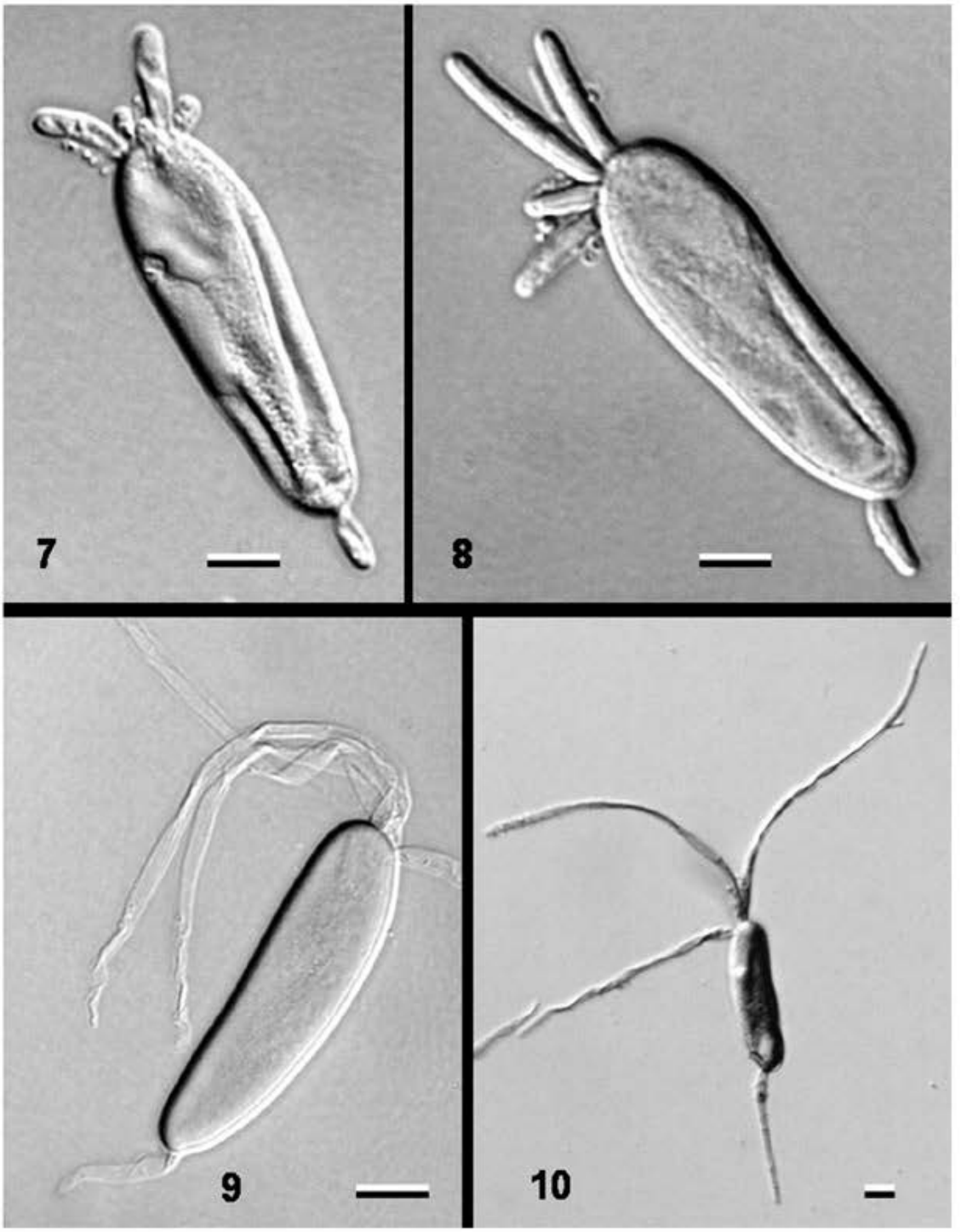
Type: Egypt, Sohag, El Balyana city, on decayed stem of *Phragmites australis* (Cav.) Steud. at irrigation canal, March 2005, F.A. Abdel-Aziz (**Holotype**, IMI 398675; ex-type culture, MF644 (JAMSTEC, Japan); iso-type, MD644 (authors' culture collection).



FIGS 2–6: *Lolia aquatica*. Differential interference contrast light micrographs (from holotype, mounted in water). 2. Vertical section through the gelatinous acervular (in phase contrast). 3-4. Magnified part of the peridial wall that forms textura intricata. 5. Young developing conidium at the tip of the conidiogenous cell. 6. Young conidium stained in toluidine blue shows initials of apical and basal appendages. Bars: 2 = 40 µm, 3–4 = 20 µm, 5–6 = 5 µm.

ETYMOLOGY: From the Latin adjective *aquaticus*, in reference to the freshwater habitat of the fungus.

Conidiomata acervular, 400–480 µm high, 380–540 µm diam, pearl white when wet, dull yellow brown when dry, superficial, single or aggregated (FIG. 2). Peridium 57–80 µm thick, forming textura intricata, hyaline, embedded in gel (FIGS 3–4). Conidiophores lining the acervuli wall and arising from innermost elements of the wall, loosely aggregated, branched and septate, colorless, smooth, embedded in gel. Conidiogenous cells cylindrical to sub-cylindrical,



FIGS 7–10: *Lolia aquatica*. Differential interference contrast light micrographs of conidia at different stages of development. 10. Stained in toluidine blue. Bars: 7–10 = 5 µm.

colorless, smooth, bearing a single terminal conidium. Conidiogenesis: ontogeny holoblastic with apical wall building; delimitation by a transverse septum; secession schizolytic (FIG. 5). Conidia 31–45 × 7–10 µm (mean = 36 × 8.6 µm, n = 50), unicellular, hyaline, clavate, ellipsoidal, cylindrical, hyaline, smooth, thin-walled, solitary. Mean conidium length/width ratio = 4.2:1. Apical

appendages 55–90 × 1.5–3 µm (mean = 68.6 × 2.6 µm, n = 20), three to five sub-apical cellular appendages, attenuating, tapering. Basal appendage 10–85 × 1.5–3 µm (mean = 27.9 × 2.3 µm), excentric, cellular, attenuating, tapering. Both apical and basal appendages are on one side of the conidia and arising as tubular extension of the conidium body and not separated from it at maturity by septa (FIGS 6–10).

Discussion

Several groups of anamorphic fungi are present in freshwater habitats (Shearer et al. 2004, 2007). The best-known and the most studied group is the "aquatic" or "Ingoldian" hyphomycetes, which are distinguished by their tetraradiate, branched, or sigmoid conidia that are released into and dispersed by water (Ingold 1975, Webster & Descals 1981, Bärlocher 1992). About 300 species of aquatic hyphomycetes have been described thus far (Bärlocher 1992, Shearer et al. 2007). The "aeroaquatic hyphomycetes," whose conidia are modified in a variety of ways to trap air for flotation, comprise a second group of anamorphic fungi (Fisher 1979, Michaelides & Kendrick 1982, Webster & Descals 1981, Premdas & Kendrick 1991). Coelomycetes are encountered regularly on a wide variety of submerged plant substrata in both lentic and lotic habitats (Shearer et al. 2004).

Phylogenetic analyses of partial 28S rDNA of *Lolia aquatica* show that it is a member of *Lindgomycetaceae*, *Pleosporales*. Phylogenetically, there are four major exclusive freshwater clades in the *Dothideomycetes* (Schoch et al. 2009), namely, the order *Jahnulales* (Pang et al. 2002, Campbell et al. 2007) and three recently described families: *Lindgomycetaceae*, *Amniculicolaceae* and *Lentitheciaceae* (Schoch et al. 2009, Shearer et al. 2009, Zhang et al. 2009, Hirayama et al. 2010).

There are several coelomycetous genera with hyaline, unicellular, appendages conidia that are somewhat similar to *Lolia aquatica*, e.g., *Chaetospermum* Sacc., *Giulia* Tassi, and *Mycotribulus* Nag Raj & W.B. Kend. *Lolia aquatica* is strikingly similar to *Chaetospermum* species, both having pearl white conidiomata, heavily gelatinized walls that consist of textura intricata, and conidia bearing type A appendages. However *Chaetospermum* species differ in having stromatic, pycnoid conidiomata, and an equal number of conidial appendages (3 to 6) at each end (Sutton 1980, Nag Raj 1993). Phylogenetic analyses of SSU and LSU rDNA placed *Chaetospermum* in the *Basidiomycota* (*Sebacinaceae*; Rungjindamai et al. 2008), whereas *L. aquatica* is in the *Ascomycota*.

The genus *Giulia* has dark-brown to black, immersed pycnidia, conidia bearing apical extra-cellular type D appendages arising by differential gelatinization of the conidium sheath. *Mycotribulus* has immersed to erumpent, brown pycnidia, filamentous paraphyses, and conidia bearing type A appendages at both sides

(one apical centric single appendage and 2-4 lateral basal appendages slightly above the truncate base). Phylogenetic analyses of SSU and LSU rDNA placed *Giulia* and *Mycotribulus* in the *Basidiomycota* (*Corticiaceae* and *Physalacriaceae*, respectively; Rungjindamai et al. 2008).

There are several coelomycetous genera with septate hyaline or colored conidia with cellular apical and basal appendages: e.g., *Bartalinia* Tassi, *Discostroma* Clem., *Discosia* Lib., *Monochaetia* (Sacc.) Allesch., *Pestalotia* De Not., *Pestalotiopsis* Steyaert, *Seimatosporium* Corda, *Seiridium* Nees, *Truncatella* Steyaert. Phylogenetic analyses of LSU rDNA placed all the above-mentioned genera in the family *Amphisphaeriaceae*, *Xylariales* (Jeewon et al. 2002).

Acknowledgments

We would like to thank Prof. Gareth Jones and Dr. Huzefa Raja, for reviewing the manuscript and for their valuable comments. We are very grateful to Dr. Takahiko Nagahama for his support and guidance during the course of this work. We are very grateful to Prof. Uwe Braun, Martin-Luther Universität, Germany, for revising the Latin description. This work was funded by grants from the Japan Society for the Promotion of Science (JSPS) (No. 185701000001 and No. 18-06620). M.A. Abdel-Wahab is grateful to JSPS for an award of a postdoctoral fellowship. Sohag University is acknowledged for providing funds for collecting samples from the field. M.A. Abdel-Wahab is grateful to the Third World Academy of Science (TWAS) for awarding a research grant (No. 03-117 RG/BIO/AF/AC).

Literature cited

Abdel-Aziz FA. 2008. Diversity of aquatic fungi on *Phragmites australis* at Lake Manzala, Egypt. Sydowia 60: 1-14.

Abdel-Wahab MA, Nagahama T, Abdel-Aziz FA. 2009. Two new *Corollospora* species and one new anamorph based on morphological and molecular data. Mycoscience 50: 147-155. doi:10.1007/s10267-008-0466-9

Bärlocher F. 1992. Ecology of aquatic hyphomycetes. Springer-Verlag, Berlin, Germany.

Bunyard BA, Nicholson MS, Royse DJ. 1994. A systematic assessment of *Morchella* using RFLP analysis of the 28S rRNA gene. Mycologia 86: 762–772. doi:10.2307/3760589

Campbell J, Ferrer A, Raja HA, Sivichai S, Shearer C.A. 2007. Phylogenetic relationships among taxa in the *Jahnulales* inferred from 18S and 28S nuclear ribosomal DNA sequences. Can. J. Bot. 85: 873–882. doi:10.1139/B07-080

Cole GT, Samson RA. 1979. Patterns of development in conidial fungi. Pitman Publishing, London.

Dyko BJ, Sutton BC. 1979. Two unusual deutromycetes. Trans. Br. Mycol. Soc. 72: 411-417. doi:10.1016/S0007-1536(79)80147-3

Felsenstein J. 1981. Evolutionary trees from DNA sequences: a maximum likelihood approach. J. Mol. Evol. 17: 368–376. doi:10.1007/BF01734359

Felsenstein J. 1985. Confidence limits on phylogenies: an approach using the bootstrap. Evolution 39: 783–791. doi:10.2307/2408678

Fisher PJ. 1979. Colonization of freshly abscised and decaying leaves by aero-aquatic hyphomycetes. Trans. Br. Mycol. Soc. 73: 99–102. doi:10.1016/S0007-1536(79)80078-9

Hirayama K, Tanaka K, Raja HA, Miller AN, Shearer CA. 2010. A molecular phylogenetic assessment of *Massarina ingoldiana* sensu lato. Mycologia 102: 729-746. doi:10.3852/09-230

Huelsenbeck JP, Ronquist F. 2001. MRBAYES: Bayesian inference of phylogeny. Bioinformatics 17: 754–755. doi:10.1093/bioinformatics/17.8.754

Ingold CT. 1975. An illustrated guide to aquatic and water-borne hyphomycetes (fungi imperfecti) with notes on their biology. Freshwater Biological Association, Scientific Publication No.30.

Jeewon R, Liew ECY, Hyde KD. 2002. Phylogenetic relationships of *Pestalotiopsis* and allied genera inferred from ribosomal DNA sequences and morphological characters. Mol. Phyl. Evol. 25: 378-392. doi:10.1016/S1055-7903(02)00422-0

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth and Bisby's dictionary of the fungi, 10th edn. CABI International, Wallingford.

Michaelides J, Kendrick B. 1982. The bubble-trap propagules of *Beverwykella*, *Helicoon* and other aero-aquatic fungi. Mycotaxon 14: 247–260.

Nag Raj TR. 1978. Genera coelomycetum. XIV. *Allelochaeta*, *Basilocula*, *Ceuthosira*, *Microgloeum*, *Neobarclaya*, *Polynema*, *Pycnidiochaeta* and *Xenodomus*. Can. J. Bot. 56: 686-707.

Nag Raj TR. 1980. Genera coelomycetum. XVIII. *Ellula* anam.-gen. nov. another coelomycete with basidiomycetous affinities. Can. J. Bot. 59: 2001-2014.

Nag Raj TR. 1993. Coelomycetous anamorphs with appendage-bearing conidia. Waterloo, Ontario, Canada: Mycologue Publications.

Nag Raj TR, Holubova-Jechova V, Castañeda RF. 1989. Genera coelomycetum. XXVIII. *Pycnovellomyces* redescribed. Can. J. Bot. 67: 3386-3390.

Nylander JAA. 2004. MrModeltest v2. Program distributed by the author. Evolutionary Biology Center, Uppsala University, Uppsala.

Pang KL, Abdel-Wahab MA, Sivichai S, El-Sharouny HM, Jones EBG. 2002. *Jahnulales* (*Dothideomycetes*, *Ascomycota*): a new order of lignicolous freshwater ascomycetes. Mycol. Res. 106: 1031–1042. doi:10.1017/S095375620200638X

Posada D, Crandall KA. 1998. MODELTEST: testing the model of DNA substitution. Bioinformatics 14: 817–818. doi:10.1093/bioinformatics/14.9.817

Premdas PD, Kendrick B. 1991. Colonization of autumn-shed leaves by four aero-aquatic fungi. Mycologia 83: 317–321. doi:10.2307/3759992

Ronquist F, Huelsenbeck JP. 2003. MRBAYES 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. doi:10.1093/bioinformatics/btg180

Rungjindamai N, Sakayaroj J, Plaingam N, Somrithipol S, Jones EBG. 2008. Putative basidiomycete teleomorphs and phylogenetic placement of the coelomycete genera: *Chaetospermum*, *Giulia* and *Mycotribulus* based on nu-rDNA sequences. Mycol. Res. 112: 802-810. doi:10.1016/j.mycres.2008.01.002

Schoch CL, Crous PW, Groenewald JZ, Barrés B, Boehm EWA, De Gruyter J, de Hoog GS, Dixon LJ, Fournier J, Grube M, Gueidan C, Harada Y, Hatakeyama S, Hirayama K, Hosoya T, Hyde KD, Jones EBG., Kohlmeyer J, Lücking R, Lumbsch HT, Lutzoni F, Marvanová, Mbatchou JS, Miller AN, Mugambi GK, Muggia L, Nelson MP, Nelson P, Ownesby CA, Phongpaichit S, Pointing SB., Pujade-Renaud V, Raja HA, Plata ER, Robbertse B, Ruibal C, Sakayaroj J, Sano T, Selbmann L, Shearer CA, Shirouzu T, Slippers B, Suetrong S, Tanaka K, Volmkann-Kohlmeyer B, Wood AR, Woudenberg JHC, Yonezawa H, Zhang Y, Spatafora JW. 2009. A class-wide phylogenetic assessment of *Dothideomycetes*. Stud. Mycol. 64: 1–15. doi:10.3114/sim.2009.64.01

Shearer CA, Langsam DM, Longcore JE. 2004. Fungi in freshwater habitats. 513–531, in Mueller et al. (eds.) Biodiversity of fungi: inventory and monitoring methods. Elsevier, Amsterdam.

Shearer CA, Descals E, Volkmann-Kohlmeyer B, Kohlmeyer J, Marvanova L, Padgett DE, Porter D, Raja HA, Schmit JP, Thorton HA. Voglymayr H. 2007. Fungal biodiversity in aquatic habitats. Biodiv Conser 16:49–67. doi:10.1007/s10531-006-9120-z

Shearer CA, Raja HA, Miller AN, Nelson P, Tanaka K, Hirayama K, Marvanová L, Hyde KD, Zhang Y. 2009. The molecular phylogeny of freshwater *Dothideomycetes*. Stud. Mycol. 64: 145-153. doi:10.3114/sim.2009.64.08

Swofford DL. 2002. PAUP* 4.0: Phylogenetic analysis using parsimony (*and other methods). Sinauer, Sunderland, MA.

Sutton BC. 1980. The Coelomycetes: Fungi imperfecti with pycnidia, acervular and stromata. Commonwealth Mycological Institute, Kew, Surrey, England.

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Res. 25: 4876–4882. doi:10.1093/nar/25.24.4876

Van Ryckegem G, Gessner MO, Verbeken A. 2007. Fungi on leaf blades of *Phragmites australis* in a brackish tidal marsh: Diversity, succession, and leaf decomposition. Microb. Ecol. 53: 600–611. doi:10.1007/s00248-006-9132-y

Van Ryckegem G, Verbeken A. 2005a. Fungal diversity and community structure on *Phragmites australis* (Poaceae) along a salinity gradient in the Scheldt estuary (Belgium). Nov. Hedwig. 80: 173-197. doi:10.1127/0029-5035/2005/0080-0173

Van Ryckegem G, Verbeken A. 2005b. Fungal ecology and succession on *Phragmites australis* in a brackish tidal marsh. II. Stems. Fungal Diver. 20: 209-233.

Webster J, Descals E. 1981. Morphology, distribution, and ecology of conidial fungi in freshwater habitats. 295-355, in Cole and Kendrick (eds.), The Biology of Conidial Fungi. Vol. 1. Academic Press, New York.

Zhang Y, Schoch CL, Fournier J, Crous PW, de Gruyter JHC, Hirayama K, Tanaka K, Pointing SB, Spatafora J, Hyde K.D. 2009. Mutlilocus phylogeny of the *Pleosporales*: a taxonomic, ecological and evolutionary re-evaluation. Stud. Mycol. 64: 85–102. doi:10.3114/sim.2009.64.04

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.43

Volume 114, pp. 43–47 October–December 2010

Chlamydopsis: an emendment of the genus and its type species

PRISCILA DA SILVA* & ROSELY ANA PICCOLO GRANDI

silva_pri@yahoo.com.br

Instituto de Botânica, Núcleo de Pesquisa em Micologia e Liquenologia

Caixa Postal 3005, 01031-970 São Paulo, SP, Brazil

Abstract — *Chlamydopsis proliferans*, the type of a monotypic genus, was isolated on decaying leaves of *Caesalpinia echinata* in the Reserva Biológica de Mogi-Guaçu, São Paulo State, Brazil. During our study, we observed differences between our new collection and the original description. We therefore emend the circumscriptions of the genus and the species, which is reported for the first time from South America.

Key words — litter fungi, hyphomycetes, brazil-wood

Introduction

During investigations of conidial fungi that occur on leaf litter of *Caesalpinia echinata*, brazil-wood (Silva & Grandi 2008), an interesting dematiaceous hyphomycete was isolated. The collection was identified as *Chlamydopsis proliferans* but showed distinct features different from the original description (Holubová-Jechová & Castañeda 1986).

Chlamydopsis is a monotypic genus, described from decaying leaves of *Lauraceae* in the Province of Camagüey, Cuba; since it was proposed there have been no other records nor have new species been added to the genus (Kirk et al. 2008, www.indexfungorum.org, consulted 14 June 2010). The conidia of our collection are typical and divided into two parts composed of one unicellular basal cell and an apical part with a central globose brown cell. Many delicate pale brown cells surround the central cell as illustrated by Holubová-Jechová & Castañeda Ruiz (1986), but in disagreement with their interpretation. Moreover the conidia are muriform since they possess septa in more than one plane (Kirk et al. 2008).

Therefore, emendments to the genus and species are proposed and the description and illustrations of the Brazilian material presented.

Materials and methods

The leaf litter of *Caesalpinia echinata* was collected from February 2005 to February 2006 in the "Reserva Biológica de Mogi-Guaçu", (22°15'02.4"S 47°09'28.9"W), São Paulo State, Brazil. After the dead leaves were successively washed, they were incubated in moist chambers at room temperature (Harley & Waid 1955, Grandi & Gusmão 1998). The fungal specimens were transferred to slide mounts prepared with lactophenol-cotton blue, polyvinyl alcohol, and glycerin (adapted from Morton et al. 1993, Mueller et al. 2004). Identification was made with microscope Axiostar plus and pictures with Axioskop 40, AxioCam MR and AxioVision, both Carl Zeiss. Permanent slides were deposited in the "Herbário Científico do Estado Maria Eneyda P. Kauffmann Fidalgo (SP)", Brazil. In addition, the type specimen PRM 842703 (isotype) was requested from the Herbarium PRM, at Czech Republic, and analyzed.

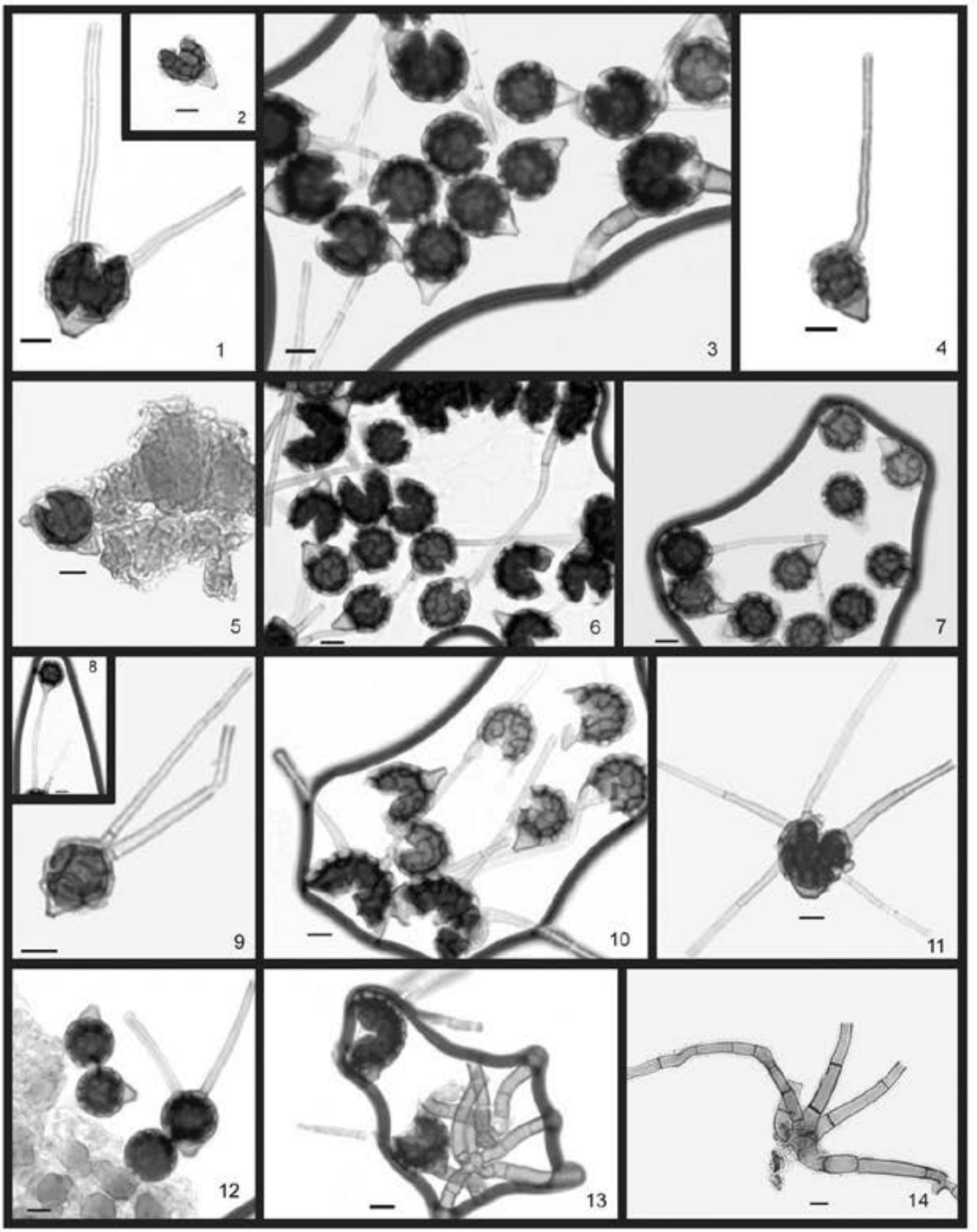
Taxonomy

Chlamydopsis Hol.-Jech. & R.F. Castañeda, Česká Mykologie 40: 74. 1986.

EMENDED DESCRIPTION: Conidiophores smooth, single or in groups, arising from basal cell. Conidiogenous cell cylindric, smooth, pale brown. Conidium complex, muriform, dry; basal cell obpyriform to subconical, conical-truncate, thick-walled at the base, smooth, pale brown; apical cell globose, dark brown, surrounded by a layer of small, thin-walled, smooth, pale brown cells.

Chlamydopsis proliferans Hol.-Jech. & R.F. Castañeda, Česká Mykologie 40: 74. 1986. FIGS 1–14

EMENDED DESCRIPTION: Conidiophores arising from a less distinct basal cell and in groups of up to 5; distinct, simple, 2–7-septate, smooth, pale brown to brown 46–55(–122) µm long, 5–6(–7.5) µm wide, measurement including conidiogenous cells. Conidiogenous cells cylindrical, integrated, terminal, monoblastic, smooth, pale brown, bearing one conidium at the apex. Conidia complex, muriform, solitary, dry, obovoid or obpyriform, with a unicellular basal cell and another terminal portion larger, globose, smooth, brown. Basal cell obpyriform, conical-truncate, thick-walled at the base, smooth, pale brown, 6–8.5 µm long, 6–10 µm wide in the apex, 1–5(–6) µm wide in the base. Terminal portion globose, with a dark brown thick-walled central cell and with a layer of cells covered this portion, 12.5–21 µm diam. Layer of cells surrounding the central cell composing by thin-walled, smooth, pale brown cells, 2–3.5(–5) µm wide. A group of 3–5 conidiophores arising from this layer of cells, simple, 1–3-septate, thin-walled, smooth, pale brown, 37.5–47.5 µm long, 2.5–3.5 µm wide.



FIGS. 1–14. *Chlamydopsis proliferans*. 1–4. Conidia (note thick-walled basal cell). 5–7, 10. Conidia, each with a layer of outer thin cells surrounding the globose dark central cell. 8. Attached conidium. 9–12. Conidiophores arising from the thin outer layer of cells. 13–14. Conidiophores arising from somatic hyphae in groups up to five.

(Bars = 10 µm; FIGS. 1, 2, 4, 5, 9, 11: Brazilian material, SP 381595; FIGS. 3, 6, 7, 8, 10, 12, 13: Cuban isotype, PRM 842703)

Specimens examined: **BRAZIL. São Paulo:** Mogi-Guaçu, "Reserva Biológica de Mogi-Guaçu", on decaying leaf litter of *Caesalpinia echinata* Lam. (*Caesalpiniaceae*), 30.XII.2005, R.A.P. Grandi & P. Silva. (SP 381595). **CUBA. Província Camagüey:** Hoyo de Bonet, on rotten leaves of *Lauraceae*, 29.XI.1984, R.F. Castañeda. **(ISOTYPE:** PRM 842703).

Habitat and Distribution – on leaf litter from tropical rainforest in Brazil and Cuba.

Comments – The species was studied through permanent slides from both the Brazilian material and the isotype. In the generic diagnosis the conidia were originally described as uniseptate, with the two cells described as: "terminal cell globose, dark brown, thick-walled and distinctly warted, basal cell subconic, smaller, pale brown, smooth" (Holubová-Jechová & Castañeda Ruiz 1986). However, examination of both collections showed that the conidia are neither warted nor subdivided into two cells. The basal cell of the conidium is conico-truncate at the base as originally described and illustrated and it is thick-walled at the base (Figs. 1–4). After detailed observations we noted that the "warted" ornamentation of the wall mentioned for the "terminal cell" of the conidia in the original description is actually a lighter coloured layer of cells surrounding the globose dark brown central cell of the conidia (Figs. 5–7); this species does not have warts. It is well observed that when the conidia are broken, the wall cracks in many directions and the superficial delicate layer is perfectly visible (Fig 1, 2, 5, 6, 10, 11,13). At first the central brown part of the conidia seems to be divided into many cells, but this appearance results from the delicate layer over the globose central cell (Figs. 5–7, 10). Some cells of this external layer give rise to new conidiophores (Figs. 8–12); it appears that the conidia may or may not proliferate, depending on the stage of development of the material.

The illustrations in the original paper showed probably 5 conidiophores, which we also observed (Figs. 13–14), but the species description cites only "up to 4". In addition, there are no minutely roughened conidiophores observed in the Brazilian material. Unfortunately the illustrations of Holubová-Jechová & Castañeda Ruiz (1986) were at odds with the interpretation in the text.

Chlamydopsis proliferans is known only from permanent slides and at the moment its distribution appears to be essentially tropical. This is the second occurrence of the species and the first in South America.

Acknowledgments

The authors thank the FAPESP (Fundação de Apoio a Pesquisa do Estado de São Paulo) for funding provided for this work (05/51732-5) and the "Programa de Pós-Graduação em Biodiversidade Vegetal e Meio Ambiente", of Instituto de Botânica, São Paulo, Brazil. We are grateful to Dr. Jan Holec, curator of the Herbarium PRM (Czech Republic) for the loan of the isotype and for allowing the publication of its images, also to Dr. Tarciso S. Filgueiras and MSc. Pedro Bond Schwartsburd for their comments on

this manuscript. We are also thank Dr. Eric H.C. McKenzie and Dr. Paul M. Kirk for reviewing the manuscript.

Literature cited

Bills GF, Foster MS. 2004. Formulae for selected materials used to isolate and study fungi and fungal allies. In: Biodiversity of fungi – inventory and monitoring methods (Mueller GM, Bills GF, Foster MS, eds). Elsevier Academic Press. pp. 595–618.

Grandi RAP, Gusmão LFP. 1998. A técnica da lavagem sucessiva de substratos de plantas como subsídio para estudos da associação fungo/substrato e diversidade de Hyphomycetes nos ecossistemas. Anais do IV Simpósio de Ecossistemas Brasileiros (S. Watanabe, coord.). ACIESP, 2: 80–90.

Harley JL, Waid JS. 1955. A method of studying active mycelia on living roots and other surfaces in the soil. Trans. Br. Mycol. Soc. 38: 104–118. doi: 10.1016/S0007-1536(55)80022-8

Holubová-Jechová V, Castañeda Ruiz RF. 1986. Studies on Hyphomycetes from Cuba III. New and interesting dematiaceous taxa from leaf litter. Ceská Mykol. 40: 74–85.

Morton JB, Bentivenga SP, Wheeler WW. 1993. Germ plasm in the International Collection of Arbuscular and Vesicular-arbuscular Mycorrhizal Fungi (INVAM) and procedures for culture development, documentation and storage. Mycotaxon 48: 491–528.

Silva P, Grandi RAP. 2008. Hyphomycetes sobre o folhedo de *Caesalpinia echinata* Lam. com duas novas citações para o Brasil. Hoehnea 35: 477–488.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.49

Volume 114, pp. 49–54 October–December 2010

Amparoina spinosissima: a continental Asian record and some taxonomic observations

DOLLYMOL M. ARAVINDAKSHAN & P. MANIMOHAN

dollyma3@gmail.com & pmanimohan@gmail.com
Department of Botany, University of Calicut
Kerala, 673 635, India

Abstract —*Amparoina spinosissima* is described and illustrated from Kerala State, India. This is the first record of the species from continental Asia. Basidiospores of the Indian specimens are inamyloid in support of Singer's original observation.

Key words — *Agaricales, Basidiomycota,* floristics, systematics, *Tricholomataceae*

Introduction

The genus *Amparoina* Singer (*Agaricales, Tricholomataceae*), although little known, has a chequered taxonomic history. The type species of the genus, *A. spinosissima*, was originally described as *Marasmius spinosissimus* and was first discovered in Argentina (Singer 1950). Singer (1958) erected *Amparoina* to accommodate *M. spinosissimus,* which he (Singer 1958, 1976) interpreted as having inamyloid spores, an epicutis covered by cherocytes (loose, globose cells with long excrescences or spines; Singer 1986), and a secotioid habit. Later, Singer (1976) proposed a monotypic family, *Amparoinaceae* Singer, and excluded it from *Agaricales.* Singer (1976) also added a second species to *Amparoina, A. heteracantha* Singer. Horak (1980), based on his own collections of *A. spinosissima* made in Argentina and New Caledonia, concluded that the species is not secotioid. After examining the type material of *A. heteracantha*, Horak (1980) considered it to be conspecific with *A. spinosissima.* Horak (1968, 1980), however, never questioned the autonomy of *Amparoina.* Although Singer (1983) did not agree with Horak's merging of the two *Amparoina* species, he conceded that *A. spinosissima* was not secotioid. On the basis of Horak's observations, Singer (1986) reinstated *Amparoina* in the *Tricholomataceae* (*Agaricales*).

Based on the study of several collections of *A. spinosissima* made from Colombia, Puerto Rico, and Hawaii, Desjardin (1995) agreed with most of

Horak's conclusions. However, he found the basidiospores to be amyloid in the specimens he examined and this prompted him to transfer the species to *Mycena* sect. *Sacchariferae*. Although Singer observed the basidiospores of *A. spinosissima* to be inamyloid, this cannot be confirmed as the holotype of *A. spinosissima* no longer exists. Horak's observations (1968, 1980, and his pers. comm. quoted by Desjardin 1995) on the amyloidy of basidiospores from his collections of *A. spinosissima* were not consistent. Takahashi (1999) observed amyloid spores in Japanese collections of the species. We did not re-examine spores from the collections made by Horak and Takahashi, so that the possible variation in amyloid reaction remains an open question. Meanwhile, taxonomic and nomenclatural resources such as the Dictionary of the Fungi (Kirk et al. 2008) and the Index Fungorum (www. indexfungorum.org) continue to recognize *Amparoina*. We accept this point of view for the time being and note that molecular analyses may clarify the relationships among *Amparoina*, *Mycena*, and other agarics in the future. *Mycena* in the present wide sense includes also some species with inamyloid spores as well as species with cherocytes, similar to those of *Amparoina*, on the pileus surface but with amyloid spores (Singer 1986).

Although only rarely collected, *A. spinosissima* is known thus far from Argentina, Colombia, Hawaii, Japan, New Caledonia, and Puerto Rico. During our studies on the agarics of Kerala State, India, we collected a decaying twig bearing primordia of this species, which when incubated in the lab yielded well-developed basidiomata. We present here a full description of the Indian collection along with some taxonomic observations.

Materials and methods

Conventional morphology-based methods were employed for this study. Microscopic observations were made on material stained with 1% aqueous solutions of phloxine and Congo red and mounted in 3% aqueous KOH. Melzer's reagent was used to observe whether the spores and tissues were amyloid. For statistical evaluation 40 spores (20 basidiospores each from two specimens) were measured. The examined collection cited is deposited at the Kew (Mycology) Herbarium.

Taxonomy

Amparoina spinosissima (Singer) Singer, Mycologia 50: 110. 1958. FIGURE 1A–E

= *Marasmius spinosissimus* Singer, Schweiz. Z. Pilzk. 28: 193. 1950.

= *Mycena spinosissima* (Singer) Desjardin, Bibliotheca Mycol. 159: 15. 1995.

BASIDIOMATA small, delicate. PILEUS 2–5.5 mm wide, 2–4.5 mm high, initially conical, becoming broadly campanulate; surface white to whitish all over,

entirely covered in the primordial stage with a universal veil made up of pale greenish or ivory-colored, erect or curved, conic, detersile spines up to 0.75 mm long that disappear first from the middle, then from the margin and finally from the pileus disc with age, pruinose, dry, very thin, translucently striate, becoming slightly plicate towards the margin; margin initially straight and appendiculate with spines, becoming plane and undulate or finely torn with age. LAMELLAE adnexed, fairly close, 15–20 reaching the stipe, with lamellulae in 1–3 tiers, ventricose, up to 0.5 mm broad, white; edge finely torn under a lens. STIPE 20–38 × 0.5–1.25 mm, central, terete or slightly compressed, almost equal or with a slightly dilated apex, hollow; surface translucent-white, dry, densely pruinose to hirsute towards the base, almost glabrous at apex; base often subbulbous, not discoid. CONTEXT very thin. ODOR not distinctive.

BASIDIOSPORES (6–)8–9.5(–12) × 4.5–6(–9.5) (8.86 ± 0.17 × 5.96 ± 0.15) µm, Q = 1.24–1.73, Qm = 1.5, ellipsoid, ovoid or rarely subamygdaliform, thin-walled, smooth, with refractive guttules, inamyloid. BASIDIA 11–18 × 6–11.5 µm, broadly clavate to almost subglobose, thin-walled, hyaline, 4-spored; sterigmata up to 4 µm long. LAMELLA-EDGE sterile. CHEILOCYSTIDIA 7–23.5 × 5–12.5 µm, cylindrico-clavate, subglobose or vesiculose, covered entirely or at least at the apex with minute excrescences, occasionally smooth, thin- to slightly thick-walled (0.5 µm), hyaline; excrescences 0.5–0.75 µm long, cylindrical or subconical. PLEUROCYSTIDIA absent. LAMELLAR TRAMA subregular to almost regular; hyphae 2.5–32 µm wide, thin-walled, hyaline to pale yellowish, faintly dextrinoid. PILEAL TRAMA subregular; hyphae 2–20 µm wide, slightly inflated, thin-walled, hyaline to pale yellowish. PILEIPELLIS basically a cutis composed of hyphae that are covered entirely with minute excrescences and terminating in acanthocytes which overlap in such a way as to give an apparent subhymeniform appearance; hyphae 2.5–5.5 µm wide, thin-walled, hyaline; acanthocytes 18–54 × 10–41 µm, versiform: globose, subglobose, clavate, ovoid or sphaeropedunculate, thin-walled, hyaline; excrescences 0.5–2 × 0.5–1.5 µm, cylindrical or subconical; hypoderm composed of distinctly more inflated hyphae lacking excrescences. PILEUS MARGIN made up entirely of cells similar to cheilocystidia, 10–26 × 4.5–15.5 µm, thin-walled, hyaline. SPINES of the universal veil made of cherocytes 25–90 × 2–31 µm, central and terminal ones mostly globose, clavate or fusiform, peripheral ones often cylindric, subcylindric or irregularly elongated, thick-walled (1–2 µm), with sparse excrescences, with 8–24 erect, pointed spine-like projections, 3–26 µm long. STIPITIPELLIS a cutis with numerous caulocystidia; hyphae 2.5–13 µm wide, thin- to slightly thick-walled (0.25 µm), hyaline; caulocystidia 34.5–331.5+ × 6.5–15(–20) µm, long, scattered or in clusters, cylindrical, mostly with an obtuse apex, densely covered with excrescences all over. Both acanthocytes and cherocytes observed in the covering layers of the extreme base of the stipe; acanthocytes 11.5–71

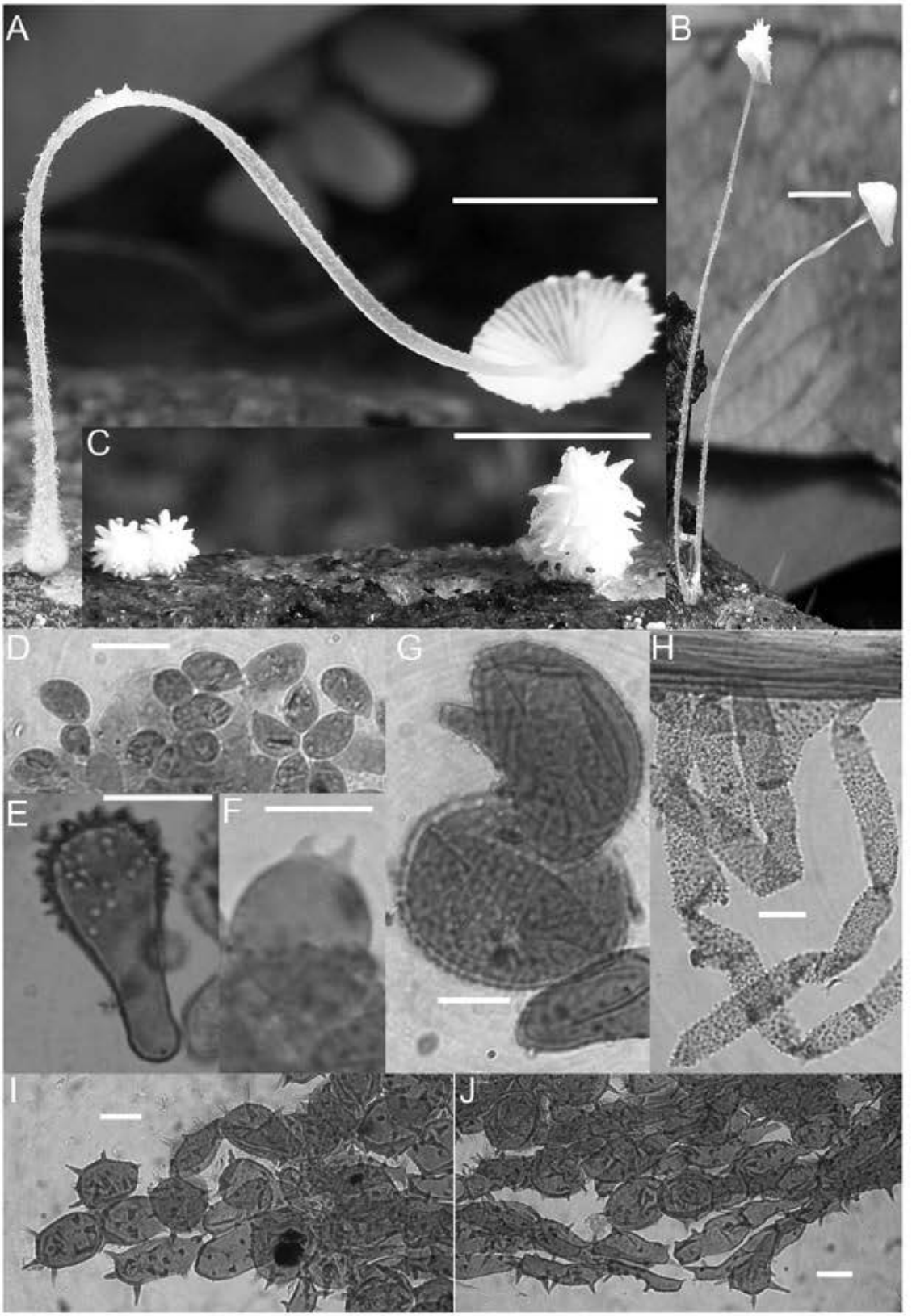


FIGURE 1, A–J: *Amparoina spinosissima*: A–B, basidiomata; C, primordia; D, spores; E, cheilocystidium; F, basidium; G, acanthocytes; H, stipitipellis and caulocystidia; I, cherocytes of terminal part of spine; J, cherocytes of basal part of spine. Scale bars: 5 mm for basidiomata and primordia and 10 µm for microscopic structures.

× 7.5–30.5 µm, subglobose to clavate, obpyriform or lageniform or nearly sphaeropedunculate, with evenly distributed excrescences 0.5–2 × 0.5–1.5 µm; cherocytes 23.5–33 × 12–27 µm, globose to subglobose or clavate, thick (1–2 µm)-walled, with excrescences all over, and with 5–12 pointed spine-like projections, up to 8 µm long. CLAMP CONNECTIONS observed in all hyphae except at the base of caulocystidia and on pileipellis hyphae. Cherocytes of both the pileal surface and stipe base showed a tendency to germinate when mounted in water.

HABITAT: On a decaying dicotyledonous twig, scattered or caespitose.

COLLECTION EXAMINED—**INDIA, KERALA STATE, Calicut District**, KOYILANDY, Poyilkaavu: 31 July 2009, D.M. Aravindakshan *DM314* [K(M)165810].

DISCUSSION: The Indian collection shows all diagnostic characters of *A. spinosissima*, such as small, fragile, whitish basidiomata growing on dicotyledonous twigs, a universal veil composed of conical spines comprising thick-walled cherocytes, a pileipellis with detersile acanthocytes, a stipitipellis with very long and cylindrical caulocystidia with excrescences, cheilocystidia with excrescences, and non-discoid stipe base. However, some minor differences were noticed in the present collection compared to earlier descriptions. In their respective collections, Horak (1980) found all hyphae to be clampless and Desjardin (1995) found clamp connections only in the universal veil. On the contrary, we found clamp connections in most parts of the basidiomata of the Indian collections. While Desjardin found the cherocytes of the medullary region of the spines devoid of spine-like projections, all cherocytes had such projections in the present collections. Additionally, the maximum length of the cherocytes (90 µm), the maximum number of spine-like projections on the cherocytes (24), and the maximum length of the spine-like projections (26 µm) in the Indian collection were almost twice as much as what Desjardin (1995) has recorded. Also, in addition to the normal warty cheilocystidia, occasionally some totally smooth ones were seen. In view of these differences and the reported amyloid spores, Desjardin's collection may represent a different taxon.

As already mentioned, the reaction of the spores of *A. spinosissima* with Melzer's reagent has been a contentious issue and has a bearing on the autonomy of *Amparoina*. The spores of the Indian collection were found beyond any doubt to be inamyloid. This observation lends support for what Singer (1950, 1958, 1976, 1983) has recorded for the species and also for the autonomy of the genus. Another remarkable observation that we made on the Indian specimen is that the cherocytes from the veil tend to germinate when mounted in water. According to Singer (1983, 1986), the cherocytes of *Mycena* and *Amparoina* may be interpreted as chlamydospores.

This is the first record of *A. spinosissima* from continental Asia and it extends the known geographical distribution of this species beyond the Pacific Rim to

South Asia. Our findings support Singer's (1983) contention that *A. spinosissima* has a disjunct distribution and this may be indicative of its primitiveness.

Acknowledgments

We are greatly indebted to Dr. Eef Arnolds and Dr. Brandon Matheny for pre-submission reviews of this manuscript.

Literature cited

Desjardin DE. 1995. A preliminary accounting of the worldwide members of *Mycena* sect. *Sacchariferae*. Bibliotheca Mycologica 159: 1–89.

Horak E. 1968. Synopsis generum Agaricalium. Beitrage zur Kryptogamenflora der Schweiz 13: 1–741.

Horak E. 1980. Taxonomy and distribution of two little known, monotypic genera of *Agaricales*: *Amparoina, Cystoagaricus*. Sydowia 33: 64–70.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Dictionary of the Fungi, 10th edn. CABI, Wallingford, UK.

Singer R. 1950. Die höheren Pilze Argentiniens. Schweizerische Zeitschrift fur Pilzkunde 28: 181–196.

Singer R. 1958. New genera of fungi. VIII. Notes concerning the sections of the genus *Marasmius* Fr. Mycologia 50: 103–110. doi:10.2307/3756041

Singer R. 1976. *Amparoinaceae* and *Montagneaceae*. Revue de Mycologie 40: 57–64.

Singer R. 1983. Acanthocytes in *Amparoina* and *Mycena*. Cryptogamie, Mycologie 4: 11–115.

Singer R. 1986. The *Agaricales* in modern taxonomy, 4th Ed. Koeltz Scientific Books, Koenigstein, Germany.

Takahashi H. 1999. *Mycena auricoma*, a new species of *Mycena* section *Radiatae* from Japan, and *Mycena spinosissima*, a new record in Japan. Mycoscience 40: 73–80. doi:10.1007/BF02465677.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.55

Volume 114, pp. 55–59 *October–December 2010*

Hyphopolynema ingae sp. nov., associated with leaf-spot disease on *Inga edulis* in Brazil

DANILO B. PINHO, ANDRE L. FIRMINO & OLINTO L. PEREIRA

oliparini@ufv.br
Departamento de Fitopatologia, Universidade Federal de Viçosa
Viçosa, Minas Gerais, 36570-000, Brazil

Abstract — A leaf-spot forming anamorphic fungus, *Hyphopolynema ingae* sp. nov., collected on *Inga edulis* in a fragment of Atlantic forest in Brazil, is described, illustrated and compared with five previously described *Hyphopolynema* species.

Key words — appendages, biodiversity, foliicolous fungi, hyphomycetes, taxonomy

Introduction

Inga edulis Mart. (*Mimosaceae*) is a widespread tree in the tropical secondary forest of the Amazonian region and the fragments of Brazilian Atlantic forest (Marangon et al. 2003, Lorenzi 2009). The plant is known by the local population for its sweet edible fruits and antioxidant property of leaves and in folk medicine for its anti-inflammatory and anti-diarrheic properties (Silva et al. 2007, Souza et al. 2007, Lorenzi 2009). During a mycofloristic survey in a fragment of Atlantic forest in the municipality area of Viçosa, Minas Gerais, Brazil, leaves of *I. edulis* showing a leaf-spot disease were collected. On microscopic examination, it was observed that an appendage-bearing anamorphic fungus was associated with the leaf spots. The fungus, which was found to represent a new species of the genus *Hyphopolynema* Nag Raj, is described, illustrated, and discussed in this paper.

Material and methods

Samples of infected leaves were collected, photographed, and dried in a plant press. Freshly collected samples were examined under a stereomicroscope (Olympus SZ40). Hand sections and fungal material scraped with a scalpel from the plant surfaces were mounted on glass slides with lactophenol. Measurement

and illustrations were carried out with a Carl Zeiss Standard W fitted with a camera lucida drawing apparatus. Photomicrographs were taken in an Olympus BX51 light microscope fitted with a digital camera (Evolt E330). Specimen of the fungus examined was deposited in the Herbarium at the Universidade Federal de Viçosa (Herbarium VIC).

Taxonomy

Hyphopolynema ingae Pinho & O.L. Pereira, **sp. nov.** FIGS 1-2

MYCOBANK 518225

Ad Hyphopolynema tropicale *differt in cellulae conidiogenae 21–33 × 2–5 µm, collis notatis absentibus, setae sporodochio, conidia non guttulata, 0-septata, appendicibus non ramosis.*

HOLOTYPE: on leaves of *Inga edulis* Mart. (*Mimosaceae*), Brazil, Minas Gerais, Viçosa, Reserva Florestal Mata do Paraíso, 6 February 2009, O.L. Pereira (VIC 31222).

ETYMOLOGY: from the host genus *Inga*.

Lesions on living leaves, amphigenous, irregular, 0.2–1.4 cm diam., light brown, whitish to grayish at center, surrounded by a purple well defined border, coalescent and necrotic with age. Conidiomata scattered, discrete or often confluent, circular to oval in outline, sporodochial, pulvinate, superficial. Setae sparse in sporodochia, peripheral, erect, straight or slightly curved, medium brown, smooth, 6–9 septate, slightly tapered and paler towards the obtuse apex, 102.5–145.0 × 4.0–5.0 µm. Conidiophores generally reduced to conidiogenous cells, 1–3 septate, pale brown, smooth. Conidiogenous cells terminal, determinate, clustered, integrated or discrete on conidiophores, branched especially at the base, monophialidic, pale brown, smooth, cylindrical or long lageniform and tapered gradually towards the apex, mostly straight, 21.5–37.0 × 2.0–5.0 µm, conidiogenous locus apical, single to each cell, phialide aperture 1.0–2.0 µm wide, with an inconspicuous collarette. Conidia formed in white masses, blastic-phialidic, hyaline, aseptate, smooth, not guttulate, straight, curved or irregular, fusiform, apex acute or rounded, base truncate, often protuberant, 9.0–15.0 × 3.0–6.0 µm; with one apical and 2–4 basal unbranched filamentous appendages, 5.0–10.0 µm long.

COMMENTS — Five species have previously been described in the genus *Hyphopolynema*. *Hyphopolynema ingae* is the second species reported on *Mimosaceae*. The other species, *H. tropicale* Nag Raj, is distinguished from *H. ingae* by smaller conidiogenous cells, absence of collarette, absence of setae on conidiomata, guttulate septate conidia, and branched appendages (TABLE 1). *Hyphopolynema tropicale* occurs on pods of *Inga spectabilis* (Vahl) Willd. (Nag Raj 1977), whereas *H. ingae* was found growing on living leaves of *I. edulis*. Among the six *Hyphopolynema* spp., only *H. ingae* and *H. australe* B. Sutton &

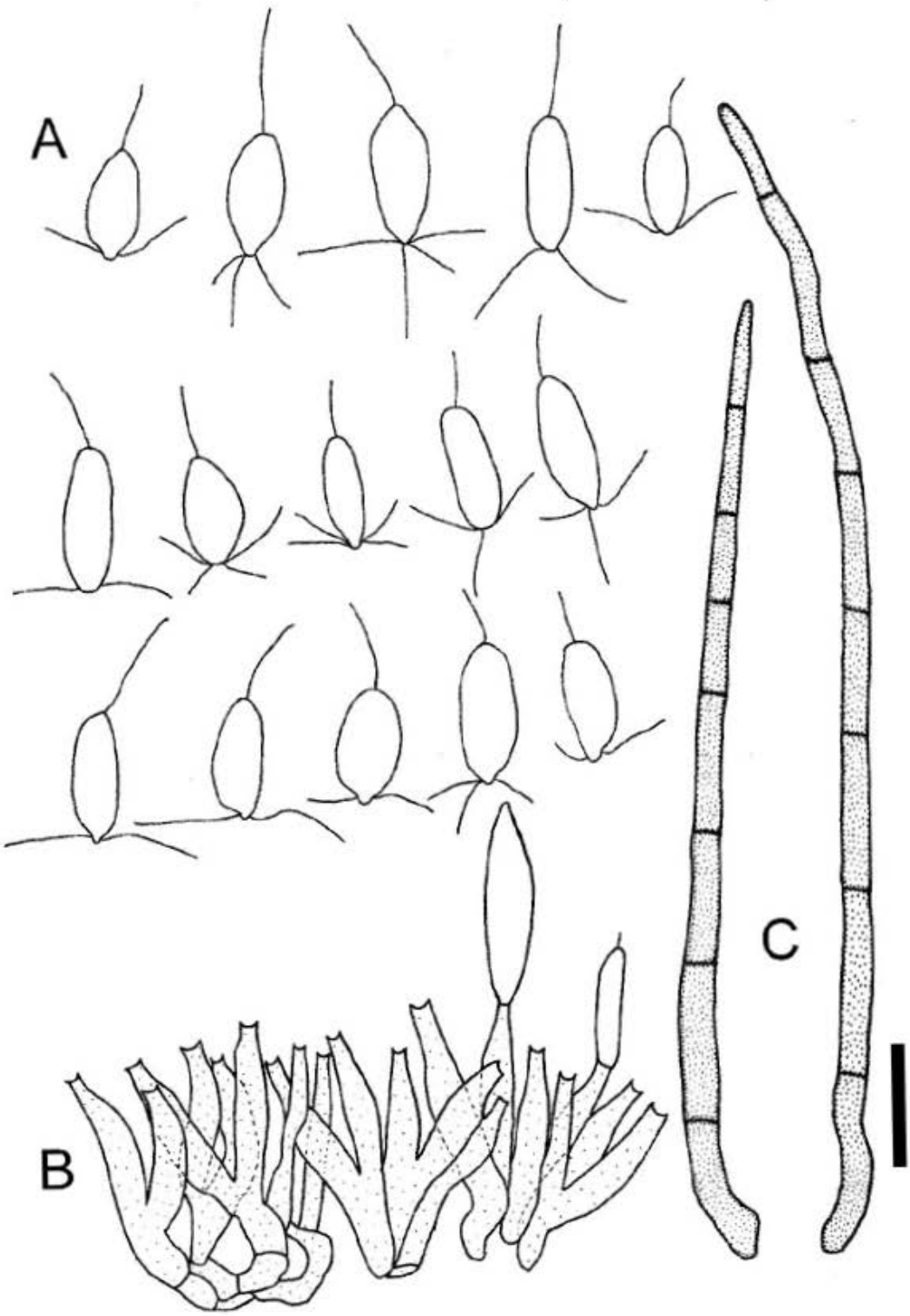


FIGURE 1. *Hyphopolynema ingae* (VIC 31222, holotype) on *Inga edulis*.
Conidia with flexuous appendages (A).
Conidiogenous cells arranged in sporodochia (B) and sporodochial setae (C).
Scale bar = 15 µm.

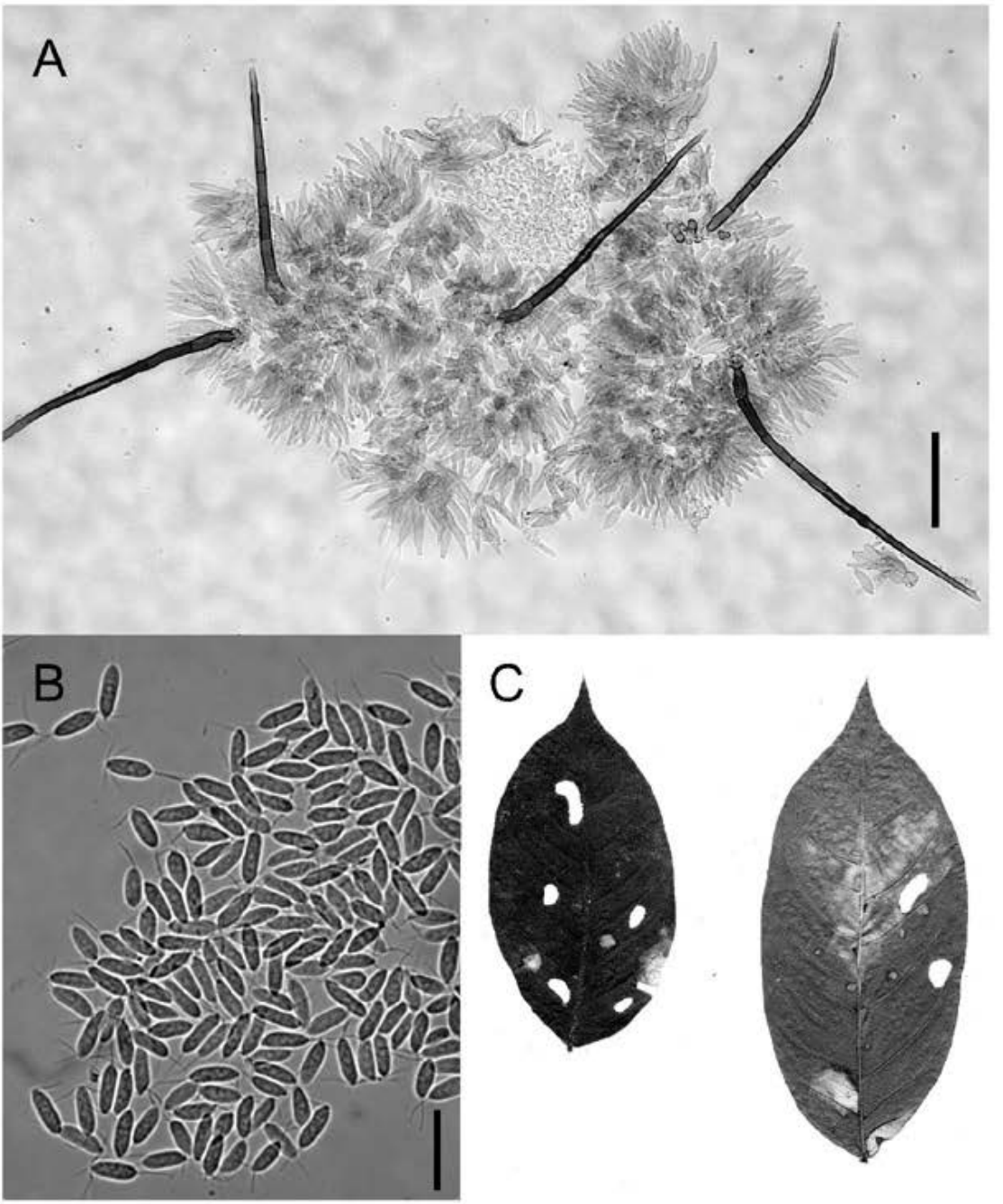


FIGURE 2. *Hyphopolynema ingae* (VIC 31222, holotype). A. Conidiogenous cells arranged in sporodochia. B. Mass of conidia with flexuous appendages. C. Leaf spots associated with *Hyphopolynema ingae* in adaxial and abaxial surfaces from *Inga edulis*.
Scale bars = 40 µm (A); 25 µm (B).

Alcorn are known to occur on living host leaves. In addition, in *H. australe* and *H. ellisiorum* B. Sutton & Alcorn, the conidiophores and conidiogenous cells are hyaline (Sutton & Alcorn 1984). *Hyphopolynema juncatile* Kohlm. & Volkm.-Kohlm. forms a pseudostroma in the cortical tissue of the host (Kohlmeyer

& Volkmann-Kohlmeyer 1999). The sixth species, *H. stilboideum* Bhat & W.B. Kendr., has synnematal conidiomata without setae and produces conidia that are slightly constricted at the septum (Bhat & Kendrick 1993).

Table 1. Biometric data (µm) of the species of *Hyphopolynema*.

Species	Conidiogenous cells	Conidia	Appendages	Setae
H. tropicale	11–25 × 3–4	10–17.5 × 4–6	4–9	absent
H. ellisiorum	4–15 × 2.5–4	12.5–13.5 × 2.5–3	7–11	150 × 4
H. australe	7–19 × 2–2.5	15–24 × 2–2.5	4–18	265 × 5–6
H. stilboideum	30–40 × 3–4.5	13–19 × 5–7	8–15	absent
H. juncatile	–	13–16 × 3–4	7–10	55–90 × 4–7
H. ingae	21.5–33 × 2–5	9–15 × 3–6	5–10	102.5–145 × 4–5

Acknowledgments

This work is part of an ongoing program of surveying and describing the foliicolous and phytopathogenic mycodiversity of fragments of Brazilian Atlantic forest. The authors wish to thank Prof. Rafael F. Castañeda Ruiz (Instituto de Investigações Fundamentais em Agricultura Tropical "Alejandro de Humboldt", Cuba) and Prof. Darbhe Jayarama Bhat (Goa University, India) for reviewing the manuscript.

Literature cited

Bhat DJ, Kendrick B. 1993. Twenty-five new conidial fungi from the Western Ghats and the Andaman Islands (India). Mycotaxon 49: 19–90.

Kohlmeyer J, Volkmann-Kohlmeyer B. 1999. Fungi on *Juncus roemerianus*. 13. *Hyphopolynema juncatile* sp. nov. Mycotaxon 70: 489–495.

Lorenzi H. 2009. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. 3ed. Vol. 2. Nova Odessa: Editora Plantarum. 384 p.

Marangon LC, Soares JJ, Feliciano ALP. 2003. Florística arbórea da Mata da Pedreira, município de Viçosa, Minas Gerais. Revista Árvore 27: 207–215. doi:10.1590/S0100-67622003000200010

Nag Raj TR. 1977. Miscellaneous microfungi. II. Canadian Journal of Botany 55: 757–765. doi:10.1139/b77-091

Silva EM, Souza JNS, Rogez H, Rees JF, Larondelle Y. 2007. Antioxidant activities and polyphenolic contents of fifteen selected plant species from the Amazonian region. Food Chemistry 101: 1012–1018. doi:10.1016/j.foodchem.2006.02.055

Souza JNS, Silva EM, Silva MN, Arruda MSP, Larondelle Y, Rogez H. 2007. Identification and antioxidant activity of several flavonoids of *Inga edulis* leaves. Journal of the Brazilian Chemical Society 18: 1276–1280. doi:10.1590/S0103-50532007000600025

Sutton BC, Alcorn JL. 1984. Additions to *Hyphopolynema*. Australian Journal of Botany 32: 551–559. doi:10.1071/BT9840551

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.61

Volume 114, pp. 61–65 *October–December 2010*

A new species of *Entoloma* from Western Ghats of India

GUNASEKARAN SENTHILARASU[1], VADIVELU KUMARESAN[2] & SANJAY K SINGH[1]

senthilarasug@rediffmail.com, singhsksingh@rediffmail.com
[1]National Facility for Culture Collection of Fungi
Mycology and Plant Pathology Group, MACS' Agharkar Research Institute
Pune – 411 004, India

vkumaresan36@yahoo.com
[2]Department of Plant Science, Mahatma Gandhi Govt. Arts College
Mahe – 673 311, India

Abstract — A new species, *Entoloma vittalii* (sect. *Cyanula*, subg. *Leptonia*, *Entolomataceae*), collected from paleotropical regions of the Uppangala forest, Western Ghats, Karnataka, is described and illustrated. Macro- and microscopic differences and similarities are compared with closely related taxa.

Key words — *Agaricales*, *Basidiomycota*, fungal taxonomy, macrofungi

Introduction

Species of *Entoloma*, one of the largest genera in the *Agaricales*, are distributed throughout the world. In India, Pegler (1977) revised descriptions of *Entolomataceae* species, and Horak (1980) also treated several entolomatoid taxa. Manimohan et al. (1995, 2002, 2006) contributed the most notable records, describing 39 *Entoloma* species from Kerala state alone. As a result, a total of 69 entolomatoid species have been described from different regions in India (Manjula 1983, Natarajan et al. 2005). During our studies on diversity of macrofungi from Western Ghats of Karnataka, we collected several *Entoloma* species, of which six represented first records for India (Senthilarasu & Natarajan 2003). One species, which differs macro- and microscopically from known allied species, is described below as new to science.

Materials and methods

The collections described here are from paleotropical regions of the Uppangala forest, Western Ghats, Karnataka, India. Sections were prepared by hand, revived

in 10% KOH and examined in 2% phloxine. Approximately 50 basidiospores obtained from spore prints were measured. Mean spore measurements (in parentheses) are followed by spore size range, with extreme values in parentheses. Colour terminologies follow Kornerup & Wanscher (1978). The examined type specimens are deposited at Herbarium of Madras University Botany Laboratory (MUBL).

Entoloma vittalii Senthil., Kumaresan & S.K. Singh, **sp. nov.** PLATE 1

MYCOBANK MB 518331

Pileus 35–45 mm latus, plano-convexus, umbonatus, acutus ad discum rubrobrunneus, ad marginem fuscus, laevis, glaber; margine laevis, erosus, lucido-striatus. Lamellae emarginatae, cremeus, pallescens aurantiacus, confertae, latissimae, cum tribus ordinibus lamellularum intermixtae. Stipes 40–55 × 6–10 mm, cylindricus vel expansus, cavus, ad apicem lilacinus, ad basim lilacinus griseus, laevis, glaber. Caro tenuissima, albida, 3 mm latus. Sporae (8.9 ± 0.6 × 6.1 ± 0.4), (7–)7.5–10(–10.5) × 5.5–7(–7.5) µm, Q = 1.45, heterodiametrico-ellipsoidea, angulatae. Basidia 24–34 × 7.5–9.5 µm, clavata, 4 sporigera. Acies lamellarum fertilis. Cystidia nulla. Trama hymenophoralis regularis, hyalina. Epicutis ex hyphis cylindricus, 1.5–12 µm latus. Hyphae omnes defibulatae.

HOLOTYPE: India, Karnataka State, Western Ghats, Manadukka, Uppangala Forest, 12°30'N 79°30'W, 500 masl, on ground (soil), Senthilarasu G. (MUBL 3496).

ETYMOLOGY: This species is named in honor of Prof. B.P.R. Vittal of the Centre for Advanced Studies in Botany, University of Madras, India.

Pileus 35–45 mm diam., plano-convex, becoming uplifted, acutely umbonate; surface reddish brown (8F8) at the center, paler (8D4) towards margin, smooth, glabrous; margin smooth, eroded, pellucid striate. Lamellae emarginate, cream, becoming pale orange (5A3), crowded, moderately broad with lamellulae of three lengths. Stipe 40–55 × 6–10 mm, cylindric to compressed, hollow; surface violet white (15A2) at the apex, lilac grey (15B2) below, smooth, glabrous, arising from white, rhizomorphs. Context thin, whitish, up to 3 mm thick.

Basidiospores (8.9 ± 0.6 × 6.1 ± 0.4), (7–)7.5–10(–10.5) × 5.5–7(–7.5) µm, Q = 1.45, heterodiametric-elliptic, with well marked angles, with 5–7 occasionally 8 plane to few concave facets visible in profile, with a thickened stramineous wall, containing a single, large refractive guttule. Basidia 24–34 × 7.5–9.5 µm, clavate, bearing four sterigmata, up to 5.5 µm long. Lamella-edge fertile. Cystidia absent. Hymenophoral trama regular, with hyaline, thin-walled hyphae, 1.5–11.5 µm diam. inflated to 17 µm diam. Subhymenial layer poorly developed, up to 6 µm wide, interwoven. Pileal surface a repent epicutis of radially arranged parallel hyphae, 1.5–12 µm diam. Pileal context consisting of tightly interwoven, thin-walled, hyaline hyphae, 1.5–17.5 µm diam., inflated to 37.5 µm diam. All hyphae lacking clamp-connections.

HABITAT - On ground, solitary, scattered in wet evergreen forest.

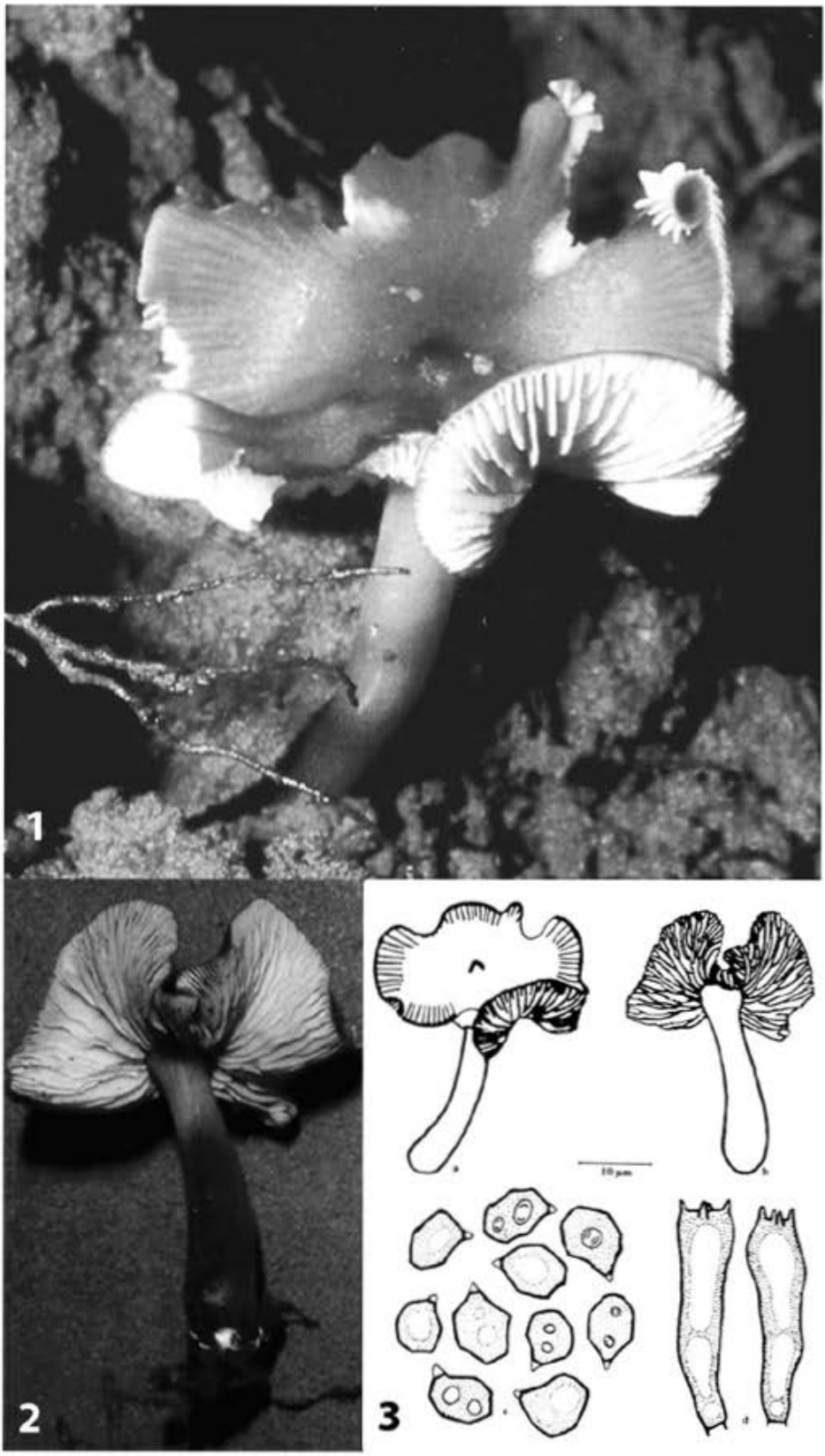


PLATE 1. *Entoloma vittalii*: 1–2—In situ, Uppangala forest (Photo G. Senthilarasu): 1. Habit. 2. Gill view. 3—Line drawings (a–b. ×1; c–d, bar = 10 µm): a. Habit. b. Gill view. c. Basidiospores. d. Basidia.

DISCUSSION—The characteristic features of *Entoloma vittalii* are the plano-convex to uplifted and acutely umbonate, reddish brown, smooth pileus, violet white to lilac grey stipe, heterodiametric-elliptic spores, and absence of cystidia. Species with uplifted, acutely umbonate reddish brown pilei with violet white to lilac grey stipes are uncommon, and very few species have been reported in the literature. *Entoloma vittalii* seems to fit best in subg. *Leptonia*, sect. *Cyanula* (Noordeloos 1992) based on collybioid habit, violaceous stipe, heterodiametric basidiospores, and lack of cheilocystidia and clamp connections. However, the umbonate, glabrous pileus is somewhat out of place for this subgenus and section, which are typically defined by an umbilicate, squamulose pileus surface. It is not clear at this time where *E. vittalii* belongs in the genus as recognized by Noordeloos (1992).

Entoloma vittalii resembles *E. parvum* (Peck) Hesler (Hesler 1967) in similarly sized basidiomes, heterodiametric elliptic spores, and absence of cystidia. However, its conic-convex, bluish black pileus, adnate lamellae, and bluish black stipe clearly differentiate *E. parvum* from *E. vittalii*.

Entoloma vittalii also closely resembles the paleotropic species *E. maderaspatanum* (Pegler) E. Horak (Horak 1980) in having an umbonate, brown, smooth pileus and lacking cheilocystidia and clamp-connections. However, *E. maderaspatanum* clearly differs in its conic-convex, dark brown pileus, long (8 cm vs 4–5.5 cm) white or cream colored stipe, and somewhat larger spores (9–12.5 µm vs 7–10.5 µm).

Acknowledgments

The authors are grateful to Dr. Timothy J. Baroni, Department of Biological Sciences, PO Box 2000, State University of New York – Cortland College, Cortland, NewYork 13045 and Dr. Michael Noordeloos, Netherlands Centre for Biodiversity Naturalis, section NHN, PO. Box 9514, 2300 RA Leiden, The Netherlands for their valuable comments and careful review of this article. SG wishes to express his sincere thanks to Prof. P. Manimohan, Calicut University, Kerala, India and Dr. Shaun Pennycook for providing the literatures on *Entoloma*. Sincere thanks to Dr. Taiana Riviere and Dr. Dennis Depomier of Institut Francais de Pondichery, Pondicherry, India. We would like to thank the Ministry of Environment and Forests (MoEF), Government of India, New Delhi, for providing financial assistance and Department of Science and Technology (DST), Government of India, New Delhi, for providing financial support under the IRPHA Programme for setting up State-of the- art National Facility for Culture Collection of Fungi (No. SP/SO/PS-55/2005) at Agharkar Research Institute, Pune, India.

Literature cited

Hesler LR. 1967. *Entoloma (Rhodophyllus)* in South East North America. Beih. Nova Hedwigia 23: 1–192.

Horak E. 1980. *Entoloma* (*Agaricales*) in Indomalaya and Australasia. Beihefte zur Nova Hedwigia 65: 1–352.

Kornerup A, Wanscher JH. 1978. Methuen Handbook of Colour. 3rd edn. Methuen and Co., Ltd., London. 243 pp.

Manimohan P, Leelavathy KM, Noordeloos ME. 2002. Three new species of *Entoloma* from Kerala State, India. Persoonia 17: 625–630.

Manimohan P, Noordeloos ME, Dhanya AM. 2006. Studies on the genus *Entoloma* (*Basidiomycetes, Agaricales*) in Kerala State, India. Persoonia 19(1): 45–93.

Manimohan P, Vijaya Joseph A, Leelavathy KM. 1995. The genus *Entoloma* in Kerala State, India. Mycological Research 99(9): 1083–1097. doi:10.1016/S0953-7562(09)80777-6

Manjula B. 1983. A revised list of the agaricoid and boletoid basidiomycetes from India and Nepal. Proceedings of Indian Academy of Sciences (Plant Science) 92: 81–213.

Natarajan K, Kumaresan V, Narayanan K. 2005. A checklist of Indian agarics and boletes (1984–2002). Kavaka 33: 61–128.

Noordeloos ME. 1992. *Entoloma* sl. Fungi Europaei, Saronno, Italia.

Pegler DN. 1977. A revision of *Entolomataceae* (*Agaricales*) from India and Sri Lanka. Kew Bulletin 32: 189–220. doi:10.2307/4117266

Senthilarasu G, Natarajan K. 2003. Additions to the genus *Entoloma* from India. Kavaka 31: 153–159.

ISSN (print) 0093-4666 © 2010. Mycotaxon, Ltd. ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.67

Volume 114, pp. 67–70 *October–December 2010*

New records of smut fungi. 2. *Anthracoidea arnellii* sp. nov.

CVETOMIR M. DENCHEV[1*], TEODOR T. DENCHEV[1] & IGOR V. KARATYGIN[2]

cmdenchev@yahoo.co.uk & tdenchev@abv.bg
[1]*Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences*
2 Gagarin St., 1113 Sofia, Bulgaria

ikar34@yandex.ru
[2]*Komarov Botanical Institute, Russian Academy of Sciences*
2 Prof. Popov St., 197376 St Petersburg, Russia

Abstract — A new smut fungus, *Anthracoidea arnellii* on *Carex arnellii*, is described and illustrated from Russia.

Key words — *Anthracoideaceae*, taxonomy, *Ustilaginomycetes*

Introduction

A specimen of *Carex arnellii* from the Altai Mts (West Siberia), Russia was found to be infected by an undescribed species of *Anthracoidea* smut fungus. *Carex arnellii* is a member of the sect. *Silvaticae* Rouy, which includes nine species and subspecies from Europe, Asia, and North Africa. *Carex arnellii* is distributed in the European part of Russia, West and East Siberia, the Russian Far East, northern Mongolia, NE China, and the northern part of the Korean Peninsula (Egorova 1999). The species of *Anthracoidea* are restricted to host plants belonging to the same or closely related sections of *Carex*. No species of *Anthracoidea* has previously been reported on a representative of sect. *Silvaticae*.

Material and methods

Material from the herbarium of Komarov Botanical Institute, Russian Academy of Sciences, St Petersburg (LE) was examined under light microscope (LM) and scanning electron microscope (SEM). For LM observations, the spores were

*Author for correspondence

mounted in lactophenol solution on glass slides, gently heated to boiling point, and then cooled. The measurements of spores are given in the form: min–max (mean ± 1 standard deviation). For SEM, the spores were attached to specimen holders by double-sided adhesive tape and coated with gold with an ion sputter. The surface structure of spores was observed at 10 kV and photographed with a JEOL SM-6390 scanning electron microscope.

Taxonomy

Anthracoidea arnellii Denchev, T. Denchev & Karatygin, **sp. nov.** FIGS 1–4

MycoBank MB 518336

Sori in ovariis in inflorescentia dispersi, sicut corpora subglobosa, late ellipsoidea vel ovoidea, nigra, 2–3 mm longa, in superficie pulverei. Sporae irregulariter polyangulares, interdum protuberationibus, a fronte visus 16.5–26 × 14.5–20.5 (20.4±1.9 × 17.9±1.5) µm, a latere visus 11.5–13.5 µm, rufobrunneae; paries inaequaliter incrassatus, 1–2.5 (–3) µm crassus, plerumque 1–3 (–4) gibberis internis, et raro etiam maculis lucem refringentibus; superficie verruculosa.

Holotype: On *Carex arnellii* Christ: RUSSIA, Altai Republic, the Altai Mts, near Teletskoe Lake, valley of Chiri River, 3 August 1985, leg. I.V. Karatygin (LE 68 682).

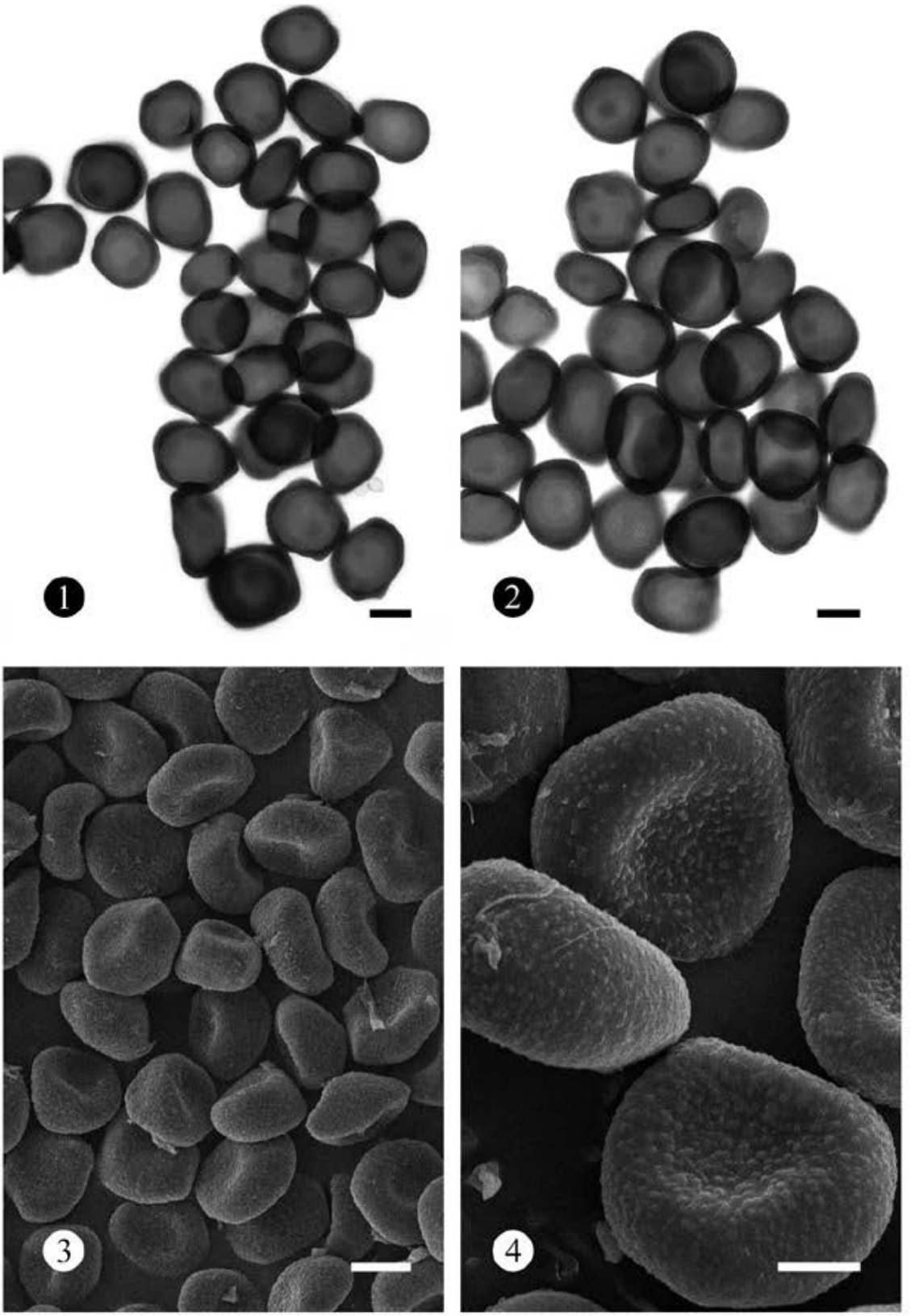
Etymology: the name refers to the host species.

Sori in ovaries, scattered in the inflorescence, as subglobose to broadly ellipsoidal or ovoid, black, hard bodies, 2–3 mm long, when young covered by a thin, silvery membrane; later becoming exposed but partly hidden by the glumes; mature sori powdery on the surface. Spores irregularly polyangular, sometimes with protuberances, in plane view 16.5–26 × 14.5–20.5 (20.4±1.9 × 17.9±1.5) µm (n = 50), in side view 11.5–13.5 µm thick, reddish brown; wall unevenly thickened, 1–2.5 (–3) µm thick, thickest at the angles and protuberances, with 1–3 (–4), distinct internal swellings, rarely with light-refractive areas, verruculose. Germination unknown.

Distribution — On *Cyperaceae: Carex* (subgen. *Carex*, sect. *Silvaticae*), Asia (West Siberia, the Russian Far East).

Comments — On *Carex arnellii*, Kawai & Ôtani (1931: 230) reported *Anthracoidea* sp. (as "*Cintractia caricis*") from Sakhalin (the Russian Far East; collected on 23 July 1930 by E.C. Higashi-Taraika). Unfortunately, there is no information if this specimen is kept in any Japanese herbarium.

Anthracoidea arnellii possesses irregularly polyangular spores with distinct internal swellings like *A. capillaris* Kukkonen but the spores of the latter are smaller. *Anthracoidea capillaris* is known to attack only *Carex capillaris* L. In older taxonomic schemes, *Carex arnellii*, *C. sylvatica* Huds., and *C. capillaris* were included in sect. *Strigosae* Christ (Chater 1980). In recent taxonomic schemes (e.g., in Egorova 1999), the three species are treated as members of two different, non-related sections: *C. arnellii* and *C. sylvatica* in *Silvaticae*,



Figs 1–4. Spores of *Anthracoidea arnellii* on *Carex arnellii* (holotype).
1–2. In LM. 3–4. In SEM. Scale bars: 1–3 = 10 µm, 4 = 5 µm.

and *C. capillaris* in *Chlorostachyae* Meinsh. (synonyms: sect. *Hymenochlaenae* subsect. *Capillares* (Asch. & Graebn.) Kük.; sect. *Capillares* (Asch. & Graebn.) Rouy). For *Carex sylvatica* and *C. capillaris,* Hendrichs et al. (2004) found that they "are neither clustered together nor with any other member of section *Hymenochlaenae*" and that the section *Hymenochlaenae* is heterogeneous. Because of these reasons, we consider *Anthracoidea arnellii,* on a member of sect. *Silvaticae,* as a distinct species.

Acknowledgements

We gratefully acknowledge Dr Kálmán Vánky (Herbarium *Ustilaginales* Vánky, Tübingen, Germany) and Dr Roger G. Shivas (Queensland Primary Industries and Fisheries, Australia) for critically reading the manuscript and serving as pre-submission reviewers.

Literature cited

Chater AO. 1980. *Carex* L. 290–323, in T.G. Tutin et al. (eds), Flora Europaea, Vol. 5, Cambridge University Press, Cambridge.

Egorova TV. 1999. The sedges (*Carex* L.) of Russia and adjacent states (within the limits of the former USSR). St. Petersburg State Chemical-Pharmaceutical Academy, St. Petersburg & Missouri Botanical Garden Press, St. Louis. 773 pp.

Hendrichs M, Oberwinkler F, Begerow D, Bauer R. 2004. *Carex,* subgenus *Carex* (*Cyperaceae*) – a phylogenetic approach using ITS sequences. Plant Systematics and Evolution 246: 89–107. doi:10.1007/s00606-004-0128-0

Kawai K, Ôtani H. 1931. A provisional list of fungi collected in Southern Saghalien. Transactions of the Sapporo Natural History Society 11: 227–242.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.71

Volume 114, pp. 71–84 October–December 2010

Cetraspora helvetica, a new ornamented species in the *Glomeromycetes* from Swiss agricultural fields

FRITZ OEHL[1], JAN JANSA[2], FRANCISCO ADRIANO DE SOUZA[3], & GLADSTONE ALVES DA SILVA[4]

*[,1] *fritz.oehl@art.admin.ch*

[1]*Agroscope Reckenholz-Tänikon Research Station ART, Ecological Farming Systems Reckenholzstrasse 191, CH-8046 Zürich, Switzerland*

[2]*Swiss Federal Institute of Technology (ETH) Zürich, Institute of Plant, Animal and Agroecosystem Sciences, Eschikon 33, CH-8315 Lindau, Switzerland*

[3]*Embrapa Milho e Sorgo, Núcleo de Biologia Aplicada, Rod. MG 424 KM 45, Sete Lagoas, MG, Brazil*

[4]*Departamento de Micologia, CCB, Universidade Federal de Pernambuco, Av. Prof. Nelson Chaves s/n, Cidade Universitaria, 50670-420, Recife, PE, Brazil*

Abstract — A new arbuscular mycorrhizal fungus, *Cetraspora helvetica*, was found in three Swiss agricultural soils: a no-till crop production system and two temporary grasslands. It forms white spores, 210–270 µm diam, on dark yellow sporogenous cells. The spores have three walls: a triple-layered outer, a bi-layered middle and a triple-layered inner wall. The spore surface is crowded with convex warts, 5–12 µm diam at the base and 1.5–5.0 µm high. The germination shield is hyaline with multiple (6–10) lobes. Glomerospores of two other *Gigasporineae* spp. have also three walls, multiple-lobed hyaline germination shields, and projections on the outer spore surface: *C. spinosissima* and *C. striata*. However, spores of these fungi are substantially pigmented (ochraceous yellow to rust) and crowded with short, thin spines or fingerprint-like processes, respectively. Partial sequences of the 28S ribosomal gene place the new species adjacent to *C. spinosissima*, *C. pellucida*, and *C. gilmorei*. Phylogenetic analyses demonstrate the monophyly of the two genera *Racocetra* and *Cetraspora* within the *Racocetraceae*.

Key words — *Gigasporaceae*, *Glomeromycota*, *Scutellospora*, conservation tillage

Introduction

Several species of the *Gigasporineae* sensu Morton & Benny (1990) have been recently described (e.g. Silva et al. 2008, Goto et al. 2009, 2010; Tchabi et al. 2009). However, most of the so far nearly 50 species described in this old sub-order have been known only for the warmer climates, and indeed species

richness of the *Gigasporineae* appears to be much lower in colder climates, especially in Europe north of the Alps (e.g. Jansa et al. 2002, Oehl et al. 2009b, 2010). In Northern and Central Europe, so far only ten species of this group has been found: *Gigaspora margarita* W.N. Becker & I.R. Hall 1976, *G. gigantea* (T.H. Nicolson & Gerd.) Gerd. & Trappe 1974, *Scutellospora calospora* (T.H. Nicolson & Gerd.) C. Walker & F.E. Sanders 1986, *S. dipurpurescens* J.B. Morton & Koske 1988, *S. arenicola* Koske & Halvorson 1990, *S. nodosa* Błaszk. 1991, *Racocetra castanea* (C. Walker) Oehl et al. 2009, *R. persica* (Koske & C. Walker) Oehl et al. 2009, *Cetraspora pellucida* (T.H. Nicolson & N.C. Schenck) Oehl et al. 2009, and *C. armeniaca* (Błaszk.) Oehl et al. 2009 (e.g. Błaszkowski 1991, Błaszkowski & Tadych 1997, Tadych & Błaszkowski 2000, Vestberg et al. 1995, Merryweather & Fitter 1998, Jansa et al. 2002, 2003, Oehl et al. 2005, 2010). Our morphological and molecular analyses revealed that one isolate, registered at the International Bank for *Glomeromycota* (BEG) and identified as *Scutellospora pellucida* (= *C. pellucida*) is not *C. pellucida* but a closely related, undescribed species whose spores have conspicuous warty ornamentation on the outer surface. The fungus, collected from three agricultural soils in Switzerland, is here described under the epithet *Cetraspora helvetica*.

Material and methods

Study area and sites

Between 1998 and 2009, AMF species richness was determined in > 100 Swiss agricultural soils distributed all over the country and including permanent grassland, conservation and no-tillage, biological and conventional agroecosystems (e.g. Jansa et al. 2002, Oehl et al. 2003, 2004, 2010, Oehl unpublished). The AMF communities of these sites were propagated in bait cultures for 8–32 months, in most of the cases for 18–24 months. At only three sites, the AM fungus, which is hereafter described, was detected. The sites are a long-term tillage experiment at Agroscope ART in Tänikon (Kanton Thurgau, 47°29'10.0"N, 8°55'10.1"E, at 540 m a.s.l.), a temporary grassland in the community Langnau im Emmental (Kanton Bern, 46°56'35.0"N, 7°45'46.8"E, at 656 m a.s.l.), and a temporary grassland in the community Grasswil (Kanton Bern, 47°08'34.0"N, 7°39'58.2"E, at 525 m a.s.l.). The locations have a temperate climate (typical for Central Europe), with mean annual temperatures of 8.5, 8.0, and 9.2 °C and mean annual rainfall of about 1200, 1450, and 1100 mm, respectively.

Soil sampling and soil parameters

In Tänikon, soils were sampled in January 1999 as described in Jansa et al. (2002). The soil samples in Langnau were sampled accordingly in April 2009. The soil type in Tänikon and Grasswil is a Haplic Luvisol developed on Moräne, while the soil type in Langnau was a Fluvic Cambisol developed on alluvial sediments. The pH (H_2O) of the topsoil was 6.0 at all three sites. The organic carbon content was 19.1, 21.1 and 12.2 mg C g^{-1} soil at Tänikon, Langnau and Grasswil, respectively. Total N and available P (according to Dirks & Scheffer 1930) were 2.3, 2.5 and 3.0 mg N g^{-1} soil and 2.3, 2.2, and 7.4 mg P kg^{-1} soil, respectively.

AMF bait and pure cultures

The AMF bait cultures for the soil from Tänikon were established at ETH Zurich in Eschikon-Lindau (Kanton Zurich) as described in Jansa et al. (2002) using *Zea mays* L., *Allium porrum* L., *Plantago lanceolata* L., *Helianthus annuus* L. and *Glycine max* (L.) Merr. as bait plants. The bait cultures for the soils from Langnau and Grasswil were established at Agroscope ART in Zürich-Reckenholz on *P. lanceolata*, *Lolium perenne* L., *Trifolium pratense* L., and *Hieracium pilosella* L. as host plants, as described for *Acaulospora alpina* (Oehl et al. 2006) but with the pots substantially larger than in the former work (volume 3.5 L instead of 1.0 L).

Pure cultures of the new fungus were established by inoculating leek plants with 15 spores obtained from the Tänikon soil bait cultures. The cultures have been maintained for several cycles of 15-24 months at ETH (alternating *A. porrum* and *Tagetes erecta* L. as host plants, and on *Medicago truncatula* L.). The isolate was also deposited in the European Bank of *Glomeromycota* under the accession number BEG153 and is maintained in the Swiss Collection of Arbuscular Mycorrhizal Fungi (SAF) at Agroscope ART in Zürich-Reckenholz under the accession number SAF15.

Morphological analyses

Glomerospores were extracted from field soils by wet sieving (Gerdemann & Nicolson 1963) and sucrose centrifugation (Jenkins 1964). The spores were thereafter mounted in polyvinyl-alcohol-lacto-glycerin (PVLG), PVLG + Melzer's reagent, and water (Brundrett et al. 1994, Spain 1990). About 100 spores of the fungus were examined. For the species description, terminology follows that used for the *Diversisporales* by Oehl et al. (2006), Sieverding & Oehl (2006), and Palenzuela et al. (2008, 2010), for germ shield structures by Walker & Sanders (1986), Oehl et al. (2009a), and Goto et al. (2010), and for spore denomination by Goto & Maia (2006).

Spore wall composition was compared with that observed in spores in type specimens of *Cetraspora armeniaca* [ex type: Błaszkowski collection], *C. gilmorei* (Trappe & Gerd.) Oehl et al. 2009 [Holotype OSC 30'990; paratype OSC 31'018; paratype OSC 30'921, *C. pellucida* [Holotype OSC 37'515], *C. spinosissima* (C. Walker & Cuenca) Oehl et al. 2009 [Ex type: (Gisela Cuenca collection, Oehl collection], and *C. striata* (Cuenca & R.A. Herrera) Oehl et al. 2009 [Ex type: Gisela Cuenca collection, slides 1642-7 & 1641-3].

Molecular analyses

The DNA from single spores was extracted according to Sanders et al. (1995). Single spores were crushed in 10 µl of PCR-grade water by freshly flamed Pasteur pipette. After 5 µl of Chelex-100 (20%, Bio-Rad Laboratories, Hercules, California, USA) were added, samples were placed onto a 95°C hot plate for 3 minutes and then incubated on ice at 0°C for 5 minutes. Five µl of the liquid phase were taken as template for PCR amplification of the large ribosomal subunit gene, 28S.

Spore DNA samples underwent a nested PCR procedure, first using eukaryotic-specific primers ITS3 and NDL22 (White et al. 1990), followed by fungal-specific primers LR1 and FLR2 (van Tuinen et al. 1998; Turnau et al. 2001). There were 30 cycles with each primer pair. The product of the first PCR was cloned or further diluted 1000 times, and 5 µL of the diluted mixture was used as a template for the second PCR reaction. PCR conditions followed van Tuinen et al. (1998), the annealing temperature

being 60°C in both PCR steps. The PCR products were then purified using QIAquick PCR Purification Kit (Qiagen Sciences), cloned into a blue script vector (pGEM-T Easy, Promega-Catalys AG, Wallisellen, Switzerland), and transformed into bacterial strain *E. coli* JM109 by the heat-shock method. The size of the insert in growing bacterial colonies was checked after PCR amplification using M13f and M13r primers that were targeted to the cloning site of the vector. Plasmid DNA was isolated from transformed bacteria following standard miniprep procedure (Sambrook et al. 1989), and used as a template for cycle sequencing using BigDye Terminator (Applied Biosystems, Faster City, California, USA). Sequencing analysis was performed on ABI-310 Capillary Sequencer (PerkinElmer, Wellesley Massachusetts, USA). Four sequences were obtained and deposited at GenBank (National Center for Biotechnology Information, Bethesda, Maryland, USA) under the accession numbers AF396784 and HM565944–HM565946.

The sequences of the new species were aligned with other glomeromycotean sequences from the GenBank using ClustalX (Larkin et al. 2007) and edited by BioEdit (Hall 1999) to obtain a final alignment.

For phylogenetic analyses and tree construction, maximum parsimony (MP) and neighbor joining (NJ) analyses with 1000 bootstrap replications for each, were performed using the Phylogenetic Analysis Using Parsimony program version 4 (Swofford 2003). The NJ analysis was performed using parameters obtained from ModelTest 3.7 (Posada & Crandall 1998). Sequences from *Pacispora scintillans* were used as outgroup.

Taxonomy

Cetraspora helvetica Oehl, Jansa, F.A. Souza, G.A. Silva, **sp. nov.** FIGS. 1–19

MYCOBANK MB 518578

Sporocarpia ignota. Sporae singulatim in solo efformatae anguste adiacetae ad cellulas sporogeneas subterminales vel intercalares flavasque, albae, globosae (210–270 µm in diametro) vel subglobosae vel ovales (205–265 × 210–280 µm); sporae tunicis tribus: tunica exterior stratis tribus, in totum 8.4–15.0 µm crassa; stratum exterius tunicae exterioris hyalinum, semi-persistens, 0.9–1.6 µm crassum, cum verrucis exiguis 1.5–5.0 altis et 5–12 µm latis; stratum medium laminatum, album, 8.4–15.0 µm crassum; stratum interius tunicae exterioris album, 1.0–1.6 µm crassum; tunica media stratis duobus hyalinibus, 1.5–2.5 µm crassa in totum; tunica interior stratis tribus hyalinibus, 2.5–5.9 µm crassa in totum; stratum secundum et stratum interius tunicae exterioris et stratum secundum tunicae interioris purpureum vel oscuro-purpureum colorantes reagente Melzeri; scutellum germinale in superficie exteriore tunicae interioris, hyalinum ad subhyalinum ad albo-flavum; subglobosum vel ovale vel ellipsoidum, 120–150 × 120–200 in diameter, lobatum, paucioribus 6–10 lobis; structurae mycorrhizarum arbuscularum colorantes caeruleae Trypan blue; cellulae auxiliares formans.

TYPE: SWITZERLAND: Kanton Thurgau, Tänikon, Agroscope Reckenholz-Tänikon Research Station (ART), from agricultural soil under no-till wheat–maize–canola production, 1999 by J. Jansa". (**Holotype:** 88-8801 (Z+ZT Myc 3037); pure cultures—ETZ Zürich (Eschikon) and Swiss Collection of Arbuscular Mycorrhizal Fungi (SAF; Zürich Reckenholz). **Isotypes:** 88-8802, 88-8803, 88-8804, 88-8805, 88-8806 (Z+ZT Myc 3038); 88-8807, 88-8808 (OSC 136'595); 88-8809, 88-8810 (URM).

ETYMOLOGY: *helvetica* (Latin) = Swiss, referring to the country where the fungus was detected first.

GLOMEROSPORES formed singly in soil, terminally on subterminal or sometimes intercalary bulbous suspensor cell (= 'sporogenous' cell; FIGS. 1–6). Glomerospores are brilliant white when young, and may slightly darken to creamy-white when ageing in soils, trap culture substrates or after several months in lactic acid based mountants (FIGS. 1–3). The spores are globose (210–270 µm in diameter) to subglobose (205–265 × 210–280 µm), become dark purple to black purple when exposed to Melzer's reagent (FIG. 5), and have three walls: an outer, a middle, and an inner wall (FIG. 7).

OUTER WALL is 8.4–15.0 µm thick in total and consists of three layers (FIGS. 7–8): outermost wall layer (OWL1) is hyaline, semi-persistent and 1.1–1.6 µm thick crowded with convex warts that are 5-12 µm in diameter at their base and 1.5–5.0 µm high (FIGS. 8–9). OWL2 is brilliant white, and may become creamy-white with age. It is laminate, persistent and 5.0–12.0 µm thick. Third layer (OWL3) is also white, semi-flexible (1.0–1.6 µm thick). OWL2 and OWL3 stain dark purple to black purple in Melzer's reagent, while OWL1 generally does not stain (FIG. 8). The straight pore channel at the spore base (about 2.5–3.9 µm broad) is often closed by a plug formed by spore wall material of OWL2, and by OWL3, but also can appear open.

MIDDLE WALL (MW) is 1.8–2.7 µm thick in total and consists of two hyaline layers: a flexible outer layer MWL1 and a semi-flexible layer MWL2 (FIGS. 7, 10). MWL1 is 0.7–1.2 µm thick and generally does not separate from underlying MWL2 but often shows several folds in crushed spores (FIG. 10). MWL2 is 1.1–2.0 µm thick, and generally more rigid than MWL1.

INNER WALL (IW) is triple-layered (FIGS. 7), 2.5–4.5(–5.9) µm thick, bearing a germ shield on the outer surface (FIG. 4, 11). The outer IW layer (IWL1) is hyaline, semi-flexible and 0.6–0.8 µm thick. The second layer (IWL2) is semi-flexible, unite to finely laminate, amorphous when slightly expanding in PVLG based mounting, and is 2.0–2.7(–3.9) µm thick. The innermost layer (IWL3) is relatively thin (0.6–1.2 µm thick), flexible, mostly tightly adherent to IWL2, and therefore generally difficult to observe. IWL2 stains purple to dark purple to black purple in Melzer's reagent (FIG. 11).

SPOROGENOUS CELL (SC) is globose to elongate, 34–70 µm long and 30–48 µm broad (FIGS. 1–4, 6) and generally dark yellow. Two wall layers are visible on the young sporogenous cell, which are continuous with OWL1 and with laminated OWL2. OWL1 is 0.4–1.0 µm thick and semi-persistent, and OWL2 is 1.5–2.8 µm thick and persistent as long as SC remains attached on the spore. One to (rarely) two 'hyphal pegs' are often formed on the sporogenous cells, and are 4–10 µm thick at the sporogenous cell base tapering to 3.0–4.5 µm within its 12–30 µm length. Sometimes one peg continues as mycelial hypha or as a sporogenous hypha that may bear another SC in 400–800 µm distances from the first SC.

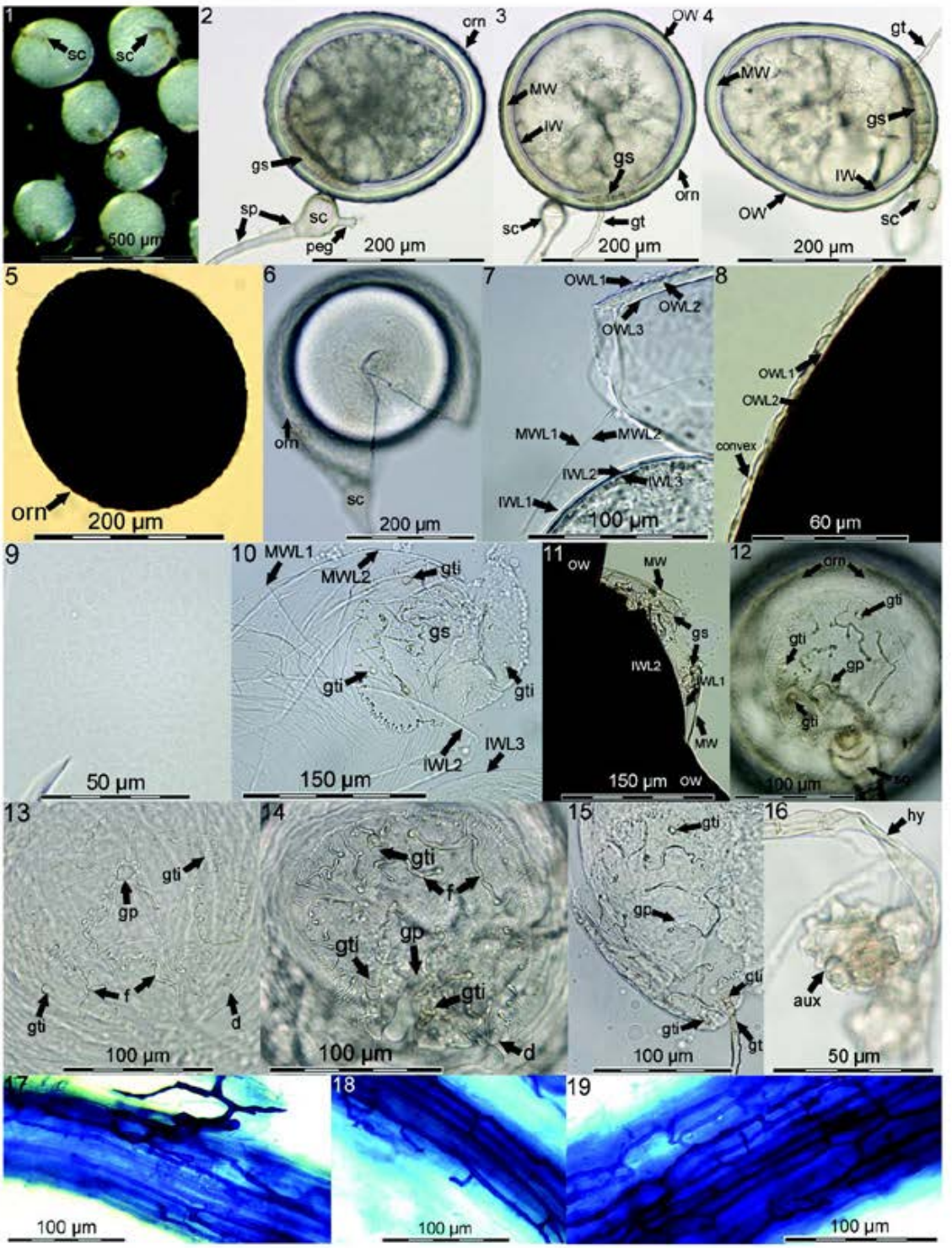
Then, the formation of the sc can be called intercalary instead of sub-terminal. The sporogenous hypha attached to the cell is also bi-layered, 12–25 µm thick and tapering to 5–7 µm within 100–450 µm distances from the sporogenous cell. Within these distances, the sporogenous hyphal wall tapers from 1.5–2.5 µm to 1.1–1.6 µm, and 2–9 septa originating from OWL2 may be visible in the sporogenous hypha (FIG. 2).

GERMINATION SHIELD is hyaline to subhyaline (FIGS. 6, 10–15), infrequently light yellow in aged spores, subglobose to oval to rarely ellipsoid, 120–125 × 135–180 µm in diameter, and generally has 6–10 lobes (FIGS. 10, 12–15). Large folds (~7–30 µm long) arise from the shield wall separating the lobes (FIGS. 10, 12–15). The one-layered shield wall and the folds are hyaline to subhyaline and generally only 0.9–1.8 µm thick. The shield periphery regularly appears slightly dentate until the germination has started. Each lobe may bear one rounded germ tube initiation (gti, FIGS. 10, 12–15), 2.5–4.5 µm in diameter. The majority of the gti's may remain undetected in young spores or in crushed mature spores due to the pressure applied on the cover slide, especially when the shields are completely separated from the spores by applying harsh pressure (FIG. 10). Single germination tubes may simultaneously emerge from 1 to 3 gti's during early germination (FIGS. 3–4, 15). They penetrate the OW (FIGS. 3–4) and branch in the spore periphery within a short distance.

SPORE DEVELOPMENT — The key stages of spore development observed in the pure and bait cultures are the same as known for other species in the *Racocetraceae*: First the outer spore wall differentiated into one semi-persistent outer layer (OWL1), the laminate, structural layer (OWL2) which differentiates the characteristic convex projections, and the adherent inner layer (OWL3). The MW and IW developed de novo with no visible connection with the outer wall. Finally, the germination shield differentiated its multiple-lobed structure, beginning from the initial germ hole (= germ pore) and forming a gti at the end

---

FIGS. 1–19. *Cetraspora helvetica*. FIG. 1. White spores with pigmented sporogenous cells (sc) in a Petri dish. FIGS. 2–4. Spores have three walls: an outer, middle and inner wall (OW, MW, IW). On sc, short hyphal pegs (peg) may be differentiated, and one to several septa (sp) may be visible in the sporogenous hypha. Germination shields (gs) are formed on the outer IW surface, and sometimes germ tubes (gt) are visible in germinating spores. The convex warty projections (orn) are not obvious under low magnification in PVLG mountants. FIG. 5. Spores stain dark purple to purple black in Melzer's reagent. Here, the convex projections are conspicuous. FIG. 6. Crushed spore with focus on the ornamentation in planar view. FIG. 7. Triple-layered OW (OWL1-3), bi-layered MW (MWL1-2) and triple-layered IW (IWL1-3). FIG. 8. Laminate OWL2 stains dark purple to black purple in Melzer's reagent, while OWL1 with the convex projections (here in cross view) does not stain. FIG. 9. Ornamentation in planar view. FIG. 10. MW with thin MWL1 that slightly wrinkle, and thus, shows several folds; three germ tube initiations (gti) are in focus on the slightly crushed germ shield. FIG. 11. Crushed spore in Melzer's with gs between MW and IW; MW does not stain, while OW



and IWL2 stain dark purple to black purple. FIGS. 12–15. Germ shields (gs) in (semi-)planar view; shields have a initial germ pore (gp; = germ hole) and several lobes that are generally separated by large folds (f); the lobes may regularly bear one germ tube initiation (gti) each but the gti's often become invisible following pressure needed to present the gs in planar view or to separate the gs from overlaying OW and MW; shield periphery is slightly dentate (d) in mature spores. FIG. 16. Light yellow to yellow, knobby auxiliary cells (aux) formed on light yellow to yellow mycelial hyphae. FIGS. 17–19. Mycorrhizal structures (here roots of *Medicago truncatula*, 12 weeks after inoculation) lack intraradical vesicles.

of the shield development usually in each of the lobes; from 1–3 of these gti, the germination tubes emerge during initial germination.

GERMINATION — One to two germ tubes may arise. They are light yellow to bright yellow, 5–7 µm in diameter and emerge from one or two gti's (FIGS. 3–4, 15). Germ tubes directly penetrate the ow and branch then almost immediately in the soil environment. The mono- to bi-layered germ tube walls are ~1.2–2.0 µm thick in close spore vicinity.

AUXILIARY CELLS are formed singly or in small aggregates (2–4 cells) on light yellow to yellow mycelial hyphae (FIG. 16). They are yellow, knobby and 20–25 µm in diameter.

ARBUSCULAR MYCORRHIZA FORMATION is without formation of vesicles (FIGS. 17–19).

ADDITIONAL COLLECTIONS: **SWITZERLAND: Kanton Bern**, Langnau im Emmental, temporary grassland in April, 2009, specimens from 8 trap cultures (in July 2009; Z+ZT Myc 3040a–h); Grasswil, temporary grassland in April, 2009, specimens from 2 trap cultures (in July 2010; Z+ZT Myc 3202a–b).

DISTRIBUTION —*Cetraspora helvetica* has thus far been detected only at the cited locations in the Kantons Thurgau and Bern, Switzerland.

MOLECULAR ANALYSES — Four partial sequences of the large (LSU, 28S) subunit (~700 bp) of the ribosomal gene were obtained. Phylogenetic analyses firmly placed the newly described fungus into the genus *Cetraspora* adjacent to *C. spinosissima*, *C. pellucida* and *C. gilmorei* (FIG. 20). The analyses also demonstrate the monophyly of the two genera *Racocetra* and *Cetraspora* of the family *Racocetraceae* recently described (FIG. 20).

Discussion

The three-walled glomerospores and the multiply lobed, hyaline germination shield place the newly described species in the genus *Cetraspora* in the *Racocetraceae* (Oehl et al. 2009a) of the *Diversisporales* (Schüßler et al. 2001). The molecular analyses using the 28S ribosomal gene confirmed the morphological findings: *Cetraspora helvetica* clustered in the phylogenetic tree next to *C. spinosissima*, *C. pellucida*, and *C. gilmorei*. *Cetraspora helvetica* is readily distinguished from all other known species in the *Racocetraceae* by spore color, staining features in Melzer's reagent, and the spore wall characteristics, including the characteristic convex warts on the outer spore surface.

There are only five species known within *Cetraspora* sensu Oehl et al. (2009a), i.e. species of *Scutellospora* group C sensu de Souza et al. (2005) with three spore walls and multiple-lobed germination shields. These species are: *C. armeniaca*, *C. gilmorei*, *C. pellucida*, *C. spinosissima*, and *C. striata* (Oehl et al. 2009a). However, these species have either smooth spore surfaces

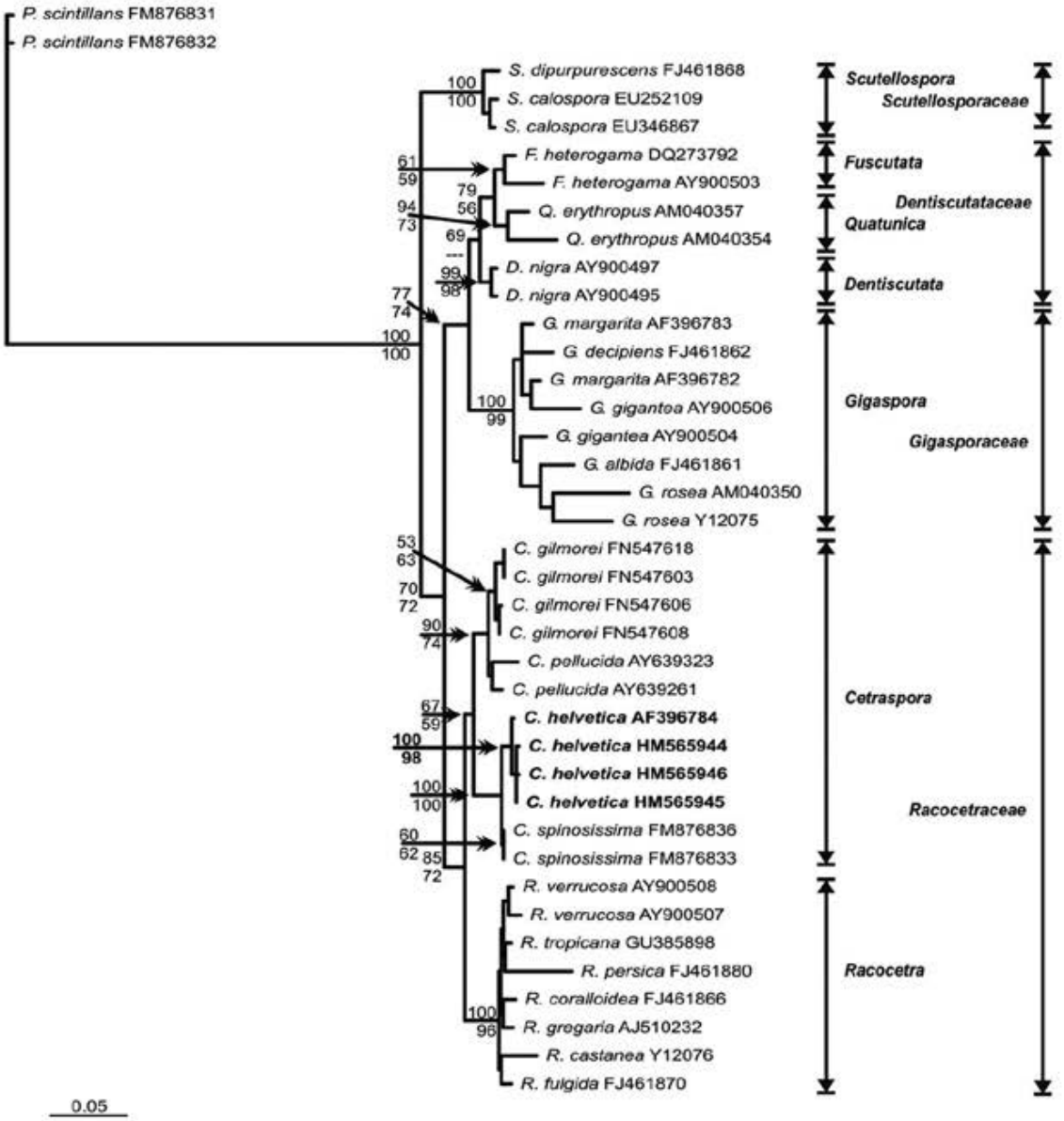


FIG. 20. Phylogenetic reconstruction of the *Gigasporineae* sensu Morton and Benny (1990) obtained from partial LSU rDNA sequences (~700 bp). The neighbor-joining (NJ) analysis was performed with GTR substitution model using the following ModelTest parameters: rate matrix (a = 0.9199, b = 10.3397, c = 2.6872, d = 0.6133, e = 21.1774); number of substitutions types = 6; nucleotide frequencies (A = 0.32210, C = 0.13470, G = 0.23930, T = 0.30390); rates = gamma; shape=0.6497 and proportion of invariable sites = 0. The four new sequences obtained are indicated in bold. Sequences are labeled with their database accession numbers. Bootstrap values (in %) are from neighbor-joining (NJ) and maximum parsimony (MP) analyses (1000 bootstraps), respectively. Only topologies with bootstrap values of at least 50% are shown. The lines to the right show the current genera and families of the *Gigasporineae*. (Consistency Index = 0.6077; Retention Index = 0.7799).

(*C. armeniaca*, *C. gilmorei*, *C. pellucida*; Błaszkowski 1993, Gerdemann & Trappe 1974, Nicolson & Schenck 1979, Koske & Walker 1986) and/or do not form white spores (*C. armeniaca*, *C. spinosissima* and *C. striata*; Błaszkowski 1993, Walker et al. 1998, Cuenca et al. 2008). Moreover, the ornamentations of *C. spinosissima* and *C. striata* consist of spines and fingerprint-like procedures, respectively, and not of convex warts (Walker et al. 1998, Cuenca et al. 2008).

Besides *C. helvetica*, there is only one other fungus in the *Racocetraceae* forming hyaline or white spores with a warty surface ornamentation. This is *Racocetra beninensis* Oehl et al. 2009 (Tchabi et al. 2009). However, *R. beninensis* has only two spore walls and its projections are smaller and more irregular than those of *C. helvetica*. Moreover, its inner spore wall does not stain in Melzer's reagent, while the outer wall stains bright yellow to dark yellow but not purple to dark purple as in *C. helvetica*.

Only *Scutellospora nodosa* (Błaszkowski 1991), which phylogenetically belongs to *Scutellospora* group A sensu de Souza et al. (2005) and to the monogeneric family *Scutellosporaceae* sensu Oehl et al. (2009a), has a similar warty ornamentation as *C. helvetica*. However, differences in sporogenous cell color, germination shield size and structure, inner wall structure, and the staining behavior in Melzer's clearly differentiate *C. helvetica* and *S. nodosa*. *Scutellospora nodosa* has sc's that are concolorous with the spore, a simpler and substantially smaller germ shield, and an outer wall that stains brownish-red instead of dark to black purple. Additionally, of the inner wall only IWL3 stains purple in *S. nodosa*, while in *C. helvetica* it is IWL2. The IWL2 stains purple in all known *Cetraspora* spp.

It is remarkable that species of *Racocetraceae* and *Dentiscutataceae* generally have pigmented sporogenous cells (sc) even when the spore color is hyaline or white to light creamy. This is known for *R. beninensis* and *R. fulgida*, *C. pellucida*, *C. gilmorei*, and *C. helvetica*, and for *Dentiscutata cerradensis*, *D. scutata*, and *Fuscutata savannicola*, which all form light colored, hyaline to subhyaline or white spores. In *C. helvetica*, the germ tube, the mycelial hyphae, and the auxiliary cells are also concolorous with the sc, i.e. bright yellow to dark yellow. It will be interesting to determine later whether this feature is common for all (or a majority) of the *Racocetraceae* and *Dentiscutataceae* spp. Our observation is even more remarkable when considering that *Racocetraceae* spp. form hyaline to subhyaline germ shields while *Dentiscutataceae* spp. have yellow-brown to brown shields. However, the database for the mycelial hyphae and auxiliary cell morphologies is, to our knowledge, still incomplete and in need of improvement.

Notably, our study is the first to report that sporogenous cells can form not only sub-terminally, but also intercalarly. It will be interestingly to follow up in the future if this feature is unique within the *Glomeromycota*.

Our phylogenetic analyses demonstrate the monophyly of the genera *Racocetra* and *Cetraspora* in the *Racocetraceae* and fully support the analyses and classification of Oehl et al. (2009a), which have been recently criticized by Morton & Msiska (2010), who did not find major congruency between spore morphology and molecular phylogeny in this species group. In our opinion, those authors included some characters in their morphological-phylogenetic analyses that weakened their analyses. The authors also found a much higher intraspecific variability of the shields than Oehl et al. (2009a) and Oehl and co-workers who investigated the intraspecific variability of mature shields for a series of *Scutellosporaceae*, *Racocetraceae* and *Dentiscutataceae* spp (e.g. Silva et al. 2008, Tchabi et al. 2009, Goto et al. 2010, 2011, Oehl unpublished results). This discrepancy is due partly to the fact that in their attempt to include ontogeny in their analyses, Morton & Msiska considered also young, immature shields, which was not particularly helpful. Moreover, we believe that their isolates did not always derive from completely pure cultures but from oligospecies cultures — especially evident for *C. pellucida* where *Fuscutata savannicola*, *Dentiscutata scutata*, or similar species most probably co-existed in the cultures, which would invalidate the analyses and the conclusions drawn from those isolates. After investigating many specimens from several locations worldwide, we have never found brown shields in *C. pellucida*, nor have we found brown shields in the other five known *Cetraspora* spp. (e.g. Oehl et al. 2009a).

Cetraspora helvetica has been found thus far only in Switzerland. However, it was found in two different soil preservational agro-ecosystems —a no-till crop rotation system and two temporary grasslands that are rarely ploughed and characterized by long-interval (5–7 year) crop rotations dominated by 3–4 years of continued grass-clover production. It will be interesting to elucidate the biogeographical distribution of our new species in Switzerland and in the surrounding countries in more detail. This would be especially interesting in that the sporulation of *C. helvetica* appears to differ from that of *C. pellucida* and other sporogenous cell-forming arbuscular mycorrhizal fungi such as *S. calospora* and *G. margarita* that most commonly sporulate in late fall (e.g. Oehl et al. 2004, 2009b); in contrast, under more or less ambient light and temperature conditions, *C. helvetica* has formed spores only in early summer during our experiments (Oehl, unpublished).

Acknowledgements

We thank our collaborators at Agroscope ART in Tänikon (especially Thomas Anken) and at the Kanton Bern Bodenschutzfachstelle (especially Claudia Maurer, Andre Chervet & Wolfgang Sturny) for the good collaboration and support at the sampling sites. The technical help of Richard Ruh (ETH Zurich) and Caroline Scherrer and Urs Zihlmann (both at Agroscope ART) is acknowledged. We are grateful to Javier

Palenzuela (CSIC, Estación Experimental del Zaidín, Granada, Spain) and Bruno Tomio Goto (Universidade Federal do Rio Grande do Norte, Natal, Brazil) for the valuable comments on the manuscript. This study was funded by the Swiss National Science Foundation (SNSF, Project 315230_130764/1).

Literature cited

Błaszkowski J. 1991. Polish *Glomales*. 8. *Scutellispora [sic] nodosa* – a new species with knobby spores. Mycologia 83: 537–542.

Błaszkowski J. 1993 ['1992']. *Scutellospora armeniaca*, a new species in *Glomales* (*Zygomycetes*) from Poland. Mycologia 84: 939–944.

Błaszkowski J, Tadych M. 1997. *Scutellospora persica* (*Glomales, Zygomycetes*), an arbuscular mycorrhizal fungus new to the mycota of Poland. Mycotaxon 65: 379–390.

Brundrett M, Melville L, Peterson L. 1994. Practical Methods in Mycorrhizal Research. University of Guelph, Mycologue Publications, Guelph, Ontario.

Cuenca G, Herrera-Peraza R. 2008. *Scutellospora striata* sp. nov., a newly described glomeromycotan fungus from La Gran Sabana, Venezuela. Mycotaxon 105: 79–87.

De Souza FA, Declerck S, Smit E, Kowalchuk GA. 2005. Morphological, ontogenetic and molecular characterization of *Scutellospora reticulata* (*Glomeromycota*). Mycol. Res. 109: 697–706. doi:10.1017/S0953756205002546

Dirks B, Scheffer F. 1930. Der Kohlensäuure-Bikarbonatauszug und der Wasserauszug als Grundlage zur Ermittlung der Phosphorsäurebedürftigkeit der Böden. Landwirtschaftliche Jahrbücher 71: 73–99.

Gerdemann JW, Nicolson TH. 1963. Spores of mycorrhizal *Endogone* species extracted from soil by wet sieving and decanting. Trans. Br. Mycol. Soc. 46: 235–244.

Gerdemann JW, Trappe JM. 1974. The *Endogonaceae* in the Pacific Northwest. Mycologia Memoir No. 5. 76 pp.

Goto BT, Maia LC. 2006. Glomerospores, a new denomination for the spores of *Glomeromycota*, a group molecularly distinct from *Zygomycota*. Mycotaxon 96: 129–132.

Goto BT, Maia LC, Silva GA, Oehl F. 2009. *Racocetra intraornata*, a new species in the *Glomeromycetes* with a unique spore wall structure. Mycotaxon 109: 483–491.

Goto BT, Silva GA, Maia LC, Oehl F. 2010. *Dentiscutata colliculosa*, a new species in the *Glomeromycetes* from Northeastern Brazil with colliculate spore ornamentation. Nova Hedwigia 90: 383–393. doi:10.1127/0029-5035/2010/0090-0383

Goto BT, Silva GA, Maia LC, Souza RG, Coyne D, Tchabi A, Lawouin L, Hountondji F, Oehl F. 2011. *Racocetra tropicana*, a new species in the *Glomeromycetes* from tropical areas. Nova Hedwigia 92: 69–82. doi: 10.1127/0029-5035/2011/0092-0069

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucl. Acids Symp. Ser. 41: 95–98.

Jansa J, Mozafar A, Anken T, Ruh R, Sanders IR, Frossard E. 2002. Diversity and structure of AMF communities as affected by tillage in a temperate soil. Mycorrhiza 12: 225–234. doi:10.1007/s00572-002-0163-z

Jansa J, Mozafar A, Kuhn G, Anken T, Ruh R, Sanders IR, Frossard E. 2003. Soil tillage affects the community structures of mycorrhizal fungi in maize roots. Ecol. Applications 13: 1164–1176.

Jenkins WR. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Rep. 48: 692.

Koske RE, Walker C. 1986. Species of *Scutellospora* (*Endogonaceae*) with smooth-walled spores from maritime sand dunes: Two new species and a redescription of the spores of *Scutellospora pellucida* and *Scutellospora calospora*. Mycotaxon 27: 219–235.

Larkin MA, Blackshields G, Brown NP, Chenna R, McGettigan PA, McWilliam H, Valentin F, Wallace IM, Wilm A, Lopez R, Thompson JD, Gibson TJ, Higgins DG. 2007. Clustal W and Clustal X version 2.0. Bioinformatics 23: 2947–2948.

Merryweather J, Fitter AH. 1998. The arbuscular mycorrhizal fungi of *Hyacinthoides non-scripta* I. Diversity of fungal taxa. New Phytol. 138: 117–129.

Morton JB, Benny GL. 1990. Revised classification of arbuscular mycorrhizal fungi (*Zygomycetes*): A new order, *Glomales*, two new suborders, *Glomineae* and *Gigasporineae*, and two new families, *Acaulosporaceae* and *Gigasporaceae*, with an emendation of *Glomaceae*. Mycotaxon 37: 471–491.

Morton JB, Msiska Z. 2010. Phylogenies from genetic and morphological characters do not support a revision of *Gigasporaceae* (*Glomeromycota*) into four families and five genera. Mycorrhiza 20: 483–496. doi:10.1007/s00572-010-0303-9

Nicolson TH, Schenck NC. 1979. Endogonaceous mycorrhizal endophytes from Florida. Mycologia 71: 178–198.

Oehl F, Sieverding E, Ineichen K, Mäder P, Boller T, Wiemken A. 2003. Impact of land use intensity on the species diversity of arbuscular mycorrhizal fungi in agroecosystems of Central Europe. Appl Environ. Microbiol. 69: 2816–2824. doi: 10.1128/AEM.69.5.2816–2824.2003

Oehl F, Sieverding E, Mäder P, Dubois D, Ineichen K, Boller T, Wiemken A. 2004. Impact of long-term conventional and organic farming on the diversity of arbuscular mycorrhizal fungi. Oecologia 138: 574–583. doi:10.1007/s00442-003-1458-2

Oehl F, Sieverding E, Ineichen K, Ris E-A, Boller T & Wiemken A. 2005. Community structure of arbuscular mycorrhizal fungi at different soil depths in extensively and intensively managed agroecosystems. New Phytol. 165: 273–283. doi:10.1111/j.1469-8137.2004.01235.x

Oehl F, Sýkorová Z, Redecker D, Wiemken A, Sieverding E. 2006. *Acaulospora alpina*, a new arbuscular mycorrhizal fungal species characteristic for high mountainous and alpine grasslands of the Swiss Alps. Mycologia 98: 286–294. doi:10.3852/mycologia.98.2.286

Oehl F, de Souza FA, Sieverding E. 2009a ['2008']. Revision of *Scutellospora* and description of five new genera and three new families in the arbuscular mycorrhiza-forming *Glomeromycetes*. Mycotaxon 106: 311–360.

Oehl F, Sieverding E, Ineichen K, Mäder P, Wiemken A, Boller T. 2009b. Distinct sporulation dynamics of arbuscular mycorrhizal fungal communities from different agroecosystems in long-term microcosms. Agric. Ecosys. Environ. 134: 257–268. doi:10.1016/j.agee.2009.07.008

Oehl F, Laczko E, Bogenrieder A, Stahr K, Bösch R, van der Heijden MGA, Sieverding E. 2010. Soil type and land use intensity determine the composition of arbuscular mycorrhizal fungal communities. Soil Biol. Biochem. 42: 724–732. doi:10.1016/j.soilbio.2010.01.006

Palenzuela J, Ferrol N, Boller T, Azcón-Aquilar C, Oehl F. 2008. *Otospora bareai*, a new fungal species in the *Glomeromycetes* from a dolomitic shrub-land in the Natural Park of Sierra de Baza (Granada, Spain). Mycologia 100: 296–305. doi:10.3852/mycologia.100.2.296

Palenzuela J, Barea JM, Ferrol N, Azcón-Aquilar C, Oehl F. 2010. *Entrophospora nevadensis*, a new arbuscular mycorrhizal fungus, from Sierra Nevada National Park (southeastern Spain). Mycologia 102: 624–632. doi:10.3852/09-145

Posada D, Crandall KA. 1998. Modeltest: testing the model of DNA substitution. Bioinformatics 14: 817–818.

Sambrook J, Fritsch EF, Maniatis T. 1989. Molecular cloning, a laboratory manual. Cold Spring Harbor Laboratory Press, New York 1: 1.25–1.31.

Sanders IR, Alt M, Groppe K, Boller T, Wiemken A. 1995. Identification of ribosomal DNA polymorphisms among and within spores of the *Glomales* – application to studies on the genetic diversity of arbuscular mycorrhizal fungal communities. New Phytol. 130: 419–427.

Schüßler A, Schwarzott D, Walker C. 2001. A new fungal phylum, the *Glomeromycota*: phylogeny and evolution. Mycol Res. 105: 1413–1421. doi:10.1017/S0953756201005196

Sieverding E, Oehl F. 2006. Revision of *Entrophospora*, and description of *Kuklospora* and *Intraspora*, two new genera in the arbuscular mycorrhizal *Glomeromycetes*. J. Appl. Bot. Food Qual. – Angew. Bot. 80: 69–81.

Silva DK, Freitas NO, Maia LC, Oehl F. 2008. *Scutellospora pernambucana*, a new fungal species in the *Glomeromycetes* with a diagnostic germination orb. Mycotaxon 106: 361–370.

Spain JL. 1990. Arguments for diagnoses based on unaltered wall structures. Mycotaxon 38: 71–76.

Swofford DL. 2003. PAUP*. Phylogenetic Analysis Using Parsimony (* and Other Methods), Version 4. Sinauer Associates, Sunderland, Massachusetts.

Tadych M, Błaszkowski J. 2000. Arbuscular fungi and mycorrhizae (*Glomales*) of the Slowinski National Park, Poland. Mycotaxon 74: 463–483.

Tchabi A, Hountondji F, Lawouin L, Coyne D, Oehl F. 2009. *Racocetra beninensis* from sub-Saharan savannas: a new species in the *Glomeromycetes* with ornamented spores. Mycotaxon 110: 199–209.

Turnau K, Ryszka P, Gianinazzi-Pearson V, van Tuinen. 2001. Identification of arbuscular mycorrhizal fungi in soils and roots of plants colonizing zinc wastes in southern Poland. Mycorrhiza 10: 169–174.

van Tuinen D, Zhao B, Gianinazzi-Pearson V. 1998. PCR in studies of AM fungi: from primers to application. In: Varma, AK. (ed.) Mycorrhizal manual: 387–399. Springer, Berlin Heidelberg New York.

Vestberg M. 1995. Occurrence of some *Glomales* in Finland. Mycorrhiza 5: 329–336.

Walker C, Sanders FE. 1986. Taxonomic concepts in the *Endogonaceae*: III. The separation of *Scutellospora* gen. nov. from *Gigaspora* Gerd. & Trappe. Mycotaxon 27: 169–182.

Walker C, Cuenca G, Sánchez F. 1998. *Scutellospora spinosissima* sp. nov. a newly described Glomalean fungus from acidic, low nutrient plant communities in Venezuela. Annals Bot. 82: 721–725.

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis MA, Gelfand D, Sninsky J, White T (eds.). PCR protocols: a guide to methods and applications: 315–322. Academic Press, San Diego, California.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.85

Volume 114, pp. 85–90 *October–December 2010*

New and interesting records of lichens from Turkey

KADIR KINALIOGLU

kkinalioglu@hotmail.com
Giresun University, Faculty of Science and Arts, Department of Biology
28049, Giresun, Turkey

Abstract—Eight species of lichenized and lichenicolous fungi are reported from the Turkish provinces of Giresun, Samsun, and Trabzon. Four taxa, *Dactylospora glaucomarioides*, *Lecania polycycla*, *Lecanora thysanophora*, and *Strigula stigmatella*, are new records for Turkey. A short description based on Turkish material is presented for each taxon.

Key Words—biota, biodiversity, Konakönü

Introduction

Studies aiming to determine the lichens of the biota of Turkey have intensified in recent years (e.g. Candan & Özdemir Türk 2008, Halıcı et al. 2007, Kınalıoğlu 2009b, Öztürk & Güvenç 2010, Yazıcı et al. 2010). However large parts of the lichen biota of Turkey are still largely unknown. Until now the number of taxa recorded from different regions of Trabzon province was 518 (John 1995 [and references therein], 1999, 2000, 2002; John & Breuss 2004, John & Nimis 1998, John et al. 2000, Kınalıoğlu 2007b, 2008, Kınalıoğlu & Engin 2004, Yazıcı 1996, 1999, 2006; Yazıcı & Aslan 2002, 2005), and 431 from Giresun province (Aslan et al. 2002, Aslan & Yazıcı 2006, Duman & Yurdakulol 2007, Halıcı & Şenkardeşler 2009, John & Breuss 2004, Kınalıoğlu 2005, 2006, 2008, 2009a, Kınalıoğlu & Engin 2004, Küçük 1990, Özgen et al. 2003, Steiner 1909, Süleyman et al. 2002, Yazıcı 2006, Yazıcı & Aptroot 2008). The lichen biota of Samsun province, with 129 species reported (John et al. 2000, Kınalıoğlu 2007a, Söylemez et al. 1998), is less known than that of Trabzon and Giresun provinces. This contribution reports further species as first records for Turkey or for the provinces of Giresun, Samsun, or Trabzon.

Materials and methods

The lichen samples were collected from the three provinces Samsun, Giresun and Trabzon between 25 August 2004 and 10 April 2010. All samples were

identified with various lichen guides (e.g. Brodo et al. 2001, Hafellner 1979, Mayrhofer 1988, Purvis et al. 1992, Wirth 1995). The specimens are deposited in the herbarium of the Faculty of Science and Arts, Giresun University, Giresun, Turkey; with some duplicates in personal herbaria of H. Sipman and T. Tønsberg. The accession numbers of the collections are given in parentheses after the locality details.

Taxonomy

Caloplaca arcis (Poelt & Vežda) Arup

A detailed description is provided by Vondrak et al. (2009).

SPECIMEN EXAMINED: **Giresun:** Center, Ayvasıl place, sea shore, 40°55'37"N, 38°18'45"E, 10 m, 25 May 2006, on mortar, det. H. Sipman, (Kınalıoğlu 1529).

Thallus yellowish. Apothecia 0.4–0.8 mm diam., rare; thalline exciple yellow; disc orange. Ascospores ellipsoid, 10–14 µm × 5–6.5; septum 4–5 wide. Thallus K+ violet, C–, PD–.

Recently recorded as new to Turkey by Vondrak et al. (2009) from Sinop province. New to Giresun province.

Known also from Europe (Bulgaria, Italy, Netherlands, Slovakia, Spain) mainly growing on inland sun-exposed hard siliceous rocks, but also on pure limestone (Vondrak et al. 2009). In Turkey it was collected from mortar.

Caloplaca limonia Nimis & Poelt

Detailed descriptions are provided by Vondrak et al. (2009) and Nimis & Martellos (2004).

SPECIMEN EXAMINED: **Giresun:** Piraziz, Gökçeali village, 40°54'24"N, 38°05'39"E, 422 m, 30 Mar. 2006, on mortar, det. H. Sipman, (Kınalıoğlu 1608).

Thallus bright yellow. Apothecia 0.4–0.7 mm diam., numerous; thalline exciple yellow; disc orange. Ascospores ellipsoid, 12–15 µm × 5.5–8; septum 5–6.5 wide. Thallus K+ violet, C–, PD–.

Recently recorded as new to Turkey by Vondrak et al. (2009) from Çanakkale and Sinop provinces. New to Giresun province.

Known also from Bulgaria, Croatia, Czech Republic, Georgia, Italy, Morocco, Romania, Russia, Ukraine. It mainly grows on coastal calcareous rocks or base-rich, hard siliceous cliffs in dry sun exposed to shaded and damp situations, but also on twigs of maritime shrubs or on mosses and soil. It is also known from inland localities (Vondrak et al. 2009). In Turkey it was collected only from mortar.

Dactylospora glaucomarioides (Tuck.) Hafellner

A detailed description is provided by Hafellner (1979).

SPECIMEN EXAMINED: **Giresun:** Dereli, Karagöl mountains, 40°35'51"N, 38°10'30"E, 3050 m, 29 Jul. 2007, on *Ochrolechia* sp. on soil, det. H. Sipman, (Kınalıoğlu 1591).

Apothecia black, scattered on the thallus surface of the host; disc 0.1–0.5 mm diam., mostly flat, with thick margin, (0.2–0.4 mm diam.). Paraphyses septate, 1.3–2 µm thick. Ascospores dark brown, 1–3 septate, 12.5–20 × 5–7.5 µm.

New to Turkey. This lichenicolous species known also from America and Russia growing on *Ochrolechia upsaliensis* (mostly thallus, occasionally apothecia), and on *Megaspora verrucosa* (apothecia, thallus) (Hafellner 1979, Zhurbenko 2004). In Turkey, it was collected on thallus of epigeic *Ochrolechia* sp. on exposed mountain ridges.

Lecania polycycla (Anzi) Lettau

Detailed descriptions are provided by CNALH (2009) and Mayrhofer (1988).

SPECIMEN EXAMINED: **Samsun**, Ayvacık, near Suatuğurlu dam, 41°04'40"N, 36°40'13"E, 50 m, 22 Jul. 2006, on mortar, det. H. Sipman, (Kınalıoğlu 1797).

Thallus granular or rimose to areolate, olive-brown. Apothecia abundant, 0.3–0.9 mm in diam; disc flat to slightly convex, brownish; margin whitish-gray. Hymenium 40–50 µm. Ascospores ellipsoid, 0–1 septate, 9–12.5× 3–5 µm. Thallus C–, K–, PD–.

New to Turkey. Widespread in Europe, Africa and North America growing on calcareous rocks and rarely on acidic rocks (CNALH 2009, Mayrhofer 1988). In Turkey it was only collected from mortar in sun exposed area.

Lecanora thysanophora R.C. Harris

Detailed descriptions are provided by Brodo et al. (2001), Harris et al. (2000), and Kowalewska & Kukwa (2003).

SPECIMENS EXAMINED: **Giresun**: Keşap district, Geçit village, 40°46'13"N, 38°32'48"E, 720 m, 25 Aug. 2004, on *Corylus* sp., det. Tor Tønsberg, (Kınalıoğlu 1794). **Giresun:** SW of city centre, Boztekke village, 40°55'05"N, 38°18'31"E, 8 m, 10 Apr. 2010, on *Corylus* sp., det. Tor Tønsberg, (Kınalıoğlu 1795).

Thallus thin, green-yellow, leprose, continuous or patchy. Apothecia not observed. Fibrous prothallus conspicuous at the thallus margins. Thallus K+ yellow, KC+ deep yellow, C–, PD–,

New to Turkey. Known also from North America and many European Countries mainly growing on trunks of deciduous trees, especially *Acer saccharum* and *Thuja occidentalis*, but also on *Populus*, *Tilia*, or even on shaded siliceous rocks, in shaded or partly shaded forest (Brodo et al. 2001, Harris et al. 2000, Kowalewska & Kukwa 2003). In Turkey it was collected from *Corylus* sp. in partly shaded and damp hazelnut gardens.

Melanelia substygia (Räsänen) Essl.

Detailed descriptions (as *Melanelia tominii*) are provided by Brodo et al. (2001) and CNALH (2009).

Specimen examined: **Trabzon:** Araklı, Near the Uzuntarla, 40°39'47"N 40°2'49"E, 2390, 22 Aug. 2005, on moss, det. H. Sipman, (Kınalıoğlu 1478).

Thallus dark brown to black; lobes flat to weakly convex, 1–2.5 mm wide, pseudocyphellae laminal, whitish to dark. Apothecia not observed. Medulla C+ red, KC+ red, PD–, K–.

In Turkey *Melanelia substygia* was previously recorded from Erzurum province (Yazıcı & Aslan 2000). New to Trabzon province.

Known also from Europe, North America, North Africa and Asia growing on non-calcareous rocks, usually in open, dry sites and also in forested regions (Brodo et al. 2001, CNALH 2009). In Turkey it was collected from on mosses in exposed areas at high elevation.

Mycobilimbia berengeriana (A. Massal.) Hafellner & V. Wirth

Detailed descriptions (as *Lecidea berengeriana*) are provided by CNALH (2009), Purvis et al. (1992), and Thomson (1997).

Specimen examined: **Giresun:** Dereli, Karagöl mountais, 40°35'51" N, 38°10'30" E, 3050 m, 29 Jul. 2007, on turf, det. H. Sipman, (Kınalıoğlu 1594).

Thallus thick, white-grey, with granular warts 0.1–0.2 mm diam. Apothecia 0.3–1.2 mm diam.; disc flat or weakly convex, brownish- black. Hymenium 55–65 µm tall. Ascospores ellipsoid, 9–17 × 4–5.5 µm. Thallus C–, K–, KC–, PD–.

In Turkey previously recorded from Gümüşhane (Yazıcı & Aslan 2000) New to Giresun province.

Known also from North America, England and Scotland growing on mosses over soil and on ± calcareous rocks or on exposed turf of mountain ridges or summits (CNALH 2009, Purvis et al. 1992, Thomson 1997). In Turkey it was only collected from turf at high elevation.

Strigula stigmatella (Ach.) R.C. Harris

Detailed descriptions are provided by CNALH (2009), Purvis et al. (1992), and Brodo (2001).

Specimen examined: **Giresun:** Dereli, Tepeköknarlı village, 40°47'28"N, 38°26'44"E, 605 m, 14. Apr. 2005, on *Carpinus* sp., conf. H. Sipman, (Kınalıoğlu 1622).

Thallus whitish-grey, very thin. Perithecia black, semi-immersed, 0.2–0.5 mm diam. Ascospores 25–36 × 5–7.5 µm, 6–7 septate, fusiform. Thallus C–, K–, KC–, PD–.

New to Turkey. Known also from the Europe, America and Canada growing on the bark of old broad-leaved trees, or over mosses on tree bases (Purvis et al. 1992). In Turkey it was only collected from on trunk of *Carpinus* sp. in entrance of shaded forest.

Acknowledgements

The identification and confirmation of numerous samples by Dr. H. Sipman and Dr. Tor Tønsberg is gratefully acknowledged. I also thank peer-reviewers Dr. A. Nordin & Dr. P. Giordani for their contributions on revising article.

Literature cited

Aslan A, Yazıcı K. 2006. Contribution to the lichen flora of Giresun Province of Turkey. Acta Botanica Hungarica 48(3–4): 231–245. doi:10.1556/ABot.48.2006.3-4.1

Aslan A, Aptroot A, Yazıcı K. 2002. New lichens for Turkey. Mycotaxon 84: 227–280.

Brodo IM, Sharnoff SD, Sharnoff S. 2001. Lichens of North America. Yale University Press, London.

Candan M, Özdemir Türk A. 2008. Lichens of Malatya, Elaziğ and Adıyaman provinces (Turkey). Mycotaxon 105: 19–22.

CNALH [Consortium of North American Lichen Herbaria]. 2009.
<http://symbiota.org/nalichens/>.

Duman C, Yurdakulol E. 2007. Lichen Records from Sarıçiçek Mountain in Southern Giresun Province, Turkey. Turk J. Bot. 31: 357–365.

Hafellner J. 1979. Karschia. Revision einer Sammelgattung an der Grenze von lichenisierten und nichlichenisierten Ascomyceten. Beiheft zur Nova Hedwigia 62: 1–248.

Halıcı MG, Şenkardeşler A. 2009. Giresun için yeni kayıt: Phaeosporobolus usneae. Türk Liken Toluluğu Bülteni 7: 11–12.

Halıcı MG, Candan M, Özdemir Türk A. 2007. New records of lichenicolous and lichenized fungi from Turkey. Mycotaxon 100: 255–260.

Harris RC, Brodo IM, Tønsberg T. 2000. *Lecanora thysanophora*, a common leprose lichen in Eastern North America. The Bryologist 103(4): 790–793. doi:10.1639/0007-2745(2000)103[0790:LTACLL]2.0.CO;2

John V. 1995. Flechten der Türkei IV. Ergänzungen zum die Türkei betreffende lichenologische Schrifttum. Neunkirchener Druckerei und Verlag, Neunkirchen, Germany.

John V. 1999. Lichenes Anatolici Exsiccati. Fasc. 1–3 (No: 1–75). Arnoldia 16: 1–41.

John V. 2000. Lichenes Anatolici Exsiccati. Fasc. 4–5 (No: 76–125). Arnoldia 19: 1–27.

John V. 2002. Lichenes Anatolici Exsiccati. Fasc. 6–7 (No: 126–175). Arnoldia 21: 1–28.

John V, Breuss O. 2004. Flechten der östlichen Schwarzmeer-Region in der Türkei (BLAM Exkursion 1997). Herzogia 17: 137–156.

John V, Nimis PL. 1998. Lichen flora of Amanos mountain and the province of Hatay. Turkish Journal of Botany 22: 257–267.

John V, Seaward MRD, Beaty JW. 2000. A neglected lichen collection from Turkey: Berkhamsted School Expedition 1971. Turkish Journal of Botany 24: 239–248.

Kınalıoglu K. 2005. Lichens of Giresun District, Giresun Province, Turkey. Turkish Journal of Botany 29: 417–423.

Kınalıglu K. 2006. Lichens of Keşap District (Giresun, Turkey). Acta Botanica Hungarica 48(12): 65–76. doi:10.1556/ABot.48.2006.1-2.9

Kınalıoglu 2007a. The Lichen Flora of Kocadağ Mountains and Its Environs (Samsun, Turkey). Acata Botanica Hungarica49 (1-2): 94-104. doi:10.1556/ABot.49.2007.1-2.10

Kınalıglu K. 2007b. Lichens of the alpine region in Araklı–Sürmene district, Trabzon province (Turkey). Cryptogamie, Mycologie 28(2): 159–168.

Kınalıoglu K. 2008. Three new records for the lichen biota of Turkey. Mycotaxon 103: 123–126.

Kınalıoglu K. 2009a. Additional lichen records from Giresun Province, Turkey, Mycotaxon, 109: 137–140.

Kınalıoglu K. 2009b. Lichens from the Amasya, Corum, and Tokat regions of Turkey. Mycotaxon 109: 181–184.

Kınalıoglu K, Engin A. 2004. Bülbülan (Artvin), Ayder, Anzer (Rize), Kalecik (Trabzon) ve Kümbet (Giresun) Yaylalarının Likenleri. Ot Sistematik Botanik Dergisi 11(2): 167–190.

Kowalewska A, Kukwa M. 2003. Additions to the Polish lichen flora. Graphis Scripta 14: 11–17.

Küçük M. 1990. Giresun Adası'nın Floristik Yapısı. Ormancılık Araştırma Enstitüsü Yayınları 36(2): 58.

Özgen U, Aslan A, Terzi Z. 2003. Phytochemical screening of some lichen species collected from Giresun Province. I. International Congrees on the Chemistry of Natural Products (ICNP) 16–19 October, Trabzon, Türkiye.

Öztürk S, Güvenç S. 2010. Additional lichen records from the western Black Sea region of Turkey. Acta Botanica Hungarica 52(1–2): 159–175. doi:10.1556/ABot.52.2010.1-2.14

Mayrhofer M. 1988. Studien über die saxicolen Arten der Flechtengattung *Lecania* in Europa. II. *Lecania* s. str. Bibliotheca Lichenologica 28: 1–133.

Nimis PL, Martellos S. 2004. Keys to the lichens of Italy. I. Terricolous species. Edizioni Goliardiche, Trieste.

Purvis OW, Coppins BJ, Hawksworth DL, James PW, Moore DM. 1992. The lichen flora of Great Britain and Ireland. Natural History Museum & British Lichen Society, London.

Söylemez M, Gönülol A, Kınalıoğlu K. (1998). Ondokuz Mayıs Üniversitesi Kurupelit Kampüs Alanı (Samsun) Liken Florası Üzerine Bir Araştırma. 14. Ulusal Biyoloji

Steiner J. 1909. Lichenes. In: Handel Mazzetti, D.H.F.V.: Ergebnisse einer botanischen Reisein das Pontische Randgebirge im Sandschak Trapezunt, etc. Annal. Naturhist. Hofmus. Wien 23: 107–123.

Süleyman H, Yıldırım D, Aslan A, Göçer F, Gepdiremen A, Güvenalp Z. 2002. An investigation of the antiinflammatory effects of an extract from Cladonia rangiformis Hoffm. Biol. and Pharm. Bull. 25: 10–13. doi:10.1248/bpb.25.10

Thomson JW. 1997. American Arctic Lichens. 2. The Microlichens. The University of Wisconsin Press, Madison.

Vondrák J, Riha P, Arup U, Sochting U. 2009. the taxonomy of the *Caloplaca* (*Teloschistaceae*) in the Black Sea region; with contributions to the cryptic species concept in lichenology. The Lichenologist 41(6): 571–604. doi:10.1017/S0024282909008317

Wirth V. 1995. Die Flechten Baden–Württembergs. Ulmer, Stuttgart.

Yazıcı K. 1996. Altındere Vadisi Milli Parkı Liken Florası. Turkish Journal of Botany 20: 263–265.

Yazıcı K. 1999. Lichen Flora of Trabzon. Turkish Journal of Botany 23: 97–112.

Yazıcı K. 2006. Four new lichens from Turkey. Myxotaxon 95: 315–318.

Yazıcı K, Aptroot A. 2008. Corticolous lichens of the city of Giresun with descriptions of four species new to Turkey. Mycotaxon 105: 95–104.

Yazıcı K, Aslan A. 2000. Lichens from the regions of Artvin, Erzurum, and Kars (Turkey). Israel J. of Plant Sciences 48: 143–155.

Yazıcı K, Aslan A. 2002. New records for the lichen flora of Turkey. Turkish Journal of Botany 26: 117–118.

Yazıcı K, Aslan A. 2005. Six new lichen records from Turkey. Myxotaxon 93: 359–363.

Yazıcı K, Aptroot A, Aslan A. 2010. Three lichenized fungi new to Turkey and the Middle East. Mycotaxon 111: 127–130.

Zhurbenko MP. 2004. Lichenicolous and some interesting lichenized fungi from the Northern Ural, Komi Republic of Russia. Herzogia 17: 77–86.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.91

Volume 114, pp. 91–97 October–December 2010

Coccostromopsis palmicola on *Butia yatay* from Argentina

MARIANA CAPDET*, SUSANA PEREIRA & ANDREA IRENE ROMERO

*marianacapdet@gmail.com

PRHIDEB-CONICET, Depto. Biodiversidad y Biología Experimental
Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires
Av. Int. Güiraldes 2620, Buenos Aires C1428EHA, Argentina.

Abstract — *Coccostromopsis palmicola* on living leaves of *Butia yatay* (*Arecaceae*) is reported for the first time from Argentina. This fungus is briefly described and illustrated. Some phytogeographical and phythopathological aspects are discussed.

Key words — *Ascomycota*, endangered palm, *Phyllachorales*, tar spots

Introduction

According to Hyde & Cannon (1999) the genus *Coccostromopsis* (*Phyllachorales*, *Phyllachoraceae*) was reintroduced for species on palms and bamboos having pulvinate, gelatinous, stromata with a yellowish sheen when young and strongly erumpent when mature, and with hyaline to yellow-brown or brown ascospores when mature. In respect to geographic distribution, species of *Coccostromopsis* are found wherever their palm hosts occur, i.e. mostly in tropical and subtropical regions (Blomberry & Rodd 1982). *Coccostromopsis* currently comprises five species. Hyde & Cannon (1999) provided a key to three of them, namely *C. diplothemii* (of which the type species, *C. palmigena,* is a synonym), *C. chamaedoreae,* and *C. palmicola.* These three species have been recorded from various countries of Central and South America. One additional species, *C. bambusae* (Sawada 1959), occurs on bamboo in China. Species of *Coccostromopsis* are considered tar spot fungi, because of the significant blackening of the surface layers of their ascomata (Hyde & Cannon 1999). The number of fungi associated with diseases of palm leaves is comparatively low, perhaps a reflection of the tough tissues of palms (Hyde & Cannon 1999). In Australia, Fröhlich (1993) identified 27 species associated with 14 palm species. Recently Capdet & Romero (2010) summarized previous information about fungi of palms and their occurrence in Argentina.

The purpose of this article is to communicate the presence of *Coccostromopsis palmicola* on living leaves of *Butia yatay* (Mart.) Becc. (*Arecaceae*) and to determine whether *C. palmicola* occurs on other palm species in Argentina.

Materials and methods

The sampling areas comprised parts of two national parks: Iguazú in Misiones Province and El Palmar in Entre Ríos Province (Fig. 1).

Iguazú National Park covers an area of 67,620 hectares (25°41'S, 54°18'W; APN 2008). This park is included in the "Paranaense province" (Cabrera & Willink 1980) of the Argentine phytogeographical regions. The climate is subtropical without a dry season. Annual rainfall averages vary between 1600 mm and 2000 mm and the annual average temperature is 20°C. The vegetation is subtropical forest and represents the highest animal and plant biodiversity in the country (Dirección de Bosques 2003). The two palms studied in this area were *Euterpe edulis* Mart. and *Syagrus romanzoffiana* (Cham.) Glassman. El Palmar National Park, covers an area of 8,500 hectares (31°55'S, 58°14'W) and was established in 1965 with the aim of preserving *Butia yatay*, an endangered species (Chebez 1994). It is included in the Argentine phytogeographical region called "Espinal province" (Cabrera & Willink 1980). The climate is warm and humid in the north, and temperate and dry in the west and south. Rainfall ranges from 400 mm to 1500 mm, mainly in spring and summer (Dirección de Bosques 2003). The vegetation includes savanna with palms, shrubs and gallery forest along the Uruguay River and grasslands. *Butia yatay*, the only palm present in the Park, has an endemic distribution in southern South America occurring in Argentina, Brazil, Paraguay and Uruguay.

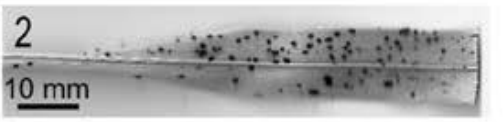
Intensive collecting was conducted in El Palmar National Park over the past three years (2007-2009). Living leaves of palm were collected in different seasons. The material was air-dried. Microscopic characters were observed in vivo using light microscopy. Sizes of all the structures were based on 20 measurements. Drawings were made with a camera lucida. Photographs were taken with a Sony Digital camera. The specimens are deposited in the BAFC fungal reference collection (Holmgren et al. 1990).

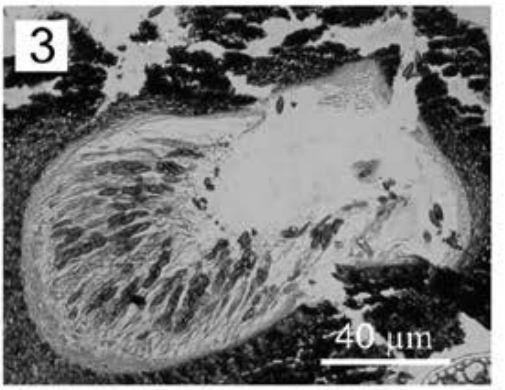
Results

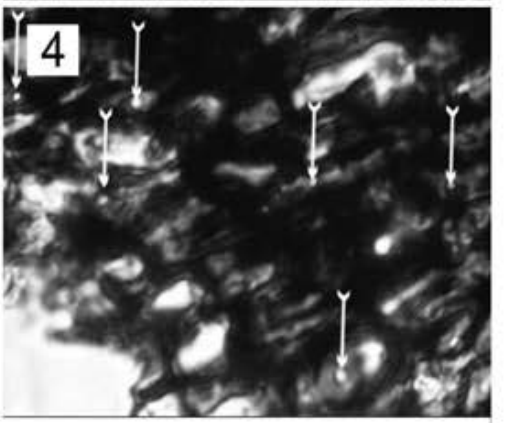
No specimens were found on *Euterpe edulis* or *Syagrus romanzoffiana* in Iguazú National Park. In contrast, most of the leaf pinnae of the palms trees observed of *Butia yatay* in the El Palmar National Park, Entre Ríos, had many stromata along the length of the leaflet.

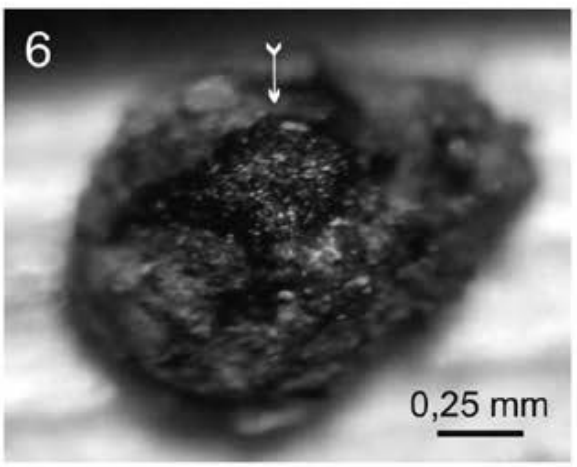
Figs 1–8. **1.** Sampling sites. **2.** Stromata on pinna of *Butia yatay*; scale bar = 10 mm. **3.** Longitudinal section through a perithecial ascoma; scale bar = 40 µm. **4.** Peridium cells with Munk pores; scale bar = 10 µm. **5.** Young stroma on host surface; scale bar = 0.25 mm. **6.** Teleomorphic stroma on leaf; arrow points to black ascospore mass; scale bar = 0.25 mm. **7.** Stroma with conidioma; arrow points to caramel brown conidial mass with cerebriform aspect; scale bar = 0.5 mm. **8.** Stroma with hyperparasitic conidioma; arrow points to translucent white cirrus; scale bar = 1 mm.

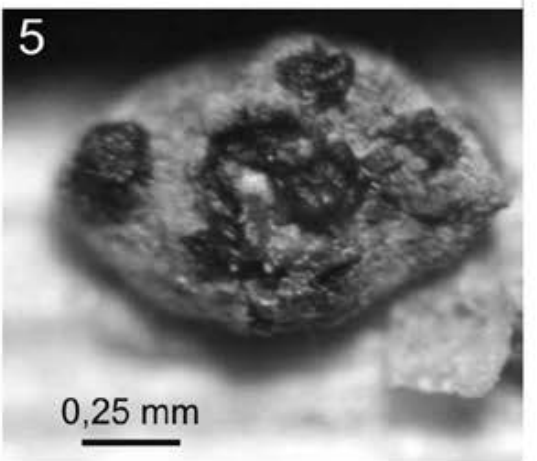

1
ASUNCIÓN
río Pilcomayo
río Bermejo
PARAGUAY
río Iguazú
Iguazú national park
río Paraná
BRASIL
río Paraná
río Uruguay
El Palmar national park
Argentina
URUGUAY
BUENOS AIRES

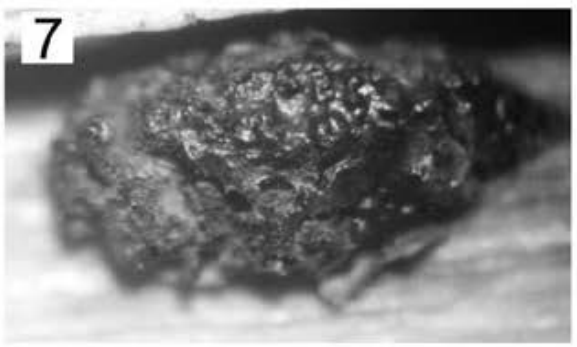

2
10 mm

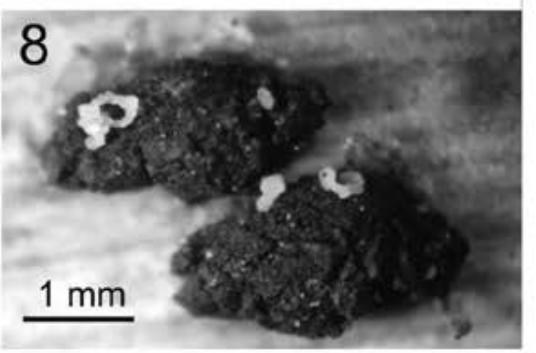

3
40 µm


4


6
0,25 mm


5
0,25 mm


7


8
1 mm

Coccostromopsis palmicola (Speg.) K.D. Hyde & P.F. Cannon, Mycol. Pap. 175: 67, 1999. FIGS. 2–14

= *Auerswaldia palmicola* Speg., Anal. Soc. cient. argent. 19: 247, 1885. Type LPS 277!

ADDITIONAL SYNONYMY: see Hyde & Cannon (1999).

STROMATA 1.8–2.7 mm long, 1–1.6 mm wide, on living leaves, distributed along the veins, primarily on adaxial surface but also present on abaxial surface, with a sulphur-yellow patina when young, usually hemispherical or elongated, erumpent, verrucose, opaque black with shiny black areas formed by ascospore mass when mature. Cells of the stroma with Munk pores.

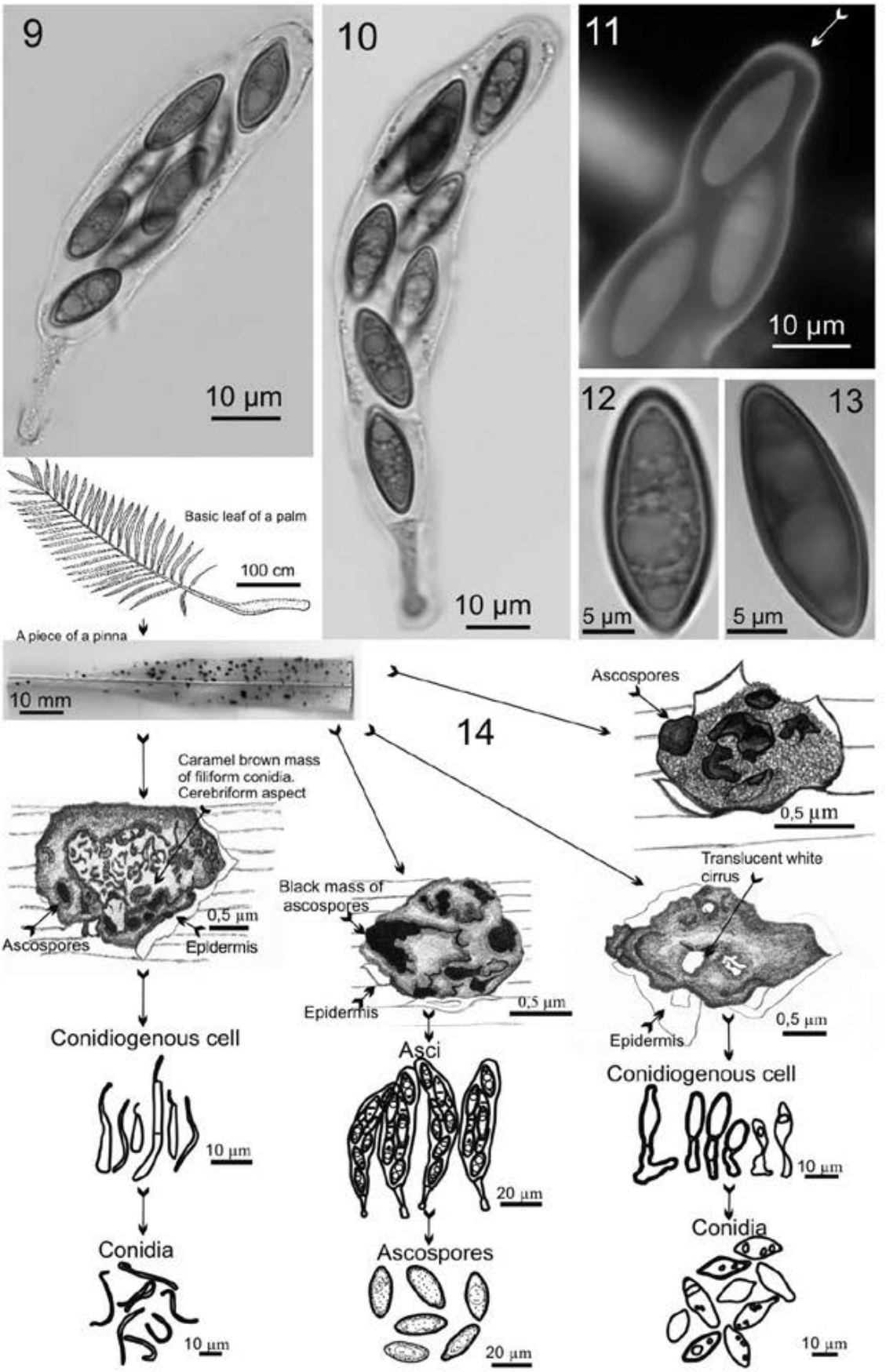
TELEOMORPH. ASCI cylindric-clavate, apex truncate, 8-spored, 120–155 × 16–25 µm, long-stalked, 35–45 µm long. ASCOSPORES 25–28 × 8–11 µm, arranged multiseriately, guttulate, aseptate, fusiform-ellipsoidal, mid brown, surrounded by a mucilaginous sheath. ANAMORPH. CONIDIOMATA formed locules in upper part of stroma, irregularly shaped. CONIDIOGENOUS CELLS in cluster on short branched conidiophores, cylindrical, enteroblastic. CONIDIA 14–31 × 1–2 µm, filiform, round towards both ends, often curved, aseptate, smooth, hyalines. Some of the stromata are parasitized by an anamorph producing conidiomata inside the stroma with a white cirrus consisting of fusiform to flabelliform conidia, 9–14 × 2–3 µm.

MATERIAL EXAMINED — ARGENTINA. ENTRE RÍOS, DPTO. COLÓN: EL PALMAR NATIONAL PARK, coll. Cabral, D., Iannone, L. & Pereira, S. 22.II.2007 (BAFC 51782), 22.II.2007 (BAFC 51783); 23.II.2007 (BAFC 51784); 24.II.2007 (BAFC 51780); coll. Capdet, M. & Romero, A.I. 22.IV.2008 (BAFC 51779); 23.IV.2008 (BAFC 51778); 24.IV.2008 (BAFC 51777); 18.VIII.2008 (BAFC 51785); 20.VIII.2008 (BAFC 51785); 02.II.2009 (BAFC 51781).

NOTES: This is the first record of *Coccostromopsis palmicola* on *Butia yatay* from Argentina. Spegazzini (1885) originally described this fungus on leaves of *Butia yatay* from Paraguay. Later Viégas (1944) reported it from Brazil on leaves of *Allagoptera arenaria* (Gomes) Kuntze. Although the collections from Paraguay and Brazil were collected in springtime, we have found it during all the seasons, although the summer collections were in the best condition. Of the 50 *Butia yatay* trees observed in different parts of the park, all were infected with *C. palmicola*.

Knowing that the fungus occurs in Brazil on other palm species, we also looked in Iguazú National Park close to the boundary with Brazil. *Butia yatay* is not present in Misiones province (Cabral & Castro 2007), but we examined two palms: *Euterpe edulis* and *Syagrus romanzoffiana* that grow in Brazil and Paraguay (Cabral & Castro 2007). *Coccostromopsis palmicola* was not found on these hosts. How can we explain its presence in Paraguay and Argentina

FIGS 9–14. **9–11.** Asci; arrow indicates apex details; scale bars = 10 µm. **12–13.** Ascospores; scale bars = 5 µm. **14.** General outlines of the different morphologies found on pinnae of *Butia yatay*.


9
10 µm
10
10 µm
11
10 µm
12
5 µm
13
5 µm
Basic leaf of a palm
100 cm
A piece of a pinna
10 mm
14
Caramel brown mass of filiform conidia. Cerebriform aspect
0,5 µm
Ascospores
Epidermis
Conidiogenous cell
10 µm
Conidia
10 µm
Black mass of ascospores
Epidermis
0,5 µm
Asci
20 µm
Ascospores
20 µm
Ascospores
0,5 µm
Translucent white cirrus
Epidermis
0,5 µm
Conidiogenous cell
10 µm
Conidia
10 µm

in El Palmar National Park? As observed in FIG. 1, in Argentina there are two main riverine systems: the Uruguay riverine system and the Paraguay-Paraná riverine system, which is a 3400 km long natural corridor through various ecosystems (tropical rain forest, savannas, steppes and brushlands) between 16 and 34° of south latitude (Neiff et al. 2005). The Uruguay system connects Brazil-Misiones to Entre Ríos provinces. The National Park of Entre Ríos is on the Uruguay side of the river side east of the province while the Paraná River is on the west side of the province. Therefore, the fact that Paraguay is connected through the Paraná River with the Entre Ríos province explains the presence of *C. palmicola* in both sites.

We cannot answer the question why *C. palmicola* is not in Misiones province, which shares the climate and most of the flora with Brazil and Paraguay. Although we did not find *C. palmicola* on *Euterpe edulis* and *Syagrus romanzoffiana,* we cannot say that the fungus is host specific on *Butia yatay* because in Brazil it is found on *Allagoptera arenaria* (Viégas 1944).

In our results we mentioned above that the stromata were parasitized by another anamorph. In his revision of *Phyllachoraceae,* Cannon (1991) noted that members of this family are among the most heavily parasitized fungi.

Acknowledgments

This study was supported by Consejo Nacional de Investigaciones Científicas y Técnicas (Conicet) (PRHIDEB Publication N° 184) and by the UK Darwin Initiative. We thank Aristóbulo Maranta from El Palmar National Park (Entre Ríos) and his team, and also to technician Gabriela Zarlavsky for the histological microscopic sections. We want to thank the expert reviewers, Dr. Amy Rossman and Dr. Paul Cannon, for their efforts to improve this paper.

Literature cited

APN (Administración de Parques Nacionales). 2008. Parque Nacional El Palmar. http://www.parquesnacionales.gov.ar/03_ap/11_palmar_PN/11_palmar_PN.htm

Blombery A, Rodd T. 1982. **An informative, practical guide to palms of the world: their cultivation, and landscape use.** Angus & Robertson Book (Australia). 199 pp.

Cabral EL, Castro M. 2007. Palmeras Argentinas, guía para el reconocimiento. Literature of Latin America: Buenos Aires (República Argentina). 88 pp.

Cabrera AL, Willink A. 1980. Biogeografía de América Latina. 2° ed. O.E.A., Washington, D.C. 130 pp.

Cannon PF. 1991. A revision of *Phyllachora* and some similar genera on the host family *Leguminosae.* Mycological Papers, N° 163: 1–302.

Capdet M, Romero AI. 2010. Fungi from palms in Argentina.1. Mycotaxon 112: 339–355.

Chebez JC. 1994. Los que se van. Especies Argentinas en peligro. Editorial Albatros: Buenos Aires (República Argentina). 604 pp.

Dirección de Bosques. 2003. Atlas de los bosques nativos Argentinos. Secretaría de Ambiente y Desarrollo Sustentable: Buenos Aires (Argentina). 243 pp.

Fröhlich J.1993. Palm diseases of Australia associated with fungi and Oomycetes. (a literature review). Journal of The Palmetum 3(1): 20–40.

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index Herbariorum. Part I: The Herbaria of the world. New York Botanical Garden: New York (U.S.A.). 693 pp.

Hyde KD, Cannon, PF. 1999. Fungi causing tar spots on palms. Mycological Papers, N° 175: 114 pp.

Neiff JJ, Poi de Neiff ASG, Casco SL. 2005. Importancia ecológica del corredor fluvial Paraguay-Paraná como contexto del manejo sostenible, pp 193–210. In: Humedales fluviales de América del Sur. Hacia un manejo sustentable. Capatto J, Peteán J. (eds.). Fundación Proteger. 350 pp.

Sawada K. 1959. Descriptive Catalogue of Formosan Fungi. Part XI. College of Agriculture, National Taiwan University. Special Publication N° 8: 1–268.

Spegazzini CL. 1885. Fungi Guaranitici. Pugillus I. Nos 268–315. Anales de la Sociedad Científica de Argentina 19(6): 241-265.

Viégas AP. 1944. Alguns fongos do Brasil II. Ascomicetos. Bragantia 4: 392 pp. ISSN 0006-8705.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.99

Volume 114, pp. 99–107 *October–December 2010*

Morphological studies of *Hyphoderma cremeoalbum* and *Radulomyces roseolus*

KAREN K. NAKASONE

knakasone@fs.fed.us
Northern Research Station, U.S. Forest Service
One Gifford Pinchot Drive, Madison, WI 53726–2398, USA

Abstract — Type studies reveal that *Radulomyces roseolus* is conspecific with *Hyphoderma cremeoalbum* (*Basidiomycota, Polyporales*). Embedded, fusoid cystidia and haplohyphidia are critical diagnostic features of *H. cremeoalbum*. Known from Europe, United States, Argentina, and New Zealand, its preferred substrate is decorticated and decayed gymnospermous wood, especially *Picea*, but the species also occurs on woody angiosperms.

Key words — *Corticiaceae* sensu lato, *Corticium cremeoalbum*, phlebioid clade, taxonomy

Introduction

Hyphoderma Wallr. is a genus of ubiquitous corticioid homobasidiomycetes with about 100 species reported worldwide (Parmasto et al. 2004). An old but vaguely circumscribed genus, recent molecular studies demonstrate that *Hyphoderma* is polyphyletic with most species distributed in two clades — the *Hymenochaetales* and the *Polyporales* (Langer 2001; Larsson 2007; Larsson et al. 2004). Larsson (2007) resurrected the genus *Peniophorella* P. Karst. to accommodate most of the *Hyphoderma* species in the *Hymenochaetales*. *Hyphoderma* sensu stricto, in the *Polyporales*, consists of species with resupinate, effuse basidiomes, monomitic hyphal systems of clamped hyphae, often with leptocystidia or other types of cystidia, suburniform to subcylindrical basidia with four sterigmata, and thin-walled, smooth basidiospores that range from cylindrical to subglobose (Larsson 2007).

Radulomyces roseolus (Parmasto 1968), known only from the type from Georgia in eastern Europe, is morphologically similar to *Hyphoderma cremeoalbum*. In this study, type specimens of *Corticium cremeoalbum* and *R. roseolus* were examined and determined to be conspecific. The types are

described, illustrated, and compared, and a description of *H. cremeoalbum* is provided.

Materials and methods

Thin, freehand sections or scrapings from the basidiomes were mounted in a Melzer's reagent (Kirk et al. 2008) or 1% (weight/volume) aqueous phloxine and 1% (w/v) aqueous potassium hydroxide. Drawings were made with a camera lucida attachment on an Olympus BH2 compound microscope. Q values were obtained from dividing average basidiospore length by width (Kirk et al. 2008). Basidiospores are often scarce in specimens, thus Q values based on less than 30 basidiospores are approximate and indicated with an asterisk (*). Color names are from Kornerup & Wanscher (1978), and herbarium designations follow that of Index Herbariorum (Thiers, continuously updated).

The term "haplohyphidia" refers to the simple, unbranched, unmodified hyphal ends developed in the hymenium (Donk 1964). Although little used, this term is useful to distinguish among the various types of hyphidia produced in corticioid fungi.

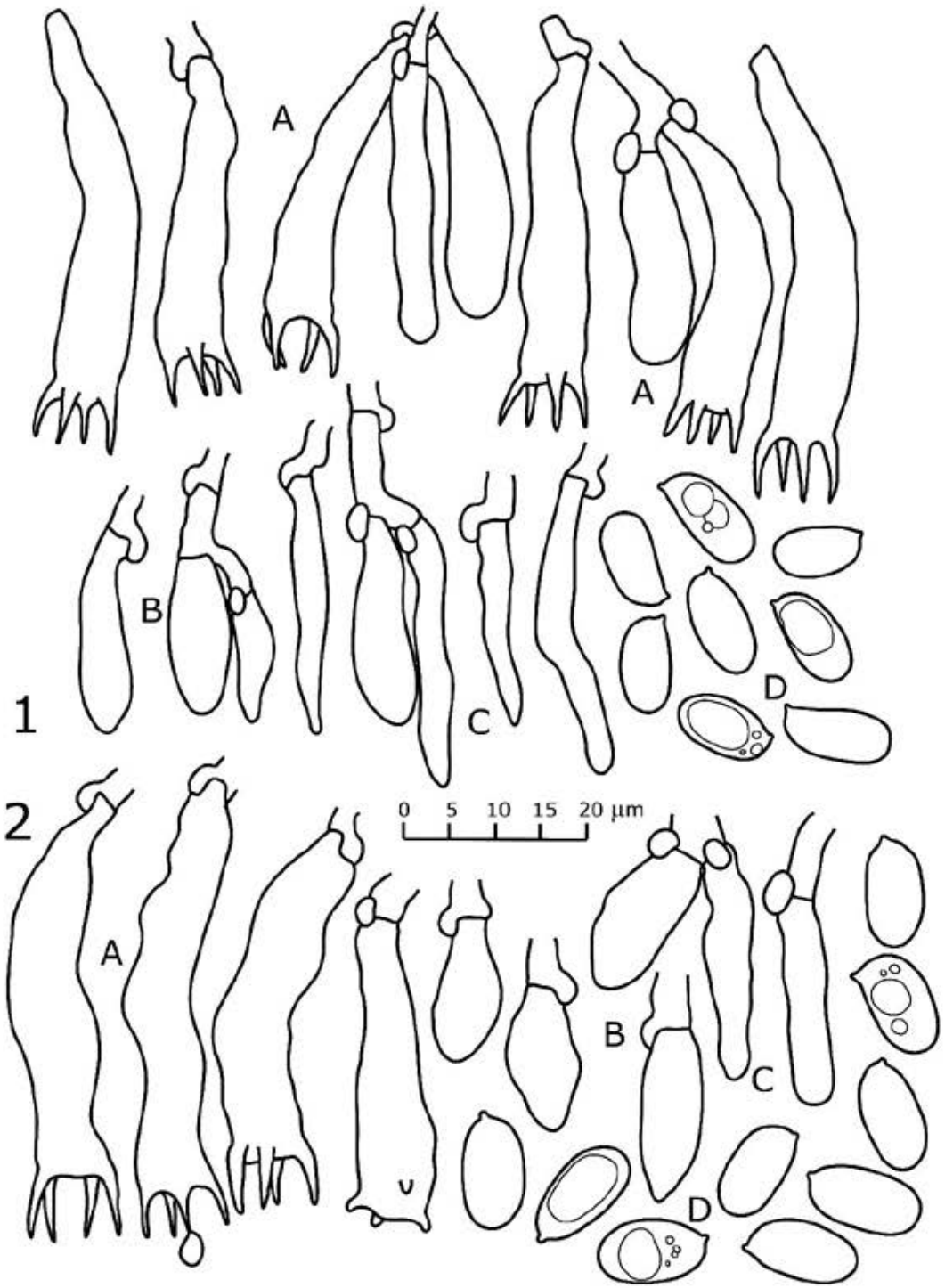
Taxonomy

Type species descriptions

Radulomyces roseolus Parmasto, Consp. syst. cortic. p. 222. 1968. FIG. 1

HOLOTYPE: **RPSS.** Georgica: Hulo in piceeto, ALT. 1300 M., ad caudicem Piceae orientalis prolapsum, 7 October 1963, E. Parmasto (*TAA 16822*).

BASIDIOME resupinate, effuse, colonies irregular, up to 8 × 6 mm, thin, up to 100 µm thick, subceraceous to submembranous. HYMENIAL SURFACE smooth, pruinose, yellowish white (4A2), orange white [5A(2–3)], or greyish orange (5B3). MARGIN thinning out, pruinose, concolorous with hymenial surface or white to off-white. HYPHAL SYSTEM monomitic with clamped generative hyphae. SUBICULUM indistinct, up to 30 µm thick; subicular hyphae 3.5–5.5 µm diam, clamped, moderately branched, walls thin, hyaline, smooth. SUBHYMENIUM up to 30 µm thick, a dense, compact tissue; subhymenial hyphae similar to subicular hyphae. HYMENIUM up to 50 µm thick, a dense palisade of haplohyphidia, cystidia, and basidia. HAPLOHYPHIDIA embedded, numerous, cylindrical, tapering slightly toward apex, (13–)23–40 × 3–4 µm, clamped at base, simple, unbranched, walls thin, hyaline, smooth. CYSTIDIA embedded, inconspicuous, clavate to broadly fusiform with an obtuse apex, 17–22 × 5.5–7.5 µm, clamped at base, walls thin, hyaline, smooth. BASIDIA clavate, 28–45(–55) × 6.5–8(–9) µm, clamped at base, walls thin, hyaline, smooth; 4-sterigmate. BASIDIOSPORES cylindrical, (9.3–)10–12(–13) × 5–6 µm, average of 16 spores 10.9 ± 1.0 × 5.6 ± 0.3 µm, Q = 1.9*, with oil-like globules, walls thin, hyaline, smooth, acyanophilous, not reacting in Melzer's reagent.



FIGS. 1–2. Line drawings of microscopic elements.
1. *Radulomyces roseolus* holotype (TAA16822). 2. *Corticium cremeoalbum* holotype (Höhnel 684).
A, basidia; B, cystidia; C. haplohyphidia; D, basidiospores.

COMMENTS — In the type, the well-decayed wood is broken up into fragments that support even smaller fragments of the basidiome. On one fragment is a brown-colored basidiome, which represents a *Tomentella* species, probably *T. sublilacina* (Ellis & Holw.) Wakef. Observations of the type correlate closely to the protologue except for minor differences. For example, the basidiospores observed were slightly smaller than originally cited —10–14(–15) × 5.5–6.5 (–7) µm — and yellow resinous materials in the hymenium and subiculum described in the protologue were not observed. In addition, the hymenium color is described as "incarnato-roseum, nonnumquam cremeo coloratum", but pink-colored hymenia were not observed in the type material, possibly because the pink color of fresh specimens fades to cream in dried material. Although the presence of haplohyphidia probably led to the placement of this taxon in *Radulomyces,* most *Radulomyces* species have thicker, robust basidiomes with distinct tubercules or spines. In a note included in the type envelope, B. Duhem noted a similarity of *R. roseolus* with *H. cremeoalbum* and suggested that they were conspecific.

Corticium cremeoalbum Höhn. & Litsch., Wiesner-Festschrift p. 63. 1908. FIG. 2

HOLOTYPE: (AUSTRIA) Wiener Wald, am Sattelberg bei Preßbaum, auf morschem Nadelholz, 2 October 1901, Höhnel no. *684* (*FH 00258439*).

BASIDIOME resupinate, widely effuse, thin, up to 75 µm thick, subceraceous to membranous. HYMENIAL SURFACE discontinuous, smooth to slightly uneven with barely differentiated warts, pruinose to porulose, yellowish white (4A2) to greyish yellow (4B3). MARGIN indistinct, thinning out, pruinose, concolorous with hymenial surface. HYPHAL SYSTEM monomitic with clamped generative hyphae. SUBICULUM up to 40 µm thick, composed of partially agglutinated hyphae arranged perpendicular to substrate; subicular hyphae 5–7 µm diam, clamped, moderately branched, walls thin, hyaline, smooth. SUBHYMENIUM indistinct. HYMENIUM up to 40 µm thick, a dense palisade of haplohyphidia, cystidia, and basidia. HAPLOHYPHIDIA embedded, scattered, cylindrical or tapering slightly toward apex, 23–25 × 5 µm, clamped at base, simple, unbranched, walls thin, hyaline, smooth. CYSTIDIA embedded, scattered, broadly fusoid to ovoid, 16–21 × 6–8.5 µm, clamped at base, walls thin, hyaline, smooth. BASIDIA more or less cylindrical with slight, irregular constrictions or clavate, 30–55 × (6.5–)8–10 µm, clamped at base, walls thin, hyaline, smooth; 4-sterigmate. BASIDIOSPORES broadly cylindrical (9.5–)10–12(–13) × 6–7 µm, average of 20 spores 11.5 ± 0.8 × 6.3 ± 0.3 µm, Q = 1.8*, with oil-like globules, walls thin, hyaline, smooth, acyanophilous, not reacting in Melzer's reagent.

COMMENTS — The type of *C. cremeoalbum* is in good condition. The protologue, however, does not mention the presence of haplohyphidia or fusoid cystidia. Basidiospore length, given in the protologue as 10–14 × 5.5–6.5 µm,

is slightly longer than observed. Except for these differences, the type does not deviate significantly from the protologue. Litschauer's specimen, mislabeled as holotype in Eriksson & Ryvarden (1975, p. 464), differs from the holotype at FH in lacking cystidia. Haplohyphidia are illustrated but interpreted as immature basidia.

No significant discrepancies were observed between the types of *R. roseolus* and *C. cremeoalbum*. In fact, the morphological similarities are overwhelming, and one can only conclude that these taxa are conspecific. An additional 25 herbarium specimens of *H. cremeoalbum* were studied to provide the expanded and inclusive description below.

Species description

Hyphoderma cremeoalbum (Höhn. & Litsch.) Jülich, Persoonia 8(1): 80. 1974.

FIG. 3

= *Corticium cremeoalbum* Höhn. & Litsch., Wiesner-Festschrift p. 63. 1908.
= *Radulomyces roseolus* Parmasto, Consp. syst. cortic. p. 222. 1968.
= *Cerocorticium roseolum* (Parmasto) Jülich & Stalpers, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk. II 74: 72. 1980.

BASIDIOME resupinate, widely effuse, thin, up to 200 µm thick, subceraceous to membranous. HYMENIAL SURFACE smooth to slightly uneven, sometimes verruculose, up to 3 warts per mm, sometimes discontinuous, porulose to pruinose or subfelty, yellowish white [(2–4)A2], dull yellow [3B3], pale yellow [4A2], orange white [5A(2–3)], yellowish grey [4B2], greyish yellow [(4–5)B3], pale orange [5A3], or greyish orange [(5–6)B3], warts occasionally discolored brown. MARGIN thinning out, indistinct, pruinose. HYPHAL SYSTEM monomitic with nodose-septate generative hyphae. SUBICULUM up to 150 µm thick, a moderately dense tissue of partially agglutinated ascending hyphae and coarse, hyaline crystal clusters; subicular hyphae 3.5–7 µm diam, occasionally inflated up to 11 µm diam at nodes, clamped, moderately to frequently branched, walls thin, hyaline, smooth. SUBHYMENIUM indistinct, up to 30 µm thick, a moderately dense tissue of partially agglutinated, short-celled hyphae; subhymenial hyphae 4–8 µm diam, clamped, frequently branched, walls thin, hyaline, smooth. HYMENIUM up to 50 µm thick, a dense palisade of haplohyphidia, cystidia and basidia. HAPLOHYPHIDIA scattered to numerous, cylindrical or tapering slightly toward apex, (16–)22–35(–48) × 3–6 µm, clamped at base, simple, rarely branched, walls thin, hyaline, smooth. CYSTIDIA enclosed, scattered, broadly fusoid to ovoid, rarely globose, 14–28 × 6–14 µm, clamped at base, walls thin, hyaline, smooth. BASIDIA clavate, suburniform to subcylindrical with slight, irregular constrictions, (23–)30–55 × 6.5–10.5 µm, clamped at base, walls thin, hyaline, smooth; 4-sterigmate. BASIDIOSPORES broadly cylindrical to cylindrical, (9.5–)10–14(–17) × 5–7(–8) µm, average size 11.6–13.4 × 5.5–6.6

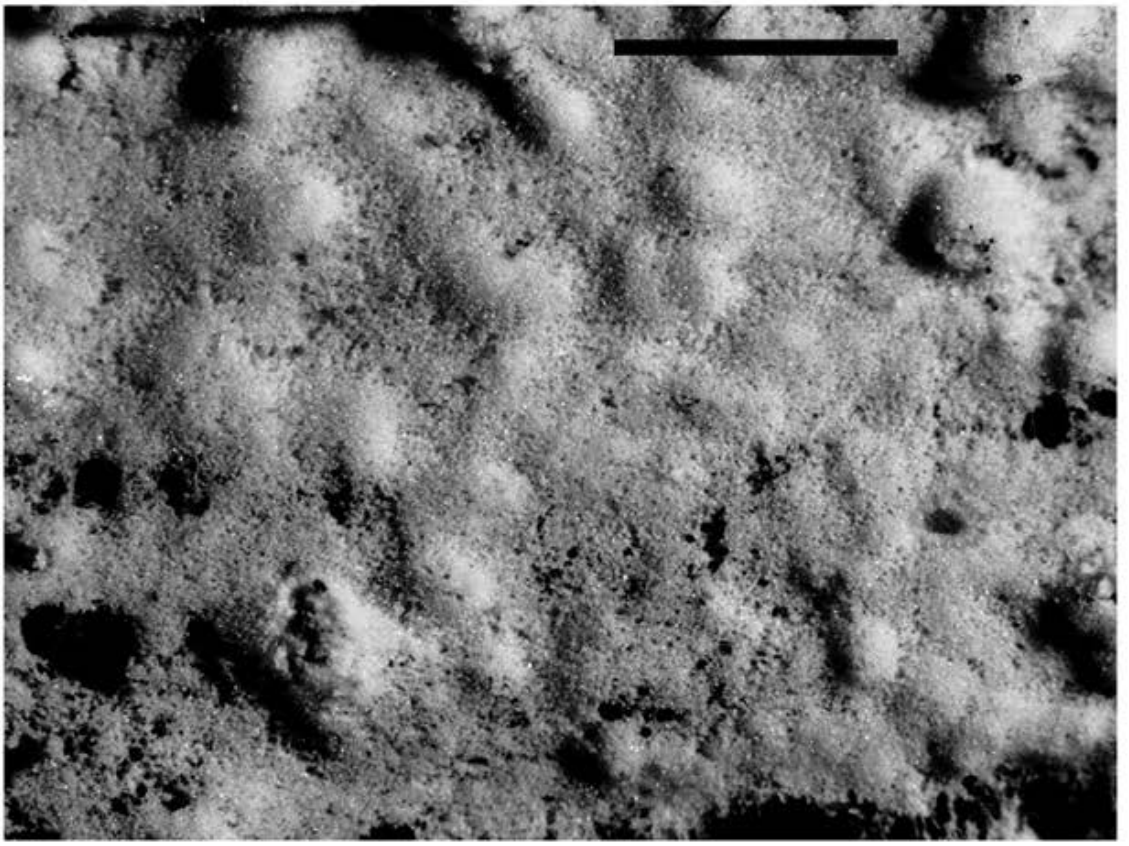


FIG. 3. Verruculose basidiome surface of *Hyphoderma cremeoalbum* (KHL4100). Bar = 1 mm.

µm, Q = 2*–2.1, often containing oil-like globules, occasionally germinating, walls thin, hyaline, smooth, acyanophilous, not reacting in Melzer's reagent.

HABITAT — Well-decayed wood and bark of gymnosperms, especially *Picea*, and angiosperms.

DISTRIBUTION — Argentina, Austria, Finland (Kotiranta & Larsson 1989), France, Georgia, Germany (Grosse-Brauckmann 1990), Italy, New Zealand, Norway, Romania, Spain (Hjortstam et al. 1981, Tellería 1990), Sweden, Switzerland, Turkey, United States (Washington).

HOLOTYPE SPECIMENS EXAMINED — *Radulomyces roseolus* and *Corticium cremeoalbum* – see above.

REPRESENTATIVE SPECIMENS EXAMINED — **ARGENTINA.** DEPARTAMENTO CHUBUT: Languiñeo, Lago Guacho, on (well-decayed) *Nothofagus pumilio* (Poepp. & Endl.) Krasser, 18 April 1997, A Greslebin *807*; Tierra del Fuego, DEPARTAMENTO USHUAIA: Estanica El Valdéz, on (well-decayed) N. *pumilio*, 04–05 March 1996, A. Greslebin *225* and *354*. **AUSTRIA.** Salzburg, Hohe Tauern, Taxenbach, 1200 m s.m., on *Picea abies* (L.) H. Karst., 13 July 1997, W. Dämon, *RP96/257E* (Herb. Dämon); Kalkalpen, Golling, 1500–1600 m s.m., on *P. abies*, 10 August 1997, W. Dämon, *RP96/257G* (Herb. Dämon). **FRANCE.** Forêt de Fontainebleau, Gorge aux Loups, parcella 527, on decayed trunk of *Fagus sylvatica* L., 31 October 2006, E. Martini *9490* (Herb. Martini). **Italy.** Riserva di

Sesso Fratino (FC), 720 m, on *Abies alba* Mill., 10 October 1991, A. Bernicchia *5651* (HUBO). **New Zealand.** Bay of Plenty, Te Waiiti, on decaying wood (bark), 17 May 2006, B.C. Paulus and P.R. Johnston, *BCP3640*, *PDD89111* (PDD). **Norway.** Hedmark, Löten, Gitvola, on well-decayed, decorticated *Picea* log, 11 September 1986, K.-H. Larsson *6508*, *GB1773*, *GB0052597* (GB). **Romania.** Neamt, Monastry Sihastria, in *Fagus* forest, on decayed, decorticate *Fagus* log, 17 October 1985, N. Hallenberg *9216*, *GB1549*, *GB0052600* (GB). **Sweden.** Dalarna: Särna Parish, Fulufjället at Göjån, close to Falun, on (decorticate, decayed) *Picea abies* 10 September 2004, K.-H. Larsson *12404*, *GB0052601* (GB); Lycksele Lappmark: Sorsele Parish, Grannäs, Västra Lairobäcken, on timber at abandoned saw mill, 28 August 1983, K.-H. Larsson *4110*, *GB885*, *GB0052598* (GB); Lycksele Lappmark Kirjesålandet, Vittertj. in alpine *Picea-Betula* forest, on stem of *Betula*, 16 August 1982, K.-H. Larsson *2677*, *GB456*, *GB0052766* (GB). **Switzerland.** (Tessin) Malvaglia, on decayed coniferous wood, 19 September 1987, E. Martini *1206* (herb. Martini); (Tessin) Meride, Bagno, on decayed, decorticated *Tilia cordata* Mill., 2 June 2007, E. Martini *9834* (Herb. Martini). **Turkey.** NE Anatolia, Trabzon area, Sumela Monastry, on (decorticate, decayed) *Picea* wood, 2 October 1989, N. Hallenberg *11538*, *GB2270*, *GB0052599* (GB). **United States.** Washington: Olympic National Forest, Quinault Research National Area, Plot 10-1-A-5, on decayed *Picea sitchensis* (Bong.) Carrière log, 15 October 1992, H.H. Burdsall, Jr. and M. Banik, *HHB14826* (CFMR); Plot 10-1-A-13, on bark of *P. sitchensis*, 15 October 1992, H.H. Burdsall, Jr., *HHB14834* (CFMR).

Comments — *Hyphoderma cremeoalbum* is characterized by thin, smooth to verruculose basidiomes, cylindrical basidiospores, haplohyphidia, and enclosed fusoid cystidia. Because the cystidia are enclosed in the hymenium and haplocystidia are barely differentiated, they are easily overlooked. The description and illustrations of *H. cremeoalbum* in Eriksson & Ryvarden (1975) does not include information on cystidia, and haplohyphidia are interpreted as developing basidia. Hallenberg (1991) found that haploid isolates of *H. cremeoalbum* from Norway, Sweden, Turkey and Romania were partially or fully compatible. Although most frequently collected in Europe, *H. cremeoalbum* is widely distributed as evidence by collections from northwestern United States, southern Argentina (Greslebin 2002, Greslebin & Rajchenberg 2003), and New Zealand.

There are three species of *Hyphoderma* morphologically similar to *H. cremeoalbum*. In *Hyphoderma nemorale* K.H. Larss. and *H. incrustatum* K.H. Larss., the cylindrical basidiospores are slightly narrower (Q = 2.55 and 2.57, respectively) than in *H. cremeoalbum*. Additionally, they produce large, cylindrical, embedded cystidia as well as capitate or subcapitate hymenial cystidia (Larsson 1998). Like *H. cremeoalbum*, *H. sibiricum* (Parmasto) J. Erikss. & Å. Strid has haplohyphidia but significantly smaller basidia, 25–35(–40) × 5–7 µm, and basidiospores, 7–8(–9) × (4–)4.5–5 µm (Eriksson & Ryvarden 1975; Ginns 1982).

Hyphoderma cremeoalbum was reported on *Quercus ilex* L. from Sardinia, AB6632 (Bernicchia et al. 2008); however, this specimen appears to be

H. malenconii (Manjón & G. Moreno) Manjón et al. Jung (1987) cited two specimens of *H. cremeoalbum* from southeastern United States on *Abies fraseri* (Pursh) Poir. but neither is correctly identified. TENN 46846 is probably *H. pilisetum* (Burt) Liberta. In TENN 46975, the basidiospores are narrower than typical for *H. cremeoalbum*; this specimen appears to represent *H. occidentale* (D.P. Rogers) Boidin & Gilles. From Arizona, Gilbertson & Bigelow (1998) reported *H. cremeoalbum*, RLG 16887, on *Pseudotsuga menziesii* (Mirb.) Franco, but this specimen is *Peniophorella praetermissa* (P. Karst.) K.H. Larss. Gilbertson et al. (2002) listed *H. cremeoalbum* from Moloka`i, Hawaii, on *Eucalyptus robusta* Sm. The specimen, RLG 22966, has numerous fusoid gloeocystidia and appears to be an undescribed species with close affiliation to *P. praetermissa*. The report of *H. cremeoalbum* from the Leningrad region on *Populus tremula* L. should be reconfirmed because cystidia and haplohyphidia were not observed (Zmitrovich & Spirin 2002). Similarly, reports of *H. cremeoalbum* from Italy on *Castanea sativa* Mill. (Mayrhofer et al. 2001) and from China (Maekawa & Zang 1995, Maekawa et al. 2002), need to be confirmed.

Acknowledgements

The curators of the following herbaria arranged specimen loans: ARIZ, BPI, FH, GB, HUBO, PDD, TAA, TENN. Elia Martini of Bignasco, Switzerland, and Dr. Wolfgang Dämon of Salzburg, Austria, loaned specimens from their private herbaria. Drs. Harold H. Burdsall, Jr. and Wolfgang Dämon reviewed an earlier draft of this manuscript and provided valuable comments and corrections.

Literature cited

Bernicchia A, Arras L, Piga A, Ryvarden L. 2008. Biodiversity of Sardinian aphyllophoraceous fungi. Synopsis Fungorum 25: 53–124.

Donk MA. 1964. A conspectus of the families of *Aphyllophorales*. Persoonia 3: 199–324.

Eriksson J, Ryvarden L. 1975. The *Corticiaceae* of North Europe. Volume 3. *Coronicium – Hyphoderma*. Fungiflora: Oslo (Norway).

Gilbertson RL, Bigelow DM. 1998. Annotated check list of wood-rotting basidiomycetes of the sky islands of southeastern Arizona. Journal of the Arizona-Nevada Academy of Science 31: 13–36.

Gilbertson RL, Bigelow DM, Hemmes DE, Desjardin DE. 2002. Annotated check list of wood-rotting basidiomycetes of Hawai`i. Mycotaxon 8: 215–239.

Ginns J. 1982. Hyphoderma sibiricum. Fungi Canadenses No. 230. Agriculture Canada: Ottawa (Canada).

Greslebin AG. 2002. Flora Criptogámica de Tierra del Fuego. *Fungi, Basidiomycota, Aphyllophorales: Coniophoraceae, Corticiaceae, Gomphaceae, Hymenochaetaceae, Lachnocladiaceae, Stereaceae, Thelephoraceae. Tulasnellales: Tulasnellaceae.* Consejo National de Investigaciones Científicas y Técnicas de la República Argentina (CONICET): Buenos Aires (Argentina). 212 pp.

Greslebin AG, Rajchenberg M. 2003. Diversity of *Corticiaceae* sens. lat. in Patagonia, Southern Argentina. New Zealand Journal of Botany 41: 437–446.

Grosse-Brauckmann H. 1990. Corticioide Basidiomyceten in der Bundesrepublik Deutschland. Funde 1960–1989. Zeitschrift für Mykologie 56(1): 95–130.

Hallenberg N. 1991. Pairing tests with species of *Aphyllophorales* (*Basidiomycetes*) from two phytogeographically isolated areas. Mycotaxon 42: 355–386.

Hjortstam K, Telleria MT, Ryvarden L, Calonge FD. 1991. Notes on the *Aphyllophorales* of Spain II. Nova Hedwigia 34: 525–538.

Jung HS. 1987. Wood-rotting *Aphyllophorales* of the southern Appalachian spruce-fir forest. J. Cramer: Berlin (Germany). 260 pp.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth & Bisby's Dictionary of the fungi. 10th ed. CAB International: Wallingford (United Kingdom). 771 pp.

Kotiranta H, Larsson K-H. 1989. New or little collected corticolous fungi from Finland (*Aphyllophorales, Basidiomycetes*). Windahlia 18: 1–14.

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour. Eyre Methuen: London (United Kingdom). 252 pp.

Langer E. 2001. Phylogeny of non-gilled and gilled basidiomycetes – DNA sequence inference, ultrastructure and comparative morphology. Habilitationsschrift, Tübingen University, Tübingen (Germany). 54 pp.

Larsson K-H. 1998. Two new species in *Hyphoderma*. Nordic Journal of Botany 18: 121–127.

Larsson K-H. 2007. Molecular phylogeny of *Hyphoderma* and the reinstatement of *Peniophorella*. Mycological Research 111: 186–195. doi:10.1016/j.mycres.2007.10.001

Larsson K-H, Larsson E, Kõljalg U. 2004. High phylogenetic diversity among corticioid homobasidiomycetes. Mycological Research 108: 983–1002. doi: 10.1017/S0953756204000851

Maekawa N, Zang M. 1995. Corticiaceous fungi (*Aphyllophorales, Basidiomycotina*) collected in Yunnan, China. Bulletin of the National Science Museum, Tokyo 21: 87–84.

Maekawa N, Yang ZL, Zang M. 2002. Corticioid fungi (*Basidiomycetes*) collected in Sichuan Province, China. Mycotaxon 83: 81–95.

Mayrhofer S, Peintner U, Bernicchia A. 2001. Aphyllophoraceous fungi on *Castanea sativa* in Italy. Mycotaxon 80: 267–279.

Parmasto E. 1968. Conspectus systematis corticiacearum. Academiae Scientiarum R.P.S.S. Estonicae: Tartu (Estonia). 261 pp.

Parmasto E, Nilsson RH, Larsson K-H. 2004. Cortbase version 2. Extensive updates of a nomenclatural database for corticioid fungi (*Hymenomycetes*). Phyloinformatics 5: 1–7.

Telleria MT. 1990. Annotated list of the *Corticiaceae*, sensu lato (*Aphyllophorales, Basidiomycotina*), for peninsular Spain and Balearic Islands. Bibliotheca Mycologica 135: 1–152.

Thiers B. [continuously updated]. Index Herbariorum. A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/

Zmitrovich IV, Spirin WA. 2002. Notes on the aphyllophoroid fungi of the Leningrad region I. Novosti Sistematiki Nizshikh Rastenii 36: 36–44.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.109

Volume 114, pp. 109–114 *October–December 2010*

Taxonomic studies of *Alternaria* from Russia: new species on *Asteraceae*

PHILIPP B. GANNIBAL

phbgannibal@yandex.ru

Lab. of Mycology and Phytopathology, All-Russian Institute of Plant Protection
Shosse Podbelskogo 3, Saint Petersburg, 196608, Russia

Abstract — Two new species are added to the 32 *Alternaria* species known on plants of *Asteraceae*. The newly described species are *A. silybi* from *Silybum marianum* and *Alternaria simmonsii* from *Sonchus* sp.

Key words — milk thistle, sow thistle

Introduction

There are 32 accepted *Alternaria* species known on plants of *Asteraceae* (Simmons, 2007). Most of them (24) belong to the group of large-spored species characterized by relatively long conidia with filiform beak. Usually they are pathogenic and have strong host specialization. During the study of mycobiota of weeds and wild herbaceous plants we have obtained a few isolates of two new *Alternaria* species on leaves of milk thistle and sow thistle. The leaves collected had a number of spots and abundant sporulation of *Cercospora* sp. on leaves of milk thistle and *Septoria sonchifolia* Cooke on sow thistle. No *Alternaria* conidia were found on these leaves until specimens were held in damp chambers. Monoconidial isolates were obtained from sporulation produced under damp-chamber conditions.

Materials and methods

For morphological observations cultures were obtained under conditions closely approximate to those recommended by E.G. Simmons (1992, 2007). Monoconidial isolates were cultivated in Petri dishes on potato-carrot agar (PCA) and V-4 (for 1 l medium: 150 ml juice mixture [beet, celery, carrot, tomato 4:3:2:1] and 20 g agar; Mikhailova et al., 2002), which is analogous to V-8, at 24°C under light/dark cycle (12/12 h). Preparations for microscopy

were made after 10–12 days of growth. All strains are kept in the All-Russian Institute of Plant Protection (St. Petersburg) and the All-Russian Collection of Microorganisms – VKM (Moscow). The dried leaves and dried cultures on PCA and V-4 of all strains are available at the herbarium of the Institute – LEP.

Taxonomic description

Alternaria silybi Gannibal, **sp. nov.** FIG. 1

MYCOBANK MB518505

Ex cultura in agaro V-4 descripta. Conidiophora primaria solitaria, simplicia, ad ca. 50–90(–150) × 5.0–5.5 µm, apice dilatato ad 6.0–7.0 µm. Conidia solitaria; corpus conidiorum in maturitate longe anguste ellipsoideum vel subcylindricum, 50–90 × 15–22 µm, 5–10 transverse septatum, 1-longiseptatum in 1–4(–5) segmentis transversis, laeve, dilute brunneum, 1(–2)-rostratum. Rostrum filamentosum, 70–190 × 2.5–3.5 µm, 1–4(–5) transverse septatum. Habitatio typi in foliis vivis Silybum marianum, Russia, Primorskiy kray, Vladivostok, 1.IX.2006, leg. Ph. B. Gannibal.

TYPE – Rusia. Primorskiy kray: Vladivostok, Trudovoe, Experimental and Industrial Farm 'Fruit and Berry Experimental Station' (43°18.18'N, 132°06.50'E), from leaf lesion of milk thistle, *Silybum marianum* (L.) Gaertn. (*Asteraceae*), 1.IX.2006, coll. Ph.B. Gannibal. **(Holotype**, LEP 12650 (dried V-4 agar culture); live strain, MF-P050011 (VKM F-4109)).

ETYMOLOGY: from the Latin *Silybum*, the host genus (milk thistle).

DESCRIPTION – On V-4 CULTURES are dark olive-grey, later almost black, velvety; AERIAL MYCELIUM is very weak or absent; diameter of 7-d old COLONIES is about 60 mm. On PCA COLONIES are almost colorless with pale brown or olive shade; AERIAL MYCELIUM is very weak or absent; diameter of 7-d old COLONIES is 25–35 mm.

On V-4 agar PRIMARY CONIDIOPHORES usually are solitary and uncrowded. They are simple with a single apical conidiogenous locus or sometimes with two loci; (35–)50–90(–150) × 5.0–5.5 µm swollen at the apex up to 6.0–7.0 µm. CONIDIA are solitary. In old cultures occasionally they can form CHAINS of 2 conidia.

JUVENILE CONIDIA are pale and wedge-shaped, long-narrow ellipsoid or subcylindric; usually they initiate production of a narrow-taper BEAK at a very early stage of development. The BODY of mature conidia is long-ellipsoid, subcylindric or long-ovoid; usually pale olive brown, sometimes dark; 50–80 × 15–20(–22) µm. Most conidial BODIES have (5–)7–10 TRANSVERSE SEPTA. LONGISEPTA may be absent or present as 1(–2) in 1–3 transverse segments, occasionally in 4–5 segments. The CONIDIAL BODY is slightly constricted near the transverse septa. Sometimes CONIDIA have specific shape of composite cylinder due to blocks of 1–3 transverse segments that have conspicuously different width in comparison with neighbor segments. Conidia have one

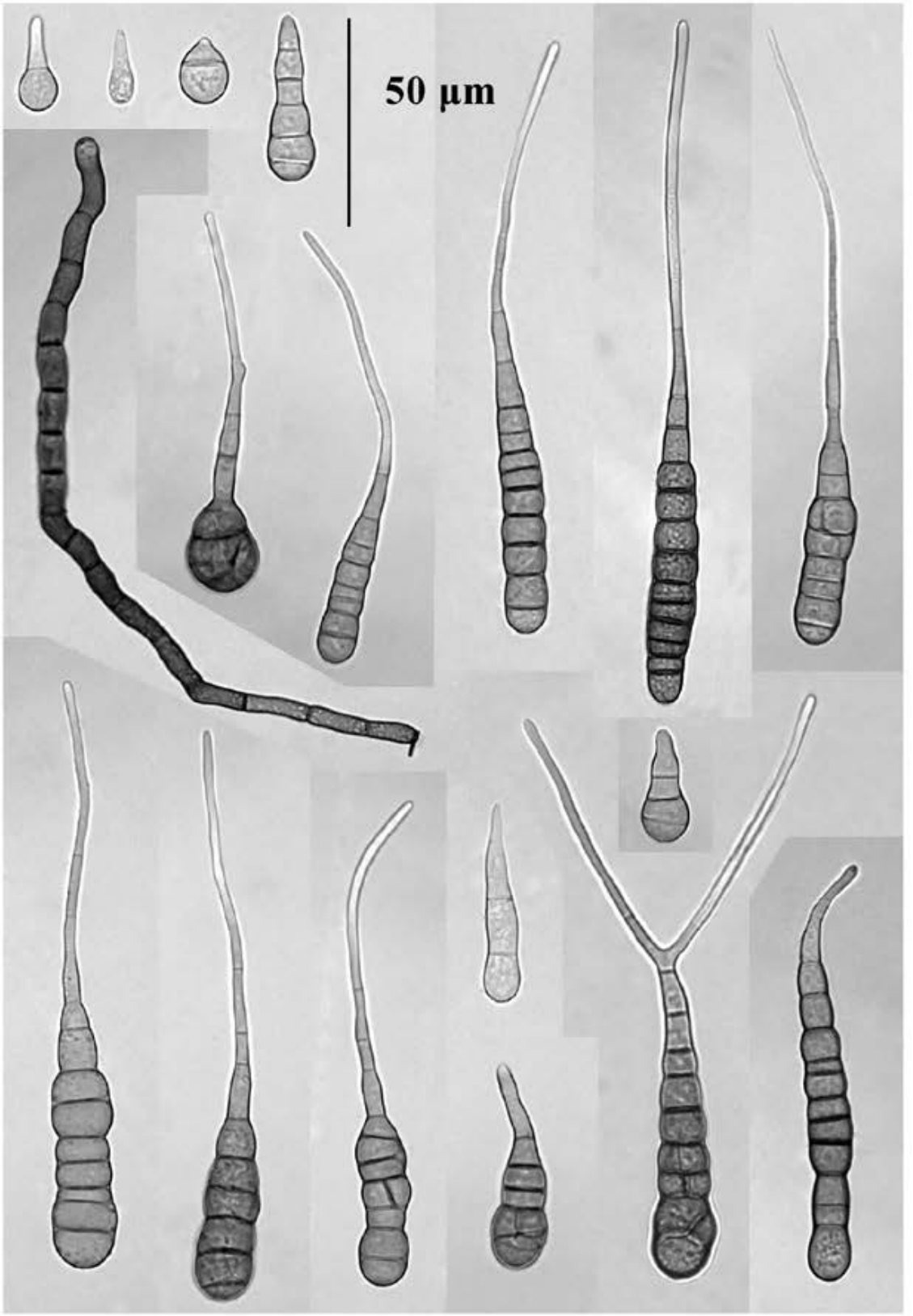


FIG. 1. *Alternaria silybi*: conidia and conidiophores ex holotype

BEAK, very rarely produce two beaks and/or apical and lateral SECONDARY CONIDIOPHORES. Filamentous BEAK length reaches into a range of 70–130 (–190) µm; beaks are ca 3 µm wide throughout most of their length and have 1–4 (–6) transverse septa. In most cases length of the BEAKS is the same as length of conidial body or rather more; rarely the beak is two times longer.

On PCA CONIDIA are negligibly bigger, 50–90 × 15–22 µm (body) + 100–190 µm (beak).

STRAINS EXAMINED – **RUSSIA. PRIMORSKIY KRAY: Vladivostok**, Trudovoe, Experimental and Industrial Farm 'Fruit and Berry Experimental Station' (43°18.18'N, 132°06.50'E)—from leaf lesion of milk thistle, 1.IX.2006 (VKM F-4109 and F-4118). **PRIMORSKIY KRAY: Vladivostok**, Botanical Garden-Institute—from leaf lesion of milk thistle, 6.IX.2006 (VKM F-4117).

COMMENTS – *A. silybi* is similar to *A. protenta* E.G. Simmons, which was also found on *Asteraceae*. *A. silybi* differs by smaller maximal conidium body size, longer beak lengths, and smooth walls.

Alternaria simmonsii Gannibal, **sp. nov.** FIG. 2

MYCOBANK MB518504

Ex cultura in agaro V-4 descripta. Conidiophora primaria solitaria, simplicia, ad ca. 40–200 × 5–6 µm, brunnea. Conidia solitaria vel in catenis conidiorum bini. Corpus conidiorum late ovoideum vel ellipsoideum, ad 50–90 × 22–30(–36) µm; 5–8 transverse septatum, 1–3 longiseptatum, clare brunneum. Conidia rostrata vel erostrata, rostro longo ad 100 × 3 µm, 1–2(–4) transverse septata. Habitatio typi in foliis vivis Sonchus sp., Russia, Voronezhskaya oblast, Semilukskiy rayon, selo Veduga, 20.V.2005, leg. I. V. Bilder.

TYPE – Russia. Voronezhskaya oblast: Semilukskiy rayon, selo Veduga, from leaf lesion of sow thistle, *Sonchus* sp. (*Asteraceae*), 20.V.2005, coll. I.V. Bilder. (**Holotype**, LEP 12651 (dried V-4 agar culture); live strain, MF-P024011 (VKM F-4110)).

ETYMOLOGY: the epithet honours Emory G. Simmons, who has studied *Alternaria* taxonomy for 50 years.

DESCRIPTION – On V-4 CULTURES are dark olive, later almost black, velvety; AERIAL MYCELIUM is sparse; diameter of 7-d old COLONIES is ca 65 mm. On PCA COLONIES are pale brown or light olive grey; AERIAL MYCELIUM is very weak or absent; diameter of 7-d old COLONIES is ca 40 mm.

PRIMARY CONIDIOPHORES on V-4 agar arise directly from the agar substrate surface or from branches of the woolly aerial mycelium. Usually they are solitary, simple, straight or slightly sinuous, 40–200 × 5–6 µm, with a single apical conidiogenous locus or sometimes with two loci. CONIDIA are solitary; sometimes they can form chains of 2 conidia.

JUVENILE CONIDIA are ovate, rarely ellipsoid or cylindrical, light brown, commonly without beak. The MATURE CONIDIUM BODY is brown, long ovoid, ellipsoid or bag-shaped, sometimes asymmetric, and becomes fully developed in a size range of ca 50–90 × 22–30(–36) µm. It has 5–8 main transverse

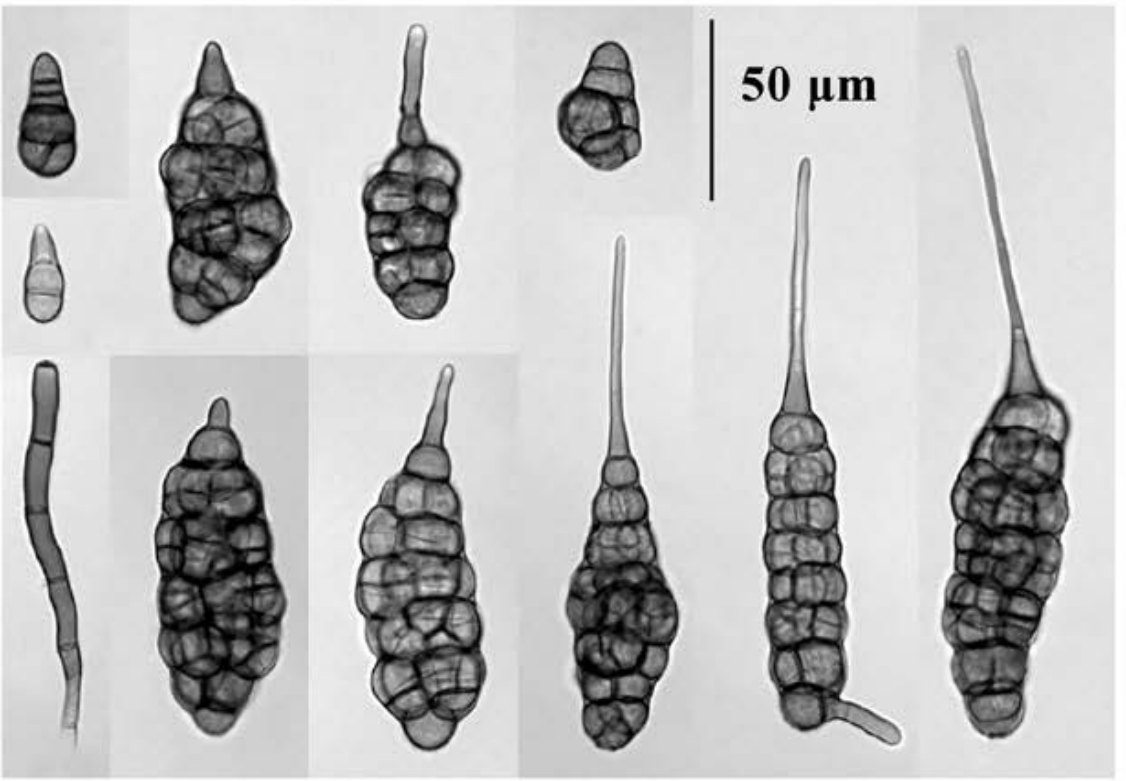


FIG. 2. *Alternaria simmonsii*: conidia and conidiophores ex holotype

constricting divisions. Nearly all well-developed conidia have 1–3 longitudinal and 1 secondary transverse DISTOSEPTUM divisions in most of the transverse segments. The filamentous, unbranched solitary BEAK frequently is lacking; when present it is variable in length, and sometimes becomes as long as 100 µm. BEAKS are ca 3 µm wide throughout most of their length and have 1–2(–4) transverse septa. Sometimes BEAKS are slightly swollen at the end. Some basal conidia form 1 apical or/and 1–2 lateral SECONDARY CONIDIOPHORES.

On PCA the CONIDIAL BODY has a more regular ellipsoid shape than on V-4 and is smaller (40–75 × 17–23 µm); however, the BEAK is conspicuously longer and sometimes reaches 155 µm long.

STRAINS EXAMINED – **RUSSIA. VORONEZHSKAYA OBLAST: Semilukskiy rayon**, selo Veduga—from leaf lesion of sow thistle, 20.V.2005 (VKM F-4110 and F-4119).

Acknowledgments

It is my pleasure to acknowledge the attention of Dr. Emory G. Simmons and Dr. Vadim A. Mel'nik to their presubmission reviews of this article.

Literature cited

Mikhailova LA, Gogoleva SG, Gultyaeva EI. 2002. The interactions of *Bipolaris sorokiniana* strains and wheat samples. Mikol. Fitopatol. 36(2): 63–66.

Simmons EG. 1992. *Alternaria* taxonomy: current status, viewpoint, challenge. 1–35, in J Chelkowski, A Visconti (eds), *Alternaria* biology, plant diseases and metabolites. Amsterdam: Elsevier Science Publishers.

Simmons EG. 2007. *Alternaria*: an identification manual. Utrecht: CBS. 775 pp.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.115

Volume 114, pp. 115–126 October–December 2010

The *Entolomataceae* of the Pakaraima Mountains of Guyana 5: new species of *Alboleptonia*

T.W. Henkel*[1], M.C. Aime[2], D.L. Largent[1] & T.J. Baroni[3]

* *twh5@humboldt.edu*

[1]*Department of Biological Sciences, Humboldt State University Arcata, California, USA. 95521*

[2]*Department of Plant Pathology and Crop Physiology, Louisiana State University Agricultural Center, Baton Rouge, Louisiana, USA. 70803*

[3]*Department of Biological Sciences, State University of New York—College at Cortland, New York, USA. 13045*

Abstract—This paper is the fifth in a series documenting the *Entolomataceae* taxa (*Agaricales*, *Basidiomycota*) from Guyana. Three new species are described — *Alboleptonia angustospora*, *A. cystidiosa*, and *A. minima* — occurring in tropical rainforests of the Upper Potaro River Basin in Guyana's Pakaraima Mountains. Macromorphological, micromorphological, and habitat data are provided for each. *Alboleptonia* has not been previously reported from Guyana.

Key words—*Agaricomycotina*, fungal taxonomy, Guayana Highlands, Guiana Shield, neotropics

Introduction

Species of *Alboleptonia* Largent & R.G. Benedict are easily classified into the *Entolomataceae* (*Agaricales*) due to their dull pink basidiospores that are angular in all views. *Alboleptonia* was erected (Largent & Benedict 1970) to accommodate entolomatoid species that combine diagnostic features of the type species, *Alboleptonia sericella* (Fr.) Largent & R.G. Benedict, including a white to pale cinereous basidioma, a silky to appressed-fibrillose or minutely appressed-squamulose, opaque (NOT translucent striate), non-hygrophanous pileal surface, which microscopically is composed of an entangled layer of hyphae, unique color reactions in Ehrlich's reagent, and a low urea concentration. Also, under scanning electron microscopy *Alboleptonia* basidiospores exhibit a dihedral base and a pair of 4-angled facets on the apico-adaxial side that

results in a 5-sided apical facet (Pegler & Young, 1978). This original concept of *Alboleptonia* has subsequently been applied by Largent (1994), Baroni & Lodge (1998), Pegler (1983, 1997), and Orton (1991a, b). A recent molecular study (Co-David et al. 2009), which putatively shows *Alboleptonia* as polyphyletic, suffered from small sample size (two species) and incongruent application of generic/subgeneric concepts regarding *Alboleptonia* sensu Largent & Benedict and *Entoloma* subgen. *Alboleptonia* (Largent & R.G. Benedict) Noordel. (Noordeloos 1979, 1987, 1988, 1992, 2004).

New World tropical and subtropical species meeting the diagnostic requirements of *Alboleptonia* sensu Largent & Benedict have been found in the Lesser and Greater Antilles (Baroni & Lodge 1998; Pegler 1983), Trinidad and Venezuela (Dennis 1953, 1970), Brazil (Pegler 1997), and elsewhere in South America (Horak 1977, 1982). Over the course of several years of field expeditions in a remote region of the Pakaraima Mountains of Guyana, we have collected fungi representing at least four distinct entolomatoid taxa corresponding to *Alboleptonia* sensu Largent & Benedict, three of which are described here.

Materials and methods

Collections were made during the 2001–03, 2006, and 2009 May–July rainy seasons and the 2003 and 2009 December rainy seasons from the Upper Potaro River Basin, within a 15 km radius of a permanent base camp at 5°18'04.8"N; 59°54'40.4"W; elevation 710 m. This collecting area, located in an undulating valley approximately 20 km east of Mt. Ayanganna (2200 m), is densely forested with a mosaic of primary *Dicymbe*-dominated and mixed forests of the *Eschweilera–Licania* association (Henkel 2003). Methods for field descriptions, microscopic analyses, and image capture were those of Largent et al. (2008). Fungi were field-dried with silica gel. Color designations follow Kornerup & Wanscher (1978) with color plates noted in parentheses (e.g., 4A7). Specimens were deposited in the following herbaria: BRG, HSU, and LSUM (Holmgren et al. 1990). Microscopic structures were measured as described in Largent (1994) and Largent et al. (2008a). Statistics determined include: means of basidiospore length and width, ± standard deviations; E, the quotient of length by width indicated as a range variation in n objects measured; Q, the mean of E-values; n = number of objects measured.

Taxonomy

Alboleptonia angustospora Largent, Aime & T.W. Henkel, **sp. nov.** FIG 1

MYCOBANK MB 518326

Pileus 10–17 mm latus, late convexus vel plano-convexus, ad centrum depressus, albus vel eburneus, implexus appressus fibrillosus, siccus. Lamellae adnatae, sub-adnexae, vel subdecurrentes, subdistantes, albae vel roseae; margine concolori, cystidiata. Stipes 33–57

× 1–3 mm, equalis, albus, glaber, apice pruinoso. Basidiosporae 5–6-angulares, 7.3–10 × 5.1–7.6 µm. Basidia 4-sterigmata, late cylindracea, 20–34.3 × 6.6–10.4 µm. Cheilocystidia abundantes, cylindro-clavata. Pleurocystidia carentes. Pileipellis constata e intricatis hyphis. Fibulae carentes.

TYPE: *Aime 3159* (BRG, **holotype**; LSUM, **isotype**).

ETYMOLOGY: *angustus* (L. adj.) = narrow; *-sporus* (L. adj.) = spored; referring to the narrow basidiospores.

KEY CHARACTERS — *Alboleptonia angustospora* is easily recognized as a member of *Alboleptonia* because of its white, non-hygrophanous, non-striate, convex-depressed (occasionally umbonate), entirely matted-tomentulose to matted-fibrillose pileus and its 5–6-angled, heterodiametric basidiospores. It is unique among macromorphologically similar species of *Alboleptonia* in its combination of cylindric to cylindro-clavate, somewhat strangulated cheilocystidia, 5–6-angled, heterodiametric basidiospores that average < 9 µm long and < 7 µm broad, and the lack of pleurocystidia, clamp connections, and pigmentation.

MACROCHARACTERS — PILEUS 10–17 mm broad, 5–8 mm high, broadly convex to plano-convex with a distinct central depression occasionally with a very small, blunt umbo, entirely matted-tomentulose to matted-appressed fibrillose, chalky white to off-white to pale cream (4A1–4A2) at times with a faint hint of yellow (2A4) at disc, opaque, dry, not hygrophanous, not translucent; margin somewhat downcurved, entire but under hand lens irregularly and finely crenulate. LAMELLAE subclose to subdistant, adnate, subadnexed, or subdecurrent, 1.5–2.4 mm tall, chalky white, faintly pink at maturity (5A2–5A3); margin concolorous, finely eroded-cystidiate under hand lens; lamellulae 3, of different lengths. STIPE 33–57 mm × 1–3 mm, equal, glabrous, occasionally white-pruinose at apex, concolorous, yellowing with age, cartilaginous, very fragile, hollow. BASAL MYCELIUM scant, white. ODOR none, pleasantly fungoid, or slightly fragrant; TASTE slightly fungoid. SPORE DEPOSIT not obtained.

MICROCHARACTERS — BASIDIOSPORES distinctly 5–6-angled, isodiametric in polar view, subisodiametric to heterodiametric (rarely isodiametric) in profile view, 7.3–10 × 5.1–7.6 µm (mean = 8.5 ± 0.56 × 6.44 ± 0.54 µm; E = 1.1–1.68, Q = 1.33 ± 0.12, n = 104). BASIDIA 4-sterigmate, broadly cylindric and rounded at the base, 20–34.3 (–38.4) × 6.6–10.4 µm (mean = 28.0 ± 2.9 × 8.8 ± 0.79 µm; E = 2.3–4.2, Q = 3.1 ± 0.49; n = 29). CHEILOCYSTIDIA abundant, cylindric to cylindro-clavate, many somewhat strangulated, 17.3–86.0 × 3.8–9.4 µm (mean = 46.8 ± 15.94 × 6.0 ± 1.28 µm; E = 2.15–19.13, Q = 7.72; n = 29). PLEUROCYSTIDIA absent. LAMELLAR TRAMA composed of parallel to subparallel, rather short hyphae, cells 44.8–145.1 × 2.4–15.9 µm. PILEIPELLIS an entangled layer of hyphae throughout; terminal cells cylindric to cylindro-clavate, 23.4–57.1 × 5.6–11.3 µm. PILEAL TRAMA composed of entangled hyphae, cells 44.3–140.2

× 6.3–21.0 µm. STIPITIPELLIS a cutis; hymenial clusters occasionally present; caulocystidioid elements 45.0–55.4 × 2.4–6.7 µm. REFRACTIVE HYPHAE scattered to abundant in the pileal trama. REFRACTIVE GRANULES, BRILLIANT GRANULES, and PIGMENTATION absent. CLAMP CONNECTIONS absent.

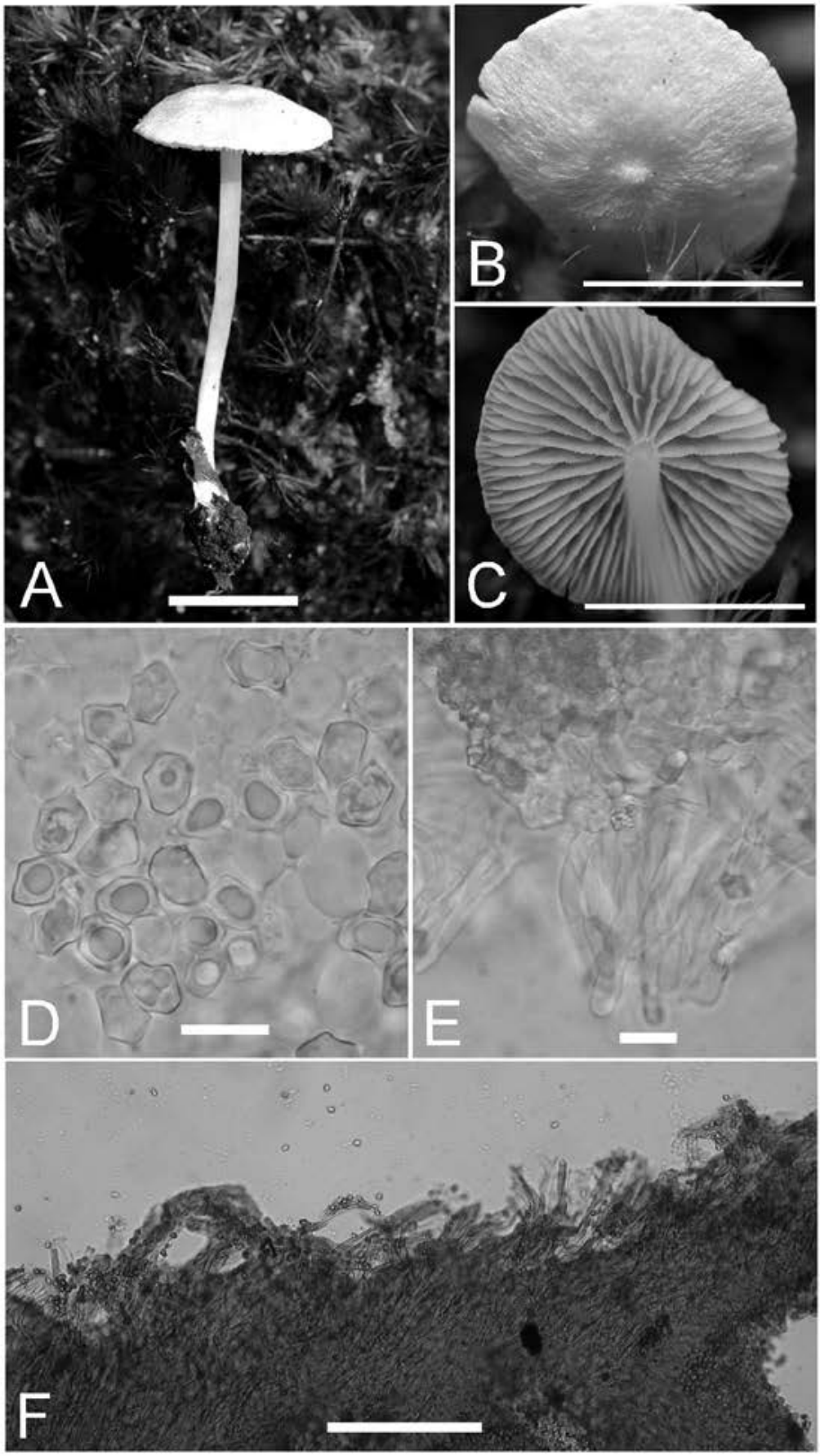
ECOLOGY, RANGE, DISTRIBUTION — Solitary on humic mat on forest floor or clay soil in mixed *Dicymbe* spp. forest, known only from the Upper Potaro River Basin of Guyana.

REPRESENTATIVE SPECIMENS EXAMINED. GUYANA. REGION 8: POTARO-SIPARUNI. Pakaraima Mountains. Upper Potaro River Basin, 15–20 km east of Mt. Ayanganna, environs of base camp located on Potaro River one km upstream from confluence with Whitewater Creek at 5°18′04.8″N, 59°54′40.4″W, elevation 710–750 m: vicinity of base camp, 11 May 2001, *Henkel 8095* (BRG; HSU); 2.5 km southeast of base camp, *Dicymbe* plot 2 in humic mat, 12 June 2002, *Aime 1978* (BRG; LSUM); 0.5 km west of base camp, in *Dicymbe* forest, 29 June 2002, *Aime 2161* (BRG; LSUM); 1 km southeast of base camp on Benny's ridge in clay soil, 2 July 2006, *Aime 3159* (BRG, **holotype**; LSUM, **isotype**); vicinity of Tadang Creek base camp, 29 December 2009, *Henkel 9148* (BRG; HSU).

COMMENTS — *Alboleptonia angustospora* resembles a group of species including *Entoloma parasericellum* Corner & E. Horak , *E. neosericellum* E. Horak, *E. subsericellum* Murrill, *E. peralbidum* Horak, *E. percandidum* Noordel., and *E. hololeucum* (Singer) E. Horak. *Alboleptonia angustospora* can be separated from this group of species by a combination of the following characters: cylindric to cylindro-clavate cheilocystidia, 5–6-angled, heterodiametric basidiospores that average < 9 µm in length and < 7 µm in width, and the lack of pleurocystidia, clamp connections, and pigmentation.

In Guyana, *A. angustospora* may be confused with *Alboleptonia minima* and *A. cystidiosa* (described here) as each of these species has a white basidioma with an appressed-fibrillose, opaque, non-translucent striate pileus, similarly shaped and sized basidiospores, and lacks clamp connections. *Alboleptonia minima* can be separated from *A. angustospora* by its small pileus (< 10 mm broad) and somewhat longer stipe (both of which lack cream or yellowish tones), dense tomentose basal mycelium, and anatomically similar stipitipellis, pileipellis, and lamellar edges that include non-strangulated cheilocystidia. *Alboleptonia cystidiosa* is distinct from *A. angustospora* due to its cylindro-clavate caulocystidia, clavate to obclavate cheilocystidia and pleurocystidia, and weakly acrid taste. In Guyana, several other as yet unidentified white entolomatoid species superficially resemble *A. angustospora*. However these taxa either have differently shaped basidiospores and/or a different pileipellis structure compared to *A. angustospora* (Henkel & Aime unpubl. data).

FIG. 1. Macro- and microscopic features of *Alboleptonia angustospora* (BRG HOLOTYPE Aime 3159). A. Basidioma. B. Matted-fibrillose pileus surface with umbo. C. Lamellae with cystidiate margins. Bar = 10 mm. D. Basidiospores. E. Cheilocystidia. Bar = 10 µm. F. Pileus surface in longitudinal section. Bar = 100 µm.


A
B
C
D
E
F

Alboleptonia earlei (Murrill) Largent & R.G. Benedict from Cuba and Costa Rica (Baroni & Lodge, 1998) is the only other neotropical *Alboleptonia* species known that lacks clamp connections and has basidiospores similar in size (7–9 × 5.5–6.5 µm) and shape to those of *A. angustospora*. *Alboleptonia earlei* can be differentiated by its lack of cheilocystidia and garlic or onion odor (Largent & Benedict 1970; Baroni & Lodge 1998).

Among Old World alboleptonioid fungi, *Entoloma inficetum* Corner & E. Horak from the Solomon Islands has many of the same characteristics as *Alboleptonia angustospora*. However, *E. inficetum* has a smooth pileus with an entirely repent pileipellis and cheilocystidia with a yellowish, protoplasmic pigment; in *A. angustospora*, the pileus is consistently matted-fibrillose to matted-tomentose, the pileipellis is an entangled hyphal layer that is never repent, and the cheilocystidia lack pigment (Horak 1980).

Alboleptonia cystidiosa Largent & Aime, **sp. nov.** FIG 2

MYCOBANK MB 518327

Pileus 8–35 mm latus, convexus vel plano-convexus, albus, cinereo humili umbone centrum occupanti, radiatim appressus fibrillosus. Lamellae adnatae, concolores. Stipes 25–48 × 2.5–7 mm, concolor. Basidiosporae 5–6-angulares, 7.6–9.8 × 5.3–8.4 µm. Basidia 2 vel 4-sterigmatae, clavatae, 28–38.2 × 7.6–10.7 µm. Cheilocystidia et pleurocystidia abundantes, obclavata. Pileipellis constata e intricatis hyphis. Fibulae carentes.

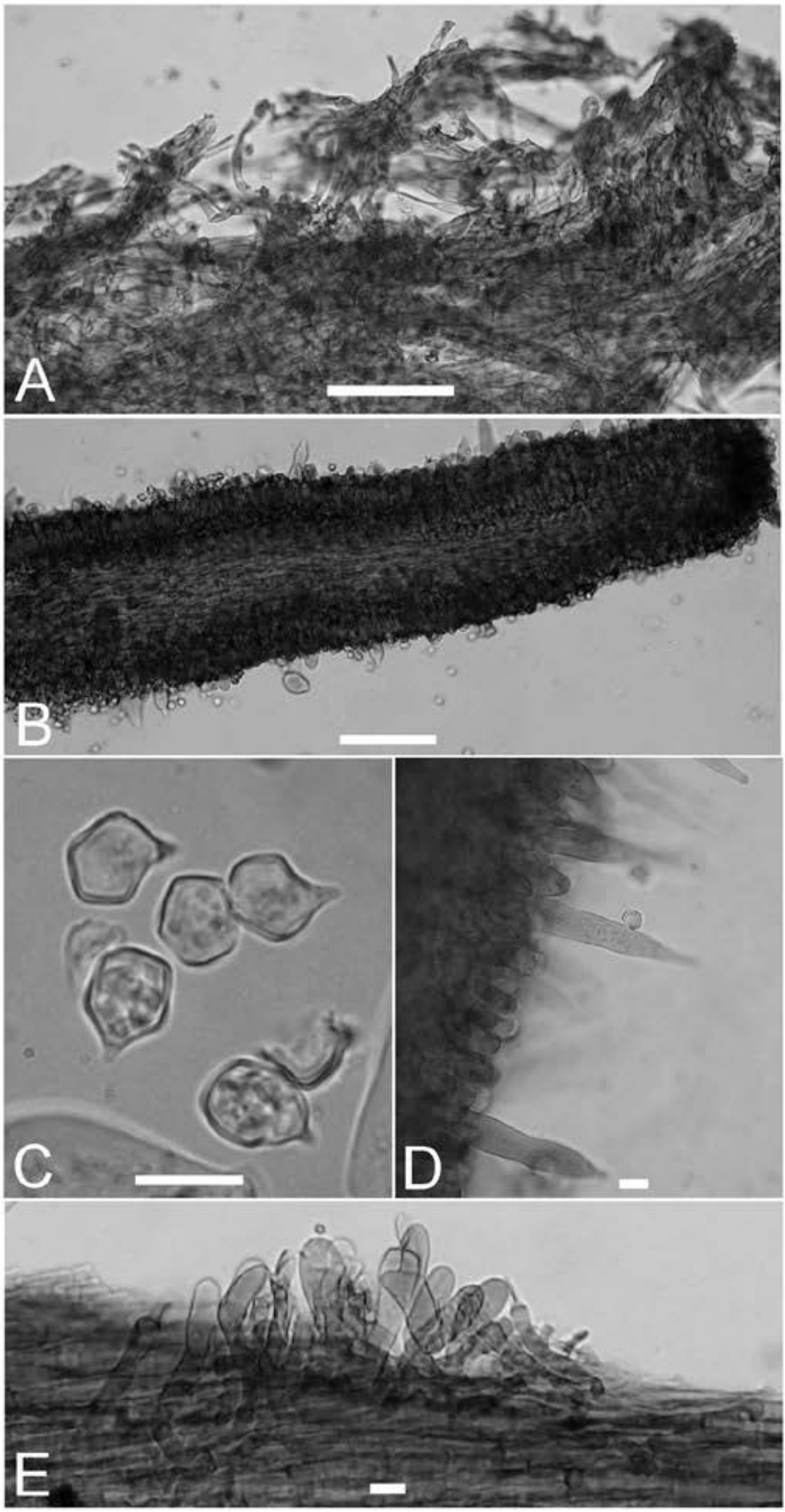
TYPE: *Aime 2395* (BRG, **holotype**; LSUM, **isotype**).

ETYMOLOGY: *cystidiosus* (L. adj.) referring to the abundant hymenial cystidia.

KEY CHARACTERS — *Alboleptonia cystidiosa* is unique in its combination of a convex pileus with a rounded to flattened grayish umbo, slightly acrid taste, small, heterodiametric basidiospores, abundant clavate to obclavate cheilocystidia and pleurocystidia, cylindro-clavate to clavate caulocystidia, and lack of clamp connections.

MACROCHARACTERS — PILEUS 8–35 mm broad, narrowly convex to broadly convex to nearly plane but wavy with age, chalky white with a greyish, low flattened umbo; appearing glabrous, under hand lens radially fibrillose, scurfy over umbo; margin entire, finely eroded with age; trama very thin, < 1 mm over stipe. LAMELLAE close, adnate, thin, narrow, < 1 mm tall, white, faintly pink at maturity, occasionally forking near margin; lamellulae 4–6, of different lengths. STIPE 25–48 × 2.5–7.0 mm, slightly broader and flattened towards base, chalky white, glabrous, finely longitudinally striate under handlens; context white, unchanging, hollow. BASAL MYCELIUM lacking. ODOR faint, indistinct; TASTE slightly acrid. SPORE DEPOSIT salmon pink (7B4).

FIG. 2. Microscopic features of *Alboleptonia cystidiosa* (BRG HOLOTYPE Aime 2395). A. Pileus surface in longitudinal section. B. Lamellar section showing abundant pleurocystidia. Bar = 100 µm. C. Basidiospores. D. Cheilocystidia. E. Caulocystidia near stipe apex. Bar = 10 µm.


A
B
C
D
E

MICROCHARACTERS — BASIDIOSPORES distinctly 5–6-angled, isodiametric in polar view, subisodiametric to heterodiametric in profile view, rarely isodiametric, 7.6–9.8 × 5.3–8.4 µm, (mean = 8.88 ± 0.53 × 6.92 ± 0.72 µm, E = 1.09–1.56, Q = 1.29 ± 0.1; n = 28). BASIDIA clavate, 2 or 4-sterigmate, 28.0–38.2 × 7.6–10.7 µm, (E = 3.07–4.72, Q = 3.7 ± 0.38; n = 13). CHEILOCYSTIDIA abundant, obclavate, occasionally clavate, hyaline, 36.0–129.0 × 8.8–15.4 µm. PLEUROCYSTIDIA abundant, similar in shape to but smaller than the cheilocystidia, hyaline, 47.2–86.6 × 10.0–15.84 µm. PILEIPELLIS an entangled layer of cylindric hyphae throughout. PILEOCYSTIDIA clavate to cylindro-clavate, 20.5–50.9 × 4.5–15.7 µm. CAULOCYSTIDIA in scattered but abundant clusters, cylindro-clavate to clavate to broadly clavate, 17.3–59.1 × 5.3–19.3 µm. REFRACTIVE HYPHAE scattered in the pileus and stipe tramas. REFRACTIVE GRANULES, BRILLIANT GRANULES, and PIGMENTATION absent. CLAMP CONNECTIONS absent.

ECOLOGY, RANGE, DISTRIBUTION — Clustered on sandy soils in mixed riverine forest, known only from the Upper Potaro River Basin of Guyana.

REPRESENTATIVE SPECIMENS EXAMINED. GUYANA. REGION 8: POTARO-SIPARUNI. Pakaraima Mountains. Upper Potaro River Basin, ~15 km east of Mt. Ayanganna, environs of Ayanganna airstrip, elevation ~720 m: on trail between airstrip and Potaro River in sandy soil, 29 December 2003, *Aime 2395* (BRG, **holotype**; LSUM, **isotype**).

COMMENTS — *Alboleptonia cystidiosa* is similar to the pantropical *Alboleptonia stylophora* (Berk. & Broome) Pegler and *Entoloma niveum* G. Stev. from New Zealand in possessing a white, umbonate pileus that is non-hygrophanous and non-striate, cheilocystidia, and an absence of clamp connections. *Alboleptonia stylophora* can be distinguished from *A. cystidiosa* by its cuspidate pileus that tends to develop yellowish hues, cylindro-clavate cheilocystidia, lack of pleurocystidia, and considerably larger basidiospores (9.3–13.8 × 7.7–9.7 µm; Baroni & Lodge, 1998). *Entoloma niveum* differs from *A. cystidiosa* in its papillate pileus, farinaceous odor, strangulated cheilocystidia, and lack of pleurocystidia (Horak 1973, 2008). *Entoloma neosericellum* from New Zealand resembles *A. cystidiosa* in having a white, innately fibrillose pileus, cheilocystidia and pleurocystidia, and an absence of clamp connections. *Entoloma neosericellum* is nonetheless easily separated from *A. cystidiosa* by its ventricose-rostrate pleurocystidia, larger basidiospores (10–11.5 × 7.5–8.5 µm), and hygrophanous, translucent-striate, non-umbonate pileus (Horak 2008).

Alboleptonia minima Largent & T.W. Henkel, **sp. nov.** FIG 3

MYCOBANK MB 518328

Pileus 7–8 mm latus, late convexus vel planus, ad centrum depressus, albus, minute appressus-fibrillosus. Lamellae adnatae, confertae, albae vel roseae. Stipes 50–56 × 2–3 mm, apicem versus leviter contractus, albus, apice pruinosus. Basidiosporae 6-angulares, 7.5–9.1 × 5.8–7.4 µm. Basidia 4-sterigmata, clavata, 24.3–31.7 × 7.2–9.5 µm. Cheilocystidia abundantes, cylindro-clavata. Pleurocystidia carentes. Pileipellis constata e intricatis hyphis sub-erectis terminalibus cellulis. Fibulae carentes.

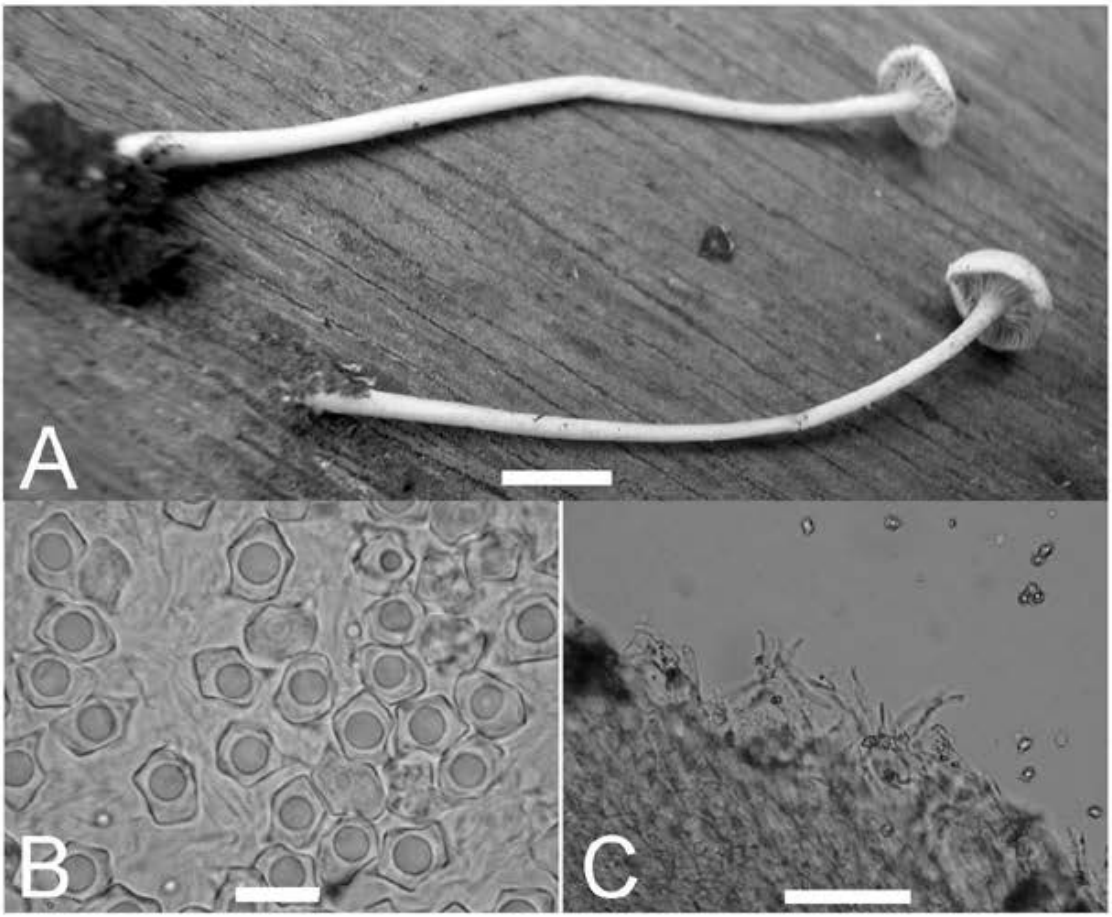


FIG. 3. Macro- and microscopic features of *Alboleptonia minima* (BRG HOLOTYPE Henkel 9037). A. Basidiomata. Bar = 10 mm. B. Basidiospores. C. Pileipellis with sub-erect terminal elements. Bar = 10 µm.

TYPE: *Henkel 9037* (BRG, **holotype**; HSU, **isotype**).

ETYMOLOGY: *minimus* (L. adj.) = very small or tiny, referring to the width of the pileus.

KEY CHARACTERS — *Alboleptonia minima* is distinguished by its white basidioma with a depressed < 10 mm broad pileus, narrow, relatively long stipe, lack of clamp connections, and a stipitipellis, pileipellis, and lamellar edges composed of an entangled layer of hyphae.

MACROCHARACTERS — PILEUS 7–8 mm broad, 1–2 mm high, broadly convex to plane with a broad central depression, white, minutely appressed-fibrillose, opaque, not translucent, not hygrophanous; margin decurved to nearly plane, entire. LAMELLAE 2–3 mm long, 1 mm tall, white at first, faintly pink with age, adnate, close; margin minutely fringed under hand lens; lamellulae not recorded. STIPE 50–56 × 2–3 mm, enlarging slightly toward base, white, minutely pruinose at the apex and minutely fibrillose elsewhere, hollow. BASAL MYCELIUM a moderately dense white tomentum. TASTE, ODOR, and SPORE DEPOSIT not recorded.

MICROCHARACTERS — BASIDIOSPORES distinctly 6-angled, isodiametric in polar view, subisodiametric or more often heterodiametric in profile view, apex typically rounded and triangular, 7.5–9.1 × 5.8–7.4 µm (mean = 8.5 ± 0.4 × 6.6 ± 0.5 µm; E = 1.15–1.47, Q = 1.29 ± 0.1; n = 28). BASIDIA 4-sterigmate, clavate, distinctly tapered downward, 24.3–31.7 × 7.2–9.5 µm (mean = 28.1 ± 2.4 × 8.61 ± 0.6 µm; E = 2.66–3.95; Q = 3.27 ± 0.3; n = 14). LAMELLAR EDGE a sterile layer of entangled hyphae. CHEILOCYSTIDIA abundant, cylindric to cylindro-clavate, 31.1–47.6×3.8–5.5µm. PLEUROCYSTIDIA absent. LAMELLAR TRAMA subparallel, of relatively short and narrow hyphae, cells 48.9–87.5 × 3.0–4.3 µm. PILEIPELLIS an entangled layer of hyphae with semi-erect terminal cells, particularly over disc. PILEOCYSTIDIA cylindric to narrowly cylindro-clavate, 21.5–38.9 × 2.8–8.3 µm. PILEUS TRAMA composed of interwoven hyphae, cells 68.0–110.9 × 7.0–10.4 µm. STIPITIPELLIS an entangled hyphal layer. CAULOCYSTIDIA similar in size and shape to the cheilocystidia. REFRACTIVE HYPHAE abundant in the subhymenium and pileus trama adjacent to lamellae, yellowish in 3% KOH, apparently absent in the lamellar trama. REFRACTIVE GRANULES, BRILLIANT GRANULES, and PIGMENTATION absent. CLAMP CONNECTIONS absent.

ECOLOGY, RANGE, DISTRIBUTION — Scattered on humus of forest floor in *Dicymbe* forest, known only from the Upper Potaro River Basin of Guyana.

REPRESENTATIVE SPECIMENS EXAMINED. GUYANA. REGION 8: POTARO-SIPARUNI. Pakaraima Mountains. Upper Potaro River Basin, 15–20 km east of Mt. Ayanganna, environs of base camp located on Potaro River one km upstream from confluence with Whitewater Creek at 5°18′04.8″N, 59°54′40.4″W, elevation 710–750 m: in *Dicymbe* plot 2, 11 July 2009, *Henkel 9037* (BRG, **holotype**; HSU, **isotype**).

COMMENTS — *Alboleptonia minima* is unique among entolomatoid fungi worldwide because of its white basidioma with a depressed pileus < 10 mm broad, narrow, relatively long stipe, and a stipitipellis, pileipellis, and lamellar edge composed of a similarly entangled layer of hyphae. Although *Rhodophyllus pilosellus* Romagn. & Gilles from Gabon shares a number of features with *A. minima*, it can be differentiated by its strongly fibrillose to flocculose pileus and its broader (11–17 µm) cheilocystidia that are covered over their apices with a hyaline, resinous substance (Romagnesi & Gilles 1979).

Acknowledgments

This research was made possible by grants from the National Geographic Society's Committee for Research and Exploration and NSF DEB-0918591 to TWH and by an Explorer's Club Exploration and Field Research Grant to MCA. Mimi Chin, C. Andrew, V. Joseph, F. Edmond, and L. Edmond provided field assistance in Guyana. Christian Feuillet provided Latin translations. Research permits were granted by the Guyana Environmental Protection Agency. This paper is number 168 in the Smithsonian Institution's Biological Diversity of the Guiana Shield Program publication series. Our

special thanks go to Drs. A. Methven and J.L. Mata for their critical comments and revisions.

Literature cited

Baroni TJ, DJ Lodge. 1998. *Alboleptonia* from the Greater Antilles. Mycologia 90: 680–696. doi:10.2307/3761227

Co-David C, Langeveld D, Noordeloos ME. 2009. Molecular phylogeny and spore evolution of *Entolomataceae*. Persoonia 23: 147–176. doi:10.3767/003158509X480944

Dennis RWG. 1953. Les Agaricales de l'Ile de la Trinité. *Rhodosporae-Ochrosporae*. Bulletinde la Société Mycologique de France 69: 145–198.

Dennis RWG. 1970. Fungus Flora of Venezuela and adjacent countries. Kew Bulletin Additional Series 3: 1–531.

Henkel TW. 2003. Monodominance in the ectomycorrhizal *Dicymbe corymbosa* (*Caesalpiniaceae*) in Guyana. Journal of Tropical Ecology 19: 417–437. doi: 10.1017/S0266467403003468

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index Herbariorum I: the herbaria of the world. Regnum Vegetabile 120: 1–693.

Horak E. 1973. Fungi Agaricini Novaezelandiae I–V. Beihefte Nova Hedwigia 43: 1–200.

Horak E. 1977. *Entoloma* in South America I. Sydowia 30: 40–111.

Horak E. 1980. *Entoloma* (*Agaricales*) in Indomalaya and Australasia. Beihefte Nova Hedwigia 65: 1–352.

Horak E. 1982. *Entoloma* in South America II. Sydowia 35: 75–99.

Horak E. 2008. *Agaricales* of New Zealand 1: *Pluteaceae* (*Pluteus*, *Volvariella*), *Entolomataceae* (*Claudopus*, *Clitopilus*, *Entoloma*, *Pouzarella*, *Rhodocybe*, *Richoniella*). Fungi of New Zealand Volume 5. Hong Kong, Fungal Diversity Press..

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour. 3rd ed. Chichester, Richard Clay Ltd.

Largent DL. 1994. Entolomatoid Fungi of the Western United States and Alaska. Eureka, Mad River Press Inc.

Largent DL, Benedict RG. 1970. Studies in the rhodophylloid fungi II: *Alboleptonia*, a new genus. Mycologia 62: 437–452. doi:10.2307/3757517

Largent DL, Henkel TW, Aime MC, Baroni TJ. 2008. The *Entolomataceae* of the Pakaraima Mountains of Guyana I: four new species of *Entoloma* s. str. Mycologia 100: 132–140. doi:10.3852/mycologia.100.1.132

Noordeloos ME. 1979. Type studies in the Entolomatoid fungi in the Velenovsky herbarium I. Species described in the genera *Nolanea*, *Leptonia*, and *Telamonia*. Persoonia 10: 245–265.

Noordeloos ME. 1987. *Entoloma* (*Agaricales*) in Europe. Synopsis and keys to all species and a monograph of the subgenera *Trichopilus*, *Inocephalus*, *Alboleptonia*, *Leptonia*, *Paraleptonia*, and *Omphaliopsis*. Beihefte Nova Hedwigia 91: 1–419.

Noordeloos ME. 1988. Entolomataceae Kotl. & P. 77–177, in C Bas et al. (eds.), Flora Agaricina Neerlandica Vol. 1. 1998 second printing. Rotterdam, A. A. Balkema.

Noordeloos ME. 1992. *Entoloma* s. l. Fungi Europaei 5: 1–760.

Noordeloos ME. 2004. *Entoloma* s. l. Fungi Europaei 5a: 761–1378.

Orton PD. 1991a. A revised list of the British species of *Entoloma* sensu lato. Mycologist 5: 123–138. doi:10.1016/S0269-915X(09)80307-8

Orton PD. 1991b. A revised list of the British species of *Entoloma* sensu lato. Mycologist 5: 172–176. doi:10.1016/S0269-915X(09)80478-3

Pegler DN. 1983. Agaric Flora of the Lesser Antilles. Kew Bulletin Additional Series 9: 1–668.

Pegler DN. 1997. The Agarics of São Paulo, Brazil. London, Royal Botanic Garden Kew.

Pegler DN, Young TK. 1978. *Entolomataceae* Kotl. & Pouz. World Pollen Spore Flora 7: 1–32.

Romagnesi H., Gilles G. 1979. Les Rhodophylles des forêts côtières du Gabon et de la Côte d'Ivoire avec une introduction générale sur la taxonomie du genre. Beihefte Nova Hedwigia 59: 1–649.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.127

Volume 114, pp. 127–133 October–December 2010

Tuber foetidum found in Finland

Kund Ákos Orczán[1], Ossi Turunen[2], Zsolt Merényi[1], Szabolcs Rudnóy[1], Zoltán Bratek[1]* & Salem Shamekh[2]

* *bratek@ludens.elte.hu*

[1] *Department of Plant Physiology and Molecular Plant Biology*
Eötvös University (ELTE)
Pázmány Péter sétány 1/C. Budapest H-1117 Hungary

[2]*Department of Biotechnology and Chemical Technology*
School of Chemical Technology, Aalto University
P.O.Box 16100, 00076 Aalto, Finland

Abstract – *Tuber foetidum*, a white truffle belonging to the *T. macrosporum* group, is confirmed from Finland based on morphological and DNA analyses. The Finnish specimen was found in soil with relatively high pH in coniferous forest. The phylogenetic tree based on nuclear ribosomal ITS sequences indicated that the Finnish material is most similar to, but not identical with, *Tuber foetidum* samples from Hungary and Estonia.

Key words – *Ascomycota, Tuberales*, ectomycorrhiza, nrITS sequence

Introduction

Truffles, as strictly defined, are hypogeous fungi of the genus *Tuber,* which grow in symbiosis with certain trees. Due to rather controversial taxonomic treatments of large numbers of synonyms and varying species definitions, the real number of species is still unknown. The genus is mainly distributed in the Northern Hemisphere (Jeandroz et al. 2008). Truffles in Fenno-Scandinavia are less well documented compared with the Mediterranean region. Fries (1909), who gave the first modern account of *Tuber* species in Scandinavia, listed three species: *T. aestivum* Vittad., *T. maculatum* Vittad., and *T. rufum* Picco. Up to now, Denmark has the most records in this region, with 6 white and 3 black truffle species (Lange 1956). Five *Tuber* species are known from Sweden, including two black truffles, *T. aestivum* and *T. mesentericum* Vittad. (Danell 1996, Wedén et al. 2001). Recently the Burgundy truffle (*T. aestivum* f. *uncinatum* (Chatin) Montecchi & Borelli) has been produced on a small commercial scale in Gotland (Wedén et al. 2009). In Finland, where truffles are

not part of the culinary tradition, the first records of *Tuber* are *T. borchii* Vittad. and *T. maculatum* (Kosonen 2002). *Tuber borchii* is the only truffle species with gastronomic value found in Finland so far.

On 26 November 2006 a truffle ascocarp was found in a natural spruce forest dominated by *Picea abies* trees located in Lahti, Finland (100 km north to Helsinki) with the help of Ciro, a trained truffle dog. The truffle was morphologically and molecularly confirmed as *T. foetidum* Vittad., which represents the third *Tuber* species in Finland and the northernmost record for the species.

Materials and methods

Morphology

Morphological examinations of the ascocarp followed methods set forth in Pegler et al. (1993). Macroscopical descriptions are based on the field notes of the fresh ascocarp. The collection was air-dried with an electrical drier at 50–60°C. Ascospores were observed and measured in KOH. Sections through the peridium were cut anticlinally. All pictures were taken on an Olympus Optiphot-2 microscope. A voucher specimen is deposited in the institutional herbarium of Zoltán Bratek (ZB-3454).

Soil analysis

One kg of soil was collected by removing the litter and covering vegetation from the spruce forest near Lahti. Soil analyses were performed according to Wedén et al. (2004).

Sequence analysis

DNA extraction and PCR amplification of ITS-rDNA region was performed according to Kårén et al. (1997) with minor modifications. ITS1 and ITS4 primers (White et al. 1990) were used for PCR and sequencing reactions. For cycle sequencing ABI Prism BigDye™ Terminator Cycle Sequencing Ready Reaction Kit 3.1 (Applied Biosystems) was used. Capillary electrophoresis was carried out on an ABI PRISM 3100 Genetic Analyzer (Applied Biosystems) according to the manufacturer's instructions. The BlastN 2.2.2. program (Altschul et al. 1997) was used to search for published data similar to the monitored sequences in the international database (GenBank-EMBL-DDBJ-PDB). Phylogenetic analysis was performed with MEGA version 3.1 (Kumar et al. 2004). For tree reconstruction Neighbor-Joining analysis was used by default parameters of MEGA programs with one thousand replicates in bootstrap test. *Tuber melanosporum* Vittad. ITS sequence (AF132501) was selected as outgroup based on preliminary phylogenetic analysis. Phylogenetic trees were built using the Neighbor-Joining (NJ) methods (Kumar et al. 2004). The GenBank accession number of the new ITS sequence obtained by this work is FN568055.

Results

Ecology

The *T. foetidum* sample was found at a depth of 15 cm in a forest dominated by Norway spruce (*Picea abies*), with scattered birch (*Betula* sp.) and pine (*Pinus sylvestris*). Norway spruce, which comprised 80% of the canopy, averaged 25 m

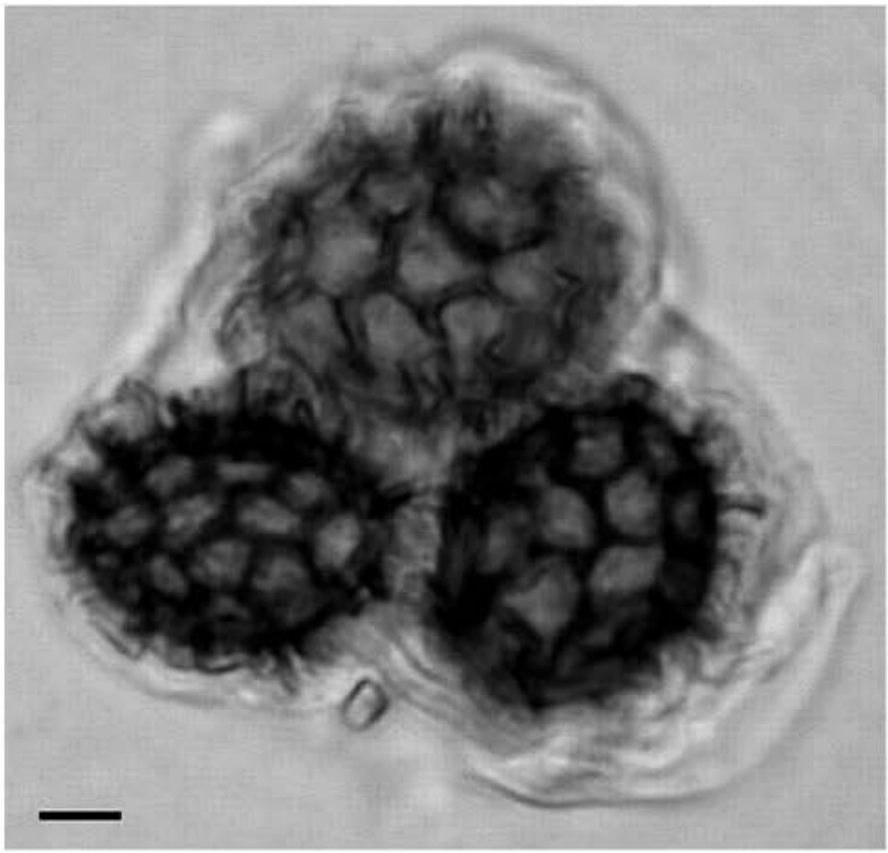


FIGURE 1. Spores of the Finnish *Tuber foetidum* sample. Magnification is 100-fold. Scale bar = 10 µm.

in height, 25 cm in diameter, and 40–50 years of age. The soil is cambisol-type silt with a litter layer, lacking stone and organic humus layer. The pH at a ~40 cm measured 6.5; Finnish forest soil pH values generally average 3.5–4.5. The high pH implies that the site may have been used as a farm field or lime fertilizers have been applied earlier.

Morphology

Ascocarp 9 mm in diam.; surface pale ochraceous brownish, minutely warted to verrucose, not hairy; gleba paler than the surface, rarely marbled; with unpleasant odor. Peridium 330–380 µm thick, pseudoparenchymatous with polygonal or roundish cells 15–19 µm in diam.; cell wall yellow, 0.5–1 µm thick; cystidia lacking. Asci ellipsoid, hyaline, thin-walled, 1–5 spored, lacking a stem; 1-spored asci counting for 20.2%, 2-spored 35.8%, 3-spored 33.9%, 4-spored 9.2% and 5-spored 0.9%. Ascospores ellipsoid, in 1-spored asci: 43.7–36.5 × 38.9–25.5 µm, on average: 40.9 × 31.1 µm (n=10), in 1–2 spored asci 43.3–21.7 × 31.7–21.7 µm, in 4-spored asci 28.7 × 21.3 µm; spore wall 2–4 µm thick, light golden brown, ornamented with a regular reticulum, formed by mostly hexagonal meshes 3.6–12.2 µm along the spore length and 2.4–8.5 µm across the spore width. A 3-spored ascus is shown in FIGURE 1.

Sequence analysis

The ITS sequence obtained from the truffle sample covered the entire 560 bp long ITS region; lengths of ITS-1, ITS-2, and 5.8S rRNA gene are 207, 196, and 157 bp, respectively. BLAST searches indicate that the sample sequence matches most closely three identical ITS sequences (FIGURE 2), two from *Tuber foetidum* (AJ557543, AJ557544 in Halász et al. 2005) found in Hungary and one from a *Tuber* sp. (AJ534706) sample found in Estonia (Tedersoo et al. 2003). The 5.8S rRNA gene sequence is identical in our sample and the Hungarian and Estonian *Tuber* materials. Five and two base differences between the Finnish sample and the three above mentioned sequences were found in the ITS-1 and ITS-2 regions, respectively.

Discussion

In the *Tuber macrosporum* group, *T. foetidum* is known by its stinking odor and verrucose ascocarp surface (Lange 1956, Pegler et al. 1993, Halász et al. 2005). The peridial surface with minute brownish warts, the ellipsoid reticulate spores, and the pseudoparenchymatic peridium of the Finnish specimen correspond to the morphological criteria of *T. foetidum* (Riousset et al. 2001, Montecchi & Sarasini 2000).

The N-J tree clustered the Finnish sample into the clade that harbors two Hungarian *T. foetidum* ascocarp samples and the Estonian ectomycorrhizal sample. Inside this clade, the Hungarian and Estonian samples form a well-supported branch with 100% bootstrap support apart from the Finnish sample sequence (FIGURE 2). *Tuber maculatum, T. puberulum,* and *T. borchii* (Hungarian samples now deposited in the Zoltán Bratek herbarium; see Halász et al. 2005) clearly belong to a different branch. Despite intraspecific sequence variability of *T. puberulum* sequences from samples originating from different habitats, the *T. puberulum* sequences cluster together with high bootstrap support, just like *T. borchii* sequences. The *T. foetidum* clade (including ZB3454), which shows less variation than the *T. puberulum* clade, is clearly separated from the *T. maculatum–T. borchii–T. puberulum* groups. For these reasons we classify the Finnish specimen as *T. foetidum*.

ITS sequence differences indicate, however, that the Finnish genotype has begun to evolve apart from the other *T. foetidum* specimens. Further research is needed to explore the origin and status of Finnish *T. foetidum* population. This raises the possibility that *T. foetidum* sequences from other regions might also differ, as suggested by the separation of the two French *T. macrosporum* (FM205664, FM205663) sequences from the other clades. *Tuber foetidum,* which is found in western Europe between 39°N and 62°N (Jeandroz et al. 2008) and has been recorded in the Scandinavian region from Denmark (Lange 1956)

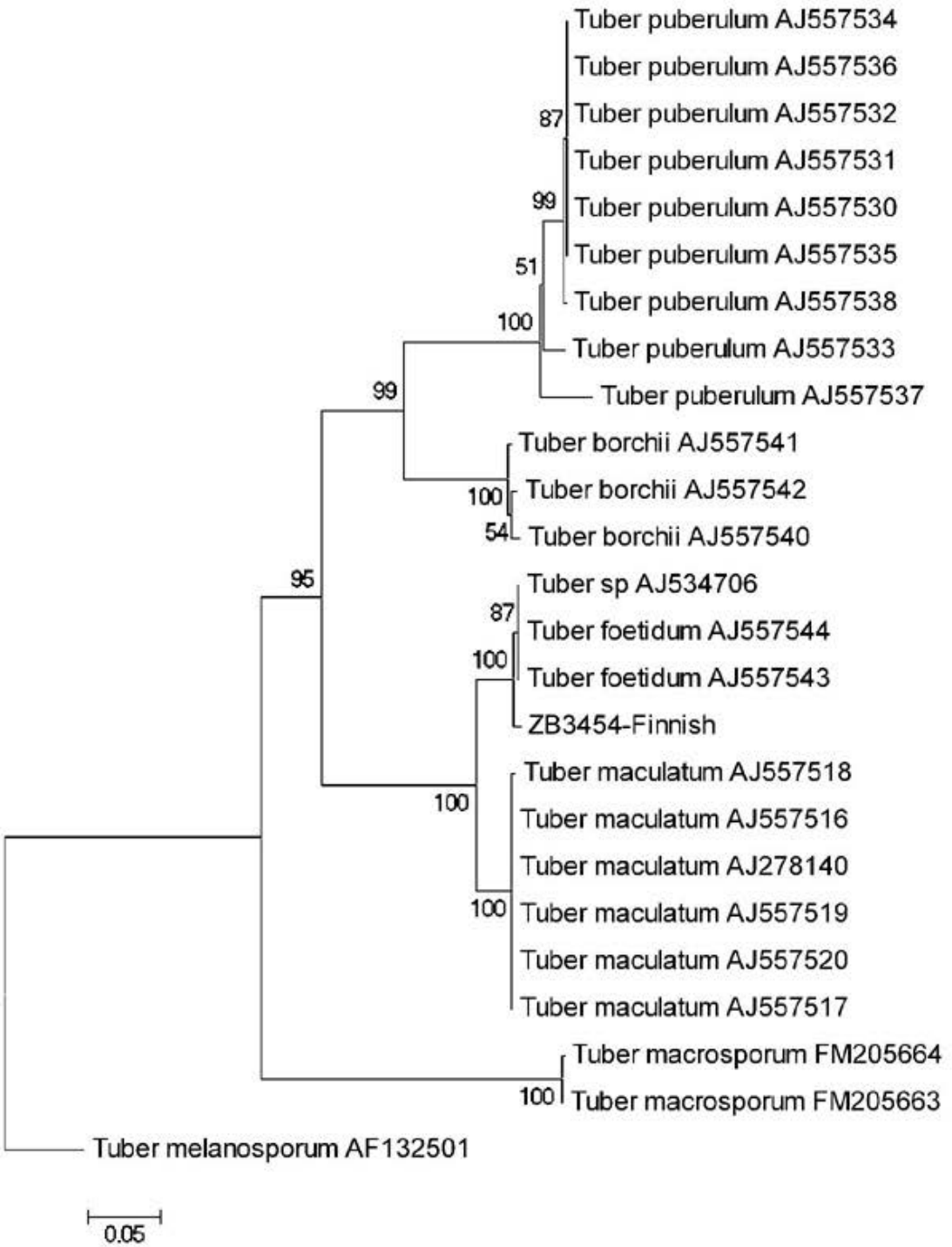


FIGURE 2. Phylogenetic tree based on ITS sequences (ITS-1 and ITS-2). Bootstrap consensus Neighbor-Joining tree based on K-2-p distance matrix (1000 replicates) is shown. Outgroup is *Tuber melanosporum* (AF132501). Scale bar indicates number of nucleotide changes per site.

and Uppland, Sweden (Anderberg & Anderberg 2001) is regarded as a rare species both inside and outside Scandinavia (Lange 1956, Pegler et al. 1993).

Tuber foetidum seems to have a broad range of host trees. In southern Europe, it grows in association with fagaceous trees (*Quercus* and *Fagus*) but in the British Isles it has been found in association with *Larix* (Pegler et al. 1993). The truffle was found in deciduous forests with unknown host associations in Denmark (Lange 1956) and under hazel in Sweden (Anderberg & Anderberg 2001). Sequence analyses by Tedersoo et al. (2003) confirm that *T. foetidum* (as "*Tuber* aff. *maculatum*") formed ectomycorrhizae with birch (*Betula pendula*). Spruce is not a commonly reported host tree for *Tuber* spp. We were unable to trace the ectomycorrhizae, but Norway spruce was the dominant tree in the Finnish forest, we feel that either spruce or Scots pine may serve as hosts of *T. foetidum*.

Acknowledgements

This work was supported in Hungary by the project under the Ányos Jedlik Programme entitled MIKOQUAL and by the project under the National Technology Programme entitled QUTAOMEL. The authors thank Dr. Tytti Sarjala from METLA for here helping with soil analysis and Dr. Gérard Chevalier and Dr. Alexander Urban for their reviews.

Literature cited

Altschul SF, Madden TL, Schäffer AA, Zhang J, Zhang Z, Miller W, Lipman DJ. 1997. Gapped BLAST and PSI-BLAST: a new generation of protein database search programs. Nucleic Acids Res. 25: 3389–3402. doi:10.1093/nar/25.17.3389

Anderberg AA, Anderberg AL. 2001. Flora och vegetation i Fasterna socken, Uppland. Daphne 12: 3–86.

Danell E. 1996. Truffles and false truffles in Sweden and abroad. Svensk Botanishk Tidskrif 90: 215–230.

Fries TM. 1909. Skandivaviens trytflar och tryffelliknande svampar. Svensk Bot. Tidskr. 3: 223–300.

Halász K, Bratek Z, Szegő D, Rudnóy S, Rácz I, Lásztity D, Trappe JM. 2005. Tests of species concepts of the small, white, European group of *Tuber* spp. based on morphology and rDNA ITS sequences with special reference to *Tuber rapaeodorum*. Mycological Progress 4: 281–290. doi:10.1007/s11557-006-0132-6

Jeandroz S, Murat C, Wang YJ, Bonfante P, Le Tacon F. 2008. Molecular phylogeny and historical biogeography of the genus *Tuber*, the 'true truffles'. Journal of Biogeography 35: 815–829. doi:10.1111/j.1365-2699.2007.01851.x

Kårén O, Högberg N, Dahlberg A, Jonsson L, Nylund JE. 1997. Inter- and intra-specific variation in the ITS region of rDNA of ectomycorrhizal fungi in Fennoscandia as detected by endonuclease analysis. New Phytologist 136: 313–325. doi:10.1046/j.1469-8137.1997.00742.x

Kosonen L. 2002. Mitä kasvaako Suomessakin tryffeleitä. Sienilehti 54(4): 105–110.

Kumar S, Tamura K, Nei M. 2004. MEGA3: Integrated software for molecular evolutionary genetics analysis and sequence alignment. Briefings in Bioinformatics 5: 150–163. doi:10.1093/bib/5.2.150

Lange M. 1956. Danish hypogeous macromycetes. Dansk Botanisk Arkiv 16: 1–84.

Montecchi A, Sarasini M. 2000. Funghi ipogei d'Europa. Associazione Micologica Bresadola, Vicenza, Centro Studi Micologici.

Pegler DN, Spooner BB, Young TWK. 1993. British truffles. A Revision of British Hypogeous Fungi. Kew, Royal Botanic Gardens.

Riousset L, Riousset G, Chevalier G, Bardet MC. 2001 Truffes d' Europe et de Chine. Paris, INRA.

Tedersoo L, Hallenberg N, Larsson KH, Koljalg U. 2003. Fine scale distribution of ectomycorrhizal fungi and roots across substrate layers including coarse woody debris in a mixed forest. New Phytologist 159: 153–165. doi:10.1046/j.1469-8137.2003.00792.x

Wedén C, Ericsson L, Danell E. 2001. Research on *Tuber aestivum* syn. *T. uncinatum* and *T. mesentericum* reported from Sweden for the first time. Svensk Botanisk Tidskrift 95: 205–211.

Wedén C, Chevalier G, Danell E. 2004. *Tuber aestivum* (syn. *T. uncinatum*) biotopes and their history on Gotland, Sweden. Mycological Research 108: 304–310. doi:10.1017/S0953756204009256

Wedén C, Pettersson L, Danell E. 2009. Truffle cultivation in Sweden: Results from *Quercus robur* and *Corylus avellana* field trials on the island of Gotland. Scandinavian Journal of Forest Research 24 **(1)**: 37–53. doi:10.1080/02827580802562056

White TJ, Bruns TD, Lee S, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in: Innis MA, Gelfand DH, Sninsky JJ, White TJ. (eds.), PCR protocols: a guide to methods and applications. San-Diego, Academic Press.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.135

Volume 114, pp. 135–144 October–December 2010

Revisiting the taxonomy of *Daruvedia bacillata*

HONG-LI HU[1,2], JACQUES FOURNIER[3], RAJESH JEEWON[4], ALI H. BAHKALI[5] & KEVIN D. HYDE[5,6*]

[1,2] *huhongli7905@gmail.com*

[1] *Division of Microbiology, School of Biological Sciences, The University of Hong Kong, Pokfulam Road, Hong Kong SAR, PR China &*

[2] *Ministry of Agriculture Key Laboratory of Subtropical Agro-biological Disaster and Management, Fujian Agriculture and Forestry University, Fuzhou, 350002, China*

[3] *jacques.fournier@club-internet.fr, Las Muros, Rimont, Ariège, F09420, France*

[4] *r.jeewon@uom.ac.mu Department of Health Sciences, Faculty of Science, University of Mauritius*

[5] *abahkali@ksu.edu.sa* & [5,6] *kdhyde3@gmail.com*

[5] *Botany and Microbiology Department, College of Science King Saud University, Riyadh, Saudi Arabia*

[6] *School of Science, Mae Fah Luang University, Chiang Rai 57100, Thailand*

Abstract — *Daruvedia bacillata*, the type species of the monotypic genus *Daruvedia*, has rarely been collected or reported, but has been placed in many unrelated genera. This paper gives a description of the fungus based on studies of the type specimen, a collection by R.W.G. Dennis, and freshly collected material. The taxon is epitypified and a discussion on its systematic placement is provided.

Key words — systematics, *Dothideomycetes*

Introduction

We have been carrying out systematic and phylogenetic studies on the *Dothideomycetes* in order to obtain a natural classification system (Zhang et al. 2008a,b,c, 2009a,b,c). This study reports on *Daruvedia* Dennis, an ascomycete genus first proposed for *Sphaeria bacillata* Cooke, a fungus originally collected on decorticated rotten wood by Capron and described in the protologue as a "long-spored sunken *Sphaeria*" (Cooke 1871). This species was later referred to *Acerbia* (Sacc.) Sacc. & P. Syd., *Ceratostomella* Sacc., and *Ophioceras* Sacc.

None of these genera were deemed suitable when Dennis (1988) characterised *Daruvedia* based on a fresh collection from the Hebrides. Dennis (1988) found no ascomata in the type material of *Sphaeria bacillata,* but Cooke's habit sketch and drawings of the ascomata, ascus, and distinctive ascospore on the herbarium packet (FIG. 1) allowed Dennis to identify his new collection as identical with *Sphaeria bacillata* and to propose a new genus for it. Later, Dennis (1989) provided a more detailed account of the taxonomic history and derivation of the word *Daruvedia* but did not assign it to any family or order (Dennis 1988, 1989).

Barr (1994), who studied *Daruvedia* in her survey of North American pyrenomycetes, agreed with Dennis that a separate genus was needed for *Sphaeria bacillata.* Although she did not examine any specimens, Barr (1994) classified *Daruvedia* in the *Pleurotremataceae*, based on her belief that the asci were unitunicate and the genus shared characteristics with other genera included in that family. However, *Pleurotremataceae* sensu Barr is no longer accepted: the 9th edition of the Dictionary of the Fungi (Kirk et al. 2001) lists *Daruvedia* as *Dothideales* inc. sed., while the 10th Edition (Kirk et al. 2008) lists it as *Dothideomycetes* inc. sed. Eriksson (2006) and Lumbsch & Huhndorf (2007), who retain *Daruvedia* in the *Pleurotremataceae*, classify the family in *Ascomycota* inc. sed. and represented by just two genera, *Pleurotrema* and *Daruvedia.*

We carried out a study using fresh collections, the collection described by Dennis (1988) (designated here as epitype), and the *Sphaeria bacillata* type material to (1) provide a detailed description of this taxon, (2) clarify the taxonomic placement of *Daruvedia bacillata*, and (3) designate an epitype. We also present a preliminary description of an associated coelomycete.

Materials and methods

Fresh material was collected by Jacques Fournier at different seasons in France. The type specimen of M.C. Cooke and the collection of R.W.G. Dennis were loaned from the Royal Botanic Gardens, Kew (K), UK, for confirmation and more detailed descriptions.

The freshly collected samples were treated following the method used by Hyde et al. (2000) with modification. Dried materials were rehydrated with water first, before checking the morphological characters in water.

Single spore cultures were obtained with the modified method used by Goh (1999).

Total genomic DNA from specimens was extracted directly from ascomata by using Forensic Kits following the instructions. The genomic DNA from cultures was extracted following a protocol as outlined by Cai et al. (2005, 2006). Polymerase chain reaction (PCR) amplification products were obtained with the two pairs of primers, ITS4 and ITS5 (White et al. 1990) and LROR and LR5 for partial rDNA LSU (Vilgalys & Hester 1990).

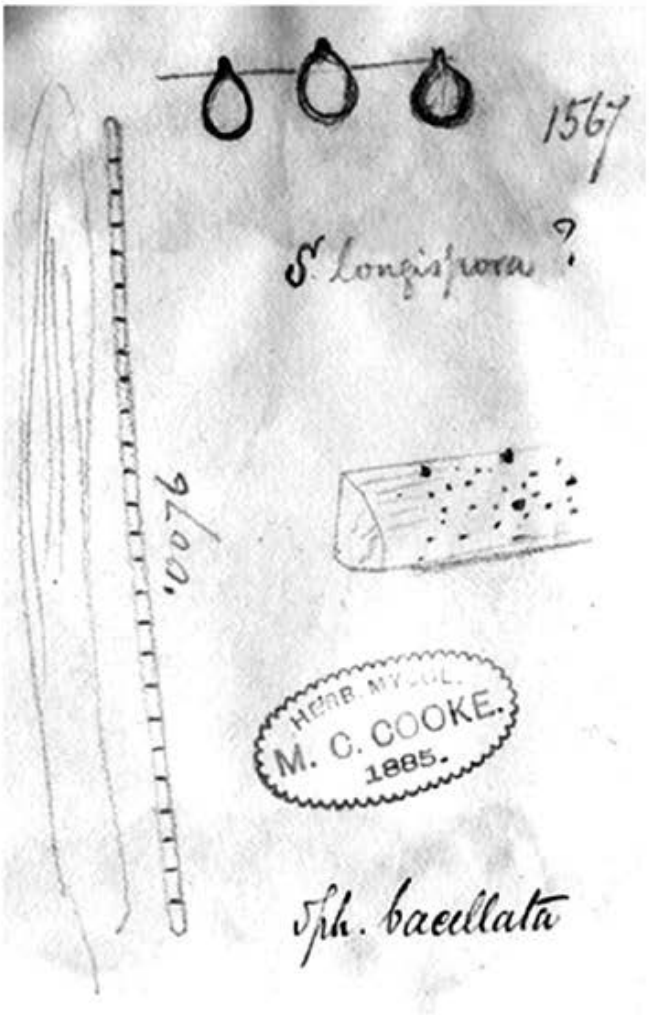


FIG.1. Cooke's drawings of *Sphaeria bacillata* from the holotype (K).

Results

After examining the specimens, including the drawings of Cooke on the herbarium packet (FIG. 1) and those of Dennis (1988), we concur with Dennis that *Daruvedia* should be maintained as a distinct genus for *Sphaeria bacillata*.

We found that Cooke's type material lacked ascomata as Dennis (1988) had mentioned, but Dennis's material is still in good condition. Here we provide a detailed description based on Cooke's drawing, Dennis's specimen and drawing, and our recent collections from France and designate Dennis's specimen as an epitype.

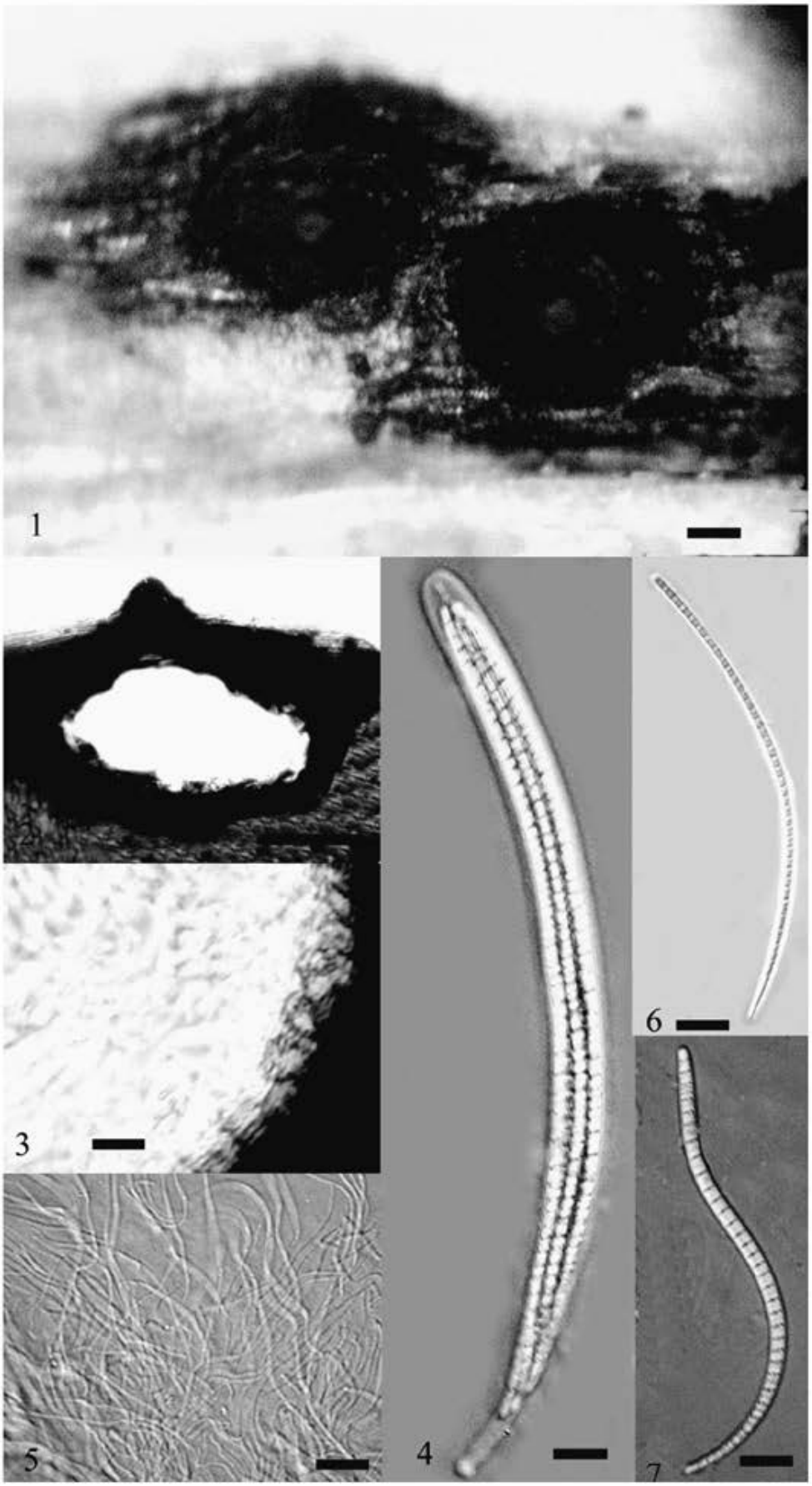
Daruvedia bacillata (Cooke) Dennis, Belarra 2(4): 25, 1988. FIGS. 2–4

≡ *Sphaeria bacillata* Cooke, Handbook of British Fungi 2: 879, 1871.

≡ *Ophioceras bacillata* (Cooke) Sacc., Sylloge Fungorum 2: 360, 1883.

≡ *Ceratostomella bacillata* (Cooke) Cooke, Grevillea 17: 50, 1889.

≡ *Acerbia bacillata* (Cooke) Berl., Icones Fungorum 2: 142, 1899.


1
3
4
5
6
7

= *Rhaphidophora macrocarpa* Sacc., Nuovo Giornale Botánico Italiano 7: 306, 1875.
≡ *Ophioceras macrocarpum* (Sacc.) Sacc., Sylloge Fungorum 2: 359, 1883.

Ascomata scattered, rarely gregarious, erumpent through bark or wood, immersed to nearly superficial with base remaining immersed in the host tissue (FIGS. 2.1, 3.1), depressed spherical, subglobose, broadly or narrowly conical, black, roughened, 500–1000 µm high, 350–800 µm diam.; apex obtuse, pointed, discoid-flattened, up to 250 µm high, 200 µm broad (FIGS. 2.2, 3.2), sometimes hardly protruding in case of small fully immersed ascomata, and then surrounded by a black clypeus-like disc. The discs often bear tufts of brown hairs seated on an easily removed cushion-like structure; this material (a setose acervular coelomycete) was found to belong to a different taxon (see DISCUSSION) and does not represent an anamorphic state of *D. capillata* (FIGS. 3.1, 4.1). Peridium 30–40 µm thick for immersed parts, 60–100 µm thick above, two-layered; outer layer nearly homogenous, of very thick-walled cells with small lumina, inner layer textura prismatica, about 25 µm thick, of flattened cells 7–12 × 2.2–5 µm with unevenly pigmented walls, giving the appearance of alternating dark and pale columns oriented perpendicular to the surface (FIGS. 2.3, 3.3). Hamathecium of dense, very long pseudoparaphyses, 1–1.5 µm broad, sparse (FIGS. 2.5, 3.4). Asci 240–270 × 15–17 µm, 8-spored, bitunicate, but not fissitunicate, cylindrical to fusiform, short stipitate, with a narrow ocular chamber and a small inconspicuous apical apparatus (FIGS. 2.4, 3.5). Ascospores 180–200 × 4–5 µm, filiform, apex obtusely rounded without evident mucilage, base slightly tapered with inconspicuous mucilaginous material on some spores, yellowish, lying parallel in the ascus, filled with guttules, obscurely 30–40-septate, slightly constricted at septa at full maturity, smooth-walled (FIGS. 2.6–7, 3.6).

SPECIMENS EXAMINED: **ENGLAND.** SURREY: Shere, on dead stick, probably *Hedera*, leg. Capron 1567, M.C. Cooke (K, **holotype** of *Sphaeria bacillata*). **SCOTLAND.** ISLE OF ISLAY: Bridgend, Islay House, on dead stem of *Hedera helix*, old garden wall, 24 Jun. 1987, R.W.G. Dennis (K, **epitype** of *Sphaeria bacillata* **designated here**). **FRANCE.** Ariège, Rimont, Las Muros, on *Lonicera nigra*, 9 Jun. 1996, JF 96083; same locality, on *Acer campestre*, 17 Jun. 1996, JF 96086; same locality, on *Cornus sanguinea*, 2 Mar. 1997, JF 97057; Rimont, Le Baup, on *Populus tremula*, 14 Apr. 2005, JF 05050; same locality, on *Frangula alnus*, 14 Apr. 2005, JF 05051; Rimont, Peyrau on *Acer campestre*, 5 Oct. 2005, JF 05126; Rimont, Las Muros, on twigs of *Hedera helix*, 7 December 2005, leg. J. Fournier, det. Paul Leroy, JF 05159; same locality, on twigs of *Hedera helix*, 14 Mar. 2007, JF07026; same locality, on dead twigs of *Clematis vitalba*, 470m, 19 Jun. 2008, JF 08144; same locality, on dead decorticated twig of *Hedera helix*, 470 m, 1 Jul. 2008, JF 08155.

FIG. 2 (at left). Dennis's collection of *Daruvedia bacillata* from Scotland (K). 1. Ascomata on substrate. 2. Section of ascoma. 3. Peridium. 4. Ascus. 5. Pseudoparaphyses. 6, 7. Ascospore. Scale bars: 1, 2 = 100 µm, 3–7 = 10 µm.

Discussion

Daruvedia bacillata is uncommon but has been found on various hosts in diverse families: *Acer campestre* (*Aceraceae*), *Clematis vitalba* (*Ranunculaceae*), *Cornus sanguinea* (*Cornaceae*), *Frangula alnus* (*Rhamnaceae*), *Hedera helix* (*Araliaceae*), *Lonicera nigra* (*Caprifoliaceae*), and *Populus tremula* (*Salicaceae*), mainly on decorticated wood. Its occurrence is perennial. The ascoma shape and degree of immersion in the substrate are highly variable. The striking wig-like conidial hairy structure at the apex of the ascomata, which is fragile, easily removed, and often absent when fully mature, appears to be an associated fungus.

When Cooke (1871) first described this fungus, he provided a drawing of the ascomata, one ascus, and one ascospore. Later, Dennis (1988) described a new genus *Daruvedia* for this fungus, but did not assign the genus to any family or order. As *Daruvedia capillata* has bitunicate asci, it does not belong in unitunicate *Pleurotremataceae* in the broad sense of Barr (1994). Because mature fruitbodies of *D. capillata* remain embedded in sterile tissues, the genus does not belong in *Dothideales* (Kirk et al. 2001), which is characterised by the lack of hymenium when mature. Based on our results we agree with Kirk et al. (2008), who placed *Daruvedia* in the *Dothideomycetes* in the *Pleosporales*; further molecular work is needed to place the fungus in a suitable family.

We tried to isolate *Daruvedia bacillata* from single spores and conidia from the setose acervular coelomycete but failed. However, we were able to obtain pure cultures from the ascomatal spore mass. We sequenced the fungus from the cultures and were surprised when the sequence data blasted closest to *Exophiala pisciphila* McGinnis & Ajello (ITS: AF050272; LSU: DQ823101). Extraction of DNA directly from the ascomata produced the same result. As *Exophiala* spp. have teleomorphs in *Capronia* (a genus with short, fusiform, 1–2-celled ascospores), it was obvious that our isolated fungus and sequences do not derive from *Daruvedia capillata,* which has long filiform ascospores. A prolonged dry period in Pyrenees prevented our collecting more material for further study.

No anamorph has been linked to *Daruvedia bacillata.* In this study we found one associated anamorphic taxon that may represent a hyperparasite on *Daruvedia bacillata.* This unidentified fungus has acervuli comprising numerous cylindrical, long and narrow (150–200 × 4-5 µm), thick-walled, nonseptate, brown hairs with paler obtuse ends that are often constricted just beneath the apex (Fig. 4.1) and which arise from a basal brown pseudoparenchymatous tissue with the hairs aggregating into stellate tufts (Fig. 4.2–3). Other characters include < 2 µm diam. conidiophores that form at the base of the hairs and are composed of palisade or dense ramified, hyaline bunches (Fig. 4.4–5);, percurrent, denticulate, < 2 µm diam. conidiogenous cells (Fig. 4.4–5), and

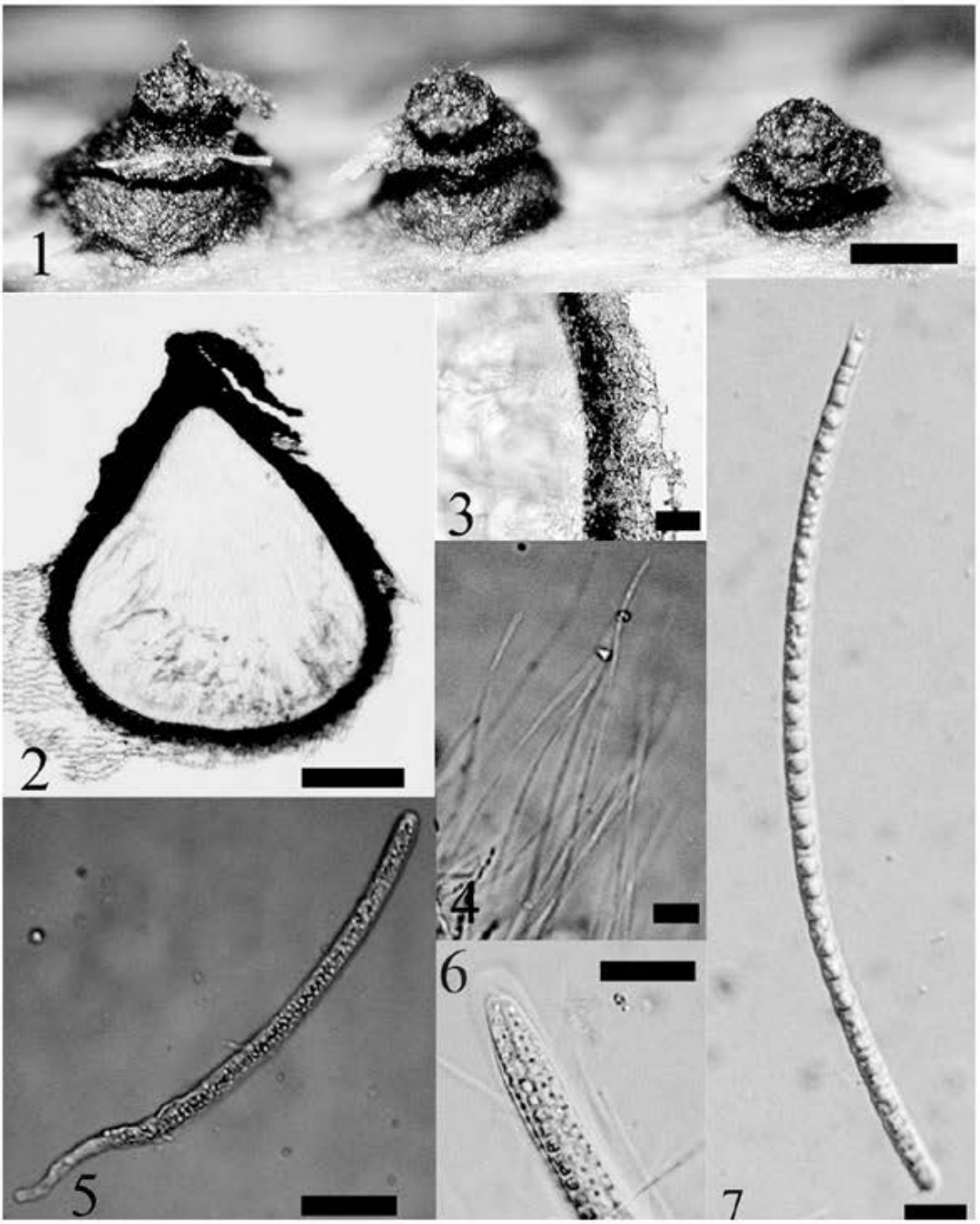


FIG. 3. Collections of *Daruvedia bacillata* from France (JF05159). 1. Mature ascoma on host surface. 2. Section of ascoma. 3. Peridium. 4. Pseudoparaphyses. 5. Ascus with ascospores. 6. Apical portion of an ascus showing ocular chamber. 7. Ascospore. Scale bars: 1 = 300 µm, 2 = 200 µm, 3 = 10 µm, 4 = 10 µm, 5 = 50 µm, 6 = 20 µm, 7 = 10 µm.

ovoid, hyaline, conidia with narrow hila and measuring 3.5–4 × 1.8 µm (FIG. 4.5–6). This structure is only usually present on young erumpent ascomata and has always been dislodged from older mature ascomata. Further research is needed to establish the nature of the association between *D. capillata* and the unknown coelomycete.

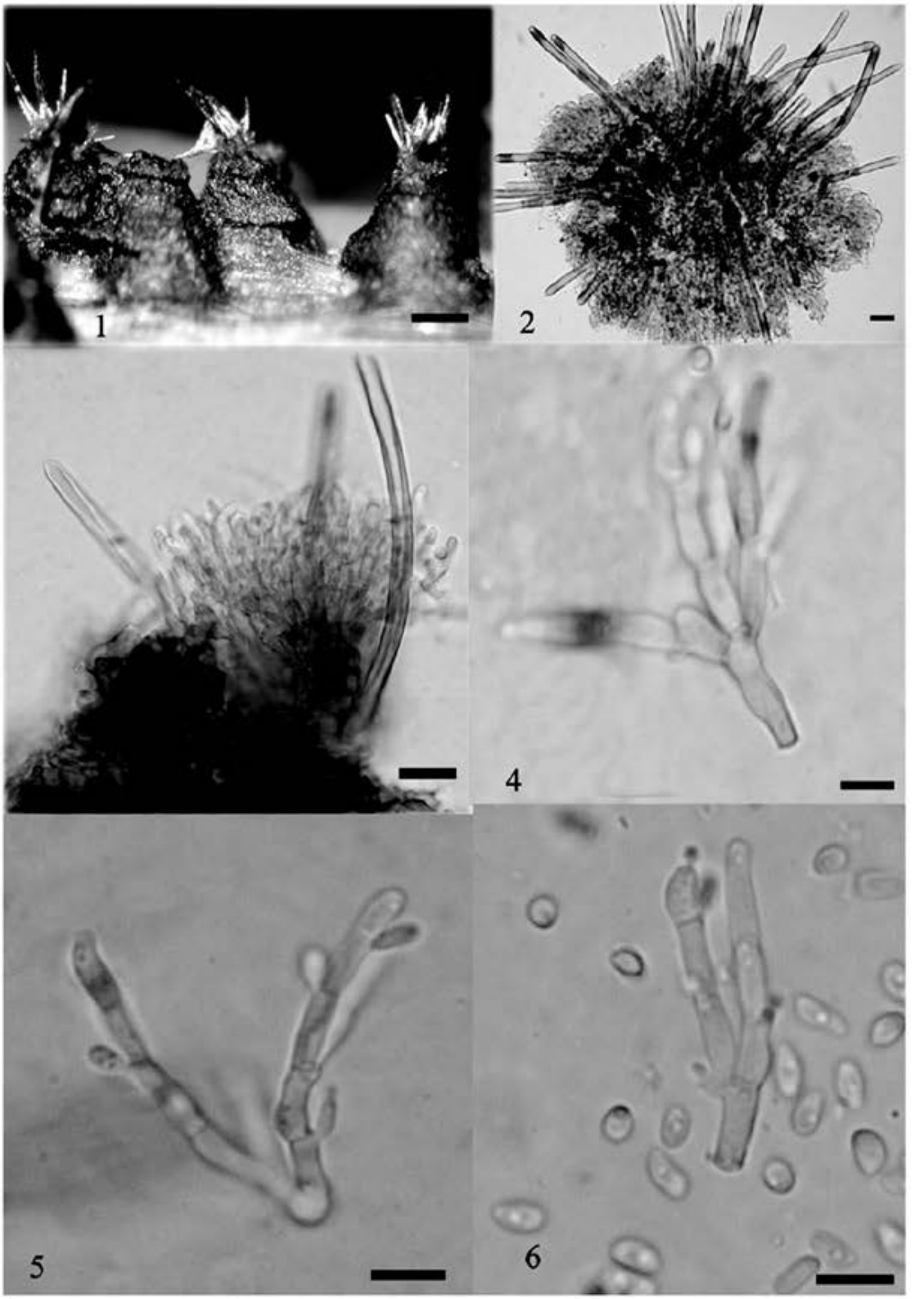


FIG. 4. Coelomycetous fungus associated with *Daruvedia bacillata*. 1. Immature *Daruvedia* ascomata with associated unknown conidiomata on natural substrate. 2, 3. Acervulus. 4–6. Conidiogenous cells and conidia from natural substrate. Scale bars: 1 = 200 µm, 2–6 = 10 µm.

Acknowledgements

Hu Hongli thanks the University of Hong Kong for the award of a postgraduate studentship. Helen Leung is thanked for her kind laboratory assistance. K.D. Hyde thanks BRT grant number R253012 for the award of a scholarship to study *Dothideomycetes*. Wen-Ying Zhuang, De-Qun Zhou, Eric McKenzie are thanked for the pre-submission reviews of our manuscript.

Literature cited

Barr ME. 1994. Notes on the *Amphisphaeriaceae* and related families. Mycotaxon 51: 191–224.

Cai L, Jeewon R, Hyde KD. 2005. Phylogenetic evaluation and taxonomic revision of *Schizothecium* based on ribosomal DNA and protein coding genes. Fungal Diversity 19: 1–21.

Cai L, Jeewon R, Hyde KD. 2006. Phylogenetic investigations of *Sordariaceae* based on multiple gene sequences and morphology. Mycological Research 110: 137–150. doi:10.1016/j.mycres.2005.09.014

Cooke MC. 1871. Handbook of British Fungi, with full descriptions of all the species, and illustrations of the genera (Volume 2). London, Macmillan and Co.

Dennis RWG. 1988. A new genus for *Sphaeria bacillata* Cooke. Belarra 2(4): 25–28.

Dennis RWG. 1989. Two little-known monotypic genera of ascomycetes in Italy. Micologia e Vegetazione Mediterranea 4(2): 13–20.

Eriksson OE (ed.). 2006. Outline of *Ascomycota*. 12: 1–82.

Goh TK. 1999. Single-spore isolation using a hand-made glass needle. Fungal Diversity 2: 47–63.

Hyde KD, Taylor JE, Fröhlich J. 2000. Genera of *Ascomycetes* from Palms. Fungal Diversity Press, Hong Kong SAR, China

Kirk PM, Cannon PF, David JC, Stalpers JA. 2001. Ainsworth & Bisby's Dictionary of the Fungi (9th edition). CAB International, UK.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth & Bisby's Dictionary of the Fungi. (10th edition). CAB International, UK.

Lumbsch HT, Huhndorf SM (ed.). 2007. Outline of *Ascomycota*. 2007. Myconet 13: 1–58.

Vilgalys R, Hester M. 1990. Rapid genetic identification and mapping of enzymatically amplified ribosomal DNA from several *Cryptococcus* species. Journal of Bacteriology 172: 4238–4246. doi: 0021-9193/90/084238-09$02.00/0

White TJ, Bruns TL, Lee S, Taylor JW. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: PCR Protocols: a Guide to Methods and Applications (eds. M Innis, DH Gelfand, JJ Sninsky, JT White). Academic Press, San Diego, USA.

Zhang Y, Fournier J, Jeewon R, Hyde KD. 2008a. *Quintaria microsporum* sp. nov., from a stream in France. Cryptogamie Mycologie 29: 179–182.

Zhang Y, Jeewon R, Fournier J, Hyde KD. 2008b. Multi-gene phylogeny and morphotaxonomy of *Amniculicola lignicola*: a novel freshwater fungus from France and its relationships to the *Pleosporales*. Mycological Research 112: 1186–1194. doi:10.1016/j.mycres.2008.04.004

Zhang Y, Fournier J, Pointing SB, Hyde KD. 2008c. Are *Melanomma pulvis-pyrius* and *Trematosphaeria pertusa* congeneric? Fungal Diversity 33: 47–60.

Zhang Y, Wang HK, Fournier J, Crous PW, Jeewon R, Pointing SB, Hyde KD. 2009a. Towards a phylogenetic clarification of *Lophiostoma* / *Massarina* and morphologically similar genera in the *Pleosporales*. Fungal Diversity 38: 225–251.

Zhang Y, Fournier J, Crous PW, Pointing SB, Hyde KD. 2009b. Phylogenetic and morphological assessment of two new species of *Annuculicola* and their allies (*Pleosporales*). Persoonia 23: 48–54. doi:10.3767/003158509X472187

Zhang Y, Schoch CL, Fournier J, Crous PW, De Gruyter J, Woudenberg JHC, Hirayama K, Tanaka K, Pointing SB, Spatafora JW, Hyde KD. 2009c. Multi-locus phylogeny of *Pleosporales*: a taxonomic, ecological and evolutionary re-evaluation. Studies in Mycology 64: 85–102. doi:10.3114/sim.2009.64.04

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.145

Volume 114, pp. 145–149 *October–December 2010*

Observations on the *Bolbitiaceae* 31. *Conocybe volviradicata* sp. nov.

ROY WATLING[1], MUSTAFA IŞILOĞLU[2] & HAYRÜNISA BAŞ SERMENLI[2]*

[1] *caledonianmyc@blueyonder.co.uk*
Caledonian Mycological Enterprises, Edinburgh, EH4 3HU, Scotland

[2] *isiloglu48@gmail.com & *hayba2000@gmail.com*
Muğla University, Faculty of Science and Arts, Biology Department
48170, Muğla, Turkey

Abstract — A new species of *Conocybe* from southwest Turkey, with the unique combination of a volva and long radicating stipe-base, is described as new to science; it is placed in *Conocybe* section *Singerella*.

Key words — new taxa, *Conocybe corneri, Conocybe antipus*

Introduction

Other than *Conocybe peronata* Kühner & Watling, now assigned to *Pholiotina*, no peronate or volvate species were treated in the classical studies of the genus by Atkinson (1918; as *Galerula*) and Kühner (1935). Watling (1979) was the first to describe two species from South East Asia with a distinct volva — *C. corneri* Watling and *C. vaginata* Watling — and to transfer *Galerula locellina* Murrill from Florida, North America, to *Conocybe*, noting that it also possessed a volvate stipe-base. Over the intervening years, a clutch of taxa have been recognized with this character, with Horak & Hausknecht (2002) eventually providing a key to nine species. Since then Hausknecht & Krisai-Greilhuber (2009) have added a tenth species, *C. reinwaldii*. Whilst documenting the mycota of southwest Turkey, we discovered a new member of this group that differed from all others by possessing a radicating stipe-base. This new taxon, formally described herein, is the twelfth representative of *Conocybe* in the Turkish macromycota (Solak et al. 2007).

* Corresponding author

Taxonomy

Conocybe volviradicata Watling, Işıloğlu & Baş Sermenli, **sp. nov.** FIGS 1–4

MYCOBANK 516620

Pileus 15 mm, e convexo vel campanulato rariore expansus clare cinnamomeus vel ferrugineo-mellinus siccitate bubalinus vel flavo-cremeus glabrus ad marginem striatus tenuis. Lamellae fere liberae aggregatae mellino-luteolobrunneae. Stipe 30 ×3 mm, tenax cremeus conspicue pruinoso-striatus ad basim leviter incrassatus volvatus et radicatus (< 20 mm longus). Caro tenuis. Sporae in cumulo ochraceo-brunneae vel cinnamomeae. Sporae hexagoneae poro germinativo 8–10 × 6–7 µm. Cystidia aciei lamellarum lecythiformia 22–25 × 4–7 µm. Cystidia stipitis 1) lecythiformia 25–35 × 2–6 µm; 2) ellipsoidea vel clavata 18–21 × 6–8 µm; et 3) utriformia vel lageniformia 25–30 × 6–9 µm. Fibuligeris nullus. Habitatio in fimo putrido. Turkey; Muğla, Göktepe. Typus H. Baş 12 in E.

TYPE: Turkey; Muğla, Göktepe village, 11 September 2004, Işıloğlu 7700, H. Bas 12. **Holotype:** in E.

ETYMOLOGY: The epithet *volviradicata* refers to the volvate, rooting stipe.

PILEUS 15 mm conical to campanulate (FIG. 1), deep cinnamon to sienna, drying buff to yellowish cream, smooth, margin striate, silky and very thin. GILLS almost free, crowded, pale ochraceous. STIPE 30 × 3 mm, tough, cream-colour, distinctly striate to beginning of the volva, volvate, rooting base < 20 mm long. FLESH thin, < 1 mm thick in cap-center. TASTE AND SMELL not recorded. SPORE PRINT ochraceous-brown to cinnamon. SPORES hexagonal (FIG. 2) 8–10 × 6–7 µm, sienna, thick walled, with a distinct germ-pore. CHEILOCYSTIDIA lecythiform (Fig. 3) 22–25 × 4–7 µm. CAULOCYSTIDIA mixed of 3 different types: 1) lecythiform, 25–35 × 3–6 µm; 2) ellipsoid to clavate, 18–21 × 6–8 µm; 3) nettle hair-shaped to lageniform, 25–30 × 6–9 µm (FIG. 4). CLAMP CONNECTIONS not seen.

HABITAT. On manured soil bordering a vegetable garden.

Discussion

Conocybe volviradicata is very easily recognized in the field by its distinct membranous volva and long, radicating stipe-base. The presence of lecythiform cheilocystidia combined with the field characters places this new species firmly in section *Singerella* Watling, and the presence of lecythiform caulocystidia places it in a slightly modified series *Corneri* Hauskn. & Krisai, as outlined by Hausknecht & Krisai-Greilhuber (2006). The stipitipellis in series *Corneri* consists of capilliform, ellipsoid, and sphaerical to lageniform elements; only in one species are these elements intermixed with lecythiform cells.

The volva in *C. volviradicata* is striate on the upper surface, and although it has been impossible to track the development to the degree followed by the senior author for *C. corneri* (Watling 1979), a striate volva characterizes both species. There are other parallels. *Conocybe corneri* is coprophilous, with the primordia

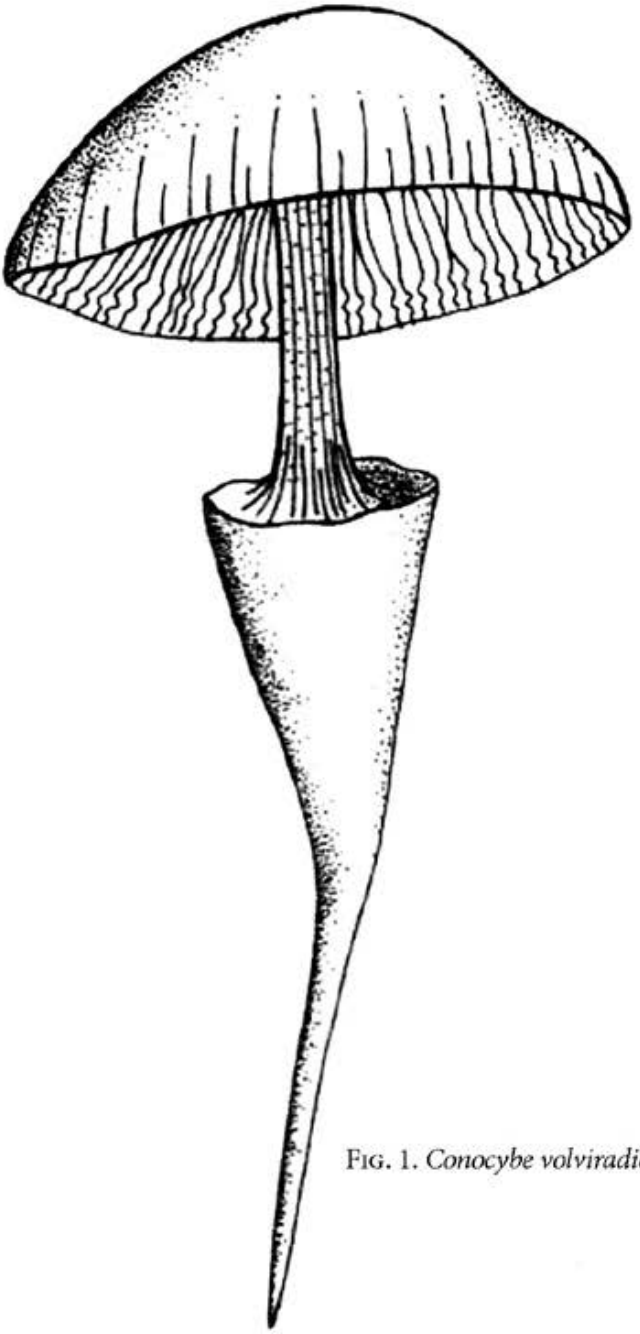
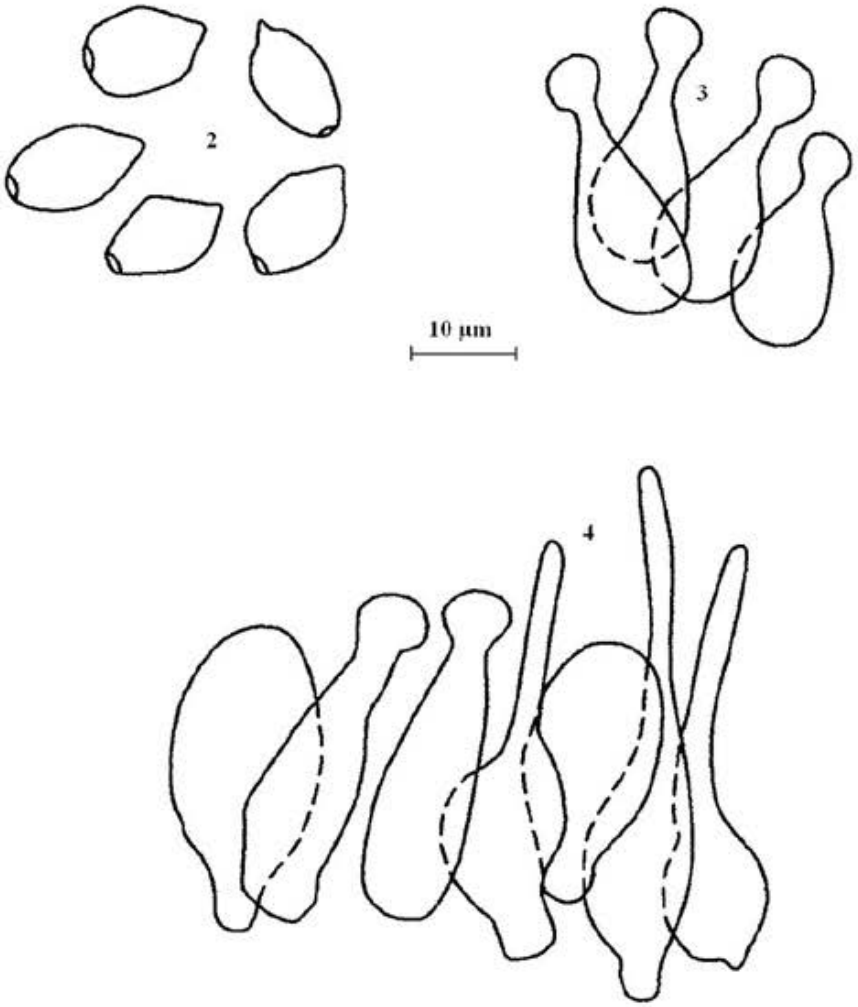


FIG. 1. *Conocybe volviradicata*. Habit.

developing below the surface of the dung, whereas in *C. volviradicata* the stipe was found buried in manured soil.

The long rooting base of *C. volviradicata* resembles that found in *C. antipus* (Lasch) Fayod known from Europe and North America, *C. humicola* (Thiers) Hauskn. et al. (≡ *C. antipus* var. *humicola* Thiers) from North America, and the European *C. fiorii* (D. Sacc.) Watling, *C. leporina* (Velen.) Singer, and *C. alboradicans* Arnolds—all assignable to *Conocybe* series *Antipus* (Hausknecht & Krisai-Greilhuber 2006). Although none of these species ever develop a volva



FIGS. 2–4. *Conocybe volviradicata*. 2. Basidiospores. 3. Cheilocystidia. 4. Caulocystidia.

immediately above or at the base of the rooting stipe, *C. volviradicata* resembles *C. antipus* in producing basidiospores that are hexagonal in face view.

Hausknecht (1996, 2009), who treated European *Conocybe* species with rooting or deeply inserted stipe-bases including the species indicated above, recognized eight additional species in his key but did not depict any possessing the slightest volvate development. The recently described *C. reinwaldii* from Europe (Hausknecht & Krisai-Greilhuber 2009) and *C. radicata* Singer, an extra-European radicate taxon with minutely ornamented basidiospores, are placed in *Conocybe* section *Ochromarasmius* subsection *Pseudocystidiatae*. The spores of *C. volviradicata,* however, are smooth. *Conocybe reinwaldii* differs significantly in the lack of a volva.

Conocybe radicata from South America possesses lecythiform pleurocystidia, but no such structures are found in *C. volviradicata*. *Conocybe radicata* is also lignicolous, whereas the Turkish material is found in manured garden soil.

Acknowledgements

The authors would like to express their thanks to Anton Hausknecht (Fakultätszentrum für Botanik der Universität Wien, Wien, Austria) and Henning Knudsen (Natural History Museum of Denmark, Copenhagen, Denmark) for reviewing the manuscript and to Gülnur Ekşi (Hacettepe University) for drawing the figure of the new taxon.

Literature cited

Atkinson G. 1918. The Genus *Galerula* in North America. Proc. Amer. Phil. Soc. 57: 357–374.

Hausknecht A. 1996. Beiträge zur Kenntnis der *Bolbitiaceae* 3. Europäische *Conocybe*-Arten mit wurzelndem oder tief im Substrat eingesenktem Stiel. Österr. Z. Pilzk. 5: 161–200.

Hausknecht A. 2009. Fungi Europaei: *Conocybe* Fayod/*Pholiotina* Fayod. Edizioni Candusso, Alassio SV, Italy. 968 pp.

Hausknecht A, Krisai-Greilhuber I. 2006. Infrageneric division of the genus *Conocybe* – a classical approach. Österr. Z. Pilzk. 15: 187–212.

Hausknecht A, Krisai-Greilhuber I. 2009. Zwei neue *Conocybe*-Arten aus Europa und Korrekturen zur Monografie *Conocybe–Pholiotina*. Österr. Z. Pilzk. 18: 183–191.

Horak E, Hausknecht A. 2002. Notes on extra-European Taxa of *Bolbitiaceae* (*Agaricales, Basidiomycota*). Österr. Z. Pilzk. 11: 213–204.

Kühner R. 1935. Le Genre *Galera*. Paris, Lechevalier.

Solak MH, Işıloğlu M, Kalmış E, Allı H. 2007. Macrofungi of Turkey, Checklist. Üniversiteliler offset, İzmir.

Watling R. 1979. Observations on the *Bolbitiaceae* XVII. Volvate species of *Conocybe*. Sydowia Beih. 8: 401–415.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.151

Volume 114, pp. 151–161 October–December 2010

Postia stellifera sp. nov., a stipitate and terrestrial polypore from Malaysia

Tsutomu Hattori[1*], Kozue Sotome[2], Yuko Ota[3], Bee-kin Thi[4], Su-see Lee[4] & Baharuddin Salleh[5]

*hattori@affrc.go.jp

[1]Kansai Research Center, Forestry and Forest Products Research Institute
Nagai-Kyuotaro 68, Momoyama, Fushimi, Kyoto 612-0855, Japan

[2]National Museum of Nature and Science
Tokyo Ten-nodai, Tsukuba, Ibaraki 305-0005, Japan

[3]Forestry and Forest Products Research Institute
Matsunosato 1, Tsukuba, Ibaraki 305-8687, Japan

[4]Forest Research Institute, Kepong, 52109 Selangor, Malaysia

[5]School of Biological Sciences, University of Sains Malaysia
11800 Penang, Malaysia

Abstract — *Postia stellifera* sp. nov. from Malaysia is described. This fungus is characterized by the distinctly stipitate basidiomata, terrestrial habit, and verrucose chlamydospores both in the context and in culture. Its macromorphology resembles that of *Albatrellus*, but phylogenetic analysis based on LSU places it within a clade comprising *Postia*, *Amylocystis*, and *Jahnoporus* where all species have a white and fleshy to soft corky context and monomitic hyphal system with clamped generative hyphae. Most sequences showing high homology with *P. stellifera* represent brown rot polypores.

Key words —*Fomitopsidaceae*, *Oligoporus*, phylogeny, *Polyporaceae*, taxonomy

Introduction

Postia Fr. (*Fomitopsidaceae*, *Polyporales*) is typified by *Polyporus lacteus* Fr. [lectotypified by Donk (1960); = *Postia tephroleuca* (Fr.) Jülich]. The genus is characterized by resupinate to sessile basidiomata with a fleshy context in fresh condition, a monomitic hyphal system with clamped generative hyphae, and causing a brown rot. A few species such as *P. ceriflua* (Berk. & M.A. Curtis) Jülich, *P. folliculocystidiata* (Kotl. & Vampola) Niemelä & Vampola, and *P. subundosa* Y.L. Wei & Y.C. Dai occasionally produce substipitate or pendent

basidiomata (Ryvarden & Gilbertson 1994, Wei & Dai 2006), but so far, species with terrestrial and distinctly stipitate basidiomata are unknown in the genus.

Oligoporus Bref. has been used for the same group of fungi (Ryvarden 1991), but *Postia* was published prior to *Oligoporus* and has been widely accepted (Buchanan & Ryvarden 2000, Dai et al. 2004, Dai et al. 2007, Niemelä et al. 2001, Rajchenberg 2006).

Tyromyces P. Karst. (type: *Tyromyces chioneus* (Fr.) P. Karst.) is morphologically similar to *Postia*, and many species now accommodated in *Postia* were once placed in *Tyromyces* (Lowe 1975, Ryvarden 1978). *Tyromyces* has been restricted to species producing a white rot, however. Phylogenetic studies also suggest that *Tyromyces* is phylogenetically distinct from *Postia* (Binder et al. 2005, Yao et al. 1999).

During field trips in Peninsular Malaysia in 2002 and 2007, we collected a polypore with distinctly stipitate and terrestrial basidiomata, a white and fleshy context, oblong ellipsoid basidiospores, and verrucose chlamydospores in the context. Its mycelium in pure culture did not react with 1-naphthol, suggesting a lack of laccase and, consequently, that it is not a white rot fungus (Käärik 1965).

Within the genera of polypores (Ryvarden 1991), the micro-morphological and physiological features of this species would point toward *Postia*. However, the terrestrial and stipitate habit together with the verrucose chlamydospores deviates from *Postia* as currently circumscribed.

In this study, we examined the phylogenetic position of the present fungus in relation to several *Postia* spp. and related polypores. After detailed morphological examinations and other characteristics, we describe it as a new species.

Materials and methods

Sequencing and phylogenetic analysis

Five fungal isolates including *Postia* spp. (Table 1) were grown and harvested according to Ota & Hattori (2008). DNA was extracted using a DNeasy Plant Mini Kit (Qiagen, Valencia, CA, USA). Nuclear ribosomal LSU sequences were generated following the methods of Ota & Hattori (2008) or Sotome et al. (2008). DNA sequences were determined using a BigDye Terminator 3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA, USA) with the ABI 3100 DNA sequencer (Applied Biosystems). Sequences were edited with Vector NTI advance 9.0 (InforMax, Frederick, MD, USA) then submitted to GenBank (accession numbers AB569119-569123, Table 1). Twelve additional nrLSU sequences were retrieved from GenBank. *Lentinus tigrinus* (Bull.) Fr. and *Polyporus squamosus* (Huds.) Fr. were used as outgroups because they belong to *Polyporaceae* but are outside of the family *Fomitopsidaceae* that accommodates *Postia* species and their allies. The sequences were aligned using Clustal X (Thompson et al. 1997). The alignment of the nrLSU regions was deposited in TreeBase (accession

TABLE 1. List .of species, strains, and voucher specimens newly sequenced in this study and GenBank accession numbers for the LSU sequences.

SPECIES	STRAIN NO.	VOUCHER NO.	ORIGIN	ACCESSION NO.
Postia caesia	WD-1974	F-18596	Japan, Kochi	AB569119
P. caesia	WD-1976	F-18605	Japan, Kochi	AB569120
P. japonica	WD-2103	F-19345	Japan, Kyoto	AB569121
P. japonica	WD-2338	IFP Dai 8046	Japan, Ibaraki	AB569122
P. stellifera	PEN49	F-20668	Malaysia, Penang	AB569123

S10658). The data set was analyzed in PAUP* 4.0b10 (Swofford 2003). Maximum parsimony analysis was performed for the dataset with the heuristic search option with 100 random addition sequences and tree bisection and reconstruction (TBR) as the branch-swapping algorithm. All gaps were treated as missing data. The robustness of individual branches was estimated based on 1000 bootstrap replications.

Morphological studies

Macroscopic characteristics were described based on fresh and dried specimens. Microscopic characteristics based on dried specimens were determined by examining free-hand sections mounted in Melzer's reagent or in 5% (w/v) KOH solution. A non-dextrinoid and non-amyloid reaction was described as IKI–. The following abbreviations are used in the text: L, mean spore length; W, mean width; r, the ratio of length/width of a basidiospore; R, mean of r. The term (n = x/y) means x measurements of basidiospores from y specimens. The examined specimens were deposited in TFM or KEP.

Cultural characteristics were studied on potato dextrose agar plates at 25°C and described according to Nobles (1965) and Stalpers (1978). Presence of extracellular oxidase was tested with 1-naphthol ethanol solution and tyrosine ethanol suspension (Käärik 1965). The examined culture was deposited in the culture bank of Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Japan.

Results

Phylogenetic analysis

A preliminary search using the blast option showed homology with several brown rot polypores. The phylogenetic affinities of the present fungus were estimated using 20 LSU sequences, with an aligned length of 751 base pairs. Fifty positions were variable but uninformative and 86 positions parsimony were informative. Parsimony analysis of the nrLSU data set yielded two most parsimonious trees, 269 steps in length (CI = 0.58, RI = 0.68, RC = 0.40) (FIG. 1).

The present fungus was placed within a weakly supported clade that includes the species *Postia caesia* (Schrad.) P. Karst., *P. guttulata* (Peck) Jülich, *P. japonica* Y.C. Dai & T. Hatt. and *P. rennyi* (Berk. & Broome) Rajchenb. This clade is included in a larger one (*Postia* s.l. clade) that includes *Amylocystis*

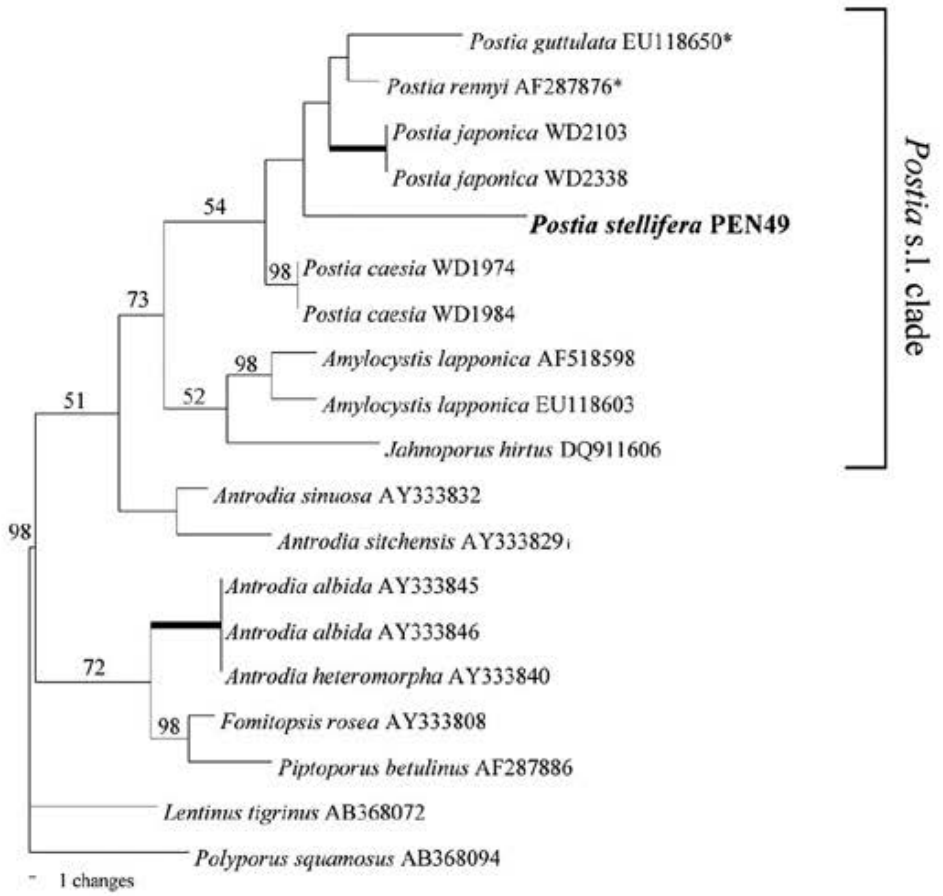


FIG. 1. One of the two most parsimonious trees obtained from heuristic searches based on LSU sequence dataset of *Postia stellifera* and its related species. Bootstrap support values above 50% are indicated at the nodes. Taxa marked with * were originally submitted to GenBank as *Oligoporus*.

lapponica (Romell) Bondartsev & Singer ex Singer, and *Jahnoporus hirtus* (Cooke) Nuss. The cultural characteristics of *J. hirtus* are still not fully known, but other members of this clade are brown rot polypores with a monomitic hyphal system.

Description

Postia stellifera T. Hatt. & Sotome, **sp. nov.** FIGS 2, 3

MYCOBANK 518628

Basidiocarpia annua, stipitata, terrestria. Pilei circulares, subtomentosi, brunneoli. Contextus carnosus, albus. Facies pororum alba, pori angulares, (1–)2–3 per mm. Stipes centrales, albi. Systema hypharum monomiticum, hyphae generativae hyalinae, fibulatae, hyphae in contextu inflatae. Basidiosporae oblongae, hyalinae, haud dextrinoideae, 4.5–5.5 × 1.8–2.3 µm. Chlamydosporae verrucosae, hyalinae vel luteolae, 7.5–12.5 × 6.8–10.8 µm.

HOLOTYPUS: **Malaysia.** *Penang, Gertak Saggul, ad terram in silva, 26.XII.2002, leg. T. Hattori & S. Baharuddin (TFM F-20668).*

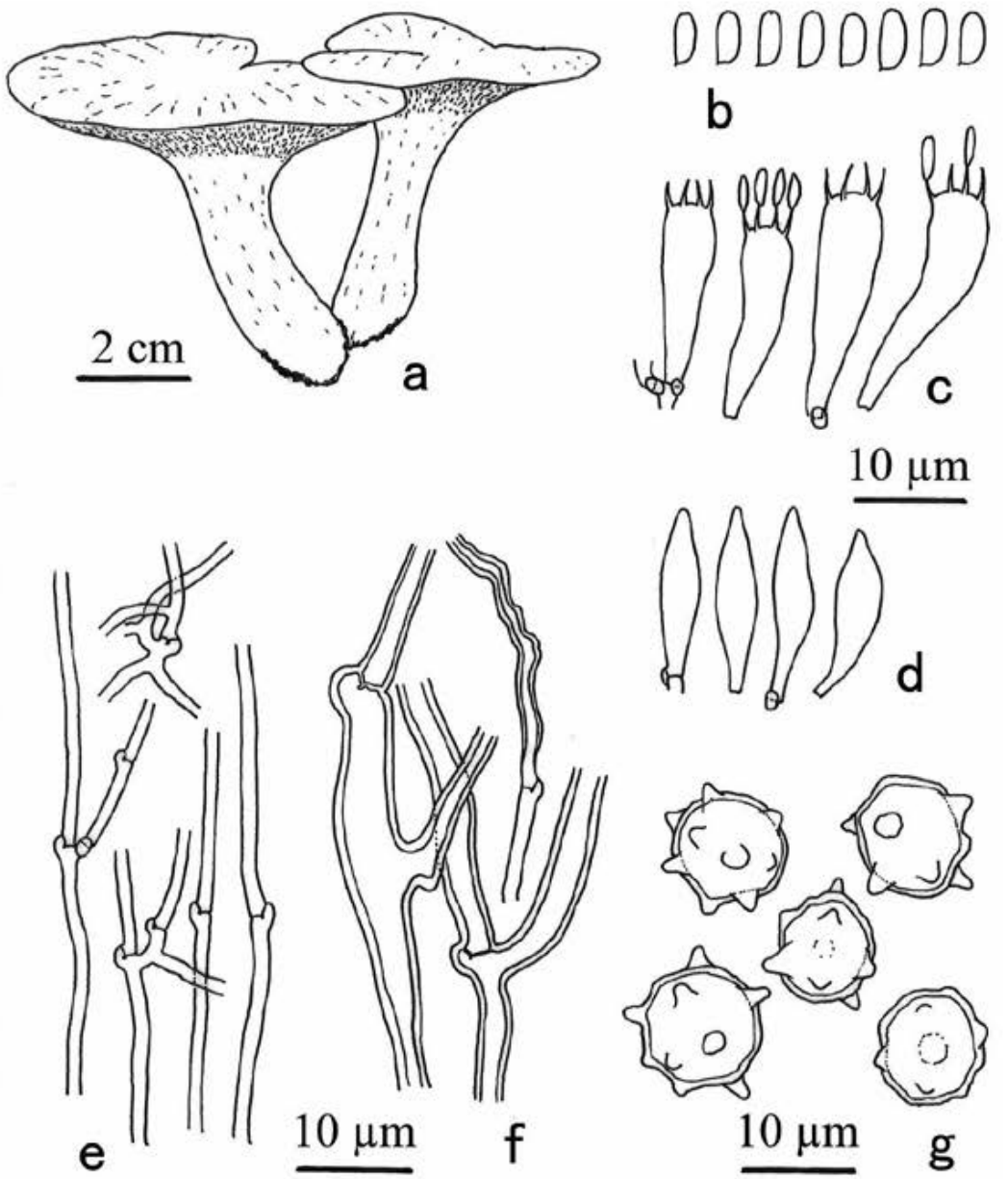


FIG. 2. Structures of *Postia stellifera* (from holotype).
—a: Basidiocarps. —b: Basidiospores. —c: Basidia. —d: Cystidioles. —e: Chlamydospores from context. —f: Generative hyphae from trama. —g: Generative hyphae from context.

ETYMOLOGY: Latin, *stellifera* = with stars, referring to the star-shaped chlamydospores seen both in the context of the basidiomata and in the culture.

Basidiomata annual, centrally stipitate, terrestrial. Pilei circular, applanate to convex, pileus surface subtomentose to pubescent, azonate, light brown to light grayish brown, whitish near the margin, pileus margin thin and acute, entire, up to 7 cm in diam. Pore surface white to cream in fresh condition drying

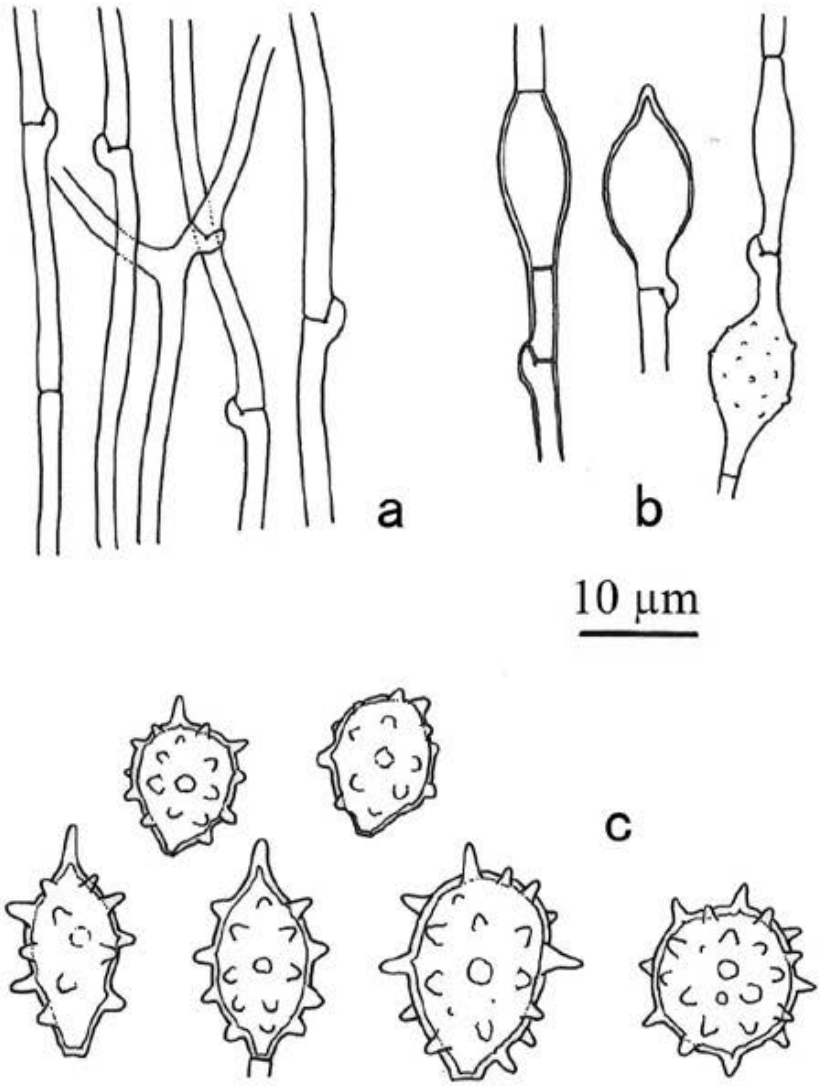


FIG. 3. Structures of *Postia stellifera* (from ex-type culture).
—a: Generative hyphae from advancing zone. —b: Young chlamydospores.
—c: Mature chlamydospores.

sordid white to grayish; pores angular, (1–)2–3 per mm, dissepiments thin, entire, with conspicuous hyphal pegs near the pore mouth. Context fleshy in fresh condition, soft and flexible in dried condition, spongy near the pileus surface, dense near the tubes; grayish brown near the pileus surface, partly light brown near the tubes, otherwise whitish to pale orange, up to 7 mm thick. Tubes whitish, fleshy in fresh condition, drying more or less brittle, decurrent on stipe, up to 5 mm deep. Stipes cylindrical, stipe surface pubescent, white in fresh condition, light brown to grayish in dried condition, up to 5 cm long and 1.5 cm wide.

Hyphal system monomitic both in context and trama. Contextual generative hyphae with clamp-connections, thin- to thick-walled with a distinct lumen,

mostly sinuous, occasionally branched, hyaline, IKI–, inflated hyphae abundant, 2–15 µm wide. Chlamydospores scattered to abundant in the context, verrucose, appendages up to 2.5 µm long, hyaline to yellow, 7.5–12.5 × 6.8–10.8 µm (excluding appendages). Tramal generative hyphae with clamp-connections, thin-walled, straight or sinuous, sparsely to conspicuously branched, hyaline, IKI–, 1.8–5 µm wide. Cystidioles present in hymenium, fusoid to mammillate, smooth, thin-walled, 14–22 × 4–5.5 µm. Basidia clavate, 4-sterigmate, with a basal clamp, 18–25 × 5–7 µm. Basidiospores oblong ellipsoid to short cylindrical, thin-walled, smooth, hyaline, IKI–, 4.5–5.5 × 1.8–2.3 µm, L = 5.07 µm, W = 2.86 µm, r = 2.21–2.78, R = 2.44 (n = 23/1).

CULTURAL CHARACTERISTICS — Growth slow, 1.2–1.4 mm/day, plates covered in 6 weeks. Advancing zone bayed, appressed, white. Mat at first white, aerial mycelium woolly to flat, becoming cream to light brown from the center. Reverse unchanged. Odor indistinctive. Hymenophore development not seen within 6 weeks. Generative hyphae from the advancing zone thin-walled, moderately branched, hyaline, 1.5–4 µm wide, with clamp-connections. Generative hyphae from aerial mycelium and submerged mycelium as in advancing zone. Chlamydospores abundant, produced intercalary or on the apex of hyphae, at first fusoid, thin-walled, smooth and hyaline, later ellipsoid to subglobose, thick-walled, distinctly verrucose to spinose, appendages up to 4 µm long, hyaline to yellow, 7–20 x 6–12 µm (excluding appendages).

EXTRACELLULAR OXIDASE ACTIVITIES — 1-naphthol, –; tyrosine, +.

SPECIES CODE — 2, 3, 7, 34, 36, 38, 46, 56 (Nobles 1965); 2, 9, 13, 15, 22, 30, 31, 39, 45, 52, (53), 85, 91 (Stalpers 1978).

EXAMINED CULTURE — PEN49 (ex-type strain, isolated from TFM F-20668).

TYPE OF ROT — unknown, but probably brown rot.

OTHER SPECIMEN EXAMINED — Malaysia. Perak, Taman Negara Royal Belum, alt. 259 m, on soil, 18 June 2007, leg. BK Thi (KEP FRIM4583).

Discussion

Within the genera of polypores (Ryvarden 1991), the micro-morphological and physiological (type of rot — viz. in all probability a brown rot) features of this species would point toward *Postia* as a possible genus. In addition to the decay type, the following characteristics are common to the present fungus, *Postia* and its allies: white and fleshy to soft corky context, poroid hymenophore, monomitic hyphal system, generative hyphae with clamp-connections, and smooth basidiospores without distinct reactions in iodine reagents.

Our phylogenetic study also indicates that this fungus is related to several *Postia* species, *Amylocystis lapponica,* and *Jahnoporus hirtus.* However, the phylogenetic position of *P. stellifera* within a hypothetic *Postia* s.l. clade is still

unclear, because sequences of many *Postia*, including the type species, are still unavailable and the clade consisting of *Postia* species is weakly supported.

One of the very distinctive characteristics of *P. stellifera* is the presence of a well-developed stipe with a terrestrial habit, a feature hitherto unknown in *Postia* and other related genera. Several polypore genera accommodate only stipitate and terrestrial species such as *Albatrellus* Gray, *Coltricia* S.F. Gray, *Boletopsis* Fayod, *Corneroporus* T. Hatt., *Diacanthodes* Singer and *Polyporoletus* Snell in addition to *Jahnoporus*. However, a few genera include both lignicolous and terrestrial species, e.g., *Microporellus* Murrill with *M. clemensiae* (Murrill) Ryvarden and *M. inusitatus* (Lloyd) Corner both terrestrial versus *M. grandiporus* Corner and *M. peninsularis* (Corner) Decock, both lignicolous (Corner 1987, Decock 2001). *Phylloporia* Murrill and *Amauroderma* Murrill also accommodate both lignicolous and terrestrial species.

Another distinctive characteristic of *P. stellifera* is the presence of verrucose chlamydospores in the context, also present in culture on artificial media. Chlamydospores are present in the context of several *Postia* species such as *P. ptychogaster* (F. Ludw.) Vesterh., *P. rennyi* and *P. brunnea* Rajchenb. & P.K. Buchanan (Rajchenberg & Buchanan 1996, Ryvarden & Gilbertson 1994), and many produce subglobose to ellipsoid chlamydospores in cultures, but they are always smooth.

After intensive examination of the oxidative reactions of wood-decay fungi, Käärik (1965) listed the following 3 species that did not have laccase but had tyrosinase as in *P. stellifera*: *Lentinus lepideus* (Fr.) Fr. [≡ *Neolentinus lepideus* (Fr.) Redhead & Ginns], *Merulius lacrymans* (Wulfen) Schumach. [≡ *Serpula lacrymans* (Wulfen) J. Schröt.], and *Trechispora brinkmannii* (Bres.) D.P. Rogers & H.S. Jacks. [≡ *Sistotrema brinkmannii* (Bres.) J. Erikss.]. Like these three species, *P. stellifera* is in all probability also a brown rot fungus.

Amylocystis lapponica is characterized by amyloid cystidia and hyphae but is otherwise similar to *Postia* with monomitic hyphal system and a rot (Ryvarden & Gilbertson 1993). Nobles (1958) placed *J. hirtus* in the group positive for extracellular oxidases on the basis of the Bavendamm reaction and application of ethanol gum guaiacum. Chang (1994) also concluded that this is a white rot fungus using Bavendamm reaction. However, these methods cannot differentiate laccase and tyrosinase (Harkin et al. 1974) and are unable to evaluate the decay type.

Jahnoporus is the only genus to accommodate a stipitate and terrestrial species among the allied genera of *P. stellifera* and is often placed in *Albatrellaceae* (Kirk et al. 2008). Another distinctive characteristic of *Jahnoporus* is the large and spindle-shaped basidiospores that are unknown both in phylogenetically related genera and the morphologically similar genus *Albatrellus* (Gilbertson & Ryvarden 1986). We prefer not to put *P. stellifera* into *Jahnoporus* because

of the difference in basidiospore morphology and the presence of verrucose chlamydospores in the context of the former. The phylogenetic position of another species of *Jahnoporus*, *J. pekingensis* (J.D. Zhao & L.W. Xu) Y.C. Dai, is still unknown, but it also has large and more or less fusiform basidiospores that are different from those of *P. stellifera* (Dai 2003).

The present fungus may be easily mistaken for an *Albatrellus* species because of the terrestrial habit and macro-morphology, but this genus is hitherto unknown from lowland rainforest of Southeast Asia, although there are a few reports of it from the highlands of Malaysia and Papua New Guinea (Corner 1989, Quanten 1997). Most of the *Albatrellus* species are considered to be mycorrhizal and difficult to cultivate on artificial media and/or their growth is much slower (18.3-33.0 mm/8-wks on PDA, Akama et al. 2008). Most of the *Albatrellus* species have short ellipsoid to subglobose basidiospores (Gilbertson & Ryvarden 1986; Ryvarden & Gilbertson 1993) while our species has long ellipsoid basidiospores. Additionally, verrucose chlamydospores are unknown in *Albatrellus*.

Most *Albatrellus* species are included in the russuloid clade, except *A. syringae* (Parmasto) Pouzar and *A. peckianus* (Cooke) Niemelä, which are placed in 'the residual polyporoid clade' where other members of this clade are lignicolous and associated with a white rot (Binder et al. 2005, Bruns et al. 1998, Cui et al. 2008, Ryman et al. 2003). In addition to their phylogenetic status, the cultural characteristics suggest that *A. syringae* is possibly a white rot fungus (Niemelä 1970, Stalpers 1992), and Ryman et al. (2003) implied that it should be excluded from *Albatrellus*. *Albatrellus peckianus*, which has been reported to be attached to buried wood of *Fagus* and *Tilia* (Lowe 1942, Overholts 1953), is also possibly a saprobe. As in *A. syringae* and *A. peckianus*, *P. stellifera* is phylogenetically isolated from *Albatrellus* sensu stricto, despite their macro-morphological similarity.

Acknowledgements

We express our gratitude to Dr. C. Decock (MUCL) and Dr. Y.-C. Dai (Beijing Forestry University) for reviewing the manuscript. We are grateful to Prof. M. Kakishima (Univ. Tsukuba) and Prof. Y. Ono (Ibaraki Univ.) for arrangement of the research project. This research was partly supported by a Grant-in-Aid for Scientific Research, JSPS Japan (No. 14255004; No. 21405023).

Literature cited

Akama K, Okabe H, Yamanaka T. 2008. Growth of ectomycorrhizal fungi on various culture media. Bulletin of FFPRI 7:165–181 [in Japanese with English summary].

Binder M, Hibbett DS, Larsson KH, Larsson E, Langer E, Langer G. 2005. The phylogenetic distribution of resupinate forms across the major clades of mushroom-forming fungi (*Homobasidiomycetes*). Systematics and Biodiversity 3: 113–157. doi: 10.1017/S1477200005001623

Bruns TD, Szaro TM, Gardes M, Cullings KW, Pan JJ, Taylor DL, Horton TR, Kretzer A, Garbelotto M, Li Y. 1998. A sequence database for the identification of ectomycorrhizal basidiomycetes by phylogenetic analysis. Molecular Ecology 7: 257–272. doi: 10.1046/j.1365-294X.1998.00337.x

Buchanan PK., Ryvarden L. 2000. An annotated checklist of polypore and polypore-like fungi recorded from New Zealand. NZJ Bot 38: 265–323. doi: 10.1080/0028825X.2000.9512683

Chang TT. 1994. Some new Taiwan polypores (*Basidiomycotina*). Trans mycol Soc ROC 9: 111–122.

Corner EJH. 1987. Ad Polyporaceas IV. The genera *Daedalea*, *Flabellophora*, *Flavodon*, *Gloeophyllum*, *Heteroporus*, *Irpex*, *Lenzites*, *Microporellus*, *Nigrofomes*, *Nigroporus*, *Oxyporus*, *Paratrichaptum*, *Rigidoporus*, *Scenidium*, *Trichaptum*, *Vanderbylia*, and *Steccherinum*. Beih Nova Hedwigia 86: 1–265.

Corner EJH. 1989. Ad Polyporaceas V. The genera *Albatrellus*, *Boletopsis*, *Coriolopsis* (dimitic), *Cristelloporia*, *Diachanthodes*, *Elmerina*, *Fomitopsis* (dimitic), *Gloeoporus*, *Grifola*, *Hapalopilus*, *Heterobasidion*, *Hydnopolyporus*, *Ischnoderma*, *Loweporus*, *Parmastomyces*, *Perenniporia*, *Pyrofomes*, *Steccherinum*, *Trechispora*, *Truncatospora* and *Tyromyces*. Beih Nova Hedwigia 96: 1–218.

Cui BK, Wang Z, Dai YC. 2008. *Albatrellus piceiphilus* sp. nov. on the basis of morphological and molecular characters. Fungal Diversity 28: 41–48.

Dai YC. 2003. *Jahnoporus pekingensis* (*Basidiomycota*), a new combination. Fungal Science 18: 55–58.

Dai YC, Wei YL, Wang Z. 2004. Wood-inhabiting fungi in southern China 2. Polypores from Sichuan Province. Annales Botanici Fennici 41: 319–329.

Dai YC, Yu CJ, Wang HC. 2007. Polypores from eastern Xizang (Tibet), western China. Annales Botanici Fennici 44: 135–145.

Decock C. 2001. Studies in *Perenniporia*. Some Southeast Asian taxa revised. Mycologia 93: 774–795. doi:10.2307/3761833

Donk MA. 1960. The generic names proposed for *Polyporaceae*. Persoonia 1: 173–302.

Gilbertson RL, Ryvarden L. 1986 North American Polypores Vol. 1. Oslo, Fungiflora.

Harkin JM, Larsen MJ, Obst JR. 1974. Use of syringaldazine for detection of laccase in sporophores of wood rotting fungi. Mycologia 66: 469–476. doi:10.2307/3758490

Käärik A. 1965. The identification of the mycelia of wood-decay fungi by their oxidation reactions with phenolic compounds. Studia Forestalia Suecia 31: 1–80.

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

Lowe JL. 1942. The *Polyporaceae* of New York State (Except *Poria*). Bulletin of the New York State College of Forestry at Syracuse University Technical Publication 60: 1–128.

Lowe JL. 1975. *Polyporaceae* of North America the genus *Tyromyces*. Mycotaxon 2: 1–82.

Niemelä T. 1970. New data on *Albatrellus syringae* (Parm.) Pouzar and *A. peckianus* (Cooke) Niemelä n. comb. Annales Botanici Fennici 7: 52–57.

Niemelä T, Kinnunen J, Lindgren M, Manninen O, Miettinen O, Penttilä R, Turunen O. 2001. Novelties and records of poroid basidiomycetes in Finland and adjacent Russia. Karstenia 41: 1–21.

Nobles MK. 1958. Cultural characters as a guide to the taxonomy and phylogeny of the *Polyporaceae*. Canadian Journal of Botany 36: 883–926. doi:10.1139/b58-071

Nobles MK. 1965. Identification of cultures of wood-inhabiting Hymenomycetes. Canadian Journal of Botany 43: 1097–1139. doi:10.1139/b65-126

Ota Y, Hattori T. 2008. Relationships among three Japanese *Laetiporus* taxa based on phylogenetic analysis and incompatibility tests. Mycoscience 49: 168–177. doi:10.1007/s10267-007-0403-3

Overholts LO. 1953. The *Polyporaceae* of the United States, Alaska, and Canada. Ann Arbor, the University of Michigan Press (3rd printing, 1977).

Quanten E. 1997. The polypores (*Polyporaceae* s.l.) of Papua New Guinea. Opera Botanica Belgica 11: 1–352.

Rajchenberg M. 2006. Los Poliporos (*Basidiomycetes*) de los Bosques Andino Patagónicos de Argentina. Bibliotheca Mycologica 201: 1–300.

Rajchenberg M, Buchanan PK. 1996. Two newly described polypores from Australasia and southern South America. Australian Systematic Botany 9: 877–885. doi:10.1071/SB9960877

Ryman S, Fransson P, Johannesson H, Danell E. 2003. *Albatrellus citrinus* sp. nov., connected to *Picea abies* on lime rich soils. Mycological Research 107: 1243–1246. doi:10.1017/S0953756203008359

Ryvarden L. 1978. The *Polyporaceae* of North Europe. Vol. 2. Oslo, Fungiflora.

Ryvarden L. 1991. Genera of polypores nomenclature and taxonomy. Synopsis Fungorum 5: 1–363.

Ryvarden L, Gilbertson RL. 1993. European polypores part 1. Synopsis Fungorum 6: 1–387.

Ryvarden L, Gilbertson RL. 1994. European polypores part 2. Synopsis Fungorum 7: 394–743.

Sotome K, Hattori T, Ota Y, To-anun C, Salleh B, Kakishima M. 2008. Phylogenetic relationships of *Polyporus* and morphologically allied genera. Mycologia 100: 603–615. doi:10.3852/07-191R

Stalpers JA. 1978. Identification of wood-inhabiting *Aphyllophorales* in pure culture. Studies in Mycology 16: 1–248.

Stalpers JA. 1992. *Albatrellus* and the *Hericiaceae*. Persoonia 14(4): 537–541.

Swofford DL. 2003. PAUP 4.0b10: phylogenetic analysis using parsimony. Sunderland, Sinauer Associates.

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The CLUSTAL X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Research 24: 4876-4882. doi:10.1093/nar/25.24.4876

Wei YL, Dai YC. 2006. Three new species of *Postia* (*Aphyllophorales, Basidiomycota*) from China. Fungal Diversity 23: 405–416.

Yao YJ, Pegler DN, Chase MW. 1999. Application of ITS (nrDNA) sequences in the phylogenetic study of *Tyromyces* s.l. Mycological Research 103: 219–229. doi:10.1017/S0953756298007138

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.161

Volume 114, pp. 163–169 *October–December 2010*

A new record of *Gliocephalotrichum simplex* from India

SANJAY K. SINGH, LAL SAHAB YADAV, PARAS N. SINGH, RAHUL SHARMA & KUNHIRAMAN C. RAJESHKUMAR

singhsksingh@rediffmail.com
National Facility for Culture Collection of Fungi, MACS' Agharkar Research Institute
G. G. Agarkar Road, Pune - 411 004, India

Abstract — During a survey of interesting and rare fungi infecting economically important plants in the forests of the Western Ghats in India, an uncommon fungal species was isolated from fruits of *Terminalia chebula*. The fungus has distinctive morphological features such as a whorl of sterile arms subtending penicillate branches bearing yellowish masses of elongated to ellipsoidal conidia. Based on morphological characters and a comparison of sequences of the internal transcribed spacer region of rDNA (ITS1-5.8S-ITS2), the fungus was determined to be *Gliocephalotrichum simplex*, a species not previously known from India.

Key words — anamorph, fungal diversity, *Hypocreales*, ITS sequence

Introduction

India is a tropical country that harbors considerable fungal biodiversity (Bilgrami et al. 1991, Jamaluddin et al. 2004). As part of our ongoing effort to discover and preserve fungi, we are making regular surveys and isolating rare and unusual fungi. During 2008–09 partially degraded fruits of *Terminalia chebula* were collected from the forest floor in Western Ghats in Maharashtra state, India. From these fruits a fungus was isolated and identified as *Gliocephalotrichum simplex*. This fungus has never been recorded from India. The present communication describes this fungus from India on artificial media isolated from fruits of *T. chebula*.

Materials and methods

Isolation, pure culture and microscopic examination

Samples of *Terminalia* fruits were collected in separate paper bags and transported to the laboratory. The fruit samples were surface-sterilized by dipping in 70% ethanol for 10 min, then rinsed in distilled water and incubated in a moist chamber at 25 ± 2°C. A yellowish to grayish fungal growth appeared on the fruit surface after 4 days. Direct

streak and serial dilution plate methods were used to isolate the fungus as a pure culture. Potato dextrose agar (potatoes, peeled, sliced 200 g, dextrose 20.0 g, agar 20 g, water 1L) and V8 (HIMEDIA) were used as the isolation medium. The isolation plates were sealed with parafilm (M250-HIMEDIA) and incubated at ambient lab temperature (25°C).

A Nikon trinocular stereozoom microscope (Model SMZ- 1500 with Digi CAM) was used for direct observation of the fungal growth pattern on the fruit surface. For microscopic details and photomicrographs, an Olympus CX-41 microscope was used. Specimens were mounted in lactophenol-cotton blue and distilled water for microscopic studies. Measurements of fungal structures were made with an ocular micrometer.

The specimen is deposited in Ajrekar Mycological Herbarium (AMH, according to Holmgren et al. 1990) and a pure culture is deposited in the National Fungal Culture Collection of India (NFCCI-WDCM 932), MACS' Agharkar Research Institute, Pune, India.

DNA isolation

The fungal strain was maintained on PDA slants. DNA was extracted from cultures grown on PDA plates for two weeks at 28°C by first homogenizing the mycelium in FastPrep®24 tissue homogenizer (MP Biomedicals GmbH, Germany) and then using the CTAB method of Graeser et al. (1999).

PCR amplification

For ITS-PCR the universal primers ITS4 (5' TCC TCC GCT TAT TGA TAT GC3') and ITS5 (5' GGA AGT AAA AGT CGTAAC AAG G 3') amplifying a DNA fragment of about 700 bp of the rDNA gene were used (White et al. 1990). The PCR mixture contained reaction buffer (10 mM TrisHCl pH 8.0, 50 mM KCl, 1.5 mM $MgCl_2$), 200 µM of each deoxynucleoside triphosphates (Genei, Bangalore, India), 50 pM each of primers, 1U of Taq polymerase (Genei, Bangalore, India), and 25 ng of template DNA. Samples were overlaid with sterile mineral oil and amplified through 30 cycles in a thermocycler (Eppendorf MastercyclerAG, Hamberg, Germany) as follows: initial denaturation for 5 min at 95°C, denaturation for 1 min at 95°C, annealing for 1 min at 56°C, and extension for 1 min at 72°C. This was followed by a final extension step for 10 min at 72°C. The resulting PCR product was checked on 1.2% agarose gel (Sigma).

Sequencing

PCR products were cleaned with Axygen PCR cleanup kit (Axygen Scientific Inc, CA, USA) and sequenced using primers ITS4 and ITS5 (White et al. 1990) on an automated DNA Sequencer ABI 3130 (Applied Biosystems, USA).

Sequence Alignment & Phylogenetic tree

rDNA sequences (ITS1-5.8S-ITS2) of the Indian isolate of *G. simplex* were manually aligned with those of known *G. simplex* sequences and the other six species of *Gliocephalotrichum* in the NCBI database (Table 1) using text editor option of the software MEGA for similarity. The manually edited sequence of NFCCI1496 was deposited in the EMBL nucleotide sequence database (FN550111) and was also subjected to a BLAST search. The neighbor-joining tree was derived from analyses of ITS1-5.8S- ITS2 sequences using Mega4.0 software.

Taxonomic description

Gliocephalotrichum simplex (J.A. Mey.) B.J. Wiley & E.G. Simmons, Mycologia 63(3): 578, 1971. FIGS 1–8

HABITAT: On rotting fruit of *Terminalia chebula* Retz. (*Combretaceae*).

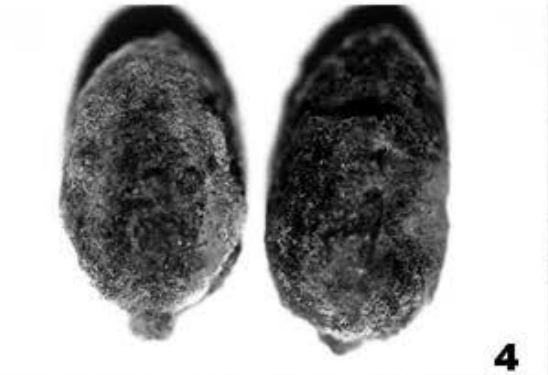
TELEOMORPH: Unknown.

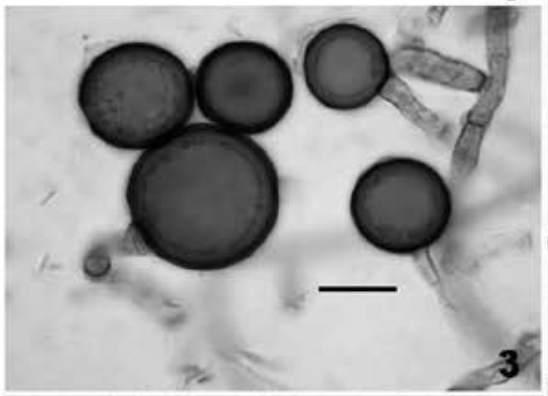
ANAMORPH: Optimum temperature for growth 25–28°C. Colony radius after 3 d on PDA (80 mm), CMA (75 mm) and V8 (70 mm). Colonies on PDA off-white in centre, floccose cottony, buff, golden brown, sporulating, margin irregular. Reverse buff. Appearance in nature: Substrate brown to blackish, covered with grayish-white colonies that later turn yellowish and spread over entire outer surface. Hyphae branched, septate, hyaline, smooth, 7.5–10.5 µm wide. Chlamydospores one-celled, terminal to intercalary or lateral, subglobose to mostly globose, thick-walled, golden brown with short stalk, 20–35 × 20–32 µm diam. Sterile hairs 1–2, originating from branching point of conidiophores or beneath septum subtending penicillus, hairs hyaline 3–8 septate, 125–412 µm long, base broad, tip narrow. Conidiophores erect, simple to branched, arising directly from submerged mycelium, hyaline to subhyaline, 80–162.5 × 7.5–10 µm, broad at base gradually narrower towards apex, 2–6-septate, at apex bearing a compact penicillus, with slimy head. Penicillus of successive branches, primary branches 7–10 × 4–6 µm, secondary branches 6–8 × 4–5 µm, tertiary branches 5–7 × 4–5 µm, quaternary branches 5–6 × 2–4 µm. Conidia cylindrical to ellipsoidal, smooth, hyaline, 7.5–9(–10) × 1–1.5 µm.

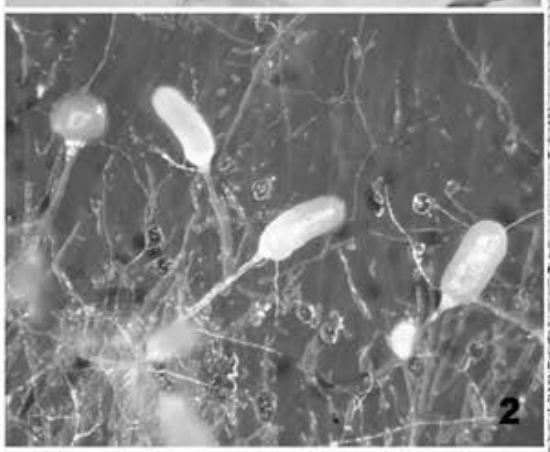
SPECIMEN EXAMINED: India, Mahabaleshwar (17°55'15"N 73°39'21"E), Maharashtra, on degraded fruits of *Terminalia chebula* (*Combretaceae*), Oct. 2008, *L. S. Yadav*, AMH 9279, Culture No. NFCCI1496

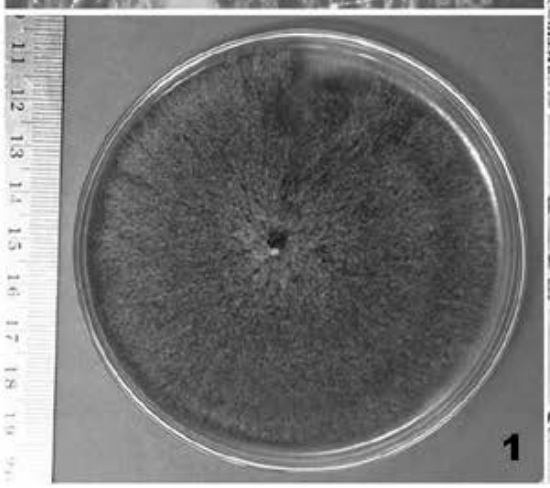
NOTES—The genus *Gliocephalotrichum* J.J. Ellis & Hesselt., typified by *G. bulbilium* J.J. Ellis & Hesselt., is mainly characterized by the origin of the sterile arms and the conidia along with the morphology and dimension of chlamydospores (Ellis & Hesseltine 1962, Decock et al. 2006). This genus has been expanded to include six additional species: *G. bacillisporum* Decock & Huret, *G. cylindrosporum* B.J. Wiley & E.G. Simmons, *G. longibrachium* Decock & Charue, *G. microchlamydosporum* (J.A. Mey.) B.J. Wiley & E.G. Simmons, *G. ohiense* L.H. Huang & J.A. Schmitt, and *G. simplex* (Ellis & Hesseltine 1962, Wiley & Simmons 1971, Huang & Schmitt 1973, Decock et al. 2006).

Sequencing of rDNA (ITS1, ITS2 and 5.8S) shows that our isolate is *Gliocephalotrichum simplex*, a species not previously recorded from India. The present strain NFCCI 1496 is part of the clade formed by other strains of *G. simplex* (Fig. 9), however, it differs slightly from its closest strain MUCL46551 from Singapore by three nucleotide positions, i.e. two transition of C→T at 202 and 316 bases along with an insertion of an A at position 8 (Fig. 10).


4


3

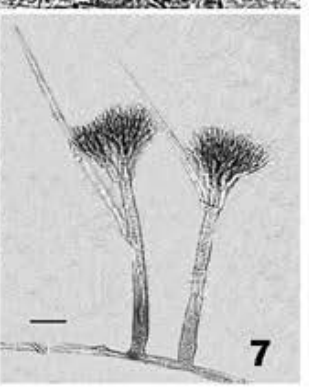

2


1


5


6


8


7

Initially, morphological differences viz. number and size of sterile arms and branched conidiophores produced on different media showed slight variation in morphological features from *G. simplex* (Wiley & Simmons 1971), but rDNA sequence comparisons showed that our isolate is indeed *G. simplex*. The setae of our isolate originate directly below the penicillus unlike the descriptions of this species. *Gliocephalotrichum simplex* is distinguished by the presence of 1–3 sterile hairs originating from 10–15 µm below the penicillus and cylindrical conidia measuring 7.5–9(–10) × 1–1.5 µm (n = 100 spores) accommodate this isolate in *G. simplex* (Wiley & Simmons 1971).

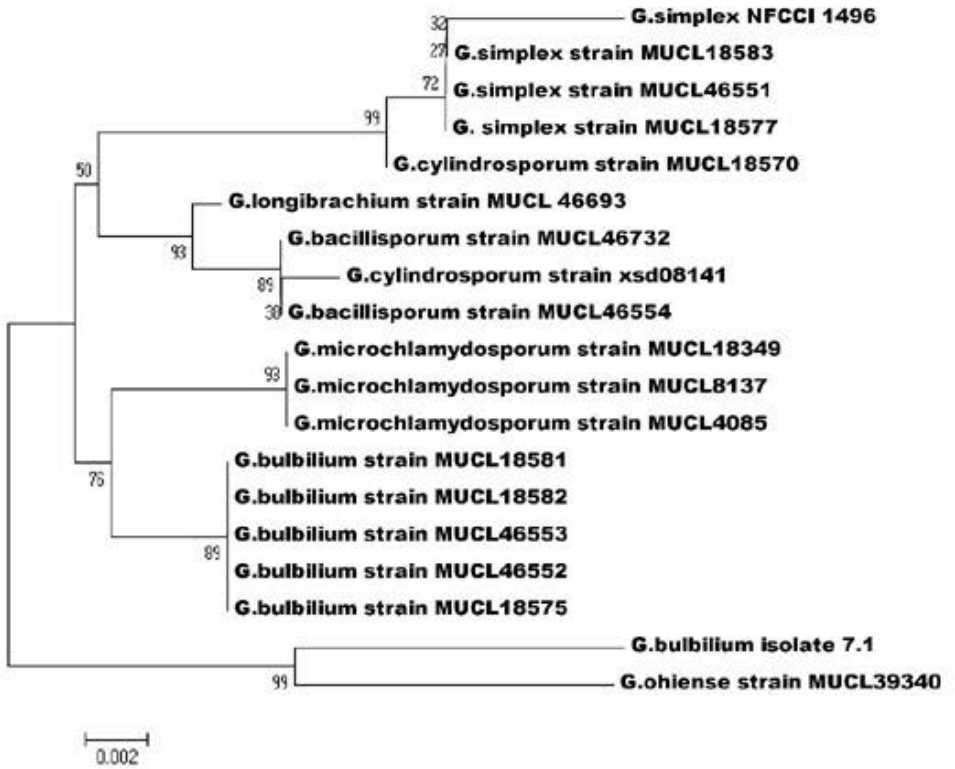


FIG. 9. Neighbour joining tree based on ITS1-5.8S-ITS2 sequences showing the relationships among 21 *Gliocephalotrichum* strains representing 7 species.

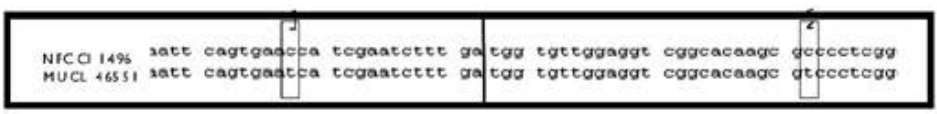


FIG. 10. Inversion (C to T) noted at two locations in *Gliocephalotrichum simplex* MUCL46551 from Singapore in comparison to NFCCI-1496 from India: position 1-base 202 (part of 5.8S gene); position 2 - base 316 (part of ITS2 region of rDNA).

FIGS. 1–8 (left). *Gliocephalotrichum simplex*. 1. Colony on PDA after 5 days. 2. Stereoscopic view of yellowish conidial heads. 3. Thick walled, golden brown, globose chlamydospores. 4. Infected fruits of *Terminalia chebula* 5. Mature conidiophores with penicilli. 6. Conidiophores with fertile stipe extensions. 7. Conidiophores with sterile arms (setae). 8. Conidia. Scale bars = 20 µm.

TABLE 1. Comparison of the rDNA sequences (ITS1-5.8S-ITS2) among isolates of *Gliocephalotrichum*.

SPECIES	STRAIN ACCESSION §	SIMILARITY *	GENEBANK/ EMBL ACC.
G. simplex	NFCCI 1496	-	FN550111
G. simplex	MUCL 46551	99%	DQ366704
G. cylindrosporum	MUCL 18570	98%	DQ366705
G. bacillisporum	MUCL 46554	97%	DQ374408
G. longibrachium	MUCL 46695	97%	DQ278422
G. bulbilium	MUCL 18582	96%	DQ381952
G. microchlamydosporum	MUCL 18349	96%	DQ366701

§ NFCCI: National Fungal Culture Collection of India, Pune, India;
MUCL: Mycotheque de l'Universite Catholique de Louvian, Louvain-la-Neuve, Belgium.
* with NFCCI 1496

SOURCE: NCBI (http://www.ncbi.nlm.nih.gov/)

There is no previous record of *G. simplex* from India (Bilgrami et al. 1991, Jamaluddin et al. 2004). Earlier records of *G. simplex* from various parts of the world are mainly from soil and debris (Watanabe & Nakamura 2005), although it has been reported on fruit of rambutan (Nishijima et al. 2002). The isolate from India is reported for the first time from fruits of *Terminalia chebula*, a plant that has been used as a traditional medicine. Therefore, the present fungus is documented here as new record from India.

Acknowledgements

We are indebted to Dr. Amy Rossman, USDA-ARS, Beltsville, USA and Dr. Xiu-Guo Zhang, Department of Plant Pathology, Shandong Agricultural University, Taian 271018, China for kindly reviewing the manuscript, Department of Science and Technology (DST), Government of India, New Delhi for providing financial support under IRHPA programme for setting up state-of the-art National Facility for Culture Collection of Fungi (No. SP/SO/PS-55/2005) at MACS' Agharkar Research Institute, Pune, India and the Director, MACS'ARI for providing facility.

Literature cited

Bilgrami SK, Jamaluddin S, Rizvi MA. 1991. Fungi of India – list and references. Today and Tomorrows Printers and Publishers, New Delhi.

Decock C, Huret S, Charue P. 2006. Anamorphic fungi from French Guyana: two undescribed *Gliocephalotrichum* species (*Nectriaceae*, *Hypocreales*). Mycologia 98: 488–498. doi:10.3852/mycologia.98.3.488

Ellis JJ, Hesseltine CW. 1962. A new genus of *Moniliales* having penicilli subtended by sterile arms. Bulletin of the Torrey Botanical Club 89: 21–27. doi:10.2307/2483273

Graeser Y, Fari ME, Vilgalys R, Kuijpers AFA, de Hoog GS, Presber W, Tietz HJ. 1999. Phylogeny and taxonomy of the family *Arthrodermataceae* (dermatophytes) using sequence analysis of the ribosomal ITS region. Medical Mycology 37: 105–114. doi:10.1080/02681219980000171

Haung LH, Schmitt JA. 1973. *Gliocephalotrichum ohiense*, a new species from Ohio soil. Mycologia 65: 948–952. doi:10.2307/3758533

Jamaluddin S, Goswami MG, Ojha BM. 2004. Fungi of India 1989–2001. Scientific Publishers (India), Jodhpur.

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index Herbariorum part 1: The herbaria of the world. 8th Ed. Regnum Vegetabile, Vol. 120. NY Botanical Garden, New York.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth and Bisby's Dictionary of the Fungi, 10th ed. CABI Publishing, Wallingford.

Nishijima KA, Follett PA, Bushe BC, Nagao MA. 2002. First report of *Lasmenia* sp. and two species of *Gliocephalotrichum* on rambutan in Hawaii. Plant Disease 86: 71. doi:10.1094/PDIS.2002.86.1.71C

Watanabe T, Nakamura K. 2005. *Gliocephalotrichum microchlamydosporum* and *G. simplex* in the Ryukyu Islands, Japan. Mycoscience 46: 46–48. doi:10.1007/s10267-004-0207-7

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. 315–322, in MA Innis et al. (eds.) PCR protocols: a guide to methods and applications. Academic Press, New York.

Wiley BJ, Simmons EG. 1971. *Gliocephalotrichum*, new combinations and a new species. Mycologia 63: 575–585. doi:10.2307/3757554

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.171

Volume 114, pp. 171–177 October–December 2010

Two new records of *Mucorales* from the Brazilian semi-arid region

André Luiz Cabral M. de A. Santiago* & Leonor Costa Maia

andrelcabral@msn.com & leonorcmaia@yahoo.com.br
Programa de Pós-graduação em Biologia de Fungos
Universidade Federal de Pernambuco, Av. Prof. Nelson Chaves
5670-420, Recife, PE, Brasil

Abstract — *Apophysomyces elegans* and *Mycotypha microspora* are recorded for the first time in Brazil based on isolates from semiarid soil in the Northeast part of the country.

Key words — *Zygomycetes*, *Mucoromycotina*, taxonomy

Introduction

Apophysomyces and *Mycotypha* belong to the subphylum *Mucoromycotina* (Hibbett et al. 2007), family *Mucoraceae*, order *Mucorales* (Benny 2005). *Apophysomyces* was first described by Misra et al. (1979), and the description of *A. elegans* (the monotype) was based on two specimens isolated from soil. This species typically produces a pyriform, apophysate multispored sporangia developed on a sporangiophore with a funnel-shaped to bell-shaped apophysis. *Apophysomyces elegans* has also been reported as an agent of zygomycosis in immunocompromised patients (Kimura et al. 1999; Liang et al. 2006; Chakrabarti et al. 2008; Reddy et al. 2008).

Mycotypha was introduced by Fenner (1932), who described a single species, *M. microspora*. Six species have been included in the genus, but Benny et al. (1985) accepted only three as true *Mycotypha* species. *Mycotypha microspora* was isolated as a contaminant on a plate culture of a pathogen of bitter orange (*Citrus aurantium*) and was first classified in *Mucoraceae*. Since then, *Mycotypha* has been placed in the *Choanephoraceae* (Bessey 1950) and the *Cunninghamellaceae* (Hesseltine 1952). Novak & Backus (1963) described *M. africana*, which produces zygospores with a typically mucoraceous form. Young (1969), based on the electron and phase-contrast microscopy of spores, reported that *Mycotypha* should be included in the *Thamnidiaceae*. Later,

Benny et al. (1985) proposed the family *Mycotyphaceae*, including a new species *M. indica*. *Mycotypha microspora* is characterized by sporophores terminating in a mostly cylindrical fertile vesicle bearing dimorphic sporangiola subtended by conical denticles. Yeast-like budding cells and thin-walled chlamydospores are also characteristics of this species.

The purpose of this manuscript is to report the first occurrence of *Mycotypha microspora* and *Apophysomyces elegans* in Brazil. For *M. microspora* this also represents the first record for South America.

Materials and methods

Soil samples were collected at Belém de São Francisco (8°33'59"S, 38°49'59"W) and Triunfo (7°52'28"S, 38°06'03"W), located in the semi-arid region of the State of Pernambuco, Northeastern Brazil. Belém de São Francisco is characterized by xerophilous vegetation with patches of deciduous forest. The typical biome is named caatinga and the climate is tropical semi-arid. Triunfo comprises semi deciduous forest and, according to Koeppen's classification, the climate is hot and humid tropical. Both areas are included in the Brazilian semi-arid region, which covers more than 969,589 km^2 (Ministério da Integração Nacional 2005).

The samples of soil were collected with a sterilized spatula, placed in plastic bags and taken to the laboratory. Soil particles (5 mg) were placed on sets of Petri dishes containing MEYE (Benny 2008) plus chloramphenicol (100mg/L). The plates were left on a bench at room temperature (28 ± 2°C) under light and dark periods for 72 hours. Fragments of mycelium were removed directly from the samples at the stereomicroscope and transferred to Petri dishes with M agar (O'Donnell 1979). Identification and descriptions were based on macroscopical (color, aspect and diameter of the colonies) and microscopical (microstructures) characters according to Benny & Benjamin (1976) and Misra et al. (1979).

Taxonomy

Apophysomyces elegans P.C. Misra, K.J. Srivast. & Lata, Mycotaxon 8(2): 377 (1979)
FIG. 1 A–D

SPECIMEN EXAMINED: Brazil, Pernambuco, Triunfo, soil, Jan. 2010, A.L.C.M.A. Santiago (URM-Culture collection 6169).

Colonies remaining white on M agar, reverse pale yellow, 9 cm diam in 72 hour at 28°C. SPORANGIOPHORES growing slowly, after 7 days, often single, developing at right angles from aerial stolon-like hyphae which generally becomes delimited by two septa near the place of origin of the sporangiophore; erect, unbranched, thick-walled, smooth, light brown, becoming darker near the base and darker and thicker below the apophyses, up to 550 µm long and 5 µm wide near the base. SPORANGIA hyaline at first, becoming light yellowish-brown, terminally, pyriform, distinctly apophysate, 20–50 µm diam. APOPHYSES funnel-shaped to bell-shaped, 12–47 µm high and 17–27.5 µm diam at the

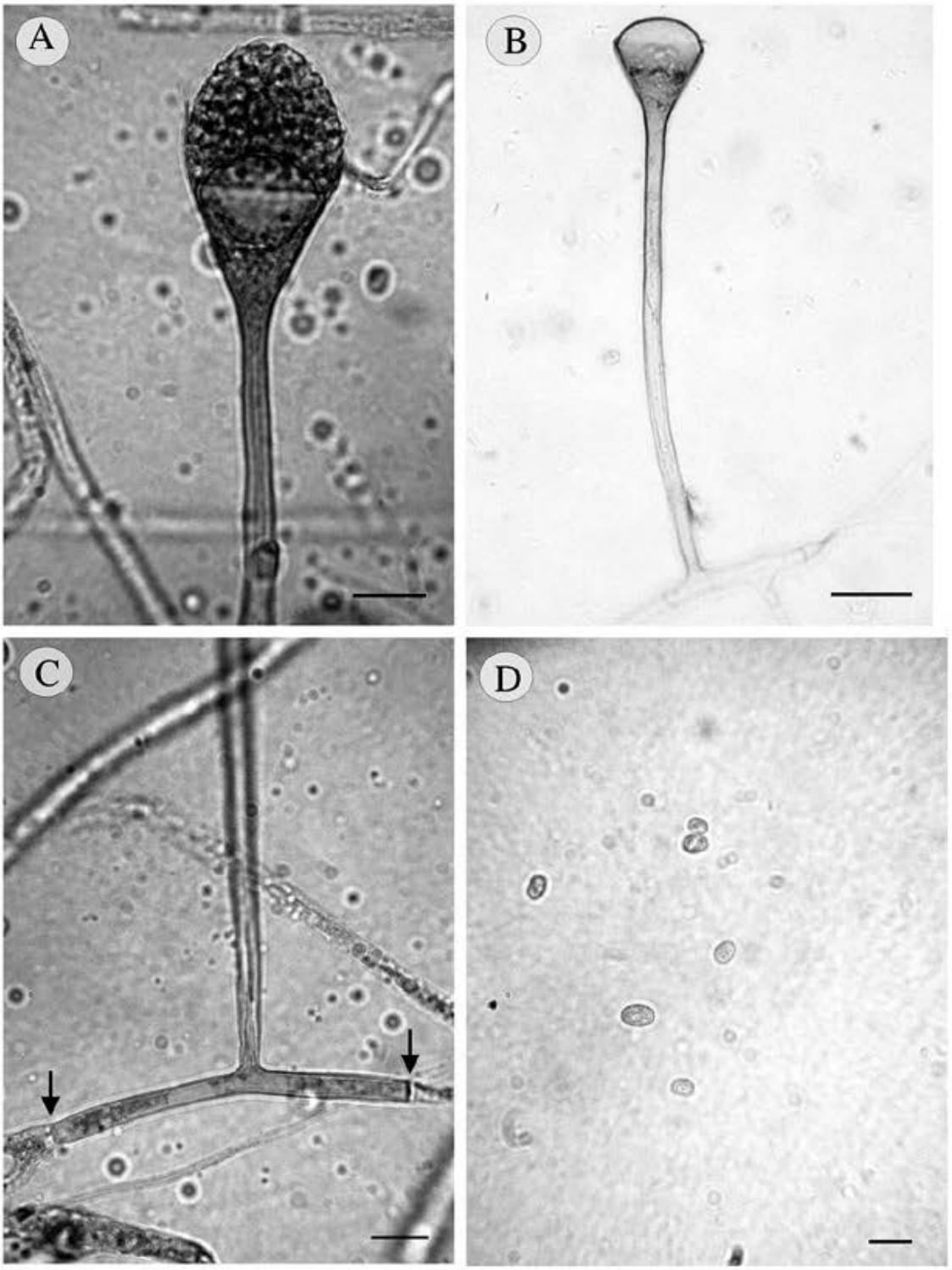


FIG. 1 *Apophysomyces elegans*. A) Sporangiophore with sporangium; B) Sporangiophore with funnel-shaped apophysis and columella; C) Stolon-like hypha delimited by two septa near the place of origin of the sporangiophore; D) Sporangiospores. Scale bars: A, C, D = 10µm, B = 20 µm.

widest part; smooth-walled, light brownish. COLUMELLAE hemispherical, thin-walled, subhyaline, 20–30 µm diam, collar distinct. SPORANGIOSPORES oblong,

sometimes subglobose, subhyaline, minutely roughened, 4.5–8.5(–12.5) × 4–5.5(–6.5) µm. RHIZOIDS unbranched, subhyaline. ZYGOSPORES not observed.

HABITAT: Soil

GEOGRAPHIC DISTRIBUTION: Australia (Cooter et al. 1990), Caribbean (Meis et al. 1994), Colombia (Ruiz et al. 2004), India (Mirza et al. 1979; Lakshmi et al. 1993; Shakrabarti el al. 2003) and USA (Blair et al. 2002; Liang et al. 2006; Ferguson et al. 2007).

REMARKS: The characteristics of the *Apophysomyces elegans* strains reported here show a close similarity with the original description of Misra et al. (1979). However, differences in colony color and sporangiospore walls were observed. The colonies were persistently white, as also described by Lakshmi et al. (1993), but Misra et al. (1979) and Cooter et al. (1990) reported colonies as white at first, becoming brownish-gray, and then creamy white to buff with age. Recently, Reedy et al. (2008) described the colonies as initially white, turning brownish-gray or yellow. The fact that different authors have used dissimilar culture media for descriptions may explain this variation of color. Curiously, the *A. elegans* sporangiospores described here are minutely roughened, differing from the smooth ones reported by Misra et al. (1979). However, we did not consider these differences enough to characterize a new taxon. *Apophysomyces elegans* has some microscopic features similar to those of species of *Absidia*, like sporangiophores arising from stolons and pyriform, apophysate sporangia. Nevertheless, *Apophysomyces* differs from *Absidia* in bearing a more pronounced, funnel-shaped to bell-shaped, apophysis. In addition, the sporangiophore wall below the apophyses is dark and thick in *Apophysomyces* (Mirza 1979; Lakshmi 1993).

Mycotypha microspora Fenner, Mycologia 24: 196 (1932) FIG. 2 A–D

SPECIMEN EXAMINED: Brazil, Pernambuco, Belém de São Francisco, soil, Jan. 2010, A. L. C. M. A. Santiago (URM-Culture collection 6170).

Colony with limited growth after 15 days at 28°C in M agar; more or less zonate, later deep gray or brown with age. SPOROPHORES simple at first, some secondarily branched, hyaline at first, becoming grayish brown in age, irregularly multiseptate, particularly below the VESICLE, 3 mm high, 3–18.5 µm diam. FERTILE VESICLES terminal, mostly cylindrical, rounded at the apex, appearing minutely roughened, bearing sporangiola over entire surface, except at extreme tip, 20–580 × 10–40 µm. SPORANGIOLA dimorphic, forming two different layers over surface of vesicle; at outer layer, ovoid to obovoid, 4–6 × 3–5 µm, pale bluish-gray, smooth, globose to subglobose borne on conical pedicels; at inner layer, 3–5.5 µm in diam, pale bluish-gray, smooth, born on conical pedicels. After dehiscence, the sporangioles bear remnant of pedicel. ZYGOSPORES not observed.

HABITAT: Soil

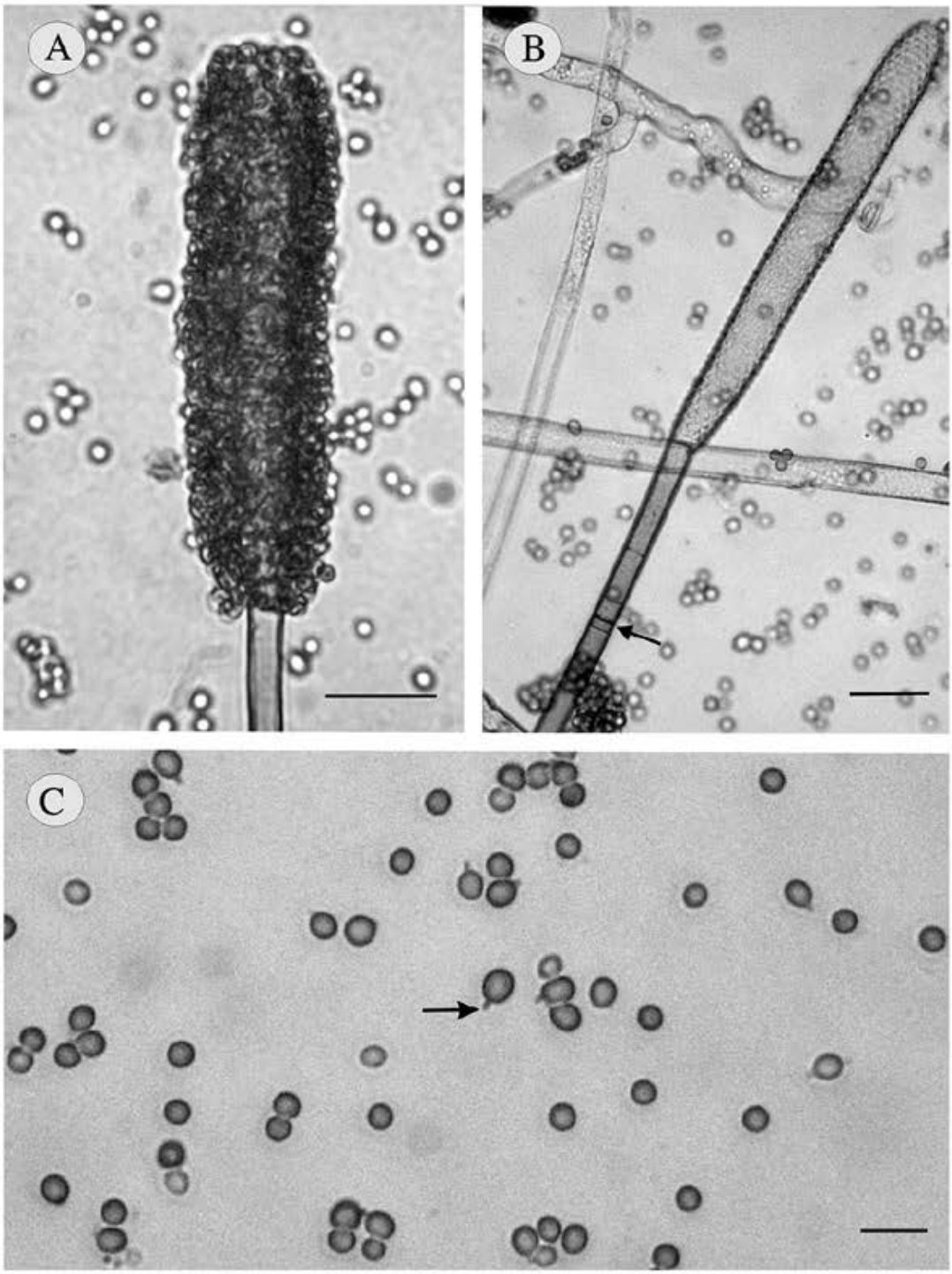


FIG. 2 *Mycotypha microspora*. A) Sporangiophore with terminal fertile vesicle and sporangiola; B) Terminal fertile vesicle after dehiscence of the sporangiola; septa produced near the vesicle. C) Globose and ovoid to obovoid sporangiola with remnant of pedicels.
Scale bars: A, B = 30 µm; C = 10 µm.

GEOGRAPHIC DISTRIBUTION: Belgium (IHEM), Finland (IMI), France (Lacroix et al. 2007; IHEM), Germany (IMI), Great Britain (IMI), India (Ray & Mukerji 1961), Japan (NBRC), Libya (IMI), Netherlands (CBS), Nigeria (IMI), Poland (IMI), USSR (CBS), Thailand (CBS), Turkey (MUCL), USA (Benny & Benjamin 1976).

REMARKS: The strain characteristics of *M. microspora* reported here are very close to the original description by Benny & Benjamin (1976). The known species of *Mycotypha* are morphologically similar, but *M. microspora* differs from *M. africana* in producing ovoid to obovoid external sporangiola, while in the latter the external sporangiola are cylindrical. In *M. microspora* the septa in the sporophore are usually produced near the apex but may also be formed near the base, while in *M. indica* the septa are only produced near the base (Benny et al. 1985).

Acknowledgments

The authors are thankful to Dr Paul Kirk and Dr José Luis Bezerra for article review. We also thank the Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE) and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing a Post-doc fellowship and a research grant to the first and second authors, respectively.

Literature cited

Benny GL. 2005. *Zygomycetes*. Published on the Internet at http://www.zygomycetes.org.

Benny GL. 2008. The methods used by Dr. R.K. Benjamin, and other mycologists, to isolate *Zygomycetes*. Aliso 26: 37–61.

Benny GL, Benjamin RK. 1976. Observations on *Thamnidiaceae* (*Mucorales*). II. *Chaetocladium*, *Cokeromyces*, *Mycotypha*, and *Phascolomyces*. Aliso 8(4): 391–424.

Benny GL, Kirk, PM, Sansom RA. 1985. Observations on *Thamnidiaceae* (*Mucorales*). III. *Mycotyphaceae* fam. nov. and a re-evaluation of *Mycotypha* sensu Benny & Benjamin illustrated by two new species. Mycotaxon 22: 119–148.

Bessey EA. 1950. Morphology and taxonomy of fungi. The Blakiston Company, Philadelphia & Toronto. doi:10.1097/00010694-195101000-00015

Blair JE, Fredrikson LJ, Pockaj BA, Lucaire CS. 2002. Locally invasive cutaneous *Apophysomyces elegans* infection acquired from snapdragon patch test. Mayo Clin. Proc. 77: 717–720. doi:10.4065/77.7.717

Chakrabarti A, Chatterjee SS, Shivaprakash MR. 2008. Overview of opportunistic fungal infections in India. Jpn. J. Med. Mycol. 49: 165–172. doi:10.3314/jjmm.49.165

Cooter, RD, Lim IS, Ellis DH, Leitch IOW. 1990. Burn wound zygomycosis caused by *Apophysomyces elegans*. J. Clin. Microbiol. 28(9): 2151–2153.

Fenner EA. 1932. *Mycotypha microspora*, a new genus of the *Mucoraceae*. Mycologia 24: 187–198. doi:10.2307/3753679

Ferguson TD, Schniederjan SD, Dionne-Odom J, Brandt ME, Rinaldi MG, Nolte FS, Langston A, Zimmer SM. 2007. Posaconazole treatment for *Apophysomyces elegans* rhino-orbital zygomycosis following trauma for a male with well-controlled diabetes. J. Clin. Microbiol. 45(5): 1648–1651. doi:10.1128/JCM.00014-07

Hibbett DS, Binder M, Bischoff JF, Blackwell M, Cannon PF, Eriksson OE, Huhndorf S, James T, Kirk PM, Lücking R, Lumbsch HT, Lutzoni F, Matheny PB, McLaughlin DJ, Powell MJ, Redhead S, Schoch CL, Spatafora JW, Stalpers JA, Vilgalys R, Aime MC, Aptroot A, Bauer R, Begerow D, Benny GL, Castlebury LA, Crous PW, Dai YC, Gams W, Geiser DM, Griffith GW, Gueidan C, Hawksworth DL, Hestmark G, Hosaka K, Humber RA, Hyde KD, Ironside JE, Kõljalg

U, Kurtzman CP, Larsson KH, Lichtwardt R, Longcore J, Miadlikowska J, Miller A, Moncalvo JM, Mozley-Standridge S, Oberwinkler F, Parmasto E, Reeb V, Rogers JD, Roux C, Ryvarden L, Sampaio JP, Schüßler A, Sugiyama J, Thorn RG, Tibell L, Untereiner WA, Walker C, Wang Z, Weir A, Weiss M, White MM, Winka K, Yao YJ, Zhang N. 2007. A higher-level phylogenetic classification of the fungi. Mycol. Res. 111: 509–547. doi:10.1016/j.mycres.2007.03.004

Kimura M, Smith MB, McGinnis MR. 1999. Zygomycosis due to *Apophysomyces elegans:* report of 2 cases and review of the literature. Arch. Pathol. Lab. Med. 123(5): 386–390.

Lakshmi V, Rani TS, Sharma S, Mohan VS, Sundaram C, Rao RR, Satyanarayana AG. 1993. Zygomycotic necrotizing fascitis caused by *Apophysomyces elegans*. J. Clin. Microbiol. 31(5): 1368–1369.

Liang KP, Tleyjeh IM, Wilson WR, Roberts GD, Temesgen Z. 2006. Rhino-orbitocerebral mucormycosis caused by *Apophysomyces elegans*. J. Clin. Microbiol. 44(3): 892–898. doi:10.1128/JCM.44.3.892-898.2006

Meis JFGM, Kullberg BJ, Pruszczynsk K M, Veth RPH. 1994. Severe osteomyelitis due to the Zygomycete *Apophysomyces elegans*. J. Clin. Microbiol. 32(12): 3078–3081.

Misra PC, Srivastava KJ, Lata K. 1979. *Apophysomyces*, a new genus of the *Mucorales*. Mycotaxon 8: 377–382.

MIN [Ministérios da Integração nacional]. 2005.Nova delimitação do semi-árido brasileiro. Secretaria de Políticas de Desenvolvimento Regional, Brasília, Brasil.

Novak RO, Backus MP. 1963. A new species of *Mycotypha* with a zygosporic stage. Mycologia 55 (6): 790–798. doi:10.2307/3756483

O'Donnell KL. 1979. *Zygomycetes* in culture. University of Georgia, Georgia.

Reddy IS, Rao NR, Reddy VM, Rao R. 2008. Primary cutaneous mucormycosis (Zygomycosis) caused by *Apophysomyces elegans*. Indian J. Dermatol. Venereol. Leprol. 74 (4): 367–370. doi:10.4103/0378-6323.42912

Ruiz CE, Arango M, Correa AL, López LS, Restrepo A. 2004. Fascitis necrosante por *Apophysomyces elegans*, moho de la familia *Mucoraceae*, en paciente inmunocompetente. Biomédica 24: 239–251.

Young TWK. 1969. Electron and phase-contrast microscopy of the spores in two species of the genus *Mycotypha* (*Mucorales*). J. Gen. Microbiol. 55: 243–249. doi:10.1099/00221287-55-2-243

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.179

Volume 114, pp. 179–191 October–December 2010

Sphaerodes mycoparasites and new *Fusarium* hosts for *S. mycoparasitica*

VLADIMIR VUJANOVIC* & YIT KHENG GOH

*vladimir.vujanovic@usask.ca & yig348@mail.usask.ca
Department of Food and Bioproduct Sciences, University of Saskatchewan
Saskatoon, SK, S7N 5A8 Canada

Abstract — A comprehensive key, based on asexual stages, contact mycoparasitic structures, parasite/host relations, and host ranges, is proposed to distinguish those species of *Sphaerodes* that are biotrophic mycoparasites of *Fusarium*: *S. mycoparasitica*, *S. quadrangularis*, and *S. retispora*. This is also the first report of *S. mycoparasitica* as a biotrophic mycoparasite on *Fusarium culmorum* and *F. equiseti* in addition to its other reported hosts (*F. avenaceum*, *F. graminearum*, and *F. oxysporum*). In slide culture assays, *S. mycoparasitica* acted as a contact mycoparasite of *F. culmorum*, and *F. equiseti* producing hook-like attachment structures. Fluorescent and confocal laser scanning microscopy showed that *S. mycoparasitica* is an intracellular mycoparasite of *F. equiseti* but not of *F. culmorum*. All three mycoparasitic *Sphaerodes* species were observed to produce asexual (anamorphic) stages when challenged with *Fusarium*. Furthermore, a phylogenetic tree, based on (large subunit) LSU rDNA sequences, depicted closer relatedness to one another of these *Fusarium*-specific *Sphaerodes* taxa than to the non-mycoparasitic *S. compressa*, *S. fimicola*, and *S. singaporensis*.

Key words — ascomycete, coevolution

Introduction

Mycoparasitism refers to the parasitic interactions between one fungus (parasite) and another fungus (host). These relationships can be categorized as either necrotrophic or biotrophic (Boosalis 1964; Butler 1957). Differences between necrotrophic and biotrophic mycoparasites were reviewed and outlined by Jeffries & Young (1994). This paper emphasizes biotrophic *Sphaerodes* Clem. (*Ascomycota*) mycoparasites and their association with fungi, in particular *Fusarium* Link. Biotrophic mycoparasitic ascomycete and basidiomycete fungi are characterized by intimate contact with host cells (Bauer & Oberwinkler 2004; Gams et al. 2004), with or without penetration. This intimate contact involves generation of short haustoria and appressoria or absorptive mycoparasitic cells.

* Corresponding author

The cytoplasm of the host hyphae remains healthy in at least some phase(s) of mycoparasitic interactions (Jeffries 1995).

Among pyrenomycetous orders, *Melanosporales* contains the largest number of biotrophic mycoparasites (Davey et al. 2008; Zhang et al. 2002), mainly within *Melanospora* Corda, *Persiciospora* P.F. Cannon & D. Hawksw., *Sphaerodes,* and *Syspastospora* P.F. Cannon & D. Hawksw. (Cannon & Hawksworth 1982; Harveson & Kimbrough 2001; Posada et al. 2004). *Sphaerodes* is a relatively small genus with unique morphological features to some extent similar to *Melanospora* and *Microthecium* Corda (García et al. 2004). Interestingly, most of the known *Sphaerodes* mycoparasitic taxa associate with *Fusarium* species — causal agents of diseases in plants and toxicosis in humans and animals (Goh & Vujanovic 2010; Harveson & Kimbrough 2001; Vujanovic & Goh 2009). To distinguish *Sphaerodes* from other genera in *Melanosporales*, ascospore characters such as wall ornamentation and shape are utilized (Zhang et al. 2002).

Identification of *Sphaerodes* species is mostly based on morphological attributes of their ascomata, structural details of ascomatal wall and neck tissues, as well as distinctive ascospore shape and ornamentation. To date, their anamorphs and their mode of mycoparasitism of *Fusarium* are poorly known.

Among all the described *Sphaerodes* species, five have been reported associated with fungal hosts (Farr & Rossman 2009). *Sphaerodes mycoparasitica* Vujan., *S. quadrangularis* Dania García, Stchigel & Guarro and *S. retispora* (Udagawa & Cain) P.F. Cannon & D. Hawksw. var. *retispora* were reported to be biotrophic mycoparasites of *Fusarium* species (Vujanovic & Goh 2009; Goh & Vujanovic 2010; Harveson & Kimbrough 2001), whereas *S. episphaeria* (W. Phillips & Plowr.) Clem. was associated with *Hypomyces* sp. (Cannon et al. 1985). *Sphaerodes retispora* var. *retispora* was the first *Sphaerodes* species reported to be a biotrophic mycoparasite of *Fusarium oxysporum* (Harveson & Kimbrough 2001). Recently, *S. mycoparasitica* and *S. quadrangularis* were also observed to establish biotrophic mycoparasitic relationships with a few *Fusarium* taxa, including red-pigmented species such as *F. avenaceum* and *F. graminearum* (Goh & Vujanovic 2010; Vujanovic & Goh 2009). However, there is no single report comparing these three *Sphaerodes* biotrophic mycoparasites, specific to *Fusarium,* in terms of differences in mycoparasitic contact structures, host ranges, and anamorphic reproductive structures.

Therefore, the purpose of this paper is to document two new *Fusarium* hosts for *S. mycoparasitica*, as well as to discuss and describe differences in these three biotrophic mycoparasites based on parasitic contact structures, phialidic stages and host ranges. Furthermore, a phylogenetic analysis based on LSU (large subunit) rDNA is incorporated into this study to determine the role of host specialization in the evolution of mycoparasitic *Sphaerodes*.

Materials and methods

Fungal isolates and growth

Sphaerodes mycoparasitica was first isolated and described by Vujanovic & Goh (2009) as an obligate biotrophic mycoparasite of various *Fusarium* taxa from Canadian agricultural fields. *Sphaerodes quadrangularis* (CBS112764 strain) was first reported as a facultative biotrophic mycoparasite of *Fusarium avenaceum*. *Sphaerodes retispora* var. *retispora* (CBS 994.72), isolated from Japanese soil, was also obtained from Centraalbureau voor Schimmelcultures (CBS, Fungal Biodiversity Centre) Baarn, The Netherlands. Biotrophic mycoparasite *Sphaerodes mycoparasitica* SMCD2220 and pathogenic *Fusarium* strains (*F. arthrosporioides* SMCD2247, *F. culmorum* SMCD2248, *F. equiseti* SMCD2134, *F. flocciferum* SMCD2135, *F. poae* SMCD2136, and *F. torulosum* SMCD2139) were obtained from the Saskatchewan Microbial Collection and Database (SMCD), Saskatchewan, Canada. All fungal isolates were grown and maintained on potato dextrose agar (PDA) (Difco, BD, Sparks, Maryland) prior to the study.

Fungal-fungal interactions

For examination of the interaction between isolates of *Sphaerodes* and *Fusarium* species, both biotrophic mycoparasite and *Fusarium* isolates were inoculated and assessed using slide culture assays proposed in Cole & Kendrick (1968) and Jacobs et al. (2005), with slight modifications as in Goh & Vujanovic (2010). Slides were maintained in a sterile humidity chamber as outlined in Kavková & Čurn (2005) and daily observations on the hyphal interactions at the meeting place (contact zone) were performed under a Carl Zeiss Axioskop2 equipped with Carl Zeiss AxioCam ICc1 camera with 20×, 40× and 100× objectives. Formation of biotrophic mycoparasitic contact structures attaching *Sphaerodes* species to *Fusarium* hyphae were examined, recorded, and compared to drawings from the literature (Jordan & Barnett 1978; Rakvidhyasastra & Butler 1973; Whaley & Barnett 1963). Diameters of both parasitized and non-parasitized *Fusarium* hyphal cells were measured under light microscopy with a 100× objective lens. Each treatment used six replications consisted of *Sphaerodes* or *Fusarium* alone, and *Sphaerodes–Fusarium* co-inoculated. The experiment was repeated twice. In the slide-culture assay, *Fusarium* mycelia infected with *Sphaerodes* haustoria were stained with lactofuchsin (Carmichael 1955). Stained hyphae of both *Fusarium* and *Sphaerodes* in slide-culture were then examined with a Carl Zeiss Axioskop2 fluorescent microscope attached to Carl Zeiss AxioCam ICc1 with 40× and 100× objectives. Slide-culture assays were also subjected to Zeiss META 510 confocal laser scanning microscopy (CLSM) analysis to observe intracellular mycoparasitism under a C-Apochromat 63× N.A.1.2 phase-contrast water immersion objective through Z-stacking mode to scan through the *Fusarium* hyphae with intracellular infection (CLSM with 514nm excitation – argon and LP585 emission filters) (Abdellatif et al. 2009).

Fungal morphology and taxonomy

The anamorphic stages of three mycoparasitic *Sphaerodes* species (*S. mycoparasitica*, *S. quadrangularis*, and *S. retispora* var. *retispora*) were compared in the presence of *Fusarium* hosts. Diameters of base and neck of monophialides were measured and base-

neck ratios were calculated. Genomic DNA of *S. retispora* var. *retispora* CBS 994.72 was extracted, amplified, and sequenced as outlined in Vujanovic & Goh (2009) by targeting LSU rDNA fragments with LS1/LR5 primers (Hausner et al. 1993; Rehner & Samuels 1995; Zhang & Blackwell 2002). The LSU sequence from this study and sequences retrieved from GenBank were aligned using Clustal X software (version 1.82) (Thompson et al. 1997), and edited in BioEdit (Hall 1999). Distance trees were generated with Phylogenetic Analysis Using Parsimony (PAUP) 4.0b10 software (Swofford 2000) using neighbor-joining approach, and validated using bootstrap analyses with 1000 repetitions. A fungal distance tree was prepared with sequences showing bootstrap values higher than 50%. The LSU sequence from *Sphaerodes retispora* var. *retispora* was submitted to GenBank as GU205261.

Statistical analysis

The difference in diameters of parasitized and non-parasitized hyphal cells was analyzed with a T-test (SPSS 1990).

Results

Fungal-fungal interaction

Hyphae-hyphae interactions and contact structures in the contact zone were examined for seven days. On day three, *Sphaerodes mycoparasitica* was found to produce hook-shaped contact structures on *Fusarium equiseti* and *F. culmorum* (FIG. 1). On day five, more hook-shaped contact structures and intracellular penetration of *F. equiseti* were observed (FIG. 2A, 3A–D). The combination of lactofuchsin dye and fluorescent or confocal laser scanning microscopy revealed that the parasitized or penetrated *Fusarium* cells became empty (loss of cytoplasm = no fluorescence) or fluoresced with low intensity (very pale) (FIG. 3A–D) as compared to healthy *Fusarium* cells. During the seven days of observation, no *S. mycoparasitica* hyphae were observed within *F. culmorum* cells. *Sphaerodes mycoparasitica* produced hook-shaped contact structures (FIG. 1A, a) more frequently than clamp-like contact structures (FIG. 1B, b) on both *F. equiseti* and *F. culmorum*. Diameters of *F. equiseti*, but not *F. culmorum*, hyphae parasitized by *S. mycoparasitica* were observed to be significantly reduced compared to non-parasitized *Fusarium* hyphae (with T-test, $P = 0.001$ and $P > 0.05$, respectively) (FIG. 4).

None of the *Fusarium* taxa tested appeared to be suitable hosts for mycoparasitic *S. quadrangularis* and *S. retispora*, even after 10 days of co-inoculation on slide cultures. No contact biotrophic parasitic structures or intracellular parasitism by *S. quadrangularis* and *S. retispora* on the tested *Fusarium* strains were observed at the interaction or contact zone. Also, *F.* arthrosporioides, *F. flocciferum*, *F. poae*, and *F. torulosum* did not appear to be suitable hosts for *S. mycoparasitica*. Around five days after inoculation

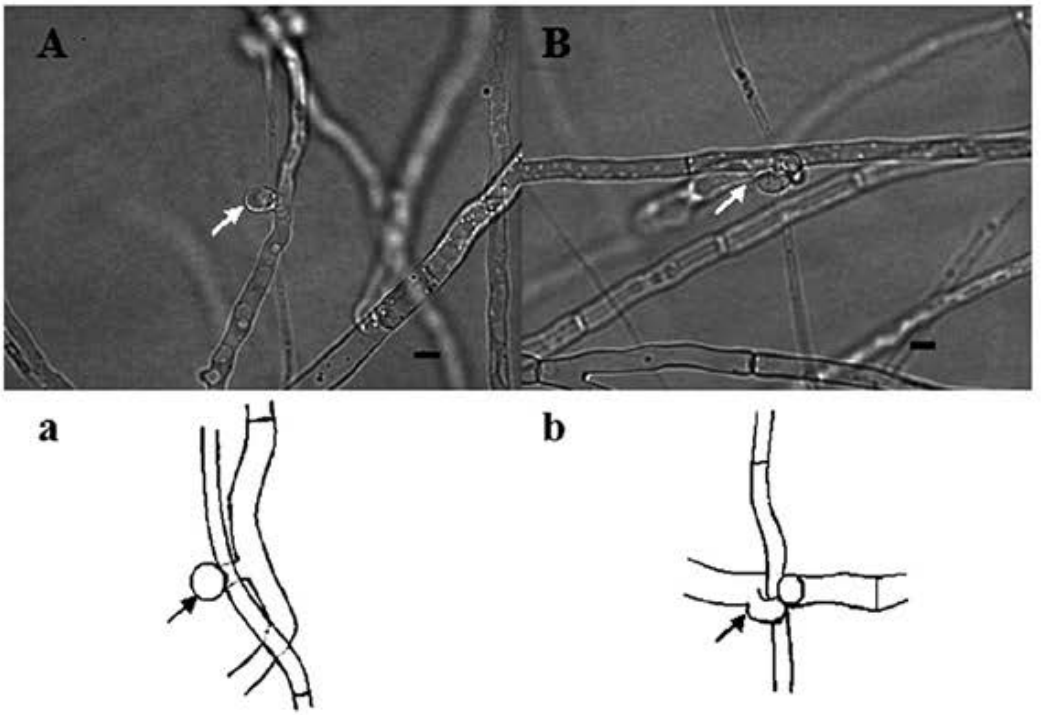


FIG. 1. *Sphaerodes mycoparasitica–Fusarium* spp. mycoparasitism assays. (A–a). Hook-shaped contact structures (arrows). (B–b). Clamp-like clasping cells (arrows). Figures a and b are diagrammatic drawings for both A and B. Scale bars = 5μm.

on slide culture assays, mycelia of *F.* arthrosporioides were inhibited by *S. mycoparasitica*. *Fusarium* arthrosporioides started to form rosette-like mycelia at the contact zone with *S. mycoparasitica* (FIG. 2B).

On the fifth and seventh days after inoculation, anamorphic structures were produced by *S. mycoparasitica* more abundantly in the zone of contact with *F. culmorum* (FIG. 2C, D). Anamorphic structures or asexual organs in close proximity to *F. culmorum* mycelia were red-colored (FIG. 2D), whereas the organs at a distance were not (FIG. 2C).

Fungus-fungus coevolution

Six *Sphaerodes* and one *Melanospora* species — *S. compressa* (Udagawa & Cain) P.F. Cannon & D. Hawksw., *S. fimicola* (E.C. Hansen) P.F. Cannon & D. Hawksw., *S. mycoparasitica, S. quadrangularis, S. retispora* var. *retispora, S. singaporensis* (Morinaga, Minoura & Udagawa) Dania García, Stchigel & Guarro, *Melanospora brevirostris* — were phylogenetically analysed. Information related to these strains is summarized in TABLE 1. Node M_1 is the point of divergence between the three *Fusarium*-specific *Sphaerodes* spp. and the other four taxa (FIG. 5; TABLE 1).

The phylogenetic tree further shows that the three *Sphaerodes* mycoparasites of *Fusarium* species — *S. mycoparasitica, S. quadrangularis* and *S. retispora* —

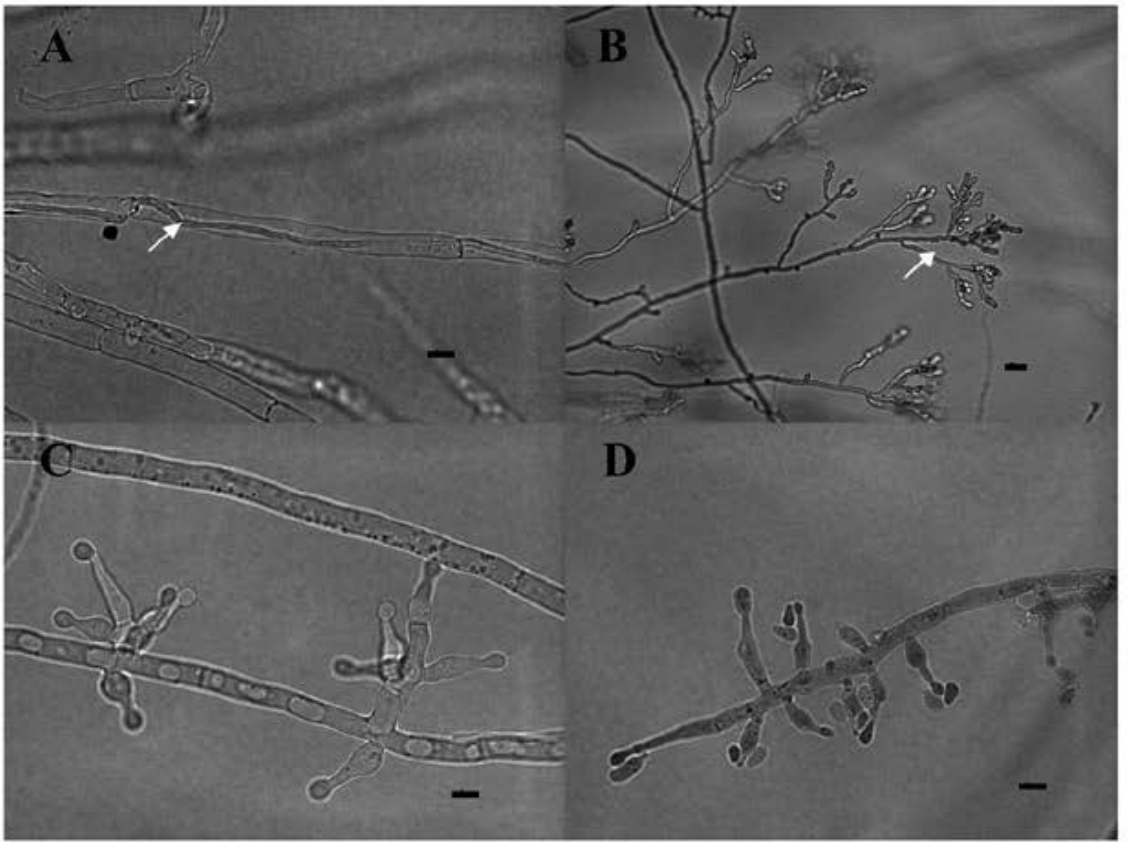


FIG. 2. Intracellular parasitism, hyphal inhibition response, and anamorphic stages during the *Sphaerodes mycoparasitica–Fusarium* spp. interactions. (A). Intracellular parasitism by *S. mycoparasitica* in *F. equiseti* (arrow). (B). *Fusarium* hyphal inhibition response when challenged with *S. mycoparasitica*; deformation of hyphae into rosette-like shapes (arrow). (C). Hyaline *S. mycoparasitica* anamorphic stages. (D). *Sphaerodes mycoparasitica* anamorphic stages with adsorption of red pigments from *F. culmorum*. Scale bars A, C, D = 5µm; B = 20µm.

diverge at M_2 to distinguish hyperparasites on white-pigmented *F. oxysporum* (such as *S. retispora*) from those on a red-pigmented *F. avenaceum* host (such as *S. quadrangularis*). Moreover, evolution from M_2 occurs at M_3 giving rise to mycoparasites of white- and red-pigmented *Fusarium*. This is the case of *S. mycoparasitica*, which attacks *F. avenaceum, F. culmorum, F. equiseti, F. graminearum*, and *F. oxysporum*, (FIG. 5; TABLE 1). Thus, M_3 is the point where polyspecificity as opposed to monospecificity on *Fusarium* appears.

Discussion

The small knobs or hook-shaped contact structures formed by *Sphaerodes mycoparasitica* on *Fusarium culmorum* and *F. equiseti* were similar to those described by Whaley & Barnett (1963) for *Gonatobotrys simplex* Corda [= *Melanospora damnosa* (Sacc.) Lindau] on *Alternaria tenuis* Nees [*A. alternata*], and by Jordan & Barnett (1978) for *Melanospora zamiae* Corda on *Tritirachium*

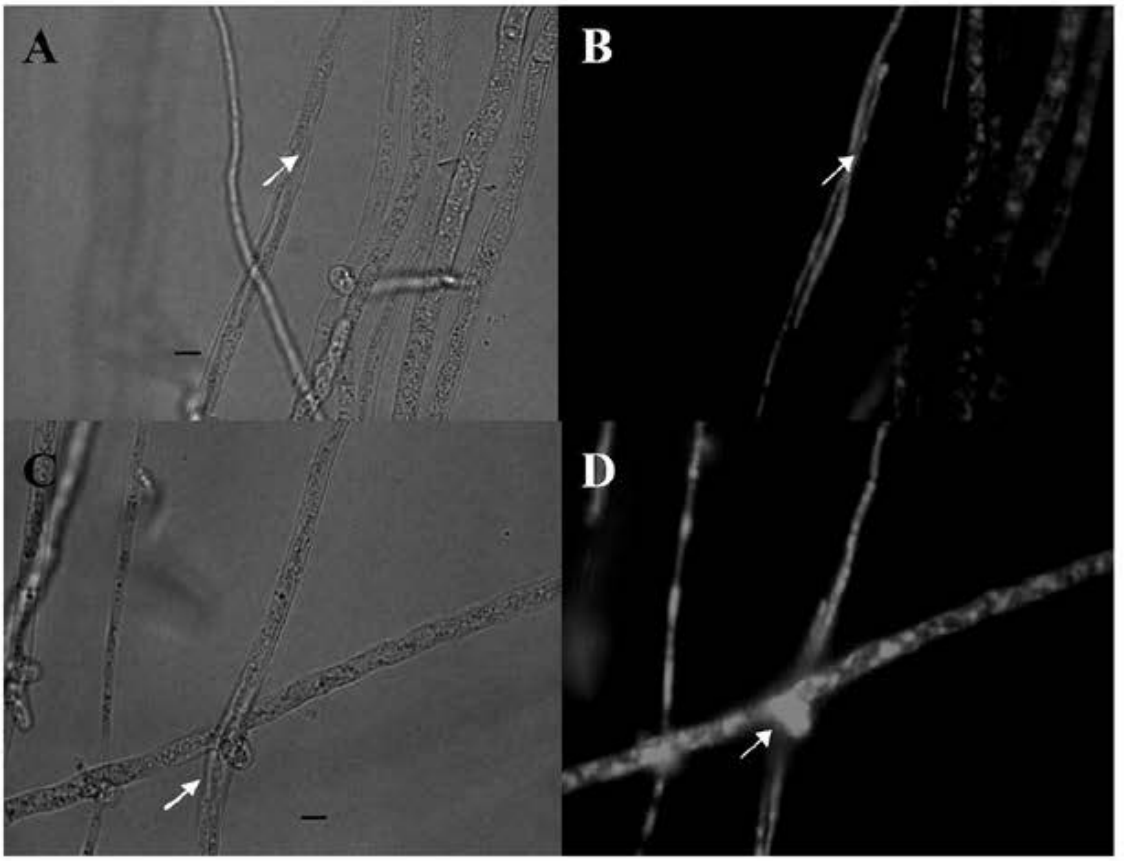


FIG. 3. (A–B) Intracellular parasitism by *Sphaerodes* inside *Fusarium equiseti* (arrows). (B–D) Intracellular hyphae produced by *Sphaerodes* inside *F. equiseti* with hook-shaped contact structure (arrows). A and C were captured under light microscopy; whereas in B and D hyphae were stained with lactofuchsin and images were captured under fluorescent and confocal laser microscopy, respectively. Scale bars = 5µm.

sp. Hook-shaped contact structures are well-known among biotrophic mycoparasites in the *Melanosporales*. Harveson & Kimbrough (2001) were the first to report *S. retispora* var. *retispora* as a contact biotrophic mycoparasite on *F. oxysporum* with hook-like contact structures. Harveson & Kimbrough (2001) also reported another melanosporaceous fungus, *Persiciospora moreaui* P.F. Cannon & D. Hawksw., as a contact biotrophic mycoparasite of *F. oxysporum* with similar contact branches as in *M. zamiae* and *S. retispora* (Harveson & Kimbrough 2000). Recently, *S. mycoparasitica* was found to produce similar hook-shaped contact structures on *Fusarium avenaceum, F. graminearum,* and *F. oxysporum* (Vujanovic & Goh 2009) and *S. quadrangularis* on *F. avenaceum* species (Goh & Vujanovic 2010). In this study, *S. mycoparasitica* was observed to form clamp- or clasp-like contact branches to attach to *F. equiseti* and *F. culmorum* (FIG. 1B, b). These structures were also reported for *Stephanoma phaeosporum* E.E. Butler & McCain, another biotrophic mycoparasite

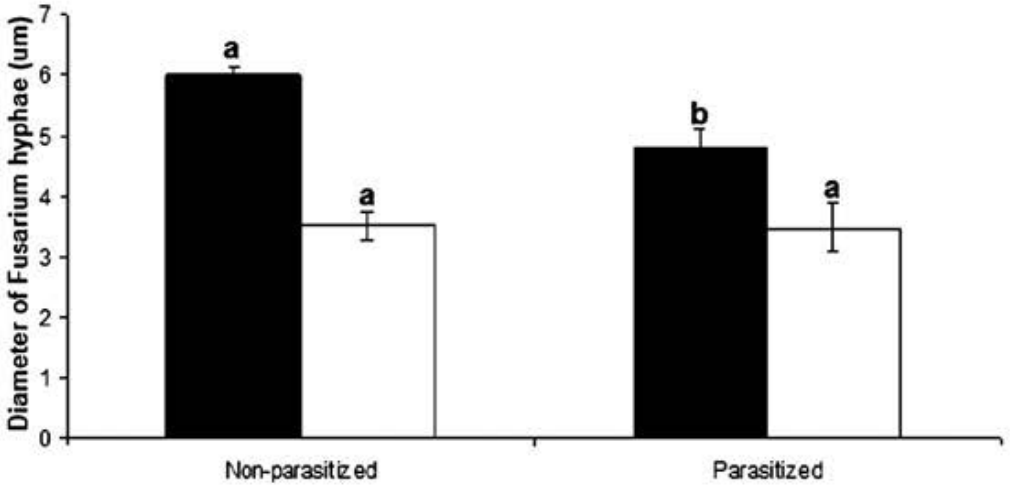


FIG. 4. Mean hyphal diameters of parasitized and non-parasitized *Fusarium equiseti* cells (■) and *F. culmorum* (□) on 1-week slide-cultures with *Sphaerodes mycoparasitica* biotrophic mycoparasite. Data are means and standard deviations. Same lowercase letters indicate no significant difference between parasitized and non-parasitized hyphae at $P = 0.05$, with T-test.

(Rakvidhyasastra & Butler 1973). These contact structures may also be employed by contact or fusion biotrophic mycoparasites as tools to acquire nutrients from the hosts (Carmichael 1955; Gams et al. 2004; Whaley & Barnett 1963). Nutrients, growth factors, biotins, mycotrophein, and thiamine have been found to be important for nourishment and proliferation of biotrophic mycoparasites (Hwang et al. 1985; Jordan & Barnett 1978).

In this study, loss of cytoplasm (FIG. 3A, C) and a reduction of the diameter of *F. equiseti* hyphae resulted from mycoparasitism (FIG. 4). Similarly, Harveson & Kimbrough (2001) noticed that *Sphaerodes retispora* and *M. zamiae* isolates reduced the total hyphal weight and aerial hyphae of *F. oxysporum*, in addition to inhibiting the growth of this *Fusarium* species. Furthermore, loss or decreased intensity of staining or colour of dye in host cells (compared to healthy) were further reported by White & Traquair (2006) as an indication of loss of cytoplasm and intracellular infection. Intracellular parasitic activity was also described in *Fusarium–Rhizoctonia* and *Mucor–Rhizopus* mycoparasitic interactions (Arora & Dwivedi 1980; Gupta & Tandon 1978; Gupta et al. 1979). Although hyphal diameter of *F. culmorum* was not reduced by *S. mycoparasitica* (FIG. 4), this could be due to the lack of intracellular penetration in *F. culmorum* during the tested period. Barnett (1963), Jordan & Barnett (1978), Jeffries & Young (1994) and Jeffries (1995), have all pointed out that biotrophic mycoparasites, in general, have narrow host ranges. Therefore, it is not surprising that not all the *Fusarium* taxa tested could act as hosts for *S. mycoparasitica, S. quadrangularis* and *S. retispora.*

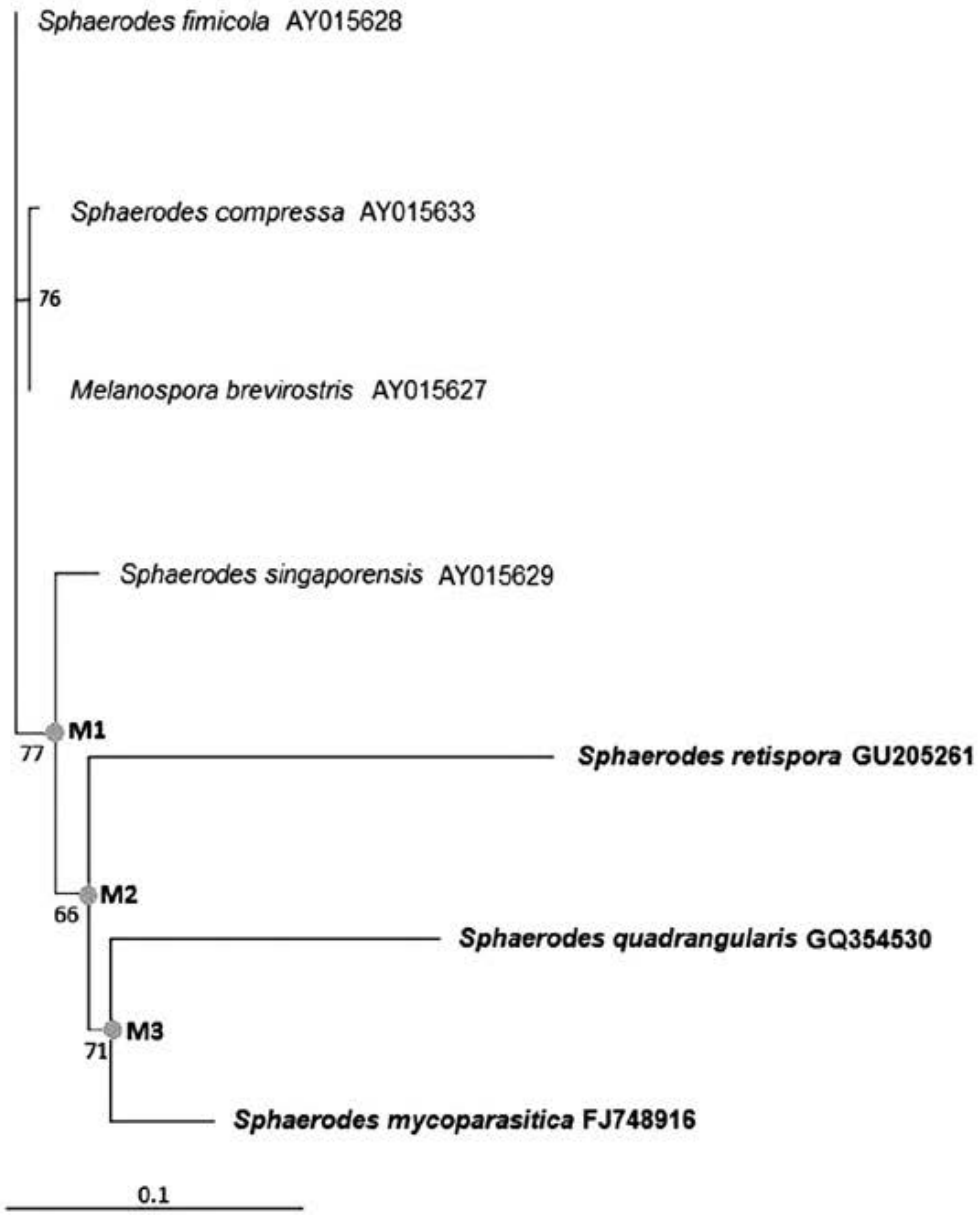


FIG. 5. Phylogenetic tree based on LSU rDNA sequences for six *Sphaerodes* species showing position of mycoparasitic taxa associated with *Fusarium* hosts. M1 – the point of evolutionary divergence between *Sphaerodes* mycoparasites associated with *Fusarium* and *Sphaerodes* taxa including closely related *Melanospora brevirostris* associated with other fungal and plant hosts; M_2 – point of branching towards specialization or monospecificity of *S. retispora* on *F. oxysporum* (white mycelium) and monospecificity of *S. quadrangularis* on *F. avenaceum* (red mycelium); M_3 – the point of evolutionary direction towards polyspecificity of *S. mycoparasitica* on various white and red *Fusarium* hosts. Bootstrap values of 50% or greater from 1000 bootstrap replications are indicated for the corresponding branches.

TABLE 1. Information related to six *Sphaerodes* species and a *Melanospora* species used for phylogenetic analysis.

	ISOLATED FROM	MYCO-PARASITE	DISTRIBUTION	REFERENCE
*Melanospora brevirostris**	Dead plant stems and decaying truffles as well as on various *Pezizales*, usually *Sepultaria* sp.	Yes	England, North Europe	Cannon et al. 1985; Cannon & Hawksworth 1982; Farr & Rossman 2009
Sphaerodes compressa	Soil, cow dung, dead leaves, aerial contaminant	No	Canada, USA, Japan, New Caledonia	Cannon et al. 1985; Farr & Rossman 2009
S. fimicola	Dung, surface litter and soil, plants	No	Europe, USA, Madeira, British Isles	Cannon et al. 1985; Farr & Rossman 2009
S. mycoparasitica	Several *Fusarium* species	Yes	Canada	Vujanovic & Goh 2009
S. quadrangularis	*F. avenaceum*	Yes	Spain	García et al. 2004; Goh & Vujanovic 2010
S. retispora var. *retispora*	*F. oxysporum*	Yes	Japan, New Guinea, USA	Cannon et al. 1985; Harveson & Kimbrough 2001
S. singaporensis	Soil	Unknown	Singapore	Morinaga et al. 1978

*Note: Information on Melanospora brevirostris (Fuckel) Höhn. was also included since the LSU rDNA sequences analyses in Fig 5. of this article suggest relatedness to *S. compressa* and *S. fimicola* in concordance with findings of Davey et al. (2008).

Sphaerodes quadrangularis was first described by García et al. (2004). At the time its anamorph was unknown. Here, *S. quadrangularis* was observed to produce mono- and polyphialides or asexual organs like those of *S. mycoparasitica* (FIG. 2C) and *S. retispora* (Harveson & Kimbrough 2001) when inoculated together with *Fusarium avenaceum*. Based on *S. mycoparasitica* analyses, Vujanovic & Goh (2009) proposed that most anamorphic traits in *Sphaerodes* (e.g., hyaline and ampulliform phialides as well as irregularly branched conidiophores) resemble those of *Trichoderma* species (sect. *Pachybasium*) in *Hypocreales*. In contrast, the base-to-neck ratios of phialides in *S. mycoparasitica, S. quadrangularis*, and *S. retispora* show interspecies differences summarized in the key to taxa of *Sphaerodes*.

Key to the mycoparasitic taxa of *Sphaerodes*

1 Clamp-like contact structures present 2

1* Clamp-like contact structures lacking. Phialides with base-neck width ratio < 2; mono- and polyphialidic anamorphic stages; monospecific on *F. oxysporum* ..... ***S. retispora* var. *retispora***

2 Intracellular penetration and haustoria present. Phialides with base-neck width ratio between 2–2.5; mono- and polyphialidic anamorphic stages; polyspecific on *F. avenaceum, F. culmorum, F. equiseti, F. graminearum*, and *F. oxysporum* ..... ***S. mycoparasitica***

2* Intracellular penetration and haustoria absent. Phialides with base-neck width ratio > 2.5; mono- and polyphialidic anamorphic stages; monospecific on *F. avenaceum* ..... ***S. quadrangularis***

In addition, this study showed that when *S. mycoparasitica* and *F. culmorum* were co-inoculated in slide culture, anamorphic structures and hyphae of the former were red-colored (FIG. 2D). Similarly, *S. quadrangularis* hyaline hyphae became red-colored after contacting *F. avenaceum* hyphae (Goh & Vujanovic 2010). This could be due to the absorption of *Fusarium* red pigments by *Sphaerodes* through biotrophic mycoparasitism (Goh & Vujanovic 2010). However, the mechanism of this phenomenon remains unclear. The red pigments of *F. avenaceum, F. culmorum,* and *F. graminearum* are aurofusarin toxins (Malz et al. 2005). Perhaps host toxins drive the evolution of mycoparasites. Thus, it would be interesting for further studies, as indicated by relatedness of these *Fusarium*-specific *Sphaerodes* taxa (FIG 5.), to explore whether it is actually the nature of fusaria toxins that create an evolutionary pressure inducing specialization within *Sphaerodes*.

Acknowledgments

This research was financially supported by Natural Sciences and Engineering Research Council of Canada (NSERC) discovery grant and Saskatchewan Agriculture

Development Fund (ADF) to V.V. We would like to thank Drs. Virginia Bianchinotti and George Newcombe for helpful comments, summer student Samuel Bourassa-Blanchette for technical assistance, and PhD student Michelle Hubbard for assistance in Confocal laser scanning microscopy (CLSM).

Literature cited

Abdellatif L, Bouzid S, Kaminskyj S, Vujanovic V. 2009. Endophytic hyphal compartmentalization is required for successful symbiotic Ascomycota association with root cells. Mycol Res 113: 782–791. doi:10.1016/j.mycres.2009.02.013.

Arora DK, Dwivedi RS. 1988. Mycoparasitism of *Fusarium* spp. on *Rhizoctonia solani* Kühn. Pl Soil 55: 43–53.

Barnett HL. 1963. The nature of mycoparasitism by fungi. Ann Rev Microbiol 17: 1–14.

Bauer R, Oberwinkler F. 2004. Cellular basidiomycete–fungus interactions. 267–279 in: Varma A, Abbott L, Werner D, Hampp R (eds). Plant Surface Microbiology. Springer-Verlag Berlin Heidelberg, Germany.

Boosalis MG. 1964. Hyperparasitism. Ann Rev Phytopathol 2: 363–376.

Butler EE. 1957. *Rhizoctonia solani* as a parasite of fungi. Mycologia 49: 354–373.

Cannon PF, Hawksworth DL. 1982. A re-evaluation of *Melanospora* Corda and similar Pyrenomycetes, with a revision of the British species. Bot J Linn Soc 84: 115–160.

Cannon PF, Hawksworth DL, Sherwood-Pike MA. 1985. The British Ascomycotina. An annotated checklist. Commonwealth Mycological Institute, Kew, Surrey, England, 302 pages.

Carmichael JW. 1955. Lactofuchsin: a new medium for mounting fungi. Mycologia 47: 611.

Cole GT, Kendrick WB. 1968. A thin culture chamber for time-lapse photomicrography of fungi at high magnifications. Mycologia 60: 340–344.

Davey ML, Tsuneda A, Currah RS. 2008. Evidence that the gemmae of *Papulaspora sepedonioides* are neotenous perithecia in the *Melanosporales*. Mycologia 100: 626–635. doi:10.3852/08-001R.

Farr DF, Rossman AY. 2009. Fungal Databases, Systematic Mycology and Microbiology Laboratory, ARS, USDA. Retrieved Sept. 16, 2009, from http://nt.ars-grin.gov/fungaldatabases/.

Gams W, Diederich P, Põldmaa K. 2004. Fungicolous fungi. 343–392 in: Mueller GM, Bills GF, Foster MS (Eds). Biodiversity of Fungi: Inventory and Monitoring Methods. Academic Press Inc., Elsevier Science, London, UK.

García D, Stchigel AM, Guarro J. 2004. Two new species of *Sphaerodes* from Spanish soils. Studies Mycol 50: 63–68.

Goh YK, Vujanovic V. 2010. *Sphaerodes quadrangularis* biotrophic mycoparasitism on *Fusarium avenaceum*. Mycologia 102:757-762. doi:10.3852/09-147.

Gupta RC, Tandon RN. 1978. *Mucor circinelloides* a destructive hyperparasite of *Rhizopus nigricans*. Mycopathol 4:125–127.

Gupta RC, Upadhyay RS, Rai B. 1979. Hyphal parasitism and chlamydospore formation by *Fusarium oxysporum* on *Rhizoctonia solani*. Mycopathol 67: 147–151.

Hall TA. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Window 95/98/NT. Nucleic Acids Symp Ser 41: 95–98.

Harveson RM, Kimbrough JW. 2000. First report of *Persiciospora moreaui*, a parasite of *Fusarium oxysporum*, in the western hemisphere. Mycotaxon 76: 361–365.

Harveson RM, Kimbrough JW. 2001. Parasitism and measurement of damage to *Fusarium oxysporum* by species of *Melanospora, Sphaerodes,* and *Persiciospora*. Mycologia 93: 249–257.

Hausner G, Reid J, Klassen GR, 1993. On the subdivision of *Ceratocystis* s. l., based on partial ribosomal DNA sequences. Can J Bot 71: 52–63.

Hwang K, Stelzig DA, Barnett HL, Roller PP, Kelsey MI. 1985. Partial purification of the growth factor mycotrophein. Mycologia 77: 109–113.

Jacobs K, Holtzman K, Seifert KA. 2005. Morphology, phylogeny and biology of *Gliocephalis hyalina*, a biotrophic contact mycoparasite of *Fusarium* species. Mycologia 97: 111–120. doi:10.3852/mycologia.97.1.111.

Jeffries P. 1995. Biology and ecology of mycoparasitism. Can J Bot 73 (Suppl. 1): S1284-1290.

Jeffries P, Young TWK. 1994. Interfungal parasitic relationships. CAB International, Wallingford.

Jordan EG, Barnett HL. 1978. Nutrition and parasitism of *Melanospora zamiae*. Mycologia 70: 300-312.

Kavková M, Čurn V. 2005. *Paecilomyces fumosoroseus* (Deuteromycotina: Hyphomycetes) as a potential mycoparasite on *Sphaerotheca fuliginea* (Ascomycotina: Erysiphales). Mycopathol 159: 53-63. doi:10.1007/s11046-003-0787-3.

Malz S, Grell MN, Thrane C, Maier FJ, Rosager P, Felk A, Albertsen, KS, Salomon S, Bohn L, Schäfer W, Giese H. 2005. Identification of a gene cluster responsible for the biosynthesis of aurofusarin in the *Fusarium graminearum* species complex. Fungal Genet Biol 42:420–433. doi:10.1016/j.fgb.2005.01.010.

Morinaga T, Minoura K, Udagawa S. 1978. New species of microfungi from southeast Asian soil. Trans Mycol Soc Japan 19: 135-148.

Posada F, Vega FE, Rehner SA, Blackwell M, Weber D, Suh SO, Humber RA. 2004. *Syspastospora parasitica*, a mycoparasite of the fungus *Beauveria bassiana* attacking the Colorado potato beetle *Leptinotarsa decemlineata*: A tritrophic association. J Insect Sci 24: 1-3.

Rakvidhyasastra V, Butler EE. 1973. Mycoparasitism by *Stephanoma phaeospora*. Mycologia 65: 580-593.

Rehner SA, Samuels GJ. 1995. Molecular systematics of the *Hypocreales:* a teleomorph gene phylogeny and the status of their anamorphs. Can J Bot 73(Suppl. 1): S816–S823.

SPSS. 1990. SPSS/PC+ 4.0 Advanced Statistics Manual. Chicago.

Swofford DL. 2000. *PAUP.* Phylogenetic Analysis Using Parsimony, Version 4.0b10. Sinauer Associates, Sunderland, MA.

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucl Acids Res 24: 4876–4882.

Vujanovic V, Goh YK. 2009. *Sphaerodes mycoparasitica* sp. nov., a new biotrophic mycoparasite on *Fusarium avenaceum, F. graminearum* and *F. oxysporum*. Mycol Res 113: 1172-1180. doi:10.1016/j.mycres.2009.07.018.

Whaley JW, Barnett HL. 1963. Parasitism and nutrition of *Gonatobotrys simplex*. Mycologia 55: 199–210.

White GJ, Traquair JA. 2006. Necrotrophic mycoparasitism of *Botrytis cinerea* by cellulolytic and ligninocellulolytic basidiomycetes. Can J Microbiol 52: 508–518. doi:10.1139/W05-141.

Zhang N, Blackwell M. 2002. Molecular phylogeny of *Melanospora* and similar pyrenomycetous fungi. Mycol Res 106: 148–155. doi:10.1017/S095375620100535.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.193

Volume 114, pp. 193–196 October–December 2010

Additional and new lichen records from Cozia National Park, Romania

GÜLŞAH ÇOBANOĞLU[1*], MUSTAFA YAVUZ[2], IULIAN COSTACHE[3] & IRINA RADU[4]

*gcoban@marmara.edu.tr
[1]Department of Biology, Faculty of Science and Literature, Marmara University
Göztepe Campus, 34722, Istanbul, Turkey

mustafay007@gmail.com
[2]Leader of Biology, Isparta Science and Art Center
Vatan M. 4405 S. No: 8, Isparta, Turkey

iuliuscostache@yahoo.com
[3]Department of Biology, Faculty of Horticulture, Craiova University
15 Libertății, 200583, Craiova, Romania

ina_radu2005@yahoo.com
[4]Teacher of Environmental Protection, The Technical Forest College
Rm.-Vâlcea, Romania

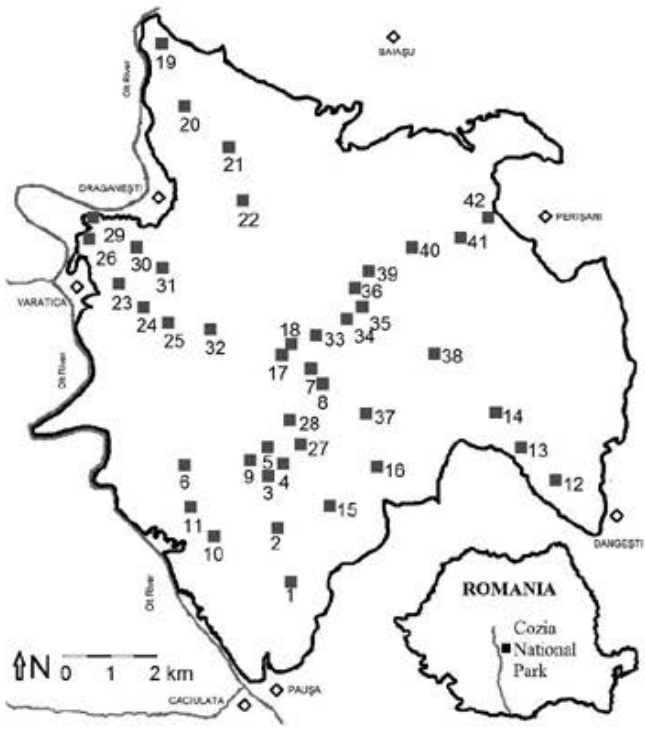
Abstract — A list of 115 lichen taxa from Cozia National Park includes 8 new records for the mycota of Romania and 77 taxa new for Cozia. Distribution and substrata are summarized, and the complete annotated species list is posted at http://www.mycotaxon.com/resources/weblists.html

Keywords — lichenized fungi, biodiversity, biota, checklist, Cozia Mount

Introduction

The present study of the lichen diversity on Cozia Mount, the primary massive area of Cozia National Park, aims to contribute to the lichen biota of Romania. As one of the most detailed lichenological surveys in recent years, the report lists 115 taxa, of which 77 are new for Cozia National Park and Valcea County and 8 are new to Romania.

Romanian lichens have been studied for over 150 years and the reports are cited in over 300 publications, including a survey of all available mycological information by Moruzi et al. (1967). Ciurchea (1998, 2007a,b) subsequently



Map of the study area — Cozia Mount and surrounding villages with sampling site numbers.

revised comprehensively the checklist of lichens and lichenicolous fungi for Romania, now available online (http://www.bgbm.org/BGBM/STAFF/Wiss/Sipman/Zschackia/Rumania/index.htm).

The lichens of Cozia Mount have previously been studied by Codoreanu & Ciurchea (1965), Ciurchea (1969, 1970), Bartók (1990), Costache et al. (2007), and Çobanoğlu et al. (2009).

Materials and methods

Cozia National Park is situated on the central-southern region of Romania, in Valcea County, inside the southern Carpathians. Cozia Mount (Ciuha Neamtului) is the highest peak, with its 1668 meter summit. It is intersected from north to south by the Olt River (Fig. 1). The climate is specific to mountain depressions without large temperature variations, with cool summers (about 20°C in July), relatively mild winters (between –5 and 0°C in January), and an average annual temperature of 9°C. Precipitation is moderate, 750–800 mm annually (Ploaie 2004).

Lichens were collected from 42 different sites on Cozia Mount, located on the East side of Olt River in Cozia National Park, Valcea County. Specimens were investigated microscopically (Olympus SZx40) and chemically by using spot tests (standard K, C, P and I) following Purvis et al. (1992). The taxa were identified to the level of species (except two genera) with the aid

of identification keys (Brodo et al. 2001, Purvis et al. 1992, Wirth 1995). The collections are preserved in the Herbarium of the Faculty of Science and Arts, Marmara University, Istanbul (MUFE), and duplicates have been stored in the Herbarium of the University of Craiova (Romania).

Results

The list of identified lichens cites 115 taxa in 61 genera in alphabetical order. Nomenclature mainly follows Index Fungorum (www.indexfungorum.com) and the recent literature (Ahti & Hawksworth 2005, Blanco et al. 2004). Author names are abbreviated according to Brummitt & Powell (1992). Eight taxa are new to Romanian lichen mycota, and 77 taxa are newly recorded from Cozia Mount. Also 26 taxa are rare for Romanian mycota according to Ciurchea (2007a,b).

Discussion

Among the 115 taxa recorded, the eight recorded as new to Romania include *Buellia griseovirens, Candelariella coralliza, Cladonia stellaris, Lecanora cinereofusca, Leproloma cacuminum, Ochrolechia inaequatula, Trapelia involuta,* and *Usnea silesiaca.* Seventy-seven taxa are new to Cozia Mount. Additionally, among the 26 species regarded as rare in Romania (Ciurchea 2007a,b) are *Cornicularia normoerica, Immersaria athroocarpa, Lecidella carpathica, Melanelia stygia, Ophioparma ventosa, Protoblastenia incrustans,* and *Sphaerophorus fragilis.* The majority of the lichen taxa designated in the list is saxicolous (89 taxa, or 77% of the total). Of the saxicolous lichens, siliceous taxa (51) are dominant followed by calcareous taxa (27), and those reported on sandstone (11). Morphologically, 81 taxa are crustose (70.4%), 20 foliose (17.4%), 9 fruticose (7.8%), one squamulose (0.9%) and four dimorphic *Cladonia* spp. (3.5%).

The present study, which represents the most detailed recent lichenological survey in Romania, provides valuable data for the lichen mycota.

Acknowledgements

This study is a part of research project supported by The Research Fund of Marmara University with the Project Number FEN-BGS-120707-0154. Gülşah Çobanoğlu was funded at the beginning of the project by the scholarship of Türk Petrol Vakfı, and Mustafa Yavuz was funded by TUBITAK (Turkish Scientific and Technical Research Council (TUBITAK BIDEB 2214-2007).

We are thankful to Ex. Grand Ambassador of Turkey in Bucharest, his Excellency Mr. Ahmet Rıfat Ökçün; special thanks to Dr. Daniel Radutoiu from University of Craiova; the Manager of the Cozia National Park, Mr. Pavel Prundurel; the Ranger Mr. Narcis Olteanu; Ms. Birkan Açıkgöz (MsD), and Mr. Laurentiu Baloniu (MsD) for assistance

in herbarium work. We thank to Dr. Kenan Yazıcı for his guidance for manuscript submission procedure. We are grateful to Dr. Heidi Döring, Michele Piercey-Normore, and Dr. Leo Spier for linguistic revision and helpful comments on an earlier draft of this paper.

Literature cited

Ahti T, Hawksworth DL. 2005. *Xanthoparmelia stenophylla*, the correct name for *X. somloënsis*, one of the most widespread usnic acid containing species of the genus. The Lichenologist 37(4): 363–366. doi:10.1017/S0024282905015197

Bartók K. 1990. Comunitati de licheni din Muntele Cozia. St. cerc. biol., Ser. Biol. Veget. 42(1): 25–29.

Blanco O, Crespo A, Elix JA, Hawksworth DL, Lumbsch HT. 2004. A molecular phylogeny and a new classification of parmelioid lichens containing *Xanthoparmelia*-type lichenan (*Ascomycota: Lecanorales*). Taxon 53(4): 959–975. doi:10.2307/4135563

Brodo IM, Sharnoff SD, Sharnoff S. 2001. Lichens of North America. Yale University Press, New Haven and London.

Brummitt RK, Powell CE. 1992. Authors of plant names. Royal Botanical Gardens, Kew.

Ciurchea M. 1969. Flora si vegetatia lichenologica saxicola de pe Valea Oltului între Proeni si Calinesti (jud. Vâlcea). Contrib. Bot. Cluj: 117–126.

Ciurchea M. 1970. Vegetatia stâncariilor de pe Valea Calinesti (jud. Vâlcea). Contrib. Bot. Cluj: 145–165.

Ciurchea M. 1998. Catalog of lichens in Romania. http://www.bgbm.org/BGBM/STAFF/ Wiss/Sipman/Zschackia/Rumania/index.htm

Ciurchea M. 2007a. Checklist of lichens and lichenicolous fungi of Romania. Preliminary version. http://www.biologie.uni-hamburg.de/checklists/lichens/europe/romania_l.htm

Ciurchea M. 2007b. Lichenologic flora of Romania - http://lichens.duci.ro

Codoreanu V, Ciurchea M. 1965. Contributii la cunoasterea florei lichenologice de pe sisturi cristaline. St. Cerc. Biol.-Botanica Bucuresti 17(2): 145–151.

Costache I, Yavuz M, Çobanoğlu G, Radutoiu D, Radu I. 2007. Preliminary data about the Romanian-Turkish collaboration in the study of the lichens from Cozia Mount. Annales of the University of Craiova (Series Biology) Vol. XII (XLVIII): 15–20.

Çobanoğlu G, Yavuz M, Costache I, Radu I, Açıkgöz B, Baloniu L. 2009. Terricolous lichen diversity in National Park Cozia (Romania). Oltenia. Studii şi comunicări. Ştiinţele Naturii XXV: 17–22.

Moruzi C, Petria E, Mantu E. 1967. Catalogul lichenilor din România (C.L.R.). Acta Bot. Horti Bucurestiensis: 1- 389.

Ploaie G. 2004. Parcul Naţional Cozia – the Cozia National Park. Editura Almarom. Ramnicu Valcea. Romania.

Purvis OW, Coppins BJ, Hawksworth DL, James PW, Moore DM. 1992. The lichen flora of Great Britain and Ireland. Natural History Museum Publications in association with the British Lichen Society, London.

Wirth V. 1995. Die Flechten Baden-Württembergs. Teil 1–2. Ulmer, Stuttgart.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.197

Volume 114, pp. 197–203 October–December 2010

A new *Asterostroma* species (*Basidiomycota*) from a subtropical region in Japan

HIROTO SUHARA[1*], NITARO MAEKAWA[1] & SHUJI USHIJIMA[2]

h_suhara@muses.tottori-u.ac.jp & kin-maek@muses.tottori-u.ac.jp
[1]*Faculty of Agriculture, Tottori University*
4-101 Koyama-Minami, Tottori, 680-8553, Japan

ushi-kintai@go4.enjoy.ne.jp
The United Graduate School of Agricultural Science, Tottori University
4-101 Koyama-Minami, Tottori, 680-8553, Japan

Abstract — A new homobasidiomycete, *Asterostroma boninense*, was found in the Bonin (Ogasawara) Islands, a subtropical region in Japan. This species is morphologically characterized by having resupinate basidiomata, a monomitic (asterodimitic) hyphal system, simple septate generative hyphae, dextrinoid asterosetae, four sterigmate basidia, and subglobose, tuberculate, amyloid basidiospores. It is similar to *A. muscicola*, but the latter has smaller basidia. In Japan, *A. muscicola* is widely distributed in warm-temperate to subtropical regions including the Bonin Islands, while *A. boninense* is restricted to the Bonin Islands. Another species in the genus, *Asterostroma andinum*, is also reported as new to Japan. A key to the Japanese species of *Asterostroma* is provided.

Key words — corticioid fungi, *Lachnocladiaceae*, oceanic island, taxonomy

Introduction

The genus *Asterostroma* Massee belonging to the family *Lachnocladiaceae* (*Basidiomycota*) is characterized by resupinate and felted-membranous basidiomata, gloeocystidia, clampless generative hyphae, and dextrinoid asterosetae (asterohyphidia). Based on basidiospore morphology, the genus is divided into two subgenera, *Austroasterostroma* Parmasto and *Asterostroma*. The former produces smooth and inamyloid basidiospores whereas species of the latter have amyloid spores (Parmasto 1970). Furthermore, the subgenus *Asterostroma* is subdivided into two sections, *Laevispora* Parmasto (with smooth basidiospores) and *Asterostroma* (with ornamented basidiospores) (Parmasto 1970, Boidin et al. 1997). According to MycoBank administered by the International Mycological Association (http://www.mycobank.org/),

twenty-six species have been described in *Asterostroma*. Among them, *A. cervicolor* (Berk. & M.A. Curtis) Massee (Aoshima et al. 1963), *A. macrosporum* N. Maek. & Suhara (Suhara et al. 2010), and *A. muscicola* (Berk. & M.A. Curtis) Massee (Suhara et al. 2010) have been earlier reported from Japan. In the present study, we describe a new species of the genus based on specimens collected in the Bonin (Ogasawara) Islands, located about 1000 km south of Tokyo, Japan. Moreover, an additional species of *Asterostroma* is reported as new to Japan.

Materials & methods

The specimens are deposited in the Tottori University Fungal Herbarium (TUFH) and the cultures in the Tottori University Mycological Culture Collection (TUMC). Morphological observations were carried out as described in Suhara et al. (2010). Color names in double quotation marks are based on Rayner (1970). The notation "basidiospores (n = 60/3)" indicates that measurements were made on 60 spores from 3 specimens. Polysporous isolates obtained from each specimen were grown on malt extract agar [MA; 1.5% (w/v) malt extract and 1.5% (w/v) bacto agar, Difco, Detroit, MI, USA]. To determine the optimum growth temperature, the isolates were grown on MA plates at 8 different temperatures: 4, 10, 15, 20, 25, 30, 35 and 40°C.

Taxonomy

Asterostroma boninense Suhara & N. Maek., **sp. nov.** FIGS. 1–7

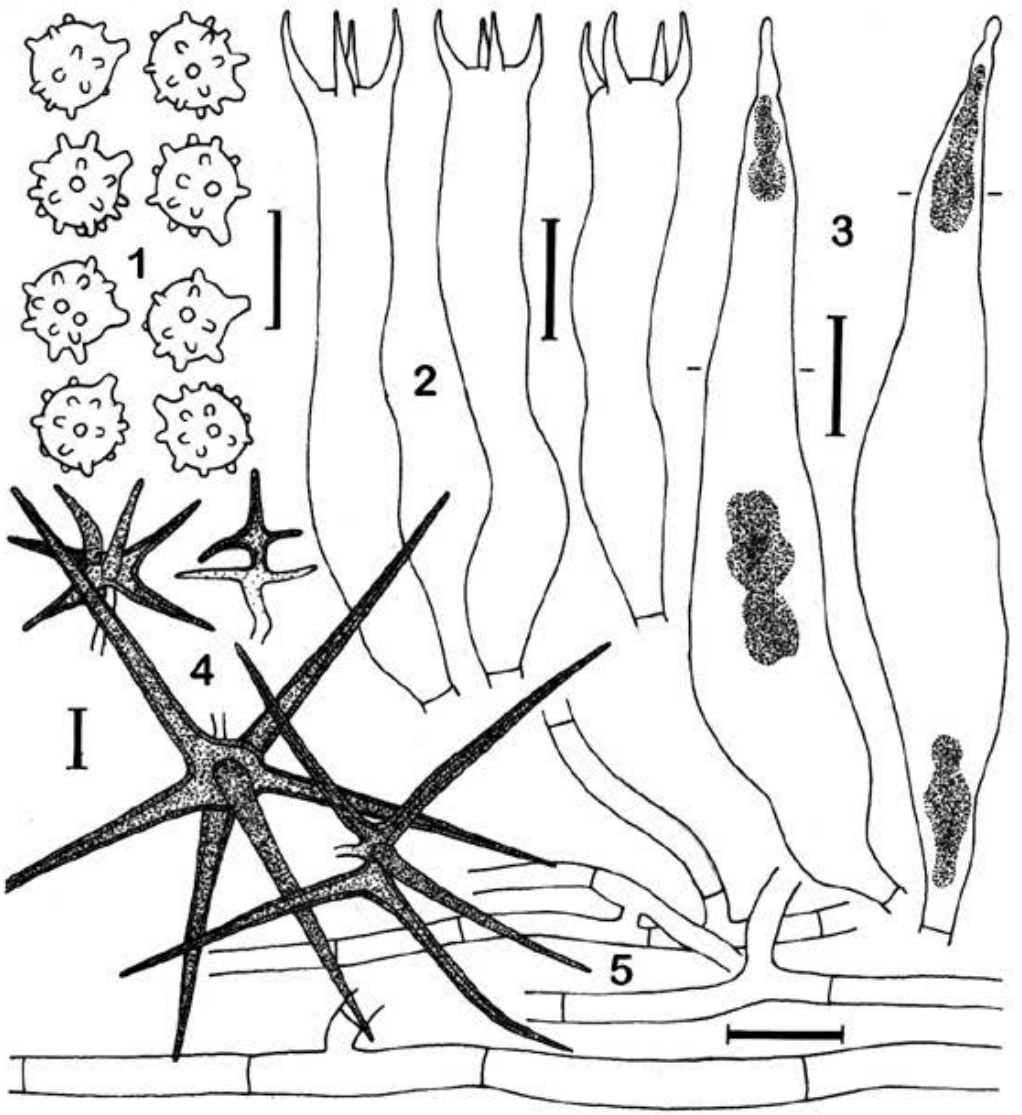
MYCOBANK 518641

Basidiomata resupinata, adnata, effusa, mollia, 200–600 µm crassa; superficies hymenialis "Buff" vel "Ochreous" (sec. Rayner 1970), laevis, sub lente (×20); margo "Ochreous", "Fulvous" vel "Cinnamon", tenuescens, interdum fimbriatus, filis hyphalibus tenuibus nonnumquam. Systema hyphale monomiticum; hyphae generatoriae cum septis, sine fibulis, 1.5–5 µm diametro, laeves, tenui-vel parum crassitunicatae (usque 0.5 µm), simpliciseptatae; asterohyphidia numerosa, radii ad 110 µm longi. Cystidia (gloeocystidia) parum numerosa, subcylindracea, ventricosa vel fusoidea, 43–95 × 7.5–16 µm. Basidia subcylindrica vel utriformia, 40–60 × 6.5–8.5 µm, 4 sterigmata gignentia. Basidiosporae subglobosae apiculo distincto armatae, 5.5–7.5 × 5–7.2 µm (praeter tuberculis), tubercula (tuberculis usque ad 1.5 µm longi), tenuitunicatae, amyloideae.

TYPE: **JAPAN. TOKYO: Ogasawara-mura**, Takinoura (Anijima Island), on dead trunk of *Clinostigma savoryanum* (Rehder & E.H. Wilson) H.E. Moore & Fosberg (*Arecaceae*), 6 Dec 1997, coll. N. Maekawa. (**Holotype**, TMI20619; ex-type culture (polysporous), TUFC33876).

ETYMOLOGY: The specific epithet *boninense* refers to the geographic origin of the type specimen.

Basidiomata resupinate, loosely adnate, effused, soft, felt-like, 200–600 µm thick; hymenial surface "Buff", partly "Ochreous", smooth, pruinose under



FIGS 1–5. Line drawings of *Asterostroma boninense* (TMI20619, holotype): 1. Basidiospores; 2. Basidia; 3. Cystidia (gloeocystidia) – short horizontal lines indicate the level of the hymenial surface; 4. Asterohyphidia (asterosetae); 5. Subicular hyphae. Scale bar = 10 µm.

the lens (×20), sometimes slightly cracked when dried; margin "Ochreous", "Fulvous" to "Cinnamon", determinate, but sometimes thinning out, fimbriate, occasionally with thin hyphal strands concolorous with the margin under the lens (×20). Context in vertical section ocher, pellicular to submembranous, the subiculum sometimes with thin hyphal strands and/or containing crystals. Hyphal system monomitic (asterodimitic); generative hyphae 1.5–5 µm in diameter, smooth, thin- to slightly thick-walled (up to 0.5 µm), clamps-less-septate, loosely intertwined in the subiculum; asterohyphidia (asterosetae)

numerous in the subiculum and subhymenium, subhyaline to brownish, 2–10 diverging branches, the branches acicular to subulate, up to 110 µm in length; cystidia (gloeocystidia) subcylindrical, ventricose to fusiform, sometimes with schizopapillae, 43–95 × 7.5–16 µm, without a basal clamp, thin-walled, with pale yellowish oily contents, imbedded in the basidiomata, but sometimes projecting 30 µm beyond the hymenial surface; basidia (n = 60/3) subcylindrical to utriform, 40–60 × 6.5–8.5 µm, thin-walled, without a basal clamp, consistently producing 4 sterigmata; basidiospores (n = 60/3) subglobose, 5.5–7.5 × 5–7.2 µm (excluding tubercles), with a distinct apiculus, tuberculate (tubercles up to 1.5 µm in length), thin-walled, amyloid.

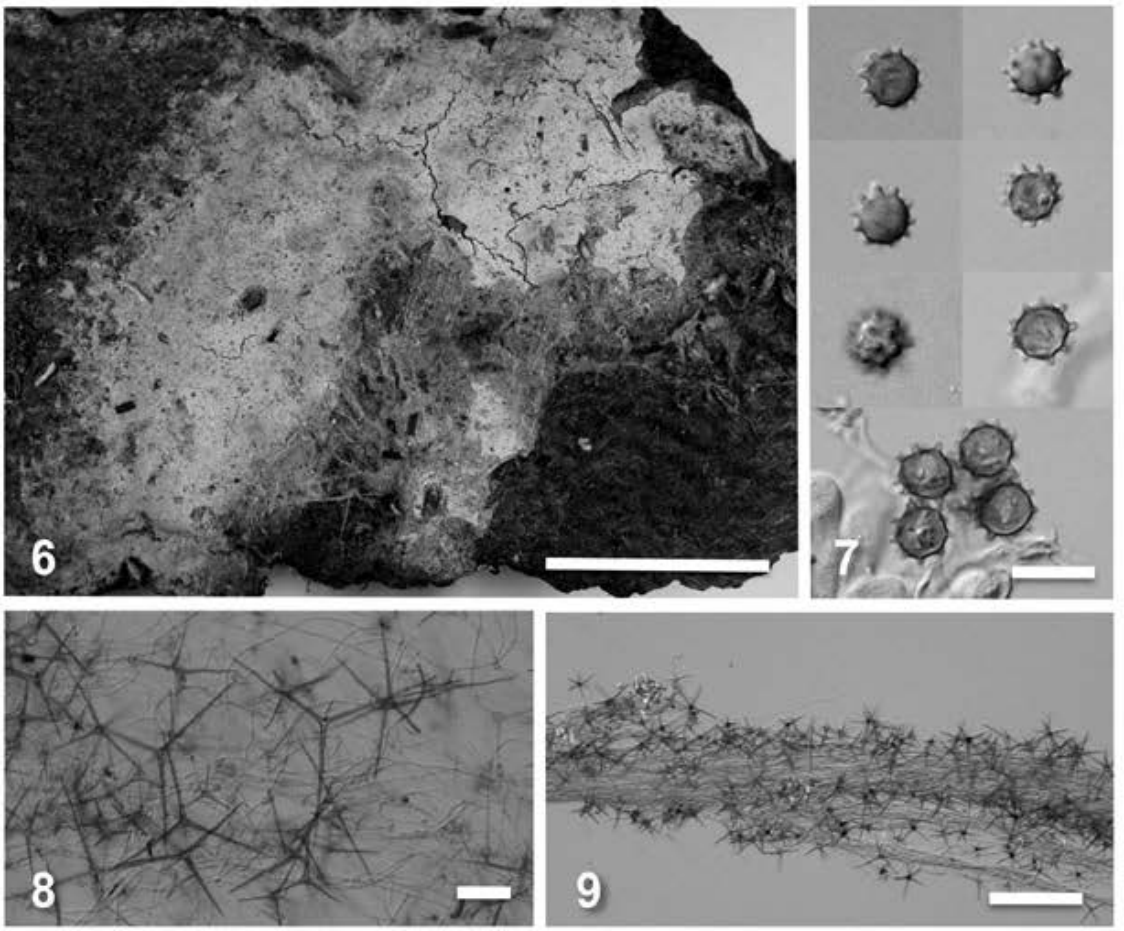
DISTRIBUTION — So far only reported from the Bonin Islands (Japan).

CULTURAL CHARACTERISTICS —Optimal temperature for the four polysporous isolates examined was 25–30°C (see TYPE and ADDITIONAL SPECIMENS EXAMINED). These isolates grew between 10 and 30°C, with no visible growth observed at 4, 35, or 40°C. Growth rate on MA: 6.7–15 mm after 1 w (25°C).

ADDITIONAL SPECIMENS EXAMINED: **JAPAN. TOKYO: Ogasawara-mura**, MINAMIZAKI (Hahajima Island), on dead wood of *Livistona boninense* (Becc.) Nakai (*Arecaceae*), 12 Dec 1997, coll. N. Maekawa, TMI20570 (polysporous culture, TUFC33791); TAKINOURA (Anijima Island), on dead trunk of *L. boninensis*, 6 Dec 1997, coll. N. Maekawa, TMI20620 (polysporous culture, TUFC33877); MT. SHIGURE (Chichijima Island), on dead branch of *Pandanus boninensis* Warb. (*Pandanaceae*), 3 Dec 2006, coll. N. Maekawa, TUMH40170 (polysporous culture, TUFC10922).

Mycelial mats white, partly pale salmon to "Flesh", cottony to woolly at 2 w, and then becoming partly floccose, "Rosy Vinaceous" to "Dark Vinaceous", sometimes with white, thin, hyphal strands, occasionally farinaceous around the inoculum; agar medium stained "Vinaceous" around the inoculum at 6 w; margin even, raised, with irregularly fan-like extensions; odor crayon-like; no fruiting by 6 w. Surface and aerial hyphae hyaline, 2.5–3.5 µm in diameter, smooth, thin-walled, clampless-septate, sparsely branched, sometimes with yellow to reddish brown oily contents, producing abundant subhyaline to pale brown asterohyphidia (FIG. 8), occasionally producing tubular gloeocystidium-like cells and gloeoplerous to swollen (monilioid) cells, up to 20 µm in diameter filled with hyaline oily contents. Hyphae of the hyphal strands hyaline to subhyaline, 1–3 µm in diameter, smooth, thin-walled, clampless-septate, sparsely branched, producing numerous subhyaline to pale brown asterohyphidia (FIG. 9), sometimes containing crystals in hyphal strands. Submerged hyphae hyaline to subhyaline, partly becoming pale "Vinaceous", 1–2.5 µm in diameter, smooth, thin-walled, clampless-septate, branched, sometimes capilliform-like; skeletal and binding hyphae absent.

Species code (Nakasone 1990): 6. 15. 16. 19. 26. 28. 29. (31.) 36. 39. 44. 49. 53. 54.



FIGS 6–9. Photographs of *Asterostroma boninense*: 6. Basidioma (TMI20619, holotype); 7. Basidiospores stained with Melzer's reagent; 8. Asterohyphidia produced in cultural mycelium (6 w); 9. Hyphal strand with asterohyphidia produced in culture (6 w). Scale bars: 6 = 1 cm; 7, 8 = 10 µm; 9 = 100 µm.

Discussion

Asterostroma boninense is primarily characterized by having asterohyphidia and tuberculate, subglobose, amyloid basidiospores. Its amyloid and ornamented basidiospores places this species into subg. *Asterostroma* sect. *Asterostroma*. Within this section, the species resembles *A. muscicola* and *A. macrosporum* in forming subglobose basidiospores with subcylindrical to obtuse ornaments. However, Gilbertson & Blackwell (1987) and Boidin et al. (1997) measured the basidia of *A. muscicola* at 25–32 × 6–8.5 µm and 18–24 × 5–6 µm respectively; the distinctly larger basidia in *A. boninense* [40–60 × 6.5–8.5 µm (50 ± 7.4 × 7.4 ± 0.5 µm, n = 60/3)] differentiate the new species from *A. muscicola* [27–41 × 5–7.5 µm (34.2 ± 3.8 × 6.3 ± 0.7 µm, n = 40/2)]. Furthermore, *A. boninense* specimens have been collected only from dead monocotyledonous angiosperm tree trunks and branches, e.g., endemic species of *Clinostigma*, *Livistona*, and *Pandanus* in the Bonin Islands (located in subtropical region of Japan). On the

other hand, *A. muscicola* occurs both on angiospermous and gymnospermous slash (Gilbertson et al. 1974, Gilbertson & Blackwell 1987) and is distributed in subtropical to warm-temperate regions in Japan (Suhara et al. 2010).

Asterostroma boninense also resembles *A. macrosporum* in basidial shape and size except that in the latter basidiospores are distinctly larger (8.5–11 × 7.5–9 µm) than those of *A. boninense*. In addition, *A. macrosporum* has been collected only from mangrove trees on Iriomote Island, approximately 1,600 km west of the Bonin Islands (Suhara et al. 2010).

We also recognized *A. andinum* Pat. as a species new to Japan based on two specimens, TMI19638 and TUMH40171, collected in Hokkaido and the Bonin Islands, respectively. This species, which has a worldwide distribution, is placed in sect. *Laevispora*. *Asterostroma andinum* is primarily diagnosed by subglobose to globose basidiospores measuring 6–7.5 × 5–6.5 µm and asterosetal rays measuring 30–130 × 4–8 µm. The morphologically similar *Asterostroma laxum* Bres. produces smaller rays measuring up to 40 µm in length (Parmasto 1970, Boidin et al. 1997).

The features distinguishing *Asterostroma* species reported from Japan can be found in the following key.

Key to species of the genus *Asterostroma* in Japan

1. Basidiospores smooth, subglobose ..... ***A. andinum***
1. Basidiospores ornamented 2
2. Basidiospores subglobose, 4.8–6 × 4–5 µm ..... ***A. cervicolor***
2. Basidiospores subglobose to globose, larger (up to 8 × 8.5 µm or more), with subcylindrical and obtuse ornaments 3
3. Basidiospores 8.5–11 × 7.5–9 µm; basidiomata only on mangrove trees ..... ***A. macrosporum***
3. Basidiospores smaller than 8.5–11 × 7.5–9 µm 4
4. Basidia 40–60 × 6.5–8.5 µm; basidiomata on monocotyledonous trees of angiosperms ..... ***A. boninense***
4. Basidia 18–41 × 5–8.5 µm; basidiomata both on angiosperms and gymnosperms ..... ***A. muscicola***

Acknowledgements

This study was supported in part by a grant from Institute for Fermentation, Osaka (IFO) to N.M. and H.S. We are grateful to Professor N. Hallenberg and Dr. T. Hattori for critical review and helpful suggestions to improve the manuscript.

Literature cited

Aoshima K, Hayashi Y, Furukawa H. 1963. The genera *Asterodon* and *Asterostroma* of *Hymenochaetaceae* (in Japanese). Trans. Mycol. Soc. Jpn. 4: 136–140

Boidin J, Lanquetin P, Gilles G. 1997. Contribution a la conassance du genre *Asterostroma* Massee 1889 (*Basidiomycotina*). Bulletin trimestriel de la Société mycologique de France 113: 269–301

Gilbertson RL, Blackwell M. 1987. Notes on wood-rotting fungi on junipers in the Gulf Coast region. II. Mycotaxon 28: 369–402

Gilbertson RL, Martin KJ, Lindsey JP. 1974. Annotated check list and host index for Arizona wood-rotting fungi. Univ. Arizona Agaric. Exp. Sta. Techn. Bull. 209: 1–48

Nakasone KK. 1990. Cultural studies and identification of wood-inhabiting *Corticiaceae* and selected hymenomycetes from North America. Mycologia Memoir No.15. Gebrüder Borntraeger, Berlin

Parmasto E. 1970. The *Lachnocladiaceae* of the Soviet Union. With a key to the boreal species. Tartu, Estonia

Rayner RW. 1970. A mycological color chart. Commonwealth Mycological Institute and British Mycological Society, Kew, Surrey

Suhara H, Maekawa N, Ushijima S, Kinjo K, Hoshi Y. 2010. *Asterostroma* species (*Basidiomycota*) from mangrove forests in Japan. Mycoscience 51: 75–80. doi:10.1007/s10267-009-0006-2

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.205

Volume 114, pp. 205–210 *October–December 2010*

Three new species of *Scytalidium* from soil

YUE-MING WU & TIAN-YU ZHANG*

tyzhang1937@yahoo.com.cn
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — Three new species of dematiaceous hyphomycetes from soil in China, *Scytalidium nielamuense, S. verruculosum,* and *S. xigazense,* are described and illustrated. The type specimens (dried cultures) and living cultures are deposited in the Herbarium of Shandong Agricultural University Plant Pathology (HSAUP). Isotypes are kept in the Herbarium of the Institute of Microbiology, Academia Sinica (HMAS).

Key words — taxonomy, soil fungi

Introduction

Since Pesante (1957) erected *Scytalidium* for *S. lignicola* Pesante, 22 species have been recognized worldwide (Index Fungorum 2010). This genus is characterized by dematiaceous, intercalary or terminal arthroconidia formed by fragmentation of undifferentiated hyphae. The arthroconidia are often thick-walled, smooth, occasionally verrucose in age, mid or dark brown, cylindrical, oblong, doliform or broadly ellipsoidal, often 0-septate, when septate with septa sometimes thick and very dark, often constricted at the septum; fission arthroconidia of a second type are hyaline, or pale to mid-brown, thin-walled, smooth, cylindrical, single-celled, truncate at each end. (Also refer to Ellis 1971.) During a recent survey of soil hyphomycetes in China, three new species of *Scytalidium* were found and are described below.

Taxonomic descriptions

Scytalidium nielamuense Y.M. Wu & T.Y. Zhang, **sp. nov.** FIG. 1

MYCOBANK MB 518543

Coloniae in PDA effusae, plus minusve radiatim sulcatae, crassae . Mycelium aerium et immersum. Vegetativae hyphae leaves, subhyalinae vel brunneolae, ramosae, septatae, inflates cellulis 1.5–2 µm latae. Fertiles hyphae laeves, hyalinae vel subhyalinae, septatae,

*Corresponding author: Tian-Yu Zhang

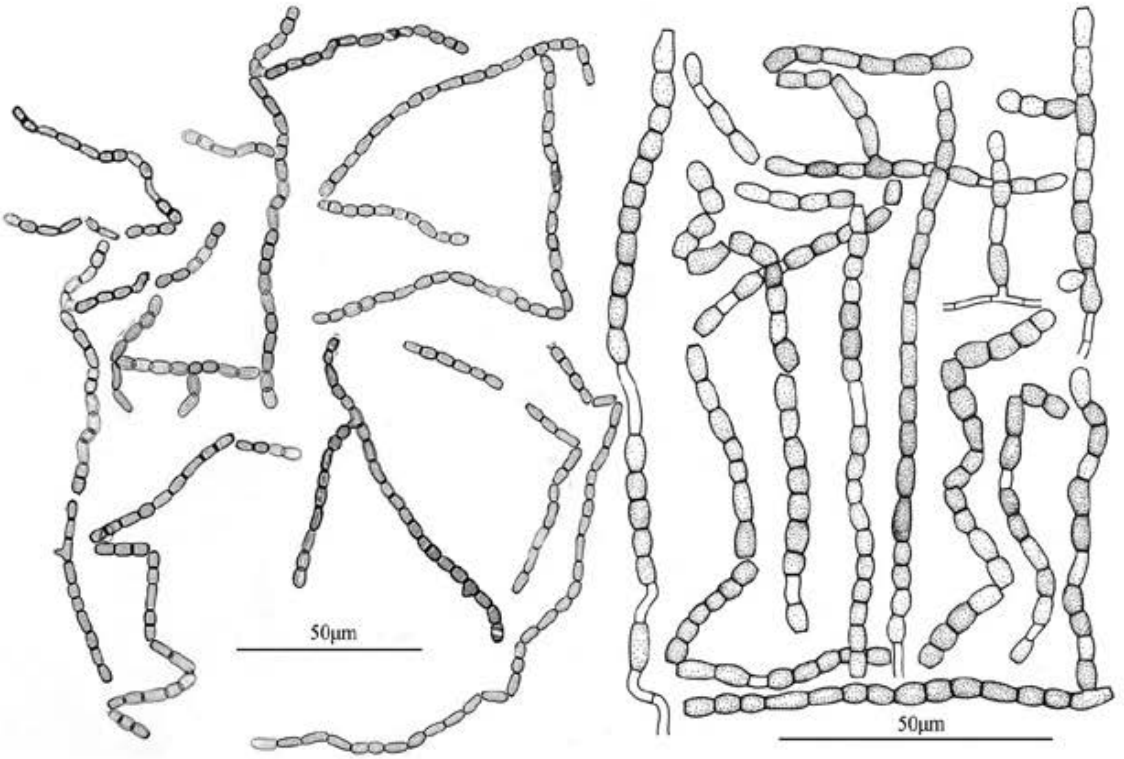


FIG. 1. Conidia and conidiogenous cells of *Scytalidium nielamuense* (ex holotype). Left: photomicrographs; right: drawings. (Bars = 50 μm).

schizolitice secedentibus arthroconidis. Conidia subhyalina vel flavo-brunnea, cylindracea, oblongo-elliptica vel doliformia, laevia, 0-septata, 3.8–7.5 × 2.5–3.8 μm.

HOLOTYPE: China, Tibet, Nielamu, from a grassland soil, altitude 2250 m, 14 Sept. 2007, Y.M. Wu, HSAUPII$_{07}$1268, **holotype**; HMAS 196252, **isotype**.

ETYMOLOGY: The epithet refers to the type location.

Colonies on PDA after two weeks at 25°C, effuse, growing slowly 2–3 cm diam., more or less radially folded, thick Mycelium partly superficial, partly immersed. Vegetative hyphae smooth, subhyaline to pale brown, branched, sparsely to regularly septate, sometimes slightly constricted at the septa, and often with individual cells rather variable in shape and slightly swollen, 1.5–2 μm wide; hyphae sometimes aggregating into strands. Fertile hyphae scarcely differentiated from vegetative hyphae, smooth, hyaline to subhyaline, with septa more closely spaced, fragmenting by schizolytic dehiscence to form arthroconidia. Conidia cylindrical to oblong-elliptical or doliform, vary in width depending on the parent hypha, subhyaline to yellow-brown, catenate, dry, simple, 0-septate, smooth, 3.8–7.5 × 2.5–3.8 μm.

This fungus somewhat resembles *Scytalidium vaccinii* Dalpé et al. (Dalpé et al. 1989) in conidial morphology. However, the latter has larger (7–14 × 3–4 μm), guttulate conidia, which remain connected in zigzag chains.

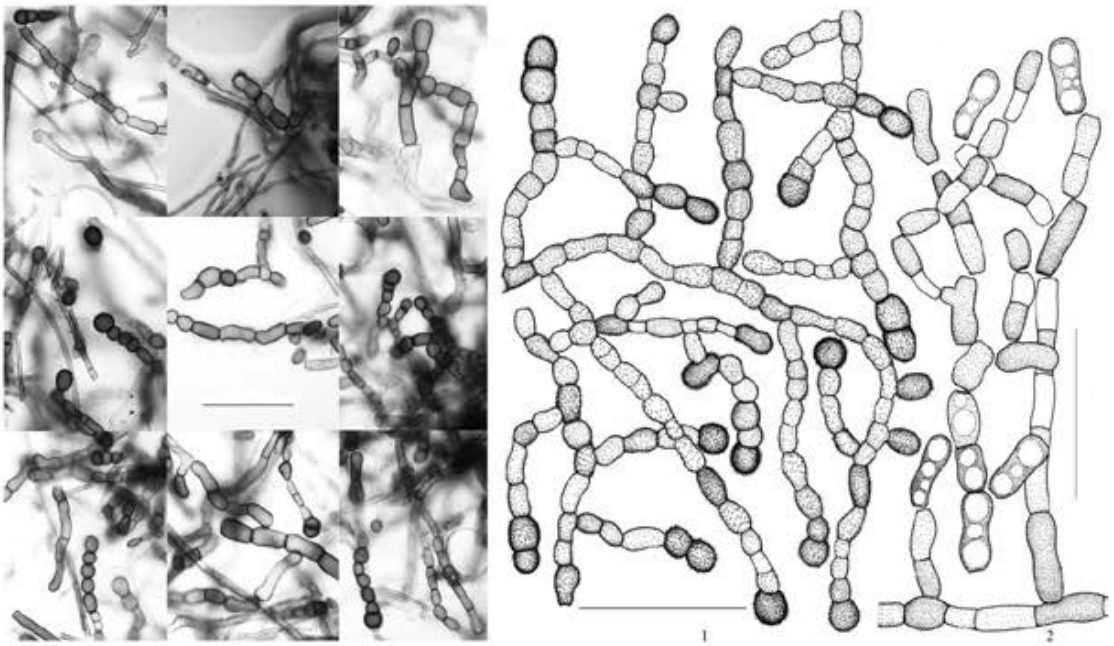


FIG. 2. Conidia and conidiogenous cells of *Scytalidium verruculosum* (ex holotype). Left: photomicrographs; right: drawings. (Bars = 50 µm).

Scytalidium verruculosum Y.M. Wu & T.Y. Zhang, **sp. nov.** FIG. 2

MYCOBANK MB 513017

Coloniae in PDA effusae. Mycelium partim superficiale et partim in substrato. Hyphae ramosae, septatae, subhyalinae vel pallide brunneae, 2–4 µm latae. Conidia biformis: (1) cylindracea, catenata, sicca, simplicia, 0–1-septata, brunnea, incrassata, verrucosa, utroque truncata, interdum clavata vel pyriformia, basi truncata et apice rotundata, aegre secedentes, 8–20 × 5–10 µm; (2) clavata vel pyriformia, cateenata, sicca, simplicia, 0-septata, pallide-brunnea, tenuia et laevia, basi truncata et apice rotundata, facile fragmentantia, 10–26.5 × 6–9 µm.

HOLOTYPE: China, Tibet, Zhangmu, from a mountain soil, altitude 2300 m, 14 Sept. 2007, Y.M. Wu, HSAUPII$_{07}$1328, **holotype**; HMAS 196253, **isotype**.

ETYMOLOGY: The epithet refers to the verrucose conidia of this species.

Colonies on PDA after two weeks at 25°C, effuse, growing very slowly, 2–3 cm diam., centre slightly raised, velvety, olivaceous brown. Mycelium partly superficial, partly immersed. Hyphae subhyaline to pale brown, smooth, septate, 2–4 µm thick, branched or unbranched. Conidia of two kinds: (1) cylindrical, catenate, dry, simple, 0–1-septate, medio-brown to dark brown, rough-walled, verrucose, truncate at both ends, sometimes clavate to pyriform, with a truncate base and rounded apex, not easily seceding, 8–20 × 5–10 µm; (2) clavate to pyriform, catenate, dry, simple, 0–catenate, dry, simple,1-septate, pale-brown, thin and smooth-walled, with a truncate base and rounded apex, seceding schizolytically and easily, 10–26.5 × 6–9 µm.

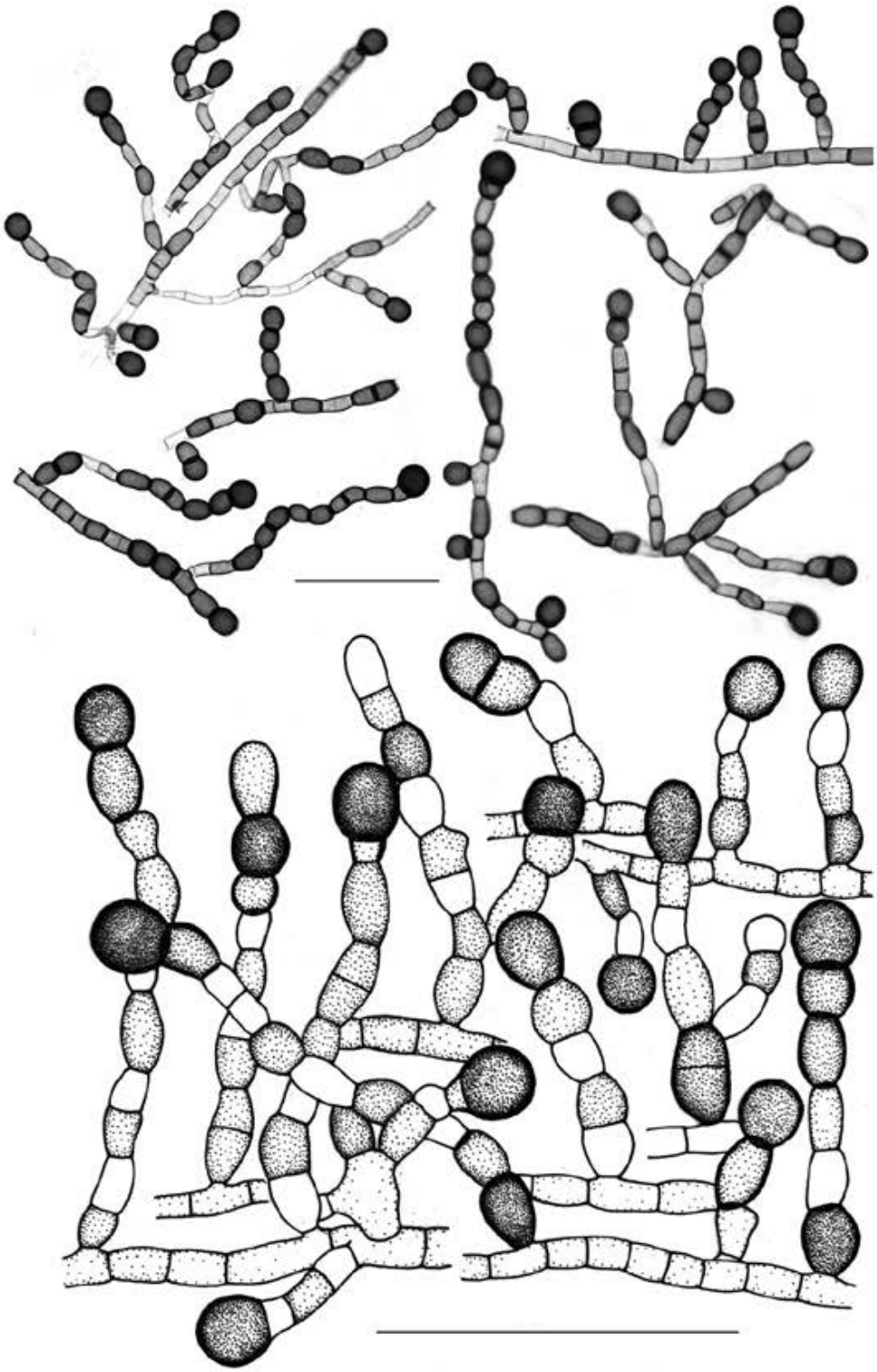


FIG. 3. Conidia and conidiogenous cells of *Scytalidium xigazense* (ex holotype) . Above: photomicrographs; below: drawings. (Bars = 50 μm).

This fungus somewhat resembles *Scytalidium infestans* Iwatsu et al. (Iwatsu et al. 1990) in conidial morphology. However, conidia of the latter are longer and narrower (4–30 × 2–4.5 µm), and rarely verrucose. *Scytalidium infestans* was described as a systemic pathogen of marine fish, whereas *S. verruculosum* is a soil fungus.

Scytalidium xigazense Y.M. Wu & T.Y. Zhang, **sp. nov.** FIG. 3

MYCOBANK MB 518397

Coloniae in PDA effusae. Mycelium partim superficiale et partim in substrato. Hyphae ramosa, septata, subhyalina vel pallide brunnea, 1–3 µm crassa. Conidia cylindracea, interdum clavata vel pyriformia, catenata, sicca, simplicia, 0–1-septata, subhyalina vel pallide brunnea, incrassata, laevia, utroque truncata, basi truncata et apice rotundata, 7–11 × 4–8 µm.

HOLOTYPE: China, Tibet, Xigaze, from a mountain soil, altitude 3700 m, 7 Sept. 2007, Y.M. Wu, HSAUPII$_{07}$0957, **holotype**; HMAS 196254, **isotype**.

ETYMOLOGY: The epithet refers to the type location.

Colonies on PDA after two weeks at 25°C, effuse, growing very slowly, 1.5–2.5 cm diam., centre slightly raised, velvety or floccose, olivaceous-gray. Mycelium partly superficial, partly immersed. Hyphae mostly subhyaline to pale brown, smooth, septate, 1–3 µm thick, branched. Conidia cylindrical, sometimes clavate to pyriform, vary in width depending on the parent hypha, catenate, dry, simple, 0–1-septate, subhyaline to brown, smooth, truncate at both ends, or with a truncate base and rounded apex, not easily seceding, 7–11 × 4–8 µm.

This fungus somewhat resembles *Scytalidium fulvum* Morgan-Jones & Gintis (Morgan-Jones et al. 1984) in conidial morphology. However, conidia of the latter are longer and narrower (12–14 × 2–3 µm).

Acknowledgments

The authors are grateful for pre-submission comments and suggestions provided by Dr. Eric McKenzie, Prof. Y.L. Guo, and Dr. Shaun Pennycook. This project was supported by the National Science Foundation of China (no. 30670014 & 30499340).

Literature cited

Dalpé Y, Litten W, Sigler L. 1989. *Scytalidium vaccinii* sp. nov., an ericoid endophyte of *Vaccinium angustifolium* roots. Mycotaxon 35: 371–377.

Ellis MB. 1971. Dematiaceous Hyphomycetes. CMI, Kew, Surrey, England. 608 p.

Index Fungorum. 2010. http://www.indexfungorum.org/Names/Names.asp; accessed 9 September 2010.

Iwatsu T, Udagawa S-i, Hatai K. 1990. *Scytalidium infestans* sp. nov., isolated from striped jack (*Pseudocaranx dentex*) as a causal agent of systemic mycosis. Trans. Mycol. Soc. Japan 31: 389–397.

Morgan-Jones G, Gintis BO, Rodriguez-Kabana R. 1984. New species of *Chalara* and *Scytalidium* isolated from cysts of *Heterodera glycines*. Mycologia, Bronx, 76: 211–217. doi: 10.2307/3793097

Pesante A. 1957. Osserazioni su una carie del platano. Ann. Sperim. Agric. 11(suppl.): 251–265.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.211

Volume 114, pp. 211–216 October–December 2010

A new species of *Phellinus (Hymenochaetaceae)* growing on bamboo in tropical China

LI-WEI ZHOU*

talent090982@163.com
Institute of Applied Ecology, Chinese Academy of Sciences
Shenyang 110016, China

Graduate University of the Chinese Academy of Sciences
Beijing 100049, China

BI-SI JIA

Institute of Microbiology, PO Box 61, Beijing Forestry University
Beijing 100083, China

Abstract — *Phellinus bambusicola* sp. nov. is described and illustrated from Hainan Province, southern China. It has annual and resupinate basidiocarps, clay-buff to pale fawn pore surface, abundant hymenial setae, broadly ellipsoid and thin-walled basidiospores, setal hyphae present in the subiculum but absent at the sterile margin, and a growth on bamboo. The new species is similar to *Phellinus ferruginosus*, but the latter has an annual to perennial growth habit, yellowish brown to dark reddish brown pore surface, smaller pores (6–8 per mm), setal hyphae present at the sterile margin, and narrowly ellipsoid basidiospores.

Key words — *Hymenochaetales*, polypore, taxonomy

Introduction

Phellinus Quél., with over 250 taxa worldwide, is the largest genus in the *Hymenochaetaceae* (Larsen & Cobb-Poulle 1990, Dai 1999, 2010, Núñez & Ryvarden 2000, Gibertoni et al. 2004, Ryvarden 2004, Parmasto 2007). Wanger & Fischer (2002), who studied *Phellinus* sensu lato and *Inonotus* sensu lato phylogenetically, divided the *Phellinus–Inonotus* complex into 13 genera. Since Dai (1999) recorded 45 species of *Phellinus* from East Asia new species or new records have been found in China, where about 50 species in the genus have

* Corresponding author

been reported thus far (Dai 1995, 1999, Dai et al. 2003, 2008, Dai & Yang 2008, Cui et al. 2009).

During a study of wood-inhabiting fungi in southern China, an unknown species of *Phellinus* growing on bamboo was identified and is described in the present paper.

Materials and methods

The studied specimens were deposited in herbaria as cited below. The microscopic procedure follows Cui & Dai (2008). In presenting the variation in the size of the spores, 5% of measurements were excluded from each end of the range, and given in parentheses. In the text the following abbreviations are used: IKI = Melzer's reagent, IKI– = negative in Melzer's reagent, KOH = 5% potassium hydroxide, CB = Cotton Blue, CB– = acyanophilous, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of all spores), Q = variation in the L/W ratios between the specimens studied, n = number of spores measured from given number of specimens. Sections were studied at magnification up to ×1000 using a Nikon Eclipse E 80i microscope and phase contrast illumination. Drawings were made with the aid of a drawing tube. Special colour terms follow Anonymous (1969) and Petersen (1996).

Taxonomy

Phellinus bambusicola L.W. Zhou & B.S. Jia, **sp. nov.** FIG. 1

MYCOBANK MB 518776

Carpophorum annuum, resupinatum. Facies pororum avellanea vel hinnulea; pori angulati, 3–5 per mm. Systema hypharum dimiticum, hyphae generatoriae septatae, efibulatae. Sporae late ellipsoideae, IKI–, CB–, 4.2–5 × 3.1–4 µm.

TYPE. — China. Hainan Province, Changjiang County, Bawangling Nature Reserve, on dead bamboo, 8.XII.2009 Cui 8692 (**holotype** in BJFC, **isotype** in IFP).

ETYMOLOGY — *bambusicola* (Lat.): refers to growth on bamboo.

FRUITBODY — Basidiocarps annual, resupinate, firmly attached to the substrate, not readily separable, without odour or taste when fresh, hard corky when dry, up to 15 cm long, 5 cm wide and 2 mm thick at centre; sterile margin pale clay-buff to pale fawn, up to 3 mm wide. Pore surface clay-buff to pale fawn when dry; pores angular, 3–5 per mm, dissepiments thin, entire when juvenile, lacerate with age. Subiculum yellowish brown to fawn-brown, hard corky, about 0.4 mm thick. Tubes concolorous with pore surface, corky, about 1.6 mm long.

HYPHAL STRUCTURE — Hyphal system dimitic; all septa without clamp connections; skeletal hyphae IKI–, CB–; tissue darkening but otherwise unchanged in KOH.

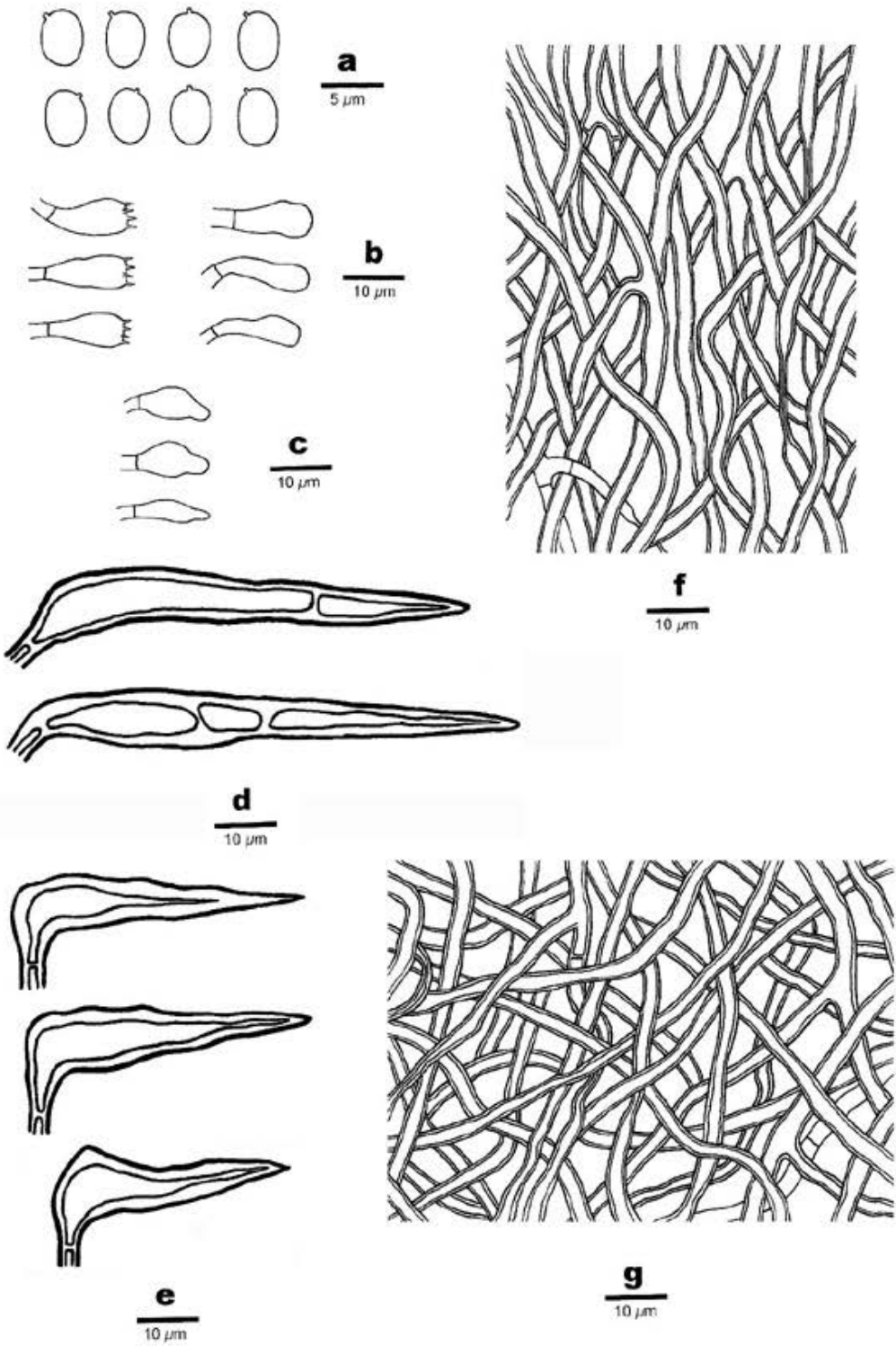


FIG. 1. Microscopic structures of *Phellinus bambusicola* (drawn from the holotype).
a: Basidiospores. b: Basidia and basidioles. c: Cystidioles.
d: Hyphoid setae. e: Setae. f: Hyphae from trama. g: Hyphae from context.

SUBICULUM — Generative hyphae infrequent, hyaline to pale yellowish, thin- to slightly thick-walled, occasionally branched, some collapsed, 2.2–3.5 μm in diam; skeletal hyphae pale yellowish to apricot-orange, thick-walled with a wide lumen, occasionally branched, some collapsed, interwoven, 2–5 μm in diam; setal hyphae frequent, apricot-orange, thick-walled, tapering to apex, 6.5–10.5 μm wide and up to 110 μm long.

TUBES — Generative hyphae infrequent, hyaline to pale yellowish, thin- to thick-walled, frequently branched and some collapsed, 1.8–3.5 μm in diam; skeletal hyphae dominant, pale yellowish to apricot-orange, thick-walled, occasionally branched, and some collapsed, parallel along the tubes, 1.6–4 μm in diam. Hymenial setae frequent, ventricose to subulate, tapering to apex, dark brown, thick-walled, 31.8–54.5 × 9.2–14.3 μm. Cystidia absent, fusoid cystidioles present, hyaline, thin-walled, 9.8–17 × 4.9–6.3 μm. Basidia clavate, bearing four sterigmata and a simple septum at the base, 8.7–18 × 3.9–6 μm; basidioles in shape similar to basidia, but slightly smaller. Irregular crystals present in trama and hymenia.

SPORES — Basidiospores broadly ellipsoid, hyaline, thin-walled, smooth, IKI–, CB–, (4–)4.2–5(–5.9) × (3–)3.1–4 μm, L = 4.68 μm, W = 3.56 μm, Q = 1.31 (n = 30/1).

TYPE OF ROT — White rot.

REMARKS — *Phellinus bambusicola* was found on bamboo in tropical China. It is characterized by annual, resupinate basidiocarps, a clay-buff to pale fawn pore surface, abundant hymenial setae, broadly ellipsoid and thin-walled basidiospores, setal hyphae present in the subiculum while absent at the sterile margin, and growth on bamboo.

This species is similar to *Phellinus ferruginosus* (Schrad.) Pat., but the latter shows an annual to perennial growth habit, yellowish brown to dark reddish brown pore surface, smaller pores (6–8 per mm, Dai 1999), setal hyphae present at the sterile margin, and narrowly ellipsoid basidiospores are (4.7–5.3 × 3.0–3.5 μm, L = 5.04 μm, W = 3.16 μm, Q = 1.59).

Phellinus bambusarum (Rick) M.J. Larsen also grows on bamboo and may be confused with *P. bambusicola*. However, *P. bambusarum* differs by a perennial growth habit, smaller pores (6–8 per mm) with thick-walled dissepiments, rare and smaller hymenial setae (13–25 × 6–8 μm), and globose to subglobose and dextrinoid basidiospores (Ryvarden 2004).

Phellinus bambusinus (Pat.) Pat., another species growing on bamboo, is distinguished from *P. bambusicola* in its pileate basidiocarps, ochraceous brown and glancing (reflective) pore surface, small invisible pores, and ovoid basidiospores (5 × 4 μm); moreover, it has conidia (Larsen & Cobb-Poulle 1990).

A key to species of *Phellinus* on bamboo

1. Basidiocarps pileate; conidia present ..... *P. bambusinus*
1. Basidiocarps resupinate; conidia absent 2
2. Pores 6–8 per mm; basidiospores subglobose, dextrinoid ..... *P. bambusarum*
2. Pores 3–5 per mm; basidiospores broadly ellipsoid, IKI– ..... *P. bambusicola*

Acknowledgements

We express our gratitude to Drs. Wjacheslav Spirin (St. Petersburg, Russia) and Zheng Wang (Yale University, USA) who reviewed the manuscript. The research was financed by the National Natural Science Foundation of China (Project No. 30910103907) and the Ministry Science and Technology of China (Project No. 2006FY110500-5).

Literature cited

Anonymous. 1969. Flora of British fungi. Colour identification chart. Her Majesty's Stationery Office, London. 1 p.

Cui BK, Dai YC. 2008. Wood-rotting fungi in eastern China 2. A new species of *Fomitiporia* (*Basidiomycota*) from Wanmulin Nature Reserve, Fujian Province. Mycotaxon 105: 343–348.

Cui BK, Dai YC, Bao HY. 2009. Wood-inhabiting fungi in southern China 3. A new species of *Phellinus* (*Hymenochaetales*) from tropical China. Mycotaxon 110: 125–130.

Dai YC. 1995. Changbai wood-rotting fungi 3. The genus *Phellinidium* (*Basidiomycetes*) and a new species, *P. aciferum*. Ann. Bot. Fennici 32: 63–73.

Dai YC. 1999. *Phellinus* sensu lato (*Aphyllophorales, Hymenochaetaceae*) in East Asia. Acta Bot. Fennici 166: 1–115.

Dai YC. 2010. *Hymenochaetaceae* (*Basidiomycota*) in China. Fungal Divers. 45: 131–343. doi:10.1007/s13225-010-0066-9

Dai YC, Cui BK, Tao WQ. 2008. *Phellinus mori* sp. nov. (*Basidiomycota, Hymenochaetales*) from northern China. Mycotaxon 105: 53–58.

Dai YC, Härkönen M, Niemelä T. 2003. Wood-inhabiting fungi in southern China 1. Polypores from Hunan Province. Ann. Bot. Fennici 40: 381–393.

Dai YC, Yang F. 2008. A new species of *Phellinus* (*Basidiomycota, Hymenochaetales*) from western China. Mycotaxon 104: 103–106.

Gibertoni TB, Ryvarden L, Cavalcanti MAQ. 2004. Studies in neotropical polypores 18. New species from Brazil. Synopsis Fungorum 18: 44–56.

Larsen MJ, Cobb-Poulle LA. 1990. *Phellinus* (*Hymenochaetaceae*). A survey of the world taxa. Synopsis Fungorum 3: 1–206.

Núñez M, Ryvarden L. 2000. East Asian polypores 1. *Ganodermataceae* and *Hymenochaetaceae*. Synopsis Fungorum 13: 1–168.

Parmasto E. 2007. *Phellinus laevigatus* s.l. (*Hymenochaetales*): a ring species. Folia Cryptog. Estonica 43: 39–49.

Petersen JH. 1996. Farvekort. The Danish Mycological Society's colour-chart. Foreningen til Svampekundskabens Fremme, Greve.

Ryvarden L. 2004. Neotropical polypores part 1. Introduction, *Ganodermataceae* and *Hymenochaetaceae*. Synopsis Fungorum 19: 1–229.

Wagner T, Fischer M. 2002. Proceedings towards a natural classification of the worldwide taxa *Phellinus* s.l. and *Inonotus* s.l., and phylogenetic relationships of allied genera. Mycologia 94: 998–1016. doi:10.2307/3761866

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.217

Volume 114, pp. 217–223 October–December 2010

Two new species of *Septobasidium* (*Septobasidiaceae*) from Hainan Province in China

CHUNXIA LU[1,2] & LIN GUO[1*]

*Ch.x.lu@hotmail.com & *guol@im.ac.cn*

[1]*Key Laboratory of Systematic Mycology and Lichenology*
Institute of Microbiology, Chinese Academy of Sciences
Beijing 100101, China

[2]*Graduate University of Chinese Academy of Sciences*
Beijing 100049, China

Abstract — Two new species, *Septobasidium hainanense* on *Harpullia* sp. associated with *Pseudaulacaspis* sp. and *Septobasidium ligustri* on *Ligustrum sinense* associated with *Lepidosaphes* sp., are described.

Key words — *Pucciniomycetes*, *Septobasidiales*, taxonomy

The mycota is very rich in tropical forests of Hainan. Several mycological investigations dealing with many new species including the genus *Septobasidium* were published recently (Dai & Cui 2006, Dai & Li 2010, Cui et al. 2009, Dai et al. 2009, Lu & Guo 2009a, 2010b, Yuan & Dai 2008, Xiong & Dai 2008, Wei & Dai 2008). The present paper belongs to a series of studies devoted to the fungal diversity of the Hainan Province. Two new species of *Septobasidium* are described as follows:

Septobasidium hainanense C.X. Lu & L. Guo, **sp. nov.** FIGS. 1–7

MYCOBANK MB 518658

Basidiomata resupinata, 0.2–2.5 cm longa, 0.15–1 cm lata, purpurea, margine determinata, superficie laevia, in sectione 220–830 µm crassa. Subiculum brunneum, 25–60 µm crassum. Columnae brunneae, 50–110 µm altae, 60–155 µm crassae vel hyphis laxe completae. Strata hyphararum 70–505 µm alta, saepe strata horizontalia formantia, interdum hyphae partim successiveque crescentes et texturam hemisphaericam tum formantes. Hymenium 50–200 µm crassum. Hyphae hymenii erectae. Basidia cylindrica, recta vel curvata, 4-cellularia, 25–36 × 7–13 µm, hyalina vel brunneola. Sine probasidio. Basidiosporae non visae. Haustoria ex hyphis irregulariter spiralibus constantia.

*corresponding author

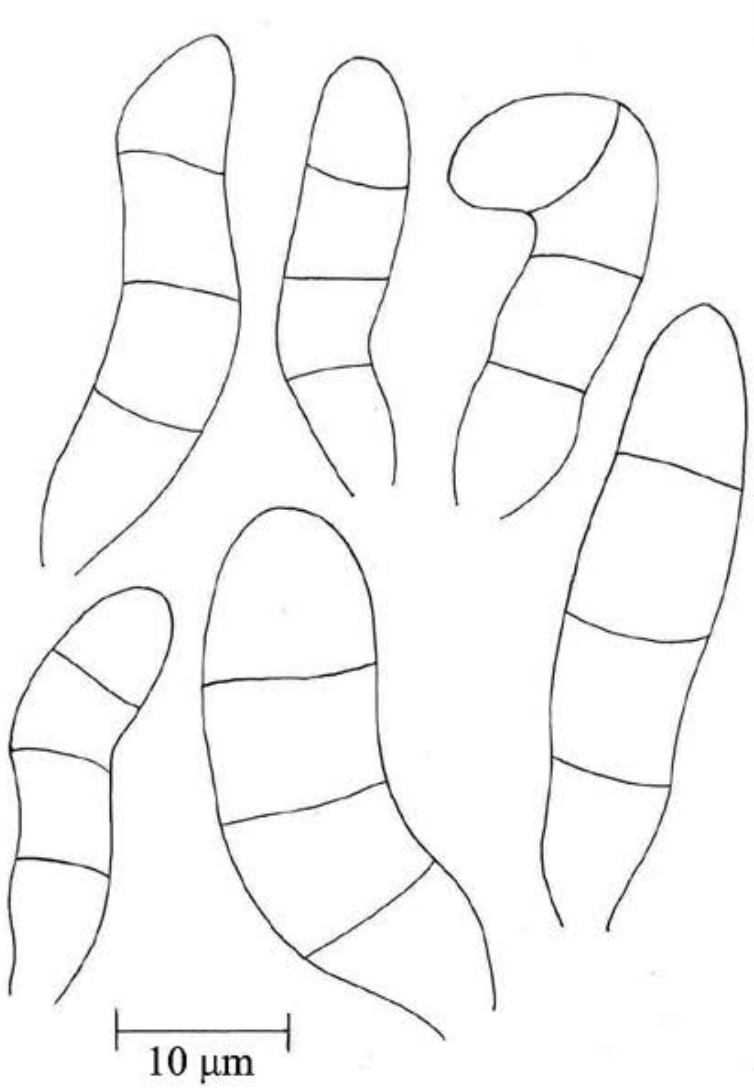


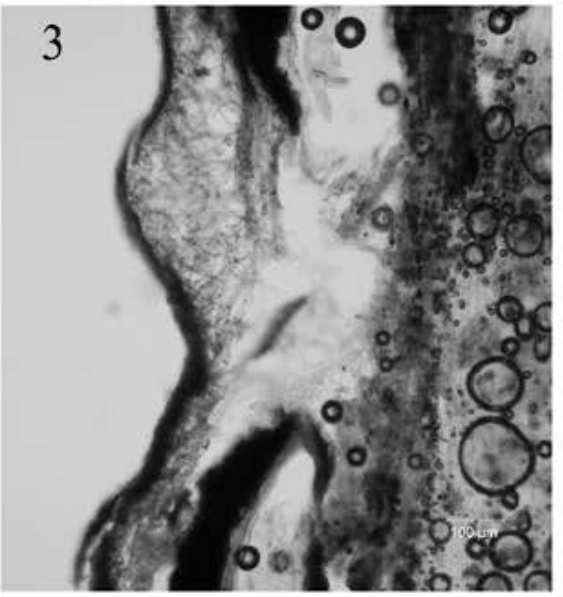
FIG. 1. Basidia of *Septobasidium hainanense* (HMAS 240078, holotype).

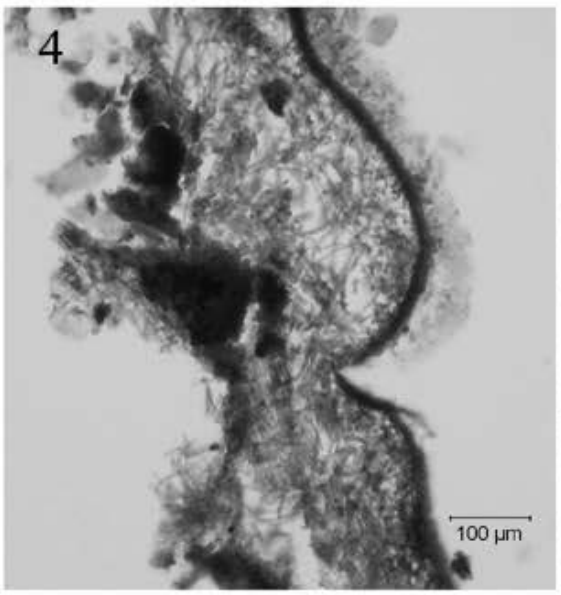
TYPE: On *Harpullia* sp. (*Sapindaceae*): China, Hainan, Bawangling, Yajia, alt. 740 m, 12.XII.2009, Y.F. Zhu & L. Guo 141, HMAS 240078 **(holotype)**, associated with *Pseudaulacaspis* sp. (*Diaspididae*).

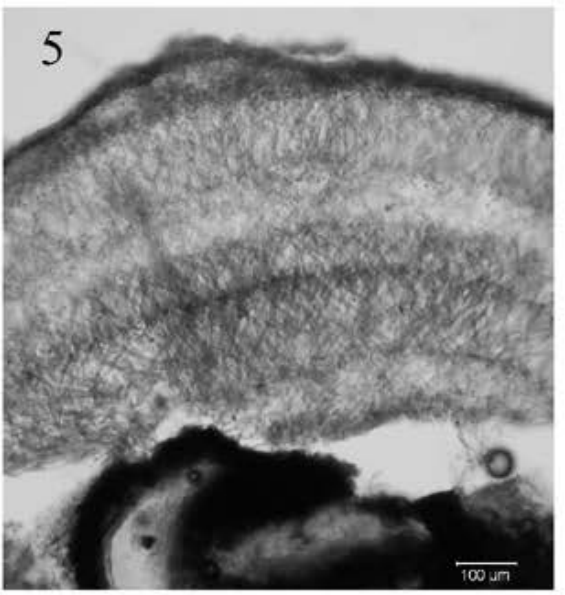
Basidiomata on trunks, resupinate, small, rounded, elongate or irregular, often confluent, 0.2–2.5 cm long, 0.15–1 cm wide, purple; margin determinate; surface smooth, often with mounds. In section 220–830 µm thick. Subiculum brown, 25–60 µm thick. Pillars brown, 50–110 µm high, 60–155 µm wide, sometimes loosely filled with hyphae from the subiculum. Hyphal layer 70–505 µm high, often forming a distinct horizontal layer, sometimes hyphae partly and successively growing and forming hemispheric tissue. Hymenial layer 50–200 µm thick, with closely arranged upright hyphae. Basidia arising directly from

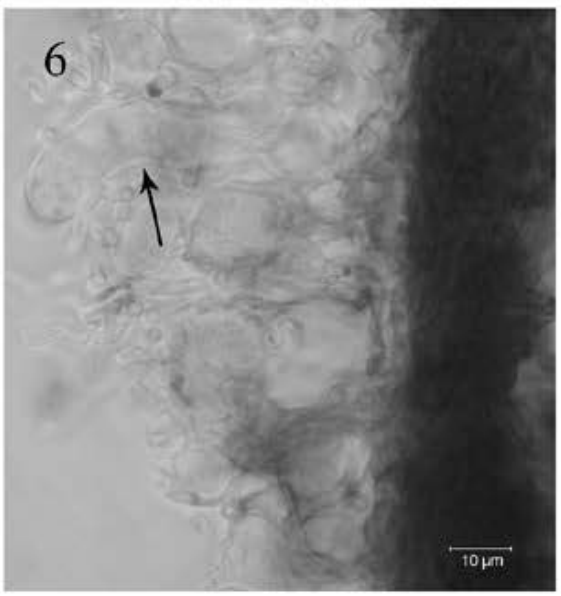
FIGS. 2–7 (right). *Septobasidium hainanense* (HMAS 240078, holotype). 2. Basidiomata on trunk. 3–5. Sections of basidiomata. 6. Basidium (arrow). 7. Haustoria.

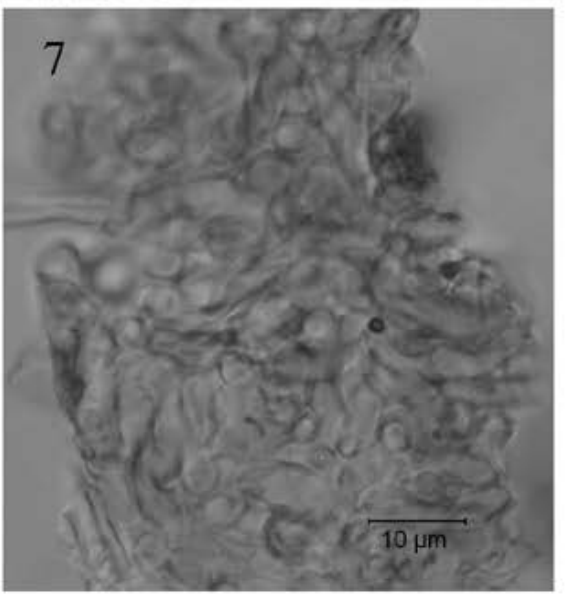

2


3


4
100 µm


5
100 µm


6
10 µm


7
10 µm

the hyphae, cylindrical, straight or curved, 4-celled, 25–36 × 7–13 µm, hyaline or brownish, without a probasidial cell. Basidiospores not seen. Haustoria consisting of irregularly coiled hyphae.

REMARKS: Morphologically, *Septobasidium hainanense* is similar to *S. lichenicola* (Berk. & Broome) Petch, from which it differs in having small patches of basidiomata, hyphae partly growing and forming hemispheric tissue, and with pillars or loosely filled with hyphae from subiculum. *Septobasidium lichenicola* has large patches of basidiomata, hyphae not forming hemispheric tissue and not loosely filled with hyphae from subiculum.

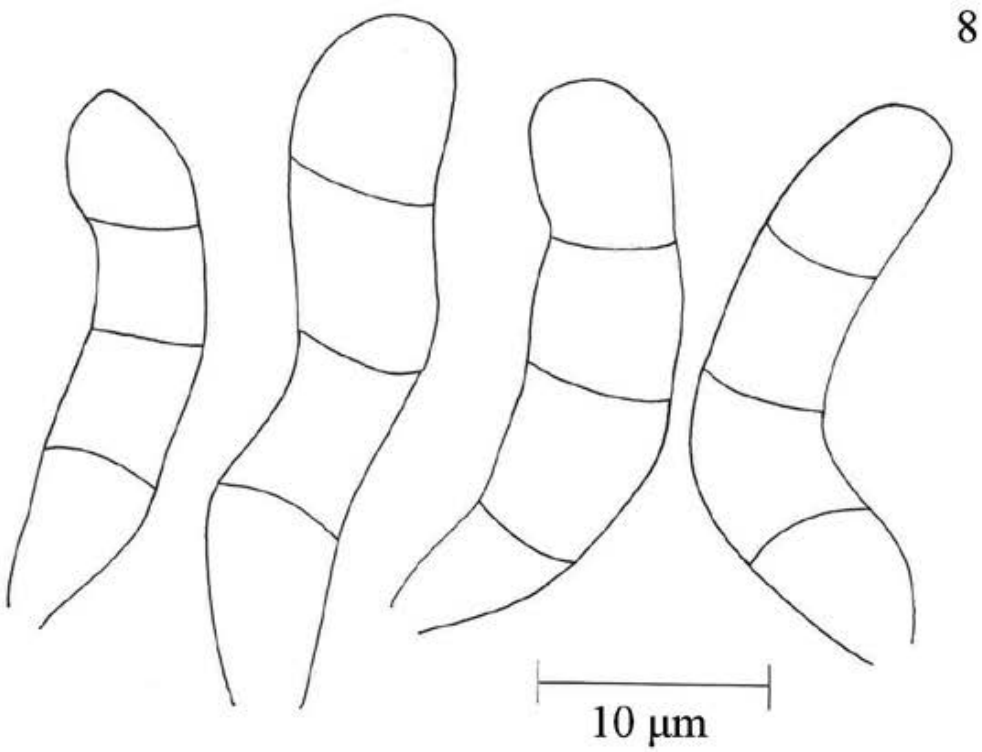


FIG. 8. Basidia of *Septobasidium ligustri* (HMAS 240079, holotype).

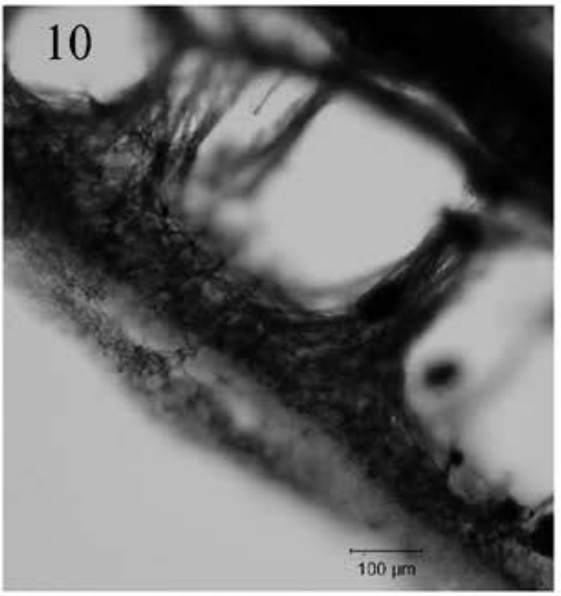
Septobasidium ligustri C.X. Lu & L. Guo, **sp. nov.** FIGS. 8–14

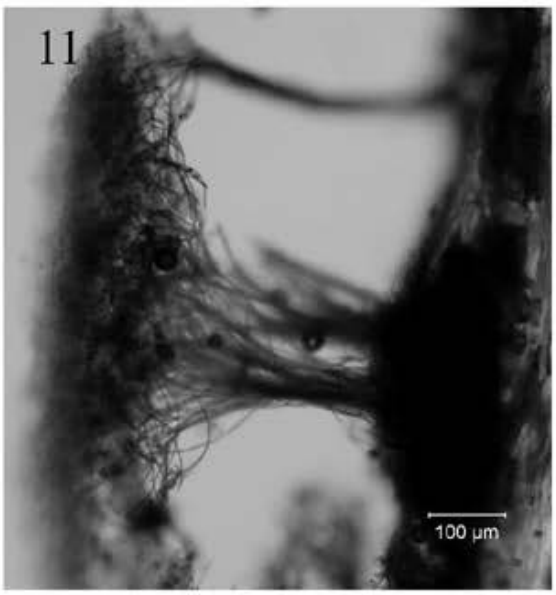
MYCOBANK MB 518659

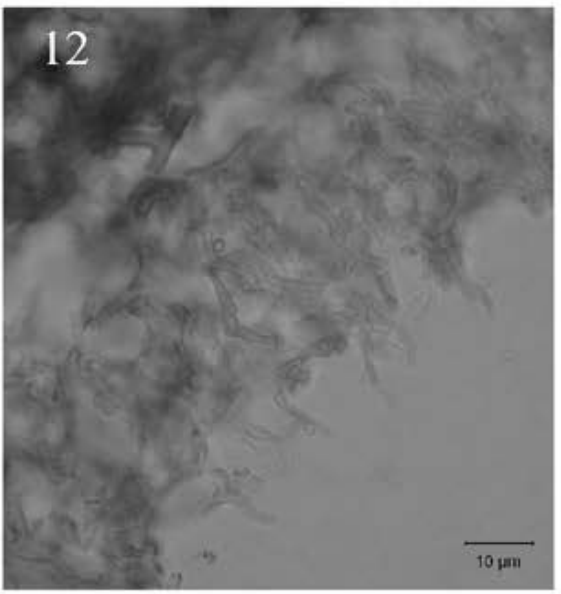
Basidiomata resupinata, 9–20 cm longa, 1–3 cm lata, griseo-brunnea, margine determinata, superficie laevia, maturitate fissurata, in sectione 480–630 µm crassa. Subiculum brunneum, 20–60 µm crassum. Columnae brunneolae, 210–390 µm altae, 30–150 µm latae, extus ramosae strata hyphararum 100–170 µm alta tum formantes. Hymenium 50–80 µm crassum. Hyphae hymenii irregulariter dispositae, erectae, ramosae. Basidia cylindrica, recta vel curvata, 4-cellularia, 15–29 × 5–7.5 µm, hyalina. Sine probasidio. Sterigmata 3–8 µm longa. Basidiospora ovoidea, 9 × 4 µm, hyalina. Haustoria ex hyphis irregulariter spiralibus constantia.

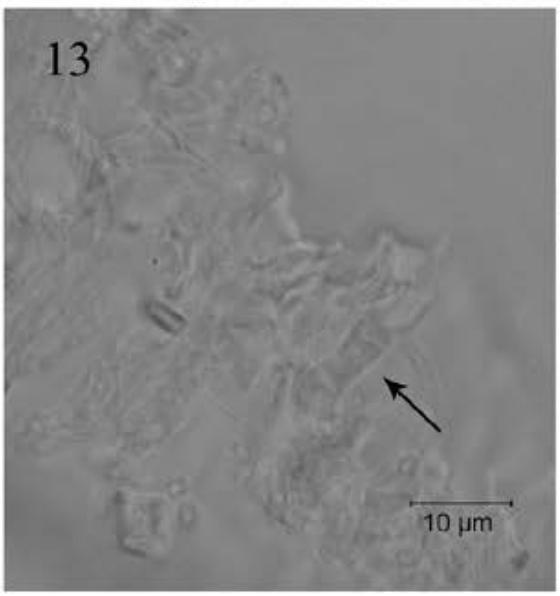
FIGS. 9–14 (right). *Septobasidium ligustri* (HMAS 240079, holotype). 9. Basidiomata on branch. 10–11. Sections of basidiomata. 12. Hymenium. 13. Basidium (arrow). 14. Haustoria.

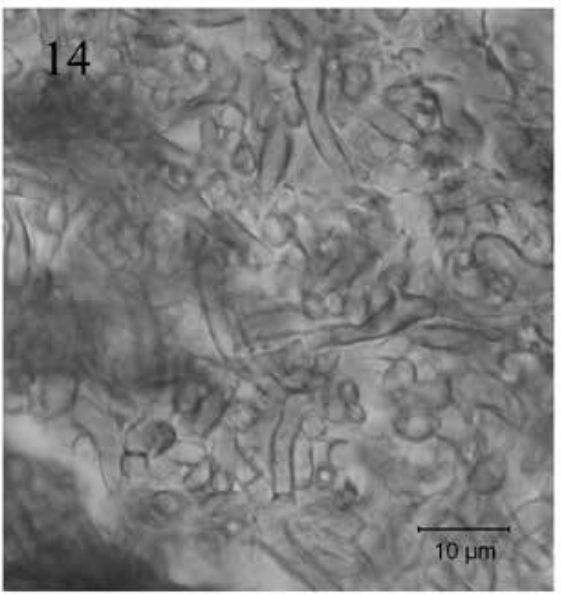

9











TYPE: On *Ligustrum sinense* Lour. (*Oleaceae*): China, Hainan, Wanning, Xinglong Tropical Plant Garden, alt. 38 m, 6.XII.2009, Y.F. Zhu & L. Guo 41, HMAS 240079 (**holotype**), associated with *Lepidosaphes* sp. (*Diaspididae*).

Basidiomata on branches, resupinate, 9–20 cm long, 1–3 cm wide, grey-brown; margin determinate; surface smooth, becoming cracked. In section 480–630 µm thick. Subiculum brown, 20–60 µm thick. Pillars brownish, 210–390 µm high, 30–150 µm wide, branched outwards to form a 100–170 µm high hyphal layer. Hymenium 50–80 µm thick, with irregularly arranged upright branched hyphae. Basidia arising directly from the hyphae, cylindrical, straight or curved, 4-celled, 15–29 × 5–7.5 µm, hyaline, without a probasidial cell. Sterigmata 3–8 µm long. Basidiospore ovoid, 9 × 4 µm, hyaline. Haustoria consisting of irregularly coiled hyphae.

REMARKS: Morphologically, *Septobasidium ligustri* is similar to *S. septobasidioides* (Henn.) Höhn. & Litsch., but differs mainly in having grey-brown basidioma, thinner section (480–630 µm vs about 1 mm) and smaller basidia (15–29 × 5–7.5 µm vs 40–55 × 8.4–10 µm).

To date, 28 species of *Septobasidium* have been reported in China (Sawada 1933, Couch 1938, Teng 1963, Tai 1979, Kirschner & Chen 2007, Lu & Guo 2009a, b, c, 2010a, b, Lu et al. 2010), including the two new species reported in this paper.

Acknowledgements

The authors would like to express their deep thanks to Drs Eric H.C. McKenzie (Auckland, New Zealand) and Shuanghui He (Beijing Forestry University) for serving as pre-submission reviewers, to Dr. Shaun Pennycook (Auckland, New Zealand) for nomenclatural review, to Prof. Jianyun Zhuang (Institute of Microbiology, Chinese Academy of Sciences) for Latin corrections, to Mr Ziyu Cao (Institute of Botany, Chinese Academy of Sciences) for identifying the host plants, to Prof. Sanan Wu (Beijing Forestry University) for identifying the scale insects, and to Mrs Xiangfei Zhu for inking in line drawings. This study was supported by the Ministry of Science and Technology of the People's Republic of China (No. 2006FY110500–5).

Literature cited

Couch JN. 1938. The genus *Septobasidium*. Univ. of North Carolina Press, Chapel Hill. 480 p.

Cui BK, Dai YC, Bao HY. 2009. Wood-inhabiting fungi in southern China 3. A new species of *Phellinus* (*Hymenochaetales*) from tropical China. Mycotaxon, 110: 125–130.

Dai YC, Cui BK. 2006. Two new species of *Wrightoporia* (*Basidiomycota*, *Aphyllophorales*) from southern China. Mycotaxon 96: 199–206.

Dai YC, Cui BK, Yuan HS. 2009. *Trichaptum* (*Basidiomycota*, *Hymenochaetales*) from China with a description of three new species. Mycol. Progr. 8: 281–287. doi:10.1007/s11557-009-0598-0

Dai YC, Li HJ. 2010. Notes on *Hydnochaete* (*Hymenochaetales*) with a seta-less new species discovered in China. Mycotaxon 111: 481–487.

Kirschner R, Chen CJ. 2007. New reports of two hypophyllous *Septobasidium* species from Taiwan. Fung. Sci. 22: 39–46.

Lu CX, Guo L. 2009a. *Septobasidium maesae* sp. nov. (*Septobasidiaceae*) from China. Mycotaxon 109: 103–106.

Lu CX, Guo L. 2009b. Two new species of *Septobasidium* (*Septobasidiaceae*) from China. Mycotaxon 109: 477–482.

Lu CX, Guo L. 2009c. *Septobasidium annulatum* sp. nov. (*Septobasidiaceae*) and *Septobasidium kameii* new to China. Mycotaxon 110: 239–245.

Lu CX, Guo L. 2010a. Three new species of *Septobasidium* (*Septobasidiaceae*) from Gaoligong Mountains in China. Mycotaxon 112: 143–151.

Lu CX, Guo L. 2010b. Two new species of *Septobasidium* (*Septobasidiaceae*) and *S. pallidum* new to China. Mycotaxon 113: 87–93. doi:10.5248/113.87

Lu CX, Guo L, Wei JG, Li JB. 2010. Two new species of *Septobasidium* (*Septobasidiaceae*) from southern China. Mycotaxon 111: 269–274.

Sawada K. 1933. Descriptive catalogue of the Formosan fungi. Part VI. Rep. Dept. Agric. Govt. Res. Inst. Formosa 61: 1–99.

Tai FL. 1979. Sylloge Fungorum Sinicorum. Science Press, Beijing. 1527 p.

Teng SC. 1963. Fungi of China. Science Press, Beijing. 808 p.

Wei YL, Dai YC. 2008. Notes on *Elmerina* and *Protomerulius* (*Basidiomycota*). Mycotaxon 105: 349–354.

Xiong HX, Dai YC. 2008. A new species of *Inonotus* (*Basidiomycota, Hymenochaetaceae*) from China. Crypt. Mycol. 29: 279–283.

Yuan HS, Dai YC. 2008. Two new species of *Junghuhnia* (*Basidiomycota, Polyporales*), and a key to the species of China. Nord. J. Bot. 26: 96–100.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.225

Volume 114, pp. 225–230 October–December 2010

New records of smut fungi. 3

CVETOMIR M. DENCHEV[1*], TEODOR T. DENCHEV[1], BRIAN M. SPOONER[2] & STEPHAN HELFER[3]

cmdenchev@yahoo.co.uk & tdenchev@abv.bg
[1]*Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences 2 Gagarin St., 1113 Sofia, Bulgaria*

b.spooner@kew.org
[2]*Mycology Section, Royal Botanic Gardens, Kew Richmond, Surrey, TW9 3AE, U.K.*

s.helfer@rbge.ac.uk
[3]*Royal Botanic Garden Edinburgh 20A Inverleith Row, Edinburgh, EH3 5LR, U.K.*

Abstract — Three rare species of smut fungi are reported for the first time from the following areas: *Anthracoidea ortegae* from the Falkland Islands, *Entorrhiza casparyana* var. *casparyana* from Egypt, on a new host, *Juncus hybridus*, and *Haradaea moenchiae-manticae* from UK.

Key words — *Anthracoideaceae, Entorrhizaceae, Microbotryaceae,* taxonomy, *Ustilaginomycetes*

Introduction

In this article, records of three rare species of smut fungi, *Anthracoidea ortegae, Entorrhiza casparyana* var. *casparyana,* and *Haradaea moenchiae-manticae,* are reported from new localities. The collections on which these records are based were obtained during visits to the herbaria at the Royal Botanic Garden Edinburgh (E) and the Royal Botanic Gardens, Kew (K, K(M)) in May 2010.

Material and methods

Material from the herbaria of the Royal Botanic Garden Edinburgh (E) and the Royal Botanic Gardens, Kew [K and K(M)] was examined by light microscope (LM) and scanning electron microscope (SEM). For LM observations, the

*Author for correspondence

spores were mounted in lactophenol solution on glass slides, gently heated to boiling point and then cooled. The measurements of spores are given in the form: min–max (mean ± 1 standard deviation). For SEM, the spores were attached to specimen holders by double-sided adhesive tape and sputter coated with gold. The surface structure of spores was observed and photographed at 10 kV using a JEOL SM-6390 scanning electron microscope. The descriptions given below are based entirely on the specimens examined.

New records

Anthracoidea ortegae Kukkonen, in Roivainen, Karstenia 17: 4, 1977. FIGS 1–2

SPECIMENS EXAMINED — On *Carex caduca* var. *ortegae* (Phil.) Kük.: **Falkland Islands,** West Falkland, Channel Hills, 1909–1911, leg. E. Vallentin (K 367 916); East Falkland, Darwin Harbour, 16 February 1908, leg. C. Skottsberg (K 367 906); East Falkland, Eliza Cove, Stanley Common, January 1938, leg. B.F., no. 49 (K(M) sine num.).

SORI in ovaries, scattered in the inflorescence, as broadly ellipsoidal or ovoid, black, hard bodies, 1.5–2 mm long, when young covered by a thin, whitish membrane; later becoming exposed but partly hidden by the glumes; mature sori powdery on the surface. SPORES irregularly polyangular, sometimes with protuberances, in plane view 14–19.5 × 12.5–17.5 (16.9±1.1 × 15.2±1.0) µm (n = 100), in side view 10–12.5 µm thick, reddish brown; wall unevenly thickened, 1–2 (–2.5) µm thick, thickest at the angles, some spores with 1–3 indistinct internal swellings, some spores with light-refractive areas, verruculose.

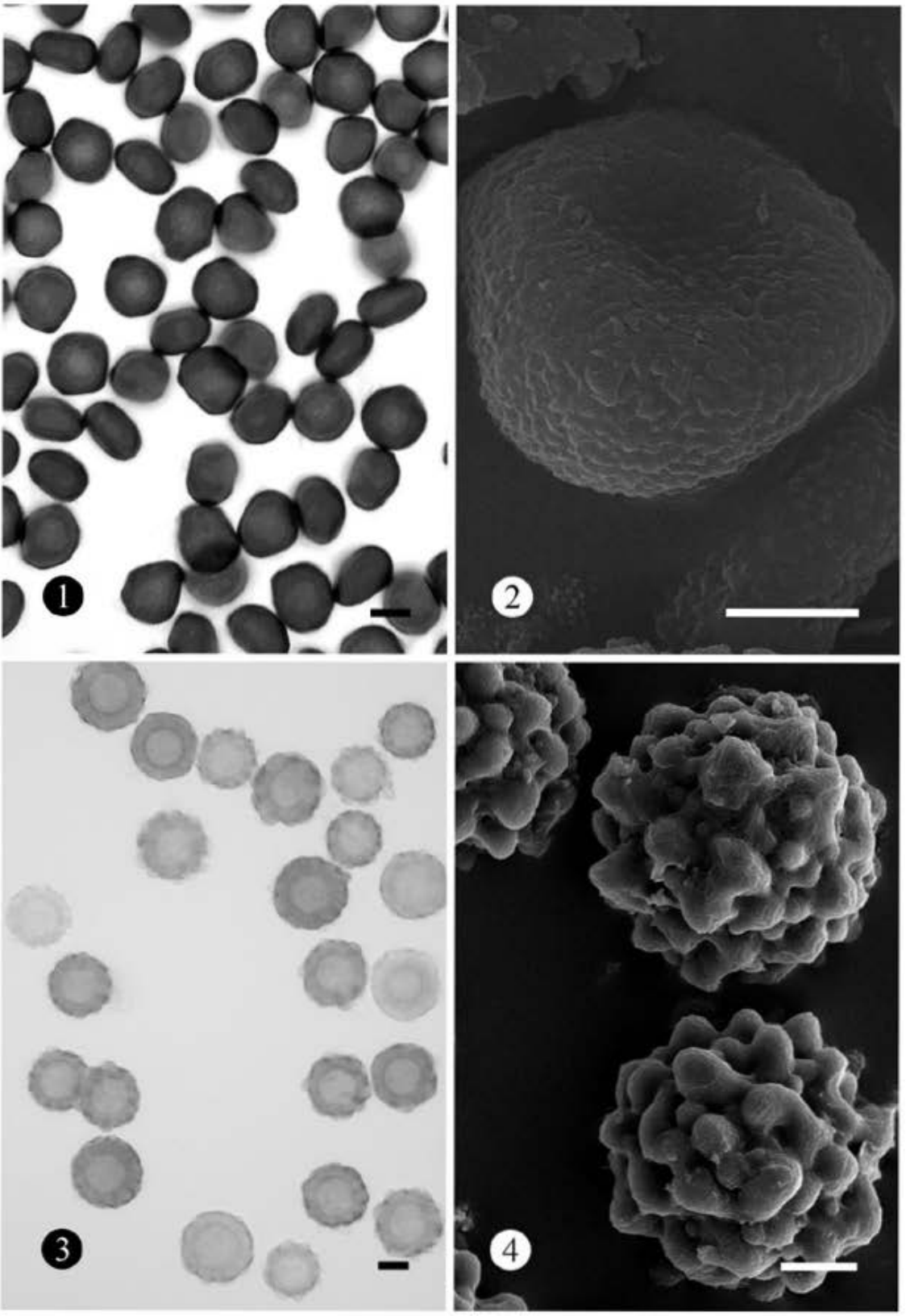
DISTRIBUTION — On *Cyperaceae: Carex* (subgen. *Primocarex*, sect. *Unciniiformes*), South America (Argentina), South Atlantic Islands (Falkland Islands).

COMMENT — *Anthracoidea ortegae* was previously known only from the type locality: Argentina, Tierra del Fuego, Baliza, Ushuaia, 54°48' S, 68°12' W, on the same host plant (Roivainen 1977).

Entorrhiza casparyana (Magnus) Lagerh. var. ***casparyana***, Hedwigia 27(9–10): 262, 1888. FIGS 3–4

SPECIMEN EXAMINED — On *Juncus hybridus* Brot. (det. G. Snogerup): **Egypt,** "prope Nafeh in Arabia", 16 May 1835, leg. W. Schimper (as *Juncus foliosus* Desf.), Unio itiner. 1835, no. 113 (E 352 462).

SORI on the roots forming elongated galls, filled with intracellularly developing spores. GALLS 4–6 mm long, brown. SPORE MASS granular. SPORES usually solitary, sometimes in pairs, globose or subglobose, 16.5–28 × 15–26 (21.9±2.0 × 20.6±1.9) µm (including ornamentation) (n = 100), occasionally some spores reach up to 32 µm in length, subhyaline, light yellow or yellowish brown; in LM, wall two-layered, the inner layer 0.5–1.5 µm thick, the outer layer variable in thickness (0.5–8 µm, including ornamentation); variable in ornamentation, tuberculate or verrucose.



Figs 1–2. Spores of *Anthracoidea ortegae* on *Carex caduca* var. *ortegae* in LM and SEM. Figs 3–4. Spores of *Entorrhiza casparyana* var. *casparyana* on *Juncus hybridus* in LM and SEM. Scale bars: 1, 3 = 10 µm, 2, 4 = 5 µm.

DISTRIBUTION (of var. *casparyana*) — On *Juncaceae: Juncus alpino-articulatus* Chaix, *J. alpinus* Vill., *J. arcticus* Willd., *J. articulatus* L. (*J. lampocarpus* Ehrh. ex Hoffm.), *J. bufonius* L., *J. bulbosus* L., *J. caespiticius* E. Mey., *J. compressus* Jacq., ? *J. conglomeratus* L., *J. effusus* L., *J. geniculatus* Schrank, *J. gregiflorus* L.A.S. Johnson, *J. hybridus*, *J. inflexus* L., *J. planifolius* R. Br., *J. tenageia* Ehrh. ex L. f., *J. thomasii* Ten., Africa (Egypt, South Africa), Australasia (Australia, New Zealand), Europe (Bulgaria, Czech Republic, Denmark, including Faeroe Islands, Finland, France, Germany, Italy including Sardinia, Norway, Poland, Romania, Russia, Sweden, Switzerland, UK), North America (Canada) (Fineran 1978, Vánky 1994, Denchev & Minter 2008, Vánky & Shivas 2008). Records on four other hosts (*Eriophorum vaginatum* L. (*Cyperaceae*), *Juncus atricapillus* Drejer, *J. filiformis* L., and *J. squarrosus* L.) were treated by Fineran (1978) as doubtful or as later misinterpretations.

COMMENTS — In Africa, *Entorrhiza casparyana* has been previously known only from South Africa. Explanations about the possible situation of the locality 'Nafeh', where this plant specimen (Unio itiner. 1835, no. 113) was collected, can be found in Kirschner et al. (2004: 374): "The locality 'Nafeh' was not safely identified. W. Schimper, from late March, 1835, collected plants in the region around the monastery of St. Catharina at the foot of Mt Sinai [Dayr al Qiddisah Katrina]. ... Nafeh is therefore expected to be in that region, too."

Entorrhiza casparyana var. *tenuis* Denchev & H.D. Shin differs from typical *E. casparyana* in the following two respects: shorter spores (11.5–20 (–21.5) µm long) and shorter sori (1.2–3 mm long while the typical variety possesses sori up to 15 mm long) (Denchev et al. 2007). It is distributed on *Juncus tenuis* Willd. and currently known from Korea, Austria, Romania, and Costa Rica. Four species of *Entorrhiza* are known on *Juncus*: *E. aschersoniana* (Magnus) Lagerh. (Europe, Central America, and New Zealand), *E. caricicola* Ferd. & Winge (Europe and New Zealand), *E. casparyana*, and *E. casparyanella* Vánky (New Zealand). A key to known *Entorrhiza* taxa on *Juncus* is given in Denchev & Minter (2008).

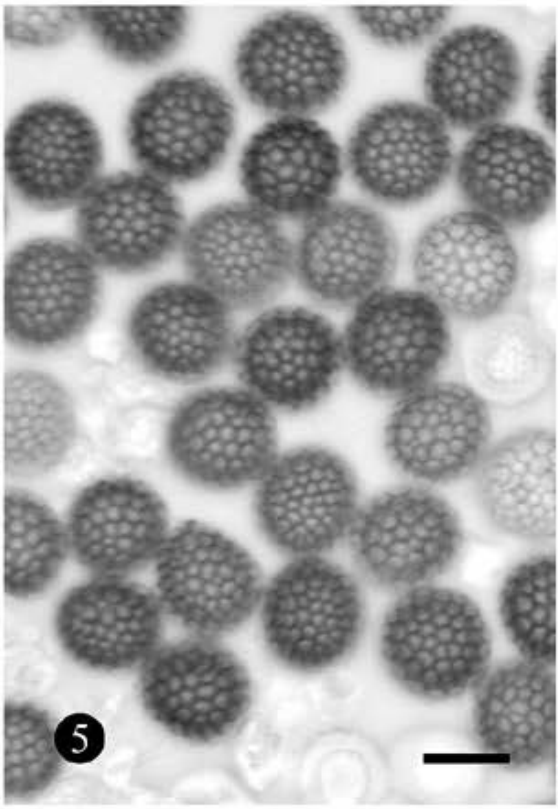
Haradaea moenchiae-manticae (Lindtner) Denchev & H.D. Shin, in Denchev et al., Mycologia Balcanica 3: 72, 2006. FIGS 5–6

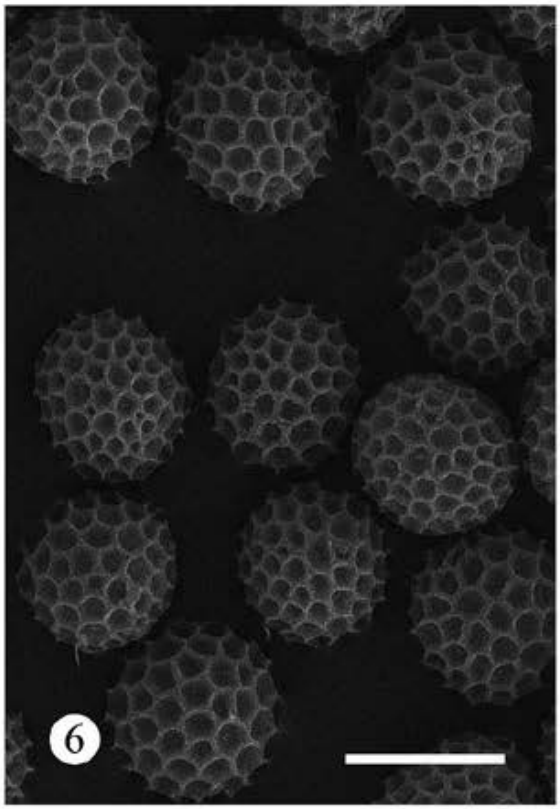
≡ *Ustilago moenchiae-manticae* Lindtner, Bulletin du Muséum d'Histoire Naturelle du Pays Serbe, Série B 3–4: 32, 1950.

≡ *Microbotryum moenchiae-manticae* (Lindtner) Vánky, Mycotaxon 67: 46, 1998.

SPECIMEN EXAMINED — On *Moenchia erecta* (L.) P. Gaertn. et al.: **UK,** Wales, Montgomeryshire, Ffridd Faldwyn, 15 May 1998, leg. A. Jones (as *Ustilago ? duriaeana*) (K(M) 106 303).

SORI destroying the ovules and filling the capsules with powdery, purplish chestnut spore mass. SPORES globose or subglobose, rarely broadly ellipsoidal, 11–15.5 × 10–13.5 (13.0±0.8 × 12.1±0.7) µm (n = 50), purplish brown; reticulate, 6–7 meshes per spore diameter, meshes irregularly polyangular (pentagonal or hexagonal), 1.2–2.7 µm long, muri (0.7–) 1.0–1.4 µm high; in SEM the meshes often with a hemispherical protuberance on the bottom.





FIGS 5–6. Spores of *Haradaea moenchiae-manticae* on *Moenchia erecta* in LM and SEM. Scale bars = 10 µm.

DISTRIBUTION — On *Caryophyllaceae*: *Moenchia erecta* (Bulgaria and UK), *M. mantica* (L.) Bartl. subsp. *mantica* (Romania and Serbia), Europe (Lindtner 1950, Vánky 1985, Denchev 1997).

COMMENT — *Haradaea moenchiae-manticae* is a new species for UK, as yet known only from a single locality in Wales. Though typically on *M. mantica*, the occurrence of this species on *M. erecta* has been previously reported from Bulgaria (Denchev 1997, as *Bauhinus jehudanus*).

Acknowledgements

This research received support from the SYNTHESYS Project (http://www.synthesys.info/), which is financed by European Community Research Infrastructure Action under the FP7 Integrating Activities Programme. The authors also gratefully acknowledge Dr Kálmán Vánky (Herbarium *Ustilaginales* Vánky, Tübingen, Germany) and Dr Roger G. Shivas (Queensland Primary Industries and Fisheries, Australia) for critically reading the manuscript and serving as pre-submission reviewers.

Literature cited

Denchev CM. 1997. Taxonomical studies on ovariicolous ustomycetes on *Caryophyllaceae*. I. *Ustilago jehudana* and *U. moenchiae-manticae*. Mycoscience 38: 323–328. doi:10.1007/BF02464090

Denchev CM, Minter DW. 2008. *Entorrhiza casparyana*. IMI Descriptions of Fungi and Bacteria. No. 1761. CAB International, Egham. 5 pp.

Denchev CM, Shin HD, Kim SM. 2007. New records of smut fungi from Korea. 2. Mycotaxon 100: 73–78.

Fineran JM. 1978. A taxonomic revision of the genus *Entorrhiza* C. Weber (*Ustilaginales*). Nova Hedwigia 30: 1–68.

Kirschner J, Rejdali M, Drábková L. 2004. A new *Juncus* of the section *Tenageia* from Morocco and Egypt. Preslia 76: 371–376.

Lindtner V. 1950. *Ustilaginales* Jugoslaviae. Bulletin du Muséum d'Histoire Naturelle du Pays Serbe, Série B 3–4: 1–110. (In Serbian)

Roivainen H. 1977. Resultados micologicos de la expedición a Argentina y Chile en 1969–1970. Karstenia 17: 1–18.

Vánky K. 1985. Carpathian *Ustilaginales*. Symbolae Botanicae Upsalienses 24(2): 1–309.

Vánky K. 1994. European Smut Fungi. Gustav Fischer Verlag, Stuttgart, Jena, New York. 570 pp.

Vánky K, Shivas RG. 2008. Fungi of Australia: The smut fungi, in *Fungi* of Australia Series. Australian Biological Resources Study (ABRS), Canberra & CSIRO Publishing, Melbourne. I–VIII + 1–267.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.231

Volume 114, pp. 231–246 *October–December 2010*

South Florida microfungi: *Kalamarospora multiflagellata* gen. et sp. nov. (hyphomycetes), with additional new records from USA

GREGORIO DELGADO

gdelgado@emlabpk.com
EMLab P&K, Southeastern Regional Laboratory
6301 NW 5th Way Suite 2850, Fort Lauderdale, FL 33309, USA

Abstract—*Kalamarospora multiflagellata* anam. gen. et sp. nov. is described and illustrated from rachides of dead leaves of *Sabal palmetto* collected in southwestern Florida, USA. The genus is characterized by having obclavate to ellipsoidal conidia internally filled with a mass of subhyaline, septate, 2–3 µm wide filaments growing upward from suprabasal cells at the bottom of the conidia and protruding apically or subapically as long, filiform, subhyaline or hyaline, sometimes 1–2 times dichotomously branched appendages. Conidia are borne on monoblastic, transversely striate, percurrently proliferating conidiogenous cells disposed on macronematous, cylindrical, solitary, unbranched, dark brown to blackish brown conidiophores. The conidial secession is rhexolytic, leaving a distinct, usually truncate frill up to 7 µm long, which remains attached to the basal cell of the conidia. *Kalamarospora* is compared with anamorphic genera and species having a similar internal conidial organization or morphologically close taxa with appendiculate conidia. *Ellisembia britannica*, *Polytretophora calcarata*, *Pseudoacrodictys corniculata*, *Sporidesmiella sinensis*, and *Triposporium verruculosum* are newly recorded from USA.

Key words—*Ceratosporella*, *Megacapitula*, palm fungi, *Piricaudilium*

Introduction

During a short visit to southwestern Florida, specifically the city of Naples and surrounding areas, some plant debris was collected in order to study the associated saprobic hyphomycetes (anamorphic fungi). A conspicuous and apparently undescribed anamorph was found growing on rachides of dead leaves of *Sabal palmetto*. The fungus shows close similarities to the monotypic genus *Megacapitula* J.L. Chen & Tzean (Chen & Tzean 1993) in conidial morphology and the presence of multiple apical, filiform appendages. Upon closer examination, however, the conidia revealed a peculiar internal

structure originating the appendages in combination with other features such as macronematous conidiophores, percurrent proliferating conidiogenous cells and a rhexolytic conidial secession. These features are significantly different from *Megacapitula* as presently conceived, and to my knowledge the combination of characters exhibited by the present fungus is distinct enough from all other previously known anamorphic genera to warrant the proposal of a new genus to accommodate it. *Kalamarospora* is therefore introduced, and a new species *K. multiflagellata* is described and illustrated herein. The type specimen and semi-permanent slides are deposited in the Herbarium of the U.S. National Fungus Collections (BPI). Five other hyphomycete species are recorded for the first time from USA, including comments on their taxonomy, morphology, and geographical distribution.

Taxonomy

Kalamarospora G. Delgado, **anam. gen. nov.**

MycoBank MB518541

Ad fungus anamorphicos, hyphomycetes, pertinens. Coloniae *in substrato naturali effusae, pilosae.* Mycelium *plerumque in substrato immersum, ex hyphis ramosis, septatis, laevibus, pallide brunneis vel brunneis compositum.* Stromata *absentia.* Conidiophora *macronematosa, mononematosa, singula vel aggregata, simplicia, erecta, recta vel leviter flexuosa, plerumque transversaliter striata, cylindrica, septata, atrobrunnea vel nigro-brunnea, percurrenter proliferentia.* Cellulae conidiogenae *monoblasticae, in conidiophoris incorporatae, terminales, cylindricae, pallide brunneae vel brunneae, transversaliter striatae, percurrentes.* Conidiorum secessio *rhexolytica.* Conidia *acrogena, solitaria, obclavata vel ellipsoidea, pallide brunnea vel brunnea, laevia, massa interna hypharum subhyalinarum, septatarum impleta, hyphis compluribus sursum protrudentibus velut appendicibus filiformibus, subhyalinis vel hyalinis, nonnumquam dichotomis.* Teleomorphosis *ignota.*

Species typica—*Kalamarospora multiflagellata* G. Delgado

Etymology—Greek, καλαμάρι, squid and σπόρος, seed, in reference to the squid-like shape of the conidia.

Anamorphic fungi, hyphomycetes. Colonies on natural substratum effuse, hairy. Mycelium predominantly immersed in the substrate, composed of branched, septate, smooth, pale brown to brown hyphae. Stromata none. Conidiophores macronematous, mononematous, single or in groups, simple, erect, straight or slightly flexuous, mostly transversally striate, cylindrical, septate, dark brown or blackish brown, regenerating percurrently. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, light brown to brown, transversely striate, percurrent. Conidial secession rhexolytic. Conidia acrogenous, solitary, obclavate or ellipsoidal, light brown to brown, smooth, internally filled with a visible mass of subhyaline, septate filaments protruding apically or subapically as multiple long, filiform, subhyaline or hyaline, dichotomously branched appendages. Teleomorph unknown.

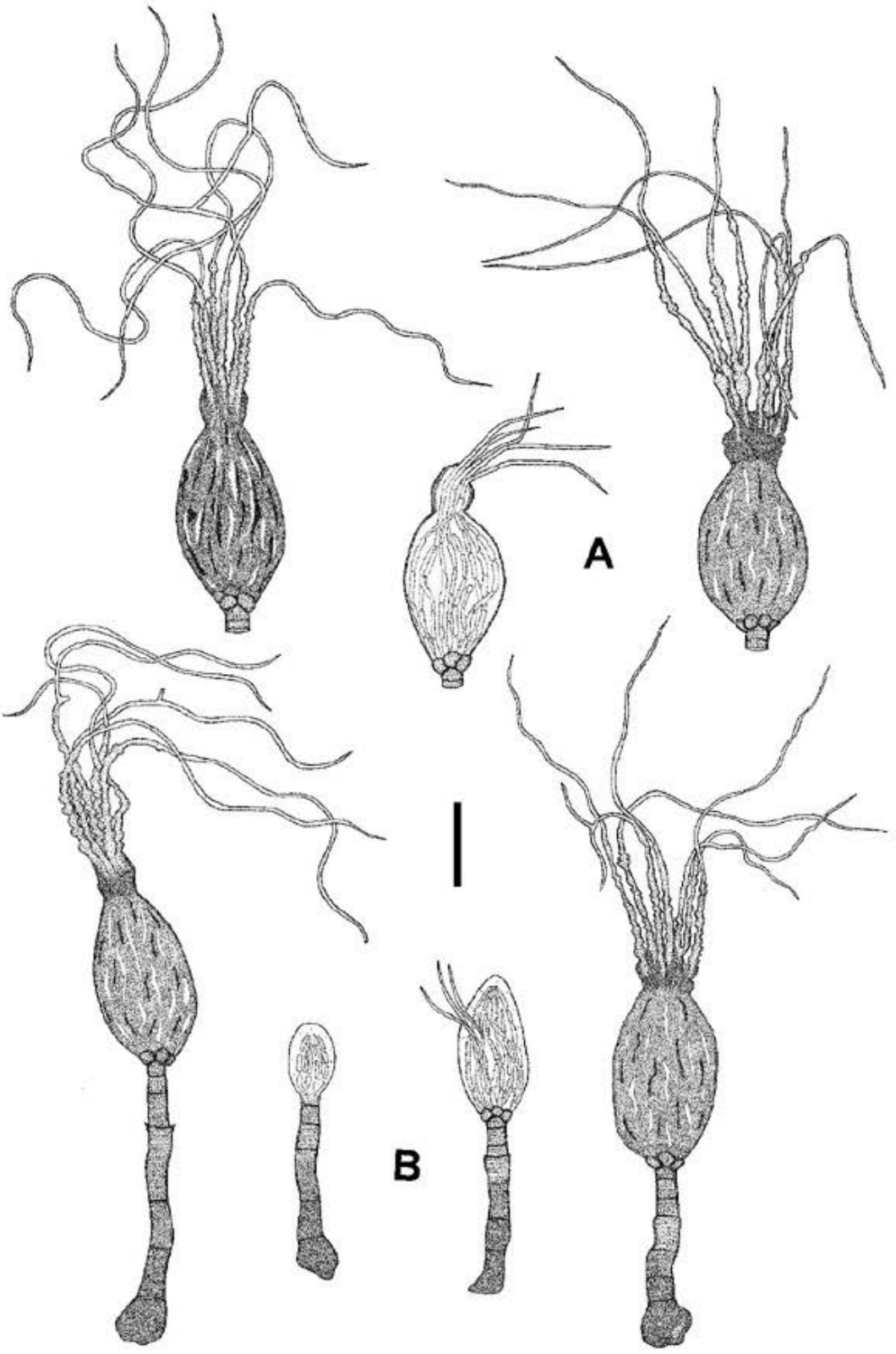


FIG. 1. *Kalamarospora multiflagellata*, from holotype (BPI 879811A). A. Conidia. B. Conidiophores, conidiogenous cells and conidia. The younger conidia show internal structure. Scale bar: 30 µm.

Kalamarospora multiflagellata G. Delgado, **anam. sp. nov.** FIGS. 1–13

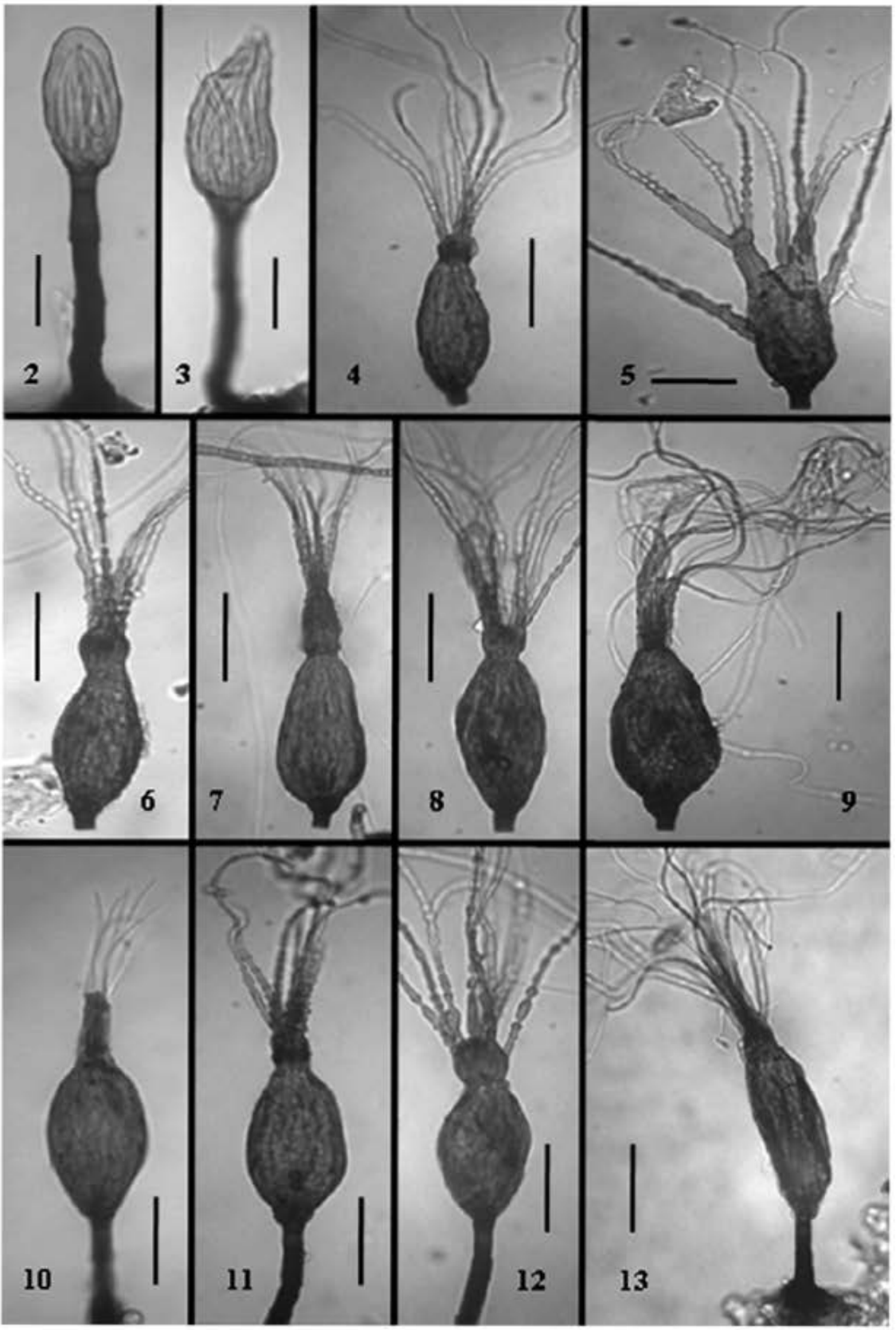
MycoBank MB518542

Coloniae in substrato naturali effusae, brunneae, pilosae. Mycelium plerumque in substrato immersum, ex hyphis ramosis, septatis, laevibus, pallide brunneis vel brunneis, 1–2.5 µm diam. compositum. Stromata absentia. Conidiophora macronemata, mononemata, singula vel 2–4 aggregata, simplicia, erecta, recta vel leviter flexuosa, transversaliter striata, irregulariter verruculosa vel laevia ad basim, crassitunicata, cylindrica, septata, atrobrunnea vel nigro-brunnea, usque ad 115 µm longa, 6–8 µm crassa, ad basim inflata, 7–15 µm crassa, semel ad quarter percurrenter proliferentia. Cellulae conidiogenae monoblasticae, in conidiophoris incorporatae, terminales, cylindricae, pallide brunneae vel brunneae, transversaliter striatae, percurrentes, ad apicem truncatae. Conidiorum secessio rhexolytica. Conidia acrogena, solitaria, obclavata vel ellipsoidea, pallide brunnea vel brunnea, tenuitunicata, laevia, 56–90 × 25–45 µm (appendice exclusa), e cellula basali, 4–6 cellulis suprabasalibus, coprore compacto fusiformi et usque ad 12 appendicibus apicalibus filiformibus composita; cellula basalis cylindrica, truncata, pallide brunnea vel brunnea, transversaliter striata, 5–8 × 5–7 µm, ad basim residuum conspicum praebens, usque 7 µm longa; cellulae suprabasales verticillatae, brunneae, laeves, 5–9 × 4–6 µm; corpus conidiale massa interna filamentorum subhyalinorum, septatorum, 2–3 µm latorum impleta, hyphis ascendentibus in summon conidio velut appendices filiformes, longae, septatae, subhyalinae vel hyalinae exeuntes, nonnumquam semel vel bis dichotomae; conidia usque ad 525 µm longa, corpus sursum attenuatum; in parte apicali saepe inflatum, atrum, tunica mucosa conspicua, pallide brunnea vel brunnea circumdatum. Teleomorphosis ignota.

Holotype—UNITED STATES. Florida: Collier Co., Naples, on rachides of dead leaves of *Sabal palmetto* (Walter) Lodd. ex Schult., (*Arecaceae*), XI.23.2007, coll. G. Delgado (BPI 879811A).

Etymology—Latin, *multiflagellata*, referring to the multiple filiform appendages of the conidia.

Anamorphic fungi, hyphomycetes. Colonies on natural substratum effuse, brown, hairy. Mycelium predominantly immersed in the substrate, composed of branched, septate, smooth-walled, pale brown to brown hyphae, 1–2.5 µm wide. Stromata none. Conidiophores macronematous, mononematous, single or sometimes aggregated in groups of 2–4, simple, erect, straight or slightly flexuous, transversely striate, irregularly verruculose or smooth toward the base, thick-walled, cylindrical, septate, dark brown or blackish brown, up to 115 µm long, 6–8 µm wide, 7–15 µm wide at the swollen base, with up to four successive, regenerative percurrent proliferations. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, light brown to brown, transversely striate, percurrent, truncate at the apex. Conidial secession rhexolytic. Conidia acrogenous, solitary, obclavate or ellipsoidal, light brown to brown, thin-walled, smooth, often with wrinkled walls, 56–90 x 25–45 µm (excluding filaments), composed of a basal cell, 4–6 suprabasal cells, an ellipsoidal or obclavate main body, and up to 12 apical filiform appendages; basal cell cylindrical, truncate, light brown to brown, transversely striate, 5–8 x 5–7 µm, with a distinct, usually truncate, rarely irregular basal frill, up to 7 µm



FIGS. 2–13. *Kalamarospora multiflagellata*, from holotype (BPI 879811A). 2–3. Young conidia showing incipient filaments. 4–9. Conidia. 10–13. Conidiophores, conidiogenous cells and conidia. Scale bars: 2–3 = 15 µm; 4–13 = 30 µm.

long; suprabasal cells disposed side by side around the upper part of the basal cell, brown, smooth, 5–9 x 4–6 µm; conidial body internally filled with a visible mass of subhyaline, septate, 2–3 µm wide filaments, growing upward from the inner portions of the suprabasal cells at the bottom of the conidia, elongating and protruding apically or subapically as divergent filiform, septate, subhyaline or hyaline, sometimes 1–2 times dichotomously branched appendages, up to 525 µm long, tapering to 1 µm at the apex; apical, protrusion region usually swollen, darker and surrounded by a light brown to brown, mucilaginous sheath extending to the proximal parts of the appendages. TELEOMORPH unknown.

Discussion

Kalamarospora is a genus of anamorphic, dematiaceous hyphomycetes with a unique combination of conidiogenesis, internal conidial organization and morphological features. The conidia are obclavate or ellipsoidal in shape, with thin, smooth, light brown to brown, often wrinkled walls, especially in well developed, older conidia, probably as a consequence of desiccation. They are internally filled with a visible mass of subhyaline, septate, 2–3 µm wide filaments, which arise from the inner parts of 4 to 6 brown suprabasal cells disposed side by side around the upper portion of a cylindrical, transversely striate, light brown to brown, truncate basal cell. The inner filaments grow upward, elongating and filling the inner space of the conidium, often with terminal cells slightly swollen and rounded. They protrude more or less synchronously through the conidial apex as a bundle of long, filiform, septate, subhyaline or hyaline, divergent, 1–2 times dichotomously branched appendages. The apical area around the protrusion is usually darker and surrounded by a light brown to brown, mucilaginous sheath, often giving a swollen appearance to the apex. Occasionally, the filaments also protrude subapically, not as a bundle but individually or in groups of 2–3 filaments. Once the filaments elongate outside the conidial wall, the mucilage extends and remains surrounding the proximal parts of the appendages, showing several discontinuities, gaps or bubbles once dry. The overall conidial morphology recalls the aspect of a minute squid, hence the name of the fungus *Kalamarospora*.

The conidia are born monoblastically on cylindrical, percurrent and transversely striate conidiogenous cells. This peculiar wall ornamentation is present also in the conidial basal cells and the upper conidiophore cells, and is apparently related with the rhexolytic break of the wall of the subtending cell of the conidium. A less pigmented, annular dehiscence zone is discernible below the basal cell delimiting septum. The transverse striations may serve as dehiscence lines where the circumscissile fracture of the lateral walls is more likely to evenly occur, usually a short distance below the basal cell delimiting septum and within the dehiscence zone. As a result, the conidiogenous cell

becomes empty and open-ended, and the detached conidium bears a cylindrical, truncate, and striate frill up to 7 µm long, which remains attached to the basal cell of the conidia. Conidiophore proliferation and subsequent conidiogenous cell delimitation occur then similarly as described for *Endophragmiella* B. Sutton (Holubová-Jechová 1986, Hughes 1979) and *Rhexoacrodictys* W.A. Baker & Morgan-Jones (Baker et al. 2002). Up to four successive, percurrent, and striate in appearance proliferations were seen in a single conidiophore, sometimes with a dark remnant of wall at the apex. However, after a percurrent proliferation emerges through the empty, non viable conidiogenous cell, two secondary septa are apparently laid down on the new proliferation, one delimiting the new conidiogenous cell and the other delimiting the basal cell of the next detached conidium. Baker et al. (2002) noticed a similar septation pattern following regenerative growth in *R. erecta*. Consequently, the conidium basal cell is more or less already established at the early stages of conidium development, showing already transversely striations. Two or three short, incipient filaments are recognizable within the conidium initial, sometimes with a very thin septum in one of them. Suprabasal cells likely originate from the lower cell of each of these incipient filaments.

Among the genera of anamorphic fungi hitherto known, the monotypic genus *Megacapitula* (Chen & Tzean 1993) closely resembles *Kalamarospora* in conidial morphology. *Megacapitula villosa* also possesses obclavate or ellipsoidal, pigmented conidia crowned with several densely packed, hairy, branched or unbranched, septate, apical appendages up to 556 µm long. The original description did not mention an existing internal structure originating the appendages, not even in early stages of conidial ontogeny, but the apical outer wall cracks open at a certain point of conidial development, apparently peeling-off easily, and the filiform appendages emerge from the conidial apex (Chen & Tzean 1993). Unfortunately, I was unable to examine the type material to confirm the presence of such an internal structure, probably present and overlooked as a result of the opaque, dark brown or black outer conidial wall. However, *Megacapitula* and *Kalamarospora* are not considered congeneric here because they differ in certain essential features. *Megacapitula* has micronematous or semi-macronematous, simple or branched, smooth, roughened, or verrucose conidiophores, with determinate, not percurrent, terminal but also lateral or occasionally intercalary conidiogenous cells. Conidia are muriform when mature, often with a reticulate wall when young, and secede schizolytically. The apical, long, filiform appendages present in both fungi, in addition to the mucilaginous sheath surrounding the conidial apex in *Kalamarospora*, are a rare combination of features among hyphomycetes. They are probably involved in the secure attachment of the conidia to the substrate after release and dispersal (Jones 2006).

The genus *Piricaudilium* Hol.-Jech. (Holubová-Jechová 1988) possesses an internal conidial organization more or less similar to *Kalamarospora*. They both share in common the presence of conidia with an internal mass of hyaline and septate filaments arising from the inner surface of the basal part of the conidia and filling their internal space once enlarging. The two genera, however, considerably differ in conidiophore, conidial morphology, and conidiogenesis. Conidiophores in *Piricaudilium* are micronematous or semi-macronematous, sometimes consisting only of monotretic, spherical or subspherical, terminal or intercalary conidiogenous cells, with an apical pore surrounded by a distinct dark scar. The conidia are turbinate or irregular in shape, ranging from obconical, spherical or subspherical to ovoid, finely rough, verrucose to spinulose around the base, with up to 10 pale brown, thick-walled, slightly flexuous or curved setiform appendages arising from distinct lobes and up to 120 µm long. The internal filaments are branched, apparently forming a network, and do not protrude outwards the conidial wall as in *Kalamarospora*, but instead end in short superficial appendages or fill the inner space of the longer setiform appendages. Holubová-Jechová (1988) noted that filaments in *Piricaudilium* were visible after long-term exposure to lactophenol cotton blue stain but were not colored in cotton blue. In *Kalamarospora*, however, filaments were mostly visible in younger, thinner-walled, developing conidia but also in older, even moderately wrinkled spores, which had been exposed to stain. Holubová-Jechová also considered these inner filaments were involved in the stabilization of the conidial morphology, which apparently occurs also in *Kalamarospora*, but stated that the filaments cells probably had a reproductive character as microconidia or were part of a synanamorph, which I was unable to verify in *Kalamarospora*. Future ultrastructural studies may be necessary to clarify the origin and role of these inner filaments in both fungi.

The propagules or sclerotia of the basidiomycetous anamorph *Akenomyces* G. Arnaud ex D. Hornby (Hornby 1984, Voglmayr & Krisai-Greilhuber 1997), with a complex internal and external structure, are also superficially comparable to *Kalamarospora*. They are dark brown, ellipsoidal-lenticular or obclavate among other shapes, with a tightly interwoven mass of internal, hyaline, thin-walled, much branched hyphae, 1.8–3.7 µm wide. The presence of hyphae bearing clamp-connections at the septa and its position within the *Basidiomycota*, however, clearly separates *Akenomyces* from *Kalamarospora*. Moreover, the sclerotia originate from sclerotial initials made up of tightly interwoven hyphae, and the walls are formed by a one-celled layer of dark, thick-walled, parallel hyphae interrupted by tubercles. They are loosely and externally enclosed by upwardly growing, curved or sinuate, hyaline hyphae densely incrusted with needle-shaped crystals. Although originally collected in a terrestrial environment, the complex sclerotial structure suggests an

adaptation of *Akenomyces* to the aero-aquatic niche (Voglmayr & Krisai-Greilhuber 1997).

Some species of *Ceratosporella* Höhn. with cheiroid conidia superficially resemble *Kalamarospora* in conidial morphology and conidiogenesis. This is one of the three types of conidial morphology currently recognized within the genus. The presence of two to sixteen branches or arms arising from a basal cell and more or less closely packed in a hand-shaped appearance characterized this group of species (Castañeda 1985, Castañeda et al. 1996b, Hughes 1952, 1971, Kuthubutheen & Nawawi 1991a, Lustrati 1980, Matsushima 1981, 1993, Sinclair et al. 1987, Wu & Zhuang, 2005, Zhang et al. 2009). *Ceratosporella disticha* Kuthub. & Nawawi, *C. compacta* R.F. Castañeda et al. and *C. flagellifera* Matsush. bear the most similarity to *K. multiflagellata*, particularly in having monoblastic, percurrent conidiogenesis and compact conidia with the apical cell of each arm forming a septate, slender appendage, surrounded by a mucilaginous sheath as in the case of *C. compacta*. They differ from *Kalamarospora*, however, in having branched conidia which schizolytically secede from the conidiogenous cells and lack an internal conidial structure.

Another group of species within the genus *Pseudoacrodictys* W.A. Baker & Morgan-Jones with appendiculate conidia (Baker & Morgan-Jones 2003, Somrithipol & Jones 2003) show also a slight resemblance with *Kalamarospora*. *Pseudoacrodictys appendiculata* (M.B. Ellis) W.A. Baker & Morgan-Jones, *P. corniculata*, *P. eickeri* (Morgan-Jones) W.A. Baker & Morgan-Jones, and *P. viridescens* (B. Sutton & Alcorn) W.A. Baker & Morgan-Jones possess conidia with a distinctly protuberant basal cell delimited by a transverse septum and somewhat hyphae-like, clustered or not, septate appendages. These appendages, however, are fewer in number and shorter in length compared with those in *Kalamarospora*, the longest reaching up to 56 µm long in *P. appendiculata*. They are not originated as a result of an internal conidial structure, and occasionally break or collapse at the thin-walled tip giving a truncate aspect. The conidia also differ in shape, ranging from subglobose to broadly pyriform, turbinate or somewhat irregularly shaped, secede schizolytically and bear numerous septa arranged in an oblique fashion. The cheiroid, ellipsoidal conidia of *P. dimorphospora* Somrith. & E.B.G. Jones (Somrithipol & Jones 2003) are reminiscent of those of *C. compacta* discussed above, and a reexamination of the type specimen might be necessary to confirm if they are conspecific.

The monotypic genus *Veracruzomyces* Mercado et al. (Mercado et al. 2002) also resembles *Kalamarospora* in having monoblastic, integrated, terminal, cylindrical, percurrent proliferating conidiogenous cells and obclavate, brown conidia similar in length, with a dark brown to black, cylindrical basal cell and a mucilaginous sheath at the apex. However, the conidia in *Veracruzomyces* are muriform, rostrate, with a paler, 1–4-septate beak, seceding schizolytically

with difficult, without apical filiform appendages or internal organization, and conidiophores often bear a lateral, pale brown, lageniform and septate protuberance which bend downwards.

Additional new records from USA

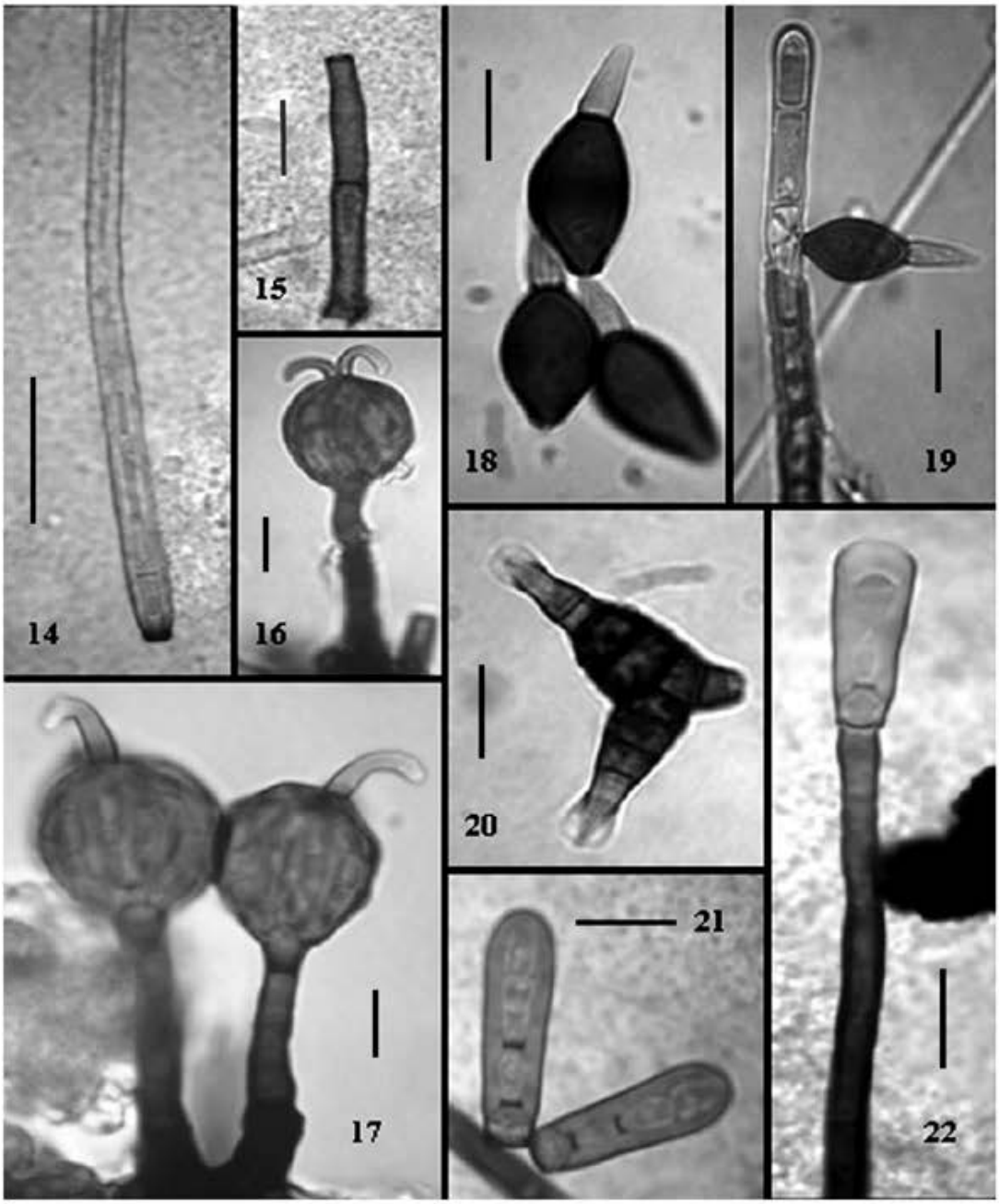
Ellisembia britannica (B. Sutton) W.P. Wu, in Wu & Zhuang, Fungal Diversity Research Series 15: 116, 2005. FIGS. 14–15

≡ *Sporidesmium britannicum* B. Sutton, in Minter, Bull. Br. mycol. Soc. 20: 87, 1986.

Colonies effuse, hairy. Conidiophores cylindrical or subcylindrical, straight or slightly flexuous, smooth, 1–3 septa, brown, 22–47 × 3–5 µm; base usually bulbous, 5–6 µm wide. Conidiogenous cells integrated, terminal, brown, apex occasionally darkened, 2–4 µm wide. Conidia narrowly obclavate, straight to curved, 5–18-distoseptate, subhyaline to pale brown, smooth, up to 350 µm long, 4.5–6 µm wide; basal cell conico-truncate, darkly pigmented, 2–2.5 µm wide at the base.

SPECIMEN EXAMINED: Florida, Collier Co., Naples, on rachides of dead leaves of *Sabal palmetto*, XI.23.2007, coll. G. Delgado (BPI 879811K).

This fungus was first described as *Sporidesmium britannicum* on a dead cupule of *Fagus sylvatica* L. from the United Kingdom (Minter 1986). Later, Wu & Zhuang (2005) collected four specimens on rotten wood and dead branches of woody plants in China, and transferred it to *Ellisembia* Subram. on the basis of its distoseptate conidia and conidiophores with irregular or without percurrent proliferations. According to the original description, conidiophores are 10–25 µm long, often proliferate percurrently, and no mention was made of dark pigmentation in the conidial basal cells. The Florida collection is closer to the Chinese specimens in conidial features and the presence of non-proliferating conidiophores. The conidia, however, are considerably longer compared to both the holotype (up to 57.5 µm long) and the Chinese specimens (up to 130 µm long). Ma et al. (2008) recently described two *Ellisembia* species from China that are morphologically similar to the present specimen of *E. britannica*. *E. artocarpi* Jian Ma & X.G. Zhang and *E. sapii* Jian Ma & X.G. Zhang are characterized by very long, obclavate to long rostrate, pale brown conidia, up to 220 µm and 240 µm long respectively. They both differ, however, in having wider conidia without a darkened basal cell, the latter with up to 23 distosepta. Another fungus, *Sporidesmajora pennsylvaniensis* Batzer & Crous collected on fruit surface of apple in USA (Yang et al. 2010), is also comparable with the Florida specimen in having very long, narrowly obclavate to long obclavate conidia up to 350 µm long, with darkly pigmented, obconical basal cells, but differs in its smooth to finely verruculose, guttulate and euseptate rather than distoseptate conidia.



FIGS. 14–15. *Ellisembia britannica* (BPI 879811A). 14. Conidium. 15. Conidiophore. 16–17. *Pseudoacrodictys corniculata* (BPI 880521A). Conidiophores and conidia. 18–19. *Polytretophora calcarata* (BPI 880519A). 18. Conidia. 19. Conidiophore with attached conidium. 20. *Triposporium verruculosum* (BPI 880518B). Conidium. 21–22. *Sporidesmiella sinensis* (BPI 880520A). 21. Conidia. 22. Conidiophore with attached young conidium. Scale bars: 14 = 20 µm; 15–22 = 10 µm.

Polytretophora calcarata Mercado, Acta Bot. Cubana 16: 3, 1983. FIGS. 18–19

■ *Spadicoides calcarata* (Mercado) Melnik, Nov. sist. Niz. Rast. 28: 68, 1992.

=*Parahelminthosporium malabaricum* Subram. & Bhat, Kavaka 15: 63, 1989 ["1987"].

Colonies effuse, hairy, brown. Conidiophores erect, straight or flexuous, unbranched but sometimes sparingly branched, brown, paler towards the

apex, dark brown towards the base, up to 700 µm long, 5–7 µm wide in the upper part, 6–11 µm wide in the middle, 12–17 µm wide at the base, up to 2 regenerating percurrent proliferations. Conidiogenous cells polytretic, terminal or intercalary, cylindrical, rounded at the apex when terminal. Conidia 2-celled, 24–32 µm long; basal cell ellipsoidal to fusiform, brown, thick-walled, guttulate, often with a slightly darker band around the middle, 13–20 × 7–11 µm, truncate at base; apical cell subhyaline, conico-truncate, 8–13 µm long, 3–4 µm wide at the base, tapering to 2 µm at the apex.

SPECIMEN EXAMINED: Florida, Collier Co., Naples, on segments of dead leaves of *Sabal palmetto*, XI.24.2007, coll. G. Delgado (BPI 880519A).

Polytretophora calcarata, the type species of the genus, is apparently pantropical in distribution. The fungus has been widely collected on *Arecaceae* and *Pandanaceae* in many tropical and subtropical Asian countries, Australia, and the Pacific Islands, as well as the Seychelles (Kuthubutheen & Nawawi 1991b, Whitton et al. 2001). In the Americas, it has been previously recorded several times from Cuba, the type locality (Mercado 1983, Hernández & Mena 1995, Mercado et al. 1997), on decaying palm petioles from Peru (Matsushima 1993) and now for the first time from the subtropical United States. The Florida specimen has occasionally branched, longer conidiophores compared with the holotype from Cuba (conidiophores simple, 150–350 µm long), but is similar in conidiophore length, branching, and conidial dimensions to other specimens cited in the literature. The presence of a darker band of pigmentation around the middle of the basal cells of the conidia was originally reported by Whitton et al. (2001) and was detected in the present specimen. Kuthubutheen & Nawawi (1991b) also reported a *Selenosporella* synanamorph in collections from Malaysia, but this feature was not observed.

Pseudoacrodictys corniculata (R.F. Castañeda) W.A. Baker & Morgan-Jones, Mycotaxon 85: 378, 2003. FIGS. 16–17

= *Acrodictys corniculata* R.F. Castañeda, Deuteromycotina de Cuba, Hyphomycetes 2: 1, 1985.

Colonies effuse, hairy. Conidiophores solitary or in small groups, mostly unbranched or sparingly branched, cylindrical, straight or slightly flexuous, smooth, brown to dark brown, 23–52 × 3–5 µm, 6–8 µm wide at base, with 0–2 percurrent proliferations. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, percurrent. Conidia subglobose to globose, rarely broadly pyriform, dictyoseptate, smooth, brown, 17–28 × 14–30 µm, with a distinct protuberant, conico-truncate basal cell, 3–6 × 4–6 µm, and 0–6 pale brown, horn-like, strongly curved, aseptate appendages, clustered or not, 6–19 x 2–4 µm. Conidial secession schizolytic.

SPECIMEN EXAMINED: Florida, Collier Co., Naples, on rachides of dead leaves of *Sabal palmetto*, XI.23.2007, coll. G. Delgado (BPI 880521A).

Castañeda (1985) originally described this peculiar anamorph as *Acrodictys corniculata* from fallen leaves of unidentified *Poaceae* in Cuba. Later, Baker & Morgan-Jones (2003) partly reformatted and amended the original description to accommodate it, along with six other formerly placed *Acrodictys* species, within the narrowly delimited genus *Pseudoacrodictys*. *Pseudoacrodictys corniculata* is distinct by the presence of relatively small conidia, with short, horn-like, strongly curved appendages, often distally clustered at the apex. The present collection is the second record of its occurrence worldwide. The Florida specimen is similar to the holotype in dimensions and morphology, but sometimes the conidial appendages were not apically clustered but segregated and laterally placed, especially in larger, broadly pyriform conidia. Conidiophores are occasionally branched, often showing an irregular tear of the proximal periclinal wall, and conidia sometimes carried away a more or less short piece of conidiophore once released, a feature mentioned by Baker & Morgan-Jones (2003) and not related with rhexolytic secession.

Sporidesmiella sinensis W.P. Wu, in Wu & Zhuang, Fungal Diversity Research Series 15: 176, 2005. FIGS. 21–22

Colonies effuse, brown, hairy. Conidiophores cylindrical, straight or flexuous, smooth, brown, paler toward the apex, up to 131 µm long, 3–5 µm wide, 6–10 µm wide at base, with up to 7 inconspicuous annellidic percurrent proliferations. Conidia clavate, 3-distoseptate, rarely 2 or 4, cell lumina reduced, pale olivaceous to pale brown, 18–26 × 5–7.5 µm; apex rounded, basal cell slightly darker, truncate, 4 µm wide at the base.

SPECIMEN EXAMINED: Florida, Collier Co., Naples, on dead liana stems, XI.24.2007, coll. G. Delgado (BPI 880520A).

Sporidesmiella sinensis was recently described from dead twigs in China (Wu & Zhuang 2005). The original discussion did not include *S. oraniopsis* Yanna et al., a morphologically similar species having also percurrent proliferating conidiophores and 3-distoseptate, pale-colored, rounded at the apex, truncate at the base, clavate conidia (Yanna et al. 2001). *Sporidesmiella sinensis*, however, has smaller (24–26 × 7.5–9 µm), also cuneiform, pale olivaceous to olivaceous brown conidia and inconspicuous, 4–8 annellidic proliferations, while *S. oraniopsis* has pale brown, larger conidia (28–40 x 8–10 µm), rarely with 4 to 5 distosepta, and conspicuous, up to 18 percurrent proliferations at the apex. The Florida specimen agrees fairly well with the holotype description of *S. sinensis*, but conidia are narrower and rarely 2 or 4-distoseptate.

Triposporium verruculosum R.F. Castañeda, Gené & Guarro, Mycotaxon 59: 207, 1996. FIG. 20

Colonies hairy, effuse. Conidiophores cylindrical, straight or slightly flexuous, smooth, brown, up to 100 µm long, 4–6 µm wide, basal cells dark brown, 8–10

µm wide. Conidiogenous cells monoblastic, integrated, terminal, cylindrical, occasionally with 1–2 doliiform percurrent proliferations, slightly attenuated and truncate at the apex. Conidia stauriform, composed of a brown, obconical or cylindrical basal cell, 4–8 × 4.5–6 µm, a dark brown, verrucose suprabasal cell, 4–6 x 5–8 µm, and 2–4 divergent, verruculose, brown arms, 3–5-septate, 14–28 µm long, 7–9 µm wide at base, paler toward the apex and frequently ending in a rounded drop of mucilage, 3.5–5 µm diam.

SPECIMEN EXAMINED: Florida, Collier Co., Naples, on rachides of dead leaves of *Sabal palmetto*, XI.23.2007, coll. G. Delgado (BPI 880518B).

Triposporium verruculosum morphologically resembles *T. elegans* Corda the type species of the genus (Ellis 1971, Wu & Zhuang 2005), but differs in having verruculose, smaller conidial arms. The fungus was originally described on rotten fallen leaf of *Laurus* sp. from Canary Islands (Castañeda et al. 1996a). A second specimen collected on dead leaf of *Quercus ilex* L. from New Zealand is deposited in PDD (NZFUNGI 2010). The Florida collection has shorter conidiophores compared with the holotype (120–260 µm long).

Acknowledgments

I am grateful to Drs. Eric McKenzie (Landcare Research, NZ) and Keith A. Seifert (Agriculture & Agri-Food, Canada) for serving as pre-submission reviewers and their helpful comments on the manuscript. Special thanks are also due to Dr. Walter Gams (formerly CBS, The Netherlands), who kindly notified me about the genera *Megacapitula* and *Akenomyces* as well as corrected and improved the Latin diagnosis. Dr. G.Z. Zhao (Beijing Forestry University, PRC), Amy Miller (Interlibrary Loan Section, Broward County Library), and José M. Pérez (TREC, UF) are thanked for providing pertinent literature, Shannon Dominick (ARS, USDA) for depositing specimens in BPI, and Elsa Delgado for assistance in the field. Balu Krishnan and Dr. Michael Berg (EMLab P&K) are acknowledged for their continual encouragement and provision of facilities.

Literature cited

Baker WA, Morgan-Jones G. 2003. Notes on Hyphomycetes. XCI. *Pseudoacrodictys*, a novel genus for seven taxa formerly placed in *Acrodictys*. Mycotaxon 85: 371–391.

Baker WA, Partridge EC, Morgan-Jones G. 2002. Notes on hyphomycetes LXXXVII. *Rhexoacrodictys*, a new segregate genus to accommodate four species previously classified in *Acrodictys*. Mycotaxon 82: 95–113.

Castañeda RF. 1985. Deuteromycotina de Cuba. Hyphomycetes 2. INIFAT, Santiago de las Vegas.

Castañeda RF, Gené J, Guarro J. 1996a. Litter hyphomycetes from La Gomera (Canaries). Mycotaxon 59: 203–215.

Castañeda RF, Guarro J, Cano J. 1996b. Notes on conidial fungi. X. A new species of *Ceratosporella* and some new combinations. Mycotaxon 60: 275–281.

Chen JL, Tzean SS. 1993. *Megacapitula villosa* gen. et sp. nov. from Taiwan. Mycol. Res. 97: 347–350. doi:10.1016/S0953-7562(09)81134-9

Ellis MB. 1971. Dematiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew.

Hernández A, Mena J. 1995. Hifomicetos asociados a *Coccothrinax* (Palmae) en diferentes localidades de la Provincia de Camagüey (Cuba). Bol. Soc. Micol. Madrid 20: 25–33.

Holubová-Jechová V. 1986. Lignicolous hyphomycetes from Czechoslovakia 8. *Endophragmiella* and *Phragmocephala*. Folia Geobot. Phytotax. 21: 173–197

Holubová-Jechová V. 1988. Studies on hyphomycetes from Cuba VIII. A new genus *Piricaudilium* and some species new for the territory of Cuba. Česká Mykol. 42: 200–204.

Hornby D. 1984. *Akenomyces costatus* sp. nov. and the validation of *Akenomyces* Arnaud. Trans. Brit. Mycol. Soc. 82: 653–664. doi:10.1016/S0007-1536(84)80106-0

Hughes SJ. 1952. *Speira stipitata*. Trans. Brit. Mycol. Soc. 35: 243–247. doi:10.1016/S0007-1536(52)80033-6

Hughes SJ. 1971. New Zealand fungi. 16. *Brachydesmiella*, *Ceratosporella*. New Zeal. J. Bot. 9: 351–354.

Hughes SJ. 1979. Relocation of some species of *Endophragmia* auct. with notes on relevant generic names. New Zeal. J. Bot. 17: 139–188.

Jones EBG. 2006. Form and function of fungal spore appendages. Mycoscience 47: 167–183. doi:10.1007/s10267-006-0295-7

Kuthubutheen AJ, Nawawi A. 1991a. A new species of *Ceratosporella* and *Triposporium lambdaseptatum* (Matsush.) comb. nov. from Malaysia. Mycol. Res. 95: 158–162. doi:10.1016/S0953-7562(09)81005-8

Kuthubutheen AJ, Nawawi A. 1991b. *Polytretophora dendroidea* sp. nov. and *P. calcarata* (hyphomycetes) from Malaysia. Mycol. Res. 95: 623–627. doi:10.1016/S0953-7562(09)80078-6

Lustrati L. 1980. *Ceratosporella caliculata*, sp. nov. nuova specie di ifale demaziaceo. Mycol. Ital. 3: 11–14.

Ma J, Zhang K, Zhang XG. 2008. Two new *Ellisembia* species from Hainan, China. Mycotaxon 104: 141-145.

Matsushima T. 1981. Matsushima Mycological Memoirs No. 2: 1–68.

Matsushima T. 1993. Matsushima Mycological Memoirs No. 7: 1–75.

Mercado A. 1983. Nuevos e interesantes hifomicetes enteroblásticos de Cuba. Acta Bot. Cubana 16: 1–8.

Mercado A, Holubová-Jechová V, Mena J. 1997. Hifomicetes demaciáceos de Cuba. Enteroblásticos. Museo Regionale di Scienze Naturali, Torino.

Mercado A, Mena J, Guarro J, Heredia G. 2002. *Veracruzomyces*, a new anamorphic genus from Mexico. Nova Hedwigia 75: 533–537. doi:10.1127/0029-5035/2002/0075-0533

Minter DW. 1986. Spring foray 1985: Watersfield, near Pulborough, West Sussex 24–30 May 1985. Bull. Brit. Mycol. Soc. 20: 82–88. doi:10.1016/S0007-1528(86)80030-X

NZFUNGI. 2010. New Zealand Fungi (and Bacteria) Database. (http://nzfungi.landcareresearch.co.nz/html/mycology.asp?ID=).

Sinclair RC, Eicker A, Morgan-Jones G. 1987. Notes on hyphomycetes. LVI. *Ceratosporella cheiroidea*, a new species. Mycotaxon 30: 351–355.

Somrithipol S, Jones EBG. 2003. *Pseudoacrodictys dimorphospora* sp. nov., a new graminicolous hyphomycete from Thailand. Sydowia 55: 365–371.

Voglmayr H, Krisai-Greilhuber I. 1997. *Akenomyces costatus*, an interesting basidiomycetous anamorph with unknown affinities. Österr. Z. Pilzk. 6: 61–66.

Whitton SR, McKenzie EHC, Hyde KD, Frohlich J. 2001. Microfungi on the *Pandanaceae*: *Polytretophora macrospora* sp. nov. Mycoscience 42: 555–558. doi:10.1007/BF02460954

Wu WP, Zhuang W. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Diversity Press, Hong Kong.

Yang HL, Sun GY, Batzer JC, Crous PW, Groenewald JZ, Gleason ML. 2010. Novel fungal genera and species associated with the sooty blotch and flyspeck complex on apple in China and the USA. Persoonia 24: 29–37. doi:10.3767/003158510X492101

Yanna, Ho WH, Hyde KD, McKenzie EHC. 2001. *Sporidesmiella oraniopsis*, a new species of dematiaceous hyphomycete from North Queensland, Australia and synopsis of the genus. Fungal Diversity 8: 183–190.

Zhang T, Zhao G, Zhang X, Liu H, Wu Y. 2009. 26 Genera of Dematiaceous Dictyosporous Hyphomycetes excluding *Alternaria*. Flora Fungorum Sinicorum Vol. 31. Science Press, Beijing.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.247

Volume 114, pp. 247–257 October–December 2010

A new species of *Colletotrichum* from *Cordyline fruticosa* and *Eugenia javanica* causing anthracnose disease

SITTISACK PHOULIVONG[1,3,4], LEI CAI[2*], NOIREUNG PARINN[1], HANG CHEN[3], KAMEL A. ABD-ELSALAM[5], EKACHAI CHUKEATIROTE[1] & KEVIN D. HYDE[1,5]

* *mrcailei@gmail.com*

[1]*School of Science, Mae Fah Luang University, Thasud, Chiang Rai 57100, Thailand*

[2]*Key Laboratory of Systematic Mycology & Lichenology, Institute of Microbiology, Chinese Academy of Sciences, Beijing 100190, P. R. China*

[3]*International Fungal Research & Development Centre, The Research Institute of Resource Insects, Chinese Academy of Forestry Bailongsi, Kunming 650224, PR China*

[4]*Department of Plant Science, Faculty of Agriculture, National University of Laos Vientiane, 7322, Lao PDR*

[5]*King Saud University, College of Science, Botany and Microbiology Department P.O. Box 2455, Riyadh 1145, Saudi Arabia*

Abstract — A new species *C. cordylinicola*, isolated from *Cordyline fruticosa*, is characterized by morphological and molecular characters. The species would previously have been considered as a member of the *Colletotrichum gloeosporioides* complex. Combined six gene analysis using ACT, GS, TUB2, ITS, CAL and GPDH shows that three strains of *C. cordylinicola* clustered in a distinct lineage as a sister clade to *C. kahawae*. Other reference taxa employed in the analysis include type strains of *C. asianum, C. fructicola, C. gloeosporioides, C. kahawae, C. siamense, C. simmondsii,* and authentic strains of *C. horii*. This is the first report of a *Colletotrichum* species causing disease of *Cordyline fruticosa* in Thailand. Pathogenicity testing using the strains isolated from *Cordyline fruticosa* and *Eugenia javanica* showed that two strains isolated from different hosts may represent different pathotypes.

Key words — leaf spot, plant pathogenic fungi, taxonomy

Introduction

Colletotrichum is one of the most economically important pathogenic genera causing anthracnose of fruits and leaves, affecting a wide range of hosts in the tropics and subtropics. (Freeman et al. 1998, Hindorf 2000, Damm et al. 2009, Hyde et al. 2009a,b, Shivas & Yu 2009). Both agricultural crops and fruit trees

TABLE 1. Sources of isolates used in this study and analysis.

Colletotrichum species	CULTURE COLLECTION	GENBANK ACCESSION NUMBER					
		ACT	TUB-2	CAL	GS	GPDH	ITS
C. asianum	MFU 090232*	FJ 903188	FJ 907434	FJ 917501	FJ 972586	FJ 972571	FJ 972605
C. asianum	MFU 090233	FJ 907424	FJ 907439	FJ 917506	FJ 972595	FJ 972576	FJ 972612
C. asianum	MFU 090234	FJ 907421	FJ 907436	FJ 917503	FJ 972598	FJ 972573	FJ 972615
C. cordylinicola	BCC 38872	**HM470234**	**HM470249**	**HM470237**	**HM470243**	**HM470240**	**HM470246**
C. cordylinicola	BCC38864	**HM470233**	**HM470248**	**HM470236**	**HM470242**	**HM470239**	**HM470245**
C. cordylinicola	MFLU 100132	**HM470235**	**HM470250**	**HM470238**	**HM470244**	**HM470241**	**HM470247**
C. fructicola	MFU 090226*	FJ 907427	FJ 907442	FJ 917509	FJ 972592	FJ 972579	FJ 972602
C. fructicola	MFU 090227	FJ 907425	FJ 907440	FJ 917507	FJ 972594	FJ 972577	FJ 972611
C. fructicola	MFU 090228	FJ 907426	FJ 907441	FJ 917508	FJ 972593	FJ 972578	FJ 972603
C. gloeosporioides	CBS 953.97*	FJ 907430	FJ 907445	FJ 917512	FJ 972589	FJ 972582	FJ 972609
C. horii	TSG001	GU133374	GU133375	GU133376	GU133377	GQ329682	AY787483
C. horii	TSG002	GU133379	GU133380	GU133381	GU133382	GQ329680	AY791890
C. kahawae	IMI 319418*	FJ 907432	FJ 907446	FJ 917514	FJ 972588	FJ 972583	FJ 972608
C. kahawae	IMI 363578*	FJ 907433	FJ 907447	FJ 917515	FJ 972587	FJ 972584	FJ 972607
C. siamense	MFU 090230*	FJ 907423	FJ 907438	FJ 917505	FJ 972596	FJ 972575	FJ 972613
C. siamense	MFU 090231	FJ 907422	FJ 907437	FJ 917504	FJ 972597	FJ 972574	FJ 972614
C. simmondsii	BRIP 28519*	FJ 907428	FJ 907443	FJ 917510	FJ 972591	FJ 972580	FJ 972601
C. simmondsii	CBS 294.67	FJ 907429	FJ 907444	FJ 917511	FJ 972590	FJ 972581	FJ 972610
C. falcatum	CGMCC3.14187	HM171665	HM171680	HM171668	HM171674	HM171671	HM171677

NOTE: ACT: actin; TUB-2: partial ß-tubulin; CAL: calmoudulin; GS: glutamine synthetase; GDPH: glyceraldehydes-3-phosphate dehydrogenase; ITS: complete rDNA-ITS region. The newly generated sequence in this study are shown in bold. CGMCC: China General Microbial Culture Collection. MFU: Mae Fah Luang University, Thailand; CBS: Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands; BRIP: Plant Pathology Herbarium, Department of Primary Industries, Queensland, Australia; IMI: CABI Europe – UK, Egham, Surrey TW209TY, UK; *: ex-type cultures

can be affected by *Colletotrichum* anthracnose, resulting in reduction in yield quantity or quality. *Colletotrichum* species are cosmopolitan with either multiple species occurring on a single host or a single species on multiple hosts (Cai et al. 2009, Crouch & Beirn 2009, Hyde et al. 2009b). Fungus/host relationships are broad, imprecise and often overlapping. *Colletotrichum* species can infect many hosts and may adapt to new environments (Sanders & Korsten 2003a), leading to serious cross infection problems in plant production. The study of pathogenic variability of *Colletotrichum* species is therefore important and the understanding of the host range of a particular pathogen may help in efficient disease control and management (Whitelaw-Weckert et al. 2007).

Artificial inoculation methods in vitro are commonly used to test the pathogenicity of a fungal species, as it is easy to control environmental conditions. Common inoculation methods for pathogenicity testing include drop inoculation and wound/drop inoculation (Cai et al. 2009, Kanchanaudomkan et al. 2004, Lin et al. 2002, Sharma et al. 2005, Than et al. 2008a).

Colletotrichum gloeosporioides sensu lato has previously been listed as causing disease of a very wide range of fruits and infecting leaves of many hosts in Thailand (and Laos) (Ratanacherdchai et al. 2007, Than et al. 2008b, Yang et al. 2009). This species has recently been epitypified with a living strain that has been sequenced with sequence data deposited in GenBank (Cannon et al. 2008). This has enabled researchers to compare their isolates of *Colletotrichum* with the *C. gloeosporioides* epitype. This has resulted in the description of several new species in the *C. gloeosporioides* species complex (Prihastuti et al. 2009, Yang et al. 2009). With the introduction of several new species it is important to establish whether they are host-specific or have a wide host range, as this will have important implication in disease control and management. The objective of this paper is to introduce a new *Colletotrichum* species causing leaf disease of *Cordyline fruticosa* in Laos and Thailand. It is characterized morphologically and phylogenetically in this paper and its ability to infect several hosts is established.

Material and methods

Isolation and morphological examination

The methods of isolation used by Cai et al. (2009), Prihastuti et al. (2009) and Yang et al. (2009) were followed. Two strains of *Colletotrichum* were isolated from anthracnose of infected leaves of *Cordyline fruticosa* from a garden in Chiang Mai, Thailand and one from leaves of rose apple in a garden in Vientiane, Laos. The growth rate was measured for 7-day old colonies on PDA. Herbarium material is deposited in MFLU while extype cultures are deposited at MFLUCC and *BIOTEC* Culture Collection (*BCC*), with some duplicate strains deposited in China General Microbial Culture Collection (CGMCC) under material transfer agreement 7/2552.

DNA extraction

Isolates were grown on PDA and incubated at 27°C for 7 days. Genomic DNA was extracted by using a Biospin Fungus Genomic DNA Extraction Kit (BioFlux®) according to the manufacturer's protocol. Quality and quantity of DNA were estimated visually by staining with ethidium bromide on 1% agarose gel electrophoresis.

PCR amplification and DNA sequencing

Partial actin (ACT), β-tubulin (TUB2), calmodulin (CAL), glutamine synthetase (GS), glyceraldehyde-3-phosphate dehydrogenase (GPDH) genes and the complete rDNA-ITS (ITS) region from three strains were amplified by PCR reactions. The primers, reaction system and thermo cycles were the same as used by Prihastuti et al. (2009).

PCR products were verified by staining with ethidium bromide on 1% agarose electrophoresis. PCR products were then purified using the GFX PCR Purification Kit (27-9602-01; Amersham Biosciences) according to the manufacturer's protocol. Sequencing was carried out at the SinoGenoMax Company Limited, Beijing.

Phylogenetic analyses

Sequences of *Colletotrichum* isolates (TABLE 1) from different hosts were aligned with ClustalX (Thompson et al. 1997) and optimized manually to allow maximum alignment and maximum sequence similarity. Gaps were treated as missing data. Phylogenetic analysis was carried out based on the aligned dataset by PAUP* 4.0b10 (Swofford 2000). Ambiguously aligned regions were excluded from all analyses. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Maxtrees were unlimited, branches of zero length were collapsed, and all multiple parsimonious trees were saved. Descriptive tree statistics such as tree length [TL], consistency index [CI], retention index [RI], rescaled consistency index [RC], homoplasy index [HI], and log likelihood [-ln L] (HKY model) were calculated for trees generated under different optimality criteria. Kishino-Hasegawa tests (Kishino & Hasegawa 1989) were performed in order to determine whether trees were significantly different. Clade stability of the tree resulting from maximum parsimony analysis was assessed by bootstrap analysis with 1000 replicates, each with 10 replicates of random stemwise addition of taxa (Felsenstein 1985). Trees were figured in TreeView (Page 1996).

The model of evolution was estimated by using Mrmodeltest 2.2 (Nylander 2004). Posterior probabilities (PP) (Rannala & Yang 1996, Zhaxybayeva & Gogarten 2002) were determined by Markov Chain Monte Carlo sampling (BMCMC) in MrBayes 3.0b4 (Huelsenbeck & Ronquist 2001). Six simultaneous Markov chains were run for 1,000,000 generations and trees were sampled every 100 generations (resulting in 10,000 total trees). The first 2000 trees, which represented the burn-in phase of the analyses, were discarded and the remaining 8000 trees were used for calculating posterior probabilities (PP) in the majority rule consensus tree.

Pathogenicity testing

The protocol followed the methods outlined by Cai et al. (2009) and Yang et al. (2009), modified as follows. Pathogenicity testing used one isolate from *Cordyline fruticosa* and one from *Eugenia javanica*. Each was inoculated onto three fruits of chilli

(*Capsicum* sp.), guava (*Psidium guajava*), mango (*Mangifera indica*), papaya (*Carica papaya*), orange (*Citrus* sp.), and rose apple *(Eugenia javanica)* and onto three detached leaves of *Cordyline fruticosa*. Incubation duration was dependent on the nature of lesion development and anthracnose symptoms were scored as a + or –.

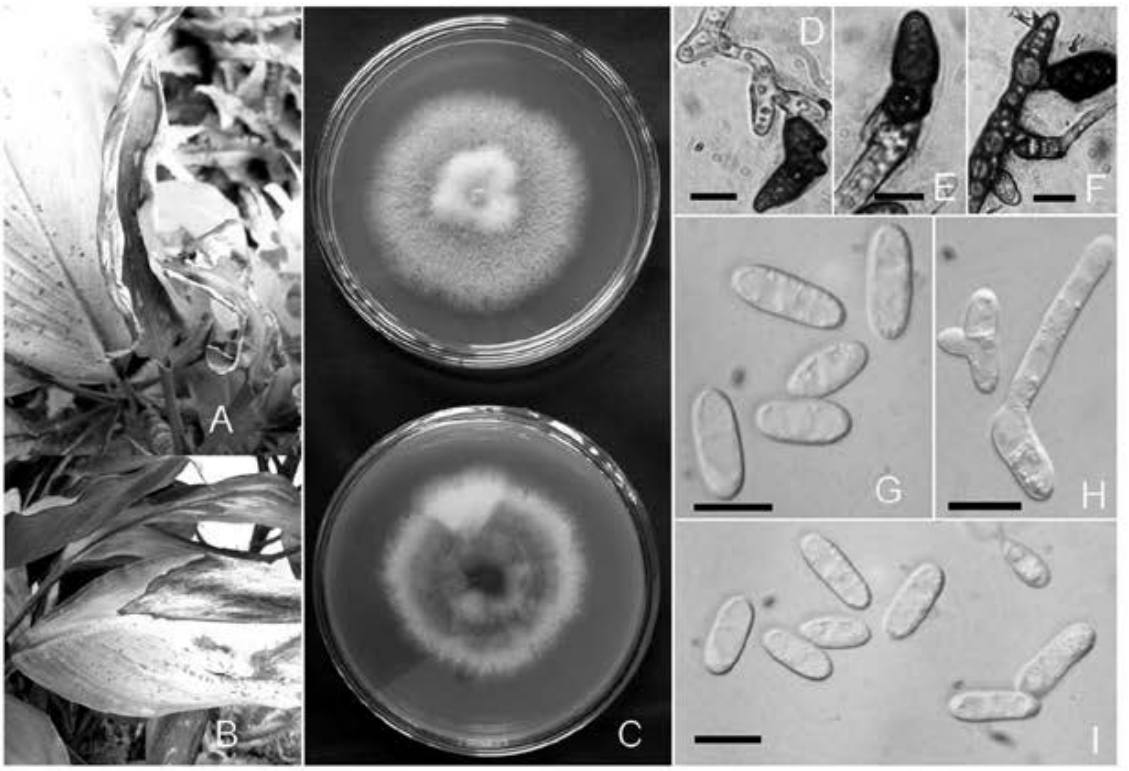


FIGURE 1. *Colletotrichum cordylinicola* (from BCC 38872, holotype) (A, B) symptoms on *Cordyline fruticosa*. (C) upper and lower view of cultures on PDA after 7 days growth; (D, E,F) appressoria; (G, I) conidia; (H) conidia germination (Bars: D–I = 10 µm).

Results

Taxonomy

Colletotrichum cordylinicola Phoulivong, L. Cai & K.D. Hyde, **sp. nov.** FIGURE 1

MYCOBANK 518577

Coloniae crescentes post 7 dies in PDA ad 27°C 75 mm diam. Conidiogenae producentia in acervulis, tubulosa. Conidia 11–20 × 4–5 µm, unicellularae, hyalinae, cylindrici, laeviaad apicem obtuse. Appressoria 13–13.4 × 7.2–7.3 µm, brunnea vel atro-brunnea, irregulariter ovoidea vel clavati.

HOLOTYPE: Thailand, Chiang Mai Province, San Sai District, Maejo Village, on *Cordyline fruticosa* (L.) A. Chev. (*Agavaceae*), 15 March 2009, Sitthisack Phoulivong, MFLU10 0289; extype living culture MFUCC 090551, BCC 38872 and CGMCC.

ETYMOLOGY: Referring to the host genus *Cordyline*.

Colonies on PDA attaining 75 mm diam. in 7 days at 27°C, growth rate 10.8–11.6 mm/day (mean= 11.2, n = 5), white, sparse, with grey-orange visible conidial masses and with floccose aerial mycelia in centre, reverse slightly greenish.

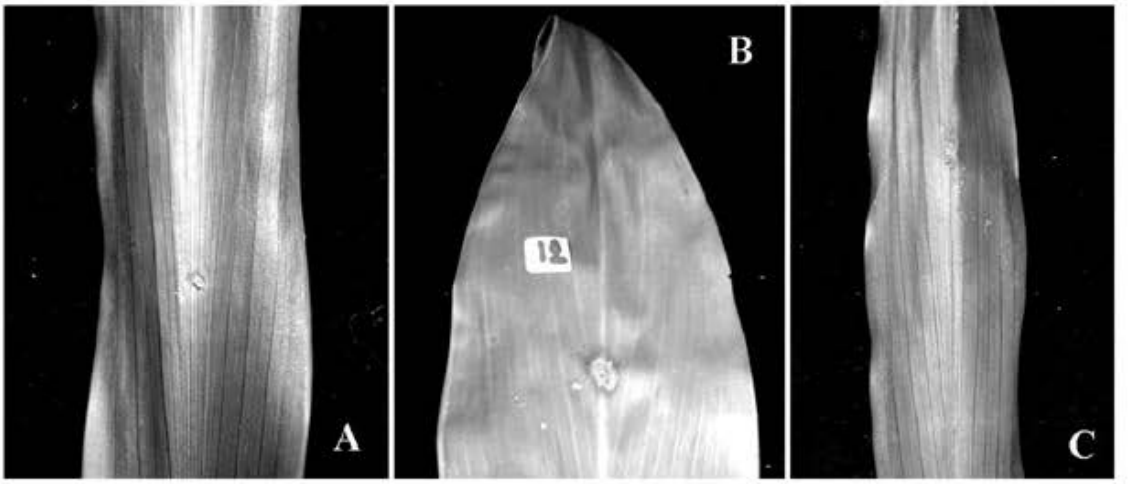


FIGURE 2. Anthracnose symptom on *Cordyline fruticosa* 7 days after inoculation.

Sclerotia absent. Setae absent. Conidiophores congregative, straight or geniculate, produced in the acervuli. Conidia 11–20 × 4–5 µm (mean = 15.37 ± 0.6 × 4.5 ± 0.56, n = 30), one-celled, hyaline, cylindrical with round ends, smooth-walled, guttulate. Spore germination on PDA mostly observed near the apex of the conidia, sometimes from the centre. Appressoria in slide culture 13–13.4 × 7.2–7.3 µm (mean = 13.20 ± 0.94 × 7.25 ± 0.61, n = 10), mostly formed from conidia, brown to dark brown, variable in shape including ovoid, clavate or slightly irregular, often becoming complex with age.

TELEOMORPH — not produced in culture.

KNOWN DISTRIBUTION — Thailand and Laos.

ADDITIONAL SPECIMENS EXAMINED: **LAOS**, Vientiane, Pakngum District, Don-ngaeng Village, on rose apple fruit (*Eugenia javanica* Lam. (*Myrtaceae*)), 26 September 2007, Sitthisack Phoulivong, MFLU10 0290, living culture MFLU 09 0636, IFRD 2149, BCC38864, CGMCC 3.14199. **THAILAND**, Chiang Rai, Doi Tung, on *Cordyline fruticosa*, Noireung Parinn, MFLU10 0291, living cultures MFLU 100132, CGMCC 3.14200.

Phylogenetic study

The dataset of six combined genes comprised 2506 characters after alignment, of which 545 characters were parsimony informative (21.7%). The KH test showed that the two trees inferred from parsimonious analysis were not significantly different. One of the most parsimonious trees (TL = 1377, CI = 0.895, RI = 0.881, RC = 0.798, HI = 0.105) generated from dataset of six combined gene regions is shown in FIGURE 3 The phylograms inferred from single genes ACT, GS, TUB2, ITS, CAL and GPDH show similar topology as that from combined datasets but with much lower statistical support for branches (results not shown). In the phylogenetic tree, three strains of *C. cordylinicola* clustered in a distinct lineage and appeared as a sister clade to *C. kahawae* (100% bootstrap and posterior probability). Other reference taxa employed in the analysis include type strains

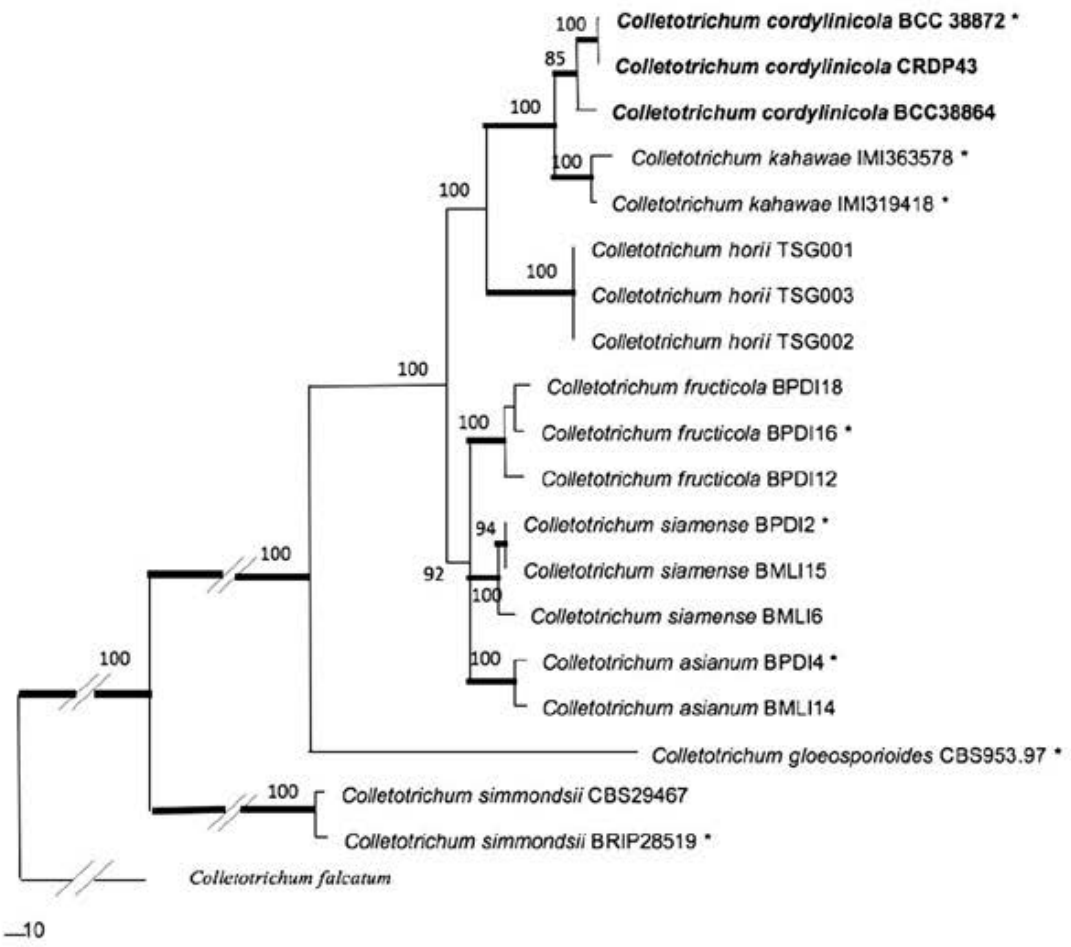


FIGURE 3. Maximum parsimony phylogram showing phylogenetic relationships among isolates of *Colletotrichum cordylinicola* and closely related taxa based on combined ACT, TUB2, CAL, GS, ITS, and GPDH sequences. Data were analysed with random addition sequence, unweighted parsimony, and treating gaps as missing data. Values above the branches are parsimony bootstrap (equal or above 50%). Thickened branches represent significant Bayesian posterior probabilities (equal or above 95%). The tree is rooted with *Colletotrichum falcatum*. * indicates sequences from type specimens.

of *C. simmondsii, C. asianum, C. fructicola, C. gloeosporioides, C. kahawae, C. siamense* and authentic strains of *C. horii.*

Pathogenicity testing

Two isolates of *C. cordylinicola* were tested for their pathogenicity and potential for cross infection. In inoculation tests, the strain isolated from *Cordyline fruticosa* infected *Cordyline fruticosa* leaves (FIGURE 2.) and papaya fruit but did not infect the other fruits tested. The *C. cordylinicola* isolate from rose apple infected rose apple as well as citrus, chilli, guava, mango and papaya fruits but not *Cordyline fruticosa* leaves. The qualitative comparison of symptom development on different hosts is shown in TABLE 2.

TABLE 2: Pathogenicity and potential of cross infection of *Colletotrichum cordylinicola* on a range of hosts.

ISOLATE NUMBER	HOSTS	Infection on inoculated fruits*						Infection on inoculated leaves of *C. fruticosa*
		CHILLI	GUAVA	MANGO	ORANGE	PAPAYA	ROSE APPLE	
BCC 38872	*Cordyline fruticosa*	-	-	-	-	+	-	+
BCC 38864	*Eugenia javanica*	+	+	+	-	+	+	-

Discussion

Colletotrichum cordylines Pollacci (from Italy) is the only species of *Colletotrichum* described from *Cordyline* (*C. indivisa*). Conidial sizes were not provided in the protologue (Pollacci 1899: 44; Saccardo & Sydow 1899: 1017) and the name has not recently been used (Hyde et al. 2009b). It is impossible to establish whether our collections have any relationship to the type of *C. cordylines*, as there are no living extype cultures and it is presently impossible to isolate DNA from such an old type specimen. It is, therefore, prudent to introduce our collections as a new species.

Colletotrichum cordylinicola is morphologically similar to several species in the *C. gloeosporioides* complex. Species in this complex are difficult to differentiate based solely on morphology. Phylogenetic analysis using ITS sequences could not confidently resolve its systematic placement but showed that this fungus is well clustered in the *C. gloeosporioides* complex (details not shown). A multi-locus phylogeny based polyphasic approach was therefore employed to infer interspecific relationships in this group of fungi (Cai et al. 2009). In the six-gene combined phylogeny, the species relationships are well defined with all the major clades supported by parsimony bootstrap support and Bayesian posterior probabilities (FIGURE 3). The conidial morphology of *C. cordylinicola* is similar to that of *C. siamense*. However, *C. cordylinicola* can be distinguished from this species by its appressoria, which are irregular in shape (FIGURE 1). In the phylogenetic tree, *C. cordylinicola* does not group with *C. siamense*, but clusters as a sister clade to *C. kahawae* (FIGURE 3). Although similar in conidial morphology, *C. cordylinicola* can be differentiated from *C. kahawae* by its significantly larger appressoria (13–13.4 × 7.2–7.3 vs 4.5–10 × 4–7 µm) and smaller conidia. This is the first report of *Colletotrichum* species causing anthracnose on *Cordyline fruticosa* in Thailand.

Identification of species within the *C. gloeosporioides* complex has been a difficult issue as these species are morphologically very similar (Bailey & Jeger 1992, Sutton 1992). Morphology of conidia and appressoria, colony characters, host association, growth rate, and biochemical data should be used in conjunction

with a multilocus phylogeny to identify a *Colletotrichum* species accurately (Cai et al. 2009; Prihastuti et al. 2009). In this study, a phylogenetically well-defined lineage is associated with distinct morphological and other phenotypic characters. It is therefore given species rank and described as a new species.

The strain of *C. cordylinicola* isolated from rose apple failed to infect *Cordyline fruticosa*, while that from *Cordyline fruticosa* failed to infect rose apple. In morphology, the two strains are essentially similar except the one from rose apple produced conidia that are slightly acute at one end, while the conidia in the strain from *Cordyline fruticosa* are rounded at both ends. The strains are, however, shown to be related based on multigene phylogenetic analysis with 100% support (FIGURE 3). The strain from rose apple infected more fruits than that from *Cordyline fruticosa*. This finding supports the statement of Johnston (2000) that "there are no general rules concerning host relationships within *Colletotrichum* . . . the group so recognized cannot be assumed genetically equivalent, even when appearing to be biologically similar". It will be interesting to establish whether these strains represent two pathotypes in nature (Bailey & Jeger 1992). Pathogenicity may be affected by several environmental factors such as variety and condition of the fruit, humidity and temperature, and the concentration of inoculum (Simmonds 1965, Freeman et al. 1998). The result reported here may not accurately reflect the true virulence potential. Future research should attempt to determine the pathogenicity of these strains according to natural infections rather than artificial inoculations. On the other hand, if more phenotypic divergence of these two strains could be identified following further collections or study, the systematic relationship between the two strains may need a re-evaluation.

Acknowledgements

This study was supported by research grants 51101010029 and 52101010002 awarded by Mae Fah Luang University, Chiang Rai, Thailand. This research was also funded by AF Grant and the Grant for Essential Scientific Research of National Non-profit Institute (no. CAFYBB2007002) from the Chinese Academy of Forestry and the Knowledge Innovation Program of the Chinese Academy of Sciences, No. KSCX2-YW-Z-1026. Yuanying Su is thanked for technical help and suggestions on this work. Drs. Jingze Zhang and Eric H.C. McKenzie are thanked for their critical review of the manuscript prior to publication.

Literature cited

Bailey JA, Jeger MJ. 1992. *Colletotrichum:* biology, pathology and control. Commonwealth Mycological Institute. Wallingford.

Cai L, Hyde KD, Taylor PWJ, Weir B, Waller J, Abang MM, Zhang JZ, Yang YL, Phoulivong S, Liu ZY, Prihastuti H, Shivas RG, McKenzie EHC, Johnston PR. 2009. A polyphasic approach for studying *Colletotrichum.* Fungal Diversity 39: 183–204.

Cannon PF, Buddie AG, Bridge PD. 2008. The typification of *Colletotrichum gloeosporioides*. Mycotaxon 104: 189–204.

Crouch JA, Beirn LA. 2009. Anthracnose of cereals and grasses. Fungal Diversity 39: 19–44.

Damm U, Woudenberg JHC, Cannon PF, Crous PW. 2009. *Colletotrichum* species with curved conidia from herbaceous hosts. Fungal Diversity 39: 45–87.

Felsenstein J. 1985. Confidence limits on phylogenies: An approach using the bootstrap. Evolution 39: 783–791. doi:10.2307/2408678.

Freeman S, Katan T, Shabi E. 1998. Characterization of *Colletotrichum* species responsible for anthracnose diseases of various fruits. Plant Disease 82: 596–605. doi:10.1094/PDIS.1998.82.6.596

Hindorf H. 2000. *Colletotrichum* species causing anthracnose of tropical crops. Plant Pathology 39: 343–366.

Huelsenbeck JP, Ronquist FR. 2001. MRBAYES: Bayesian inference of phylogenetic trees. Biometrics 17: 754–755.

Hyde KD, Cai L, McKenzie EHC, Yang YL, Zhang JZ, Prihastuti H. 2009a. *Colletotrichum*: a catalogue of confusion. Fungal Diversity 39: 1–17.

Hyde KD, Cai L, Cannon PF, Crouch JA, Crous PW, Damm U, Goodwin PH, Chen H, Johnston PR, Jones EBG, Liu ZY, McKenzie EHC, Moriwaki J, Noireung P, Pennycook SR, Pfenning LH, Prihastuti H, Sato T, Shivas RG, Taylor PWJ, Tan YP, Weir BS, Yang YL, Zhang JZ. 2009b. *Colletotrichum* – names in current use. Fungal Diversity 39: 147–182.

Johnston PR. 2000. The importance of phylogeny in understanding host relationships within *Colletotrichum*. 21–28. In: Prusky D, et al. (Eds), *Colletotrichum*: host specificity, pathology, and host-pathogen interaction. American Phytopathological Society, St Paul, MN.

Kanchana-udomkarn C, Taylor PWJ, Mongkolporn O. 2004. Development of a bioassay to study anthracnose infection of *Capsicum chinense* Jacq. fruit caused by *Colletotrichum capsici*. Thai Journal of Agricultural Science 37: 293–297.

Kishino H, Hasegawa M. 1989. Evaluation of the maximum likelihood estimate of the evolutionary tree topologies from DNA sequence data, and the branching order of *Hominoidea*. Journal of Molecular Evolution 29: 170–179. doi:10.1007/BF02100115

Lin Q, Kanchana-udomkan C, Jaunet T, **Mongkolporn O.** 2002. Genetic analysis of the resistance to pepper anthracnose caused by *Colletotrichum capsici*. Thai Journal of Agricultural Science 35: 259–264.

Nylander JAA. 2004. MrModeltest v2. Program distributed by the author. Evolutionary Biology Centre, Uppsala University.

Page RDM. 1996. TREEVIEW: An application to display phylogenetic trees on personal computers. Computer Applications in the Biosciences 12: 357–358.

Pollacci G. 1899. Contribuzione alla micologia ligustica. Atti dell' Istituto Botanico dell' Università di Pavia, Serie 2, 5: 29–46.

Prihastuti H, Cai L, Chen H, McKenzie EHC, Hyde KD. 2009. Characterization of *Colletotrichum* species associated with coffee berries in northern Thailand. Fungal Diversity 39: 89–109.

Rannala B, Yang Z. 1996. Probability distribution of molecular evolutionary trees: a new method of phylogenetic inference. Journal of Molecular Evolution 43: 304–311. doi:10.1007/BF02338839

Ratanacherdchai K, Wang HK, Lin FC, Soytong K. 2007. RAPD analysis of *Colletotrichum* species causing chilli anthracnose disease in Thailand. Journal of Agricultural Technology 3: 211–219.

Saccardo PA, Sydow P. 1899. Supplementum universale, pars IV. Sylloge fungorum 14. 1316 p.

Sanders GM, Korsten L. 2003a. Comparison of cross inoculation potential of South African avocado and mango isolates of *Colletotrichum gloeosporioides*. Microbiological Research 128: 143–150. doi:10.1078/0944-5013-00186

Sharma PN, Kaur M, Sharma OP, Sharma P, Pathania A. 2005. Morphological, pathological and molecular variability in *Colletotrichum capsici*, the cause of fruit rot of chillies in the subtropical region of North-western India. Journal of Phytopathology 153: 232–237. doi:10.1111/j.1439-0434.2005.00959.x

Shivas RG, Yu YP. 2009. A taxonomic re-assessment of *Colletotrichum acutatum*, introducing *C. fioriniae* comb. et stat. nov. and *C. simmondsii* sp. nov. Fungal Diversity 39: 111–122.

Simmonds JH. 1965. A study of the species of *Colletotrichum* causing ripe fruit rots in Queensland. Queensland Journal of Agriculture and Animal Science 22: 437–459.

Sutton BC. 1992. The genus *Glomerella* and its anamorph *Colletotrichum*. 1–26. In: Bailey JA, Jeger MJ (eds.), *Colletotrichum*: biology, pathology and control. CAB International. Wallingford, UK.

Swofford DL. 2000. PAUP* 4.0: phylogenetic analysis using parsimony (* and other methods). Sinauer Associates, Sunderland, MA.

Than PP, Jeewon R, Hyde KD, Pongsupasamit S., Mongkolporn O, Taylor PWJ. 2008a. Characterization and pathogenicity of *Colletotrichum* species associated with anthracnose disease on chilli (*Capsicum* spp.) in Thailand. Plant Pathology 57: 562–572. doi:10.1111/j.1365-3059.2007.01782.x

Than PP, Prihastuti H, Phoulivong S, Taylor PWJ, Hyde KD. 2008b. Review: chilli anthracnose disease caused by *Colletotrichum* species. Journal Zhejiang University 9: 764–778. doi:10.1631/jzus.B0860007

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The Clustal X windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucleic Acids Research 24: 4876–4882. doi:10.1093/nar/25.24.4876

Whitelaw-Weckert MA, Curtin SJ, Huang Steel RCC, Blanchard CL, Roffey PE. 2007. Phylogenetic relationships and pathogenicity of *Colletotrichum acutatum* isolates from grape in subtropical Australia. Plant Pathology 56:448–463. doi:10.1111/j.1365-3059.2007.01569.x

Yang YL, Liu ZY, Cai L, Hyde KD, Yu ZN, McKenzie EHC. 2009. *Colletotrichum* anthracnose of *Amaryllidaceae*. Fungal Diversity 39: 123–146.

Zhaxybayeva O, Gogarten JP. 2002. Bootstrap, Bayesian probability and maximum likelihood mapping: exploring new tools for comparative genome analyses. Genomics 3: 1–15. doi:10.1186/1471-2164-3-1

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.259

Volume 114, pp. 259–261 October–December 2010

Taxonomic studies of *Dactylella* from Fujian, China

YI-DONG ZHANG, JIAN MA, LI-GUO MA & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract —A new species of *Dactylella* was found during a continuing survey of anamorphic fungi in tropical areas of Fujian province, China. The new species, *Dactylella yoaniae* was found on *Yoania japonica*. It is described, illustrated and compared with closely related taxa.

Key words — hyphomycetes, taxonomy

Introduction

The genus *Dactylella* was established by Grove (1884) with *D. minuta* Grove as the type species. *Dactylella* is characterized as "Saprophytic. Vegetative hyphae creeping, sparse. Conidiophores erect, simple, septate or non-septate, smooth, hyaline. Conidia born singly at the apex of conidiophore, ellipsoidal or fusoid or cylindrical, one-celled at first, later 2- to many-septate, hyaline". These characters separate *Dactylella* from several similar genera, viz. *Arthrobotrys* Corda, *Dactylaria* Sacc., *Monacrosporium* Oudem, *Brachyphoris* Juan Chen et al, *Drechsleromyces* Subram., *Monacrosporiella* Subram., *Gangliophragma* Subram., and *Lactydina* Subram. (Subramanian 1963, 1977; Chen et al. 2007a).

Dactylella is extremely heterogeneous, and many species are predatory on microanimals. Some are oospore or nematode-egg parasites while others are saprobic on deciduous stems or wood (Chen et al. 2007b). Worldwide, more than 100 species have been validly described, of which 28 species have been described from China.

Fungi were collected on dead branches or rotten wood from tropical forest in Fujian province of China during 2009. Among the collections an undescribed species of *Dactylella* was found. The type specimen is deposited in HSAUP (Herbarium of the Department of Plant Pathology, Shandong Agricultural University) with isotype in HMAS (Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences).

*Corresponding author

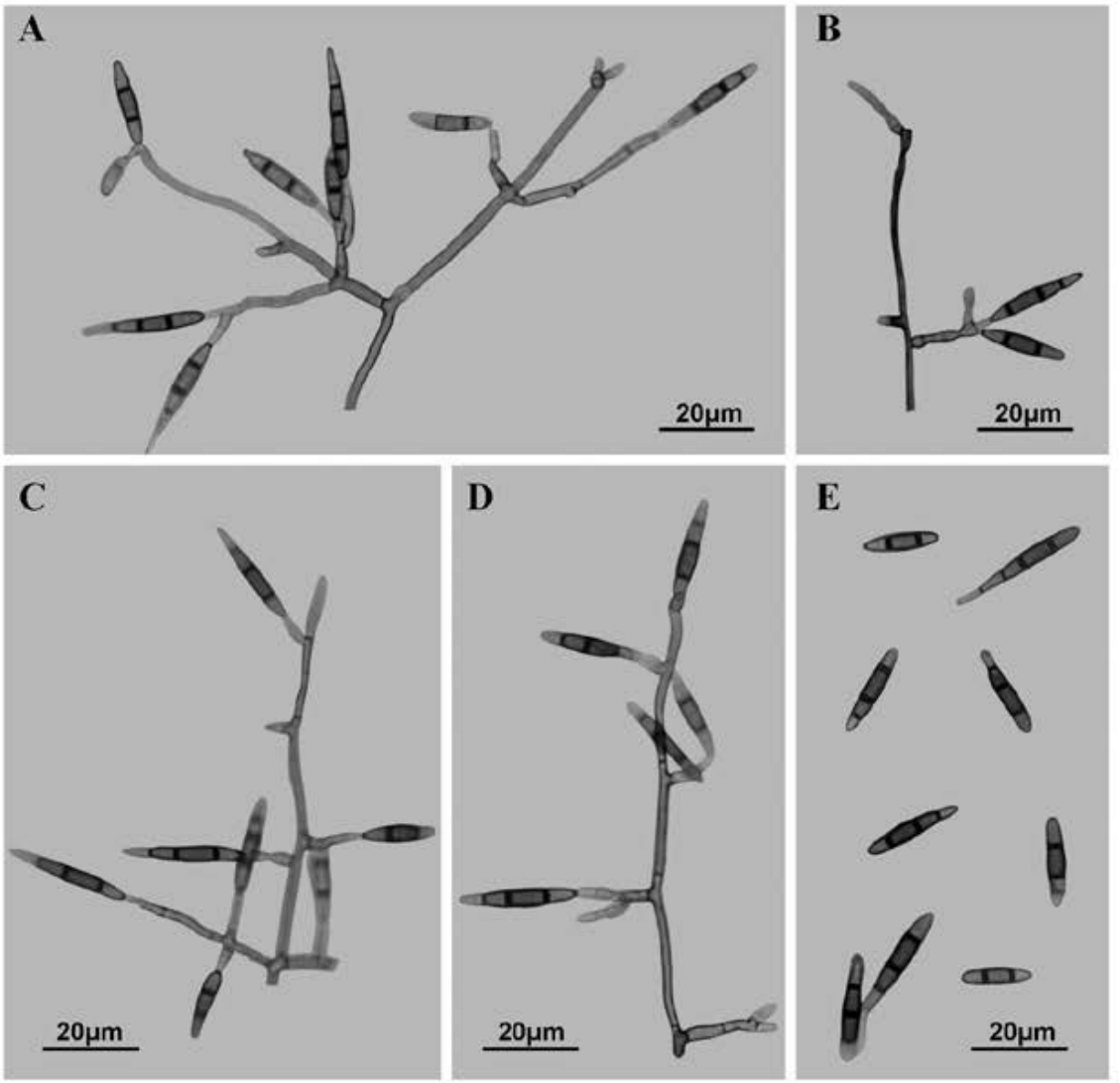


FIG. 1. *Dactylella yoaniae*. A–D. Conidiophores with conidia. E. Conidia.

Taxonomic description

Dactylella yoaniae Y.D. Zhang & X.G. Zhang, **sp. nov.** FIGURE 1

MYCOBANK MB 518743

Coloniae in substrato naturali effusae, pallide brunneae. Mycelium hyalinis, hyphae ramosae, pallide brunneae, septata, 3–4 μm crassis compositum. Conidiophora ex apice lateribusque hypharum oriunda, erecta, simplicia vel ramificata, incolorata, 1–4-septata, 11–77 μm longa, 3–4 μm lata ad basim, 2–3 μm lata ad apice. Conidia singula in apice conidiophori oriunda, fusiformis vel clavata, basi truncata, holoblastica, pallide brunneae, terminales, laevia, 2–4-septata, praecipue 3 septata, 18–34 × 3–5.5 μm.

HOLOTYPE: on dead branches of *Yoania japonica* Maxim. (*Orchidaceae*), Longjingshan, Fujian Province, China. Aug. 11. 2009, Y.D. Zhang, HSAUP H3153 (isotype HMAS 144867).

ETYMOLOGY: in reference to the host genus, *Yoania*.

Colonies on the natural substratum, effuse, pale brown. Mycelium hyaline, hyphae flexuous and composed of branched, pale brown, septate, 3–4 µm thick. Conidiophores terminally and laterally on the hyphae, erect, simple or with several branches, colourless, 1–4-septate, 11–77 µm tall, 3–4 µm wide at the base, gradually tapering upward to 2–3 µm at the tip. Conidia formed singly at the apex of the conidiophores and on short branches, fusiform to clavate, truncate at the base, holoblastic, pale brown, smooth-walled, 2–4-septate, mainly 3 septate, 18–34 × 3–5.5 µm, median cells brown, the basal and apical cell becoming gradually paler.

The fungus is placed in the genus *Dactylella* based on its conidial shape and the multiseptate, single conidia. The conidia of *D. yoaniae* resemble those of *D. arnaudii* (Yadav 1960), *D. heptameres* (Drechsler 1943), and *D. clavata* (Gao et al. 1995) in having a similar conidial shape and conidiophore branches. However, the conidia of *D. yoaniae* are smaller than those of *D. arnaudii* (54–(69)–88 × 4.5–(7)–10 µm) and *D. heptameres* [(33–42)–55 × 7.5–(8.5)–9 µm)]. In *D. heptameres* the conidia are 3–6-septate (mainly 6-septate) compared to the 2–4-septate (mainly 3-septate) conidia of *D. yoaniae*. *Dactylella clavata* has broader (4–(6)–8 µm) conidia, mainly 3–5-septate. In addition, in *D. yoaniae* the conidial basal and apical cells gradually become paler, which differs from other three species.

Acknowledgments

The authors are grateful to Dr. N.R. O'Neill and Dr. W.B. Kendrick for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (No. 30770015, 30499340, 2006FY120100).

Literature cited

Chen J, Xu LL, Liu B, Liu XZ. 2007a. Taxonomy of *Dactylella* complex and *Vermispora*. I. Generic concepts based on morphology and ITS sequences date. Fungal Diversity: 26: 73–84.

Chen J, Xu LL, Liu B, Liu XZ. 2007b. Taxonomy of *Dactylella* complex and *Vermispora*. II. The genus *Dactylella*. Fungal Diversity: 26: 85–126.

Drechsler C. 1943. A new nematode-capturing *Dactylella* and several related hyphomycetes. Mycologia 35: 339–362. doi:10.2307/3754725

Gao RH, Sun MH, Liu XZ. 1995. *Dactylella clavata* sp. nov., a hyphomycete from Xisha Islands, China. Mycotaxon 56: 191–195.

Grove WB. 1884. New or noteworthy fungi. Journal of Botany 22: 195–201.

Subramanian CV. 1963. *Dactylella*, *Monacrosporium* and *Dactylaria*. Journal of the Indian Botanical Society 42: 291–300.

Subramanian CV. 1977. Revisions of hyphomycetes – I. Kavaka 5: 93–98.

Yadav AS. 1960. *Dactylella arnaudii* sp. nov. Transactions of the British Mycological Society 43: 603–606. doi:10.1016/s0007-1536(60)80050-2

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.263

Volume 114, pp. 263–270 *October–December 2010*

Galerella nigeriensis (*Agaricales*), a new species from tropical Africa

ZDENKO TKALČEC[1], ARMIN MEŠIĆ[1] & MILAN ČERKEZ[2]

ztkalcec@irb.hr & amesic@irb.hr
[1]*Ruđer Bošković Institute*
Bijenička 54, HR-10000 Zagreb, Croatia

[2]*Croatian Mycological Society*
Sveti Duh 63/1, HR-10000 Zagreb, Croatia

Abstract — A new species, *Galerella nigeriensis,* from southwestern Nigeria is described. It is characterized by a strongly plicate, dry, yellowish to orange brown pileus, whitish veil on pileus and stipe base, white and pubescent stipe, thick-walled, mostly flattened spores, tibiiform to lageniform cheilocystidia, and presence of hymenophysalides (recorded for the first time in the genus *Galerella*). Black and white photographs of basidiomata and microscopic elements accompany the description. *G. nigeriensis* is compared to related species and a worldwide diagnostic key to the genus *Galerella* is provided.

Key words — *Basidiomycota,* biodiversity, *Bolbitiaceae,* mycobiota, taxonomy

Introduction

The third author conducted a field research of Nigerian mycobiota during the rainy season from June to August 2008. Among collected samples, we discovered a new species of *Galerella* that we describe here. *Galerella* Earle is a small genus of the family *Bolbitiaceae* Singer with five already known and well documented species: *G. fibrillosa* Hauskn., *G. floriformis* Hauskn., *G. microphues* (Berk. & Broome) Pegler, *G. plicatella* (Peck) Singer, and *G. plicatelloides* Sarwal & Locq. (see Sarwal & Locquin 1983, Hausknecht & Contu 2003). *Galerella conocephala* (Bull. : Fr.) Bon is considered a doubtful species by Hausknecht & Contu (2003) because of unclear interpretation and the lack of a holotype and recent material. *Galerella* species are saprotrophs, growing mostly on soil, but also on decaying twigs or wood. All species are rare (recorded only once or twice except *G. plicatella*). They are distributed throughout tropical and/or subtropical zone (including Mediterranean area), while *G. plicatella* also occurs

in areas with a continental climate. Morphologically, *Galerella* is characterized by a hymeniform pileipellis, rusty brown spore print, mainly dry and strikingly plicate-sulcate pileus (as in many *Coprinus* species), and by the absence of lecythiform cystidia (Horak 1968, Singer 1986, Hausknecht & Contu 2003). Although most authors consider *Galerella* an independent genus (Horak 1968, 2005, Moser 1983, Pegler 1986, Singer 1986, Bon 1992, Hausknecht & Contu 2003), some authors include *Galerella* in *Conocybe* Fayod s.l. (Watling 1982, as a subgenus) or *Pholiotina* Fayod (Arnolds 2005). In order to better understand the phylogenetic relationships between *Galerella* and related genera, molecular analyses are required.

Materials and methods

The holotype description is based on one collection containing seven basidiomata, which were photographed in the field. Color codes in the macroscopic description (given in brackets) are cited according to Kornerup & Wanscher (1981). Microscopic features were observed using a light microscope (brightfield and phase contrast) with magnification up to 1500× and photographed with a digital camera. Description and photographs of microscopic characters were made from rehydrated dried specimens mounted in 2.5% potassium hydroxide (KOH) solution. Basidiospore color was also observed in H_2O and 10% NH_4OH. Basidiospore measurements were made from the mounts of lamellae and based on calibrated digital photographs: only mature spores (determined by color and appearance) were measured. The width of germ-pore was measured as inner distance between spore walls at the spore apex. A total number of 120 randomly selected basidiospores from two mature basidiomata were measured (60 in frontal view, 60 in side view). Spore measurements are given as: (min.) stat. min. – av. – stat. max. (max), where "min." = minimum (lowest measured value), "stat. min." = statistical minimum (arithmetic average minus two times standard deviation), "av." = arithmetic average, "stat. max." = statistical maximum (arithmetic average plus two times standard deviation), "max." = maximum (highest measured value). Standard deviations (SD) of spore length, breadth, and width are also given. The length/breadth ratio of spores (frontal view) is given as the "Qf" value (min. – av. – max.) and length/width ratio of spores (side view) is given as the "Qs" value (min. – av. – max.). Holotype and accompanied data are deposited at the Croatian National Fungarium in Zagreb (CNF).

The term hymenophysalides is used according to Clémençon (1997, 2004) for sterile, short, turgescent cells that surround the basidia (present in hymenium of some *Agaricales*), also called pseudoparaphyses, brachycystidia, brachybasidioles, or pavement cells. Comparison of *G. nigeriensis* with similar taxa and the diagnostic key of *Galerella* species are based on the descriptions

FIGS 1–2. Basidiomata of *Galerella nigeriensis* in situ. Bars = 5 mm.

and illustrations in the following literature: Horak 1968, Sarwal & Locquin 1983, Pegler 1986, Thomas et al. 2001, Horak & Hausknecht 2002, Arnolds

& Hausknecht 2003, Hausknecht & Contu 2003, Hausknecht et al. 2004, Hausknecht 2009.

Taxonomy

Galerella nigeriensis Tkalčec, Mešić & Čerkez, **sp. nov.** FIGS 1–10

MycoBank MB 518311

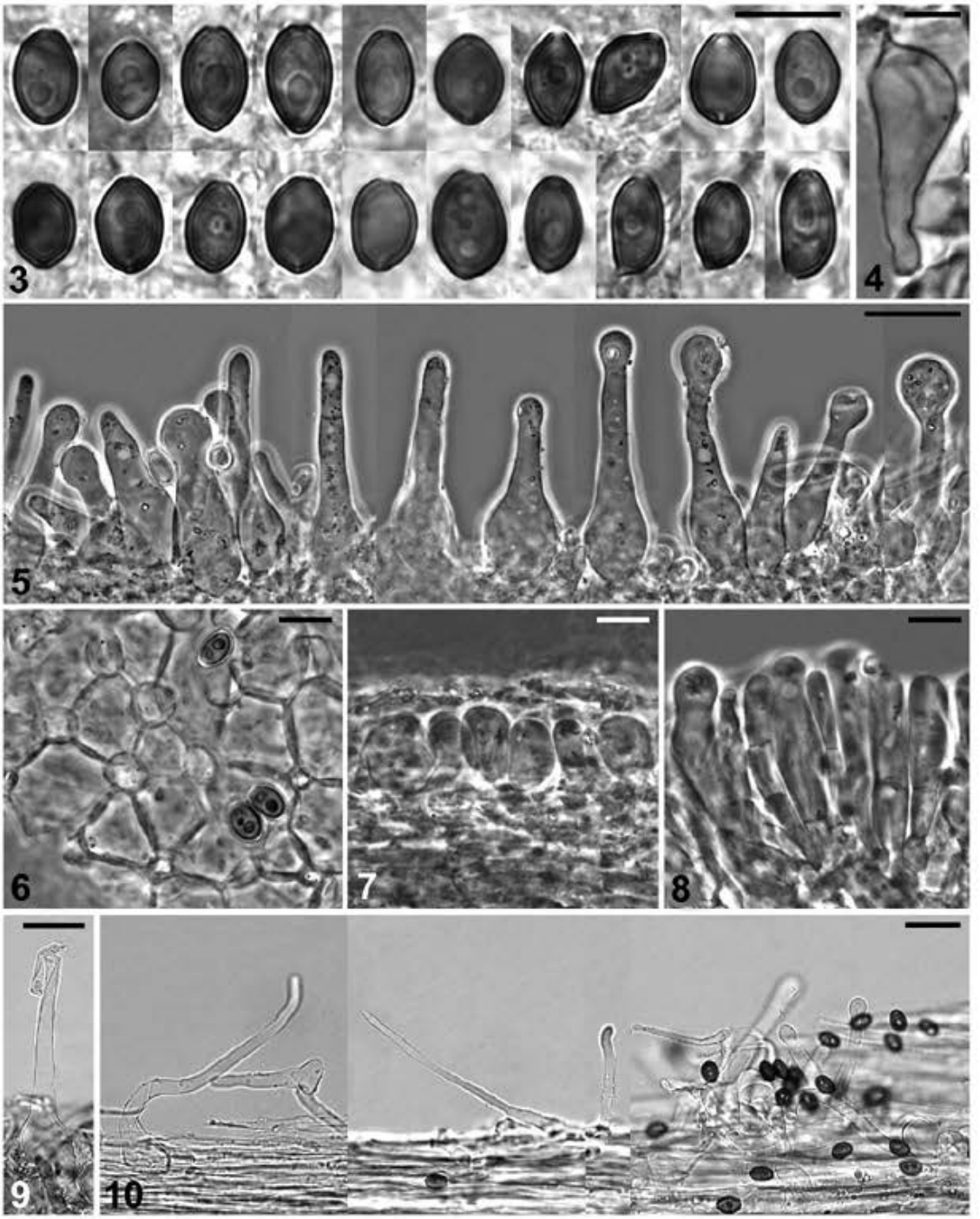
Pileus 14–17 mm latus, valde plicatus, siccus, pallide flavido-brunneus vel aurantio-brunneus. Velum praesens, filamentosum, albicans. Lamellae anguste adnatae, ferrugineae. Stipes 26–32 × 1–1.5 mm, pubescens, albus. Sporae (6.9–)7.3–8.8–10.4(–10.7) × (5.1–)5.3–6.1–6.8(–6.9) × (4.5–)4.6–5.3–6.0(–6.2) µm, plerumque lentiformes, crasse tunicatae, in KOH ferrugineae. Hymenophysalides praesentes, cheilocystidia (25–)30–65 × 8–14(–17) µm, tibiiformia vel lageniformia, pileocystidia et caulocystidia praesentia, fibulae abundantes.

Etymology: The species is named after Nigeria, the country of origin.

Holotype: NIGERIA, ONDO STATE: 11 km NW of Akure, 7°19'28" N, 5°7'31" E, alt. 400 m, 25 Jul 2008, leg. M. Čerkez (CNF 1/5859).

Pileus 14–17 mm broad, broadly ellipsoid to oblong at first, later obtusely conical with a small papilla, pale yellowish brown to light orange brown, with darker, orange brown (6C8) to dark reddish brown (8E8, 9E8, 9F8) center, not hygrophanous, surface dull, dry, strongly plicate-sulcate up to 3/4 of the radius. Veil white or whitish, only in some places light brown, densely fibrillose and covering the whole basidioma at first, in maturity remains at the center of the pileus as small patches and usually at the base of the stipe as a small volva-like remnants. Lamellae narrowly adnate, rather crowded (L = ca. 32, l = 0–3), broad (up to 2 mm), very thin, white at first, later pale to rusty brown, with paler to concolorous, slightly flocculose edge. Stipe 26–32 × 1–1.5 mm, in the lower part gradually thickening to the base (up to 3 mm wide), white to pale cream, entirely densely pubescent, weakly striate lengthwise, dry, fistulose. Context very thin, whitish in stipe, brownish in pileus when moist and whitish on drying. Smell and taste not recorded. Spore print rusty brown.

Basidiospores [120/2/1] (6.9–)7.3–*8.8*–10.4(–10.7) × (5.1–)5.3–*6.1*–6.8(–6.9) × (4.5–)4.6–5.3–6.0(–6.2) µm, SD = 0.76 × 0.37 × 0.35, Q_f = 1.29–*1.44*–1.71, Q_s = 1.51–*1.69*–2.02, variable in size and shape, ellipsoid, slightly angular to subhexagonal, ovoid, limoniform or subamygdaliform in frontal view, ellipsoid, oblong or amygdaliform in side view, mostly flattened, thick-walled (0.6–0.9 µm), with central to slightly eccentric, ± truncate, 0.6–1.4 µm wide germ-pore, rusty brown in KOH and NH_4OH, yellow brown in H_2O, non-amyloid and non-dextrinoid. Basidia 18–23 × 8–11 µm, 4-spored, clavate, hyaline, thin-walled, surrounded by 3–5 hymenophysalides. Basidioles narrowly clavate to clavate. Hymenophysalides 16–40 × 11–22(–30) µm, subglobose, sphaeropedunculate, ellipsoid or broadly clavate, hyaline, well



FIGS 3–10. *Galerella nigeriensis*. 3. Spores. 4. Basidium (phase contrast). 5. Cheilocystidia (phase contrast). 6. Hymenophysalides and basidia (phase contrast). 7. Pileipellis near margin of the pileus (phase contrast). 8. Pileipellis near center of the pileus (phase contrast). 9. Pileocystidium. 10. Caulocystidia. Bars: 3, 6–8 = 10 µm; 4 = 5 µm; 5, 9, 10 = 20 µm.

developed in mature basidiomata. LAMELLAR EDGE almost sterile (basidia very rare). CHEILOCYSTIDIA (25–)30–65 × 8–14(–17) µm, tibiiform (± 50%) with subcapitate to capitate apex 5–11 µm broad or lageniform with 3–5 µm

wide neck, less often conical, thin-walled to slightly thick-walled (≤0.5 μm), hyaline. PLEUROCYSTIDIA absent. HYMENOPHORAL TRAMA made of much branched, mostly strongly and irregularly inflated hyphae, hyaline, thin-walled to thick-walled (≤0.8 μm), 1–20(–32) μm wide. PILEIPELLIS a hymeniderm, at the center of the pileus physalo-palisadoderm, regularly formed only in young basidiomata, elements mainly broadly to narrowly clavate, less often ellipsoid, obovoid, subcylindrical or narrowly utriform, 9–50(–63) × 3.5–12(–18) μm, thin-walled, subhyaline. Yellowish brown intracellular pigment present in the subpellis and the upper part of pileal trama. PILEOCYSTIDIA scattered, lageniform with very long neck to filiform, hyaline, thin-walled, 50–250 × 6–17 μm, upper part 3–5 μm broad. STIPITIPELLIS a cutis, made of parallel, thin-walled, hyaline, 2–10 μm wide hyphae. CAULOCYSTIDIA very variable in size and shape, 10–330 × 3–15 μm, mostly filiform or lageniform (often with very long neck), but also tibiiform, subcylindrical, clavate, ellipsoid or irregularly shaped, sometimes with horizontally elongated base, thin-walled, hyaline. VEIL made of elongated, occasionally branched, thin-walled, hyaline, 1.5–4(–6.5) μm wide hyphae. CLAMP CONNECTIONS abundant in all tissues.

HABITAT — Gregarious, lignicolous, on a very rotten stump at the edge of a heavily disturbed secondary tropical forest (with *Theobroma cacao, Musa* sp., *Elaeis guineensis*).

DISTRIBUTION — Known only from the type locality in Nigeria.

REMARKS — *Galerella nigeriensis* is characterized by a strongly plicate-sulcate, completely dry, pale yellowish brown to light orange brown pileus with a darker center, whitish veil on pileus and stipe base, white and pubescent stipe, thick-walled, mostly flattened and often somewhat angular basidiospores, tibiiform to lageniform cheilocystidia, and presence of hymenophysalides. Hitherto, hymenophysalides have been recorded only in the genera *Bolbitius* Fr., *Conocybe, Coprinus* Pers. s.l., and *Leucocoprinus* Pat. (Clémençon 2004). Although our new species share this character with all *Bolbitius* and some *Conocybe* species, we placed our taxon in the genus *Galerella* on the basis of its strongly plicate-sulcate and completely dry pileus, well developed universal veil, and the absence of lecythiform cystidia. *Bolbitius* species have viscid pilei and lack universal veils, while *Conocybe* species have smooth or rugulose pilei, lecythiform cystidia, and lack universal veils. On the other hand, the presence of a delicate universal veil that covers the entire pileus in young stages was recorded by Hausknecht & Contu (2003) in three other *Galerella* species (*G. fibrillosa, G. floriformis,* and *G. plicatella*).

Galerella nigeriensis can be easily differentiated from other species in the genus by the presence of hymenophysalides and abundant tibiiform cheilocystidia (lacking in other *Galerella* species). *Pholiotina sulcata* Arnolds

& Hauskn. has until recently been mistaken for *G. plicatella* by European and probably Asian authors due to its pileus that varies from weakly striate to irregularly plicate-sulcate (Arnolds & Hausknecht 2003, Hausknecht 2009, Hausknecht et al. 2009). *Pholiotina sulcata* lacks hymenophysalides, tibiiform cheilocystidia, and a veil. The most important differences among world species of *Galerella* are presented in a diagnostic key.

Key to the world species of *Galerella*

1. Cheilocystidia absent 2
1. Cheilocystidia present, well differentiated, and abundant 3
2. Spores 11–16.5 × 7–10 µm, with germ-pore, thick-walled ..... ***G. plicatelloides***
2. Spores 7–11 × 3.5–4 µm, without germ-pore, thin-walled ..... ***G. floriformis***
3. Hymenophysalides present and well developed in mature basidiomata, cheilocystidia tibiiform and lageniform (in approximately equal proportion) ..... ***G. nigeriensis***
3. Hymenophysalides absent, cheilocystidia not tibiiform (mostly lageniform, only sometimes with slightly broadened apex) 4
4. Cheilocystidia ≤35 µm long, pileus whitish ..... ***G. microphues***
4. Cheilocystidia ≤50(–65) µm long, pileus pale yellowish- to orange- or reddish-brown 5
5. Spores thin- to slightly thick-walled, cheilocystidia 6–11(–16.5) µm broad ..... ***G. plicatella***
5. Spores distinctly thick-walled, cheilocystidia 10–20 µm broad ..... ***G. fibrillosa***

Acknowledgements

We would like to thank Marco Contu for sending us the photograph of *G. plicatella* and to Vesna Lopina for her help with the Latin description. We are very grateful to Anton Hausknecht (Fakultätszentrum für Biodiversität der Universität Wien, Austria) and Dr. Vagner Gularte Cortez (Universidade Federal do Paraná, Brazil) for their critical reviews of the manuscript.

Literature cited

Arnolds E. 2005. *Pholiotina* Fay. Pp. 180–203. In: Noordeloos ME, Kuyper TW, Vellinga EC (eds.). Flora agaricina neerlandica 6. Taylor & Francis: Boca Raton (USA).

Arnolds E, Hausknecht A. 2003. Notulae ad floram agaricinam neerlandicam – XLI: *Conocybe* and *Pholiotina*. Persoonia 18(2): 239–252.

Bon M. 1992. Clé monographique des especes galero-naucorioïdes. Doc. Mycol. 21(84): 1–89.

Clémençon H. 1997. Anatomie der Hymenomyceten. Kommissionsverlag F. Flück-Wirth: Teufen (Switzerland).

Clémençon H. 2004. Cytology and plectology of the *Hymenomycetes*. J. Cramer: Berlin - Stuttgart (Germany).

Hausknecht A. 2009. *Conocybe* Fayod – *Pholiotina* Fayod. Fungi Europaei 11. Edizioni Candusso: Alassio (Italy).

Hausknecht A, Contu M. 2003. The genus *Galerella*. A world-wide survey. Österr. Z. Pilzk. 12: 31–40.

Hausknecht A, Kalamees K, Knudsen H, Mukhin V. 2009. The genera *Conocybe* and *Pholiotina* (*Agaricomycotina, Bolbitiaceae*) in temperate Asia. Folia Cryptog. Estonica 45: 23–47.

Hausknecht A, Krisai-Greilhuber I, Voglmayr H. 2004. Type studies in North American species of *Bolbitiaceae* belonging to the genera *Conocybe* and *Pholiotina*. Österr. Z. Pilzk. 13: 153–235.

Horak E. 1968. Synopsis generum Agaricalium (Die Gattungstypen der *Agaricales*). Beiträge zur Kryptogamenflora der Schweiz. Band XIII. Komissionsverlag Druckerei Büchler: Wabern (Switzerland).

Horak E. 2005. Röhrlinge und Blätterpilze in Europa. Elsevier: München (Germany).

Horak E, Hausknecht A. 2002. Notes on extra-European taxa of *Bolbitiaceae* (*Agaricales, Basidiomycota*). Österr. Z. Pilzk. 11: 213–264.

Kornerup A, Wanscher JH. 1981. Taschenlexikon der Farben. Muster-Schmidt Verlag: Zürich (Switzerland).

Moser M. 1983. Die Röhrlinge und Blätterpilze (*Polyporales, Boletales, Agaricales, Russulales*). Gustav Fischer Verlag: Stuttgart (Germany).

Pegler DN. 1986. Agaric Flora of Sri Lanka. Kew Bulletin Additional Series XII. Royal Botanic Gardens: Kew (UK).

Sarwal BM, Locquin MV. 1983. Les champignons de l'Himalaya dans leurs relations avec la flore eurasiatique. Compt. Rend. Congr. Natl. Soc. Savantes, Sec. Sci. 108: 191–201.

Singer R. 1986. The *Agaricales* in Modern Taxonomy. 4th ed. Koeltz Scientific Books: Koenigstein (Germany).

Thomas KA, Hausknecht A, Manimohan P. 2001. *Bolbitiaceae* of Kerala State, India: New species and new and noteworthy records. Österr. Z. Pilzk. 10: 87–114.

Watling R. 1982. *Bolbitiaceae: Agrocybe, Bolbitius* & *Conocybe*. Pp. 1–139. In: Henderson DM, Orton PD, Watling R (eds.). British Fungus Flora 3. Royal Botanic Garden: Edinburgh (UK).

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.271

Volume 114, pp. 271–279 October–December 2010

Studies of *Exobasidium* new to China: *E. rhododendri-siderophylli* sp. nov. and *E. splendidum*

ZHENYING LI[1,2] & LIN GUO[1*]

*lizhying@163.com & *guol@im.ac.cn

[1]*Key Laboratory of Systematic Mycology and Lichenology*
Institute of Microbiology, Chinese Academy of Sciences
Beijing 100101, China

[2]*Donggaodi Science and Technology Center for Teenagers*
Beijing 100076, China

Abstract—A new species, *Exobasidium rhododendri-siderophylli* causing leaf hypertrophy on *Rhododendron siderophyllum*, is described and a new Chinese record, *Exobasidium splendidum* on *Vaccinium fragile*, are reported from Yunnan Province, China. The new species is characterized by symptoms, number of sterigmata, and short germ tubes. Molecular sequence analyses of 22 *Exobasidium* species reveal that phylogenetic relationships within *Exobasidium* correspond to the host plants and symptoms.

Key words—*Exobasidiomycetes*, molecular analysis, taxonomy

A new species of *Exobasidium* on *Rhododendron siderophyllum* was collected from Yunnan Province. The host plant belongs to the subfamily *Rhododendroideae* of *Ericaceae*. The *Exobasidium* species is parasitic on young leaves and fruit, causing hypertrophy. The diseased leaf is almost wholly hypertrophied, pale yellow, and 2–3.3 cm long, 0.5–1.8 cm wide, and 2.5 mm thick; when mature, the underside is covered with a white hymenium. A transverse section of a diseased leaf shows a differentiation between the palisade and mesophyll cells, but it is not clear. The diseased fruit is entirely hypertrophied, 1.8 × 1.3 cm, and also covered with white hymenium when mature. The new species — characterized by the described symptoms, possession of 3–7 sterigmata, and short germ tubes — is described as:

Exobasidium rhododendri-siderophylli ZhenYing Li & L. Guo, **sp. nov.**

MYCOBANK MB 518411 FIGS. 1–4

Hymenium hypophyllum. Basidia hyalina, cylindrica vel clavata, 5–9 µm lata, terminaliter 3–7 sterigmatibus 5–6(–7) × 1–1.5(–1.8) µm praedita. Basidiosporae ellipsoideae vel

*corresponding author

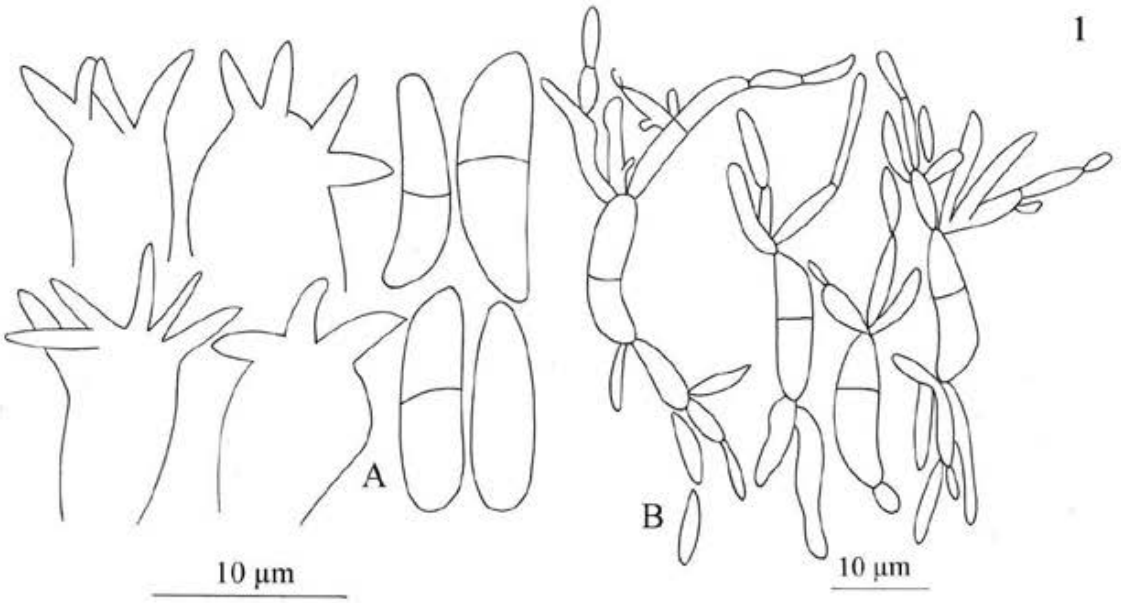


FIG. 1. Line drawings of *Exobasidium rhododendri-siderophylli* on *Rhododendron siderophyllum* (HMAS 183424, holotype). A. Basidia, sterigmata and basidiospores. B. Germinating basidiospores.

clavatae, interdum curvae, (12–)13–15(–18.5) × 3–4 μm, hyalinae, leves, primo continuae, dein 1-septatae.

TYPE: On *Rhododendron siderophyllum* Franch. (*Ericaceae*), Yunnan: Luquan, alt. 2520 m, 1.VII.2006, Z.Y. Li & L. Guo 339, HMAS 183424 **(holotype)**.

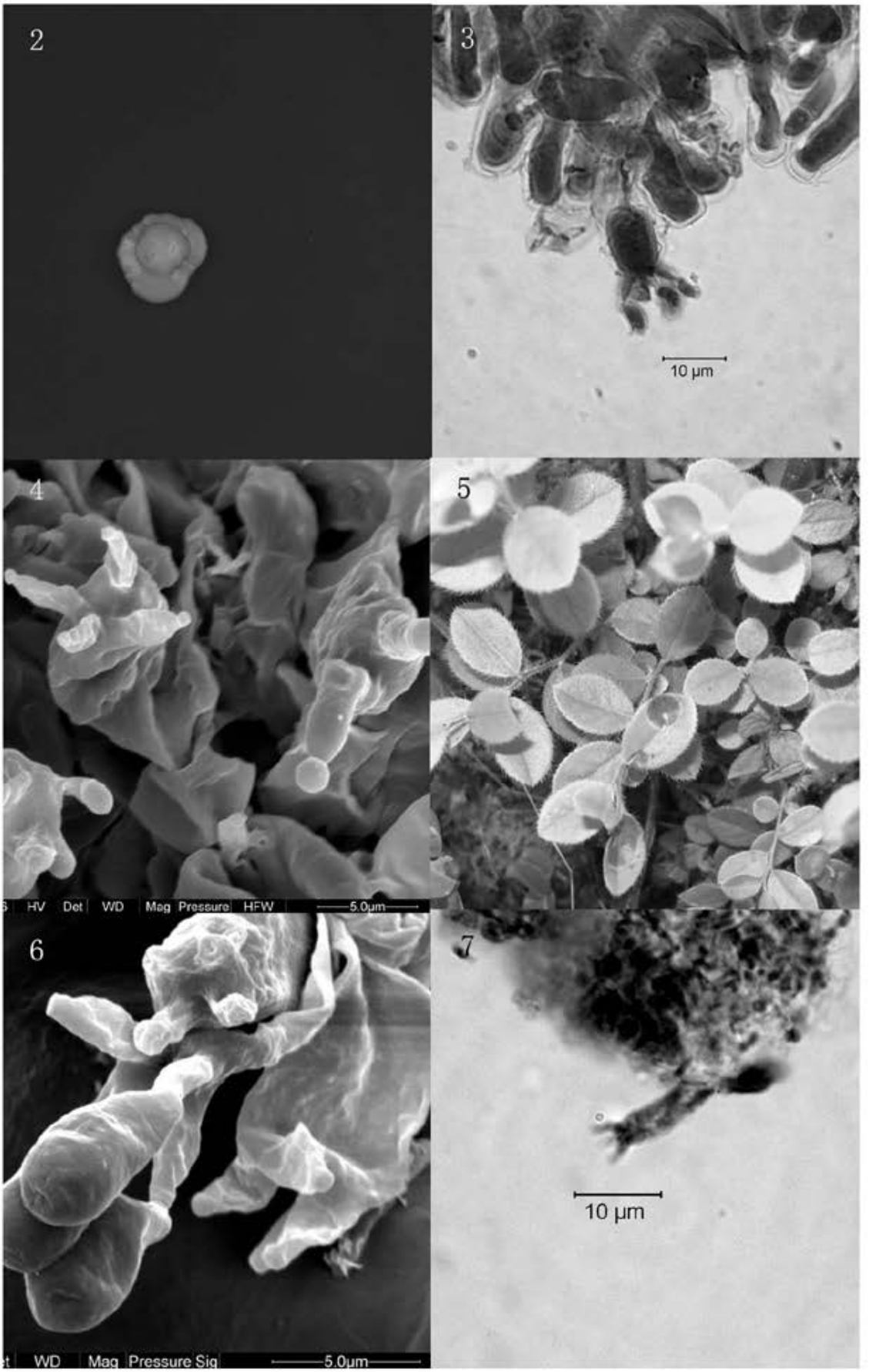
Hymenium hypophyllous. Basidia hyaline, cylindrical or clavate, 5–9 μm diam., with 3–7 sterigmata. Sterigmata conical, 5–6(–7) × 1–1.5(–1.8) μm. Basidiospores ellipsoidal or clavate, occasionally curved, (12–)13–15(–18.5) × 3–4 μm, hyaline, smooth, at first continuous, then 1-septate.

Colonies on potato dextrose agar (PDA) grew slowly, to a maximum 8 mm diameter after 21 days incubation at 25°C. The colony was pale yellow, composed of conidia. Conidia bacilliform, 5–7.5 × 1–2 μm.

ADDITIONAL SPECIMENS EXAMINED: On *Rhododendron siderophyllum* Franch. (*Ericaceae*), Yunnan: Luquan, alt. 2520 m, 1.VII.2006, Z.Y. Li & L. Guo 338, HMAS 183429 **(paratype)**; Z.Y. Li & L. Guo 336, HMAS 183428 **(paratype)**. On *Rhododendron tatsienense* Franch. (*Ericaceae*), Yunnan: Luquan, alt. 2530 m, 1.VII.2006, Z.Y. Li & L. Guo 329 HMAS 183437 **(paratype)**.

REMARKS: Morphologically, *Exobasidium rhododendri* (Fuckel) C.E. Cramer (Nannfeldt 1981) on *Rhododendron ferrugineum* L. has similarly sized

FIGS. 2–4. *Exobasidium rhododendri-siderophylli* on *Rhododendron siderophyllum* (HMAS 183424, holotype). 2. Colony on PDA. 3. Basidium, sterigmata and basidiospores as seen by LM. 4. Basidia and sterigmata as seen by SEM. FIGS. 5–7. *Exobasidium splendidum* on *Vaccinium fragile* (HMAS 183436). 5. Symptoms. 6. Basidia, sterigmata and basidiospores as seen by SEM. 7. Basidium and sterigmata as seen by LM.


2
3
10 µm
4
HV Det WD Mag Pressure HFW 5.0µm
5
6
WD Mag Pressure Sig 5.0µm
7
10 µm

basidiospores (12–15 × 2.5–4 μm) but differs from *E. rhododendri-siderophylli* in that it causes galls.

Exobasidium splendidum, discovered in Yunnan Province, is a new Chinese record. It is parasitic on *Vaccinium fragile*, causing leaf spots, usually 1(–2) on each leaf. The upper side of the diseased parts is slightly concave and red to pale red, and the underside becomes covered with white hymenium during maturation. The leaf spots can be 3.5–5.5 mm in diam. Transverse sections of the diseased leaf show clear differentiation of the palisade and mesophyll cells. There is no hypertrophy and hyperplasia of plant cells.

Exobasidium splendidum Nannf., Symb. Bot. Upsal. 23(2): 58, 1981. FIGS. 5–8

SPECIMEN EXAMINED—On *Vaccinium fragile* Franch. (*Ericaceae*), Yunnan: Yangbi, Shangjie, Mopandi, alt. 2350 m, 14.IX.2005, Z.Y. Li, L. Guo & N. Liu 117, HMAS 183436.

Hymenium hypophyllous, white. Basidia hyaline, cylindrical, 4–8 μm, with 2–4 sterigmata. Sterigmata conical, 3–5 × 1–2 μm. Basidiospores cylindrical, clavate or obovoid, often curved, (7–)9–14(–16) × 3–4.2(–5) μm, hyaline, smooth, at first continuous, then 1–3-septate.

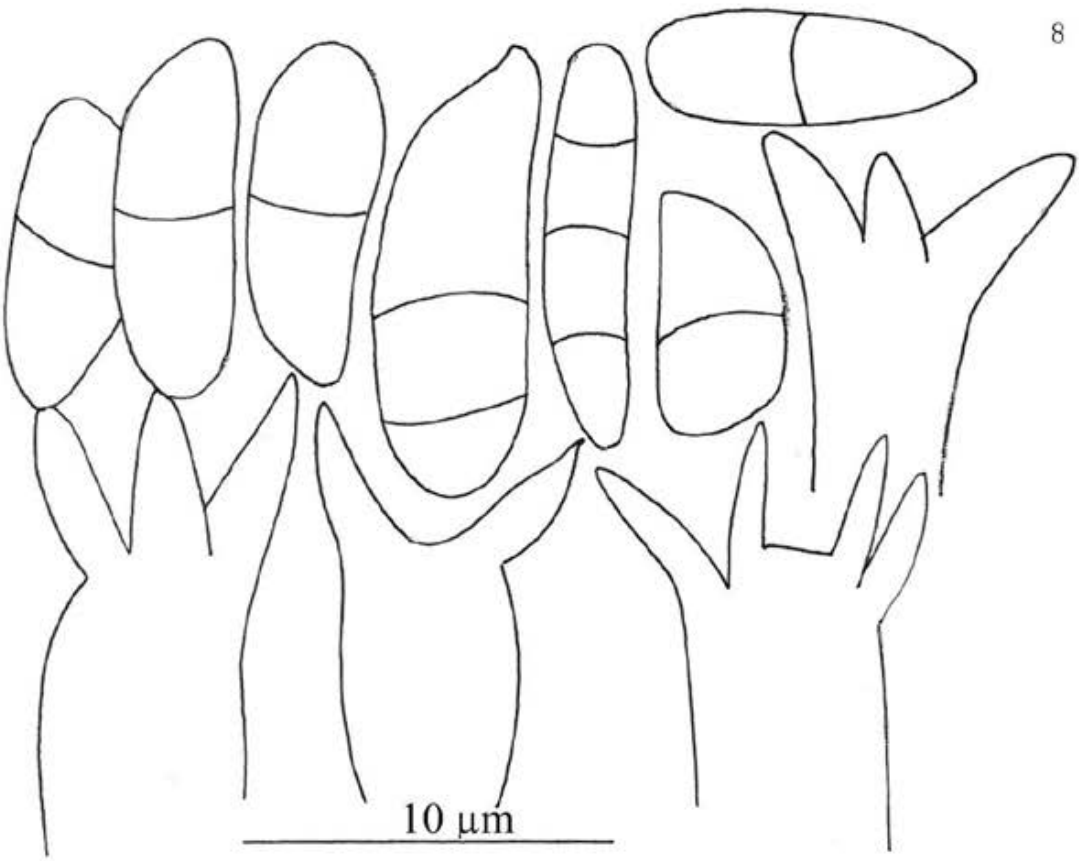


FIG. 8. Line drawings of *Exobasidium splendidum* on *Vaccinium fragile* (HMAS 183436). A. Basidia, sterigmata and basidiospores. B. Germinating basidiospores.

Thirty-three species of *Exobasidium* have been reported in China (Sawada 1922, Teng 1963, Tai 1979, Guo et al. 1991, Zang 1996, Li & Guo 2006a,b, 2008a,b, 2009a,b), including the two species recorded in this paper.

For phylogenetic analyses, the partial nrDNA-LSU (LSU) and ITS1-5.8S-ITS2 (ITS) genes were sequenced (White et al. 1990). Thirty-one sequences of 43 isolates (22 species) (TABLE 1), including 14 sequences (11 species) downloaded from Genbank, were used. Seventeen isolates (11 species) were collected by the authors. All strains collected by the authors were deposited in China General Microbiological Collection Center (CGMCC) (TABLE 1), and all sequences generated in this study were submitted to GenBank. Two *Entyloma* species were used as outgroup.

TABLE 1. Materials used in analysis of the nrDNA-LSU and nrDNA-ITS rDNA sequences

TAXON	SYMPTOM	HOST	COLLECTION	GENBANK NO.	
				LSU	ITS
E. bisporum	leaf spots	*Eu. grayana* var. *glabra*	IFO9942	AB177598	AB180364
E. camelliae	fruit & leaf hypertrophy	*C. japonica*	MAFF238578	AB176712	AB180317
*E. canadense**	leaf spots	*R. mariesii*	HMAS 173409	EU692791	EU692771
E. cylindrosporum	leaf spots	*R.* sp.	MAFF238608	AB178245	
E. cylindrosporum	leaf spots	*R. pulchrum*	MAFF238579		AB180318
*E .cylindrosporum**	leaf spots	*R.* sp.	HMAS 183415	EU692795	EU692776
*E. euryae**	galls	*C. oleifera*	HMAS 97947	EU692779	EU692759
*E. formosanum**	galls	*R. delavayi*	HMAS 183418	EU692781	EU692775
*E. formosanum**	galls	*R.* sp.	HMAS 183445	EU692796	EU692777
*E. gracile**	leaf hypertrophy	*C. oleifera*	HMAS 140210	EU692780	
*E. gracile**	leaf hypertrophy	*C. oleifera*	HMAS 140502		EU692761
E. gracile	leaf hypertrophy	*C. sasanqua*	TUK-E30	AB177592	
E. gracile	leaf hypertrophy	*C. sasanqua*	MAFF238586		AB180322
E. inconspicuum	leaf spots	*V. hirtum* var. *pubescens*	MAFF238616	AB177556	
E. inconspicuum	leaf spots	*V. hirtum* var. *pubescens*	MAFF238619		AB180350
*E. japonicum**	leaf deform & hypertrophy	*R. pulchrum*	HMAS 172284	EU692788	EU692773
*E. japonicum**	leaf hypertrophy	*R. simsii*	HMAS 175467	EU692790	EU692766
*E. japonicum**	leaf deform & hypertrophy	*R.* sp.	HMAS 175457	EU692792	EU692772
*E. japonicum**	leaf deform & hypertrophy	*R.* sp.	HMAS 175455	EU692793	EU692768

TABLE 1, concluded.

TAXON	SYMPTOM	HOST	COLLECTION	GENBANK NO.	
				LSU	ITS
*E. japonicum**	leaf deform & hypertrophy	*R.* sp.	HMAS 175454	EU692794	EU692769
E. japonicum	leaf deform & hypertrophy	*R. obtusum* var. *kaempferi*	MAFF238826	AB178253	
E. japonicum	leaf deform & hypertrophy	*R. lateritium*	IFO30756		AB180370
*E. kunmingense**	leaf spots	*L. ovalifolia*	HMAS 173147	EU692784	EU692763
*E. lushanense**	leaf spots	*R. simsii*	HMAS 173148	EU692789	EU692767
E. miyabei	leaf spots	*R. dauricum*	MAFF238583	AB177550	
E. miyabei	leaf spots	*R. dauricum*	MAFF238595		AB180330
E. nobeyamense	witches' broom	*R. wadanum*	MAFF238583	AB180378	
E. nobeyamense	witches' broom	*R. wadanum*	MAFF238598		AB180332
E. otanianum	leaf spots		IFO9960	AB177600	
E. otanianum	leaf spots	*R. hyugaense*	MAFF238612		AB180344
E. pentasporium	witches' broom & leaf spots	*R. obtusum* var. *kaempferi*	MAFF238601	AB177567	
E. pentasporium	witches' broom & leaf spots	*R. obtusum* var. *kaempferi*	MAFF238179		AB180316
E. pieridis-ovalifoliae	leaf spots	*L. neziki*	IFO9961	AB177601	AB180367
E. rhododendri	galls	*R. ferrugineum*	R.B.2050	AF009856	
E. rhododendri	galls	*R.* sp.	CBS101457		DQ667153
*E. rhododendri-russati**	galls	*R. russatum*	HMAS 183433	EU692797	EU692778
*E. rhododendri-siderophylli**	leaf hypertrophy	*R. tatsienense*	HMAS 183437	EU692782	EU692762
*E. rhododendri-siderophylli**	leaf hypertrophy	*R. siderophyllum*	HMAS 183428	EU692786	EU692765
*E. rhododendri-siderophylli**	leaf hypertrophy	*R. siderophyllum*	HMAS 183429	EU692786	EU692764
E. woronichinii	leaf spots	*R. brachycarpum*	MAFF238825	AB178252	
E. woronichinii	leaf spots	*R. brachycarpum*	MAFF238617		AB180348
E. yoshinagae	leaf spots	*R. wadanum*	MAFF238606	AB177551	
E. yoshinagae	leaf spots	*R. reticulatum*	IFO9959		AB180365
Entyloma ficariae		*Ra. ficaria*		AY081013	
Entyloma ficariae		*Ra. ficaria*			AY081035
Entyloma linariae		*Linaria vulgaris*		AY860054	
Entyloma linariae		*Linaria vulgaris*			AY081041

* = collected and sequenced by the authors.
C. = *Camellia*, *E.* = *Exobasidium*, *Eu.* = *Eubotryoides*, *L.* = *Lyonia*, *R.* = *Rhododendron*, *Ra.* = *Ranunculus*, *V.* = *Vaccinium*.

Two sequence sets, both independently and combined, were analyzed following the Minimum Evolution method (ME) (Rzhetsky & Nei 1992). As

all the ME trees derived from the independent and combined ITS and LSU sequence analyses share similar topologies structure and main clades, only the ME tree based on the combined ITS and LSU analysis is shown (FIG. 9).

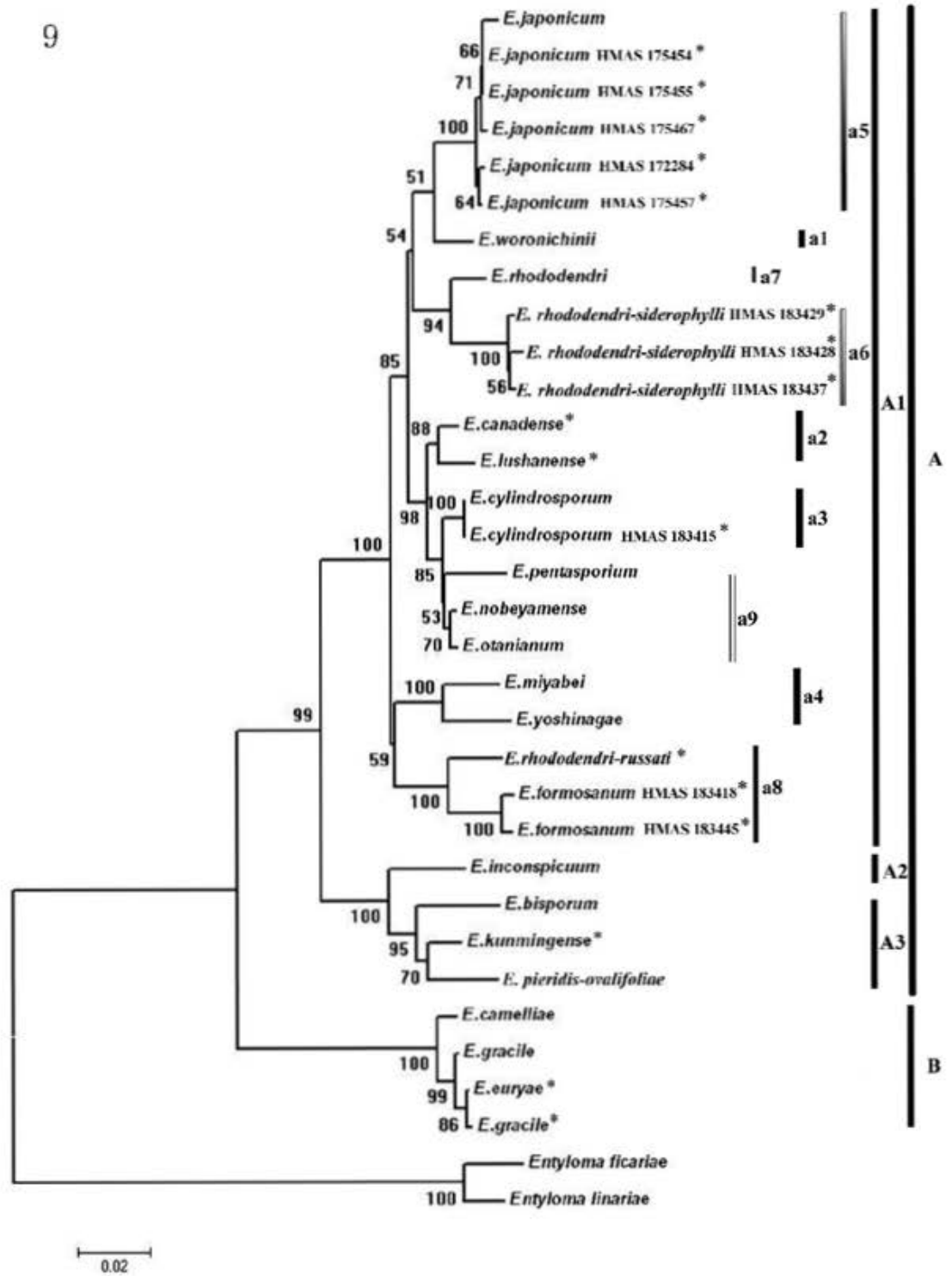


FIG. 9. ME tree based on analysis of nrDNA-ITS/nrDNA-LSU sequences. The numbers on the branches indicate bootstrap values, following the 50% majority rule. * = collected and sequenced by the authors; *E.*= *Exobasidium*. Bar types correspond to the different symptoms, i.e. leaf spots (a1–a4), leaf hypertrophy (a–a6), galls (a7–a8), and witches' broom (a9).

The combined tree is the most parsimonious following the 50% bootstrap majority-rule.

Two major clades (A–B) are identified in the ME tree: clade A consists of only the species parasitic on *Ericaceae*, while clade B contains species on *Theaceae*. Clade A includes three subclades: A1 on *Rhododendroideae* (*Rhododendron*), A2 on *Vaccinioideae*, and A3 on *Andromedoideae*. A1 encompasses nine small clades, including species causing different symptoms — a1–a4 causing leaf spots, a5–a6 leaf hypertrophy, a7–a8 galls, and a9 witches' broom.

Results of the molecular analyses indicate that the phylogenetic relationships within *Exobasidium* correspond to the host plants and symptoms. Host associations and symptoms should be regarded as important characteristics for morphological identification.

Acknowledgements

The authors would like to express their deep thanks to Drs Eric H.C. McKenzie (Auckland, New Zealand) and D. Begerow (Bochum, Germany) for serving as pre-submission reviewers, to Dr. Shaun Pennycook (Auckland, New Zealand) for nomenclatural review, to Mr. Ziyu Cao (Institute of Botany, Chinese Academy of Sciences) for identifying the host plants, to Mrs. Jiayi Xie and Jingnan Liang for assistance with SEM photographs, and to Mrs. Xiangfei Zhu for inking in line drawings. This study was supported by the National Natural Science Foundation of China (No. 30499340 and No. 30670005).

Literature cited

Guo L, Zhou YL, Li YB. 1991. Study of the genus *Elaeodema* and *Exobasidium sawadae*. Acta Mycol. Sin. 10: 31–35.

Li ZY, Guo L. 2006a. A new species of *Exobasidium* (*Exobasidiales*) on *Rhododendron* from China. Mycotaxon 96: 323–326.

Li ZY, Guo L. 2006b. A new species and a new Chinese record of *Exobasidium* (*Exobasidiales*) from China. Mycotaxon 97: 379–384.

Li ZY, Guo L. 2008a. Two new species of *Exobasidium* (*Exobasidiales*) from China. Mycotaxon 104: 331–336.

Li ZY, Guo L. 2008b. Two new species and a new Chinese record of *Exobasidium* (*Exobasidiales*) from China. Mycotaxon 105: 331–336.

Li ZY, Guo L. 2009a. Three new species of *Exobasidium* (*Exobasidiales*) from China. Mycotaxon 107: 215–220.

Li ZY, Guo L. 2009b. Two new species and a new Chinese record of *Exobasidium* (*Exobasidiales*). Mycotaxon 108: 479–484.

Nannfeldt JA. 1981. *Exobasidium*, a taxonomic reassessment applied to the European species. Symb. Bot. Upsal. 23(2): 1–72.

Rzhetsky A, Nei M. 1992. A simple method for estimating and testing minimum evolution trees. Mol. Biol. Evol. 9: 945–967.

Sawada K. 1922. Descriptive catalogue of the Formosan fungi. Part II. Dept. Agr. Govt. Res. Ins. Formosa. Report 2. *Exobasidiales*. pp. 106–110.

Tai FL. 1979. Sylloge Fungorum Sinicorum. Science Press, Beijing. 1527 p.

Teng SC. 1963. Fungi of China. Science Press, Beijing. 808 p.

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. pp. 315–322, in Innis MA, Gelfand DH, Sninsky JJ, White TJ (eds.). PCR Protocols: A Guide to Methods and Applications. Academic Press, New York.

Zang M. 1996. Fungi of the Hengduan Mountains. Science Press, Beijing. 598 p.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.281

Volume 114, pp. 281–303 *October–December 2010*

Biogeographical patterns in pyrenomycetous fungi and their taxonomy. 1. The Grayan disjunction

LARISSA N. VASILYEVA[1] & STEVEN L. STEPHENSON[2]

vasilyeva@biosoil.ru

[1]*Institute of Biology & Soil Science, Far East Branch of the Russian Academy of Sciences, Vladivostok 690022, Russia*

[2]*Department of Biological Sciences, University of Arkansas Fayetteville, AR 72701, USA*

Abstract — In this paper the biogeographical pattern known as the Grayan disjunction is discussed with respect to pyrenomycetous fungi. The importance of considering biogeographical data in taxonomy is emphasized. *Apiognomonia duschekiae* is described as a new species, *Biscogniauxia alnophila* is proposed as a new name for *B. mediterranea* var. *microspora*, and *Nemania sphaeriostoma* is proposed as a new combination.

Key words — *Ascomycota*, biogeography, distribution

Introduction

The importance of pyrenomycetous fungi in ecosystems as decomposer organisms cannot be overestimated, but many issues relating to their taxonomy, ecological preferences, and geographical patterns remain unclear on a global scale.

Many pyrenomycetous fungi are restricted to particular hosts, and this association suggests that each species follows the distribution of its substrates, at least within uniform climatic zones, such as the cold temperate, warm temperate, or tropical zones. Indeed, there are circumpolar, circum-boreal, and pan-tropical pyrenomycete species, which some might consider to represent the primary distribution patterns for these fungi. More limited and peculiar patterns have been not discussed or even suspected. As a result, although the Asian mycobiotas are not similar to the European mycobiota, mycologists often have applied European names to morphologically similar Asian fungi because they assume that fungi are widely distributed.

This paper discusses one biogeographical pattern that is usually termed the Grayan (Petersen & Hughes 2007) or Graysian (Tulloss 2005) disjunction in mycological literature. A number of plants and animals restricted to eastern North America where remnants of the ancient Tertiary flora persist can also occur in similar fragments of that flora in eastern Asia. Such a distribution, known as the famous "Asa Gray disjunction," has been reported for species of fungi, primarily macrofungi (Hongo & Yokoyama 1978, Zang 1986, Wu & Mueller 1997, Yang 2000, Mueller et al. 2001) or lichenized fungi (Culberson 1972, Dey 1976, Wei & Biazrov 1991). An examination of the biogeographical patterns of pyrenomycetous fungi, which have not been considered previously, reveals a number of examples of Grayan distribution.

Materials and methods

The specimens mentioned in this study were collected by the senior author over many years throughout eastern Russia and the eastern United States. The basic map was taken from the web site http://commons.wikimedia.org and modified with our data. Photographs of ascomata were obtained using a Nikon D40x digital camera.

Non-vicariance pattern

Among the pyrenomycetous fungi are two species groups that demonstrate a Grayan distribution—those that occur in eastern Asia and eastern North America and those that display a vicariance pattern. Examples of the first group are *Fracchiaea callista* (Berk. & M.A. Curtis) Sacc. (Fig. 1), "*Diatrypella informis*" Ellis & Everh. (Fig. 2), *Graphostroma platystoma* (Schwein.) Piroz. (Fig. 3), and possibly *Nitschkia floridana* Fitzp. (Vasilyeva et al. 2010). *Graphostroma platystoma* occurs on dead branches of many kinds of trees, suggesting a wide distribution, but the fungus displays an affinity for eastern Asia and eastern North America. Similarly *Diatrype albopruinosa* (Schwein.) Cooke is found only in these two widely separated areas (Fig. 4); it has a broad tree host range in eastern North America (Rappaz 1987) but occurs only on *Padus avium* Mill. in eastern Russia. This is not the only example of an apparent substrate preference displayed by pyrenomycetous or loculoascomycetous fungi in eastern Russia.

As another example, *Byssosphaeria rhodomphala* (Berk.) Cooke, occurs in eastern Russia only on *Maackia amurensis* Rupr., *Phellodendron amurense* Rupr., and *P. sachalinense* (F. Schmidt) Sarg., whereas in North America this species is known mostly on *Populus* spp. and *Robinia pseudoacacia* L. (Barr 1990). Both *Populus* and *Robinia* are present in eastern Russia, yet they apparently never serve as hosts to *Byssosphaeria rhodomphala*. *Maackia* and *Robinia* are both members of the *Fabaceae*, unlike the more distantly related *Phellodendron* (*Rutaceae*) and *Populus* (*Salicaceae*). The preference of the same

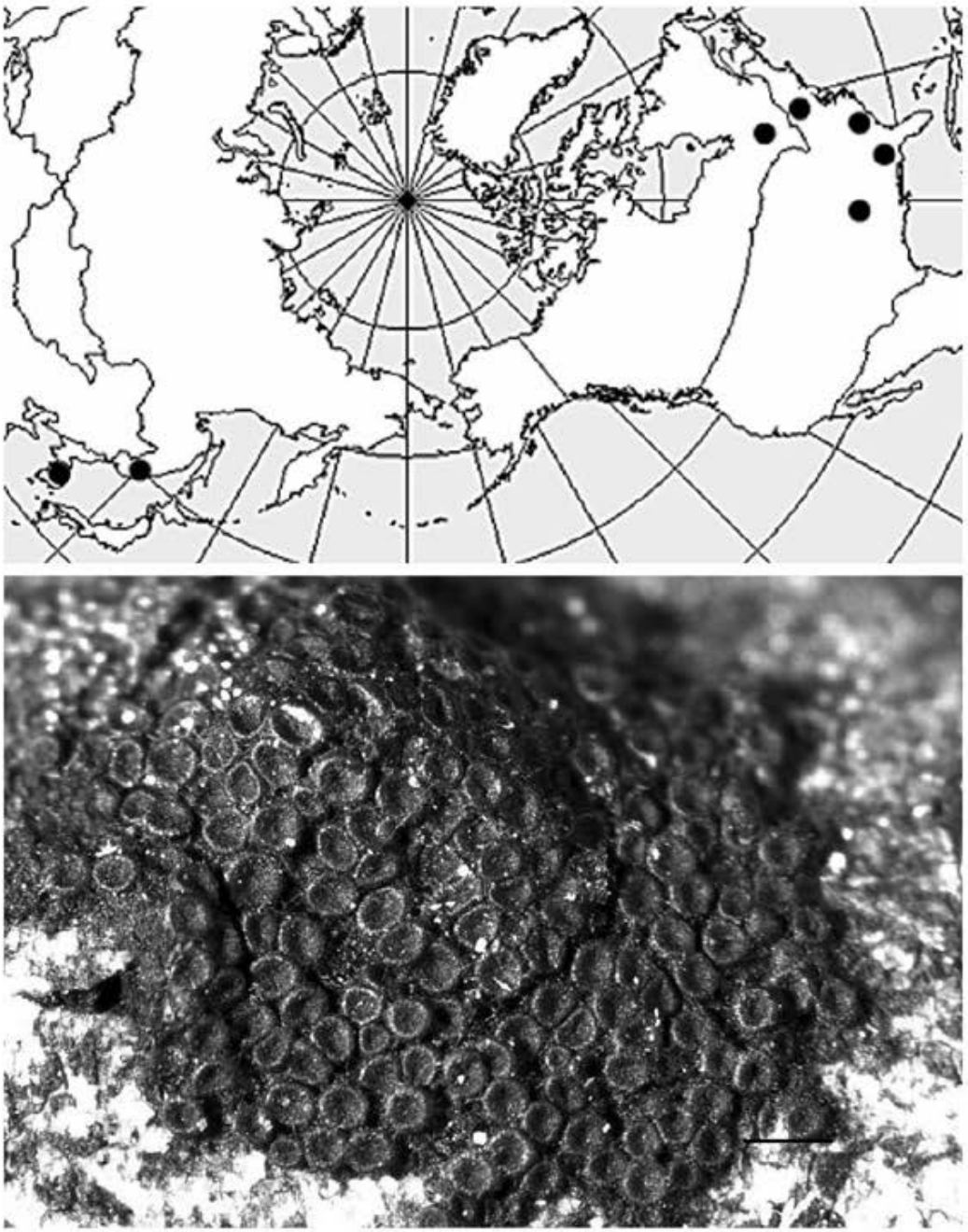


FIG. 1. Approximate biogeographical distribution of *Fracchiaea callista*. For North America, Nannfeldt (1975) cited the Alabama, Ontario, Pennsylvania, and South Carolina localities while the westernmost record thus far from Arkansas is supported by Vasilyeva's collection in the Buffalo National River; Connecticut, Maryland and Virginia are omitted. Localities in eastern Russia and South Korea are also based on the first author's own collections. Scale bar = 0.75 mm.

species for different hosts in different regions remains inexplicable — unless they are not the same species. If further studies prove them to be different species, they would represent a vicariance pattern in the Grayan distribution, discussed below.

A good example of Grayan disjunction is *Hypoxylon sphaeriostomum*, known earlier from the USA (Georgia, Ohio, and Pennsylvania; Miller 1961)

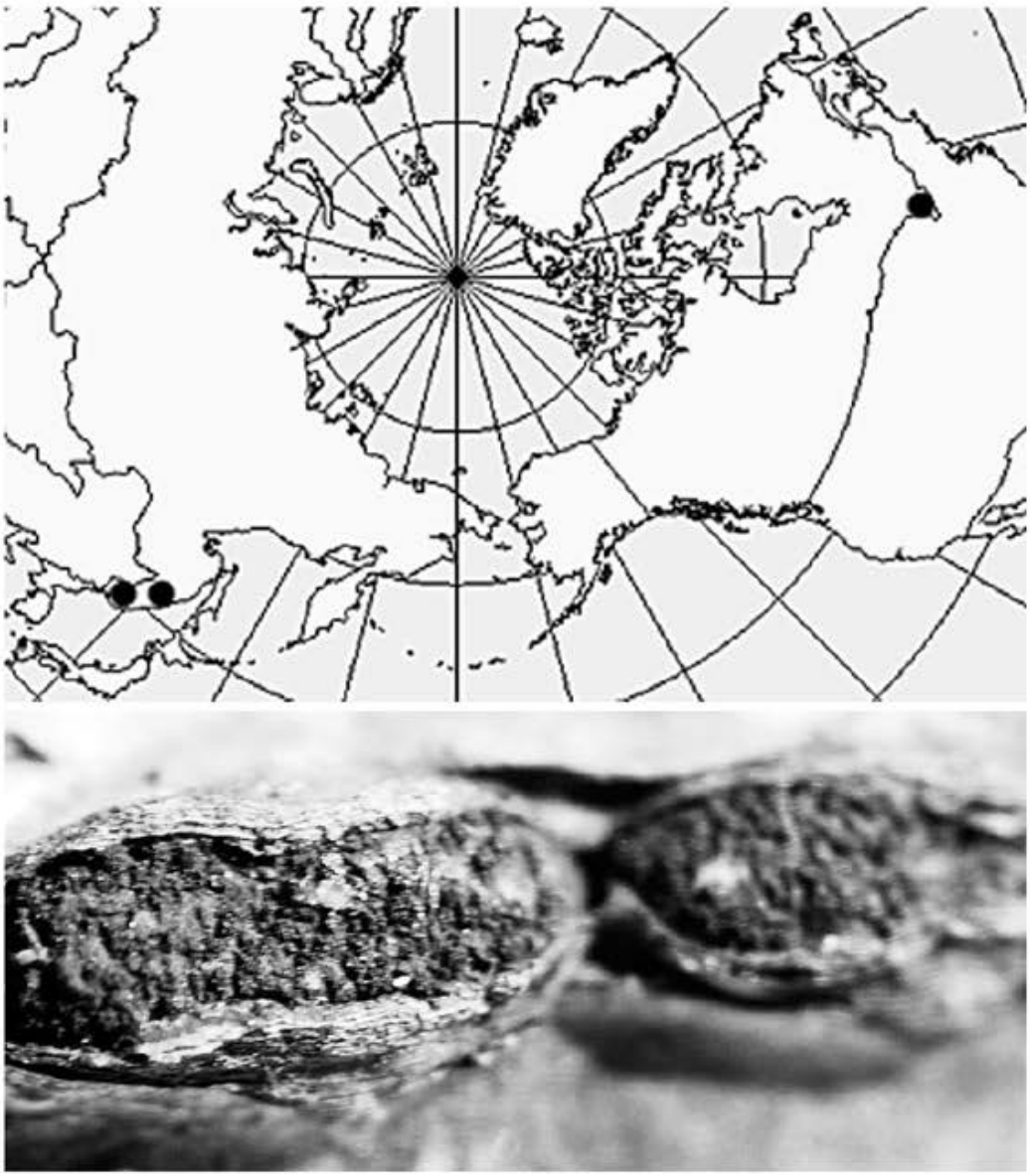


FIG. 2. Approximate biogeographical distribution of "*Diatrypella informis*". Only two localities are indicated for eastern Russia, although this species is rather common on dead branches of *Carpinus cordata* Blume and is also found throughout the Primorsky Territory, including the Sikhote-Ainsky Nature Reserve, Kedrovaya Pad Biosphere Reserve, Ussuriysky Nature Reserve, the Vladivostok vicinity, and near Anisimovka (District Shkotovo). The eastern North American locality is based on Ellis & Everhart's North American Fungi No. 2530 ("*Diatrypella informis* E. & E. n. sp. (TYPE), on dead *Carpinus*, London, Canada, Apr. 1890, J. Dearness"). Scale bar = 1 mm.

and recorded later from eastern Russia (FIG. 5). This species, which Ju & Rogers (1996) excluded from *Hypoxylon* (considering it to belong to *Euepixylon*), is treated herein as *Nemania sphaeriostoma*.

Some species that display an apparent Grayan distribution have been reduced to synonyms, although they are morphologically distinctive and have a restricted distribution. For instance, Ju et al. (1998) regarded *Biscogniauxia pezizoides* (Ellis & Everh.) Kuntze as synonymous with *B. repanda* (Fr.) Kuntze.

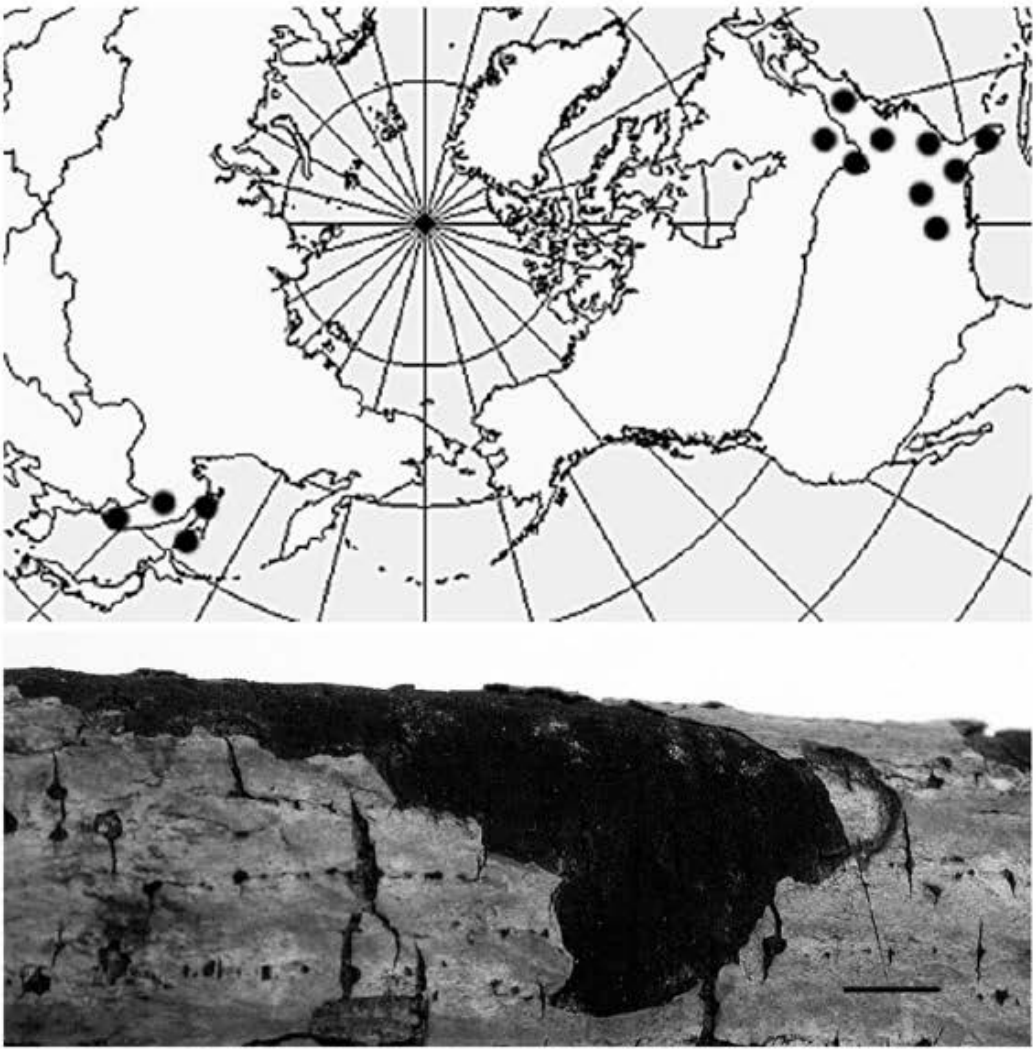


FIG. 3. Approximate biogeographical distribution of *Graphostroma platystoma*. North American localities listed by Pirozynski (1974) include Ontario and Quebec in Canada and Alabama, Arkansas, Florida, Massachusetts, Missouri, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, and Vermont in the USA. The eastern Russian specimens were collected in the Primorsky and Khabarovsk territories, the Amur Region, and on Sakhalin and Kunashir islands. Scale bar = 0.7 mm.

However these two names might just as easily represent different species that are restricted to different host plants (mostly *Ulmus* and *Sorbus*, respectively) and their occurrence on different continents has already been noted (Pouzar 1979). The later discovery of *B. pezizoides* in eastern Asia (Vasilyeva 1998) fits its distribution in the Grayan disjunction (FIG. 6). Another example is *Diaporthella platasca* (Peck) Wehm. (FIG. 7), first described from the Adirondack Mountains in eastern United States (Peck 1873) and later been shown (Wehmeyer 1933) to have smaller stromata and larger ascospores (16–23 µm long) than the European species *D. aristata* (Fr.) Petr. (ascospores 13–16 µm long). However, the two species were later confused and referred to *D. aristata* (Barr 1978, Chlebicki 2002). When *D. aristata* and *D. platasca* were found in eastern

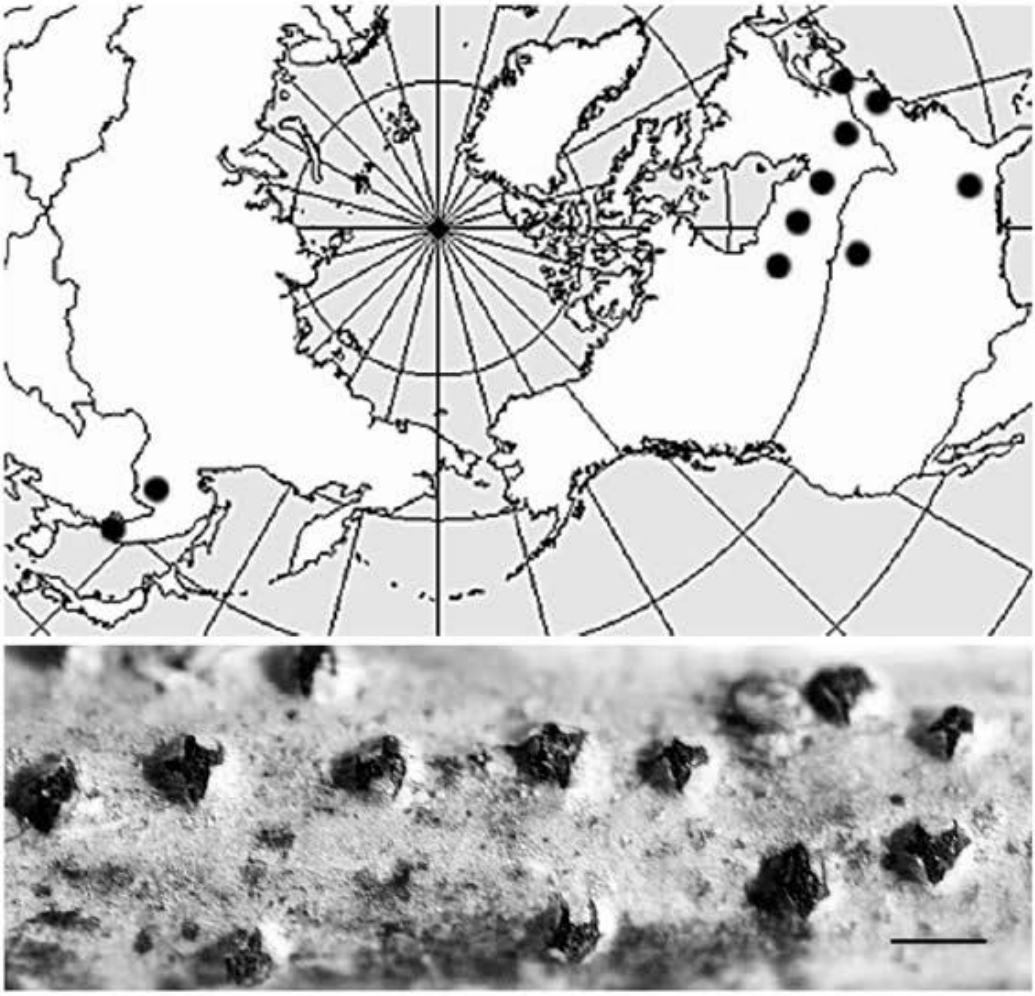


FIG. 4. Approximate biogeographical distribution of *Diatrype albopruinosa*. Some USA localities (Connecticut, the Dakotas, New Jersey, Mississippi) are from Rappaz (1987), and those for Canada (Manitoba, Ontario, Quebec, Saskatchewan) are taken from MycoBank (www.mycobank.com). The distribution range of this species in North America extends more to the west than for many other species with a Grayan disjunction. Only two collections are known from eastern Russia (in the Primorsky Territory and the Amur Region), but the senior author also found *D. albopruinosa* in China (Heilongjiang Province). Scale bar = 1 mm.

Asia—on the Kamchatka Peninsula and Sakhalin Island, respectively—their differences became evident, not only with respect to morphology but also in their ecological preferences. *Diaporthella aristata* parasitizes living branches of birch trees (*Betula ermanii* Cham.), whereas *D. platasca* occurs on dead branches of low shrubs (*Betula middendorffii* Trautv. & C.A. Mey.).

While describing the genus *Diaporthella*, Petrak (1924) noted the parasitic nature of *D. aristata*. However, the particular kind of substrate (trees or shrubs, in this case) might be of no importance, since Chlebicki (2002) indicated that *D. aristata* (with typical ascospores 14–16 µm long) occurs on living and dead twigs of a very low shrub (*Betula nana* L.). When discussing the material of *D. aristata* examined from North America, Barr (1978) made reference only to

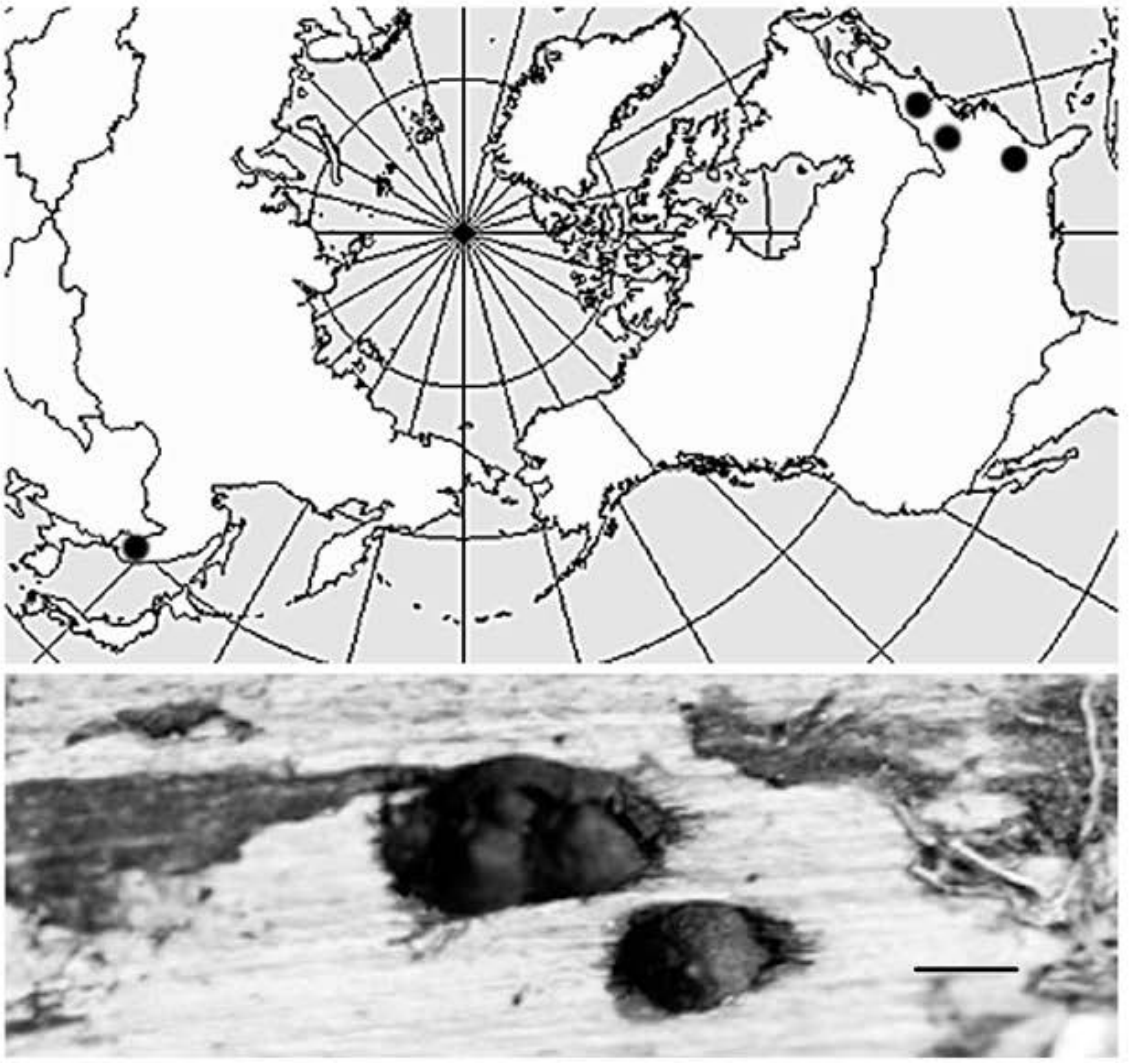


FIG. 5. Approximate biogeographical distribution of *Nemania sphaeriostoma*. The USA localities are cited by Miller (1961). The circle on the map encompasses the two collections from the Ussuriysky and Lazovsky Nature Reserves (Primorsky Territory) in eastern Russia. Scale bar = 1.5 mm

the type of *D. platasca*; therefore, the occurrence of the true *D. aristata* in North America is unknown.

The focus upon the biogeographical pattern discussed here has forced a reconsideration of species concepts. For example, specimens of *Apiognomonia alniella* (P. Karst.) Höhn. on the dead leaves of *Alnus fruticosa* Rupr. from the Magadan region (Vasilyeva 1987) fit Barr's description of a species indicated as occurring on overwintered leaves of *Alnus* spp. in Europe and North America (Barr 1978). However, Barr's North American specimens were collected in Quebec and Maine, regions in the eastern portion of the continent that share so many species in common with eastern Russia.

Further investigations showed that most of the European specimens of *Apiognomonia alniella* in exsiccatae contain living leaves of *Alnus incana* (L.) Moench covered by extensive necrotic spots caused by a parasitic fungus,

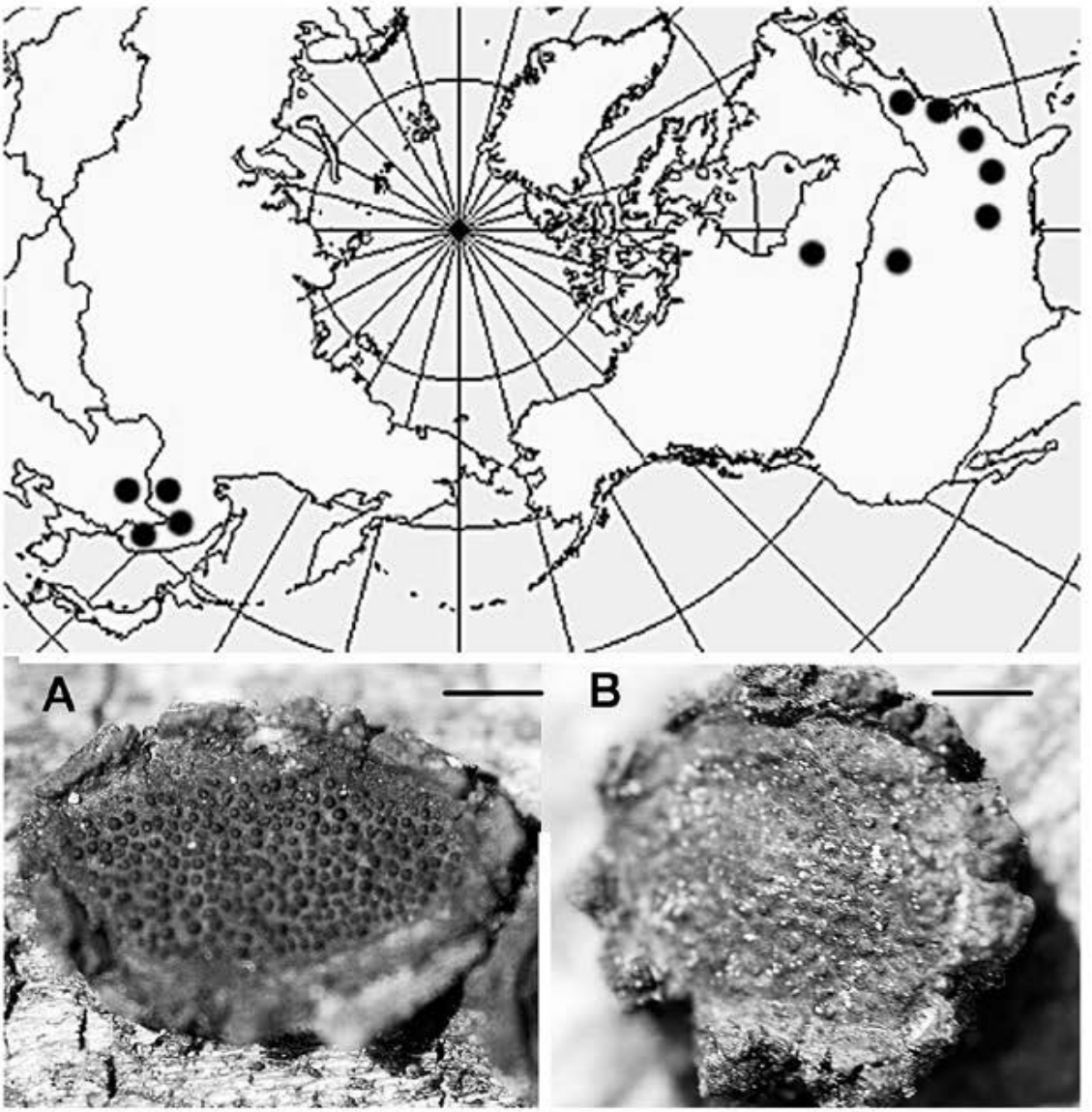


FIG. 6. Approximate biogeographical distribution of *Biscogniauxia pezizoides*. A - Stroma of *B. pezizoides* studded with the characteristic ostioles. B - Stroma of *B. repanda* [from western Russia, Leningrad Region, on *Sorbus aucuparia* L., D. Shabunin, VLA P-1429]. In North America, most localities (Delaware, Manitoba, Maryland, Nebraska, Virginia) are based on *B. pezizoides* specimens on *Ulmus* spp. (BPI collections: 595296, 595313, 595312, 595310, 595309); BPI 595300 from New York was collected on *Acer* sp., and the senior author has collected from *Acer* ap. in Tennessee (Great Smoky Mountains National Park) and from *Ulmus* sp. in Arkansas (Buffalo National River) as well as from *Acer mono* Maxim. and *Ulmus* spp. in eastern Russia and northeastern China (Heilongjiang province). Scale bars: 6A = 1.4 mm, 6B = 1.7 mm.

and the perithecia present are usually immature. We have observed exactly the same kind of a necrosis on living leaves of *A. hirsuta* (Spach) Turcz. ex Rupr. collected on the Kamchatka Peninsula. The immature perithecia were quite different from those on dead leaves of *A. fruticosa* in the Magadan region (FIG. 8). The immature state of the Kamchatka specimen did not allow us to make the proper comparison for a long time, but all the data available in the

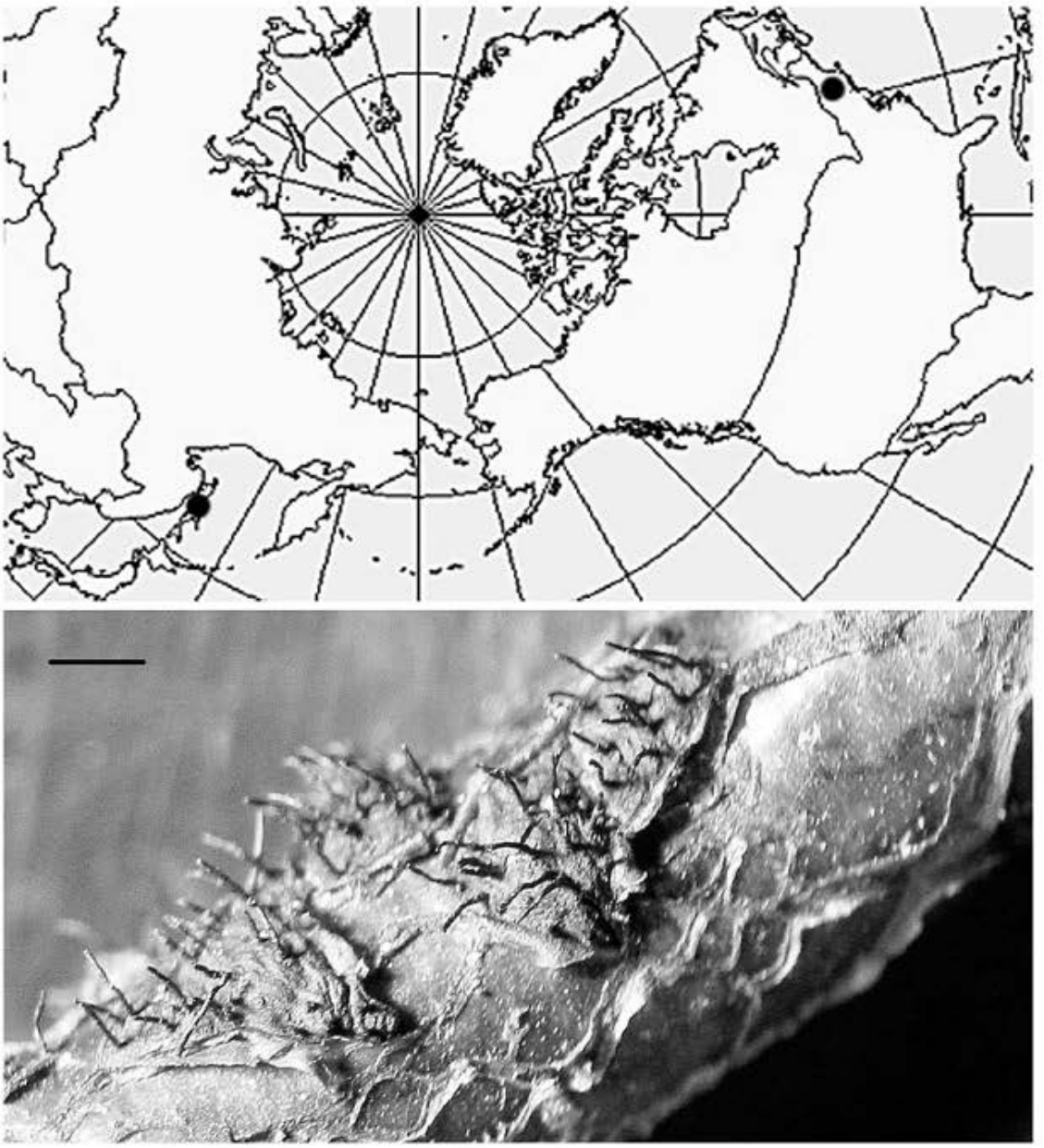


FIG. 7. Known localities for *Diaporthella platasca*. Scale bar = 1.25 mm

literature (Karsten 1873, Klebahn 1918, Monod 1983) indicate ascospores 8–10 µm long for *Apiognomonia alniella*, shorter than Barr's dimensions (10–16 µm) for her eastern North American material. This suggests that another species occurs in North America that might also be found in eastern Russia at the same latitudes.

We examined one specimen listed by Barr (Quebec: Manitou Gorge, 12 June 1955, R.T. Wilce) that appears exactly the same as specimens from Magadan region, with similar perithecia on dead leaves and same sized ascospores. Even the host leaves looked like those of *Alnus fruticosa*, sometimes referred to *Duschekia* and which supports an array of host-specific pyrenomycetes not

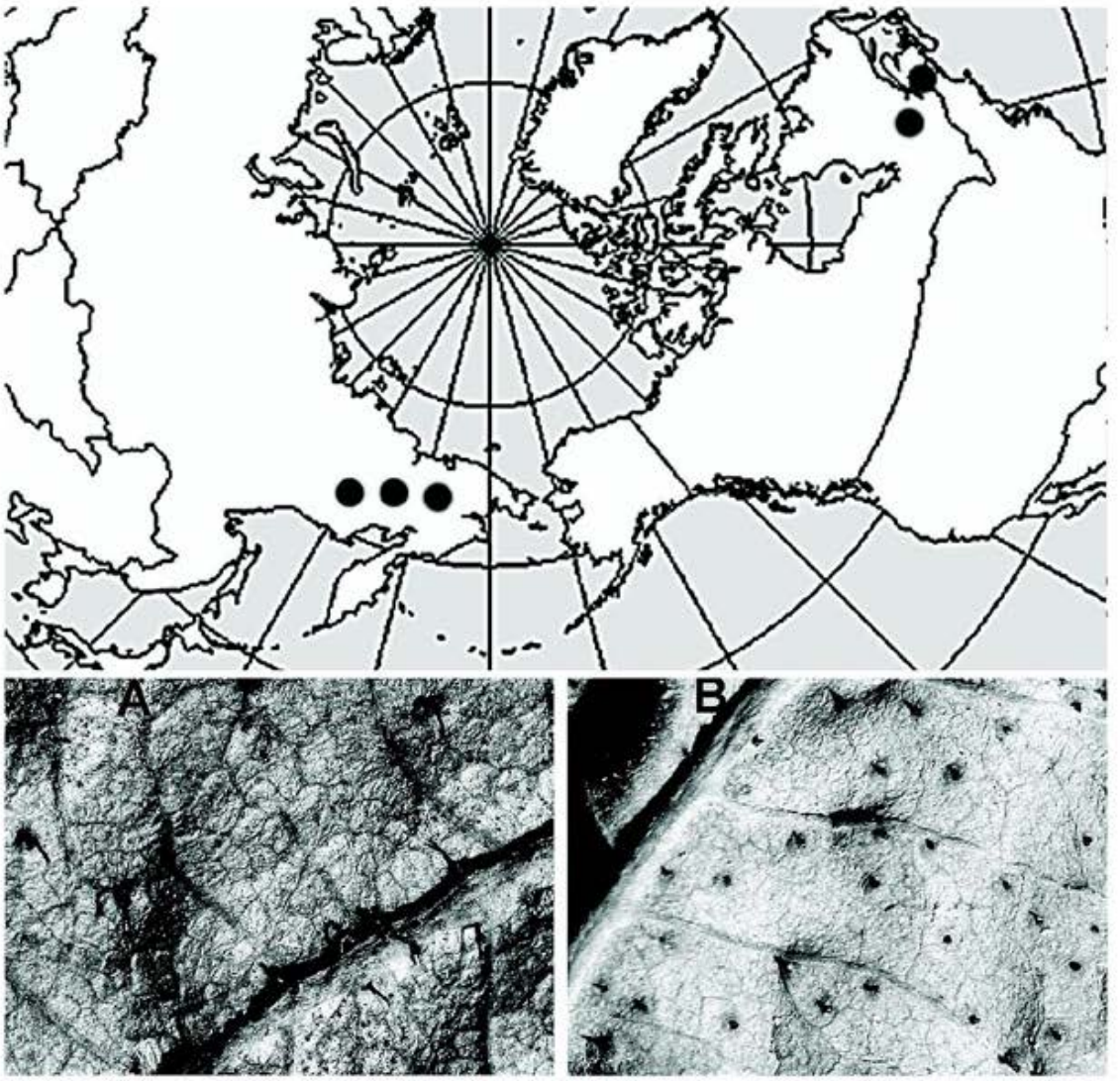


FIG. 8. Approximate biogeographical distribution of *Apiognomonia duschekiae*. The North American are from Barr (1978). In northeastern Russia, this species is rather common and found in many localities within the Magadan Region (vicinities of Kulu and Susuman; the Bol'shoy Anuy, Ilirneyveem, Kegali, Machvavaam, and Yasachnaya river basins; Lake Nizhny Ilirney) The same species should occur on dead leaves of *Duschekia fruticosa* in Yakutia (Shkarupa 1980), although we could not locate the specimen. A - elongated perithecial necks of *A. duschekiae* erumpent from leaf tissue. B - perithecial necks of *A. alniella* (from a specimen collected on *Alnus hirsuta* on the Kamchatka Peninsula).

found on true *Alnus* spp. (a kind of a substrate vicariance). For this reason, we describe below a new species of *Apiognomonia* (*A. duschekiae*), which seems to have a Grayan distribution (FIG. 8).

A similar situation can be observed in a specimen from the Magadan region identified as *Pleuroceras pleurostylum* (Auersw.) M.E. Barr following Barr's concept (Barr 1978, Vasilyeva 1987). Ascospores in the specimen averaged 50–70 µm long, corresponding with Barr's measurements of (35–)40–63 (–72) µm long. However, Monod (1983) described *P. pleurostylum* occurring

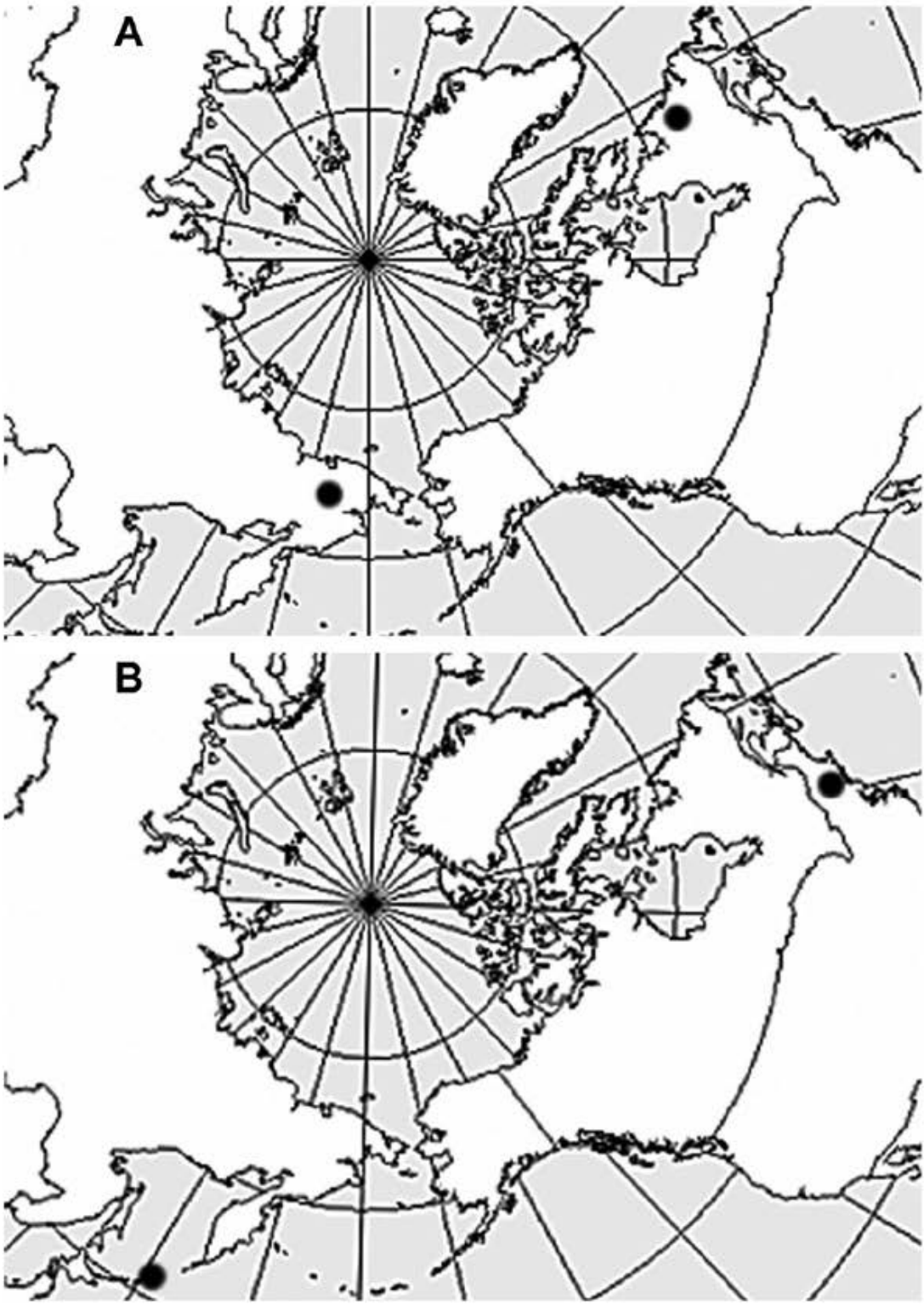


FIG. 9. Approximate biogeographical distributions:
A - *Pleuroceras labradorense*, B - *Gnomonia mirabilis*

in Europe as having ascospores 33–45 µm long, whereas the specimen from Labrador cited by Barr with longer (55–67 µm) ascospores served as the type for his new species *Pleuroceras labradorense* M. Monod. The collection from

the Magadan region better fits the description of *P. labradorense,* which appears to have disjunctive distribution in northeastern Asia and northeastern North America (FIG. 9A).

The same situation appears to be the case for *Gnomonia mirabilis* (Peck) M. Monod (FIG. 9B), which occurs on dead leaves of *Betula* spp. This fungus known from North America (New York: Barr 1978) was later found in eastern Asia (Kunashir Island: Vasilyeva 1998). Barr (1978) considered this taxon only a variety of *Plagiostoma campylostyla* (Auersw.) M.E. Barr, but *Gnomonia mirabilis* has appreciably longer ascospores (27.5–37.5 µm versus 18–27 µm in *P. campylostyla*). As this 'varietal' difference is surely larger than the difference Barr cited in her key to differentiate *Gnomonia fasciculata* Fuckel from *G. rhoicola* M.E. Barr (ascospores 11–15 and 13–16.5 µm long, respectively), it would seem appropriate also to distinguish *G. mirabilis* and *G. campylostyla* Auersw. at the species level. Monod (1983) listed three additional localities (Michigan, Ontario, Quebec) in eastern North America for *G. mirabilis*. The fungus probably occurs there, but Monod's species description cites an ascospore length of 21–32 µm, which would not distinguish it from *G. campylostyla*. Monod does not compare *G. mirabilis* with any other species of that genus in his key.

It is particularly noteworthy how often diaporthalean fungi display a Grayan disjunction. Recently, *Melanconis carpinigera* (Ellis & M.A. Curtis) Petr. was reported from eastern Russia (the Vladivostok vicinity), a species known previously from eastern North America (Wehmeyer 1941, as *M. chrysostroma* var. *ellisii* (Rehm) Wehm.) (FIG. 10) and the third species recorded from *Carpinus cordata* (along with *Fracchiaea callista* and "*Diatrypella informis*", discussed above) with such a distribution.

Testing for a Grayan distribution pattern may be useful for species already known from eastern North America when the same species is found in eastern Asia, particularly a taxonomic change might be indicated. For example, *Hypoxylon lividipigmentum* F. San Martín et al. was described from Mexico as having a teleomorph that is almost identical to *H. lividicolor* Y.M. Ju & J.D. Rogers known from Taiwan, except for the fact that the stromata of the former are thinner. Two species collected at almost the same latitudes (near the Northern tropics) in eastern North America and eastern Asia certainly warrant careful comparison. The senior author found a similar fungus in Texas (within the Big Thicket National Preserve), and there were reasons to identify it as *Hypoxylon lividipigmentum,* described from neighboring Mexico (the state of Quintana Roo), since southern Texas appears to share numerous species of pyrenomycetous fungi with Mexico. However, the stromata in the Texan specimen were rather thick, and J.D. Rogers (pers. comm.) was inclined to consider it to represent the Taiwanese *H. lividicolor*. The most probable conclusion is that the Taiwanese, Mexican, and Texan specimens belong to the same species being variable

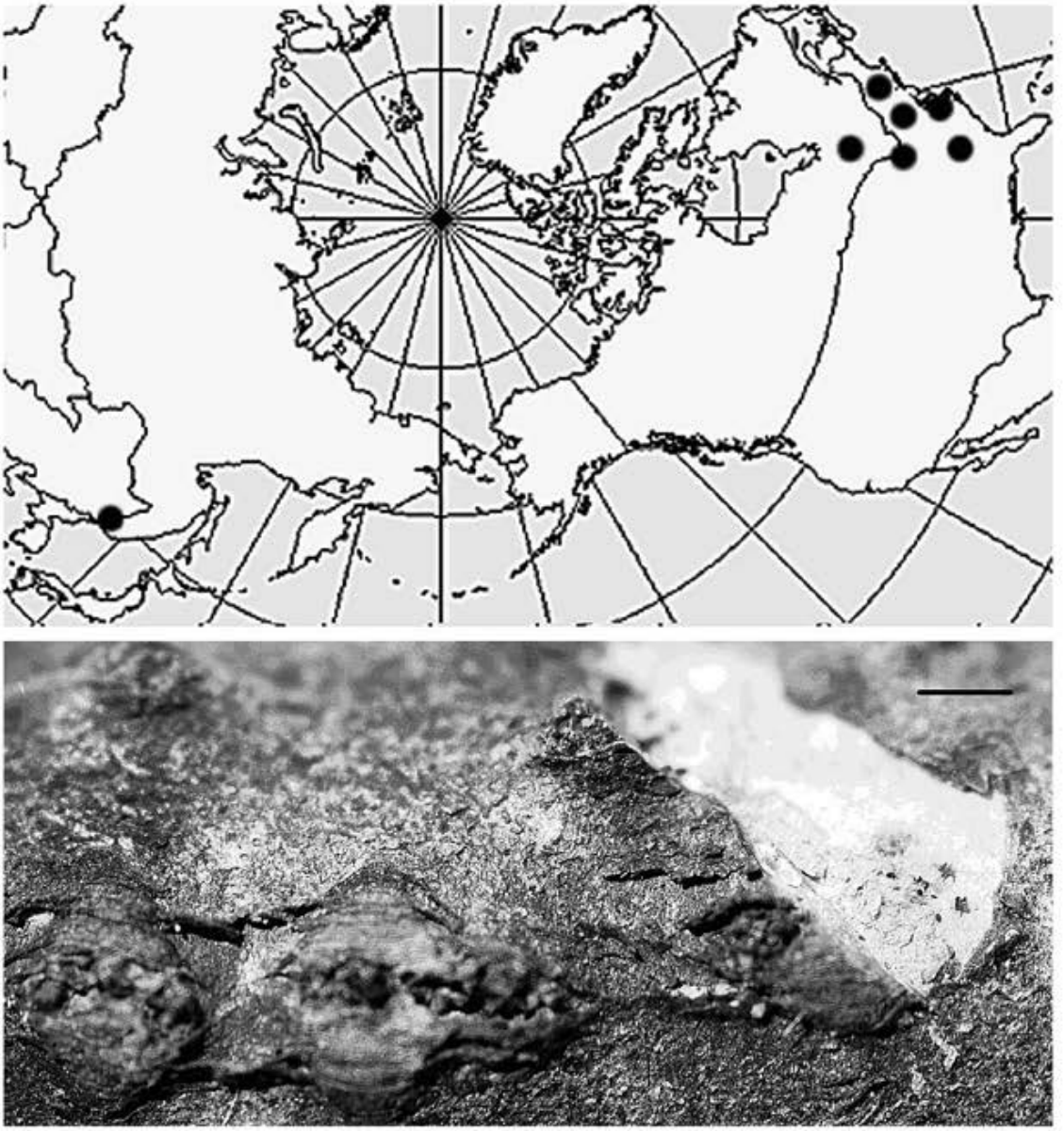


FIG. 10. Approximate biogeographical distribution of *Melanconis carpinigera*. North American localities as cited by Wehmeyer (1941: Michigan, New York, Pennsylvania, Ontario) as collected by the senior author (Maryland— BPI 843491; Tennessee—878343). Scale bar = 1.4 mm

in stromatal thickness, and this species displays a familiar disjunction in its distribution. *Hypoxylon lividipigmentum* and *H. lividicolor* are currently treated as separate species, since one of them has a *Nodulisporium*-like conidiogenous structure, whereas the other has a condiogenous structure that is *Sporothrix*-like (Ju & Rogers 1996). However, both *Nodulisporium*- and *Sporothrix*-like have been reported to occur within the same species (e.g., *Hypoxylon macrosporum* P. Karst.). Otherwise, *Hypoxylon lividipigmentum* and *H. lividicolor* represent a vicariance pattern in Grayan distribution (FIG. 11), and the specimen from Texas belongs to *H. lividipigmentum* despite its rather thick stromata.

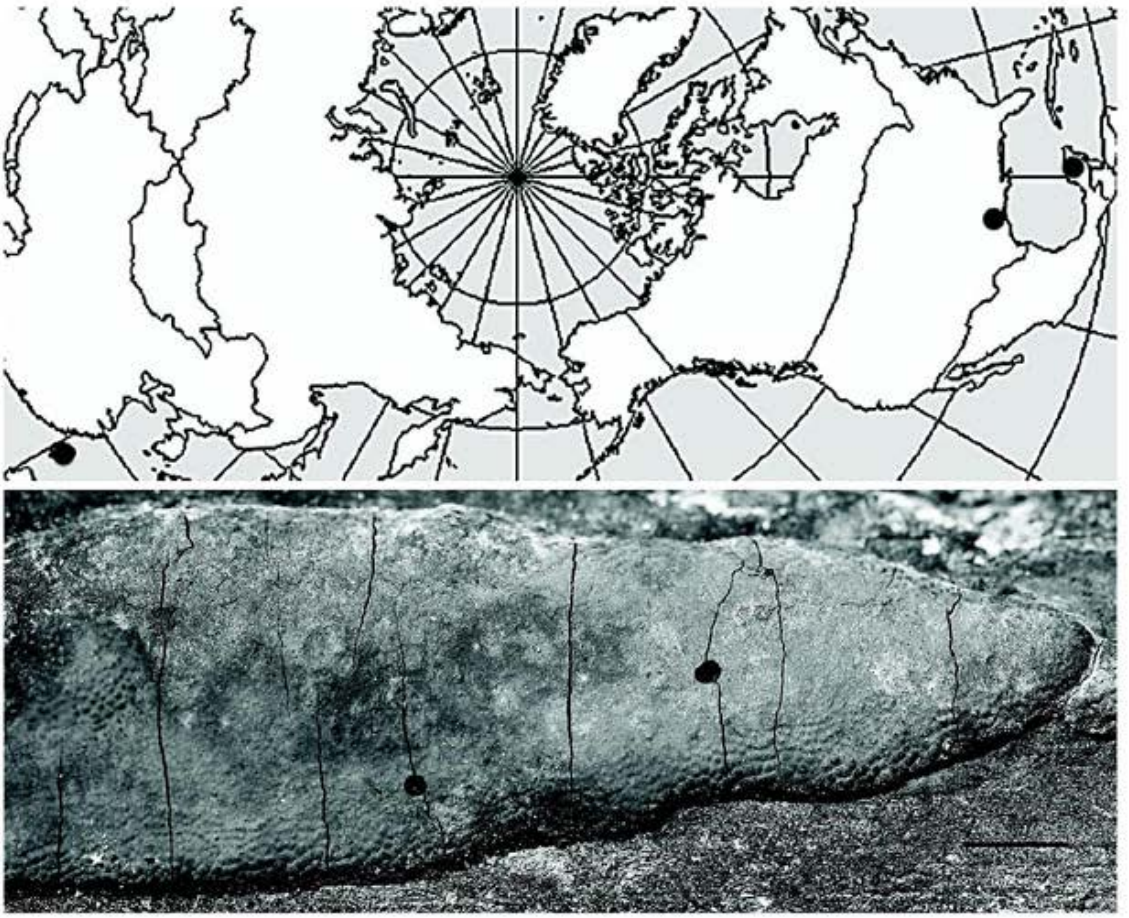


FIG. 11. Approximate biogeographical distribution of *Hypoxylon lividicolor* (Taiwan) and *H. lividipigmentum* (Mexico, Texas). Stroma: VLA P-2450 (Texas). Scale bar = 0.6 mm

Vicariance pattern

The vicariance pattern in Gray an distribution observed for some pyrenomycetous fungi is an even more interesting topic for discussion, since several species were described from eastern Russia as counterparts of eastern North American relatives, but only as varieties or synonyms of the latter. This additionally emphasizes an important taxonomic problem associated with estimating of differences in rank, which could be resolved by considering vicariant species pairs in eastern Asia and eastern North America.

One noteworthy example is *Biscogniauxia maritima* Lar.N. Vassiljeva, described as an east-Asian counterpart of the North American *B. atropunctata* (Schwein.) Pouzar (FIG. 12). In their disjunct regions, both species are restricted to *Quercus* spp. but differ considerably in ascospore size (13.2–16 × 6.6–8 µm versus 24–33 × 11–16 µm). Although *B. maritima* was later reduced to a variety of *B. atropunctata* (Ju et al. 1998), the vicariance pattern remains.

Nevertheless, the status of a taxon as a species or a variety is of importance, and the rank is determined after a careful consideration of differences that

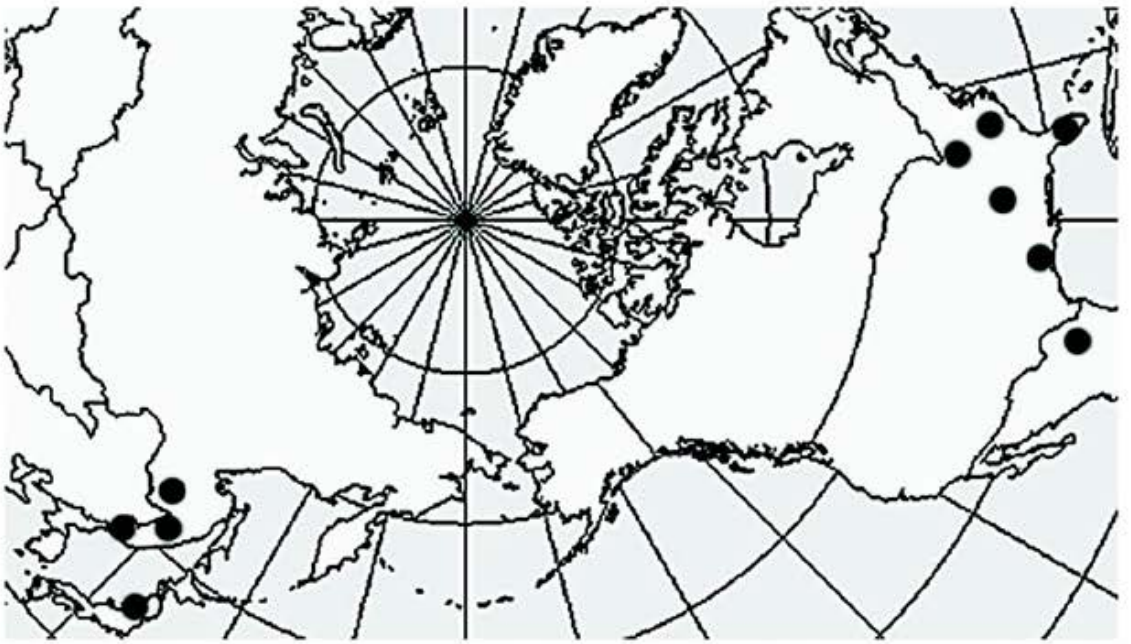


FIG. 12. Approximate biogeographical distributions of *Biscogniauxia maritima* and *B. atropunctata*. North American localities from Mexico (Nuevo León state)] and the USA (Florida, North Carolina, Ohio) are based on Ju et al. (1998) and collections by the senior author in Arkansas (Buffalo National River) and Texas (Big Thicket National Preserve). The species was also found in Tennessee (the Great Smoky Mountains National Park). All eastern Asian collections were obtained by L. Vasilyeva. Scale bar = 0.6 mm

exist within a particular genus or (sometimes) among several closely related genera. An examination of the key to *Biscogniauxia* taxa by Ju et al. (1998) reveals immediately that many taxa differ only in ascospore size (steps 3, 6, 9, 33–34, 36, 40), implying that these taxa are similar in other features. Using these examples (i.e., taxa distinguished at the steps indicated), we arranged the species and varieties on the basis of the average lengths of ascospores (TABLE 1), with each table row presenting a set of closely related taxa.

TABLE 1. Arrangement of some *Biscogniauxia* taxa in accordance with average ascospore length (data from Ju et al. 1998: Key to *Biscogniauxia*). Each table row presents a set of closely related taxa.

ASCOSPORE LENGTH			
10–13 µm	13–17 µm	18–22 µm	22–30 µm
		B. weldenii var. *microspora*	*B. weldenii*
	B. nothofagi		*B. pithodes*
	B. philippinensis var. microspora		*B. philippinensis*
B. uniapiculata	*B. uniapiculata* var. *macrospora*	*B. divergens*	
	B. maritima	*B. atropunctata* var. *intermedia*	*B. atropunctata*
B. citriformis	*B. citriformis* var. *macrospora*		
B. nummularia		*B. bartholomaei*	
	B. mediterranea var. *microspora*	*B. mediterranea*	

Consideration of the information in TABLE 1 shows, for example, that the same difference exists between *Biscogniauxia nothofagi* Whalley et al. and *B. pithodes* (Berk. & Broome) Whalley & Læssøe, *B. philippinensis* (Ricker) Whalley & Læssøe and *B. philippinensis* var. *microspora* Y.M. Ju & J.D. Rogers, and *B. atropunctata* and *B. atropunctata* var. *maritima* (Lar.N. Vassiljeva) Y.M. Ju & J.D. Rogers. Yet the taxa in the first pair are treated as different species, whereas the others are regarded only as varieties. That is taxonomically inconsistent, since the same character difference should not be used at two ranks in the same genus, and if 'varieties' within *Biscogniauxia* display their own biogeographical patterns as do the varieties *atropunctata* and *maritima* of *B. atropunctata* in eastern Asia and eastern North America (FIG. 12), they probably deserve recognition at the species level, as *B. nothofagi* and *B. pithodes* are recognized.

Biscogniauxia mediterranea (De Not.) Kuntze and *B. mediterranea* var. *microspora* display a substrate vicariance, with the autonymous variety occurring only on *Quercus* spp. and var. *microspora* not occurring on *Quercus* but seemingly preferring *Alnus* spp. The latter was found several times on *Alnus* in British Columbia and California (Ju et al. 1998), while are collections from eastern Russia (Khanka Nature Reserve) on *Corylus heterophylla* Fisch. ex Trautv., also in the *Betulaceae*. We regard *B. mediterranea* var. *microspora* as a separate species, for which we propose the name *Biscogniauxia alnophila* below.

Another example of a species with a vicariance pattern is *Hypoxylon ulmophilum* Lar.N. Vassiljeva, common on dead branches of *Ulmus* spp. in the Russian Far East. Vasilyeva (1998) described it as having glomerate stromata

TABLE 2. Arrangement of some *Hypoxylon* taxa in accordance with average ascospore length (data from Ju & Rogers 1996: Key to *Hypoxylon*). Each table row presents a set of closely related taxa.

ASCOSPORE LENGTH			
7–11 µm	11–15 µm	15–22 µm	22–26 µm
H. howeanum	*H. fragiforme*		
H. aeruginosum	*H. aeruginosum* var. *macrosporum*		
H. monticulosum	*H. rubigineoareolatum*		
H. carneum			*H. vogesiacum*
	H. notatum	*H. ulmophilum*	
H. investienS		*H. subcorticeum*	
	H. ferrugineum	*H. diatrypeoides*	
H. annulatum		*H. thouarsianum*	*H. thouarsianum* var. *macrosporum*
H. leptascum		*H. leptascum* var. *macrosporum*	

similar to those found in *Hypoxylon notatum* Berk. & M.A. Curtis but differing in larger ascospores (16.5–21 µm versus 12–15 µm long). Ju et al. (2004) rejected the new species as conspecific with *H. notatum,* but Stadler et al. (2008) later supported it as an independent taxon.

The larger ascospores, a different substrate preference, and the apparent biogeographical pattern suggested a different species. However, once again, the question could be asked as to whether it is possible to rely only upon a single morphological difference, such as the ascospore size. As with ascospore size in *Biscogniauxia*, repetitive average lengths also exist within *Hypoxylon*, where also species (and varieties) appear to differ only in ascospore size. TABLE 2 compares size differences (steps 7, 12, 31, 33, p. 58–62, etc.) in the key by Ju & Rogers (1996). One can see that the table for *Hypoxylon* contains fewer varieties when compared with the table for *Biscogniauxia*, In other words, average ascospore size (comparable in both TABLE 1 and TABLE 2) serves to delimit species in many instances, although using the same difference to delineate both species and varieties is inconsistently applied. If a number of species differ only in ascospore size, then, following simple taxonomic logic, there is justification for recognizing *Hypoxylon notatum* and *H. ulmophilum* as different species.

The concept of *Hypoxylon notatum* in the monograph by Miller (1961) is rather narrow, indicating that it occurs primarily on *Quercus* spp. in the eastern United States (FIG. 13). As such, *H. notatum* represents a counterpart to *H. ulmophilum* in the vicariance pattern under discussion. Later, the concept of *H. notatum* was widened to include some species described from Brazil and Paraguay, as well as specimens from tropical China and Taiwan (Ju & Rogers 1996). In this broader sense, what is currently recognized as *H. notatum* might

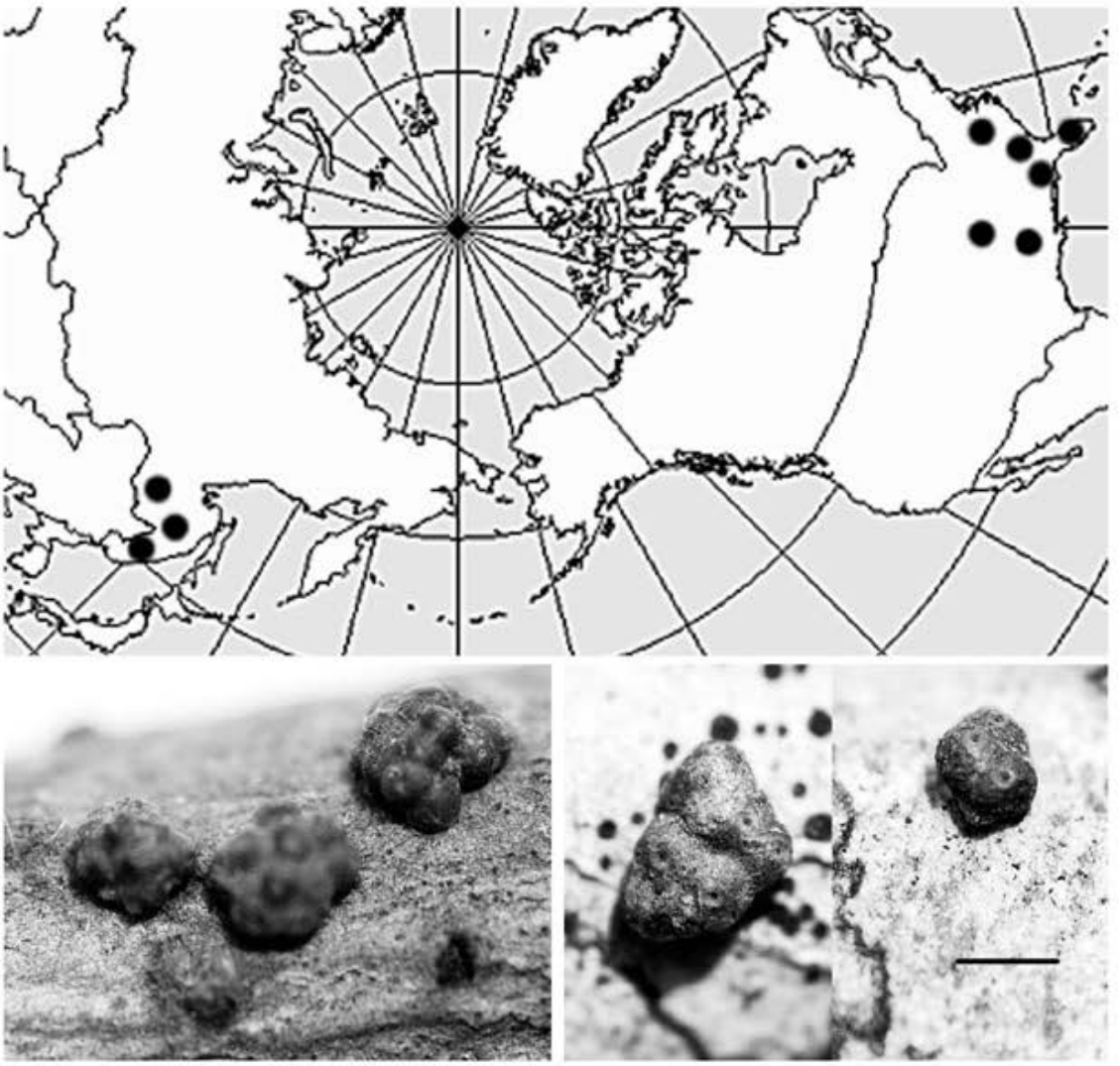


FIG. 13. Approximate biogeographical distribution of *Hypoxylon ulmophilum* (left) and *H. notatum* (right). The North American localities of *H. notatum* are those cited by Miller (1961). The *H. ulmophilum* collections in eastern Asia were obtained by L. Vasilyeva. The latter species was also found in South Korea (Gangwon province, Mt. Odaesan, 20 Sep 2006, VLA P-1651). A. Stromata of *H. ulmophilum*. B. Stromata of *H. notatum*: the widely opening mouth-like ostioles are diagnostic (cf. also Miller 1961, FIG. 7). Scale bar = 1.1 cm

represent a species complex in need of reconsideration. Some support for this view was provided by a specimen from Texas (Big Thicket National Preserve) that is very similar to *Hypoxylon notatum* as illustrated by Miller (1961: FIG. 6–7), but the KOH-extractable stromatal pigments of the Texan specimen are orange in contrast to "pure yellow with greenish yellow tone" reported for *H. notatum* by Ju & Rogers (1996). The latter pigment type was confirmed only for the Taiwanese specimen (Stadler et al. 2008), whereas material from Argentina identified as *H. notatum* had light chestnut pigments (Hladki & Romero 2006). The specimens from the USA studied by Stadler et al. (2008) had a more or less dilute umber pigment in KOH.

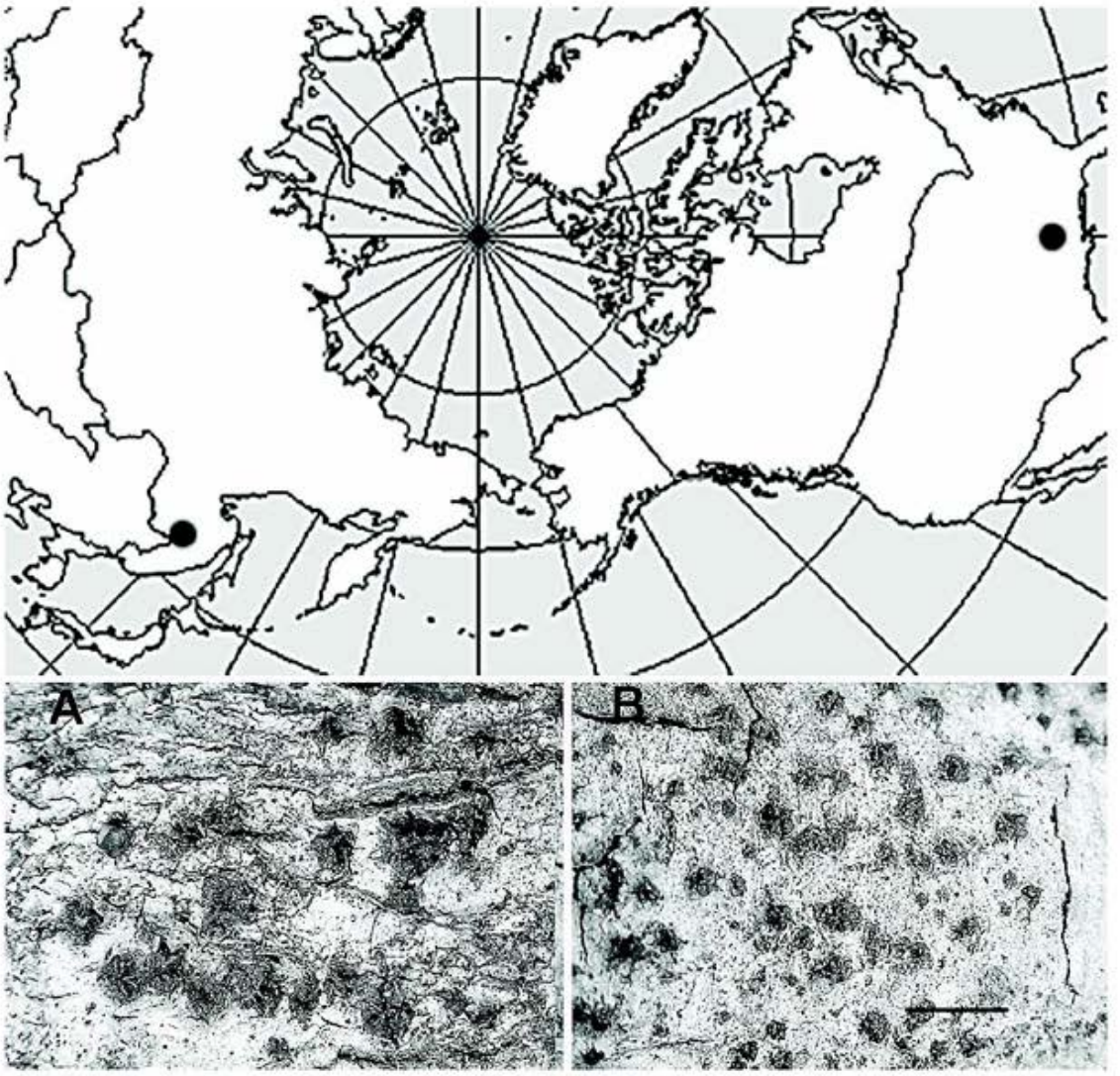


FIG. 14. Known localities for *Cryptovalsaria rossica* and *C. americana* in eastern Russia (the Khabarovsk vicinity) and the USA (Ouachita Mountains, Arkansas). A - Ostioles of *C. rossica* on bark. B - Smaller ostioles of *C. americana* on bark. Scale bar = 2.5 mm

There is no reason to extend this paper by listing additional pairs of pyrenomycetous species that display the vicariance pattern within the Grayan distribution. It is sufficient to mention a very curious case involving closely related species in eastern Asia and southeastern North America parasitizing the same kinds of host trees. These are *Cryptovalsaria rossica* Lar.N. Vassiljeva & S.L. Stephenson and *C. americana* Lar.N. Vassiljeva & S.L. Stephenson, found on living trees of *Alnus* spp. in eastern Russia and Arkansas (FIG. 15) within a time period of six years (Vasilyeva & Stephenson 2007). The situation with these two species is very similar to that with two other ascomycetous species (Whetzel & Wolf 1945), namely *Ciboria shiraiana* (Henn.) Whetzel and *C. carunculoides* (Siegler & Jenkins) Whetzel, parasitizing the fruits of *Morus* spp. in eastern Asia (Japan, South Korea, China, southeastern Russia) and the

southeastern United States (Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, South Carolina, Texas).

Taxonomy

Apiognomonia duschekiae Lar.N. Vassiljeva & S.L. Stephenson, **sp. nov.**

MycoBank MB 518664

Perithecia singula, immersa, ut plurimum ad nervi sparsa, sed frequenter ad laminae quoque dispersa, nigra, globosa, 250–300 µm diametro, cum rostri centrali, tenui, recti vel curvati, ad 300–500 µm longi, hypophylli vel epiphylli. Asci numerosi, ellipsoidei, octospori, 50–66 x 9–12 µm. Ascosporae hyalinae, ellipsoideae vel fusoideae, prope basim uniseptatae, ad septum non constrictae, 12–14(–16) × 5–6.6 µm.

Holotypus: Russia, Magadan Region, Susuman vicinity, on dead leaves of *Duschekia fruticosa* (Rupr.) Pouzar (*Betulaceae*), 19.VII.1974, L. Vasilyeva, VLA P-1093.

Perithecia solitary, immersed in leaf tissue, most often along veins, black, spherical, 250–300 µm diam., with central, thin, straight or curved necks up to 300–500 µm long, emerging from the lower or upper leaf surface. Asci numerous, ellipsoid, 8-sporous, 50–66 × 9–12 µm. Ascospores hyaline, ellipsoid or fusiform, septate near basis, not constricted, 12–14(–16) × 5–6.6 µm.

Additional specimens examined: All specimens were collected from dead leaves of *Duschekia fruticosa* by L. Vasilyeva and are deposited in VLA: MAGADAN REGION, Ygodnino District, basin of the river Yasachnaya, 19.VII.1975, P-893; Severo-Evensk District, basin of the river Kegali, 6.VIII.1976, P-894; Bilibino District, basin of the river Ulyashka, 3.VII. 1976, P-892; basin of the river Machvavaam, 13.VII.1977, P-887; basin of the river Bol'shoy Anuy, 25.VII.1980, P-890; basin of the river Ilirney, 13.VIII.1980, P-891; lake Nizhny Ilirney, 21.VIII.1980, P-888; District Ten'kinsky, Kulu vicinity, 12.IX.1975, P-895.

Biscogniauxia alnophila Lar.N. Vassiljeva & S.L. Stephenson, **nom. nov.**

MycoBank MB 518754

≡ *Hypoxylon mediterraneum* var. *microsporum* J.H. Mill., Monogr. of the World Species of *Hypoxylon*: 117 (1961).

≡ *Biscogniauxia mediterranea* var. *microspora* (J.H. Mill.) Y.M. Ju & J.D. Rogers, Mycotaxon 66: 42 (1998).

Description–Miller (1961: 117), Ju et al. (1998: 42).

Specimens examined: RUSSIA, Primorsky Territory: Khanka Nature Reserve, on dead branches of *Corylus heterophylla*, 18 Jun 2003, L. Vasilyeva, VLA P-1858.

Nemania sphaeriostoma (Schwein.) Lar.N. Vassiljeva & S.L. Stephenson, **comb. nov.**

MycoBank MB 518690

≡ *Sphaeria sphaeriostoma* Schwein., Trans. Amer. Philos. Soc., n. ser. 4: 193 (1832).

≡ *Hypoxylon sphaeriostomum* (Schwein.) Sacc., Syll. Fung. 1 : 392 (1882).

Description–Miller (1961: 67; Figs. 100, 128).

Specimens examined: RUSSIA, Primorsky Territory: Lazovsky Nature Reserve, on wood, 2 Aug 1986, L. Vasilyeva, VLA P-380; Ussuriysky Nature Reserve, on wood, 18 Sep 1996, L. Vasilyeva, VLA P-379.

COMMENTS–Superficially, the stromata in the Asian specimens of *Nemania sphaeriostoma* (FIG. 5) and in Miller's photograph (1961: FIG. 100) are similar to both *Euepixylon udum* (Pers.) Læssøe & Spooner and *Nemania confluens* (Tode) Læssøe & Spooner (Granmo et al. 1999: Figs. 17, 42), and the distribution of the two latter species among different genera was made on the basis of *Euepixylon udum* having ascospores with elliptic, poroid germ slit, whereas *Nemania confluens* is characterized by ascospores with a narrow, long germ slit. However, this difference is hardly of generic importance, since the size of germ slit (which in some instances is seemingly lacking) varies within many genera of the *Xylariaceae*, within which this difference is usually used to distinguish species in such genera as *Hypoxylon* (Ju & Rogers 1996), *Biscogniauxia* (Ju et al. 1998) and *Nemania* (Ju & Rogers 2002).

When reinstated, the genus *Euepixylon* was distinguished from *Nemania* on the basis of "a short poroid germ locus, a very short ascus stipe, and a broad, discoid apical apparatus" (Læssøe & Spooner 1993: 41), but the authors themselves expressed doubts that this genus would survive in the long run. Later, the name *Euepixylon* was said to be invalid (Eriksson & Hawksworth 1997), so the genus *Nemania* is more suitable for *Hypoxylon sphaeriostomum* on the basis of both the logics of taxonomic comparison as well as nomenclatural rules.

Acknowledgments

The authors are grateful to Dr. R.H. Petersen of the University of Tennessee and H.H. Burdsall of Fungal and Decay Diagnostics, LLC for serving as presubmission reviewers and for providing helpful comments and suggestions. One of the earlier drafts of this manuscript was kindly looked over by Dr. A.Y. Rossman of the Agricultural Research Service and her comments are greatly appreciated.

Literature cited

Barr ME. 1978. The *Diaporthales* in North America with emphasis on *Gnomonia* and its segregates. Mycologia Memoir 7: 1–232.

Barr ME. 1990. *Melanommatales* (Loculoascomycetes). North American Flora 2(13): 1–129.

Chlebicki A. 2002. Biogeographic relationships between fungi and selected glacial relict plants. Monographiae Botanicae 90: 1–230.

Culberson WL. 1972. Disjunctive distribution in the lichen-forming fungi. Annals of the Missouri Botanical Garden 59: 165–173. doi:10.2307/2394751

Dey JP. 1976. Phytogeographic relationships of the fruticose and foliose lichens of the southern Appalachian Mountains. 398–416, in: Parker BC, Roane MK (eds). The distributional history of the biota of the southern Appalachians. Part IV. Algae and fungi, biogeography, systematics and ecology. University of Virginia Press, Charlottesville.

Eriksson O, Hawksworth DL. 1997. Notes on ascomycete systematics – Nos. 2140–2245. Systema Ascomycetum 15: 139–173.

Granmo A, Læssøe T., Schumacher T. 1999. The genus *Nemania* s.l. (*Xylariaceae*) in Norden. Sommerfeltia 27: 1–96.

Hladki AI, Romero AI. 2006. Revisión de las especies de *Hypoxylon* propuestas por Spegazzini. Lilloa 43: 45–60.

Hongo T, Yokoyama K. 1978. Mycofloristic ties of Japan to the continents. Memoirs of the Shiga University. Natural Science 28: 76–80.

Ju YM, Rogers JD. 1996. A revision of the genus *Hypoxylon*. Mycologia Memoir 20: 1–365.

Ju YM. Rogers JD. 2002. The genus *Nemania* (*Xylariaceae*). Nova Hedwigia 74: 75–120. doi:10.1127/0029-5035/2002/0074-0075

Ju YM, Rogers JD, San Martín F, Granmo A. 1998. The genus *Biscogniauxia*. Mycotaxon 66: 1–98.

Ju YM, Rogers JD, Hsieh HM. 2004. New *Hypoxylon* species and notes on some names associated with or related to *Hypoxylon*. Mycologia 96: 154–161. doi:10.2307/3761997

Karsten PA. 1873. Mycologia Fennica. Pars 2. Pyrenomycetes. Bidrag till Kännedom av Finlands Natur och Folk 23: 1–250.

Klebahn H. 1918. Haupt- und Nebenfruchtformen der Askomyzeten. Gebruider Borntraeger, Leipzig. 395 p.

Læssøe T, Spooner BM. 1993. *Rosellinia* & *Astrocystis* (*Xylariaceae*): new species and generic concepts. Kew Bulletin 49: 1–70. doi:10.2307/4110199

Miller JH. 1961. A monograph of the world species of *Hypoxylon*. University of Georgia Press, Athens. 158 p.

Monod M. 1983. Monographie taxonomique des *Gnomoniaceae*. Sydowia Beiheft 9: 1–120.

Mueller GM, Wu QX, Huang YQ, et al. 2001. Assessing biogeographic relationships between North American and Chinese macrofungi. Journal of Biogeography 28: 271–281. doi:10.1046/j.1365-2699.2001.00540.x

Nannfeldt JA. 1975. Stray studies in the *Coronophorales* (Pyrenomycetes) 4–8. Svensk Botanisk Tidskrift 69: 289–335.

Peck CH. 1873. Plants found growing spontaneously in the state and not before reported. Annual Report of the New York State Museum 25: 69–106.

Petersen RH, Hughes KW. 2007. Some agaric distribution patterns involving Pacific landmasses and Pacific Rim. Mycoscience 48: 1–14. doi:10.1007/s10267-006-0333-5

Petrak F. 1924. Mykologische Notizen. VII. Annales Mycologici 22: 1–182.

Petrini LE, Müller E. Haupt- und Nebenfruchtformen europäischer *Hypoxylon*-Arten (*Xylariaceae*, *Sphaeriales*) und verwandter Pilze. Mycologia Helvetica 1: 501–627.

Pirozynski KA. 1974. *Xenotypa* Petrak and *Graphostroma* gen. nov., segregates from *Diatrypaceae*. Canadian Journal of Botany 52: 2129–2135. doi:10.1139/b74-274

Pouzar Z. 1979. Notes on taxonomy and nomenclature of *Nummularia* (Pyrenomycetes). Česká Mykologie 33: 207–218

Rappaz F. 1987. Taxonomie et nomenclature des Diatrypacees à asques octospores (1). Mycologia Helvetica 2: 285–648.

Saccardo PA. 1882. Sylloge Fungorum. Vol. 1. Patavii. 766 p.

Shkarupa AG. 1980. Flora of micromycetes of the north-eastern Yakutia. I. 105–123, in: Vegetation and soils of subarctic tundra. Nauka, Novosibirsk. (in Russian).

Stadler M, Fournier J, Granmo A, Beltrán-Tejera E. 2008. The "red *Hypoxylons*" of the temperate and subtropical Northern hemisphere. North American Fungi 3(7): 73–125.

Teng SC. Fungi of China. Mycotaxon Ltd, Ithaca. 586 p.

Tulloss R. 2005. *Amanita*-distribution in the Americas with comparison to eastern and southern Asia and notes on spore character variation with latitude and ecology. Mycotaxon 93: 189–231.

Vasilyeva LN. 1987. Pyrenomycetes and loculoascomycetes of the Northern Far East. Nauka, Leningrad. 255 p. (in Russian).

Vasilyeva LN. 1998. Pyrenomycetes and loculoascomycetes. In: Lower plants, fungi, and bryophytes of the Russian Far East. Vol. IV (ed. Azbukina ZM). Nauka, Saint-Petersburg. 419 p. (in Russian).

Vasilyeva LN, Stephenson SL. 2007. *Cryptovalsaria* gen. nov. and its two new species from eastern Asia and south central North America. Sydowia 59: 154–160.

Vasilyeva LN, Li Y, Stephenson SL. 2009. Some pyrenomycetous fungi new to China. Mycotaxon 109: 415–428.

Vasilyeva LN, Chernyshev AV, Stephenson SL. 2010. Pyrenomycetes of the Russian Far East 4: family *Nitschkiaceae* (*Coronophorales*, *Ascomycota*). Mycologia 102: 233–247. doi:10.3852/09-090

Wehmeyer LE. 1933. The genus *Diaporthe* Nitschke and its segregates. University of Michigan Press, Ann Arbor. 349 p.

Wei JC., Biazrov LG. 1991. Some disjunctions and vicarisms in the *Umbilicariaceae* (*Ascomycotina*). Mycosystema 4: 65–72.

Whetzel HH, Wolf FA. 1945. The cup fungus, *Ciboria carunculoides*, pathogenic on mulberry fruits. Mycologia 37: 476–491. doi:10.2307/3754633

Wu QX, Mueller GM. 1997. Biogeographic relationships between the macrofungi of temperate eastern Asia and eastern North America. Canadian Journal of Botany 75: 2108–2116.

Yang ZL. 2000. Species diversity of the genus *Amanita* (*Basidiomycetes*) in China. Acta Botanica Yunnanica 22: 135–142.

Zang M. 1986. The mycogeography of tropical fungi from Yunnan, Tibet. Acta Mycologica Sinica, Supplement 1: 416–418.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.305

Volume 114, pp. 305–310 *October–December 2010*

First record of *Phlebia incarnata* from the southern hemisphere

MAURO C. WESTPHALEN, MATEUS A. RECK & ROSA MARA BORGES DA SILVEIRA

maurowestphalen@yahoo.com.br
Universidade Federal do Rio Grande do Sul, Departamento de Botânica
Av. Bento Gonçalves, 9500, 91501-970, Porto Alegre, RS, BRAZIL

Abstract — During a survey of xylophilous fungi in the municipality of São Francisco de Paula, in southern Brazil, *Phlebia incarnata*, a species never before recorded for South America, was found. *Phlebia incarnata* has a pileate basidiome with vivid pink coloration, a hymenophore with folds, a monomitic hyphal system, and cylindrical basidiospores. In this work, *P. incarnata* is compared with related species; a full description and illustrations are provided.

Key words — *Meruliaceae, Merulius,* mycodiversity, neotropics

Introduction

The genera *Merulius* Fr. and *Phlebia* Fr. were described by Fries in 1821. Since then, they have both been placed in family *Meruliaceae* P. Karst. (Kirk et al. 2008) and are mainly differentiated by the habit (reflexed to dimidiate in the former and resupinate to effused in the latter). Fries (1821) included 10 species in the genus *Merulius* and later divided it into two sections according to the pigmentation of the basidiospores (Fries 1838). Patouillard (1887) transferred the *Merulius* species with colored spores to the genus *Gyrophora* Pat., and later Karsten (1889) divided *Merulius* into four distinct genera: *Merulius*, *Plicatura* Peck, *Gyrophora,* and *Serpula* (Pers.) Gray. Over the years, further work including these genera has been published (Patouillard 1900, Donk 1964, Parmasto 1968), but none satisfactorily distinguished *Merulius* and *Phlebia.* They only agreed with Karsten's (1889) idea that they were related and difficult to discern due to morphological similarities. Ginns (1975), based on morphological and cultural characters, proposed a new segregation of the species of *Merulius* s.l., keeping

only two species in *Merulius* s.s., *M. tremellosus* Schrad., and *M. incarnatus* Schwein. However, Nakasone & Burdsall (1984), who morphologically and culturally compared the type species of *Merulius* and *Phlebia* (*M. tremellosus* and *P. radiata* Fr.), considered that the differences presented (based on basidiome habit, configuration of the hymenophore, and presence of cystidia and asexual spores in culture) were not sufficient to separate them into two different genera. Consequently they considered *Merulius* a synonym of *Phlebia*.

Using RFLP analysis of 18S rRNA gene fragment and ITS region, Dresler-Nurmi et al. (1999) demonstrated that *Phlebia tremellosa* (Schrad.) Nakasone & Burds. grouped together with *P. ochraceofulva* (Bourdot & Galzin) Donk, *P. centrifuga* P. Karst., and *P. radiata*. Subsequent phylogenetic analysis of the sequences 5.8S, ITS2, and LSU nuclear rDNA by Larsson et al. (2004) showed that *P. tremellosa* is closely related to *P. rufa* (Pers.) M.P. Christ., *P. radiata*, and *P. lindtneri* (Pilát) Parmasto. As *P. tremellosa* and *P. incarnata* are very similar morphologically, and the former groups in the same clade with other *Phlebia* species, it is likely that both belong to this genus instead of *Merulius*, thus supporting the conclusions of Nakasone & Burdsall (1984).

Phlebia is characterized by effuse to effuse-reflex or dimidiate basidiomata with cartilaginous to subgelatinous or ceraceous consistency. Hymenial surfaces can be smooth, tuberculate, odontoid, phlebioid, or merulioid. A monomitic hyphal system and smooth, thin-walled and non-amyloid basidiospores characterize the genus microscopically (Nakasone & Burdsall 1984, Maekawa 1993).

Materials and methods

Specimens were collected in July and September 2009, in the municipality of São Francisco de Paula, Rio Grande do Sul, Brazil. This region is characterized by presenting subtropical vegetation with the presence of the coniferous tree *Araucaria angustifolia* (Bertol.) Kuntze (*Araucariaceae* Henkel & W. Hochst.). The climate in the region is humid subtropical of the Cfb type, according to the Köppen Climate Classification (Moreno 1961).

After the macromorphological analysis, the specimens were dried at room temperature. For microscopy, freehand basidiome sections were mounted in a drop of 5% KOH solution and 1% phloxine solution. Microstructures were drawn aided by a camera lucida. The abbreviations and codes for the measurements are modified from Coelho (2005), where Lm × Wm = means of length and width, Q = range of length/width ratios, Qm = length/width mean, and n = x/y (x = number of measurements from a given number (y) of specimens). The codes used for colors follow Kornerup & Wanscher (1978). The collected specimens are kept at the ICN herbarium (UFRGS).

Taxonomy

Phlebia incarnata (Schwein.) Nakasone & Burds., Mycotaxon 21: 245, 1984 FIGS 1–5

SPECIMEN EXAMINED: BRAZIL. Rio Grande do Sul, municipality of São Francisco de Paula, FLONA, 03.VII.2009, leg. G. Seger 1028 (ICN 154337); 19.IX.2009, leg. G. Seger 1029 (ICN 154388).

BASIDIOMATA annual, pileate, sessile to dimidiate, sometimes slightly effused-reflexed, often imbricate, spongy when fresh becoming hard upon drying, pileus conchate; upper surface tomentose, pinkish to reddish (11A4–12A7) when fresh and pinkish white to reddish blond (7A2–5C3) after dried; margin fimbriate, vivid red (11A8); hymenial surface white (11A1) when fresh, drying dull red (9C4–10B4), folds 0.5–1.0 mm deep, radiating, continuous to the margin, side branches anastomosing forming cavities resembling a pore surface (1–2/mm); context up to 2.0 mm thick, duplex, upper layer loose and spongy, concolorous with the upper surface, lower layer waxy and dense, brownish red (10D6) to dull red (11C4).

HYPHAL SYSTEM monomitic, generative hyphae with clamp connections, 2.0–5.0 µm diam., thin to slightly thick-walled, with wide lumen, amorphous granules present in contextual hyphae; cystidia lacking. Basidia clavate, 4-sterigmate; basidiospores subcylindrical to cylindrical, slightly bent, hyaline, smooth, thin walled, frequently with two oil drops, 4.5–5.5 × 2.0–2.5 µm, Lm × Wm = 5.08 × 2.10, Q = 2.0–2.75, Qm = 2.43, n = 30/1.

CULTURE DESCRIPTION: See Ginns (1975)

SUBSTRATA: On fallen logs of an unknown angiosperm.

DISTRIBUTION: Previously recorded from United States, Mexico (Ginns 1975), and Costa Rica (Halling & Mueller 2006).

ADDITIONAL SPECIMENS EXAMINED: *Phlebia incarnata* – UNITED STATES. North Carolina, Franklin County, Louisburg, 01.II.2003, leg. V. Grand s/n (BPI 844251); Texas,

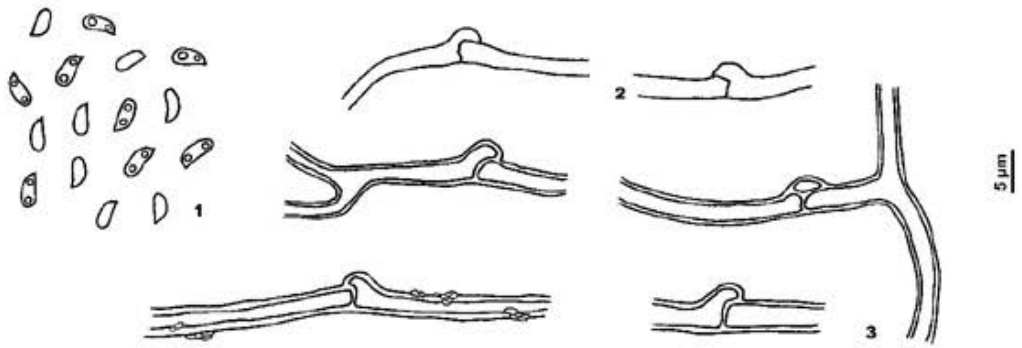


FIG. 1–3. *Phlebia incarnata* (ICN 154337).
1. Basidiospores. 2. Tramal generative hyphae. 3. Contextual generative hyphae.

FIG. 4–5. Basidiome of *Phlebia incarnata*. 4. Pileus surface. 5. Hymenophore. Scale bar = 1 cm.

Hardin County, Big Thicket National Preserve, Jack Gore Baygall Unit, 17.XI.2001, leg. D.P. Lewis 6542 (BPI 841954); Virginia, King George County, 7.XI.1972, leg. K.A. Harrison KHM 13344 (BPI 025617). *Phlebia tremellosa* — BRAZIL. Rio Grande do Sul, municipality of Cambará do Sul, Itaimbezinho, II.1981, leg. R.T. Guerrero s/n (ICN 56048 as *Merulius tremellosus*); municipality of São Francisco de Paula, CPCN Pró-Mata, 29.V.2009, leg. M.C. Westphalen 230/09 (ICN 154339); FLONA, 22.VI.2009, M.C. Westphalen 250/09 (ICN 154338).

REMARKS: *Phlebia incarnata* is easy to recognize due to its vivid reddish-pink color, spongy basidiomata, and folded hymenophore. Our specimens fit the description given by Ginns (1975), differing only in the fresh hymenial surface color, which in our specimens is white, while Ginns describes it as pale pink. Also, the specimens we examined from BPI herbarium usually presented a glabrous upper surface, sometimes with small hairs in restricted areas, while our material presented a tomentose to somewhat velvety upper surface.

Phlebia tremellosa is a similar species that also occurs in Brazil (Baltazar & Gibertoni 2009). However it presents a white to pallid pileus surface and the hymenial surface has a translucent pale orange-red coloration, which becomes deep orange-red upon drying. Microscopically, *P. tremellosa* can be differentiated by the allantoid basidiospores (4.0–4.5 × 1.0–1.5) and the presence of scattered cystidia imbedded in the hymenium.

According to Ginns (1975), *P. incarnata* frequently grows together with basidiomes of a species of *Stereum* Hill ex Pers. However, in our specimens, we did not observe this association.

This species was previously known only from countries located in the northern hemisphere. Therefore our record represents a significant addition to its biogeography distribution.

Acknowledgements

CAPES (Brazil) is acknowledged for financial support. We also wish to thank MSc. Guilherme Seger for the collections and photographs and Dr. Clarice Loguercio Leite (Universidade Federal de Santa Catarina, Brazil) and Dr. Kentaro Hosaka (National Museum of Nature and Science, Japan) for the critical review.

Literature cited

Baltazar JM, Gibertoni TB. 2009. A checklist of the aphyllophoroid fungi (*Basidiomycota*) recorded from the Brazilian Atlantic Forest. Mycotaxon 109: 439–442.

Coelho G. 2005. A Brazilian new species of *Auriporia*. Mycologia 97: 266–270. doi: 10.3852/mycologia.97.1.263

Donk M. 1964. A conspectus of the families of *Aphyllophorales*. Persoonia 3: 199–324.

Dresler-Nurmi A, Kaijalainen S, Lindström K, Hatakka A. 1999. Grouping of lignin degrading corticoid fungi based on RFLP analysis within 18S rRNA and ITS region. Mycological Research 103: 990–996. doi:10.1017/S0953756298008156

Fries EM. 1821. Systema mycologicum, vol. I. 520 p.

Fries EM. 1838. Epicrisis Systematis Mycologici, seu Synopsis Hymenomycetum. Uppsala. Typographia Academica. 608 p.

Ginns JH. 1975. *Merulius*: s.s. and s.l., taxonomic disposition and identification of species. Canadian Journal of Botany 54: 100–167.

Halling RE, Mueller GM. 2006. Macrofungi of Costa Rica (On Line): Available at: http://www.nybg.org/bsci/res/hall/costaric.html

Karsten P. 1889. Kritisk Öfversikt af Finlands Basidsvampar. Bidr. Kiinned. Finl. Nat. Folk 48: 1–470.

Kirk PM, Cannon PF, David JC, Stalpers JA. 2008. Ainsworth and Bisby's dictionary of the fungi. 10th Edition. CABI Publishing. 771 p.

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour. 3rd ed. London (UK): Eyre Methuen.

Larsson K-H, Larsson E, Kõljalg U. 2004. High phylogenetic diversity among corticioid homobasidiomycetes. Mycological Research 108(9): 983–1002. doi: 10.1017/S0953756204000851

Maekawa N. 1993. Taxonomic study of Japanese *Corticiaceae* (*Aphyllophorales*) I. Rep. Tottori Mycol. Inst. 31: 1–149.

Moreno JA. 1961. Clima do Rio Grande do Sul. Secretaria da Agricultura do Rio Grande do Sul. Porto Alegre.

Nakasone KK, Burdsall HH. 1984. *Merulius*, a synonym of *Phlebia*. Mycotaxon 21: 241–246.

Parmasto E. 1968. Conspectus systematis Corticiacearum. Institutum zoologicum et botanicum Academiae scientiarum R.P.S.S. Estonicae. Tartu. 261 p.

Patouillard NT. 1887. Les Hyménomycètes d'Europe. Anatomie et classification des champignons supérieurs (Matériaux pour l'Histoire des Champignons I). Paris. Klincksieck. 166 p.

Patouillard NT. 1900. Essai taxonomique sur les familles et les genres des Hyménomycètes. Lons-le-Saunier. Duclume. 184 p.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.311

Volume 114, pp. 311–314 *October–December 2010*

New records of lichenicolous and lichenized fungi from Turkey

MEHMET GÖKHAN HALICI[1*], ILGAZ AKATA[2] & MUSTAFA KOCAKAYA[3]

[1]*mghalici@erciyes.edu.tr*
Biyoloji Bölümü, Fen Fakültesi, Erciyes Universitesi
38039 Kayseri, Turkey

[2]*akata@science.ankara.edu.tr*
Biyoloji Bölümü, Fen Fakültesi, Ankara Universitesi
Ankara, Turkey

[3]*mustafa.kocakaya@bozok.edu.tr*
Biyoloji Bölümü, Fen - Edebiyat Fakültesi, Bozok Universitesi
Yozgat, Turkey

Abstract — In the course of studying the lichenicolous and lichenized fungi deposited in the lichen herbarium of Erciyes University, three lichenicolous fungi (*Arthonia epicladonia, Lichenostigma dimelaenae, Sphinctrina leucopoda*) and one lichenized fungus (*Rhizocarpon sublavatum*) are reported from Turkey for the first time. Comments on their habitats, substrata, and key anatomical features are provided for each taxon.

Key words — *Ascomycota*, lichens, biodiversity, Trabzon, Yozgat

Introduction

In the last 20 years, there have been intensive lichenological studies to determine the lichen mycota of Turkey (e.g. John 1996, Aslan 2000, John & Breuss 2004, Halıcı et al. 2005, Tufan et al. 2005, Candan & Özdemir Türk 2008). At the moment, approximately 1200 lichenized fungal species are known from Turkey but at least 2000 lichenized fungal species are expected in the country (Halıcı et al. 2007a). The checklist of lichenized and lichenicolous fungi of Turkey is being prepared by Volker John and should be published in a few years (V. John, pers. comm.).

The lichenicolous fungi of Turkey have started to receive more attention during the last five years, and a key to the 117 known taxa of lichenicolous *Ascomycota* (including mitosporic fungi) of Turkey was published by Halıcı (2008a). After this publication, there were some more additions (e.g. Candan &

Halıcı 2008, Halıcı 2008b,c, Halıcı & Candan 2009, Halıcı et al. 2009, Candan et al. 2010) and the number of lichenicolous fungal taxa known from Turkey has reached 157. With the 3 species reported in this paper, 160 lichenicolous fungal species are known from Turkey.

Material and methods

The specimens are deposited in the lichen herbarium of Erciyes University, Biology Department (Kayseri, Turkey). They were examined by standard microscopic techniques. Hand sections were studied in water, potassium hydroxide (KOH) and Lugol's solution (I). Measurements were made in water and the extreme values outside the main range are given in parentheses.

The species

Arthonia epicladonia (Nyl.) Alstrup & Zhurb.

A detailed description is provided by Zhurbenko & Alstrup (2004) and figures were provided by Alstrup & Hawksworth (1990) under the name *Scutula epicladonia* (Nyl.) Zopf.

TRABZON: Of, UZUNGÖL-SOĞANLI GEÇIDI, 40°36.117'N, 40°16.682'E, alt. 2110 m, on squamules of *Cladonia pyxidata* on mosses, 30 Sep. 2008, M.G. Halıcı & I. Akata (MGH 0.6320).

Arthonia epicladonia was collected on the squamules of *Cladonia pyxidata* from northeast of Turkey. The Turkish specimen seems to be pathogenic as the infected squamules eventually become brownish. Zhurbenko & Alstrup (2004) did not observe any pathogenic effect in the American specimen; they also cited a wider ascospore size range [(10–)14–17.5(–20) × 5–5.5(–6) µm] than we observed in our Turkish specimen (14–15 × (3.5–)4–5 µm). All other Turkish characters agree well with the description given in Zhurbenko & Alstrup (2004).

New to Turkey.

Lichenostigma dimelaenae Calat. & Hafellner

A detailed description is provided by Calatayud et al. (2004).

YOZGAT: Şefaatli, ŞEKERCI DAĞI, 39°32.511'N, 34°43.242'E, alt. 880 m, on areoles of *Dimelaena oreina* on siliceous rocks, 12 Jul. 2009, M. Kocakaya (MGH 0.4018).

Ascomata not connected to superficial hyphal strands and forming dense groups, centrum I + pale red. Asci 8-spored, subglobose to globose, 25–28 × 25–28 µm. Ascospores brown, 1-septate, broadly obovate and constricted at the septum, not halonate, 13–16 × 6.5–11 µm.

Previously this species was recorded only from the USA. The Turkish specimen is identical with the original species description. New to Turkey.

Rhizocarpon sublavatum Fryday

A detailed description is provided by Fryday (2000).

TRABZON: Of, UZUNGÖL-SOĞANLI GEÇIDI, 40°36.117'N, 40°16.682'E, alt. 2110 m, on exposed siliceous rocks, 30 Sep. 2008, M.G. Halıcı & I. Akata (MGH 0.2920).

The Turkish specimen has a cracked-areolate and brownish-grey thallus, which is clearly limited by a black prothallus. Ascospores are hyaline to very pale brownish, muriform with 19–20 cells, and (24–)29–30(–34) × (11–)13–14 µm.

Fryday (2000) noted that *R. sublavatum* has ascospore characters intermediate between *R. reductum* and *R. lavatum* and suggests that it is a northern montane species, probably with some oceanic affinities. The Turkish specimen, which was collected at 2110 m altitude in a very humid locality, supports confirms this observation.

Previously reported only from UK (Fryday 2000) and Norway (Ihlen 2004). New to Turkey.

Sphinctrina leucopoda Nyl.

Detailed descriptions are provided by Löfgren & Tibell (1999) and Tibell (2004).

YOZGAT: Akdağmaden, BÜYÜK NALBANT MOUNTAIN, 39°32'N, 36°00'E, alt. 2150 m, on *Lecanora swartzii* on exposed siliceous rocks, 14 Aug. 2004, M.G. Halıcı & M. Kocakaya (MGH 0.4016).

The Turkish specimen is parasymbiotic, has distinctly stalked apothecia, 8-spored asci measuring 45–53 × 6–7 µm, and non-septate brown ascospores that are minutely ornamented in maturity. Ascospores of the Turkish specimen are slightly larger [(5–)5.5–6(–7) µm vs. (4–)4.3–6.3 × 4–5.7(–5.8) µm] than the reports previously given for the species (Löfgren & Tibell 1999).

This variable species is sometimes hard to distinguish from *Sphinctrina turbinata* morphologically, but the latter species shows a characteristic K + intensified red pigment in the exciple as stated by Löfgren & Tibell (1999) and Tibell (2004). The Turkish specimen was collected on the areoles of *Lecanora swartzii*, although *S. leucopoda* is also reported frequently on *Pertusaria pertusa* and rarely on *Diploschistes* or *Lecanora* on rocks (Löfgren & Tibell 1999, Tibell 2004). *Sphinctrina leucopoda* is rarely reported on *Lecanora swartzii* from Sweden (Ihlen & Wedin 2008).

Acknowledgements

Kerry Knudsen (USA) and Sergio Pérez-Ortega (Spain) are thanked for reviewing this paper. Tuba Zeytun and Zekiye Kırış are thanked for their help in the herbarium studies.

Literature cited

Alstrup V, Hawksworth DL. 1990. The lichenicolous fungi of Greenland. Medd. Grønl. Bioscience 31: 1–90.

Aslan A. 2000. Lichens from the regions of Artvin, Erzurum and Kars (Turkey). Israel Journal of Plant Sciences 48: 143–155. doi:10.1560/KC54-1W57-F07A-09IL

Calatayud V, Hafellner J, Navarro-Rosinés P. 2004. *Lichenostigma*, pp. 664–669. In Nash TH III, Ryan BD, Diederich P, Gries C, Bungartz F. 2004. Lichen Flora of the Greater Sonoran Desert Region.Vol. 2. Tempe: Arizona State University.

Candan M, Halıcı MG. 2008. Seven new records of lichenicolous fungi from Turkey. Mycotaxon 104: 241–246.

Candan M, Özdemir Türk A. 2008. Lichens of Malatya, Elazığ and Adıyaman provinces (Turkey). Mycotaxon 105: 19–22.

Candan M, Halıcı MG, Özdemir Türk A. 2010. New Records of Peltigericolous Fungi from Turkey. Mycotaxon 111: 149–153.

Fryday A. 2000. On *Rhizocarpon obscuratum* (Ach.) Massal., with notes on some related species in the British Isles. Lichenologist 32: 207–224. doi:10.1006/lich.2000.0269

Halıcı MG. 2008a. A key to the lichenicolous *Ascomycota* (including mitosporic fungi) of Turkey. Mycotaxon 104: 253–286.

Halıcı MG. 2008b. *Arthonia hawksworthii* sp. nov. (*Ascomycota*, *Arthoniaceae*) on *Dimelaena oreina* from Turkey. Mycotaxon 105: 203–206.

Halıcı MG. 2008c. *Llimoniella muralicola* sp. nov. (*Ascomycota*, *Helotiaceae*) on *Protoparmeliopsis muralis* from western Turkey. Mycotaxon 105: 89–93.

Halıcı MG, John V, Aksoy A. 2005. Lichens of Erciyes Mountain (Kayseri, Turkey). Fl. Medit. 15: 567–580.

Halıcı MG, Hawksworth DL, Aksoy A. 2007a. Contributions to the lichenized and lichenicolous fungal biota of Turkey. Mycotaxon 102: 403–414.

Halıcı MG, Atienza V, Hawksworth DL. 2007b. Two new *Polycoccum* species from Turkey. Mycotaxon 101: 157–163.

Halıcı MG, Candan M, Özdemir Türk A. 2009. Notes on some lichenicolous fungi species from Turkey II. Turkish Journal of Botany 33: 389–392.

Ihlen PG. 2004. Taxonomy of the non-yellow species of *Rhizocarpon* (*Rhizocarpaceae*, lichenized *Ascomycota*) in the Nordic countries, with hyaline and muriform ascospores. Mycological Research 108: 533–570. doi:10.1017/S0953756204009803

John V. 1996. Preliminary catalogue of lichenized and lichenicolous fungi of Mediterranean Turkey. Bocconea 6: 173–216.

John V, Breuss O. 2004. Flechten der östlichen Schwarzmeer-Region in der Türkei (BLAM-Exkursion 1997). Herzogia 17: 137–156.

Löfgren O, Tibell L. 1979. *Sphinctrina* in Europe. Lichenologist 11: 109–137. doi:10.1017/S0024282979000189

Navarro-Rosinés P, Roux C. 1990. *Polycoccum opulentum* (Th.Fr. et. Almq.) Arnold, nelikeniĝinta fungo likenloga, ofta sed pretervidita. Bull. Soc. Linn. Provence 41: 143–150.

Tibell L. 2004. *Sphinctrina*. pp. 699–701. In Nash TH III, Ryan BD, Diederich P, Gries C, Bungartz F. 2004. Lichen Flora of the Greater Sonoran Desert Region.Vol. 2. Tempe: Arizona State University.

Tufan Ö, Sümbül H, Özdemir Türk A. 2005. The lichen flora of the Termessos National Park in Southwestern Turkey. Mycotaxon 94: 43–47.

Zhurbenko M, Alstrup V. 2004. Lichenicolous fungi on *Cladonia* mainly from the Arctic. Symb. Bot. Upsal. 34: 477–499.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.315

Volume 114, pp. 315–318 October–December 2010

A new species of *Heteroconium* from Fujian, China

YI-DONG ZHANG, JIAN MA, LI-GUO MA & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — *Heteroconium schimae* sp. nov. is described and illustrated occurring on dead branches of *Schima superba*. The specimen was collected from tropical forests in Fujian province of China. The type specimen is deposited in HSAUP (Herbarium of the Department of Plant Pathology, Shandong Agricultural University) and HMAS (Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences).

Key words — hyphomycetes, taxonomy

Introduction

The genus *Heteroconium* was erected by Petrak (1949) with *H. citharexyli* F. Petr as the type species. The generic characteristics of *Heteroconium* include macronematous, mononematous conidiophores which are unbranched or with a few branches originating after conidial secession. The conidiogenous cells are monoblastic, terminal, and proliferate percurrently, and the conidia are dry, euseptate, cylindrical to oblong, sometimes curved, and arise in acropetal unbranched chains (Petrak 1949, Castañeda et al. 1999, Taylor et al. 2001). Conidial secession is schizolytic. These characters also separate the genus from similar genera such as *Lylea* Morgan-Jones, *Xenoheteroconium* Bhat et al., *Cladophialophora* Borelli, *Septonema* Corda, *Phaeoblastophora* Partr. & Morgan-Jones, *Taeniolella* S. Hughes, *Cylindrium* Bonord, and *Hormiactis* Preuss (Castañeda et al. 1999, Kwaśna et al. 2007). To date, 18 taxa have been assigned to the genus *Heteroconium*, although several have been transferred to other genera. *Heteroconium tetracoilum* (Corda) M.B. Ellis (Ellis 1976) was transferred to *Lylea* as *L. tetracoila* (Corda) Hol.-Jech. (Holubová-Jechová 1978), while *Heteroconium solaninum* (Sacc.& P. Syd.) M.B. Ellis (Ellis 1976) was designated as the type species of the genus *Pirozynskiella* S. Hughes (Hughes 2007) based on its obligate association with asterinaceous fungi

*Corresponding author

and in the centrifugal sequence of conidium trans-septation after the initial median septum. *Heteroconium chaetospira* (Grove) M.B. Ellis (Ellis 1976) was transferred to *Cladophialophora* as *C. chaetospira* (Grove) Crous & Arzanlou (Crous et al. 2007) following a molecular study of the *Herpotrichiellaceae* and *Venturiaceae*. *Heteroconium queenslandicum* Matsush. (Matsushima 1989) has undifferentiated conidiophores and both mono- and polyblastic conidiogenous cells. It is not congeneric with *Heteroconium* species and is more closely related to the genus *Parapleurotheciopsis* P.M. Kirk (Kirk 1982), although a new combination has not been proposed from China.

The species of *Heteroconium* have been described from a variety of substrates including living or decaying leaves, dead twigs, dead wood, and bark, especially in damp conditions and warmer climates. During a study of tropical microfungi from the forest of Fujian province of southern China, numerous anamorphic fungi were collected. Among them, a previously undescribed species of *Heteroconium* was found which differed in conidial morphology. It is proposed herein as new.

Taxonomic description

Heteroconium schimae Y.D. Zhang & X.G. Zhang, **sp. nov.** FIGURE 1

MycoBank MB 518788

Coloniae in substrato naturali effusae, atro-brunneae. Mycelium partim superficiale, partim immersum, ex hyphis septatis, pallide brunneis, laevibus, 1–2 µm crassis compositum. Conidiophora macronematosa, mononematosa, nonramosa, erecta, cylindrica, recta, laevia, atro-brunnea, 4–10-septata, 59–127 × 4–5.5 µm. Cellulae conidiogenae monoblasticae, terminales, brunnea, laevia, 9–16.5 × 4–5.5 µm. Conidiorum secessio schizolytica. Conidia cylindrica, lata fusiformia usque ad obclavata, frequenter attenuata ad alternus cum terminales, holoblastica, dilute brunneae, laevibus, 0–6-euseptata, 13–44 × 5.5–10 µm. Teleomorphosis ignota.

Holotype: on dead branches of *Schima superba* Gardn. & Champ. (*Theaceae*), forest park of Wuyishan, Fujian Province, China. Aug. 16. 2009, Y.D. Zhang, HSAUP H3100 (isotype HMAS 144866).

Etymology: in reference to the substrate genus, *Schima*.

Colonies on the natural substratum, effuse, dark brown. Mycelium partly superficial, partly immersed, composed of septate, pale brown, smooth-walled hyphae, 1–2 µm thick. Conidiophores macronematous, mononematous, unbranched, erect, cylindrical, straight, smooth, dark brown, 4–10-septate, 59–127 × 4–5.5 µm. Conidiogenous cells monoblastic, terminal, brown, smooth, 9–16.5 × 4–5.5 µm. Conidial secession schizolytic. Conidia cylindrical, broad fusiform to obclavate, often tapered at one or both the ends, holoblastic, in chains of up to 4, occasionally with a secondary conidium from its neighbors or from conidial secession, pale brown, smooth-walled, 0–6-euseptate, 13–44 × 5.5–10 µm. Teleomorph unknown.

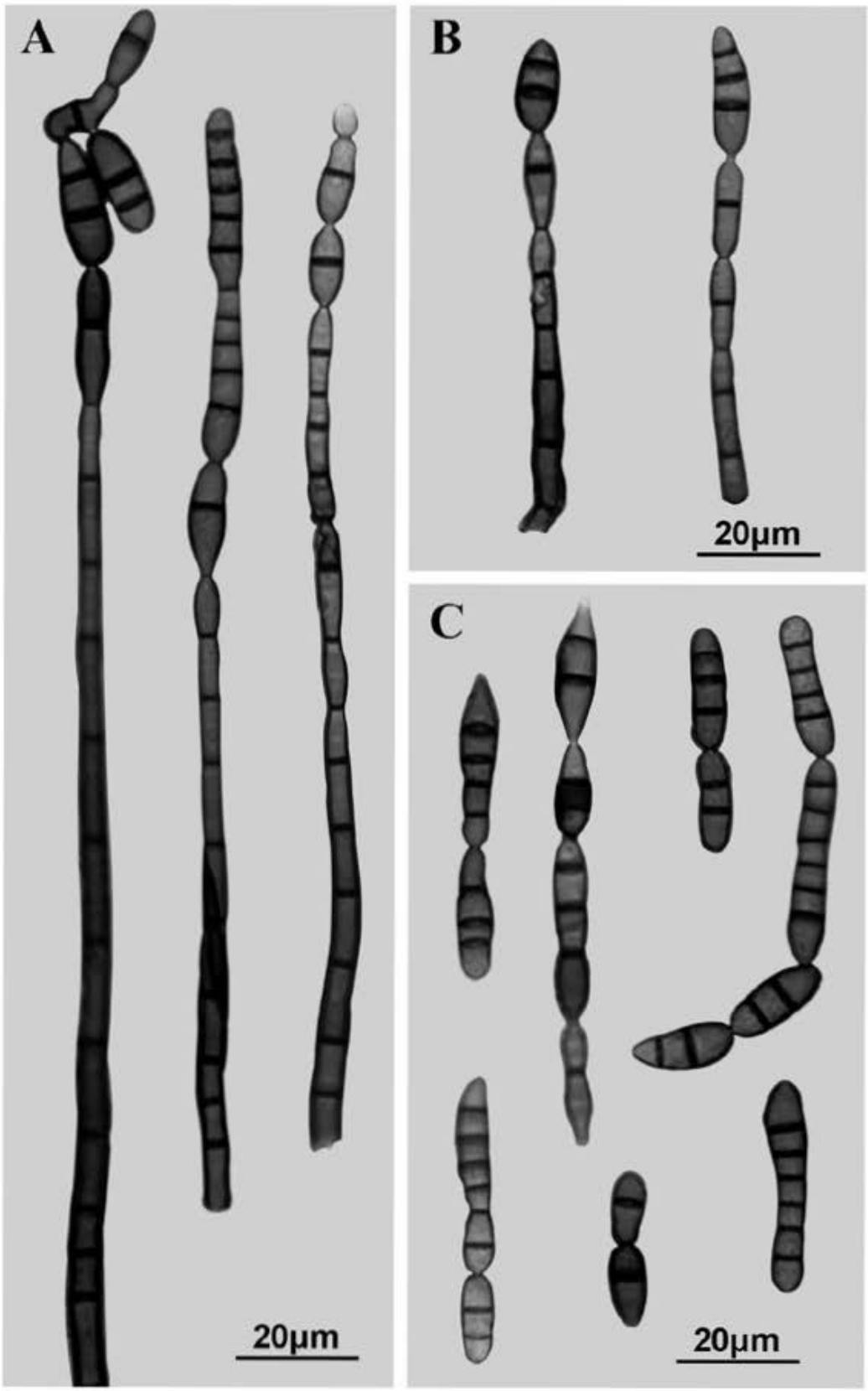


FIG. 1. *Heteroconium schimae*. A–B. Conidiophores with conidia. C. Conidia.

The conidia of *H. schimae* are similar in shape and septation to those of *H. arundicum* Chowdhry (Chowdhry 1980) and *H. citharexyli* (Petrak 1949). However, the conidia of *H. schimae* are smaller than those of *H. arundicum* (35–95 × 8–12 µm), while the conidiogenous cells of *H. citharexyli* are determinate or proliferate percurrently, a feature not found in *H. schimae*. In addition, the conidia of *H. schimae* are in chains of up to 4 and occasionally have a secondary conidium, whereas those are not produced by *H. arundicum* and *H. citharexyli*.

Acknowledgments

The authors are grateful to Dr Eric H.C. McKenzie and Dr N.R. O'Neill for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (No. 30770015, 30499340, 2006FY120100).

Literature cited

Castañeda Ruíz RF, Saikawa M, Guarro J. 1999. A new species of *Heteroconium* from a tropical rainforest. Mycotaxon 71: 295–300.

Chowdhry PN. 1980. A new species of *Heteroconium* from India. Indian Phytopathology 33: 361–362.

Crous PW, Schubert K, Braun U, Hocking AD, Shin HD, Groenewald JZ. 2007. Opportunistic, human-pathogenic species in the *Herpotrichiellaceae* are phenotypically similar to saprobic or phytopathogenic species in the *Venturiaceae*. Studies in Mycology 58: 185–217. doi:10.3114/sim.2007.58.07

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew 507 p.

Holubová-Jechová V. 1978. Lignicolous hyphomycetes from Czechoslovakia 5. *Septonema*, *Hormiactella*, and *Lylea*. Folia Geobotanica et Phytotaxonomica 13: 421–442.

Hughes SJ. 2007. *Heteroconium* and *Pirozynskiella* n. gen., with comments on conidium transseptation. Mycologia 99: 628–638. doi:10.3852/mycologia.99.4.628

Kirk PM. 1982. New or interesting microfungi. IV. Dematiaceous hyphomycetes from Devon. Transactions of the British Mycological Society 78: 55–74.

Kwaśna H, Bateman GL. 2007. *Heteroconium* sp.nov. from roots of *Triticum aestivum* in the United Kingdom. Mycologia 99: 777–785. doi:10.3852/mycologia.99.5.777

Matsushima T. 1989. Matsushima Mycological Memoirs 6: 1–100 Kobe, published by the author.

Petrak F. 1949. Neue Hyphomyzeten-Gattungen aus Ekuador. Sydowia 3: 259–266.

Taylor JE, Crous PW, Palm ME. 2001. Foliar and stem fungal pathogens of *Proteaceae* in Hawaii. Mycotaxon 78: 449–490.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.319

Volume 114, pp. 319–328 October–December 2010

Development and morphology of *Clathrus delicatus* (*Phallomycetidae, Phallaceae*) from India

S. SWAPNA[1], S. ABRAR[1], C. MANOHARACHARY[2] & M. KRISHNAPPA[1*]

swapnas1007@gmail.com, syedabrar1007@gmail.com
*cmchary@rediffmail.com & *krishnappam1007@gmail.com*

[1]*Department of Post Graduate Studies and Research in Applied Botany*
Jnana Sahyadri, Kuvempu University, Shankaraghatta-577451, Karnataka, India

[2]*Mycology and Plant Pathology Laboratory, Department of Botany*
Osmania University, Hyderabad-500007, Andhra Pradesh, India

Abstract — During fieldwork, *Clathrus delicatus* was collected from the Muthodi forest range in the Bhadra Wildlife Sanctuary in the state of Karnataka, India. Although this species was previously recorded from India, these reports did not include detailed morphological descriptions. Here we describe *C. delicatus* and provide illustrations and notes on fruitbody development, which has not been well characterized in the past.

Key words — *Phallaceae*, peridial suture, primordia, sporoma, volva-gel

Introduction

Members of *Phallales*, commonly called stinkhorns, produce foul-smelling fruitbodies that attract insects. Their distinctive odor is produced by a combination of chemicals such as hydrogen sulfide and methyl mercaptan (List & Freund 1968). Stinkhorns typically develop very quickly, often within few hours, with the spore bearing structures (receptacles) emerging from globose to ovoid structures called 'myco-eggs' (Lloyd 1906, Pegler et al. 1995). The order *Phallales* comprises 2 families, 26 genera, and 88 species (Kirk et al. 2008). Clathroid members of family *Phallaceae* form multipileate receptacles (Gäumann 1952) with beautiful and bright colored sporomata. *Clathrus* is unique in having latticed, hollow, spherical or stellate receptacles with slimy glebae (spore masses) borne on their inner surfaces (Pegler et al. 1995). Species in *Clathrus* have simple (Ingold 1971), ellipsoid spores that are typically dispersed after they adhere to the body parts of insects that have been lured to the fruitbody by its fetid aroma (Alexopoulos et al. 2002).

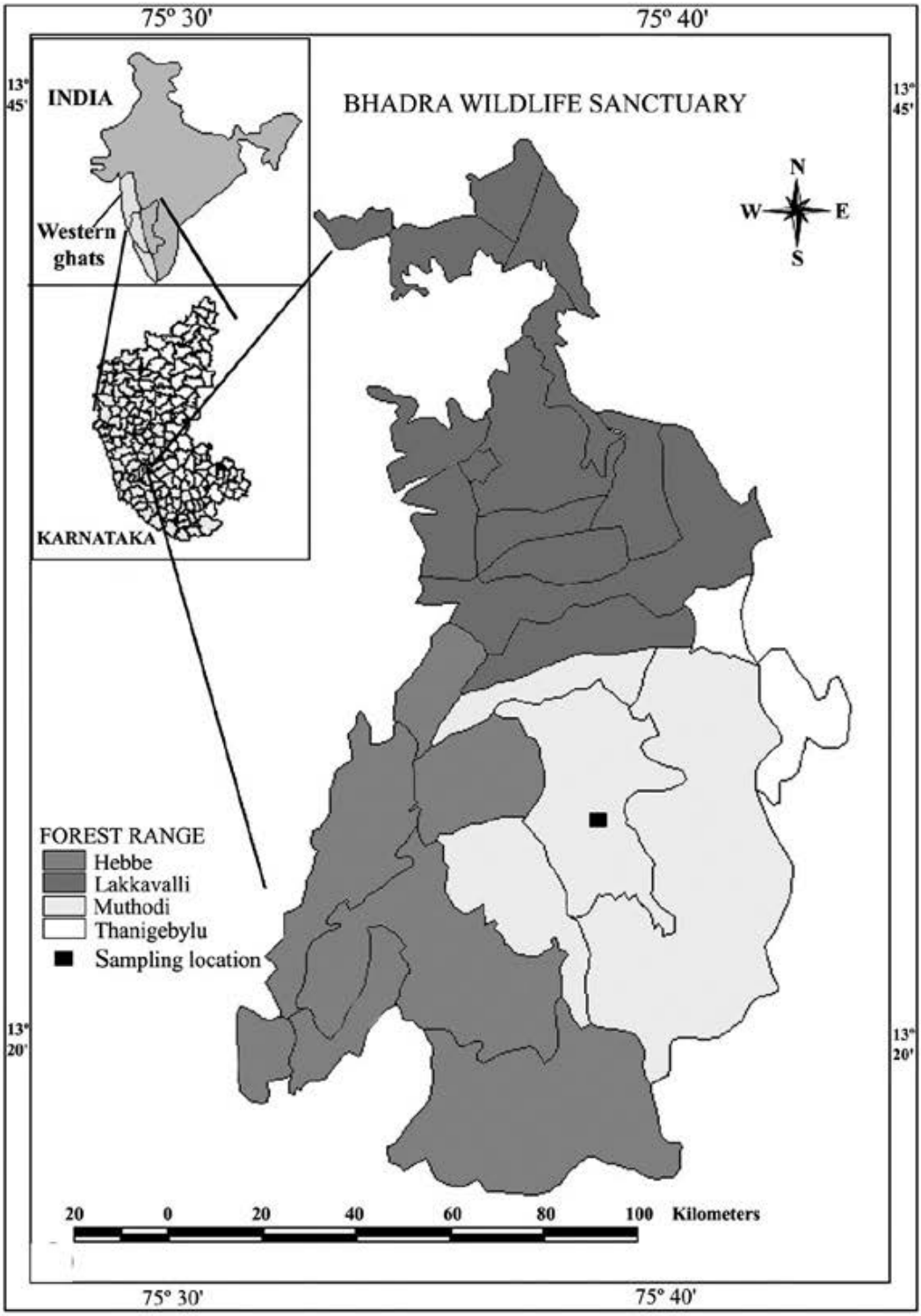


FIG. 1. Sampling location in Muthodi forest range, Bhadra Wildlife Sanctuary.

Clathrus delicatus was first described by Berkeley & Broome (1873). Fischer (1898–99) outlined growth stages of *C. delicatus* and compared its receptacle and glebal development to that of *C. chrysomycelinus* Möller. Narasimhan (1932), who published the first report of *C. delicatus* from India (Mysore, Karnataka),

gave a few details on characteristics of the gleba but did not describe the sporoma morphology (e.g., egg and receptacle color and size). Dring (1980) described the development of sporomata in *Clathraceae* (regarded as synonymous with *Phallaceae* by Kirk et al. 2008) and correlated the relationship of receptacle with the other parts of the developing fruitbody. Later, Apte (2005) collected *C. delicatus* during a survey on Owl moths (*Othreis* spp.) in Sanjay Gandhi National Park, Mumbai and sent the photographs to the Smithsonian Institution (USA) for identification but did not provide a morphological description of *C. delicatus*.

The present paper provides the first detailed taxonomic description of *C. delicatus* based on Indian material collected in India, including a systematic study of the sporoma development of this species.

Materials and methods

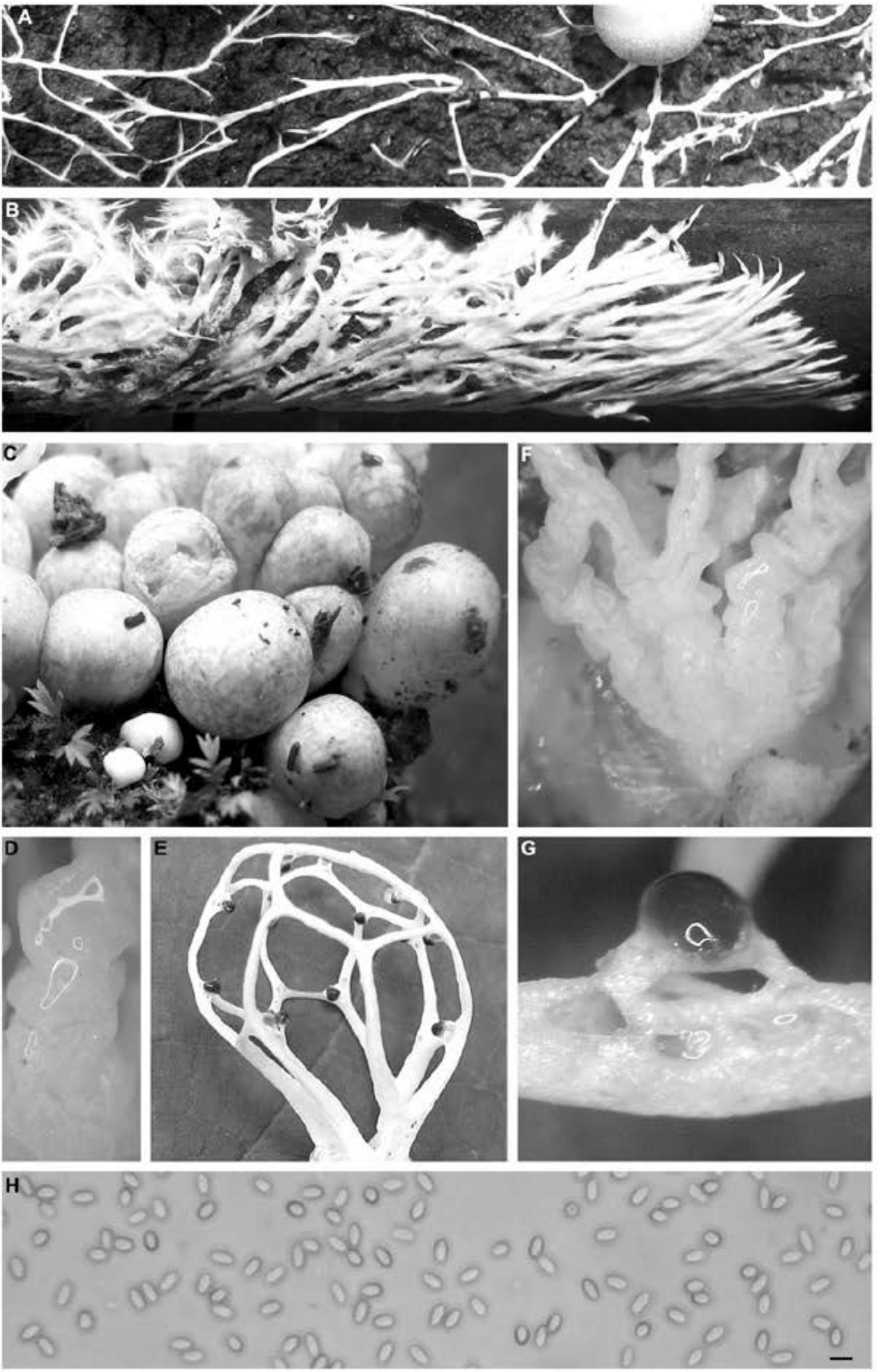
Collections were made at the Muthodi forest range in the Bhadra Wildlife Sanctuary, Karnataka, India (Fig. 1), altitude 700 m, temperature 22–28°C and relative humidity 75–90%. Fresh specimens were photographed and color notations were made according to Kornerup and Wanscher (1978). Descriptions of macroscopical characters were compiled from field notes on fresh specimens. Microscopic observations and measurements were made on mounts of receptacle material in 3% KOH stained with 3% phloxine. The primordia were fixed in Pfeiffer's solution containing methanol (absolute) and 40% formalin (w/v) in equal proportions, and then free-hand sections, stained with 1% lactophenol cotton blue and 1% phloxine, were prepared on glass slides for observations under a stereo microscope. The specimens cited are deposited in the herbarium of the Department of Applied Botany, Kuvempu University, Shankaraghatta, Shimoga Dist., Karnataka, India (KUABSAK).

Taxonomy

Clathrus delicatus Berk. & Broome, J. Linn. Soc., Bot. 14: 77, 1873 ["1875"]

Figs. 2–4

Immature Fruit Bodies ('myco-eggs') arising from thick whitish (1A1) mycelial strands (Fig. 2A) running over twigs (Fig. 2B); globose to ovoid (Fig. 2C), white (1A1) to pale orange (5A1-3), up to 10 mm in diameter, rupturing apically to reveal the expanding receptacle that is initially covered in a mucilaginous substance (Fig. 2D). Receptacle hollow with latticed network, 15–20 × 10–14 mm (Fig. 2E), chalk white (1A1), meshes about 10–12, polygonal, irregularly branched, ± isodiametric towards the apex and vertically elongated towards the base, where arms unite to form a short stipe (Fig. 2F). Arms smooth, flattened, each deeply grooved along their outer-surface. Gleba


A
B
C
F
D
E
G
H

olive brown (4E6), initially coralloid, mucilaginous, deliquescing jelly-like masses restricted to the inner surfaces of the receptacle (toward the apex where arms intersect) on specialized organs (resembling three-legged stools) called glebifers (FIG. 2G). VOLVA pale white to light orange (5A4), thin, enclosing the basal portion of the receptacle. BASIDIOSPORES elliptical, 1–2.2 × 3.6–4.8 µm, smooth, hyaline (FIG. 2H).

SPECIMEN EXAMINED: INDIA, KARNATAKA, Muthodi Forest Range, Bhadra Wildlife Sanctuary (13° 21' 13" N, 75° 38' 10" E, alt. 700m), on decaying vegetation of *Bambusa arundinacea* Retz. (*Poaceae*), 20.VIII.2007, coll. S. Swapna, S. Abrar, C. Manoharachary & M. Krishnappa (KUABSAK-MCH265).

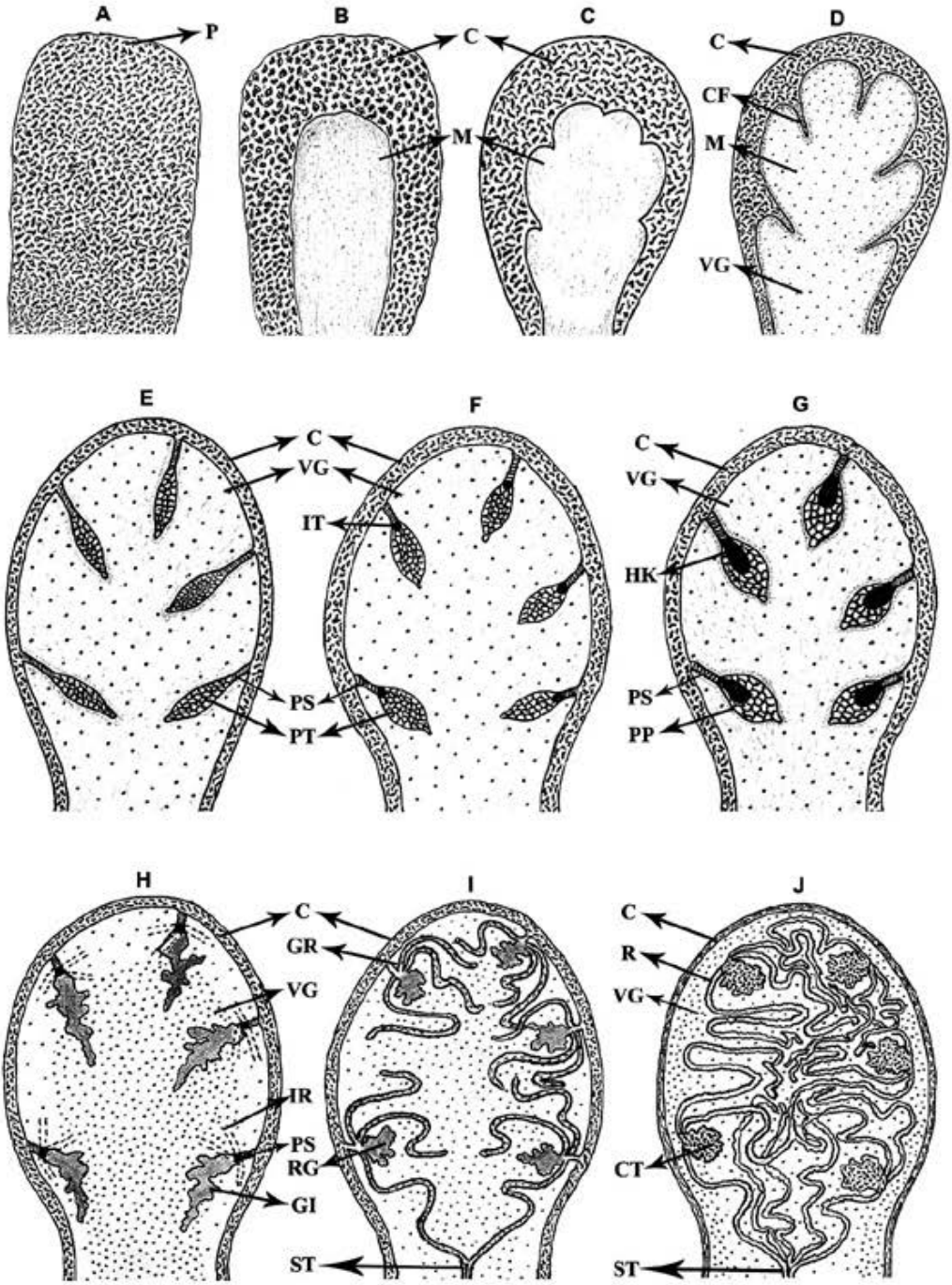
Development

C. delicatus undergoes two phases in the sporomic stage: a myco-egg phase and receptacle phase.

PRIMORDIA INITIATION: Primordia initiate at points of swellings along the mycelium strands. The primordium initial (P) lacks an internal structure and is composed of hyphal elements (FIG. 3A). The developing primordium differentiates into central medulla (M) and peripheral cortex (C) (FIG. 3B). The cortical layer develops a series of infoldings (FIG. 3C) that intrude into the inner layer on the medulla. As these infolds become more pronounced, clefts (CF) form and medulla begins to deliquesce, transforming into the volva-gel (VG) within the cortex (FIG. 3D). The primordium increases in size throughout this phase as the cortex and other internal structures develop to form recognizable small myco-eggs.

MYCO-EGG PHASE: The clefts further deepen and become compressed, forming peridial sutures (PS) at the myco-egg centres. The deepest point of each peridial suture differentiates into palisade tissue (PT) (FIG. 3E) that comprises the gleba fundamentals. At the peridial suture-palisade tissue junction, an intermediate tissue (IT) develops (FIG. 3F) and then thickens into hyphal knots (HK) while the palisade transforms into pseudoparenchymatous tissue (PP) (FIG. 3G). The hyphal knot begins to divide, branching out on three sides to initiate the receptacle (IR). Each pseudoparenchymatous mass further differentiates to form a glebal initial (GI) (FIG. 3H). The lowermost peridial suture ring producing lower branches proliferates towards the base, each fusing together to form a very short stipe (ST). The growing receptacle (GR) develops further

FIG. 2. *Clathrus delicatus* (KUABSAK-MCH 265). —A White mycelial strands. —B Mycelium covering twigs of *Bambusa arundinacea*. —C A cluster of myco-eggs. —D Mucilaginous substance (volva-gel) coating the emerging receptacle. —E The latticed network of the mature receptacle. —F Arms at the basal portion of the receptacle united to form a short stipe. —G Glebifer. —H Basidiospores. Magnifications: A–C = 15×, D = 40×, E = 12×, F = 35×, G = 45×; scale bar: H = 5 µm.



FIGS. 3A-J. Sporoma development of *Clathrus delicatus* (KUABSAK-MCH 265).

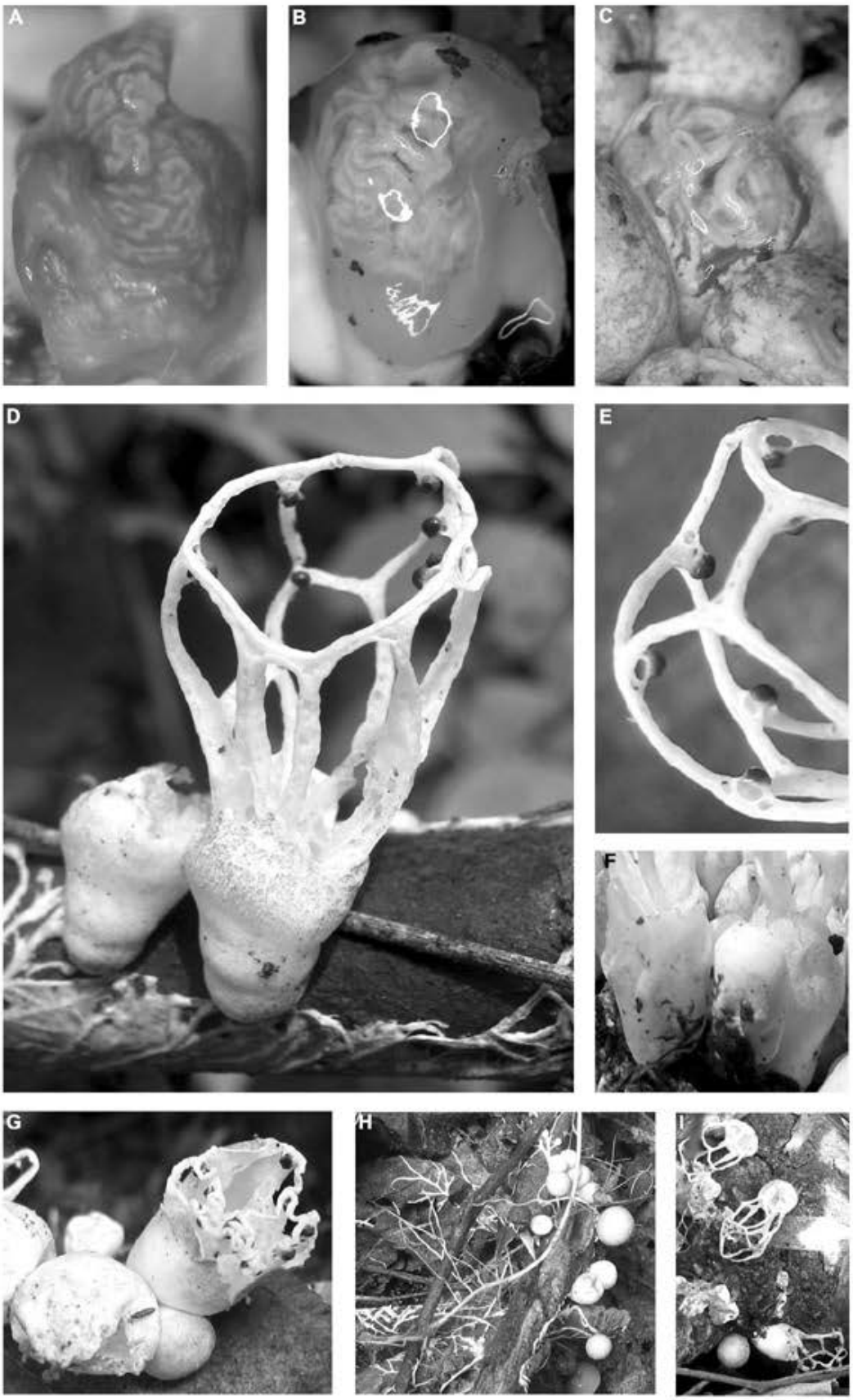
ABBREVIATIONS: C—Cortex, CF—Cleft, CT—Palisade tissue transforming into columella and trama, GR—Growing receptacle, HK—Hyphal knot, GI—Gleba initial, IR—Initiation of receptacle, IT—Intermediate tissue, M—Medulla, P—Primordium, PP—Pseudoparenchyma layer, PS—Peridial suture, PT—Palisade tissue, RG—Reduction of glebal mass, ST—Stipe, VG—Volvagel.

with the reduction of glebal mass (RG) (FIG. 3I). The continuous development and branching of the receptacle (R) at the centre displaces the volva-gel towards the periphery as the peridial sutures degrade (FIG. 3J) and the central medulla disintegrates. The palisade tissue completely transforms into gelatinized columella and trama (CT), which adheres tightly to the developing receptacle that completely surrounds it (FIG. 4A). After 8–10 days, the volva-gel becomes more viscous (FIG. 4B) as the egg increases in size and basidiospores are formed from hymenial layers forming inverted cup shaped structures (gleba) at the junction of the arms. The mature egg has three distinct layers: the exoperidium (outer skin), mesoperidium (volva-gel), and endoperidium (receptacle and gleba). After the egg ruptures apically (FIG. 4C), the expanding receptacle emerges.

RECEPTACLE PHASE: Rupture is caused by increasing turgor pressure and cell elongation in the expanding receptacle. The receptacle freely expands and this phase proceeds rapidly (2–4 minutes) until the mature sporoma has formed (FIG. 4D), with the gleba found at the arm intersections resembling three-legged stools (FIG. 4E). After 'hatching,' the ruptured exoperidium remains behind as a volva (FIG. 4F) attached to the mycelial strands. The receptacle eventually shrinks with time (FIG. 4G), and insects attracted by the fetid glebal odor disseminate the spores, thus continuing the life cycle with multiple colonies (FIG. 4H) and developing sporomata (FIG. 4I).

Discussion

In *Clathrus*, receptacle morphology varies considerably, as does the placement of the gleba within the receptacle. *Clathrus archeri* (Berk.) Dring, *C. crispatus* Thwaites ex E. Fisch., *C. kusanoi* (Kobayasi) Dring, *C. mauritianus* (Lloyd) Dring, and *C. ruber* P. Micheli ex Pers. have gleba distributed over a large portion (with the exception of the more basal areas) of the inner surfaces of the receptacle (Dring 1980, Arora & Burk 1982). In *C. baumii* Henn. and *C. preussii* Henn., the gleba spreads over the inner arm surfaces of the arms but tends to concentrate near where the arms intersect. In *C. columnatus* Bosc the gleba is found only at the more apical portions of the receptacle as a centralized glebal mass that spreads down along the inner surface of the arms (Dring 1980). In *C. chrysomycelinus* and *C. oahuensis* Dring the gleba is restricted to discrete droplets in glebifers seated on the intersection of the arms (Dring et al. 1971, Dring 1980). Finally, although the gleba of *C. delicatus* is also restricted to the arm intersections, the droplets are very minute, and the glebifers are even more specialized in their structure, resembling miniature three-legged stools (Dring 1980).


A
B
C
D
E
F
G
H
I

Dring et al. (1971) suggested that variation found within *Clathrus* could be interpreted in an evolutionary context, which Dring (1980) later placed in several evolutionary "series." From the "primitive" state, generally these series progressively "simplified" in the distribution of the gleba, accompanied by a reduction in glebal quantity. These trends were also associated with a reduced receptacle size as well as with an increasing complexity in the localization of the gleba, with glebifers occurring in the most advanced forms (Dring 1980). *Clathrus delicatus* was considered one of the more advanced species in *Clathrus*, exhibiting the most specialized and complex glebifer form (Dring et al. 1971, Dring 1980). Here we also document for *C. delicatus* the extremely small receptacle size (15–20 × 10–14 mm), which Dring (1980) also considered a more evolutionarily advanced trait.

A recent molecular phylogeny of the *Phallomycetidae* (Hosaka et al. 2006) included *Clathrus ruber* and *C. chrysomycelinus*, as well as other species in the *Phallales*. Although many early authors (Fischer 1898–99, Lloyd 1906, Petch 1908) suggested that *Clathrus* is the most primitive genus within the *Clathraceae*, Hosaka et al. (2006) placed *Clathrus* species within a more recently derived *Clathraceae* clade that is sister to the *Phallaceae* clade. As Hosaka et al. (2006) only included two species of *Clathrus* in their study, evolutionary relationships among *Clathrus* species remain poorly understood.

Acknowledgements

The work was supported in part by University Grants Commission (UGC), New Delhi. We are grateful to Dr. D.W. Minter (Principal Scientist at CABI, UK) for very promptly providing us pertinent literature through the online digital library for mycology (www.cybertruffle.org.uk). We thank Drs. P.M. Kirk and P.F. Cannon (Principal Scientists at CABI, UK) for helpful discussions. Furthermore, we greatly appreciate the valuable support of Prof. M.B. Shivanna and Mr. K.G. Somashekhara Achar (Dept. of Applied Botany, Kuvempu University, Shankaraghatta) during the course of this research. We thank Drs. Laura Guzmán Dávalos (Departamento de Botánica y Zoología, Universidad de Guadalajara, México), Vagner G. Cortez (Universidade Federal do Paraná, Brazil), and Scott T. Bates (Fierer Laboratory, University of Colorado, Boulder) for critical review of the manuscript.

FIG. 4. Sporoma development of *Clathrus delicatus* (KUABSAK-MCH 265). — A Gelatinized tissue adhering to the developing receptacle. —B Volva-gel enveloping the receptacle. —C Apical rupturing of the myco-egg. —D Expanded receptacle. —E Gleba at the intersections of arms. —F Volva. —G An aged receptacle, shrinking with desiccation. —H Mycelium strands with eggs forming intermittently. —I Expanded receptacles of a colony.

Magnifications: A = 60×, B–C, E = 25×, D, F = 20×, G = 10×.

Literature cited

Alexopoulos CJ, Mims CW, Blackwell M. 2002. Introductory mycology. 4th ed. John Wiley & Sons, Singapore. 869 pp.

Apte D. 2005. First record of *Clathrus delicatus* Berkeley & Broome (1873) from Sanjay Gandhi National Park. Journal of Bombay Natural History Society 102: 135–136.

Arora D, Burk WR. 1982. *Clathrus archeri*, a stinkhorn new to North America. Mycologia 74: 501–525. doi:10.2307/3792972

Beltrán-Tejera E, Bañares-Baudet A, Rodríguez-Armas JI. 1998. Gasteromycetes of the Canary Islands: some noteworthy new records. Mycotaxon 68: 439–453.

Berkeley MJ, Broome CE. 1873 ["1875"]. Enumeration of the fungi of Ceylon. Part II., containing the reminder of the hymenomycetes, with the remaining established tribes of fungi. Journal of the Linnean Society, Botany 14: 29–140.

Bessey ER. 1950. Morphology and taxonomy of fungi. Philadelphia, Blakiston 791 pp.

Cunningham GH. 1944. The gasteromycetes of Australia and New Zealand. John McIndoe, New Zealand. 236 pp.

Dring DM. 1980. Contributions towards a rational arrangement of the *Clathraceae*. Kew Bulletin 35: 1–96. doi:10.2307/4117008

Dring DM, Meeker J, Goos R. 1971. *Clathrus oahuensis*, a new species from Hawaii. Mycologia 63: 893–897. doi:10.2307/3758056

Fischer ED. 1898-99 ["1900"]. *Phallineae*. 276–296, in: Engler A, Prantl K (eds), Die Natürlichen Pflanzenfamilien, vol. 1(1**). Wilhelm Engelmann, Leipzig.

Gäumann EA. 1952. The fungi. Hafner publishing Co., London. 420 pp.

Hosaka K, Bates ST, Beever RE, Castellano MA, Colgan III W, Domínguez LS, Nouhra ER, Geml J, Giachini AJ, Kenney SR, Simpson NB, Spatafora JW, Trappe JM. 2006. Molecular phylogenetics of the gomphoid–phalloid fungi with an establishment of the new subclass *Phallomycetidae* and two new orders. Mycologia 98: 949–959. doi:10.3852/mycologia.98.6.949

Ingold CT. 1971. Fungal spores. Clarendon Press, Oxford. 153 pp.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth and Bisby's dictionary of the fungi, 10th ed. CABI Publishing, UK. 771 pp.

Kornerup A, Wanscher JH. 1978. Methuen handbook of colour, 3rd ed. Eyre Methuen, London. 252 pp.

List PH, Freund B. 1968. Geruchstoffe der stinkmorchen, *Phallus impudicus* L. Miteilung uber Pilzinhaltstoffe. Planta Medica supplement 18: 123–132. doi:10.1055/s-0028-1099948

Lloyd CG. 1906. Concerning the phalloids. Mycological Writings 2: 293–308.

Narasimhan MJ. 1932. The *Phalloideae* of Mysore. Journal of Indian Botanical Society 11: 248–254.

Pegler DN, Læssøe T, Spooner BM. 1995. British Puffballs, Earthstars and Stinkhorns. Royal Botanic Gardens, Kew. 265 pp.

Petch T. 1908. The *Phalloidae* of Ceylon. Annals Royal Botanical Garden Peradeniya 4(4): 60–165.

Smith AH, Schaffer RL. 1962. Key to the selected groups of the higher fungi. University of Michigan, London. 264 pp.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.329

Volume 114, pp. 329–332 October–December 2010

Catillaria, Cladonia, Strigula, and *Cresporhaphis* species new to Turkey and Asia

KADIR KINALIOĞLU

kkinalioglu@hotmail.com

Giresun University, Faculty of Science and Arts, Department of Biology

28049, Giresun, Turkey

ANDRÉ APTROOT

andreaptroot@gmail.com

Adviesbureau voor Bryologie en Lichenologie

G.v.d. Veenstraat 107, NL-3762 XK Soest, The Netherlands

Abstract—Four species of lichen-forming fungi — *Catillaria atomarioides, Cladonia cyathomorpha, Strigula brevis, Cresporhaphis wienkampii* — are reported as new to Turkey and Asia.

Key Words—biodiversity, biota, Giresun

The lichen biota of Turkey is still largely unknown. In the last three years, many new lichen species were reported (e.g. Candan & Özdemir Türk 2008, Çobanoğlu et al. 2008, Halıcı & Aksoy 2009, Kınalıoğlu 2009, Öztürk & Güvenç 2010, Yazıcı et al. 2010). This contribution reports four species as first records for Turkey.

Specimens were collected in the provinces of Hatay, Giresun, and Ordu between 17 July 2004 and 10 April 2010. They were identified with various lichen guides (mainly Smith et al. 2009). Vouchers are preserved in the herbarium of the Faculty of Science and Arts, Giresun University, Giresun, Turkey. The collector and collection number are given in parentheses after the locality details.

Species recorded

Catillaria atomarioides (Müll. Arg.) H. Kilias FIG 1

Thallus thin, dark olivaceous to blackish. Apothecia 0.1–0.25 mm diam, black, sparse, mainly plane. Epithecium mostly dark brown to dark green. Hymenium

colourless, 32.5–40 µm tall. Ascospores simple, ellipsoid, colourless, 8–10 × 2.5–3.7 µm. Thallus C–, K–, KC–, PD–.

SPECIMEN EXAMINED: **Giresun,** Keşap, sea shore, 40°58'20"N, 38°37'23"E, 0 m, 11 Apr. 2010, on siliceous rock (Kınalıoğlu 1801).

Known previously from western and northern Europe, Macaronesia, and Africa on hard acid rocks (including river shingle and slate) and brick. In Turkey the specimen was collected from siliceous rock along the coast. New to Asia.

A detailed description is provided by Smith et al. (2009).

DISCUSSION: *Catillaria atomarioides* is easily mistaken for a diminutive form of *C. chalybeia* or *C. subviridis* (coastal, pale inner roper margin), or even *Amandinea punctata* (Smith et al. 2009). The hymenium is slightly smaller in the Turkish specimen than in the European, Macaronesian, and South American material. Original descriptions of this species report hymenium up to 30–40 µm (Smith et al. 2009). The Turkish collection differs ecologically by occurring only at coastal localities.

Cladonia cyathomorpha Stirt. ex Walt. Watson FIG 2

Primary thallus dominant. Squamules 2–4 mm broad, greenish above, white below. Podetia rare, up to 2–5 mm tall, forming cups to 3 mm wide, coarsely corticate within. Thallus C–, K+ yellow, KC–, PD+ red.

SPECIMENS EXAMINED: **Giresun,** Keşap, 40°58'22"N, 38°37'36"E, 4 m, 12 Feb. 2006, on siliceous rock (Kınalıoğlu 1804). **Ordu,** N of Ünye, Çamlık, sea shore, 2 m, 21 Jul. 2006, on soil (Kınalıoğlu 1805).

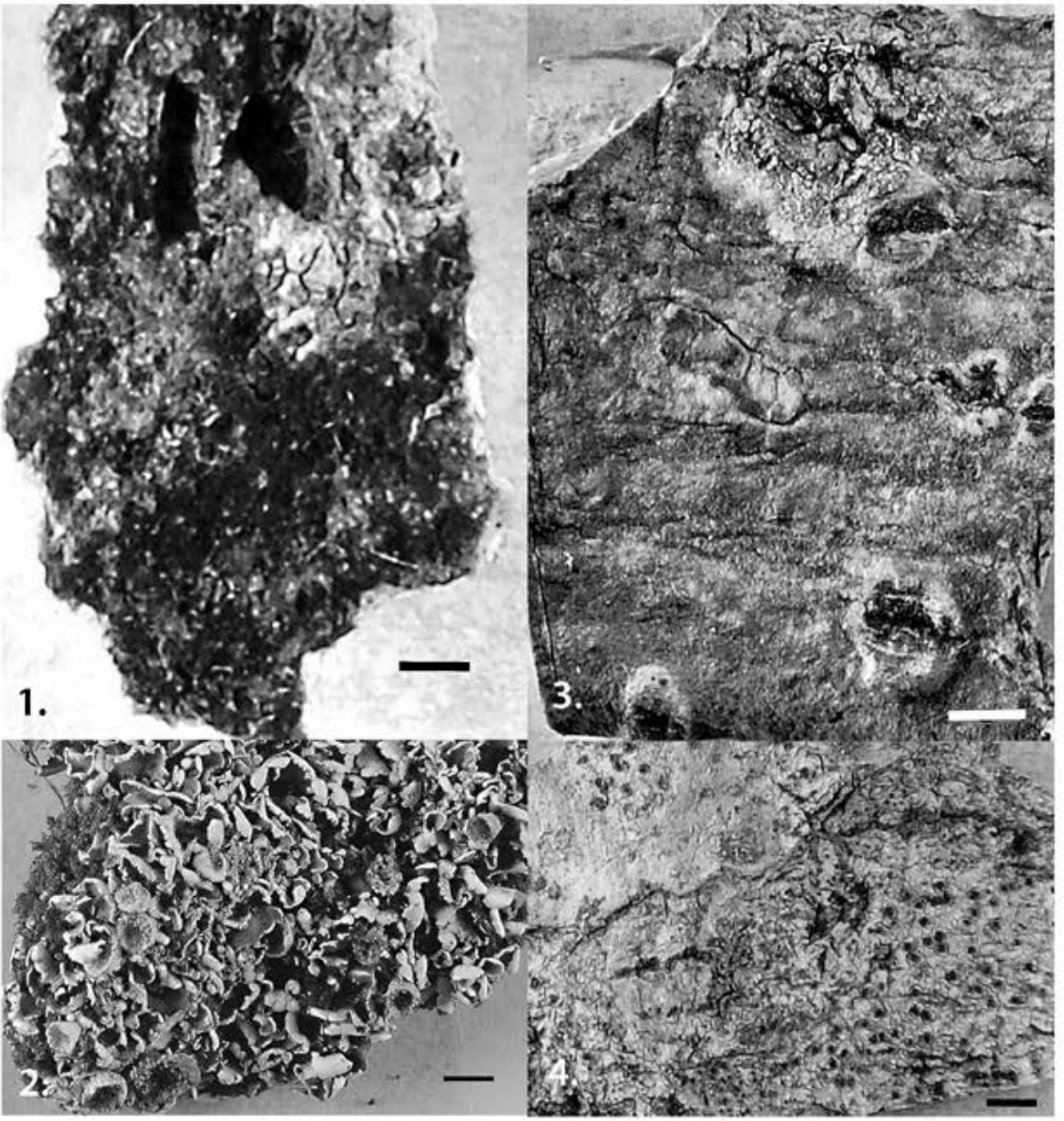
Known from western Europe, Macaronesia, and South America, mostly on vertical faces of mossy rocks in hilly and montane areas. New to Turkey and Asia. In Turkey the specimens were only collected from siliceous rock and soil along the coast.

A detailed description is provided by Smith et al. (2009).

DISCUSSION: *Cladonia cyathomorpha* is distinguished from *C. pyxidata* in having larger, veined, basal squamules and an additional unidentified compound with fumarprotocetraric acid (Smith et al. (2009). The Turkish material is distinguished from western European, Macaronesian, and South American specimens by smaller podetia and squamules. Smith et al. (2009) cite podetia as to 0.8 cm, basal squamules 5-10 mm diam. The Turkish collection differs ecologically in occurring both on siliceous rock and on soil at coastal localities.

Cresporhaphis wienkampii (J. Lahm ex Hazsl.) M.B. Aguirre FIG 3

Thallus embedded in bark cells. Perithecia black, superficial, to 0.2–0.4 mm diam. Ascospores 22.5–30 × 3–3.5 µm in size, colourless. Thallus C–, K–, KC–, PD–.



Figs. 1–4. Habitus of four lichens new to Turkey. *Catillaria atomarioides* (Kınalıoğlu 1801). Fig. 2. *Cladonia cyathomorpha* (Kınalıoğlu 1804). Fig. 3. *Cresporhaphis wienkampii* (Kınalıoğlu 1814). Fig. 4. *Strigula brevis*, (Kınalıoğlu 1811). Scales: 2 mm.

Specimen examined: **Hatay**, Dörtyol, S of Konak Village, 36°48'29"N, 36°15'10"E, 172 m, 01 Feb. 2008, on *Quercus* sp. (Kınalıoğlu 1814).

Previously known only from Europe. On living bark. New to Turkey and Asia.

A detailed description is provided by Smith et al. (2009).

Discussion: The perithecia in the Turkish collection are slightly larger than in the European specimen, where the perithecia measure 0.15–0.3 mm diam.

Strigula brevis Bricaud & Cl. Roux FIG 4

Thallus grey-white, partly immersed. Perithecia black, hemispherical, almost semi-immersed, 0.2–0.5 mm diam. Ascospores 25–37.5 × 5–7.5 µm, 3–5 septate, fusiform. Thallus C–, K–, KC–, PD–.

SPECIMEN EXAMINED: **Ordu**, Gülyalı, Turnasuyu village, 41°03'20"N, 37°59'04"E, 17 m, 17 Jul. 2004, on *Juglans regia* (Kınalıoğlu 1811).

Known from western Europe and Macaronesia (Roux & Sérusiaux 2004). On living bark. New to Turkey and Asia.

A detailed description is provided by Roux & Sérusiaux (2004).

DISCUSSION: The perithecia and ascospores of the Turkish material are larger than in the western European and Macaronesian collections, where perithecia are 0.2–0.3 mm wide and ascospores measure (17)18–23.5(25) ×3.5–4.5 µm.

Acknowledgements

We thank Dr. H. Sipman & Dr. Leo Spier for reviewing this paper.

Literature cited

Candan M, Özdemir Türk A. 2008. Lichens of Malatya, Elaziğ and Adıyaman provinces (Turkey). Mycotaxon 105: 19–22.

Çobanoğlu G, Sevgi E, Sevgi O. 2008. Epiphytic lichen mycota of, and new records from, Şerif Yüksel research forest, Bolu, Turkey. Mycologia Balcanica 5: 135–140.

Halıcı MG, Aksoy A. 2009. Lichenised and Lichenicolous Fungi of Aladağlar National Park (Niğde, Kayseri and Adana Provinces) in Turkey. Turk. J. Bot. 33: 169–189. doi:10.3906/bot-0810-14.

Kınalıoğlu K. 2009. Additional lichen records from Giresun Province, Turkey, Mycotaxon, 109: 137–140.

Öztürk Ş, Güvenç Ş. 2010. Additional lichen records from the western Black Sea region of Turkey, Acta Botanica Hungarica 52(1–2): 159–175. doi:10.1556/ABot.52.2010.1-2.14.

Roux C, Sérusiaux E. 2004. Le genre *Strigula* (Lichens) en Europe et en Macaronésie. Bibliotheca Lichenologica 90: 1–96.

Smith CW, Aptroot A, Coppins BJ, Fletcher A, Gilbert OL, James PW, Wolseley PA. 2009. The Lichens of Great Britain and Ireland. British Lichen Society, London.

Yazici K, Aptroot A, Aslan A. 2010. Three lichenized fungi new to Turkey and the Middle East. Mycotaxon 111: 127–130.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.333

Volume 114, pp. 333–342 *October–December 2010*

Lactarius fumosibrunneus in a relict *Fagus grandifolia* var. *mexicana* population in a Mexican montane cloud forest

VICTOR M. BANDALA* & LETICIA MONTOYA

victor.bandala@inecol.edu.mx; leticia.montoya@inecol.edu.mx
Biodiversidad y Sistemática, Instituto de Ecología, A.C.
P.O. Box 63, Xalapa, Veracruz 91000, Mexico

Abstract — *Lactarius fumosibrunneus*, a species considered in the literature contaxic with *L. fumosus*, is interpreted here as an independent taxon due to the differences in the structure of pileipellis and presence of cystidia. Recognition of *L. fumosibrunneus* is supported by morphological comparison with original collections, Mexican samples, and type specimens of related taxa. Collections of *L. fumosibrunneus* were found in the Mexican montane cloud forest of Central Veracruz (east coast of Mexico) where it appears to be ectomycorrhizal partner of the tree *Fagus grandifolia* var. *mexicana*.

Key words — ectomycorrhizal fungi, *Fagaceae*, neotropical fungi, *Russulaceae*, taxonomy

Introduction

Lactarius fumosibrunneus A.H. Sm. & Hesler is an American member of subgenus *Plinthogalus* (Burl.) Hesler & A.H. Sm. described by Smith & Hesler (1962) from Michigan, U.S.A. Based on the macroscopical resemblance of *L. fumosibrunneus* with *L. fumosus* Peck, Hesler & Smith (1979) considered it as conspecific. During a regular monitoring of the Mexican montane cloud forest in Veracruz (east coast of Mexico) by the authors (Montoya et al. 2010), some populations of a taxon macroscopically close to the aforementioned species were observed. After a comparative study of collections of these populations with specimens from U.S.A. (including type materials) of *L. fumosibrunneus*, *L. fumosus*, and *L. fumosoides* A.H. Sm. & Hesler, we found that based on differences in the nature of the pileipellis and cheilocystidia, *L. fumosibrunneus* appears distinct from other allied taxa. We therefore consider *L. fumosibrunneus* to represent an independent taxon and support the original concept as published by Smith & Hesler (1962).

Materials & methods

Monitoring was conducted between September 2006–09 in Acatlán Volcano, Central Veracruz (east coast of Mexico). Samples of *Lactarius* were gathered during random field trips in a stand of *Fagus grandifolia* var. *mexicana*. Collections are kept in XAL herbarium. Basidiomes were studied in fresh condition. Colors were compared with those from Kornerup & Wanscher (1967), e.g. codified as 5D5–E5, and Munsell color chart (1994), e.g. 10YR 4/3–4/4. For the study of micromorphological features, hand sections of dried specimens were rehydrated in 3% KOH. Basidiospores (measurement, shape and ornamentation pattern) were observed in Melzer's reagent. Methods to determine spore ranges are those used by Montoya & Bandala (2003). In the basidiospore descriptions, *X*m indicates the range of means of basidiospore length and width and Qm indicates the range of the means of Q (length/width ratio) from n collections (25–50 basidiospores were measured per collection then *X* indicates their mean). Line drawings were made with the aid of a drawing tube. Acronyms for herbaria follow Holmgren & Holmgren (1998).

Taxonomy

Lactarius fumosibrunneus A.H. Sm. & Hesler, Brittonia 14: 439, 1962 FIGS 1–4A

SPECIMENS EXAMINED. MEXICO. VERACRUZ: **Acatlán,** ACATLÁN VOLCANO, 14 Sep 2006, Montoya 4625, Montoya 4631, 4633, 4634, 4635; 18 Sep 2007, Montoya 4669; 19 June 2008, Montoya 4680; 30 July 2009, Montoya 4739, Montoya 4740, Montoya 4745 (all at XAL).

PILEUS 12–65 mm diam., convex, becoming plane to plano-convex, depressed in the center with age, at times subumbonate, with or without a central papilla, faintly velutinous, dull, smooth when young to rugose at center when mature or at times venose-rugose and faintly rugose in other areas, dry, firm, often pale greyish (10YR 5/4–6/4, 10YR 5/3) or brownish (5D5–E5) or with darker (5E5–E4–E6, 10YR 4/3–4/4) shades but generally conserving paler or even cream colored patches or appearing with greyish-brown tinges over a cream background or more or less uniformly greyish-brown or brownish (around 2.5Y 5/3–4; 6F7, 5B3–C4; pale 5D5–E5, 4B2), darker (7.5YR 4/3, 5E4–E5) towards the center; margin wavy, at times inflexed and irregular, lobulate, edge at times whitish. LAMELLAE narrow (2–3 mm broad), crowded, short-decurrent to decurrent, cream-colored (2.5Y 8/2–3, 3–4A2) when young to yellowish-ochraceous (5A3, 10 YR 8/3–4, 8/6, 7/6) when old, staining reddish-salmon (8A5–B7) when cut, some furcate, with lamellulae of different length (frequently one longer and two very short), generally 1–3 between two lamellae. STIPE 20–75 × 3–12 mm, subcylindrical, slender, more or less tapering downwards or with tapered base, almost straight, at times weakly sinuous, occasionally curved, firm, hollow

FIG. 1. *Lactarius fumosibrunneus* Montoya 4669. Scale bar= 10 mm.

with age, faintly velutinous, dry, dull, whitish, bone-whitish to cream-colored (2.5 Y 7/3, 8/2, 3A2), later developing pale greyish-brown (5B3–C3–D4, 10YR 5/4–6/4) shades but conserving whitish areas mainly at apex or base; base whitish. CONTEXT white to cream-colored, staining pinkish, becoming slowly reddish (9B3, 9C5), finally wine-red to salmon color (7B5–6, 7A5). ODOR mild to somewhat similar to chlorine. Taste very hot. KOH negative on pileus and context. LATEX white, unchanging, cut surfaces staining reddish, salmon-red (7A6–B6) or even brownish-red (9C8), dried drops stained reddish, staining white paper red (8C5–6), spots on paper slowly turning orange to salmon color (8B5) and to yellow (4A8–A5) with reddish-orange tinges to totally yellow (4A2–3) after some hours.

BASIDIOSPORES 7–8(–8.5) × 6.5–7.5(–8) µm, *X*m = 7.4–7.6 × 6.5–7.2 µm, Qm = 1.06–1.07, subglobose, ornamentation 1–2 µm high, subreticulate, composed of broad, sinuous bands forming a somewhat wide mesh, more or less crestate in profile, at times with isolate verrucae, often weakly amyloid in the suprahilar area. BASIDIA 42–58 × 9–13 µm, clavate, bi- or tetrasporic, sterigma 4–7 µm long. CHEILOCYSTIDIA 19–50 × 5–7.5 µm, subcylindrical, more or less narrowly lageniform or moderately tapered, apically rounded,

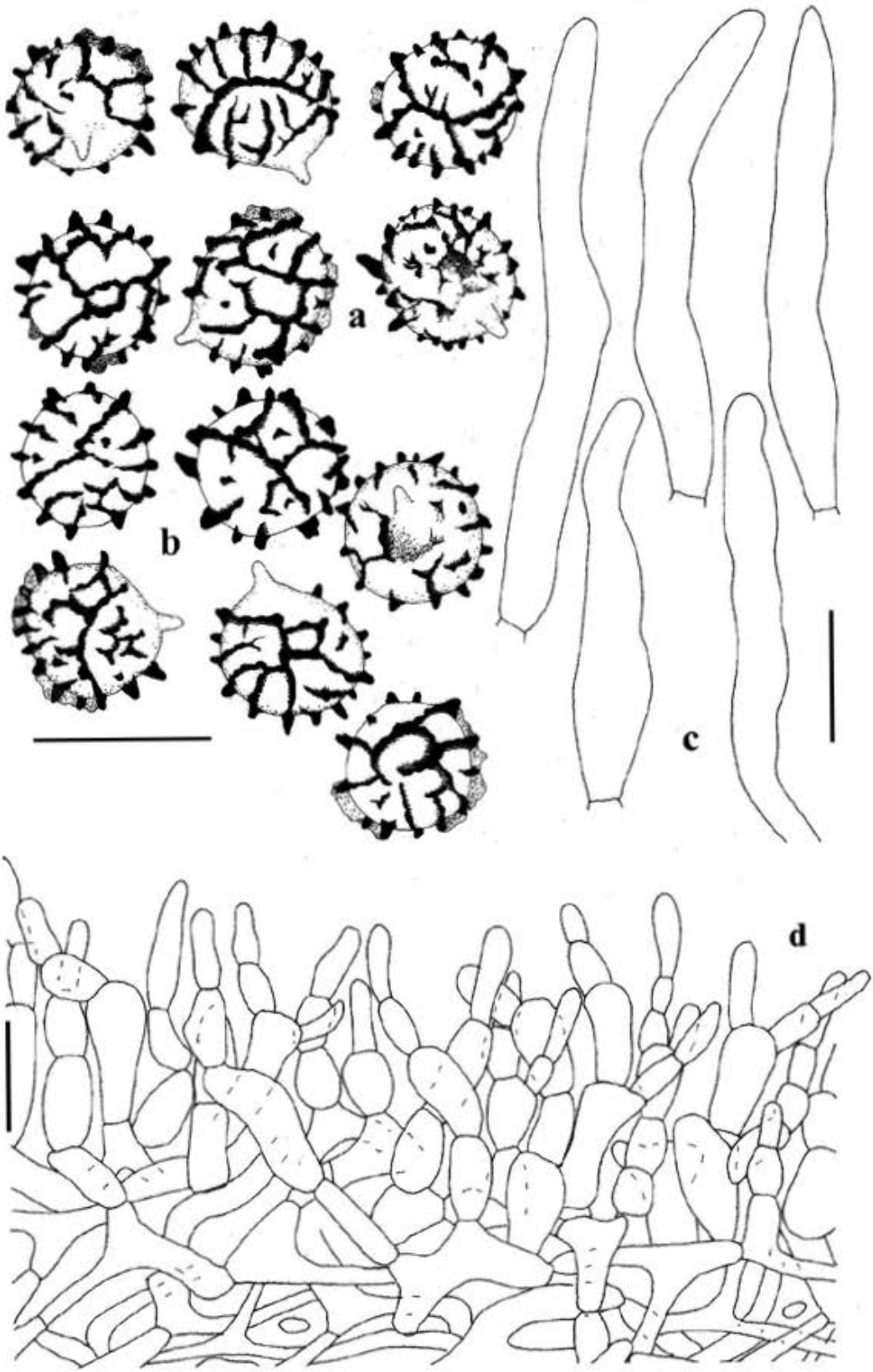


FIG. 2. *Lactarius fumosibrunneus.*
(a–b) basidiospores, (c) cheilocystidia, (d) pileipellis.
[a,c,d= Montoya 4634, b = holotype.] Bars: a–c = 10 µm, d = 20 µm.

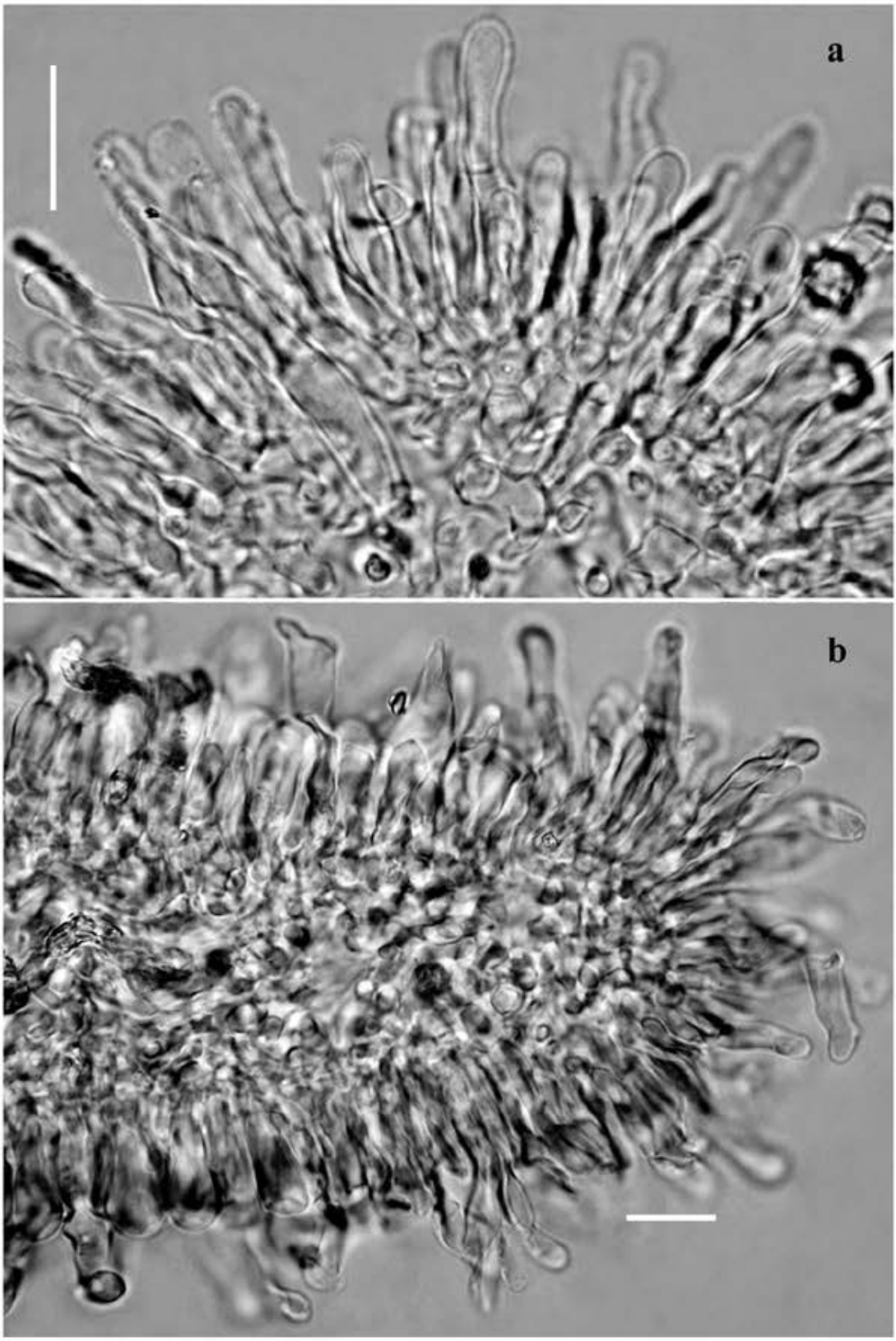


FIG. 3. *Lactarius fumosibrunneus*. Lamellar margin, Montoya 4634. Bars = 20 µm.

sinuous, abundant, emerging above hymenium level, hyaline. PLEUROCYSTIDIA absent. PSEUDOCYSTIDIA 3–4 µm diam., subcylindrical to vermiform, at times ramified, with refringent colorless contents. PILEIPELLIS a hymenoepithelium, 40–62 µm broad, the elements disposed in anticline chains of 2–4 elements long, cells with pale yellowish-brown contents; terminal cells 11–27 × 5–7 µm, subcylindrical, subventricose, pyriform, sinuous, the remaining cells in the chains versiform, those immediately below the terminal element in general broadly subcylindrical, 8–10 × 5–7 µm, other subisodiametric 9–15 µm diam. or more or less versiform and broad, 10–25 × 8–13 µm diam. CONTEXT heteromerous, hyphae 2.5–10.8 µm diam., sphaerocytes 18–39.6 µm diam., laticifers 2.5–11 µm diam. HYMENOPHORAL TRAMA heteromerous, hyphae 3–5 µm diam, laticifers 2.5–6 µm diam., with a lax tissue towards lamellar edge.

HABITAT — Gregarious in a *Fagus grandifolia* var. *mexicana* forest at 1840 m.

OTHER SPECIMENS EXAMINED. **USA. MICHIGAN: Washtenaw Co.,** SHARON HOLLOW, 13 Aug 1960, A.H. Smith 62897 (as *L. fumosus*, MICH); Cheboygan Co., Reese's Bog, 27 Aug 1960, A.H. Smith 63040 (holotype of *L. fumosoides* MICH); Cheboygan Co., Colonial Point, Burt Lake, 11 Aug 1961, A.H. Smith 63892 (holotype of *L. fumosibrunneus*, MICH). NEW YORK, Sandlake, Rensselaer Co., July, Peck s.n. (as "*L. fuliginosus* var. *fumosus* Peck", NYS).

Discussion

After comparing Mexican materials with specimens and descriptions of *L. fumosibrunneus*, *L. fumosus*, and *L. fumosoides*, we concluded that although they are apparently phenotypically similar, these three taxa could be differentiated because each possesses a unique set of characters. *Lactarius fumosibrunneus* as observed in the type specimen (Smith 63892) presents abundant cheilocystidia distributed at lamellar edges and even placed towards lateral sides of the lamellar margin (Smith & Hesler 1962: '...abundant and extending a short distance up the sides...'); their size and shape (20–57 × 5–7.5 µm, ventricose, subcylindrical, clavate, sinuous) are also similar to Mexican collections (FIGS. 2C, 3A-B). Its basidiospores are 7.3–8 × 6.5–7.5 µm, $\bar{X}$ = 7.6 × 7 µm, Q = 1.1, subreticulate (FIG. 2B). Although the pileipellis (FIG. 4B) was somewhat difficult to rehydrate in the type, it was possible to observe that, as in our Mexican specimens, it is built of groups of elements in chains, basal cells appearing irregular and subisodiametric and the terminal elements having a hymeniform appearance (FIG. 4A). The taste (described as 'burning acrid' by Smith & Hesler 1962) and narrow and crowded lamellae (also observed in Mexican collections) are distinctive. Smith & Hesler (1962) recorded *L. fumosibrunneus* from a beech–maple forest in Michigan.

According to the description by Peck (1872), *Lactarius fumosus* possesses a pileus that is convex and then expanded, slightly depressed in the center,

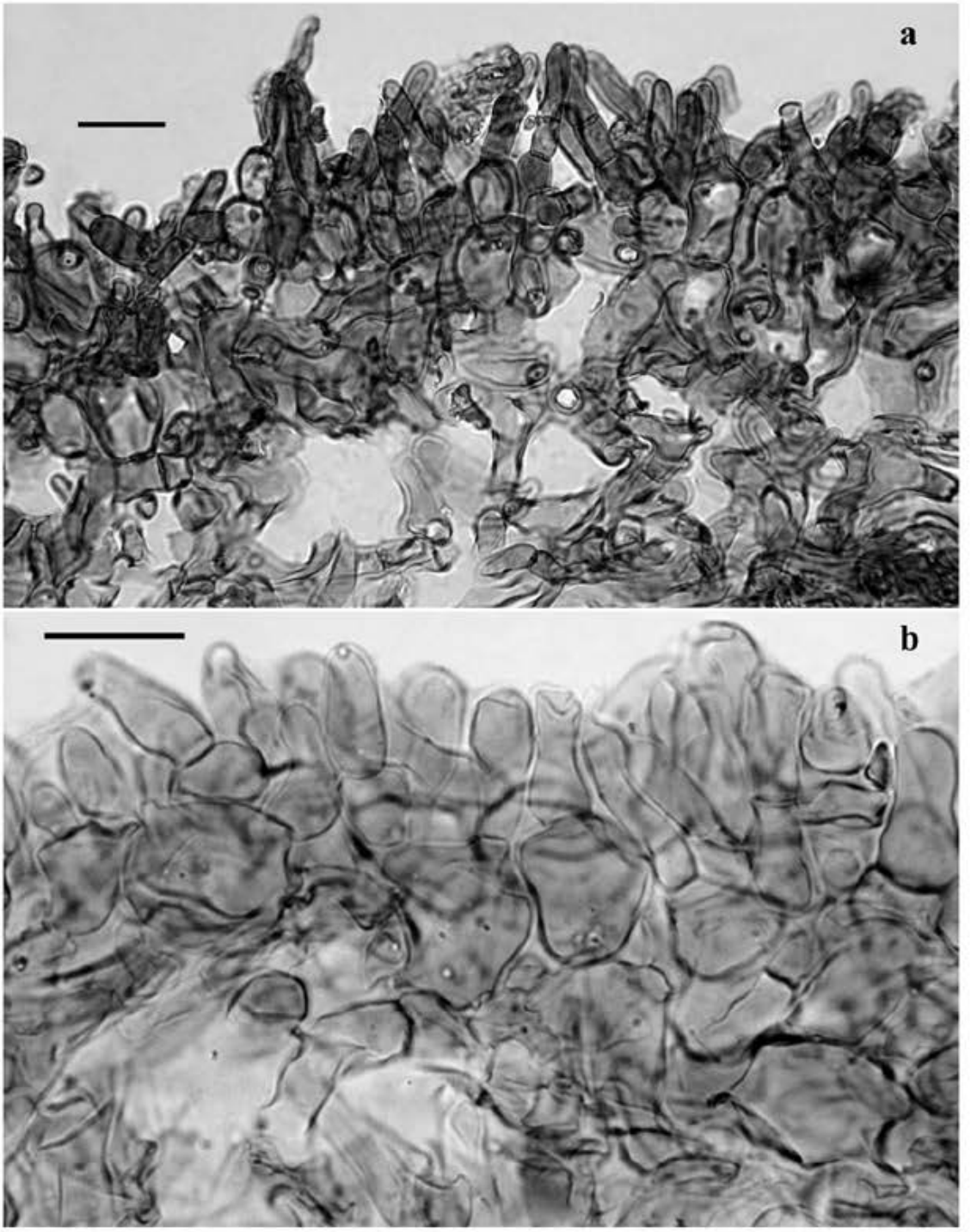


FIG. 4. Pileipellis. Bars = 20 µm.
(a) *Lactarius fumosibrunneus*, Montoya 4634, (b) *L. fumosus*, Smith 62897.

smooth, smoky-brown or sordid white, lamellae close, adnate, flesh white, taste at first mild then acrid. Smith & Hesler (1962) distinguished *L. fumosus* from *L. fumosibrunneus* because basidiomes of the latter are quickly burning-

acrid and have a more highly developed pileipellis structure (also observed for the Mexican collections). Subsequently however, Hesler & Smith (1979) synonymized their *L. fumosibrunneus* with *L. fumosus*, regarding the taste and characteristics of the pileipellis (and stipitipellis) as "... slight quantitative variations..." for recognizing two taxa. They also noted that the cheilocystidia in *L. fumosus* were 'poorly differentiated' [(9–)26–36 × 4.5–6 µm]. It has not been possible to study the type of *L. fumosus*, which according to NYS is apparently lost. For the taxonomic interpretation of *L. fumosus* we examined Peck's specimen (July, NY, Sandlake, Rensselaer Co.; see below) that he identified as *L. fuliginosus* var. *fumosus* and Smith 62897, which Hesler & Smith (1979) considered conspecific with *L. fumosus*. We corroborated in both materials that the lamellar edges lack cheilocystidia and, indeed, bear some basidia and sterile basidiole-like cells (FIGS. 5A-B) (the longest about 10–25 × 3.5–9 µm in the specimen of Peck from Sandlake and 17.5–32.5 × 5–8 µm in the specimen Smith 62897) that could not be considered differentiated cells representing cystidia. The pileipellis (FIG 4B) showed the differences as well, having broader and shorter terminal elements [12–21(–28) × 5–12 µm, broadly clavate, ovoid, subisodiametric and less frequently pyriform]. The basidiospores appear more ellipsoid in both Peck's Sandlake specimen [7–8 (–8.5) × 6.5–7.5(–8) µm, X = 7.7 × 6.7 µm, Q = 1.2, n = 25] and Smith 62897 [7–5–8 × 6.5–7.3 µm, X = 7.8 × 6.8 µm, Q = 1.15, n = 25].

The type specimen of *Lactarius fumosoides* (treated as *L. fumosus* var. *fumosoides* by Hesler & Smith 1979) was also studied for comparison. This specimen differs from the previous specimens particularly in pileipellis structure and the absence of cheilocystidia. The lamellar edges bear basidiole-like structures and some basidia but no differentiated cystidia. The pileipellis has a lax arrangement, which in some areas appears as a cutis from which some slender pileocystidia [19–68 × 5–7 µm, clavate, subcylindrical-vermiform, sinuous, capitate, these latter 9–10 µm broad at apex] appear intermixed. In most areas the pileocystidia grow from irregular (17–68 × 8–15 µm) or somewhat subisodiametric (15–20 × 15–18 µm) elements arranged in chains of up to two cells. The pileocystidia in *L. fumosoides* (type specimen) are long and slender and somewhat resemble a trichodermis and thus differing from those seen in the other collections of *L. fumosibrunneus*.

We therefore agree with Smith & Hesler (1962) that *L. fumosibrunneus* represents a distinct taxon based on the pileipellis structure, consistent presence and shape of cheilocystidia, the size, shape, and ornamentation of basidiospores, color changes and taste of basidiomes, and the shape and disposition of lamellae. It should be noted that the hot taste seems to be directly associated with latex in that basidiomes lacking latex tasted mild or at least less acrid that the basidiomes with latex.

It is interesting to note that after Peck (1885) treated *L. fumosus* as *L. fuliginosus* (Fr.) Fr., Saccardo (1887) reduced Peck's taxon to a variety, as "*L. fuliginosus* var. *fumosus* Peck". The European *Lactarius fuliginosus* (Fr.) Fr. and *L. azonites* (Bull.) Fr. (another species within this group), which share a more or less similar habit with *L. fumosibrunneus*, can be distinguished by moderately distant gills, mild or bitter to slightly acrid latex (Heilmann-Clausen et al. 1998, Basso 1999), bigger basidiospores [$X = 8.0–8.6 \times 7.4–7.8$ µm (in *L. azonites*) or $X = 8.1–8.4 \times 7.1–7.6$ µm (in *L. fuliginosus* with a wider Q range, 1.09–1.15; Heilmann-Clausen et al. 1998], and a pileipellis with somewhat longer terminal elements that give a trichodermoid aspect to the suprapellis (20–40 × 3–5 µm in *L. azonites* and 20–45 × 5–8 µm in *L. fuliginosus*; Heilmann-Clausen et al. 1998).

Acknowledgments

We thank curators of MICH and NYS for loans of specimens. We especially appreciate the information provided by Lorinda Leonardi (Collections Manager at NYS) regarding specimens of Peck (kept at NYS) that are related to *L. fumosus*. We are also grateful to Dr. Marcos Lizárraga (Universidad Autónoma de Ciudad Juárez, Chihuahua, Mexico), Dr. Kanad Das (Botanical Survey of India, Gangtok, India), and Mycotaxon editors Dr. Shaun Pennycook and Dr. Lorelei L Norvell for critically reviewing the manuscript. We appreciate the collaboration in the monitoring of *Lactarius* in the field by Biols. Pavel del Moral, David Ramos, Elsa Utrera, and MC Edith Garay (all at Instituto de Ecología, A.C., Xalapa).

Literature cited

Basso MT. 1999. *Lactarius* Pers. Fungi Europaei 7. Mykoflora, Alassio. 845 p.

Heilmann-Clausen J, Verbeken A, Vesterholt J. 1998. The genus *Lactarius*. Fungi of Northern Europe vol. 2, Denmark. 287 p.

Hesler LR, Smith AH. 1979. North American Species of *Lactarius*. University of Michigan, Ann Arbor. 841 p.

Holmgren PK, Holmgren NH. 1998 [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/

Kornerup A, Wanscher JH. 1967. Methuen Handbook of Colour. 2nd edn. Methuen, London. 243 p., 30 pl.

Montoya L, Bandala VM. 2003. Studies on *Lactarius* a new combination and two new species from Mexico. Mycotaxon 85: 393–407.

Montoya L, Haug I, Bandala VM. 2010. Two *Lactarius* species associated with a relict *Fagus grandifolia* var. *mexicana* population in a Mexican montane cloud forest. Mycologia 102: 153–162.

Munsell Soil Colour Charts. 1994. Macbeth, New Windsor. 10 p., 9 pl.

Peck CH. 1872. Twenty-fourth Annual report. Reports of the N Y St. Mus. Nat. Hist. 24: 41–108.

Peck CH. 1885. Thirty-eighth Annual report. Reports of the N Y St. Mus. Nat. Hist. 38: 75–138.

Saccardo PA. 1887. Sylloge Fungorum 5. Reimp. 1944. Edwards Bros., Ann Arbor.
Smith AH, Hesler LR. 1962. Studies on *Lactarius* III. North American Species of section *Plinthogali*. Brittonia 14: 369–440. doi:10.2307/2805252

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.343

Volume 114, pp. 343–349 October–December 2010

Hygrocybe manadukaensis sp. nov. in section *Firmae* from Western Ghats, India

GUNASEKARAN SENTHILARASU * [1], VADIVELU KUMARESAN[2] & SANJAY K SINGH[1]

senthilarasug@rediffmail.com, singhsksingh@rediffmail.com
[1]*Mycology and Plant Pathology Group, MACS' Agharkar Research Institute*
Pune – 411 004, India

vkumaresan36@yahoo.com
[2]*Department of Plant Science, Mahatma Gandhi Govt. Arts College*
Mahe – 673 311, India

Abstract — A new species *Hygrocybe manadukaensis*, in section *Firmae* collected from the Uppangala forest of Western Ghats of Karnataka, India is described and illustrated. Both macro- and microscopical features of the present collection are compared with similar or closely related taxa in section *Firmae*.

Key words — *Agaricales, Basidiomycota, Hygrophoraceae*, macrofungi

Introduction

Members of *Hygrocybe* (Fr.) P. Kumm. with dimorphic basidiospores and basidia in section *Firmae* are widely distributed in tropics. Corner (1936) studied this group in the paleotropics and described a new species, *Hygrophorus hypohaemactus* Corner [≡ *Hygrocybe hypohaemacta* (Corner) Pegler], and 16 new varieties of *Hygrophorus firmus* Berk. & Broome [≡ *Hygrocybe firma* (Berk. & Broome) Singer]. He also noted, however, that many of his varieties might represent species in their own right. Pegler (1983) stated that *Hygrocybe firma* represented an extremely variable species; he considered that of Corner's varieties, only *militaris* and *puniceoides* (in addition to the autonymous variety) were worthy of recognition at the species level, but he did not transfer any varieties to *Hygrocybe*. Although *Hygrocybe* species are well represented all over India (Manjula 1983, Natarajan et al. 2005), most have been described and reported from Kerala state (Leelavathy et al. 2006). However, only two species of *Hygrocybe* in section *Firmae* have been described so far from India:

H. alwisii (Berk. & Broome) Pegler from Kerala (Leelavathy et al. 2006), and *H. natarajanii* Senthil. & Kumaresan from Karnataka (Senthilarasu et al. 2010). In this study, we describe *Hygrocybe manadukaensis*, which differs macro- and microscopically from known species of *Hygrocybe* in section *Firmae*.

Materials and methods

The description and illustrations were based on the type specimen collected from Manaduka, Uppangala forest of Western Ghats of Karnataka. Handmade sections were obtained from the dried specimens, later revived in 3% KOH and mounted in 2% Phloxine. Approximately 50 basidiospores obtained from a spore print were measured. The mean spore measurements are given in parentheses followed by the range of spore measurements (with extreme values in parentheses). The type specimen was deposited in the Herbarium of Madras University Botany Laboratory (MUBL). The colour terminology used is that of Kornerup & Wanscher (1978).

Taxonomy

Hygrocybe manadukaensis Senthil., Kumaresan & S.K. Singh **sp. nov.** FIGS 1, 2

MYCOBANK MB 518715

Pileus 8–25 mm diam., convexus, depressus; superficie aequabiliter aurantiacus cum flavus tinctus ad discus primus, aurantiacus ad discus, aurantiacus-rubus alibi, flavus ad margine, laevis; margine regularis, laevis, non-striatus. Lamellae subdecurrentes, luteolus ad ranunculinus, ad usque 3 mm latae, subdistantes, tribus ordinibus lamellularum intermixtae; margine concolori, laevis. Stipes 13–60 × 7–12 mm, aequalis, cylindricus, compressus ad apicem, cavus, caespitosus; superficie aequabiliter aurantiacus-rubus ad atroaurantiacus, laevis. Contextus ad usque 2 mm latae at discus, albus. Sporae dimorphae; macrosporae (12.8 ± 0.7 × 7.8 ± 0.7), (11–)11.5–13.5(–15) × 7–9(–10) µm, Q = 1.6, ellipsoideae ad late ellipsoideae, hyalinae, parietibus tenuibus, guttulis refractives; microsporae (5.5 ± 0.4 × 3.4 ± 0.2), (4.5–)5–6(–6.5) × 2.9–4 µm, Q = 1.6, ellipsoideae ad late ellipsoideae, similis ad macrosporae. Basidia dimorpha; macrobasidia 42.5–57 × 10–13 µm, cylindrico-clavata, 4-spora, sterigmatus 5.5–9.5 × 1.5–2.5 µm, parietibus tenuibus, guttulis numerosis; microbasidia 29–39 × 5.5–6.5 µm, cylindrico clavata, 4-spora, sterigmatus ad usque 5.5 µm longus, similis ad macrobasidia. Margo lamellaris fertilis. Cystidia nulla. Trama hymenophoralis regularis, ex hyphis 1.5–7.5 µm diam. Pileal contextus ex hyphis 1.5–5 µm diam., hyalinae, parietibus tenuibus. Pileipellis cutis est ex hyphis repentibus, 1.5–7.5 µm diam. Fibulis abundantibus.

TYPE: India, Karnataka State, Manaduka, Uppangala Forest, 12°30'N 79°39'W, 500 masl, on ground (soil), Senthilarasu G. (**Holotype** MUBL 3429).

ETYMOLOGY: This species is named for its place of collection.

Pileus 8–25 mm diam., broadly convex, soon depressed at the disc; surface uniformly deep orange (6A8), with light yellow (4A5) tints at the disc when young, light orange (5A5) at the disc, orange-red (8B8) elsewhere, deep yellow

FIG 1. *Hygrocybe manadukaensis*.
Under natural conditions in Manaduka, Uppangala forest. Photo Senthilarasu G.

(4A8) at extreme margin with age, dry, smooth; margin regular, smooth, not striate. Lamellae subdecurrent, light yellow (4A4) to butter-yellow (4A5), up to 3 mm broad, moderately close with lamellulae of 3 lengths; edge concolorous with the sides, smooth. Stipe 13–60 × 7–12 mm, equal, slightly attenuated towards apex, cylindric, slightly compressed at the apex, hollow, caespitose; surface uniformly orange-red (8B7), becoming deep orange (6A8) at maturity, often with light yellow (4A5) tints, smooth, dry. Context very thin, up to 2 mm thick at the disc, white.

Basidiospores dimorphous: macrospores (12.8 ± 0.7 × 7.8 ± 0.7) (11–) 11.5–13.5(–15) × 7–9(–10) µm, Q=1.6, ellipsoid to elongate ellipsoid, hyaline, thin-walled with few refractive guttules; microspores (5.5 ± 0.4 × 3.4 ± 0.2) (4.5–)5–6(–6.5) × 2.9–4 µm, Q=1.6, ellipsoid to elongate ellipsoid, similar to macrospores. Basidia dimorphous: macrobasidia 42.5–57 × 10–13 µm, cylindric-clavate, bearing four thick, large sterigmata, 5.5–9.5 × 1.5–2.5 µm, thin-walled, with numerous guttules; microbasidia 29–39 × 5.5–6.5 µm, cylindric-clavate, bearing four sterigmata, up to 5.5 µm long, similar to macrobasidia. Lamella-edge fertile. Cystidia absent. Hymenophoral trama regular, hyaline, of thin-walled hyphae, 1.5–7.5 µm diam., inflated to 17.5 µm diam. Subhymenial layer little developed, up to 8 µm wide, loosely interwoven. Pileal context consisting of closely interwoven, thin-walled, hyaline hyphae, 1.5–5 µm diam., inflated to 13 µm diam.; oleiferous hyphae scattered, thick-walled, 2–7 µm diam. Pileal surface a repent cutis of radially arranged parallel hyphae, 1.5–7.5 µm diam., inflated to 22.5 µm diam. Clamp-connections abundant.

HABITAT - On ground, caespitose, in wet evergreen tropical forest.

DISCUSSION: The characteristic features of *Hygrocybe manadukaensis* are the presence of deep yellow to deep orange or orange-red, smooth, convex pileus, light yellow to butter-yellow, subdecurrent lamellae, orange-red to deep orange, long and thick stipe, caespitose growth, and strongly dimorphic spores and basidia.

Among the varieties of *Hygrophorus firmus* described by Corner (1936), *Hygrocybe manadukaensis* closely resembles var. *militaris* and var. *puniceoides* in its similar sized and shaped macrospores. However, var. *militaris* clearly differs in having scarlet pileus and white stipe and var. *puniceoides* has a much larger (70–80 mm) pileus and longer (60–75 mm) stipe.

Hygrocybe manadukaensis more closely resembles *H. trinitensis* (Dennis) Pegler (Pegler 1983) in possession of a convex, shallowly depressed pileus and dimorphous basidiospores and basidia. However, *H. trinitensis* is clearly distinguished macroscopically by its small, scurfy, umblicate pileus, coral-red lamellae, and thin, scarlet stipe and microscopically by its smaller (10–13 ×

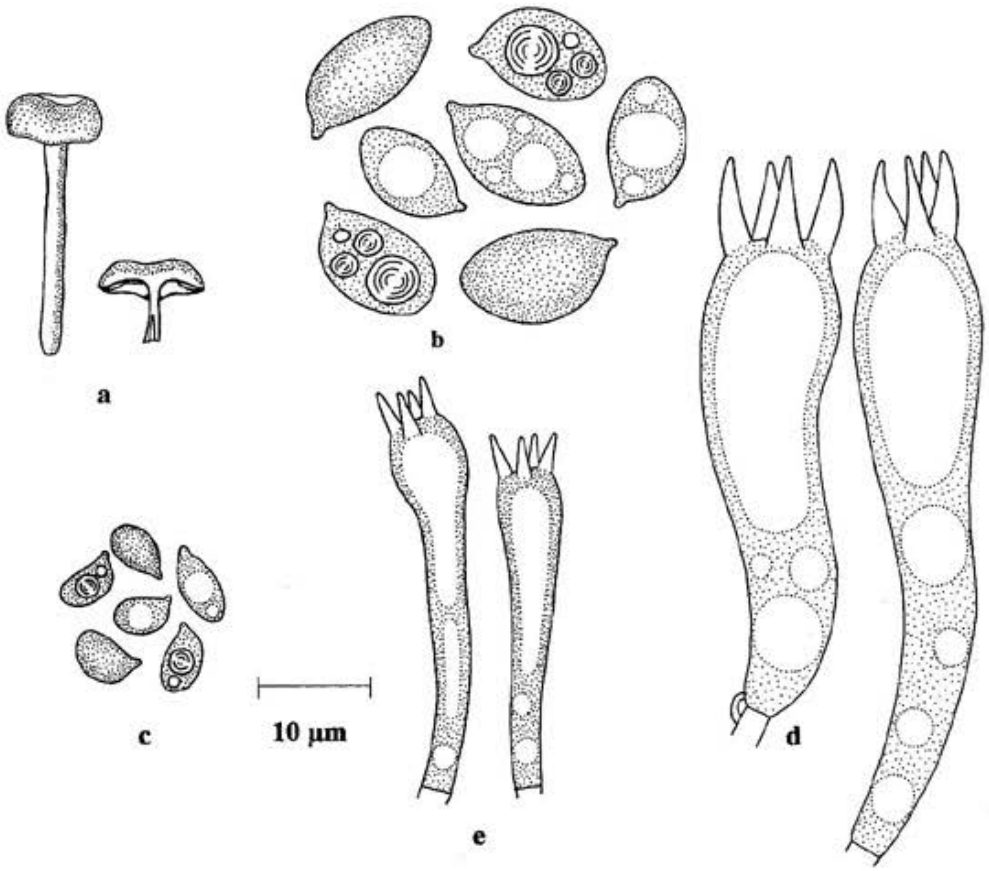


FIG 2. *Hygrocybe manadukaensis*: a. Habit ×1. b. Macrobasidiospores, c. Microbasidiospores. d. Macrobasidia. e. Microbasidia. Scale bar = 10 µm.

6–7.5 µm) macrospores, larger (7–9 × 4.5–5.5 µm) microspores, and smaller macrobasidia (35–45 × 8–9 µm) and microbasidia (20–28 µm).

Hygrocybe occidentalis (Dennis) Pegler var. *occidentalis* (Pegler 1983; Lodge & Pegler 1990) exhibits a similar range of yellow to orange colour variation and produces similarly sized macrospores and microbasidia. However, *H. occidentalis* var. *occidentalis* clearly differs macroscopically from *H. manadukaensis* in its larger (10–70 mm), convex to applanate, perforated pileus and larger (35–100 × 4–20 mm) stipe; the latter species, which possesses a convex, depressed but never perforated pileus, is differentiated microscopically by its smaller microspores (5–8 × 3.3–5 µm in *H. occidentalis* var. *occidentalis*). In addition, both species differ in their growth habit, where *H. manadukaensis* produces caespitose basidiomes in contrast to the solitary to scattered habit of *H. occidentalis* var. *occidentalis*.

Hygrocybe anisa (Berk. & Broome) Pegler (Pegler 1986) produces similarly coloured and sized, caespitose basidiomes, macrospores, and microbasidia. However, *H. anisa* differs macroscopically from *H. manadukaensis* in its

straw yellow, slightly floccose/squamose pileus that lacks the orange tints that characterize *H. manadukaensis* and slender (2–5 mm) stipe. In addition, *H. anisa* is distinguished microscopically by larger microspores (6.5–8 × 4.5–5.3 µm) and macrobasidia (60–70 µm).

While the dimensions of the macro- and microspores of *H. natarajanii* are similar to those of *H. manadukaensis*, *H. natarajanii* has a yellow pileus covered with ruby red, tomentose squamules and a light yellow, longer, slender (50–140 × 2–5 mm) stipe. In addition, *H. natarajanii* has larger macro- (55 – 68.5 µm) and micro- (37–44.5 µm) basidia (Senthilarasu et al. 2010).

Hygrocybe manadukaensis somewhat resembles *H. firma* (Berk. & Broome) Singer (Pegler 1986) in the orange to pale yellow convex pileus, subdecurrent pale yellow lamellae, long, thick, orange to pale yellow stipe, and similarly sized macrospores and microbasidia. However, *H. firma* clearly differs macroscopically in its tomentose to scurfy squamulose/fibrillose, perforated pileus, contrasting with the non-perforated smooth pileus of *H. manadukaensis*. In addition, *H. firma* microscopically differs in its larger microspores (6–8 × 4.5–6 µm) and macrobasidia (50–75 × 12–16 µm).

The morphological variation observed in the specimen from Manaduka differentiates it from the above taxa and supports it as a new species in section *Firmae*.

Acknowledgments

The authors are grateful to Dr. D. Jean Lodge (Center for Forest Mycology Research, USDA-Forest Service Forest Products Laboratory, Luquillo, Puerto Rico, USA) and Dr. Leticia Montoya (Instituto de Ecología A.C., Red Biodiversidad y Sistemática, Xalapa, México) for critically reviewing the manuscript and suggesting appropriate revisions. SG is indebted to Prof. P. Manimohan (Calicut University, Kerala, India) who provided *Hygrophorus* literature. Sincere thanks to the Department of Science and Technology (DST), Government of India, New Delhi, for providing financial support under the IRPHA Programme to establish a state-of-the-art national facility for culture collection of fungi (No. SP/SO/PS-55/2005) at Agharkar Research Institute, Pune, India. SG thanks the Ministry of Environment and Forests, Government of India, for financial assistance. Sincere thanks are also due to Dr. Taiana Riviere and Dr. Dennis Depomiere of Institut Francais de Pondichery, Pondicherry, India.

Literature cited

Corner EJH. 1936. *Hygrophorus* with dimorphous basidiospores. Transactions of the British Mycological Society 20: 157–184. doi:10.1016/S0007-1536(36)80008-4

Kornerup A, Wanscher JH. 1978. Methuen Handbook of Colour. 3rd edn. Methuen and Co., Ltd., London. 243 p.

Leelavathy KM, Manimohan P, Arnolds EJM. 2006. *Hygrocybe* in Kerala State, India. Persoonia 19: 101–151.

Lodge DJ, Pegler DN. 1990. *Hygrophoraceae* of the Luquillo Mountains of Puerto Rico. Mycological Research 94(4): 443–456. doi:10.1016/S0953-7562(10)80002-4

Manjula B. 1983. A revised list of the agaricoid and boletoid basidiomycetes from India and Nepal. Proceedings of Indian Academy of Sciences (Plant Science) 92: 81–213.

Natarajan K, Kumaresan V, Narayanan K. 2005. A checklist of Indian agarics and boletes (1984–2002). Kavaka 33: 61–128.

Pegler DN. 1983. Agaric flora of the Lesser Antilles. Kew Bulletin Additional Series IX.

Pegler DN. 1986. Agaric flora of Sri Lanka. Kew Bulletin Additional Series XII.

Senthilarasu G, Kumaresan V, Singh SK. 2010. A new species of *Hygrocybe* in section *Firmae* from Western Ghats of India. Mycotaxon 111: 301–307.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.351

Volume 114, pp. 351–360 *October–December 2010*

Coprinellus mitrinodulisporus, a new species from chamois dung

Francesco Doveri*, Sabrina Sarrocco, Susanna Pecchia, Maurizio Forti & Giovanni Vannacci

*f.doveri@sysnet.it

Department of Tree Science, Entomology and Plant Pathology "G. Scaramuzzi"
Section Plant Pathology, University of Pisa
via del Borghetto 80, 56124 Pisa, Italy

Abstract — The genus *Coprinellus* is re-examined from its establishment, through demotion as a synonym of *Coprinus*, and up through its current reinstatement. An agaric with a setulose pileus, sphaerocystic veil, and mitriform, nodulose spores has been isolated from chamois dung and, based on morphological data, is regarded as a new species in *Coprinellus*. The new taxon is compared with morphologically similar *Coprinellus* species, particularly with those having mitriform spores. Other taxa recently described in *Coprinus* are transferred to *Coprinellus*.

Key words — *Agaricales*, *Setulosi*, 28S rDNA, ITS, β-tubulin

Introduction

Persoon (1797) erected the genus *Coprinus* to accommodate agaric species with an ephemeral, membranous cap and blackening, deliquescent gills. Karsten (1879) later established the genus *Coprinellus* for species differing from *Coprinus* in having "caps covered by a cuticle or veil, finally lacerate and turned upwards" rather than "scaly from remnants of the universal veil, and covered by a veil". Ricken (1915), who accepted *Coprinellus* as a subgenus of *Coprinus* limited to non-deliquescent species, restricted subgen. *Coprinus* to species with deliquescent gills. Lange (1938) reinstated *Coprinellus* at the genus level to include some non-deliquescent species, which Singer (1986) later placed in *Coprinus* subsect. *Setulosi* J.E. Lange. Singer (1986), whose conceptions were basic to the modern taxonomy of *Agaricales* Underw., regarded *Coprinellus* as a later synonym of *Coprinus*.

M. Lange (1952), who studied pileocystidiate species from different geographical origins morphologically and with interfertility tests, showed that

some species consisted of more than one cryptic, intersterile entity. Uljé & Bas (1991) monographed the *setulosi* at subsection level of section *Pseudocoprinus* (Kühner) P.D. Orton & Watling and included species with a hymenidermal cuticle and setulae on cap and stem, sometimes in association with veil remnants.

Molecular phylogenetic studies (Hopple & Vilgalys 1994, 1999; Johnson & Vilgalys 1998; Johnson 1999; Moncalvo et al. 2000, 2002) show *Coprinus comatus* (O.F. Müll.) Pers. (the type species of *Coprinus*) and its allies as distantly related to the other *Coprinus* species, and reveal *Coprinus* sensu lato to be a heterogeneous, polyphyletic assemblage. Based on these results, Redhead et al. (2001) split *Coprinus* s.l. into four genera — *Coprinus* s. str. in *Agaricaceae* Chevall. and *Coprinellus*, *Coprinopsis* P. Karst., and *Parasola* Redhead et al. in *Psathyrellaceae* Vilgalys et al. Their concept of *Coprinellus* includes species that in traditional systematics belong to subsect. *Setulosi* and subsects. *Domestici* Singer and *Micacei* (Fr.) Uljé & Noordel. of sect. *Veliformes* (Fr.) Penn. and are characterised by a hymenidermal or cystodermal pileipellis with a globular veil and/or pileocystidia (setulae).

This new taxonomy based on phylogenetic relationships in association with morphological features is now accepted by many authors, including Keirle et al. (2004) in their research on Hawaiian *Agaricales*, Nagy et al. (2009), who applied it to a complex study on *Parasola,* and Schafer (2010), who combined earlier subsections as sections of *Parasola*, *Coprinellus,* and *Coprinopsis*.

Since Uljé & Bas (1991) monographed *Setulosi*, additional new *Coprinus* s.l. species belonging to this section have been published (Uljé & Verbeken 2002, Uljé & Keizer 2003, Uljé & Noordeloos 2003, Nagy 2006), a few of which have been recombined in *Coprinellus* (Nagy et al., in press).

Our systematic study of coprophilous ascomycetes and basidiomycetes from Italy has recently allowed us to observe the growth on dung, in a damp chamber culture, of a *Coprinus* s.l., whose morphological features match those of *Setulosi*, but whose combination of characters does not correspond to any species in this section. We describe it here as a new species of *Coprinellus*.

Materials and methods

Isolation of the fungus — Morphological studies

Samples of chamois (*Rupicapra rupicapra*) dung were dried and cultured, after nineteen months, in a non-sterilised damp chamber according to Richardson & Watling (1997) and Richardson (2001), slightly modified by Doveri (2004). The cultures, placed under natural light at room temperature (18–25°C), were observed daily for five weeks with the unaided eye and a ×7–45 magnification stereomicroscope. The macroscopic features were immediately described, and fresh material was mounted in water and Congo red and microscopically examined under a binocular light microscope. Spore

size was measured in water and calculated on 80 mature spores from 3 basidiomata, excluding the apiculum from the measurements (Q means the quotient of length divided by the breadth in face view). Small fruitbodies were dried in a few minutes with an artificial light. The collection has been preserved as dried material and slides (PI). Herbarium abbreviation follows Holmgren & Holmgren (1998).

Molecular studies

DNA extraction was performed on a dried fruitbody using the DNeasy Plant MiniKit (Qiagen), according to the manufacturer's protocol. Polymerase Chain Reaction (PCR) was used to amplify the LSU and the ITS regions of the nuclear ribosomal DNA, employing the following primers: LR7, LR5, LR3R and LROR for the first 1.5 kb of the LSU gene and ITS1 and ITS4 for the ITS region (Gardes & Bruns 1993). Amplification reaction mixtures contained 25–50 ng of template DNA, GoTaq®Green Master Mix (Promega) 1X and 0.5 mM of each primer in a volume of 50 µL.

Amplification was performed in a GeneAmp® PCR System 2400 (Perkin Elmer) using the following parameters: for LSU initial denaturation step at 94°C for 5 min, 35 cycles consisting of denaturation at 94°C for 1 min, annealing at 50°C (for LROR/LR7) or 52°C (for LROR/LR5 and LR3R/LR7) for 1 min and extension at 72°C for 2 min, final extension of 72°C for 7 min; for ITS initial denaturation step at 94°C for 1 min, 30 cycles consisting of denaturation at 94°C for 30 s, annealing at 54°C for 1 min and extension at 72°C for 1 min, final extension of 72°C for 4 min. After the final extension of 72°C reactions were held at 4°C.

In addition, a fragment of the β-tubulin gene was amplified by primers B36f_psa/B12r_psa according to Nagy et al. (2010).

PCR products were purified by the QIAquick PCR Purification Kit (Qiagen) according to the manufacturer's protocol and submitted to sequencing. Samples to be sequenced were processed by the DNA Sequence Facility at the Bio Molecular Research (BMR), Servizio di Sequenziamento – CRIBI, University of Padova (Italy). For sequencing the same primers as described above for the ITS fragments and LR16 or LR22 as additional primers for the LSU fragment (Gardes & Bruns 1993) were used. The LSU and ITS sequences derived from these studies have been deposited in GenBank and compared with other sequences in GenBank.

Taxonomy

Coprinellus mitrinodulisporus Doveri & Sarrocco **sp. nov.**

MycoBank 518735; GenBank HQ180170 PLATE 1-2

Pileus primo subglobosus vel elliptico-paraboliformis, usque ad 2 mm altus, deinde convexo-conicus vel campanulato-convexus, ultimo convexo-applanatus vel etiam revolutus, 3–10 mm latus, dense pruinoso-pubescens, radialiter striatus, deinde fissuratus. Cuticula primo ochracea, luteo vel purpureo, raro olivaceo, soffusa, deinde floris lactis colorem accipiens, plerumque ad marginem pallidior, ad postremum cinerascens. Lamellae ascendentes, stipitem non attinentes, ventricosae, infrequentes, ex albo nigricantes, ad marginem pallidiores. Stipes usque ad 45 × 0.5–0.8 mm, albidus vel modice quam pileus pallidior, flexuosus, cylindratus, aliquanto ad basim dilatatus at non bulbosus, omnino pruinoso-pubescens, saepe basali radiato mycelio praeditus. Inodorus. Velum granulatum, et ad

pileum et ad stipitem conspersum, ex crasse crustatis atque crassitunicatis sphaerocytibus, 12–20 µm diam., compositum. Sporae (9–) 9.5–11 (–11.5) × 6–7 x 5–6 µm, in adverso visu mitriformes, a latere subamygdaliformes, plerumque rotunde quadrinodosae, fuscobadiae, valde excentrico, 1.5–2 µm lato, poro germinativo praeditae. Basidia 16–27 × 6–9 µm, tetraspora, claviformia vel subcylindrata. Pleurocystidia absentia. Cheilocystidia copiosa, globosa vel late ellipsoidea, pedicularia, 25–39 × 21–32 µm. Pileipellis ex globosis, claviformibus vel late ellipsoideis, interdum crustatis cellulis, 20–48 × 16–34 µm, composita. Pileocystidia copiosa, lageniformia, et tenuitunicata, 62–78 (–90) × 12–15 µm, ad acutum apicem contracta, aliquando crustata leptocystidia, et crassitunicata, 35–45 × 11–16 µm, plerumque crustata sclerocystidia. Caulocystidia copiosa, pileocystidiis similia, 40–75 × 10–17 µm. Fibulae absentes. Holotypus hic designatus N.A. 1 in Pisani Horti Botanici viridario conservatur, ex fimo Rupicaprae rupicaprae, in Augustana Italica terra (saltus Salati) invento atque culto, ad viginti solitaria specimina remota, 28 Augustus 2008.

TYPE: Salati pass (45°52'34"N 7°52'05"E), Aosta, Italy, on chamois dung, 28.8.2008, leg.: L. Levorato (**Holotype** N.A. 1, Pisa Botanical Garden)

ETYMOLOGY: *mitri-noduli-sporus* from the Latin (in turn from the Greek) "*mitra*" = "mitre"; "*nodulus*" = "small knob"; "*spora*" = "spore", referred to the nodulose, mitriform spores

MACROCHARACTERS—PILEUS subglobose or ellipsoid-paraboloid when still closed, up to 2 mm high, convex-conic to conic-campanulate later, expanding to convex-plane or even revolute with an even margin, not umbonate, 3–10 mm diam., wholly and densely pruinose-pubescent, pruina thinning away with age, radially striate, becoming slightly grooved. Cuticle ochreous at first, with orange to purplish, rarely olive, shades, becoming cream coloured with a darker disc, finally greyish; LAMELLAE ascendant, free, ventricose, thin, distant, black at maturity with a paler edge. LAMELLULAE present; STIPE up to 45 × 0.5–0.8 mm, whitish or slightly paler than cap, wavy, cylindric, somewhat enlarged but not bulbous at the base, hollow, entirely pruinose-pubescent, often with a radial, white mycelial felt; VEIL granulose, present both on the cap and stem; CONTEXT imperceptible. No smell.

MICROCHARACTERS—BASIDIOSPORES (9–)9.5–11(–11.5) × 6–7 × 5–6 µm, mitriform in frontal view (Q = 1.38–1.69; Q average = 1.52), subamygdaliform in side view, with a conical base and conical or convex apex, nodulose usually having two knobs on each side in face view, dark reddish brown at maturity, with a well developed, prominent apiculus, and an eccentric germ pore, 1.5–2 µm diam.; BASIDIA 4-spored, 16–27 × 6–9 µm, bimorphic, claviform or subcylindric, the latter with a slight median constriction, each surrounded by 4–5 globose to claviform brachybasidia, 17–33 × 17–30 µm.; PLEUROCYSTIDIA absent; CHEILOCYSTIDIA abundant, globose or broadly ellipsoidal, with a pedicel, 25–39 × 21–32 µm.; PILEIPELLIS a hymeniderm of globose, claviform, or broadly ellipsoidal, sometimes encrusted cells, 20–48 ×16–34 µm.; PILEOCYSTIDIA numerous, of two kinds, both lageniform: 1) thin-walled (leptocystidia), 62–78(–90) × 12–15µm, bulbous at the base, with a neck tapering upwards,

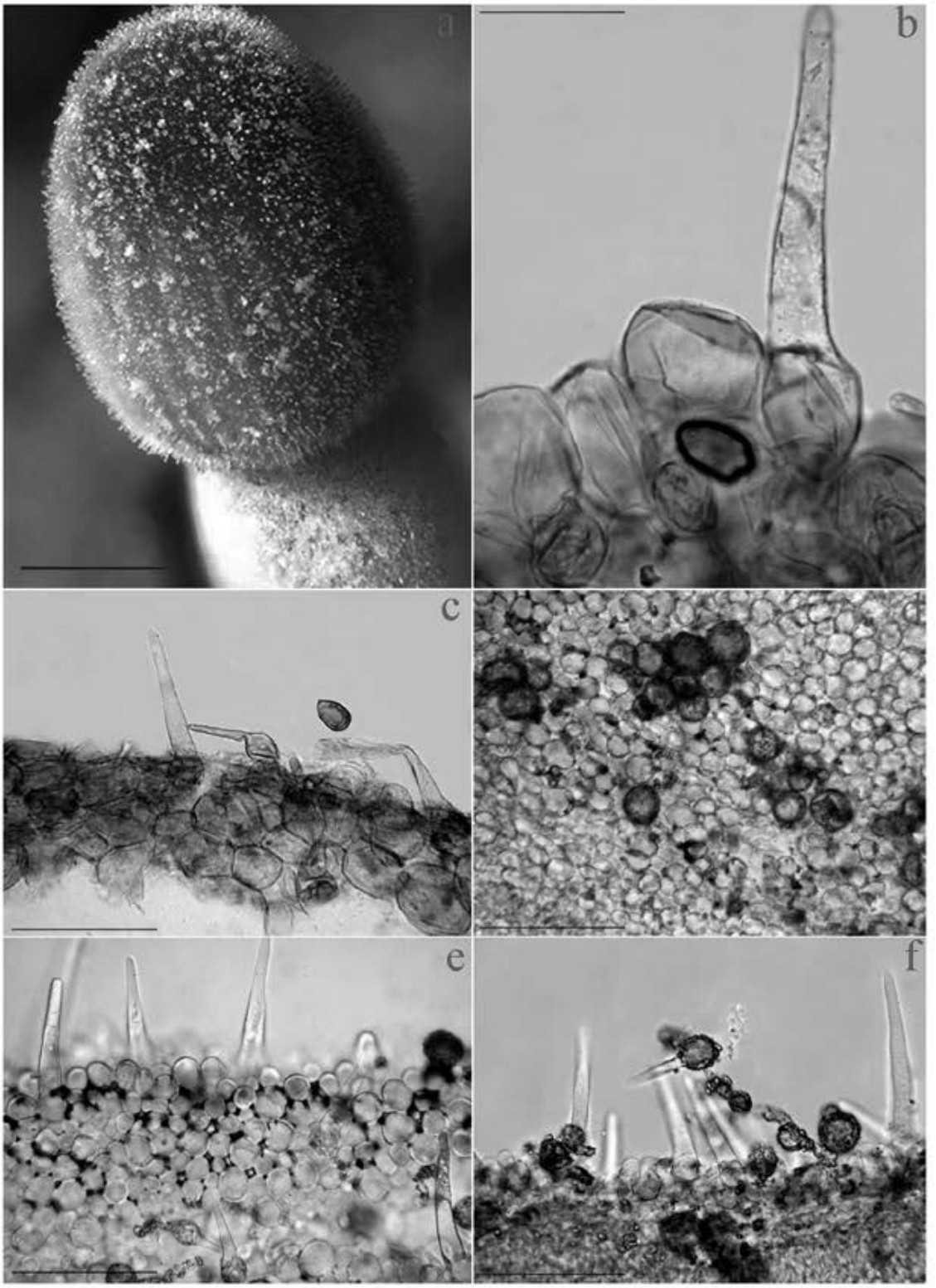


FIG. 1 *Coprinellus mitrinodulisporus* (holotype): a = basidioma in an early stage; b = hymenidermal cells interspaced with a leptopileocystidium; c, e–f = details of pileipellis with leptocystidia, sclerocystidia, and dark pigmented veil cells; d = dark pigmented veil cells above the hymenidermal cells. Scale bars: a = 500 µm; b = 20 µm; c–f = 50 µm.

7–10 µm diam. at their base, sometimes sparsely encrusted at the neck and densely and coarsely at the base; 2) thick-walled (sclerocystidia), 35–45 × 11–16 µm (3–4 µm diam. at the neck base), darker than leptocystidia, usually coarsely encrusted at their bulbous base; CAULOCUTIS with the outermost hyphae 1–3 µm diam., sometimes encrusted, supporting many cystidia similar to pileocystidia, 40–75 × 10–17 µm.; VEIL formed of coarsely encrusted, thick-walled sphaerocysts, 12–20 µm diam., globose or even in transitional forms, with hints of neck, from sphaerocysts to sclerocystidia; CLAMP-CONNECTIONS absent.

ECOLOGY, RANGE, DISTRIBUTION—About twenty scattered specimens on chamois (*Rupicapra rupicapra*) dung in a damp chamber culture. August. To date only known from the type locality.

MOLECULAR ATTRIBUTES—Amplification of the LSU and ITS regions resulted in about 1.4 kb and 600 bp long sequences, respectively. Comparison of our LSU sequence (accession number HQ180170) with those deposited in GenBank resulted in high similarity percentages (96%) with other strains of *Coprinellus* spp., and comparison of the ITS sequence (accession number HQ180171) within the same database confirmed this result. A β-tubulin sequence has been deposited (HQ180172) to support further phylogenetic studies on *C. mitrinodulisporus*.

Discussion

The main features of *Coprinellus mitrinodulisporus* are growth on dung, pileus with setulae, and a granulose, sphaerocystic veil, the latter particularly evident in the early stages, mitriform and nodulose basidiospores, and absence of clamp-connections. The presence of a hymenidermal pileipellis and setuliform pileo- and caulocystidia places the species in subs. *Setulosi* of Uljé & Bas (1991) and now in *Coprinellus*, as revised and reinstated by phylogenetic studies (Redhead et al. 2001) as section *Setulosi* (J.E. Lange) D.J. Schaf. (Schafer 2010).

Coprinellus mitrinodulisporus is very close to *Coprinus doverii* L. Nagy, a typical representative of *Setulosi* not yet recombined in *Coprinellus* (Nagy, in litt.). The two species share habitat and many macro- and microscopic features, including encrusted lageniform pileocystidia and mitriform nodulose spores, but *C. mitrinodulisporus* differs in having larger spores (6.2–8.3 × 4.5–5.8 × 3.8–4.1 µm in *C. doverii*), abundant and larger cheilocystidia (gill edge almost sterile), longer pileocystidia, abundant sclerocystidia and veil (the latter easily observable with a ×10 magnification), and in lacking clamp connections, which are absent also in the mycelial felt. In addition, *C. mitrinodulisporus* has pileocystidia with constantly tapering necks rather than with both tapering and cylindrical necks. Given the limited number of collections of both species

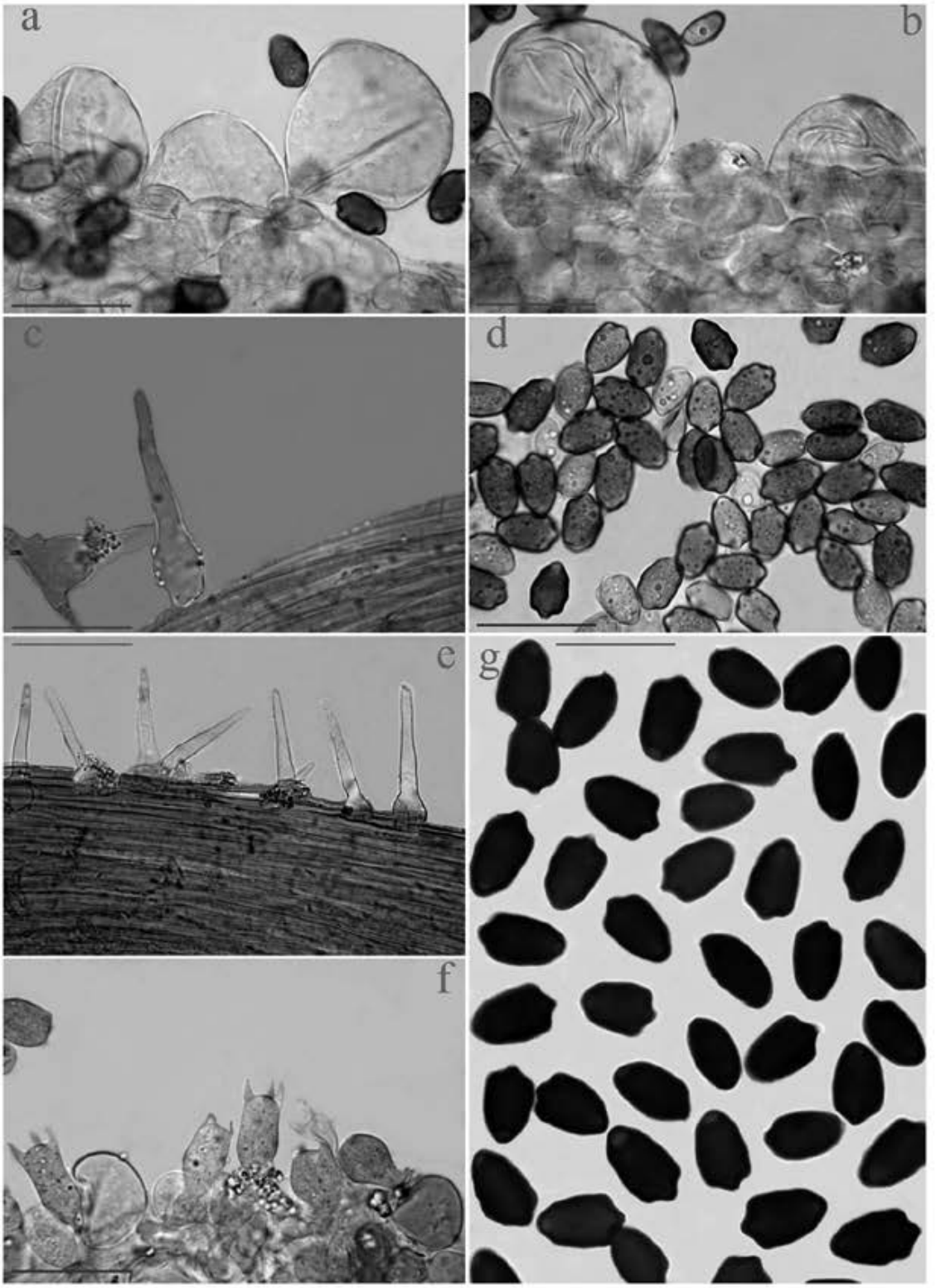


FIG. 2 *Coprinellus mitrinodulisporus* (holotype): a = brachybasidia; b = cheilocystidia; c,e = details of caulocutis with lageniform cystidia; d = immature and maturing spores; f = detail of hymenium with basidia; g = mature spores. Scale bars: a–d, f = 20 µm; e = 50 µm; g = 15 µm.

studied and the unique combination of characters they share, they might conceivably represent one, variable taxon. Further studies are clearly desirable but considering the observed differences and the possible rarity of the taxa, we prefer to treat these as separate species. As the two species occupy an isolated morphological position in *Setulosi*, a molecular phylogeny might not clearly differentiate them from each other. It would be interesting to explore their intersterility in mating studies.

Lageniform leptopileo- and scleropileocystidia tapering upwards and similarly sized (8.5–11 × 6.5–8.5 × 5–6.5 µm in Orton & Watling 1979), mitriform basidiospores are also found in *Coprinellus angulatus* (Peck) Redhead et al., which is, however, a carbonicolous species with much larger, rust-brown fruitbodies, non-nodulose, more squat basidiospores (average length/breadth = 1.25–1.35, Uljé 2005) with a central, very wide and truncate germ pore, pleurocystidia, and clamp-connections.

Coprinellus marculentus (Britzelm.) Redhead et al., a coprophilous pileocystidiate species with a granular veil and similarly sized basidiospores also shares purplish pileus shades and globose or broadly ellipsoidal cheilocystidia (Uljé & Bas 1991), but *C. marculentus* differs in its smooth, usually hexagonal, sometimes mitriform basidiospores, and pileocystidia with a cylindrical neck, equal or enlarged at its apex. It also differs from *C. mitrinodulisporus* in lacking sclerocystidia and having pleurocystidia and clamp-connections.

Although it does not have mitriform spores, *Coprinellus heptemerus* (M. Lange & A.H. Smith) Vilgalys et al. has other characters in common with *C. mitrinodulisporus*, including an encrusted veil with cells transitional between sphaerocysts and pileocystidia, a lack of clamp connections and pleurocystidia, small fruitbodies, and a habit on dung. However, the combination of characters and distinctly shaped spores distinguish *C. mitrinodulisporus* clearly from *C. heptemerus* and other previously published *Setulosi*, except *C. doverii*.

Apart from *C. doverii*, no other *Setulosi* species published after Uljé & Bas (1991) and Uljé & Noordeloos (2003) has coarsely encrusted veil sphaerocysts, sclerocystidia and mitriform basidiospores, easily distinguishing them from *C. mitrinodulisporus*. We take the opportunity to recombine some of them in *Coprinellus*:

Coprinellus allovelus (Uljé) Doveri & Sarrocco, **comb.nov.**

MycoBank 518736

≡ *Coprinus allovelus* Uljé, in Uljé & Noordeloos, Persoonia 18: 261, 2003

Coprinellus limicola (Uljé) Doveri & Sarrocco, **stat. nov., comb.nov.**

MycoBank 518737

= *Coprinus callinus* var. *limicola* Uljé, in Uljé & Noordeloos, Persoonia 18: 259, 2003 as "*limicolus*"

NOTE: Nagy (pers. comm.) reports that, based on molecular results, this is a separate species. Morphologically it has a number of differences from *C. callinus* that support its rank as a distinct species. M. Lange (1952), who reported that collections identified morphologically as *C. callinus* consisted of two intersterile taxa, was not able to distinguish these morphologically.

Coprinellus canistri (Uljé & Verbeken) Doveri & Sarrocco, **comb.nov.**

MYCOBANK 518738

≡ *Coprinus canistri* Uljé & Verbeken, Persoonia 18: 143, 2002

Coprinellus minutisporus (Uljé) Doveri & Sarrocco, **comb.nov.**

MYCOBANK 518739

≡ *Coprinus minutisporus* Uljé in Uljé & Noordeloos, Persoonia 18: 260, 2003

Coprinellus pseudoamphithallus (Uljé) Doveri & Sarrocco, **comb.nov.**

MYCOBANK 518741

≡ *Coprinus pseudoamphithallus* Uljé in Uljé & Noordeloos, Persoonia 18: 263, 2003

Acknowledgements

The authors wish to thank László Nagy, Derek Schafer, and the MYCOTAXON editors for critical revision of the manuscript, and Lucia Levorato for providing them with the substratum subject of their study.

Literature cited

Doveri F. 2004. Fungi Fimicoli Italici. A.M.B.-Fondazione Centro Studi Micologici. Vicenza

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes – application to the identification of mycorrhizae and rusts. Mol. Ecol. 2: 113–118. doi:10.1111/j.1365-294X.1993.tb00005.x

Holmgren PK, Holmgren NH. 1998 [continuously updated]. Index Herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. http://sweetgum.nybg.org/ih/ [accessed July 2010]

Hopple JS, Vilgalys R. 1994. Phylogenetic relationships among coprinoid taxa and allies based on data from restriction site mapping of nuclear rDNA. Mycologia 86: 96–107. doi:10.2307/3760723

Hopple JS, Vilgalys R. 1999. Phylogenetic relationships in the mushroom genus *Coprinus* and dark-spored allies based on sequence data from the nuclear gene coding for the large ribosomal subunit RNA: divergent domains, outgroups, and monophyly. Mol. Phylogenet. Evol. 13: 1–19. doi:10.1006/mpev.1999.0634

Johnson J. 1999. Phylogenetic relationships within *Lepiota* sensu lato based on morphological and molecular data. Mycologia 9: 443–458. doi:10.2307/3761345

Johnson J, Vilgalys R. 1998. Phylogenetic systematics of *Lepiota* sensu lato based on nuclear large subunit rDNA evidence. Mycologia 90: 971–979. doi:10.2307/3761269

Karsten PA. 1879. Rysslands, Finlands och den Skandinaviska halföns Hattsvampar. I. Skifsvampar. Bidr. Känn. Finl. Nat. Folk. 32: 1–571.

Keirle MR, Hemmes DE, Desjardin DE. 2004. *Agaricales* of the Hawaiian Islands. 8. *Agaricaceae: Coprinus and Podaxis; Psathyrellaceae: Coprinopsis, Coprinellus and Parasola.* Fungal Divers. 15: 33–124.

Lange JE. 1938. Studies in the Agarics of Denmark. Part XII. *Hebeloma, Naucoria, Tubaria, Galera, Bolbitius, Pluteolus, Crepidotus, Pseudopaxillus, Paxillus.* Additional descriptions and supplementary notes to part I–XI. Dan. Bot. Ark. 9: 1–111.

Lange M. 1952. Species Concept in the Genus *Coprinus.* A study on the significance of intersterility. Dan. Bot. Ark. 14(6): 1–164.

Moncalvo JM, Lutzoni MF, Rehner SA, Johnson J, Vilgalys R. 2000. Phylogenetic relationships of agaric fungi based on nuclear large subunit ribosomal DNA sequences. Syst. Biol. 49: 278–305. doi:10.1093/sysbio/49.2.278 doi:10.1080/10635159950173852

Moncalvo JM., Vilgalys R, Redhead SA, et al. 2002. One hundred and seventeen clades of euagarics. Mol. Phylogenet. Evol. 23: 357–400. doi:10.1016/S1055-7903(02)00027-1

Nagy L. 2006. *Coprinus doverii* sp. nov., a unique new species of subsection *Setulosi* from central and southern Europe. Mycotaxon 98: 147–151.

Nagy G, Kocsubé S, Papp T, Vágvölgyi C. 2009. Phylogeny and character evolution of the coprinoid mushroom genus *Parasola* as inferred from LSU and ITS nrDNA sequence data. Persoonia 22: 28–37. doi:10.3767/003158509X422434

Nagy GL, Walther G, Vágvölgyi CS, Papp T. 2010. Understanding the evolutionary processes of fungal fruiting bodies: correlated evolution and divergence times in the *Psathyrellaceae.* Syst. Biol. (in press).

Orton PD, Watling R. 1979. *Coprinaceae* part I: *Coprinus.* British Fungus Flora, Agarics and Boleti 2:1–149.

Persoon CH. 1797. Tentamen dispositionis methodicae fungorum. Lipsiae.

Redhead SA, Vilgalys R, Moncalvo JM, Johnson J, Hopple JS Jr. 2001. *Coprinus* Pers. and the disposition of *Coprinus* species sensu lato. Taxon 50: 203–241. doi:10.2307/1224525

Richardson MJ. 2001. Diversity and occurrence of coprophilous fungi. Mycol. Res. 105: 387–402.

Richardson MJ, Watling R. 1997. Keys to fungi on dung. British Mycological Society, Stourbridge.

Ricken A. 1915. Die Blätterpilze (*Agaricaceae*). Deutschlands und der angrenzenden Länder, besonders Oesterreichs und der Schweiz. Leipzig.

Schafer DJ. 2010. Keys to Sections of *Parasola*, *Coprinellus*, *Coprinopsis* and *Coprinus* in Britain. Field Mycology 11: 44–51. doi:10.1016/j.fldmyc.2010.04.006

Singer R. 1986. The *Agaricales* in modern taxonomy, ed. 4. Koenigstein.

Uljé CB. 2005. *Coprinus* Pers. 22–109, in: Noordeloos ME, Kuyper ThW, Vellinga EC (eds) Flora Agaricina Neerlandica 6. Taylor & Francis, Boca Raton.

Uljé CB, Bas C. 1991. Studies in *Coprinus* - II. Subsection *Setulosi* of section *Pseudocoprinus.* Persoonia 14: 275–339.

Uljé CB, Keizer PJ. 2003. *Coprinus parvulus*, a new *Coprinus* from the Netherlands. Persoonia 18: 281–283.

Uljé CB, Noordeloos ME. 2003. Notulae ad Floram Agaricinam Neerlandicam – XLII. Additions to *Coprinus* subsect. *Setulosi.* Persoonia 18: 259–264.

Uljé CB, Verbeken A. 2002. A new species in *Coprinus* subsection *Setulosi.* Persoonia 18: 143–145.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.361

Volume 114, pp. 361–366 October–December 2010

A new species of *Phlyctis* (*Phlyctidaceae*) from China

RUI MA[1], HONG-MEI LI[2], HAI-YING WANG[1*] & ZUN-TIAN ZHAO[1*]

*lichenmr@yahoo.com * lichenwhy@yahoo.com.cn * ztzhao@sohu.com*

[1]*College of Life Sciences, Shandong Normal University*
Jinan, 250014, P. R. China

[2]*College of Life Sciences, Hebei University*
Baoding, 071002, P. R. China

Abstract —A new *Phlyctis* species, *P. subargena*, characterized by a sorediate thallus, clustered apothecia and 2-spored asci, is described from north-central China.

Key words — lichen, ascomycetes, Asia, taxonomy

Introduction

After Flotow (1850) established the lichen genus *Phlyctis* (Wallr.) Flot., the genus was expanded to include taxa formerly placed in *Phlyctomia, Phlyctella,* and *Phlyctidia* (Galloway & Guzmán 1988). Following phylogenetic analyses of molecular data, *Phlyctis* was moved from the *Lecanorales* to the *Ostropales* (Wedin et al. 2005, Miadlikowska et al. 2006). *Phlyctis* species are morphologically characterized by crustose thalli; small innate or subimmersed apothecia; large, colourless, and septate or muriform ascospores, 1–2 or 8 per ascus; and globose green algae as photobionts (Purvis et al. 1992, Brodo et al. 2001, Tønsberg 2004, Galloway 2007). *Phlyctis* species contain one or several of the following depsidone acids: stictic, constictic, norstictic, connorstictic, hypostictic, salazinic, psoromic, neopsoromic, and protocetraric (Galloway & Guzmán 1988).

Phlyctis contains approximately 12 species worldwide (Kirk et al. 2008), but only *Phlyctis schizospora* Zahlbr., from Hubei Province, has been reported from China (Chen et al. 1989, Wei 1991). During our study of *Phlyctis* collected from Gansu Province, an interesting *Phlyctis* species new to science was found.

* Equal corresponding authors

Materials and methods

The specimens studied were collected from Gansu Province, China, and are preserved in SDNU (Lichen Section of Botanical Herbarium, Shandong Normal University). The morphology of the lichen specimens was examined using a stereo microscope (COIC XTL7045B2) and a compound microscope (JNOEC XS-213). Lichen substances in all specimens cited were identified using the standardized thin layer chromatography techniques (Culberson 1972). Photos of the thallus and ascospores were taken under OLYMPUS SZX12 with DP70.

Taxonomy

Phlyctis subargena R. Ma & H.Y. Wang, **sp. nov.** FIG. 1

MycoBank 518778

Species acido norstictico, sporis 2nae et sorediis copiosis a congeneribus diversa.

TYPE COLLECTION: CHINA. Gansu province, Longnan, Wenxian Co. Qiujiaba, alt. 2450m, on bark, F. Yang, 20070050, 2 August 2007. (**Holotype** in SDNU).

EXPANDED DESCRIPTION —Thallus crustose, 60–120 µm thick, distinctly sorediate; surface arachnoid-byssoid, forming patches, roughened-uneven to irregularly areolate; areolate 0.1–0.2 mm, greenish white; prothallus white at margins and breaks in thallus; soralia usually paler than thallus, powdery to granular, coalescing to form diffuse, irregular patches. Apothecia frequent, 0.1–0.3 mm in diam, 3–8(–10) clustered, immersing in thalline sorediate patches; disc reddish-brown, rounded to irregularly, plane, usually with white pruina; exciple poorly developed. Epihymenium yellow-brown, up to 30 µm thick; hymenium colourless, up to 130 µm thick, hypothecium pale to light brown, up to 30 µm thick; paraphyses slender, simple; asci broadly clavate, 110–150 × 32–40 µm, 2-spored; ascospores hyaline, muriform, 42–78 × 30–42 µm; I–. Photobiont green, globose, 12–18 µm in diam.

CHEMISTRY — Cortex K+ yellow, C–; medulla K+ yellow-orange-red, C–, PD+ yellow. Constituent in 6 specimens tested: norstictic acid.

SUBSTRATE AND DISTRIBTUION —*Phlyctis subargena* is a corticolous species, found only in the type locality at present.

ADDITIONAL SPECIMENS EXAMINED —CHINA. **Gansu:** Longnan, Wenxian Co., Qiujiaba, alt. 2450m, on bark, 2/VIII/2007, F. Yang 20070024, 20070043, 20070045; alt. 2350m, on bark, 3/VIII/2007, F. Yang 20070080; alt. 2350m, on bark, 5/VIII/2007, F. Yang 20070381, 20070383-1(SDNU).

COMMENTS —The presence of norstictic acid, abundant soredia, and two spores per ascus distinguishes *Phlyctis subargena* from all other *Phlyctis* species. *Phlyctis agelaea* (Ach.) Flot., *P. chilensis* D.J. Galloway & Guzmán, *P. oleosa* Stirt., *P. speirea* G. Merr., *P. uncinata* Stirt. and *P. argena* (Ach.) Flot.

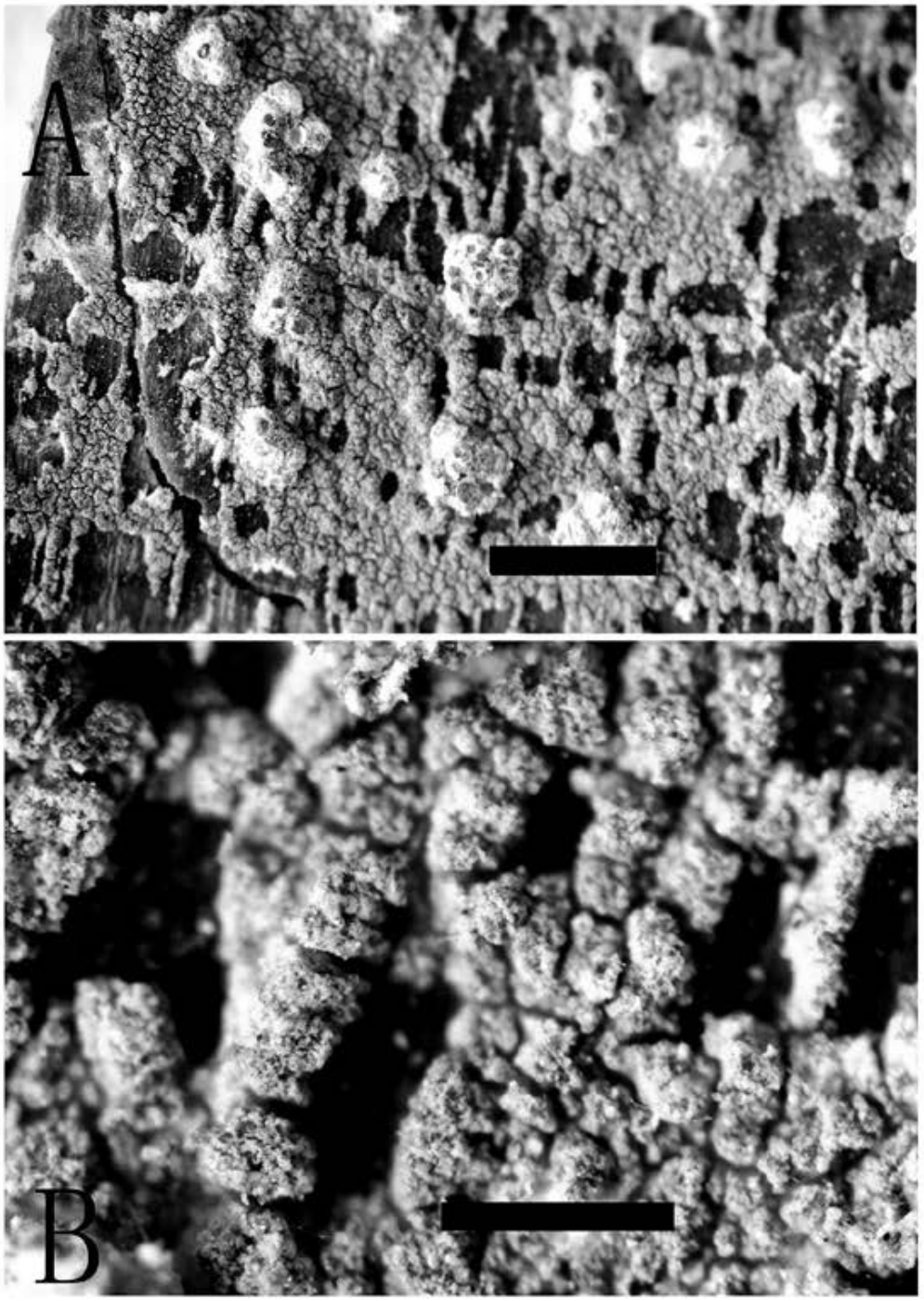


FIG. 1. *Phlyctis subargena* (holotype). A. Thallus (bar = 2 mm). B. Soralia (bar = 200 µm).

all contain norstictic acid. However, the former five are esorediate. Although *P. argena* is distinctly sorediate, *P. subargena* can be clearly separated from the former, which produces rare and solitary apothecia, only one spore per ascus, and larger spores (100–150 × 25–50 µm). In addition, *P. argena* also contains a trace of connorstictic acid, which is absent in *P. subargena*.

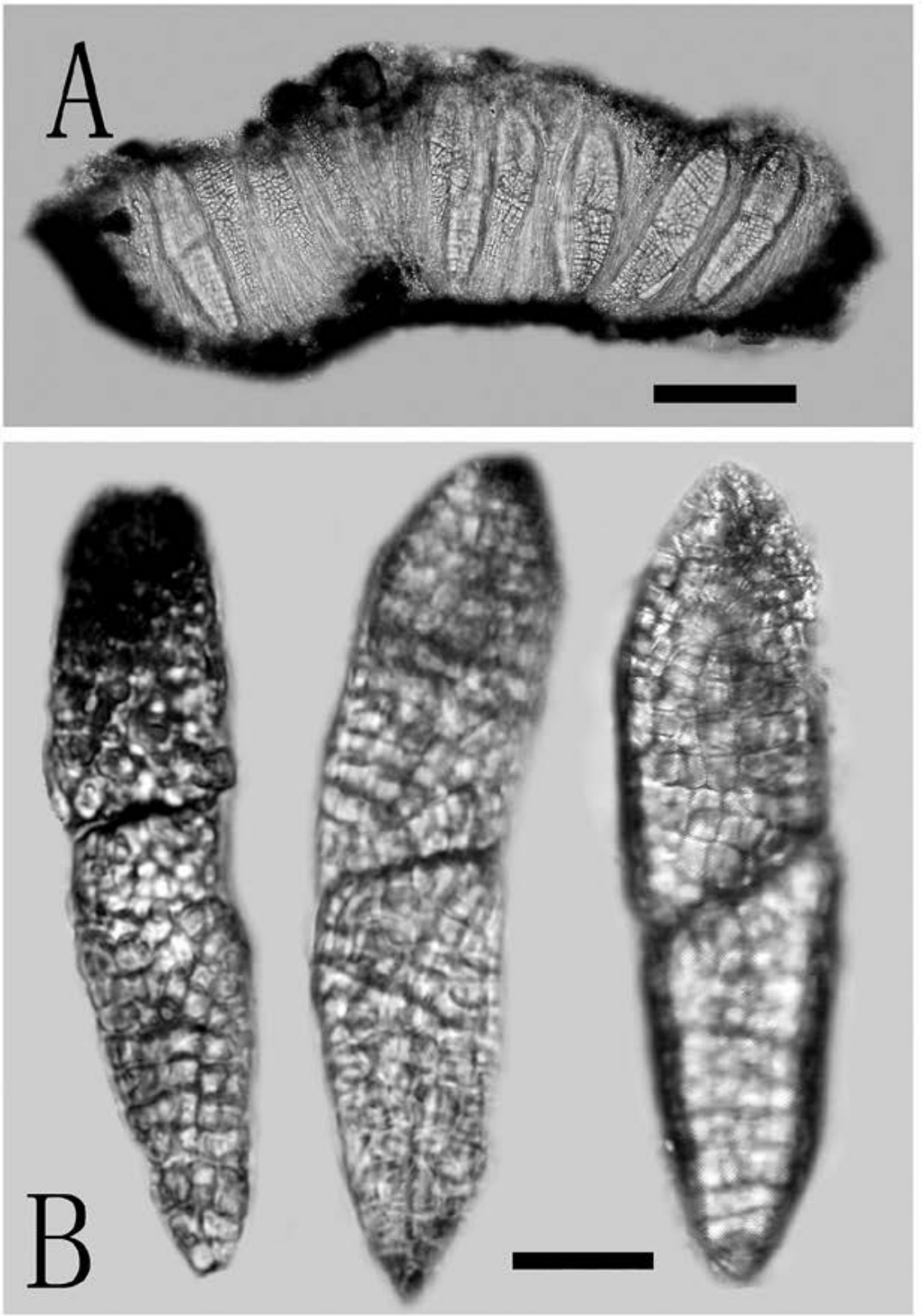


FIG. 1. *Phlyctis subargena* (holotype). A. Apothecium (bar = 50 µm). B. Ascospores, showing 2-spored ascus and muriform shape (bar = 20µm).

Phlyctis subuncinata Stirt., which is also sorediate, differs from *P. subargena* in its fusiform spores and chemistry (stictic and cryptostictic acid vs. norstictic acid).

Acknowledgements

The project was financially supported by the National Natural Science Foundation of China (31070010) and Natural Science Foundation of Shandong Province (Y2007D21). The authors would like to thank Prof. A. Aptroot (CBS, AD Utrecht, Netherlands) and Dr. Zhong-Shuai Sun (College of Life Sciences, Zhejiang University) for the assistance in the specimen identification. The authors thank Dr. Irwin M. Brodo (Research Division, Canadian Museum of Nature, Canada), Prof. Shou-Yu Guo (Key Laboratory of Systematic Mycology & Lichenology, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China) and Dr. Richard Harris (New York Botanical Garden, America) for presubmission reviews.

Literature cited

Brodo IM, Sharnoff DS, Sharnoff S. 2001. Lichens of North America. Yale University Press: New Haven and London. 795 pp.

Chen JB, Wu JN, Wei JC. 1989. Lichens. pp. 487–488, in: Fungi and Lichens of Shennongjia. World Publishing Corp., Beijing.

Culberson CF. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. Journal of Chromatography 72: 113–125. doi:10.1016/0021-9673(72)80013-X

Galloway DJ, Guzmán G. 1988. A new species of *Phlyctis* from Chile. Lichenologist 20: 393–399. doi:10.1017/S0024282988000507

Galloway DJ. 2007. *Phlyctis*. pp. 1184–1191, in: Flora of New Zealand. Lichens. 2nd ed., rev., including lichen-forming and lichenicolous Fungi. Vol. 2. Manaaki Whenua Press: Lincoln, New Zealand.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Dictionary of the fungi. 10th Edition. CABI Bioscience: CAB International. 771 pp.

Flotow J von. 1850. Lichenologische Beiträge zur Flora Europaea. Botanische Zeitung 8: 537–542, 553–559, 569–575

Miadlikowska J, Kauff F, Hofstetter V, Fraker E, Grube M, Hafellner J, Reeb V, Hodkinson BP, Kukwa M, Lücking R, Hestmark G, Otalora MG, Rauhut A, Büdel B, Scheidegger C, Timdal E, Stenroos S, Brodo IM, Perlmutter GB, Ertz D, Diederich P, Lendemer JC, May PF, Schoch C, Arnold AE, Gueidan C, Tripp E, Yahr R, Robertson C, Lutzoni F. 2006. New insights into classification and evolution of the *Lecanoromycetes* (*Pezizomycotina, Ascomycota*) from phylogenetic analyses of three ribosomal RNA- and two protein-coding genes. Mycologia 98: 1088–1103. doi:10.3852/mycologia.98.6.1088

Purvis OW, Coppins BJ, Hawksworth DL, James PW, Moore DM (eds). 1992. The lichen flora of Great Britain and Ireland. Natural History Museum Publications & British Lichen Society, London.

Tønsberg T. 2004. *Phlyctis*. pp. 415–416, in: Nash. TH III, Ryan BD, Diederich P, Gries C, Bungartz F (eds). Lichen flora of the Greater Sonoran Desert Region, Vol. 2. Lichens Unlimited: Arizona State University, Tempe, Arizona.

Wedin M, Wiklund E, Crewe A, Döring H, Ekman S, Nyberg Å, Schmitt I, Lumbsch HT. 2005. Phylogenetic relationships of *Lecanoromycetes* (*Ascomycota*) as revealed by analyses of mtSSU and nLSU rDNA sequence data. Mycological Research 109: 159–172. doi:10.1017/S0953756204002102

Wei JC. 1991. An enumeration of lichens in China. International Academic Publishers: Beijing. 278 pp.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.367

Volume 114, pp. 367–371 October–December 2010

Two new species of *Kylindria* from Fujian, China

YI-DONG ZHANG, JIAN MA, LI-GUO MA & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — Two new species of *Kylindria* were found during a survey of anamorphic fungi in tropical areas of Fujian province, China. The new species, *K. millettiae* and *K. embeliae*, occurred on the hosts *Millettia championii* and *Embelia rudis*, respectively. They are described, illustrated, and compared with closely related taxa. The type specimens are deposited in HSAUP (Herbarium of the Department of Plant Pathology, Shandong Agricultural University) and HMAS (Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences).

Key words —hyphomycetes, taxonomy

Introduction

The genus *Kylindria* was erected by DiCosmo et al. (1983) based on *Cylindrotrichum triseptatum* Matsush. (Matsushima 1975). In a revision of the species of *Cylindrotrichum* Bonord. and *Chaetopsis* Grev., five species were assigned to the new genus *Kylindria*. The distinguishing characters of *Kylindria* were considered to be the macronematous, mononematous, dark, conidiophores, the monophialidic, narrow conidiogenous cells, and aseptate or one to several septate, smooth, hyaline conidia usually with an eccentric protruding basal hilum (DiCosmo et al. 1983, Castañeda 1988). These characters separate the genus from similar genera such as *Cylindrotrichum*, *Xenokylindria* DiCosmo et al., and *Chaetopsis* (DiCosmo et al. 1983).

Up to now, the genus *Kylindria* contains 13 species, and no species have been reported from China. In our studies on hyphomycetes from deciduous stems and rotten wood in south of China, two previously undescribed species of *Kylindria* were found. They are proposed herein as new.

*Corresponding author

Taxonomy

Kylindria millettiae Y.D. Zhang & X.G. Zhang, **sp. nov.** FIG 1

MYCOBANK MB 518820

Coloniae effusae, brunneae, pilosae. Mycelium partim superficiale et partim immersum, ex hyphis ramosis, septatis, laevibus, pallide brunneis, 2.5–3 µm crassis compositum. Conidiophora macronematosa, mononematosa, nonramosa, erecta, recta vel flexuosa, laevia, atro-brunnea, apice versus pallidiora, 7–10-septata, 220–265 µm longa, 5.5–7.5 µm

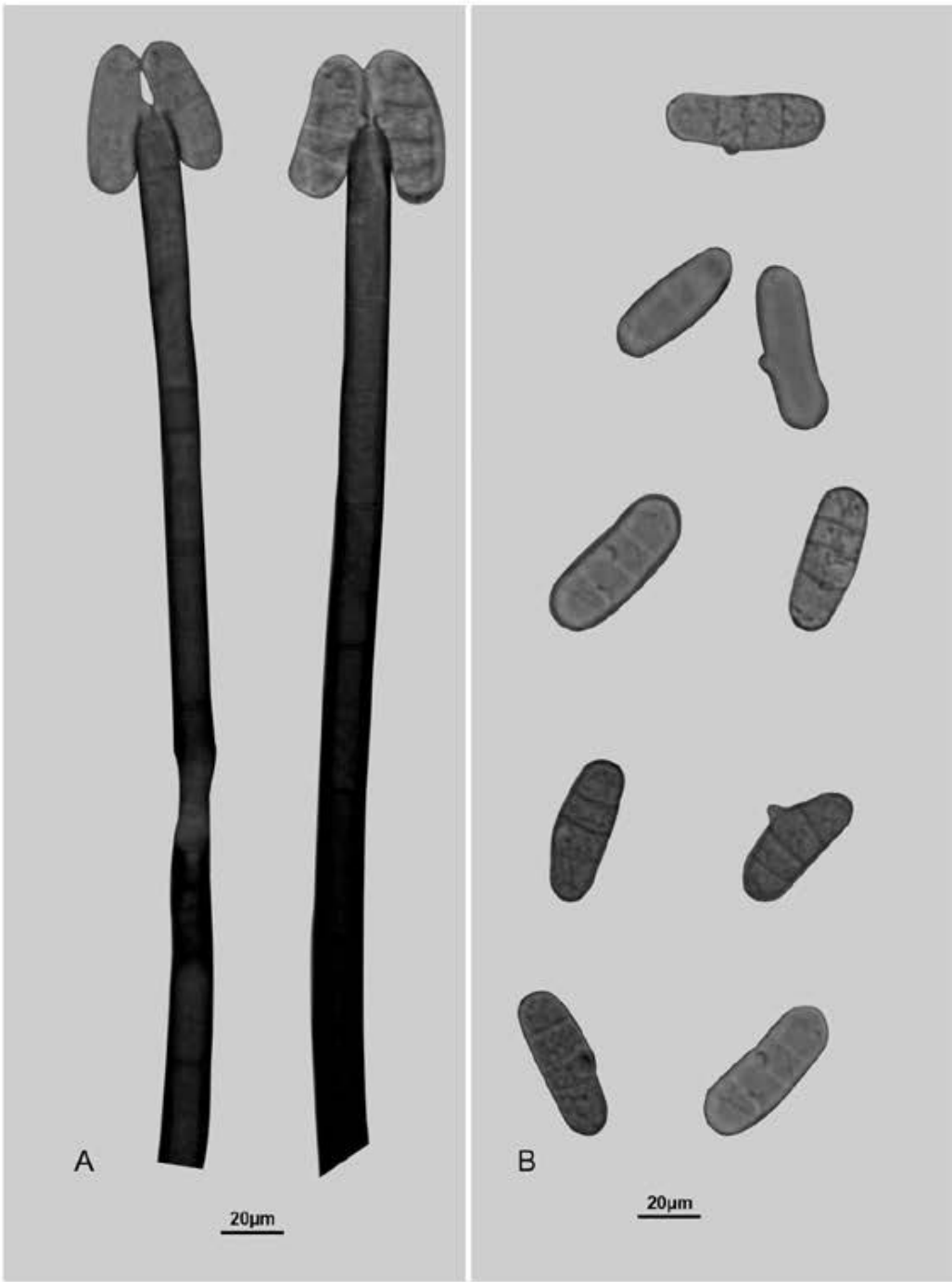


FIG. 1. *Kylindria millettiae* A. Conidiophores with conidia. B. Conidia.

crassa. Cellulae conidiogenae monophialidica, cylindrica vel leviter subulata, integratae, terminales, dilute brunnea, 10.5–17 µm longa, 4.5–5.5 µm crassa, apicem versus deminutae. Conidia solitaria, cylindrica, hyalina, laevia, 3-septata, in massis mucosis translucentibus formata, apicem obtusa, 19.5–24 µm longa, 6.5–9 µm crassa.

HOLOTYPE: on dead branches of *Millettia championii* Benth. (*Leguminosae*), forest park of Wuyishan, Fujian Province, China, 16 Aug. 2009, Y.D. Zhang, HSAUP H3023 (isotype HMAS 146114).

ETYMOLOGY: in reference to the host genus, *Millettia*.

Colonies effuse, brown, hairy. Mycelium partly superficial, partly immersed, composed of branched, septate, smooth-walled, pale brown hyphae, 2.5–3 µm thick. Conidiophores macronematous mononematous, unbranched, erect, straight or flexuous, smooth, dark brown, paler towards the apex, 7–10 septate, 220–265 µm long, 5.5–7.5 µm wide. Conidiogenous cells monophialidic, cylindrical or tapered, integrated, terminal, pale brown, 10.5–17 µm long, 4.5–5.5 µm wide, narrower at the apex. Conidia solitary, cylindrical, hyaline, smooth, 3-septate, accumulating in translucent slimy masses at the apices of conidiogenous cells, 19.5–24 µm long, 6.5–9 µm wide, obtuse at the apex, with an excentric, lateral, flat scar on the second cells from base.

The conidia of *K. millettiae* are morphologically similar to those of *K. excentrica* Bhat & B. Sutton (Bhat & Sutton 1985) in conidium morphology. However, the conidia of *K. millettiae* are smaller than those of *K. excentrica* (19.5–24 × 6.5–9 µm vs. 27.5–35 × 7.5–8.5 µm). In addition, most conidia of *K. millettiae* have an excentric lateral flat scar arising from the second cells close to base, whereas *K. excentrica* produces a lateral flat scar on the basal cells of the conidia.

Kylindria embeliae Y.D. Zhang & X.G. Zhang, **sp. nov.** FIG 2

MYCOBANK MB 518821

Coloniae effusae in substrato naturali, olivaceo-brunneae vel fuscae, pilosae. Mycelium partim superficiale et partim immersum, ex hyphis ramosis, septatis, pallide brunneis vel brunneis, laevibus, 1.5–2.5 µm crassis compositum. Conidiophora macronematosa, mononematosa, nonramosa, erecta, recta vel flexuosa, laevia, atro-brunnea, apice versus pallidiora, 5–7-septata, 130–150 µm longa, 5.5–6.5 µm crassa. Cellulae conidiogenae monophialidica, cylindrica, integratae, ad subapicem inflatae, 15–19.5 µm longa, 6.5–7.5 µm crassa, cum collaretto cupulato. Conidia solitaria, ellipsoidea vel cylindrica, hyalina, laevia, aseptata, 17.5–23 µm longa, 6–7.5 µm crassa, apice rotundata, ad basim truncata.

HOLOTYPE: on dead branches of *Embelia rudis* Hand.-Mazz. (*Myrsinaceae*), forest park of Wuyishan, Fujian Province, China, 15 Aug. 2009, Y.D. Zhang, HSAUP H3007 (isotype HMAS 146115).

ETYMOLOGY: in reference to the host genus, *Embelia*.

Colonies effuse on the natural substratum, olivaceous brown to blackish brown, hairy. Mycelium partly superficial and partly immersed composed of branched, septate, pale brown to brown, smooth-walled hyphae, 1.5–2.5 µm thick.

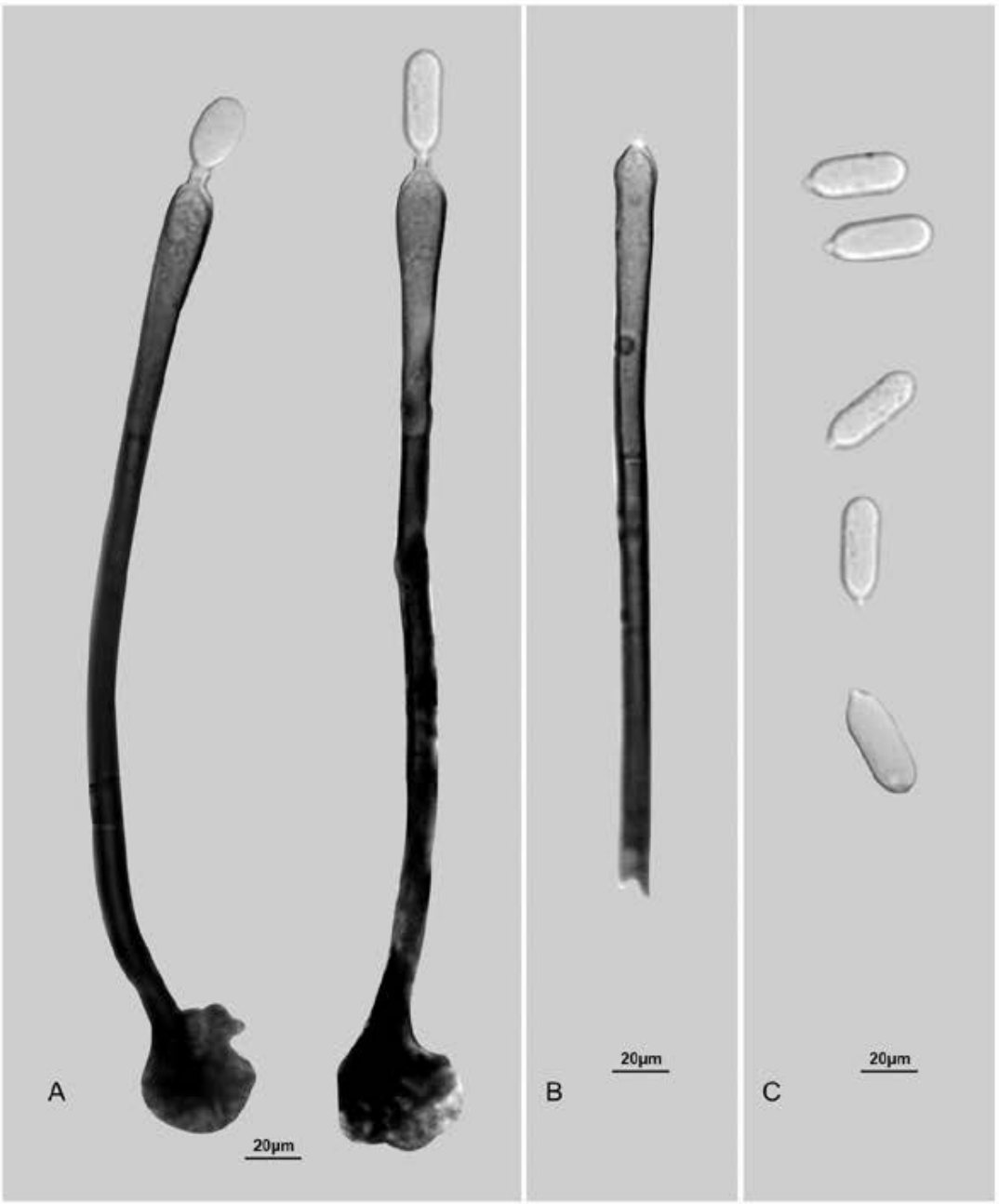


FIG. 2. *Kylindria embeliae* A. Conidiophores with conidia. B. Conidia.

Conidiophores macronematous, mononematous, unbranched, erect, straight or flexuous, smooth, dark brown, paler towards the apex, 5–7-septate, 130–150 μm long, 5.5–6.5 μm wide. Conidiogenous cells monophialidic, cylindrical, integrated, swollen at the subapical region, 15–19.5 μm long, 6.5–7.5 μm wide, occasionally with a collarette at the apex. Conidia solitary, ellipsoidal or cylindrical, hyaline, smooth, aseptate, 17.5–23 μm long, 6–7.5 μm wide, apex rounded, base truncate.

Four other described species of *Kylindria* have aseptate conidia — *K. conglutinata* Matsush. (Matsushima 1993), *K. obesispora* R.F. Castañeda

(Castañeda 1988), *K. keitae* Rambelli & Onofri (Rambelli & Onofri 1987), *K. peruamazonensis* Matsush. (Matsushima 1993), and *K. zignoellae* (Höhn.) DiCosmo et al. (DiCosmo et al. 1983). The conidia of *K. embeliae* are larger than those of *K. keitae* (17.5–23 × 6–7.5 µm vs. 12.5–16.5 × 4.5–5.5 µm). In addition, the conidiogenous cells of *K. embeliae* become swollen at the subapical region and occasionally possess a collarette.

Acknowledgments

The authors are grateful to Dr Eric H.C. McKenzie and Dr R.F. Castañeda Ruiz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (No. 30770015, 30499340, 2006FY120100).

Literature cited

Bhat DJ, Sutton BC. 1985. Some 'phialidic' hyphomycetes from Ethiopia. Transactions of the British Mycological Society 84: 723–730. doi:10.1016/S0007-1536(85)80130-3

Castañeda Ruíz RF. 1988. Fungi Cubenses III. Instituto de Investigaciones Fundamentales en Agricultura Tropical. Alejandro de Humboldt.

DiCosmo F, Berch SM, Kendrick B. 1983. *Cylindrotrichum*, *Chaetopsis*, and two new genera of hyphomycetes, *Kylindria* and *Xenokylindria*. Mycologia 75: 949–973. doi:10.2307/3792651

Matsushima T. 1975. Icones Fungorum a Matsushima Lectorum. Kobe, Japan: Published by author.

Matsushima T. 1993. Matsushima Mycological Memoirs No. 7. Kobe, Japan: Published by author.

Rambelli A, Onofri S. 1987. New species of *Kylindria* and *Xenokylindria* and notes on *Cylindrotrichum* (hyphomycetes). Transactions of the British Mycological Society 88: 393–397. doi:10.1016/S0007-1536(87)80012-8

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.373

Volume 114, pp. 373–376 *October–December 2010*

A new species of *Minimelanolocus* from Fujian, China

YI-DONG ZHANG, JIAN MA, LI-GUO MA & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — *Minimelanolocus chimonanthi* sp. nov. is described and illustrated occurring on dead branches of *Chimonanthus nitens*. The specimen was collected from tropical forests in Fujian Province of China. The type specimen is deposited in HSAUP (Herbarium of the Department of Plant Pathology, Shandong Agricultural University) with an isotype in HMAS (Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences).

Key words —anamorphic fungi, taxonomy

Introduction

Castañeda & Heredia established the genus *Minimelanolocus* based on 12 previously described species of *Pseudospiropes* M.B. Ellis, *Helminthosporium* Link, and *Belemnospora* P.M. Kirk with *M. navicularis* (R.F. Castañeda) R.F. Castañeda as the type species. The generic characteristics of *Minimelanolocus* include macronematous, mononematous, dark conidiophores, holoblastic, polyblastic, indeterminate, terminal becoming intercalary, integrated conidiogenous cells with holoblastic sympodial extensions and inconspicuous or slightly prominent, narrow, opaque, refractive to somewhat obscure dehiscence scars, and euseptate conidia; conidial secession is schizolytic (Castañeda et al. 2001).

To date, of the 18 taxa of *Minimelanolocus* accepted worldwide, most are saprobes on rotten leaves or dead twigs, dead wood, and bark. Five species (*M. endospermi*, *M. pterocarpi*, *M. magnoliae*, *M. machili*, *M. camelliae*) have been reported from China (Ma et al. 2008, Zhang et al. 2009). A survey of the saprobic fungi on dead wood from tropical forest in Fujian Province of China has revealed a previously undescribed species of *Minimelanolocus*. It is proposed herein as new.

*Corresponding author

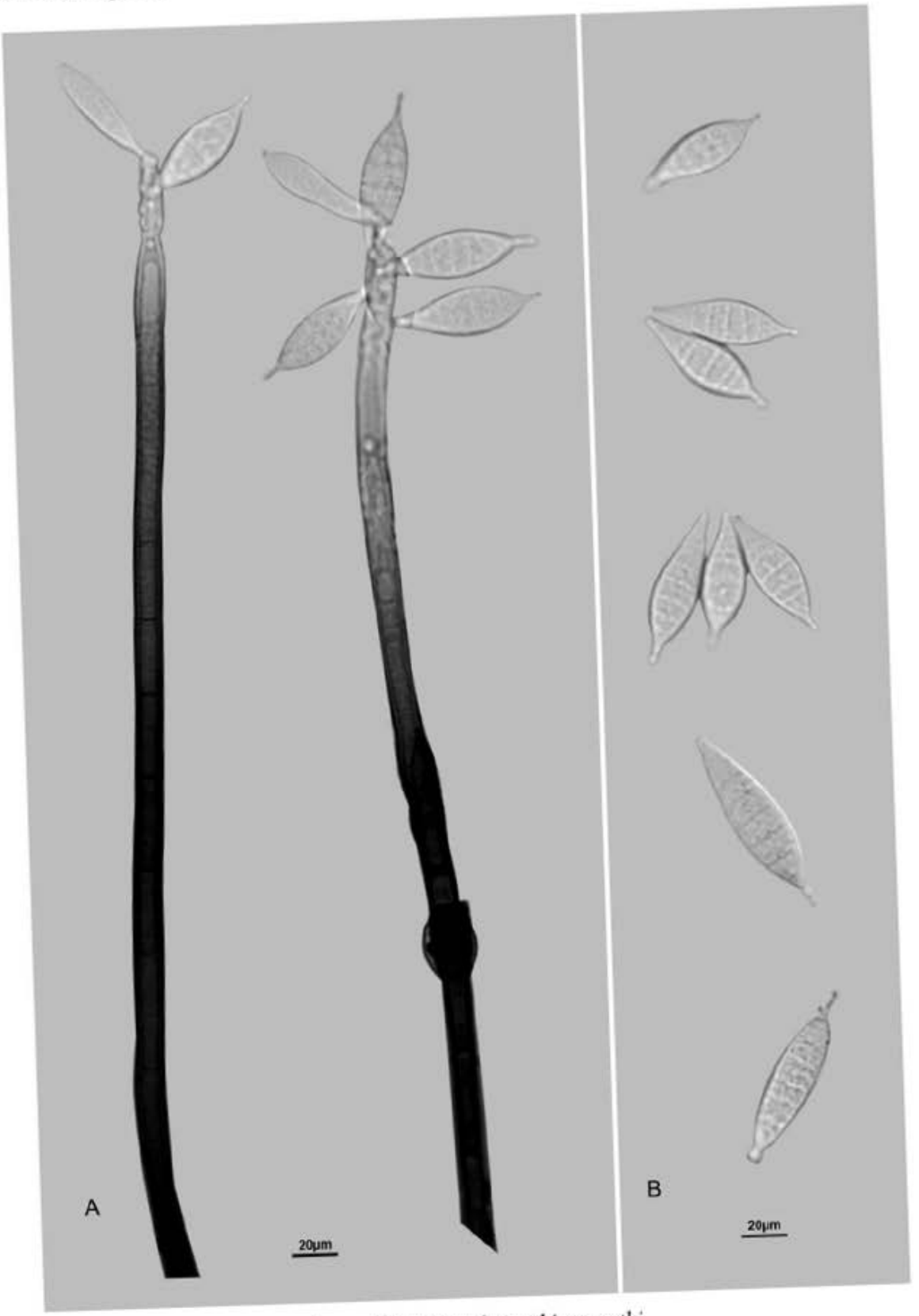


FIG. 1. *Minimelanolocus chimonanthi*
A. Conidiophores conidiogenous cells with conidia. B. Conidia.

Taxonomy

Minimelanolocus chimonanthi Y.D. Zhang & X.G. Zhang, **sp. nov.** FIG 1

MycoBank MB 518829

Coloniae effusae in substrato naturali, brunneae, pilosae. Mycelium partim superficiale et partim immersum, ex hyphis ramosis, septatis, pallide brunneis, laevibus, 2–3 µm crassis compositum. Conidiophora macronematosa, mononematosa, solitaria, nonramosa, erecta, recta vel flexuosa, laevia, atro-brunnea, apice versus pallidiora, 5–10-septata, 160–250 µm longa, 6.5–10.5 µm crassa, circa apicem 5.5–6.5 µm crassa. Cellulae conidiogenae holoblasticae, polyblasticae, in conidiophoris incorporatae, indeterminatae, sympodialiter extendentes, terminales deinde intercalares, pallide brunneae. Loci conidiogeno inconspicuo vel leviter prominentibus, subobscuro. Conidia late fusiformia, breviter rostrata ad apicem, hyalina, solitaria, acropleurogena, simplicia, brunneae, laevia, 5-7-euseptata, 26–35 µm longa, 6.5–10 µm crassa. Conidiorum secessio schizolytica.

Holotype: on dead branches of *Chimonanthus nitens* Oliv. (*Calycanthaceae*), forest park of Wuyishan, Fujian Province, China, 16 Aug. 2009, Y.D. Zhang, HSAUP H3002 (isotype HMAS 146111).

Etymology: in reference to the host genus, *Chimonanthus*.

Colonies effuse on natural substratum, brown, hairy. Mycelium partly superficial, partly immersed, composed of branched, septate, pale brown, smooth-walled hyphae, 2–3 µm thick. Conidiophores macronematous, mononematous, unbranched, erect, straight or flexuous, smooth, dark brown, paler towards the apex, 5–10-septate, 160–250 µm long, 6.5–10.5 µm thick, near the apex 5.5–6.5 µm thick. Conidiogenous cells polyblastic, integrated, indeterminate, sympodial, terminal becoming intercalary, pale brown. Conidiogenous loci inconspicuous or slightly prominent. Conidia broadly fusiform, shortly rostrate at the apex, hyaline, solitary, acropleurogenous, simple, brown, smooth-walled, 5–7-euseptate, 26–35 µm long, 6.5–10 µm thick in the broadest part. Conidial secession schizolytic.

The conidia of *M. chimonanthi* are similar to those of *M. navicularis* (Castañeda et al. 2001). However, the conidia of *M. chimonanthi* are hyaline and larger than those of *M. navicularis* (26–35 × 6.5–10 µm vs. 20–25 × 6–8 µm). In addition, the conidia of *M. chimonanthi* are 5–7 septate while those of *M. navicularis* are only 3 septate.

Acknowledgments

The authors are grateful to Dr Eric H.C. McKenzie and Dr R.F. Castañeda Ruiz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (No. 30770015, 30499340, 2006FY120100).

Literature cited

Castañeda Ruíz RF, Heredia G, Reyes M, Arias RM, Decock C. 2001. A revision of the genus *Pseudospiropes* and some new taxa. Cryptogamie Mycologie 22: 3–18. doi:10.1016/S0181-1584(01)01057-0

Ma J, Zhang K, Zhang XG. 2008. Two new species of the genus *Minimelanolocus* in China. Mycotaxon 104: 147–151.

Zhang K, Fu HB, Zhang XG. 2009. Taxonomic studies of *Minimelanolocus* from Yunnan, China. Mycotaxon 109: 95–101.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.377

Volume 114, pp. 377–393 *October–December 2010*

Austro-American lignocellulolytic basidiomycetes (*Agaricomycotina*): new records

MARISA DE CAMPOS-SANTANA & CLARICE LOGUERCIO-LEITE

marisacampossantana@gmail.com
Universidade Federal de Santa Catarina, Laboratório de Micologia
BOT/CCB/UFSC, 88090400, Florianópolis, SC, Brazil

Abstract — A survey of lignolytic basidiomycetes from Mondaí (27°06'16"S, 53°24'07"W) in the Brazilian state of Santa Catarina has revealed nine previously unrecorded species: *Dacryopinax elegans, Cotylidia aurantiaca, Hymenochaete rubiginosa, Inonotus rickii, Phellinus rhytiphloeus, Echinoporia aculeifera, Oxyporus obducens, Amauroderma sprucei,* and *Pseudofavolus miquelii*. Comments about the species and illustrations are provided.

Key words — mycodiversity, *Agaricomycetes, Dacrymycetes*

Introduction

Among the estimated 1.5 million fungal species, only 74,000 to 120,000 species have been described. With limited human and financial resources, a total inventory is not possible within any reasonable time frame, which is estimated to be 1290 years at the current rate (Garibay-Orijel et al. 2009). Within the field of mycology, there are numerous studies about the diversity of macrofungi. However, Gilbert & Souza (2002) and Piepenbring (2007) point out that a significant portion of the fungal taxa from tropical forests has not yet been described.

In the southern region of coastal South America, the Atlantic Forest is broadly defined and includes not only coastal rain forests but also inland forests and coastal seasonal forests, which are mostly semi-deciduous and mixed *Araucaria* forests (Fernandes & Bezerra 1990).

Knowledge about the abundance of lignolytic basidiomycetes in all forest types, as well as the fact that they are the largely responsible for decaying wood in most ecosystems, is well established. However, fundamental questions, such as how many species are from a specific region or whether fungal diversity is greater in one forest type versus another, remain unanswered due to taxonomic

issues and the deficiency of long-term studies in many regions (Groposo et al. 2005). There is a common belief that some wood-decaying basidiomycetes generally have low host- and habitat-specificity, and this assumption somewhat complicates evaluation of the ecological specialization and species distribution based on past studies (Gilbert et al. 2008).

Regardless of its biological richness, the Atlantic Forest is probably one of the most highly threatened tropical forests in the world (Jarenkow & Budke 2009). In the past, commercial exploitation of this area has led to deforestation. Currently the Atlantic forest is extremely fragmented and many endemic species are endangered (Metzger 2009).

In the state of Santa Catarina, several studies have been published that include data about collections from the Atlantic Forest of Santa Catarina Island. However, in other areas of the state little is known about their mycodiversity. The work presented here — a result of the first extensive survey carried out in the deciduous seasonal forest of Santa Catarina — aims to expand the knowledge about the region's mycodiversity. It is also part of a current taxonomic and biogeographical survey of wood-inhabiting basidiomycetes in this state. Additional collections made during this survey from the municipality of Mondaí (from deciduous seasonal forest) resulted in several previously unrecorded species of *Agaricomycotina*, which are briefly discussed below.

Material and methods

The municipality of Mondaí is located in the extreme western part of the state of Santa Catarina (27°06'16"S, 53°24'07"W), in Southern Brazil. Collections were made periodically between December 2005 and May 2007 at two locations (Linha Uruguai and Linha Sanga Forte) in Mondaí.

Macro- and microscopic data of the specimens were collected following traditional methodology (Singer 1975, Ryvarden 1991). Measurements were made from slide preparations stained with 1% phloxine solution + 1% or 5% KOH solution. Melzer's reagent was used to detect the presence of amyloid or dextrinoid reactions on the cell walls. Collections were identified by consulting literature and specimens in the following herbaria: BAFC, FLOR, ICN, NYBG, SP, URM (Holmgren & Holmgren 2009). Voucher specimens are stored at FLOR. Taxonomic arrangement follows Kirk et al. (2008).

Taxonomy

Dacryopinax elegans (Berk. & M.A. Curtis) G.W. Martin, Lloydia 11(2): 116. 1948. FIG. 1

≡ *Guepinia elegans* Berk. & M.A. Curtis, Hook. J. Bot. Kew Gdn Misc. 1: 239. 1849.

DESCRIPTION: McNabb (1965).

VOUCHER MATERIAL: BRAZIL. Santa Catarina: Mondaí, Linha Sanga Forte, Campos-Santana & Santana 302, 25/V/07 (FLOR 32214).

FIG. 1. *Dacryopinax elegans*. Scale =10 μm.
A. Septate hairs. B. Generative hyphae. C. Dendrohyphidium. D. Hymenium. E. Basidiospores.

COMMENTS: The species is recognized by its stipitate basidiomata, solitary or in groups; pileus spathulate, flabelliform, initially cupulate or obliquely cupulate;

consistency gelatinous or cartilaginous. Microscopically it is characterized by the presence of a cortex, medulla, and hymenium; cortex and stipe present cylindrical, tortuous, thin or thick walled, tinted brown septate hairs. The cylindrical-subclavate basidia with basal septa, become bifurcate and the basidiospores are cylindrical, thick-walled with thick septa, yellowish brown, apiculate, becoming 3-septate at maturity are characteristic. As noted by McNabb (1965), *D. elegans* is distinguished as the only *Dacryopinax* species with thick-walled hyphae and tri-septate basidiospores. In our collection, the basidiospores (12–14(–15) × 5–6(–6.5) µm) are similar to those observed by McNabb (1965; (12–)14–15.5 × 5–6.5 µm) and Fonseca et al. (2002; 13.6–15.6(–16) × 5.6–6.4 µm). However, López & Garcia (2001) cite slightly larger basidiospores ((13–)14–16(–19) × 5.6–6.04 µm).

ADDITIONAL MATERIAL: ARGENTINA, Bs. As., Llava Ilol, Sta. Cat. Inst. Fitotéc., R.T.Guerrero, 18/IV/1963 (BAFC 23086); ibid, Sgo. del Estero, Depto Choya, el Salvador, R.E.dela Sota (Det. R.T. Guerrero), 20/V/1961 (BAFC 23097).

DISTRIBUTION: Brazil (Espírito Santo, Amazonas, Rio Grande do Sul, Rio de Janeiro, Roraima), Colombia, Costa Rica, Dominican Republic, Guiana, Jamaica, Mexico, Panama, Puerto Rico, Trinidad & Tobago, Venezuela (McNabb 1965, Fonseca et al. 2002, Roberts 1996, Sobestiansky 2005).

Cotylidia aurantiaca (Pers.) A.L. Welden, Lloydia 21: 40, 1958. FIG. 2

= *Thelephora aurantiaca* Pers., Voy. Uranie, Bot. 5: 176, 1827.

DESCRIPTION: Reid (1965)

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Uruguai, Campos-Santana & Santana 205, 23/V/2007 (FLOR 32308); ibid, Linha Sanga Forte, Campos-Santana & Santana 262, 25/V/2007 (FLOR 32309).

COMMENTS: *Cotylidia aurantiaca*, which is one of the most common species collected in the tropical America (Reid 1965), exhibits a wide morphological variation, commonly spathulate, ligulate, flabellate or reniform, pseudo-infundibuliform or infundibuliform. This species is characterized by a bright yellow fresh hymenial surface that discolors to creamy-ochre when dry, basidiospores that are thin-walled, hyaline, elliptical, a monomitic hyphal system, and variably shaped cystidia, some of which develop 1–3 transverse septa and frequently constrict somewhat at these points. In our collection, the basidiospores (6–9 × (2.5–)4.5(–5) µm) are similar to those observed by Reid (1965; (5.5–)6–8.75(–9) × 3–3.75(–4) µm) and in one collection from Argentina (BAFC 24989: 7–9 × 2.5–4 µm).

ADDITIONAL MATERIAL: ARGENTINA, Misiones, Colônia Belgrano, monte al SE próximo de la Estación Forestal, Wright, Deschamps & Del Busto, M-2455, 29/X/1973 (BAFC 24989).

DISTRIBUTION: Brazil (Rio de Janeiro, Amazonas, Rio Grande do Sul), Argentina, Costa Rica, Colombia, China, Equador, Paraguay, Santo Domingo, Trinidad (Dai et al. 2004, Reid 1965).

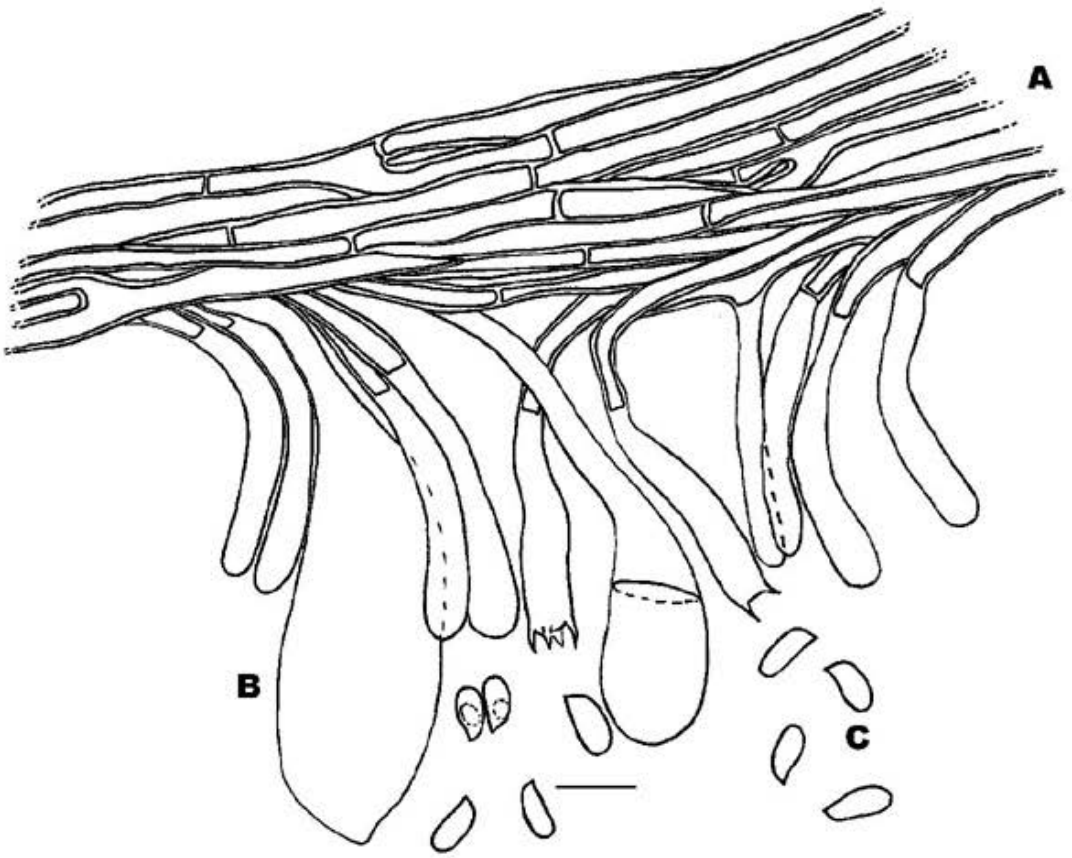


FIG. 2. *Cotylidia aurantiaca* hymenium. Scale =10 μm.
A. Generative hyphae. B. Cystidia. C. Basidiospores.

Hymenochaete rubiginosa (Dicks.) Lév., Ann. Sci. Nat. Bot., 3e Sér., 5: 151, 1846. FIG. 3

■ *Helvella rubiginosa* Dicks. Fasc. Pl. Crypt. Brit.1: 20, 1785.

DESCRIPTION: Job (1985)

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Sanga Forte, Campos-Santana, Santana & Rodrigues-Souza 10, 03/I/06 (FLOR 32215).

COMMENTS: The examined material is typical for this species. Basidiospore measurements (3–6 × 2–2.5 μm) were close to those recorded by Parmasto (2001; (3.5–)3.8–5.5 × (1.8–)2–2.8(–3) μm), and slightly smaller than those reported by Cunningham (1956; 5.5–7 × 3.5–4 μm). This species is easily recognized in the field by its rigid reflexed margin, dark brown upper surface, and light yellowish brown to yellow hymenophore. Chamuris (1988) and Cunningham (1956) point out that these features distinguish *H. rubiginosa* from *H. tabacina* (Sowerby) Lév., which has a reflex flexible region, orange-brown upper surface, and pale hymenophore. Job (1985) observed that *H. rubiginosa* is one of the few species of the genus with a cosmopolitan distribution.

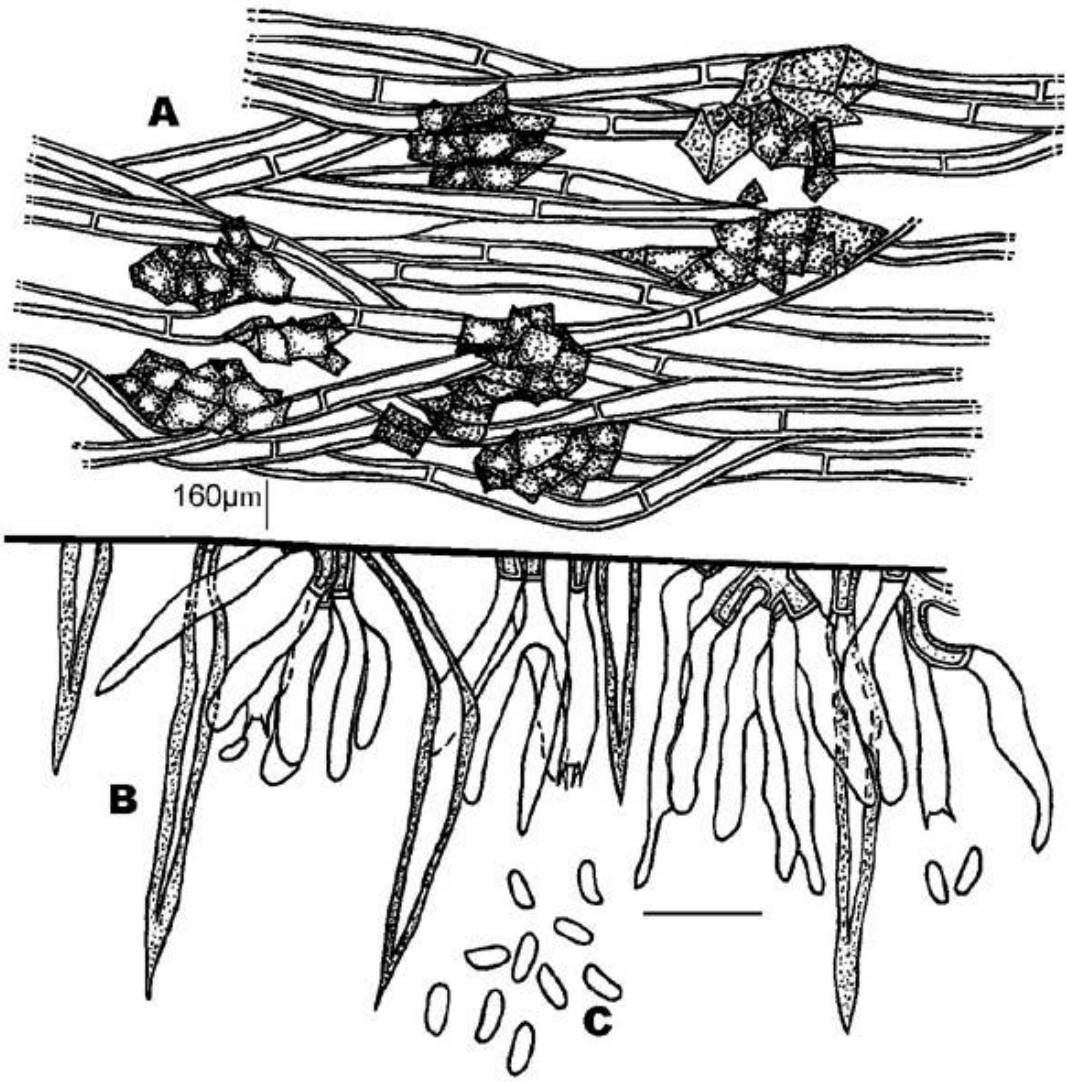


FIG. 3. *Hymenochaete rubiginosa*. Scale =10 µm.
A. Context generative hyphae. B. Setae. C. Basidiospores.

ADDITIONAL MATERIAL: BRAZIL, São Paulo: Santo André, Reserva Biológica do Alto da Serra de Paranapiacaba, Trufem SB & Grandi RAP, 09/VIII/88 (SP 307428).

DISTRIBUTION: Cosmopolitan; Brazil (Rio Grande do Sul and São Paulo), Europe, North America, New Zealand, Norway, Central America and Argentina (Cunningham 1963, Fonsêca 1999, Job 1985, Reeves & Welden 1967, Ryvarden 1971).

Inonotus rickii (Pat.) D.A. Reid, Kew Bull. 12: 141, 1957. FIG. 4

≡ *Xanthochrous rickii* Pat., Bull. Soc. Mycol. France 24(1): 6, 1908.

DESCRIPTION: Ryvarden (2005).

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Sanga Forte, Campos-Santana & Santana 288, 25/V/07 (FLOR 32216).

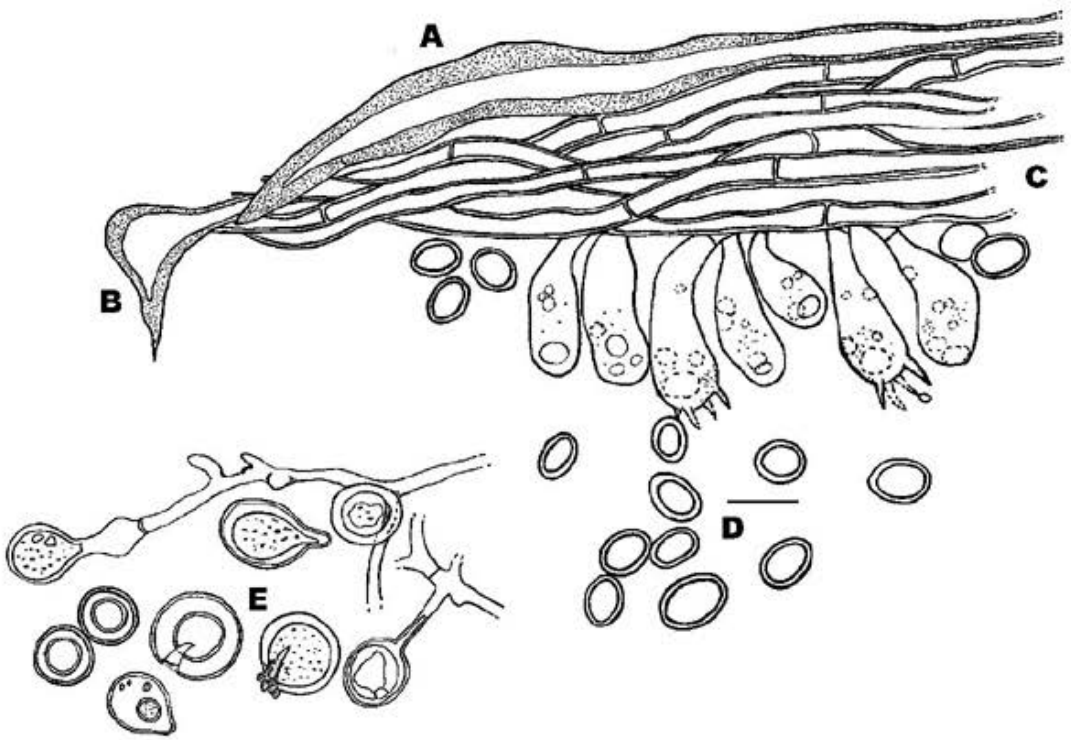


FIG. 4. *Inonotus rickii*. Scale =10 µm.
A. Setal hyphae. B. Hymenial setae. C. Generative hyphae.
D. Basidiospores. E. Chlamydospores.

COMMENTS: Some authors, such as Coelho (1994), Melo et al. (2002), and Ryvarden (2005) described setal hyphae that ranged from 250 × 17.94 µm. Although these measurements are similar to those in the Mondaí specimens, the longer hyphal setae found in the context — 400(–500) × 9–20(–22) µm) — agrees with the sizes cited reported by Intini & Tello (2003). Basidiospore size in our specimens (6–8 × 4–7 µm) is similar to that reported by Coelho (1994; 6.55–8.95 × 5.7–6.2 µm) but larger than those reported by Melo et al. (2002) and Gilbertson & Ryvarden (1986; 6–8.5(–9) × 4.5–5.5 µm). Abundant chlamydospores (8–18 × 8–17 µm) were found in the context, as observed by Melo et al. (2002).

ADDITIONAL MATERIAL: BRAZIL, Rio Grande do Sul: Porto Alegre, Ponta Grossa, Eny C.Vianna, IV/93 (ICN 97681); ibid, Parque da Redenção, R.T. Guerrero, I/90 (ICN 97594); ibid, Santa Maria, Itaara, Parque Pinhal, G. Coelho 24-13, 07/VI/1992 (ICN 97677); ibid, Caturrita, S. Aldorindo, G. Coelho 20-06, 1992 (ICN 97676).

DISTRIBUTION: Pantropical—North America, Central America, South America (Brazil in Rio Grande do Sul, Argentina), (Coelho 1994, Robledo & Rajchenberg 2007).

Phellinus rhytiphloeus (Mont.) Ryvarden, Prelim. Polyp. Fl. E. Africa: 206, 1980. FIG. 5

= *Polyporus rhytiphloeus* Mont., Ann. Sci. Nat., Bot., 4e Sér., 5: 369, 1857.

DESCRIPTION: Ryvarden & Johansen (1980).

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Uruguai, Campos-Santana, Santana & Zanella 77, 15/VI/2006 (FLOR 32218); ibid, Campos-Santana & Santana 257, 290, 25/V/07 (FLOR 32219, FLOR 32220).

COMMENTS: Our specimens show 7–9 pores per mm and basidiospores measuring 4–5(–5.5) µm in diameter, as previously reported by Ryvarden & Johansen (1980). Globose, golden to rusty brown basidiospores and absence of setae are characteristic. As observed by Gibertoni (2004), basidiospore size and color and basdioma morphology distinguish *P. rhytiphloeus* from the other *Phellinus* species that lack setae. In their original description, Ryvarden & Johansen (1980) noted that the absence of setae differentiates *P. rhytiphloeus*

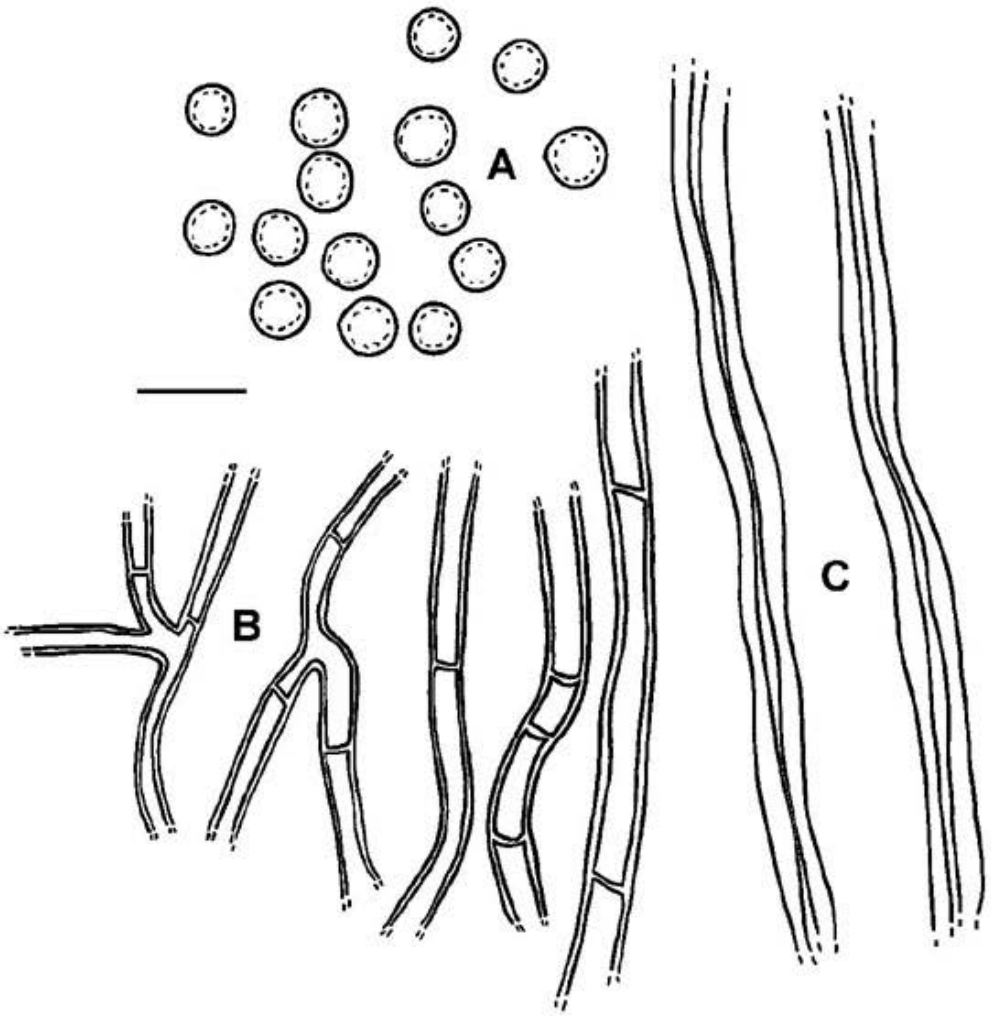


FIG. 5. *Phellinus rhytiphloeus*. Scale =10 µm.
A. Basidiospores. B. Generative hyphae. C. Skeletal hyphae.

from *Phellinus rhabarbarinus* (Berk.) G. Cunn. (Gerber & Loguercio-Leite 1997). Our examinations of *P. rhabarbarinus* specimens (FLOR 10.922; FLOR 10.929) confirm this and also show that the size (3–4 × 2–2.5 µm) of the hyaline ellipsoid basidiospores is another character that differentiates these species.

Additional material: BRAZIL, Rio Grande do Norte: Baía Formosa, RPPN Senador Antônio Faria-Mata Estrela, Gibertoni, V/20002 (URM 77794); ibid, Santa Catarina: Florianópolis, Morro da Lagoa da Conceição, Furlani & Loguercio-Leite, 186, 26/XII/1988 (FLOR 10929); ibid, Gerber & Cabral, 318, 12/XI/1993 (FLOR 10922); ibid, Willerding, A. & Santos, B., 420, 02/IV/94 (FLOR 10920); ibid, Santo Amaro da Imperatriz, Atanazio, J. & Willerding, A., 450, 20/V/1994 (FLOR 10928); ibid, Palhoça, Parque Estadual Serra do Tabuleiro-Cambirela, Groposo & Andrade, 176, 18/VII/2001 (FLOR 11957).

Distribution: Neotropical; Brazil (Rio Grande do Norte), Jamaica, Surinam, Mexico and Venezuela (Gibertoni & Cavalcanti 2003, Ryvarden & Guzmán 1993, Ryvarden & Iturriaga 2001).

Echinoporia aculeifera (Berk. & M.A. Curtis) Ryvarden, Mycotaxon 20(2): 330, 1984. Fig. 6

≡ *Trametes aculeifera* Berk. & M.A. Curtis, J. Linn. Soc., Bot. 10: 319, 1868.

Description: Silveira & Guerrero (1991).

Voucher material: BRAZIL, Santa Catarina: Mondaí, Linha Uruguai, Campos-Santana & Santana 244, 23/V/07 (FLOR 32222).

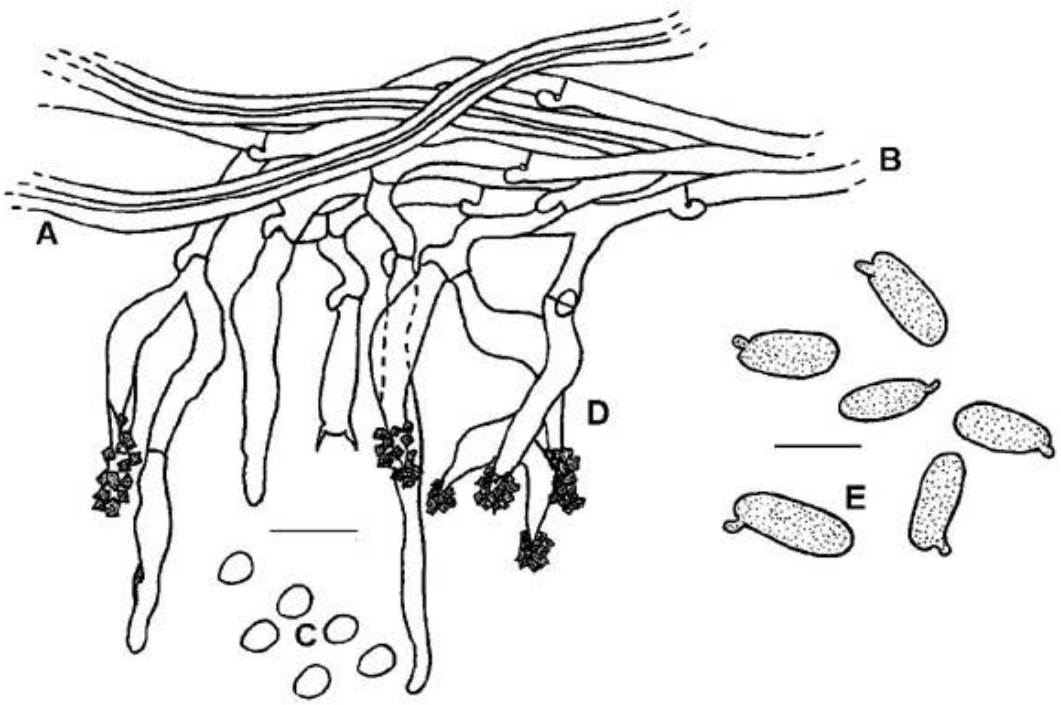


Fig. 6. *Echinoporia aculeifera*. Scale =10 µm.
A. Skeletal hyphae. B. Generative hyphae. C. Basidiospores.
D. Cystidia. E. Conidiospores.

COMMENTS: The species is easily recognized in the field by the dense cover of long yellowish-orange to red hairs (hydnoid processes) and irregular pores. *Echinoporia aculeifera* produces abundant conidiospores, absent in other polypores, as pointed out by Gilbertson & Ryvarden (1986). Wright (1983) reported rare cystidia with a crystal crown (11.3–21.7 × 4.1–5.2 µm). Our collection had abundant cystidia and incrusted hyphal terminations. The basidiospore size (5–7 × 3–4 µm) agrees with that cited by Silveira & Guerrero (1991). However, Gilbertson & Ryvarden (1986) noted smaller basidiospores (4–5 × 3–3.5 µm).

ADDITIONAL MATERIAL: ARGENTINA, Misiones, Cataratas del Iguazú, Singer & Digilio, M-132, 27/XI/49 (BAFC 27280); ibid, Parque Nacional Iguazú, plaza cerca Salto Dos Hermanos, J.E. Wright, M-3028, 28/IX/79 (BAFC 24462).

DISTRIBUTION: Neotropical; Brazil (Bahia, Rio Grande do Sul Paraná and São Paulo), North American, Central America and South America (Fonsêca 1999, Gilbertson & Ryvarden 1986, Góes-Neto 1999, Popoff & Wright 1998, Rajchenberg & Meijer 1990, Silveira & Guerrero 1991).

Oxyporus obducens (Pers.) Donk, Med. Bot. Mus. Univ. Utrecht 9: 202, 1933. FIG. 7
= *Polyporus obducens* Pers., Mycol. Eur. 2: 104, 1825.

DESCRIPTION: Núñez & Ryvarden (2001).

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Uruguai, Campos-Santana & Santana 213, 23/V/07 (FLOR 32223).

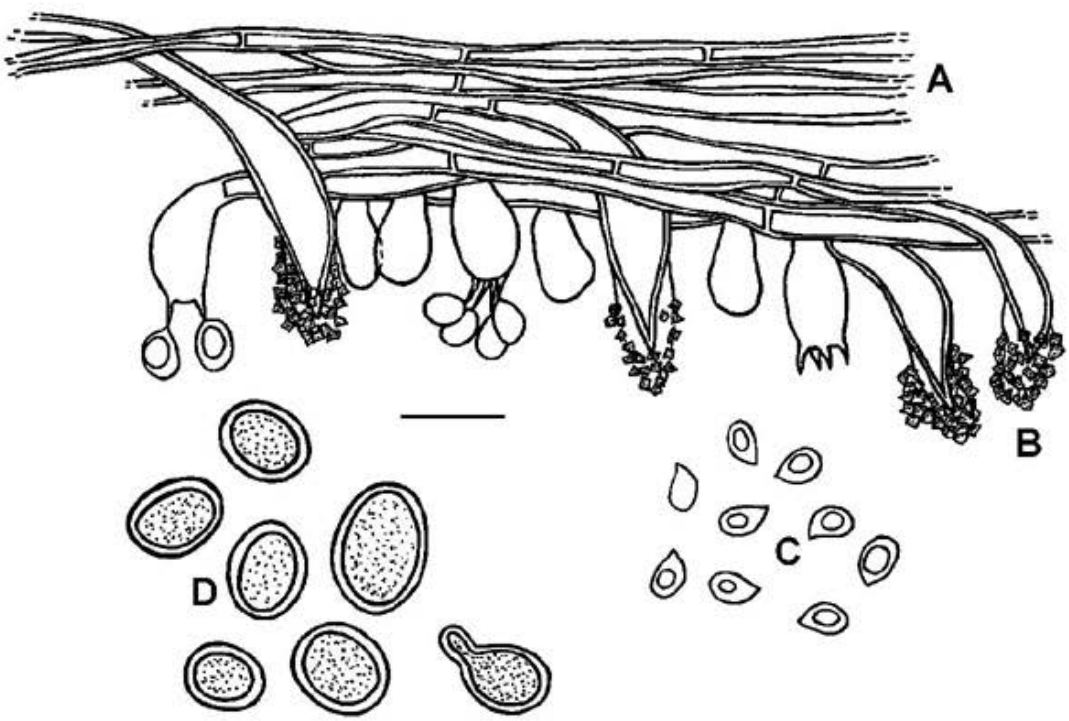


FIG. 7. *Oxyporus obducens*. Scale =10 µm.
A. Generative hyphae. B. Cystidia. C. Basidiospores. D. Chlamydospores.

COMMENTS: The specimen studied differs from other resupinate *Oxyporus* species by the number of pores (4–6 per mm), basidiospore size (3–5(–6) × 3–4 µm), and the presence of chlamydospores. There are few discrepancies between our observations and the literature. Our collection agrees with Núñez & Ryvarden (2001), who recorded similarly sized cystidia (25–55 × 7–8 µm) and basidiospores (4–5 × 2.5–3.0 µm). Ryvarden & Gilbertson (1994) reported slightly smaller basidiospores (3–4.5 × 2.5–3.5 µm) and cystidia (15–30 × 5–12 µm).

ADDITIONAL MATERIAL: BRAZIL, Santa Catarina: Santo Amaro da Imperatriz, Morro das Três Voltas, Michels, Esber, Groposo & Marcon-Baltazar 496, 20/III/2005 (FLOR 31806); ibid: Florianópolis, Ratones, Loguercio-Leite & Furlani 383, 27/I/1989 (FLOR 10702).

DISTRIBUTION: Cosmopolitan; Brazil [Rio Grande do Sul], Argentina, China, Czechoslovakia, Finland, Japan, Russia, USA, Venezuela (Núñez & Ryvarden 2001, Dai et al. 2004, Ryvarden & Gilbertson 1994, Robledo et al. 2006, Ryvarden & Iturriaga 2001, Rick 1960).

Amauroderma sprucei (Pat.) Torrend, Brotéria Bot. 18: 121, 1920. FIG. 8

≡ *Ganoderma sprucei* Pat., Bull. Soc. Mycol. France 10: 75, 1894.

DESCRIPTION: Decock & Herrera Figueroa (2006).

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Uruguai, Campos-Santana, Santana & Rodrigues-Souza 190, 27/XII/06 (FLOR 32210).

COMMENTS: The globose to subglobose basidiospores (9–10 × 7–8 µm) of our collection are similar in size to those (8.5–10 × 7–9 µm, 9–10 × 7–8 µm) seen in the additional material (URM 77450; URM 77451) as well as those reported by Ryvarden (2004) and Furtado (1981; 8–10 µm, (6–)8–10 µm in diam]. Decock & Herrera Figueroa (2006) observed basidiospores measuring (6.5–)7.5–9.8 (–10.3) × (6.5–)7–9(–9.5) µm. Although Ryvarden (2004) describes *A. sprucei* as producing globose basidiospores, the Mondaí material (FLOR32210), URM 77450, and URM 77451 showed globose to subglobose basidiospores, matching the shape reported by Decock & Herrera Figueroa (2006). *Amauroderma sprucei* differs from other *Amauroderma* species known from Santa Catarina — *A. schomburgkii* (Mont. & Berk.) Torrend, *A. omphalodes* (Berk.) Torrend, *A. intermedium* (Bres. & Pat.) Torrend, *A. brasiliense* (Singer) Ryvarden, *A. camerarium* (Berk.) J.S. Furtado — by its reddish yellow hymenophore and dextrinoid skeletal hyphae.

ADDITIONAL MATERIAL: BRAZIL, Sergipe: Itabaiana, Estação Ecológica Serra de Itabaiana, Gibertoni 44616, III/2002 (URM 77450); ibid, Gibertoni 44617, III/2002 (URM 77451); ibid, Santa Catarina: Santo Amaro da Imperatriz, Hotel Caldas da Imperatriz, Larissa T. Pereira, 31/III/2007 (FLOR 32197); ibid, Vargem Braço — PEST, Groposo 110, 28/III/2001 (FLOR 31323); ibid, Trilha da Cascata — PEST, Groposo 097, 05/I/2001 (FLOR 11902); ibid, Florianópolis, Rio Tavares, Furlani 274, 04/VII/1986 (FLOR 10460); ibid, Ilhota — Morro do Baú, Groposo, VII/2003 (FLOR 31344).

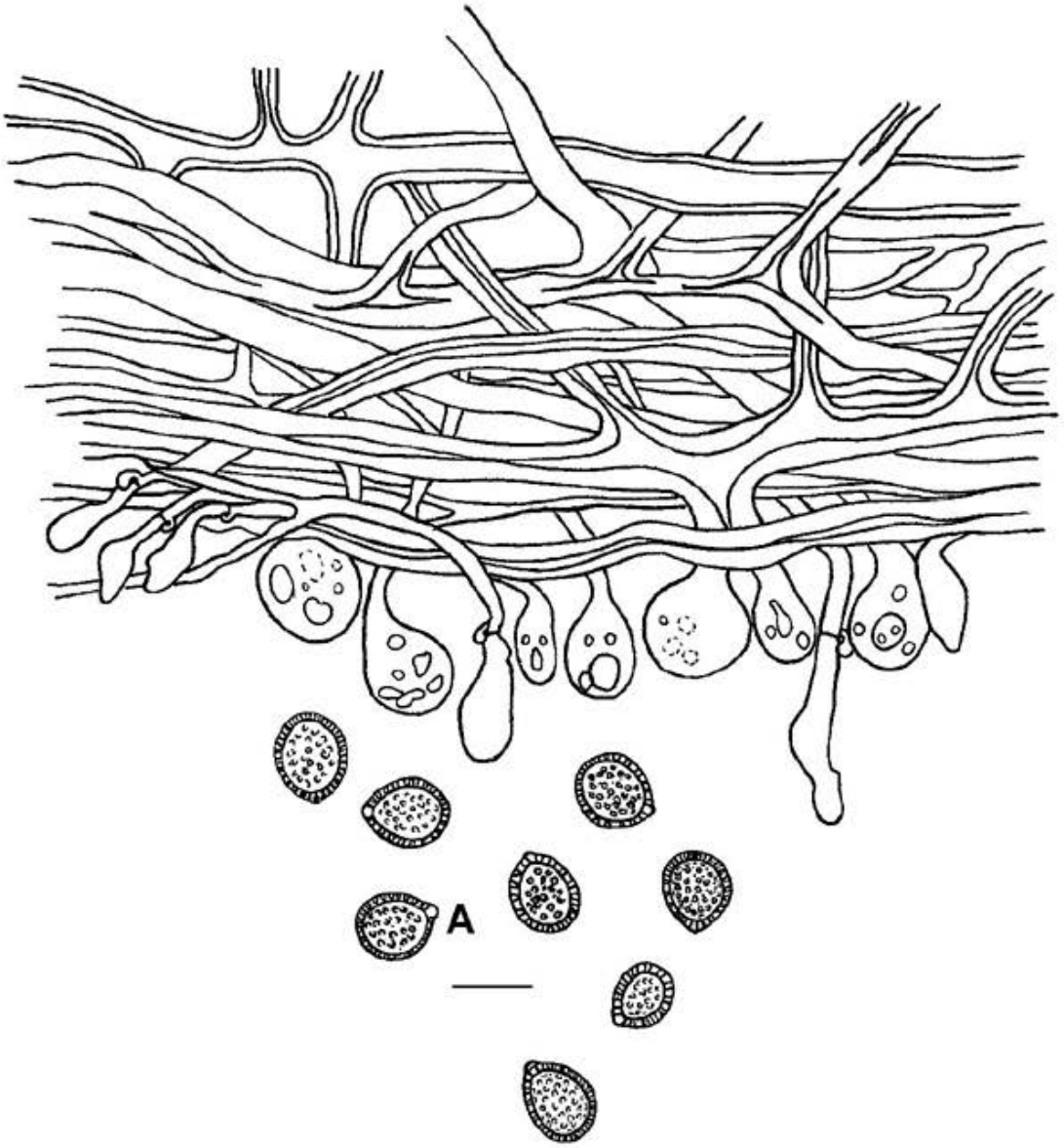


FIG. 8. *Amauroderma spruce* hymenium. Scale =10 µm.
A. Basidiospores.

DISTRIBUTION: Neotropical; Brazil (Amazonas, Rio Grande do Sul, Minas Gerais, Mato Grosso, Pernambuco, Rio de Janeiro, São Paulo, Paraná and Sergipe), Costa Rica, Cuba, Belize, French Guyana and Venezuela (Torrend 1920, Rick 1938, Furtado 1981, Ryvarden & Meijer 2002, Gibertoni 2004, Corner 1983, Ryvarden 2004, Decock & Herrera Figueroa 2006).

Pseudofavolus miquelii (Mont.) Pat., Essai Tax. Hymenomyc.: 81, 1900. FIG. 9
= *Polyporus miquelii* Mont., Ann. Sci. Nat., Bot., 3e Sér., 4:357, 1845.

DESCRIPTION: Ryvarden & Johansen (1980).

VOUCHER MATERIAL: BRAZIL, Santa Catarina: Mondaí, Linha Sanga Forte, Campos-Santana, Santana & Zanella 109, 16/VI/06 (FLOR 32225).

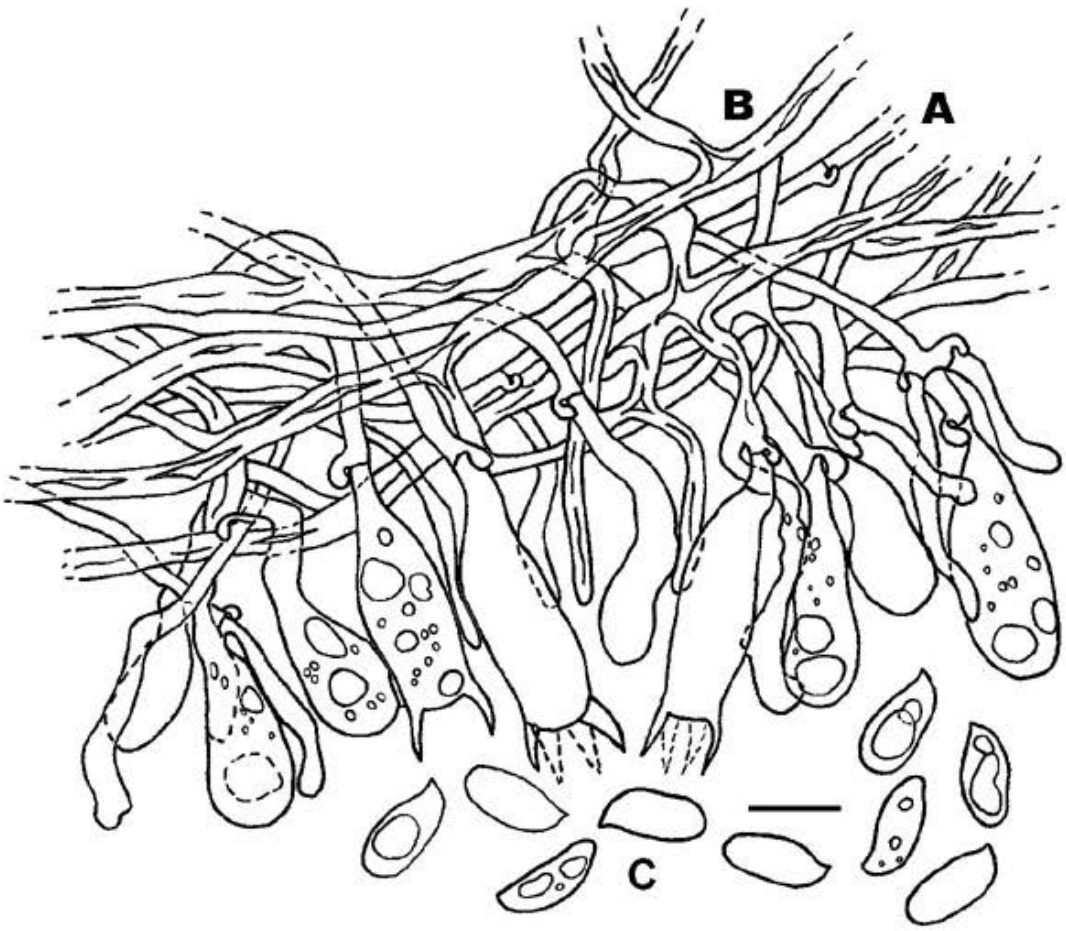


FIG. 9. *Pseudofavolus miquelii*. Scale =10 μm.
A. Generative hyphae. B. Skeleto-binding hyphae. C. Basidiospores.

COMMENTS: Núñez & Ryvarden (1995) characterized *P. miquelii* as having a very thin context, large and angular pores, and basidiospores greater than 15 μm long. Our basidiospores (10–16 × 4–6 μm) are very similar to material from Costa Rica (NYBG 00354169, NYBG 00354168: 10–17 × 5–7 μm) and slightly smaller than those recorded by Ryvarden & Johansen (1980; (14.5–)16–20 × 6.5–8.0 μm) and Corner (1984; 12–18 × 6–8.5 μm). Ryvarden & Johansen (1980) pointed out that the absence of a cuticle, the very thick context (1–2 mm), and number of the pores per mm ((1–)2–3) separate this species from *Pseudofavolus cucullatus* (Mont.) Pat. Corner (1984) considered *P. cucullatus* a variety of *Polyporus miquelii*.

ADDITIONAL MATERIAL: COSTA RICA, El Jardin, Dota, L. Echeverria 41-78, 21/III/1900 (NYBG 00354169); ibid, SJ Montana, L. Echeverria 65-78, /1900 (NYBG 00354168); BRAZIL, Santa Catarina: Santo Amaro da Imperatriz, Morro das Três Voltas, Michels, Esber, Groposo e Marcon-Baltazar 494, 20/III/2005 (FLOR 31805); ibid, Ilha de Santa Catarina, Rio Vermelho, Loguercio-Leite, 14/XII/1984 (FLOR 10104); ibid, Paraná, Capanema, Basso, 27/XII/1996 (FLOR 11500).

DISTRIBUTION: Pantropical; Brazil (Mato Grosso do Sul), Australia, Africa, Paraguay and Costa Rica (Ryvarden & Johansen 1980, Núñez & Ryvarden 1995, Popoff & Wright 1998, Velázquez & Ruíz-Boyer 2005).

Acknowledgments

We are grateful to Leif Ryvarden (Norway), Aristóteles Góes-Neto (Brazil), and Shaun Pennycook (New Zealand) for the exhaustive and invaluable criticism. Nathan Smith and Maria Alice Neves are warmly acknowledged for useful suggestions and assistance in English. This work is part of M.Sc. thesis in Biologia Vegetal (Universidade Federal de Santa Catarina, Brazil) of the first author.

Literature

Chamuris GP. 1988. The non-stipitate stereoid fungi in the northeastern United States and adjacent Canada. Mycologia Memoirs 14: 1–247.

Coelho G. 1994. Himenoquetáceas com poros (*Basidiomycetes*) do limite sul da Serra Geral em Santa Maria, RS. 112 f. Dissertação (Mestrado em Botânica). Universidade Federal do Rio Grande do Sul, Brasil, 1994.

Corner EJH. 1983. Ad Polyporaceas I. *Amauroderma* and *Ganoderma*. Nova Hedwigia 75: 1–182.

Corner EJH. 1984. Ad Polyporaceas II & III – *Polyporus*, *Mycobonia*, *Echinoporia*. Nova Hedwigia 78: 1–127.

Cunningham GH. 1956. *Thelephoraceae* of New Zealand. XIV. The Genus *Hymenochaete*. Transcations of the Royal Society of New Zealand 85(1): 1–51

Cunningham GH. 1963. The *Thelephoraceae* of Australia and New Zealand. New Zealand Department of Scientific and Industrial Research, Bulletin 145: 1–359.

Dai YC, Yuan HS, Yu CJ, Cui BK, Wei YL, Li J. 2004. Polypores from the Great Hinggan Mts., NE China. Coll. and Res. 17: 71–81.

Decock C, Herrera-Figueroa S. 2006. Neotropical *Ganodermataceae* (*Basidiomycota*): *Amauroderma sprucei* and *A. dubiopansum*. Cryptogamie Mycologie 27(1): 3–10.

Fernandes A, Bezerra P. 1990. Estudo fitogeográfico do Brasil. Stylus Comunicações, Fortaleza, Brazil. 5.

Fonseca MJH, Guzmán-Dávalos L, Rodríguez O. 2002. Contribución al conocimiento de la micobiota de la región de San Sebastián Del Oeste, Jalisco, México. Acta Botanica Mexicana 58: 19—50.

Fonsêca MP. 1999. *Aphyllophorales* lignocelulolíticos da Reserva Biológica do Alto da Serra de Paranapiacaba, Santo André, SP. 292 f. Tese (Doutorado em Botânica). Instituto de Biociências, USP, 1999.

Furtado JS. 1981. Taxonomy of *Amauroderma* (*Basidiomycetes, Polyporaceae*). Memoirs New York Bot. Garden 34: 1–104.

Garibay-Orijel R, Córdova J, Cifuentes J, Valenzuela R, Estrada-Torres A, Kong A. 2009. Integrating wild mushrooms use into a model of sustainable management for indigenous community forests. Forest Ecology and Management 258: 122–131. doi:10.1016/j.foreco.2009.03.051.

Gerber AL, Loguercio-Leite C. 1997. New records of polypores (*Aphyllophorales*) from southern Brazil. Mycotaxon 62: 305–318.

Gibertoni TB. 2004. *Aphyllophorales* (*Basidiomycotina*) em áreas de Mata Atlântica do Nordeste brasileiro. 259 f. Tese de Doutorado em Biologia de Fungos pelo Centro de Ciências Biológicas. Universidade Federal de Pernambuco, Recife, 2004.

Gibertoni TB, Cavalcanti MAQ. 2003. A mycological survey of the *Aphyllophorales* (*Basidiomycotina*) of the Atlantic Rain Forest in the state of Pernambuco, Brazil. Mycotaxon 87: 203–211.

Gilbert GS, Sousa WP, 2002. Host specialization among wooddecay polypore fungi in a Caribbean mangrove forest. Biotropica 34: 396–404. doi: 10.1646/0006-3606(2002)034[0396:HSAWDP]2.0.CO;2.

Gilbert GS, Gorospe J, Ryvarden L. 2008. Host and habitat preferences of polypore fungi in Micronesian tropical flooded forests. Mycological Research 112: 674–680. doi:10.1016/j.mycres.2007.11.009.

Gilbertson RL, Ryvarden L. 1986. North America polypores, vol. 1. *Abortiporus–Lindtneria*. Fungiflora, Oslo. 433 p.

Góes-Neto A. 1999. Polypore diversity in the State of Bahia, Brazil: a historical review. Mycotaxon 72: 43—56.

Góes-Neto A, Loguercio-Leite C, Guerrero RT. 2000. Poroid Hymenochaetales in seasonal tropical forest fragment in the State of Bahia, Brazil: taxonomy and quallitative ecological aspects. Mycotaxon 76: 197—211.

Groposo C, Loguercio-Leite C, Góes-Neto A. 2005. *Phellinus* Quélet (*Hymenochaetaceae, Basidiomycota*) no Sul do Brasil: uma abordagem filogenética. Dissertação (Mestrado em Biologia Vegetal). 198 f. Universidade Federal de Santa Catarina, Florianópolis, 2005.

Holmgren PK, Holmgren NH, Barnett LC. 2009 onwards (continuously updated). Index Herbariorum. New York Botanical Garden, New York. Disponível em: http://sciweb.nybg.org/science2/IndexHerbariorum.asp. Acesso em 02 de Fevereiro de 2009.

Intini M, Tello ML. 2003. Comunicación — investigaciones sobre hongos xilófagos de árboles urbanos em Europa: primeira cita de *Inonotus rickii* (Pat.) Reid en España. Bol. San. Veg. Plagas 29: 277—279.

Jarenkow JA, Budke JC. 2009. Padrões florísticos e análise estrutural de remanescentes florestais com *Araucaria angustifolia* no Brasil. 54–83, in: CSD Fonseca, AF Souza, AML Zanchet, T Dutra, A Backes, GMS Ganade (eds). Floresta com araucária: ecologia, conservação e desenvolvimento sustentável. Holos, Ribeirão Preto, Brazil.

Job DJ. 1985. Basidiomicetos xilófilos de la región mesopotámica VI. Espécies del gênero *Hymenochaete* Lév. Revista de Investigaciones Agropecuárias INTA 10(1): 143—165.

Kirk PM, Cannon PF, David JC, Stalpers J. 2008. Ainsworth & Bisby's dictionary of the fungi, 10. ed. Wallingford, Oxon.: CAB international. 771 p.

López AR, Garcia JA. 2001. *Fungi: Basidiomycota: Tremellaceae–Dracryopinax elegans*. Instituto de Genética Florestal, Universidade Veracruzana nº 46.

McNabb RFR. 1965. Taxonomic studies in the *Dacrymycetaceae* III. *Dacryopinax* Martin. New Zealand Journal of Botany 3: 59–72.

Melo I, Ramos P, Caetano MFF. 2002. First record of *Inonotus rickii* (*Basidiomycetes, Hymenochaetaceae*) in Portugal. Portugaliae Acta Biol. 20: 265–269.

Núñez M, Ryvarden L. 1995. *Polyporus* (*Basidiomycotina*) and related genera. Synopsis Fungorum 10: 1–85.

Núñez M, Ryvarden L. 2001. East Asia polypores 2. *Polyporaceae* s.lato. Synopsis Fungorum 14: 169–522.

Parmasto E. 2001. Hymenochaetoid fungi (*Basidiomycota*) of North America. Mycotaxon 79: 107–176.

Piepenbring M. 2007. Inventorying the fungi of Panama. Biodivers. Conserv. 16: 73–84. doi: 10.1007/s10531-006-9051-8

Popoff OF, Wright JE. 1998. Fungi of Paraguay. I. Preliminary check-list of wood-inhabiting polypores (*Aphyllophorales, Basidiomycota*). Mycotaxon 67(1): 323–340.

Rajchenberg , M.& Meijer, AAR. 1990. New and notheworthy polypores fom Paraná and São Paulo States, Brazil. Mycotaxon 38: 173—185.

Reeves F, Welden AL. 1967. West Indian species of *Hymenochaete*. Mycologia 59: 1034–1049. doi:10.2307/3757273.

Reid DA. 1965. A monograph of the stipitate stereoid fungi. Nova Hedwigia 18: 1–184.

Rick J. 1938. Poliporos Riograndenses. In: Reunião Sul-Americana de Botânica, Anais, Rio de Janeiro 2: 271-307.

Rick J. 1960. *Basidiomycetes Eubasidii* in Rio Grande do Sul, Brasília. 4. *Meruliaceae, Polyporaceae, Boletaceae*. Iheringia 7: 193–295.

Roberts P. 1996. Caribbean heterobasidiomycetes: 2. Jamaica. Mycotaxon 96(1): 83–107.

Robledo GL, Rajchenberg M. 2007. South American polypores: first annotated checklist from Argentinean Yungas. Mycotaxon 100: 5–9.

Robledo G, Urcelay C, Dominguez L, Rajchenberg M. 2006. Taxonomy, ecology, and biogeography of polypores (*Basidiomycetes*) from Argentinian *Polylepis* woodlands. Can. J. Bot. 84: 1561–1572. doi:10.1139/B06-109.

Ryvarden L. 1971. The genera *Stereum* (s.lato) and *Hymenochaete* in Norway. Norwegian Journal of Botany 18: 97–108.

Ryvarden L. 1991. Genera of polypores – Nomenclature and taxonomy. Synopsis Fungorum 5: 1–363.

Ryvarden L. 2004. Neotropical polypores Part 1. Synopsis Fungorum 19: 1–229.

Ryvarden L. 2005. The genus *Inonotus*. a synopsis. Synopsis Fungorum 21: 1–149.

Ryvarden L, Gilbertson RL. 1994. European polypores. Part 2. *Meripilus – Tyromyces*. Synopsis Fungorum 7: 388–743.

Ryvarden L, Guzmán G. 1993. New and interesting polypores from Mexico. Mycotaxon 47: 1—23.

Ryvarden L, Johansen I. 1980. A preliminary polypore flora of East Africa. Oslo: Fungiflora, 636 p.

Ryvarden L, Iturriaga T. 2001. Studies in neotropical polypores 9. A critical checklist of poroid fungi from Venezuela. Mycotaxon 78: 393–405.

Ryvarden L, Meijer AAR. 2002. Studies in neotropical polypores 14. New species from the state of Paraná, Brazil. Synopsis Fungorum 15: 34—69.

Silveira RMB, Guerrero, RT. 1991. *Aphyllophorales* poliporóides (*Basidiomycetes*) do Parque Nacional de Aparados da Serra, RS. Boletim do Instituto de Biociências 48: 1—127.

Singer R. 1975. The *Agaricales* in modern taxonomy. 3rd ed. J. Cramer: Vaduz (Liechtenstein). 912 p.

Sobestiansky G. 2005. Contribution to a macromycetes survey of the States of Rio Grande do Sul and Santa Catarina in Brazil. Brazilian Archives of Biology and Technology 48(3): 437–457. doi:10.1590/S1516-89132005000300015.

Torrend C. 1920. Les polyporacées du Brésil. Brotéria, Ser. Bot. 18: 23–43.

Velázquez JC, Ruíz-Boyer A. 2005. Checklist of polypores of Costa Rica. Revista Mexicana de Micología 20: 45—52.

Wagner T, Fischer M. 2002. Proceedings towards a natural classification of the worldwide taxa *Phellinus* s.l. and *Inonotus* s.l. and phylogenetic relationships of allied genera. Mycologia 94(6): 998–1016. doi:10.2307/3761866.

Wright JE. 1983. *Hirschioporus aculeifer*, a polypore with anamorphic pileus processes. Revista de Biologia 12: 131–134.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.395

Volume 114, pp. 395–399 October–December 2010

A phylogenetic study of *Trechispora thelephora*

STEVEN ALBEE-SCOTT[1*] & BRADLEY R. KROPP[2**]

*salbee@umich.edu & **brad.kropp@usu.edu

[1]*Intermountain Herbarium, Department of Biology, Utah State University 5305 Old Main Hill, Logan, Utah 84322-5305, USA*

[2]*Department of Biology, Utah State University 5305 Old Main Hill, Logan, Utah 84322, USA*

Abstract — Molecular data support the recent transfer of *Hydnodon thelephorus* to the genus *Trechispora*. These data also provide preliminary evidence that the pileate-stipitate basidiome morphology of *Trechispora thelephora* is ancestral to the resupinate morphology typical of the genus *Trechispora*. A photo, description, and line drawings of *Trechispora thelephora* are provided.

Key Words — *Basidiomycota*, nuclear large subunit, phylogeny

Introduction

Trechispora thelephora is a relatively common fungus that is widespread in the neotropics (Cifuentes et al. 2005, Ryvarden 2002). In spite of this and its rather striking morphology (FIG. 1), it has received relatively little attention from mycologists until recently. The basionym of *Trechispora thelephora* is *Hydnum thelephorum* (Léveillé 1844), but it was later placed in the monotypic genus *Hydnodon* (Banker 1913) where it remained for 89 years until Ryvarden (2002) proposed transferring it to the genus *Trechispora*.

Even though the micromorphology of *T. thelephora* corresponds very well to the genus *Trechispora*, the pileate-stipitate morphology of its basdiomata is unusual for this usually resupinate genus (FIG. 1a, b, c). Perhaps as a consequence of this, the nomenclatural history of *T. thelephora* is fairly complex. This has been reviewed by Cifuentes et al. (2005) and Ryvarden (2002), but molecular work would help understanding of the classification of this fungus. Our goals were to study the phylogenetics of *Trechispora thelephora*. We provide a description, photograph, and line drawings of this rarely illustrated taxon.

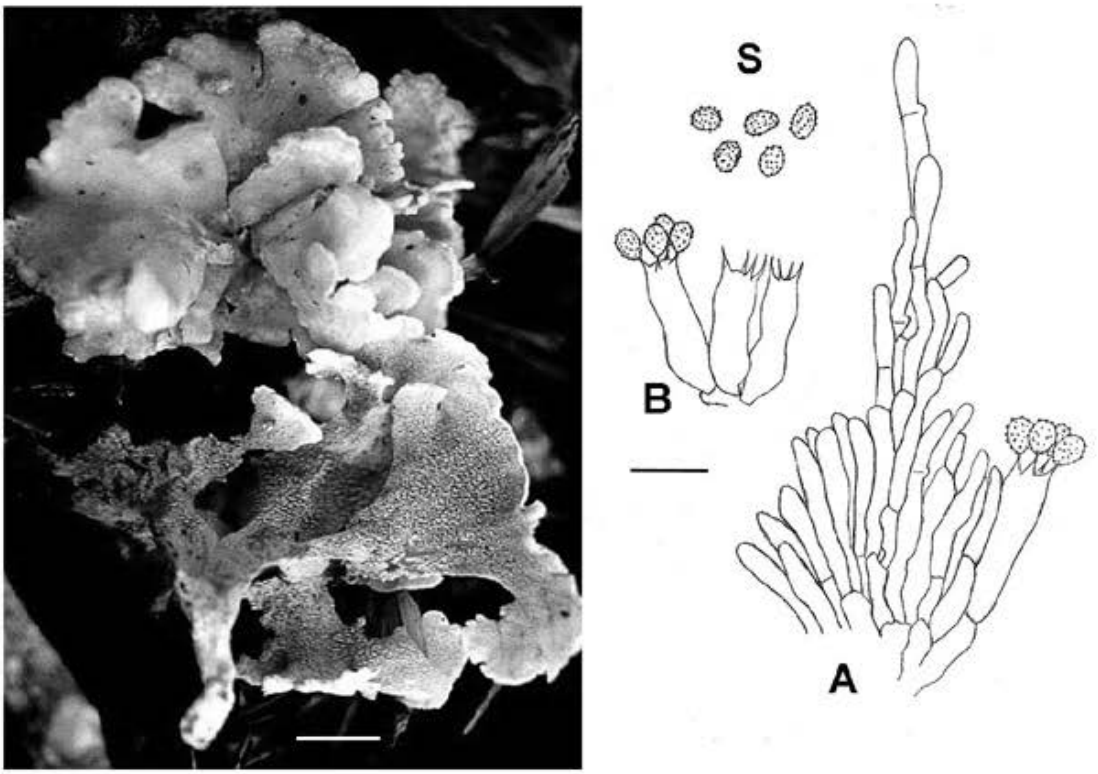


FIGURE 1. a) Pileate-stipitate basidiomata of *Trechispora thelephora* (UTC252606, Brad Kropp 13-Oct-02-23). Scale = 10 mm. b) Micromorphology of *Trechispora thelephora* showing section through aculeus (A), basidia (B), and basidiospores (S). Scale = 10 µm.

Material and methods

DNA was extracted from a basidiome of *T. thelephora* and sequence data was obtained for the portion of the nuclear large ribosomal subunit (nLSU) between primers LROR and LR5 (Moncalvo et al. 2000) and deposited in Genbank (HM104485). Sequences for additional taxa were downloaded from Genbank and aligned using ClustalX (Thompson et al. 1997). Taxon sampling included *Gloeocystidiellum porosum* (Berk. & M.A. Curtis) Donk, *Tubulicium vermiferum* (Bourdot) Jülich., and 12 members of the genus *Trechispora*. *Tubulicium vermiferum* was used as outgroup because it is sister to *Trechispora* according to Larsson et al. (2004). *Gloeocystidiellum porosum*, more distantly related to *Trechispora* (Larsson et al. 2004), was used to further polarize the crown group. A gap open of 5 and a gap extension of 1 for both pairwise and multiple alignment were used for the alignments. MrBayes 3.1 (Ronquist & Huelsenbeck 2003) was used to search tree space. All searches were performed using a time reversible model of evolution (Maddison 1994, Rodriguez et al. 1990) under the assumption of a discrete gamma distribution with six substitution types and some invariant sites (GTR+G+I). Posterior probabilities were approximated by sampling every hundred trees simulated using the Metropolis-coupled Markov chain Monte Carlo (MCMCMC) method. All runs were conducted with eight active MCMCMC chains, heated at 0.2, and started with a neighbor-joining tree to avoid entrapment in a local minimum. All runs were

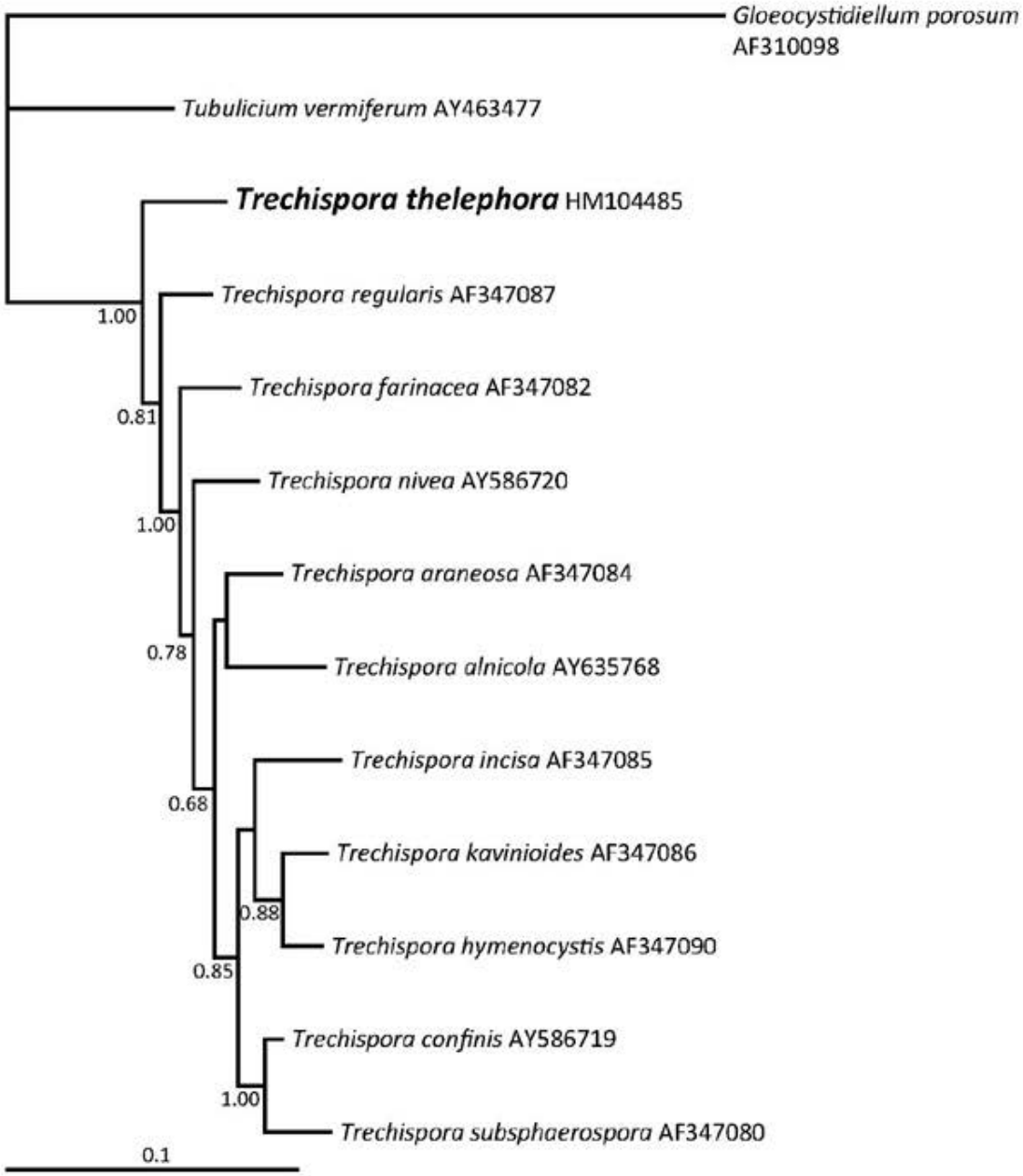


FIGURE 2. Phylogram derived from a Bayesian analysis of nLSU sequences from eleven *Trechispora* species. The phylogram has been rooted with *Gloeocystidiellum porosum*. Support measures are shown for nodes with posterior probability support of greater than 50 percent.

iterated for 1,000,000 generations. A majority consensus tree was calculated from the last 7000 trees from all runs to recover the posterior probabilities of the internal nodes using the sumt command in MrBayes. TreeView (Page 1996) was used to visualize the output from each simulation. Support measures for nodes with less than a 50% posterior probability support are not shown in FIG. 2.

Microscopical study and confirmation of the identity of our specimen was carried out using a light microscope after rehydrating sections in 10% NH_4OH. Microscopical measurements were done using oil immersion at 1000× and line drawings were made with the aid of a drawing tube. The specimen from which DNA was extracted and from which the description and illustrations in FIG. 1 were made has been accessioned into the Intermountain Herbarium (UTC252606) at Utah State University.

Results

A BLAST search using nLSU sequence data obtained from our specimen of *Trechispora thelephora* matched other *Trechispora* sequences, supporting the proposal (Ryvarden 2002) placing the species within *Trechispora*. Results of the phylogenetic analysis (FIG. 2) of nLSU sequences from other *Trechispora* taxa also support this and provide preliminary evidence that the pileate-stipitate basidiome morphology of *T. thelephora* is ancestral to the resupinate morphology that is typical for most of the genus.

Although basidiome morphology in the *Holobasidiomycota* can apparently evolve either toward or away from complex pileate-stipitate forms, Hibbett & Binder (2002) indicate that the rate of change from resupinate toward pileate-stipitate forms exceeds the rate of change away from pileate-stipitate forms. A later study by Hibbett (2004) also supports an overall evolutionary trend in the *Holobasidiomycota* toward pileate-stipitate basidiomata, indicating that the ancestral form in this group is probably resupinate, even though results vary depending on the analytical method used.

The analysis of our sequence data with additional data from Genbank allows us to postulate that within *Trechispora* evolution has favored simplification of basidiome morphology and that the predominantly resupinate *Trechispora* basdiomata have evolved from a pileate-stipitate ancestral state. However, further work, perhaps including another pileate-stipitate species, *Trechispora gillesii* (Maas Geest.) Liberta (Liberta 1973), should be done to support this observation.

Trechispora thelephora (Lév.) Ryvarden, Synopsis Fung. 15: 32 (2002) FIG. 1

Basidiome pileate-stipitate, upper surface light yellow brown, glabrous or with appressed fibrils, divided into multiple irregular lobes 24–12 mm across; lower hymenial surface pinkish, lighter toward margins, finely hydnoid with teeth 1.0–0.5 mm in length, running part way down the stipe; hymenium drying soft with the subhymenial context drying hard and brittle. Stipe 5 mm wide × 20 mm tall, glabrous, concolorous with upper surface of basidiome or pallid near the base. Context pallid and not changing color when cut. Odor pleasant, fungoid. Spore print faint salmon. Hyphal system monomitic, hyphae of hymenial layer 2.0–3.5 µm wide, thin walled, with clamps, hyphae

of subhymenial context dense, with clamps, slightly thick walled (walls up to 0.5 µm thick), 3.0–5.5 µm wide. Basidia clavate, with four sterigmata and basal clamps, 15–23 × 5–6 µm. Basidiospores ellipsoid, echinulate, 4.0–5.0 × 3.4–4.5 µm.

Specimen examined — **Belize. Cayo District**, Las Cuevas Research Station, Brad Kropp 13-Oct-02-23 (UTC 252606).

Acknowledgments

We thank Dr. Karen Nakasone and Dr. Michael Castellano for reviewing our manuscript and providing valuable comments for improving the manuscript.

Literature cited

Banker HJ. 1913. Type studies in the *Hydnaceae:* VI. The genera *Creolophus*, *Echinodontium*, *Gloiodon*, and *Hydnodon*. Mycologia 5: 293–298. doi:10.2307/3753585

Cifuentes J, Patiño-Conde V, Villegas M, García-Sandoval R, Valenzuela R. 2005. First record of *Hydnodon thelephorus* from Belize, Dominican Republic, Mexico with new data on its morphology and distribution. Mycotaxon 91: 27–34.

Hibbett DS. 2004. Trends in morphological evolution in *Homobasidiomycetes* inferred using maximum likelihood: a comparison of binary and multistate approaches. Systematic Biology 53: 889–903. doi:10.1080/10635150490522610

Hibbett DS, Binder M. 2002. Evolution of complex fruiting-body morphologies in *Homobasidiomycetes*. Proc. R. Soc. London 269: 1963–1969. doi:10.1098/rspb.2002.2123

Larsson KH, Larsson E, Koljalg U. 2004. High phylogenetic diversity among corticioid homobasidiomycetes. Mycol Res. 108: 983–1002. doi:10.1017/S0953756204000851

Léveillé JH. 1844. Champignons exotiques. Ann. Sci. Nat. Bot., Sér 3, 2: 167–221.

Liberta AE. 1973. The genus *Trechispora* (*Basidiomycetes, Corticiaceae*). Can. J. Bot. 51: 1871–1892. doi:10.1139/b73-240

Maddison DR. 1994. Phylogenetic methods for inferring the evolutionary history and processes of change in discretely valued characters. Annual Review of Entomology 39: 267–292. doi:10.1146/annurev.en.39.010194.001411

Moncalvo J-M, Lutzoni FM, Rehner SA, Johnson J, Vilgalys R. 2000. Phylogenetic relationships of Agaric fungi based on nuclear large subunit ribosomal DNA sequences. Syst. Biol. 49: 278–305. doi:10.1093/sysbio/49.2.278

Page RDM. 1996. TreeView: An application to display phylogenetic trees on personal computers. Computer Applications in the Biosciences 12: 357–358.

Rodriguez F, Oliver JL, Marin A, Medina JR. 1990. The general stochastic model of nucleotide substitution. Journal of Theoretical Biology 142: 485–501. doi:10.1016/S0022-5193(05)80104-3

Ryvarden L. 2002. A note on the genus *Hydnodon* Banker. Synopsis Fung. 15: 31–33.

Ronquist F, Huelsenbeck JP. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. Bioinformatics 19: 1572–1574. doi:10.1093/bioinformatics/btg180

Thompson JD, Gibson TJ, Plewniak F, Jeanmougin F, Higgins DG. 1997. The ClustalX windows interface: flexible strategies for multiple sequence alignment aided by quality analysis tools. Nucl. Acids Res. 24: 4876–4882. doi:10.1093/nar/25.24.4876

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.401

Volume 114, pp. 401–405 *October–December 2010*

A new species of *Podosporium* and a new record from southern China

YI-DONG ZHANG, JIAN MA, LI-GUO MA & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — Two conidial fungi, *Podosporium cyclocaryae* sp. nov. and *Endophragmiella theobromae*, occurring on dead branches of *Cyclocarya paliurus* and *Dendrocalamus giganteus*, respectively, are described and illustrated and compared with related taxa. The specimens were collected from tropical forests in Fujian Province, China.

Key words — anamorphic fungi, taxonomy

Introduction

There is an enormous diversity of anamorphic fungi growing on rotten wood and dead branches in the tropical forests of southern China, and several mycological investigations dealing with many new species have been recently published (Yuan & Dai 2008, Zhang et al. 2009, Dai et al. 2009). Two additional species have been found that are described below. One is proposed herein as a new species and the other is a new record for China. The type specimen is deposited in HSAUP (Herbarium of the Department of Plant Pathology, Shandong Agricultural University) and HMAS (Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences).

Taxonomy

Podosporium cyclocaryae Y.D. Zhang & X.G. Zhang, **sp. nov.** FIG 1

MYCOBANK MB 518832

Coloniae in substrato naturali effusae, brunneae. Mycelium hyalinum, hyphae ramosae, pallide brunneae, septata, 3–4 µm crassis. Conidiomata synnematica, solitaria, erecta, atrobrunnea vel nigra, cylindrica, usque 490 µm alta, 39–49 µm crassa ad basim, saepe inflata. Conidiophora macronematosa, synnematosa, nonramosa, septata, laevia, brunnea

*Corresponding author

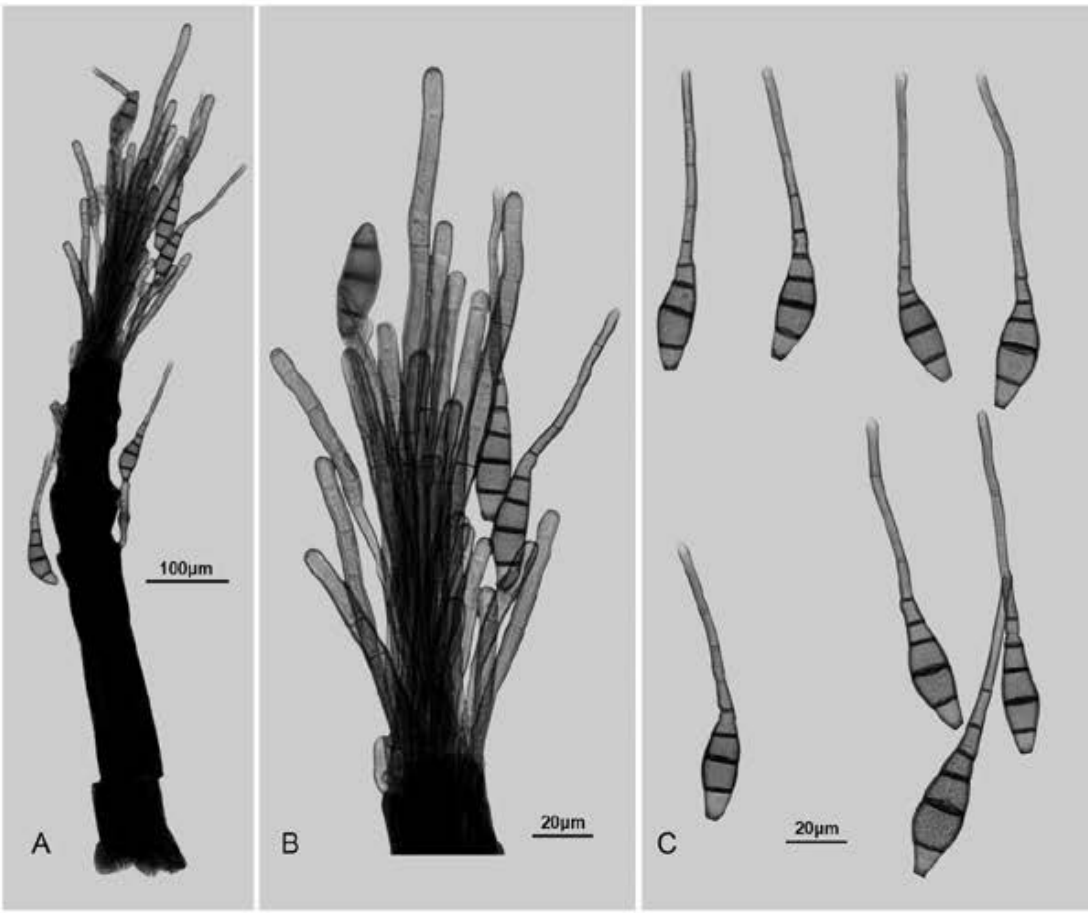


FIG. 1. *Podosporium cyclocaryae*.
A. Synnemata B. Conidiophores with conidia. C. Conidia.

vel atrobrunnea, usque 490 μm longa, 3.5–4.5 μm crassa, divergentia ad apicem et lateralia. Cellulae conidiogenae monotretica, cylindricae, integratae, terminales, determinatae, laeves, brunneae vel atrobrunneae, 6.5–10 μm longae, 2.5–3.5 μm crassa. Conidia solitaria, sicca, acrogena, obclavata, stricta vel leviter curvatae, rostrata, 7–10-septata, laevia, 77–122 × 10–15 μm, brunnea, pallidiora versus apicem, basim cum depresso hilo, 2.5–3 μm crasso, praedita.

HOLOTYPE: on dead branches of *Cyclocarya paliurus* (Batalin) Iljinsk. (*Juglandaceae*). Fujian Province, China, 11 Aug. 2009, Y.D. Zhang, HSAUP 0129 (isotype HMAS 146112).

ETYMOLOGY: in reference to the host genus, *Cyclocarya*.

Colonies on the natural substratum effuse, brown. Mycelium hyaline, hyphae flexuous branched, pale brown, septate, 3–4 μm thick. Conidiomata solitary, synnematous, erect, dark brown to black, cylindrical, scattered, up to 490 μm high, 39–49 μm wide at the often swollen base. Conidiophores macronematous, arranged in synnemata, unbranched, septate, smooth, brown to dark brown, up to 490 μm long, 3.5–4.5 μm wide, diverging laterally and also terminally. Conidiogenous cells monotretic, cylindrical, integrated, terminal, determinate,

smooth, brown to dark brown, 6.5–10 × 2.5–3.5 µm. Conidia solitary, dry, acrogenous, obclavate, straight to slightly curved, rostrate, 7–10-septate, smooth-walled, 77–122 × 10–15 µm, brown, paler toward the apex, base with a depressed hilum, 2.5–3 µm wide.

NOTES: The genus *Podosporium* was established by Schweinitz (1832), based on *P. rigidum* Schwein. After the holotype was discovered to be missing, Ellis (1971) lectotypified *P. rigidum* by specimens collected on dead stems and branches of *Ampelopsis* and *Rhus* from U.S.A. *Podosporium* is characterized by darkly pigmented and cylindrical synnemata consisting of distinct conidiophores terminating in monotretic, percurrent to rarely sympodial, clavate or cuneiform conidiogenous cells and brown, acrogenous, multiseptate, obclavate conidia (Ellis 1971, Chen & Tzean 1993). Worldwide, more than 60 species of *Podosporium* have been validly described. Only *P. elongatum* has been reported from China (Chen & Tzean 1993). Most species grow as saprobes on rotten wood and bark of various trees and shrubs or on dead herbaceous material. Of the known species, the conidia of *P. cyclocaryae* resemble those of *P. rigidum* (Schweinitz 1832) in having phragmoconidia. However, the conidia of *P. cyclocaryae* are rostrate and larger than those of *P. rigidum* (77–122 × 10–15 µm vs. 40–70 × 10–14 µm). In addition, the synnemata of *P. cyclocaryae* expand at the top and they are much shorter than those of *P. rigidum* (2 mm).

Endophragmiella theobromae M.B. Ellis, More dematiaceous hyphomycetes. 144 (1976) FIG 2

SPECIMENS EXAMINED: on dead branches of *Dendrocalamus giganteus* Munro (*Gramineae*), forest park of Wuyishan, Fujian Province, China, 18 Aug. 2009, Y.D. Zhang, HSAUP H3140 (duplicate HMAS 146113).

Colonies effuse, hairy, dark blackish brown to black. Mycelium in the substratum sparse, composed of septate, smooth, pale brown, branched hyphae 2–3 µm wide. Conidiophores macronematous, arising singly or sometimes fasciculate, branched, erect, straight or slightly flexuous, smooth, septate, brown, paler towards the apex, up to 110 µm long, 7.5–8.5 µm wide, sometimes swollen at the base, with 1–4 proliferations. Conidiogenous cells monoblastic, integrated, terminal, percurrent, cylindrical, tapered to a truncate apex. Conidial secession rhexolytic. Conidia obovoid to pyriform, usually 2-septate, basal cell pale brown, central cells and apical cell dark brown, smooth, 17.5–30 µm long, 8.5–13 µm wide, with a distinct basal frill derived from the distal end of the conidiogenous cell.

NOTES: The genus *Endophragmiella* B. Sutton was proposed and originally described by Sutton (1973) for two species: the type species *E. pallescens* B. Sutton and *E. canadensis* (Ellis & Everh.) B. Sutton. The genus is characterized

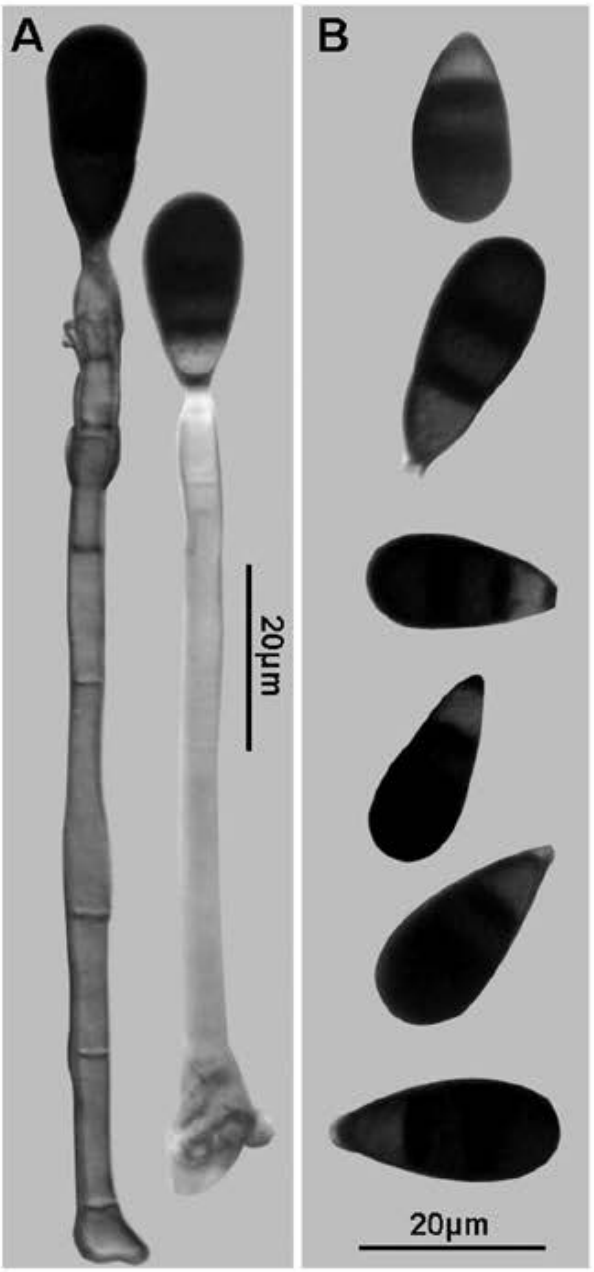


FIG. 2. *Endophragmiella theobromae*.
A. Conidiophores with conidia. B. Conidia.

by conidiophores that are macronematous, mononematous with conidiogenous cells integrated, percurrent proliferation, and solitary, euseptate or distoseptate conidia with rhexolytic secession. The genus has been revised by Hughes (1979) and enlarged by Kirk (1985) and Holubová-Jechová (1986). At present, the genus *Endophragmiella* comprises more than 80 species, most of which grow as saprobes on rotten wood and bark of various trees and shrubs or on dead herbaceous material.

E. theobromae was first described by Ellis (1976) from New Guinea on dead cortex of *Theobroma cacao*. Our species was collected from a monocotyledonous plant (family *Gramineae*) in Fujian, China, whereas *E. theobromae* is known only from a dicotyledonous tree (family *Sterculiaceae*) in New Guinea. Our specimen is much similar to the type material, but the conidia in our collection are slightly larger and the conidiophores are smaller. Despite these minor differences, we believe they are the same species in different regions. This is the first record of this species from China.

Acknowledgments

The authors are grateful to Dr Eric H.C. McKenzie and Dr R.F. Castañeda Ruiz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (No. 30770015, 30499340, 2006FY120100).

Literature cited

Chen JL, Tzean SS. 1993. *Podosporium elongatum* a new synnematous hyphomycete from Taiwan. Mycological Research 97: 637–640. doi:10.1016/S0953-7562(09)81190-8

Dai YC, Cui BK, Yuan HS. 2009. *Trichaptum* (*Basidiomycota, Hymenochaetales*) from China with a description of three new species. Mycological Progress 8: 281–287. doi: 10.1007/s11557-009-0598-0

Ellis MB. 1971. Dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Holubová-Jechová V. 1986; Lignicolous hyphomycetes from Czechoslovakia 8. *Endophragmiella* and *Phragmocephala*. Folia Geobotanica & Phytotaxonomica 21: 173–197.

Hughes SJ. 1979. Relocation of species of *Endophragmia* auct. with notes on relevant generic names. New Zealand Journal of Botany 17: 139–188.

Kirk PM. 1985. New or interesting microfungi XIV. Dematiaceous hyphomycetes from Mt Kenya. Mycotaxon 23: 305–352.

Schweinitz LD von. 1832. Synopsis fungorum in America boreali media degentium. Transactions of the American Philosophical Society: 4: 141–316. doi:10.2307/1004834

Sutton BC. 1973. Hyphomycetes from Manitoba and Saskatchewan, Canada. Mycological Papers 132:1–143.

Yuan HS, Dai YC. 2008. Two new species of *Junghuhnia* (*Basidiomycota, Polyporales*), and a key to the species of China. Nordic Journal of Botany 26: 96–100. doi:10.1111/j.1756-1051.2008.00169.x

Zhang K, Fu HB, Zhang XG. 2009. Taxonomic studies of *Corynespora* from Hainan, China. Mycotaxon 109: 85–93.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.407

Volume 114, pp. 407–415 October–December 2010

A new species of *Corynesporopsis* from Portugal

RAFAEL F. CASTAÑEDA RUIZ

rfcastaneda@inifat.co.cu

Instituto de Investigaciones Fundamentales en Agricultura Tropical "Alejandro de Humboldt" (INIFAT), Calle 1 Esq. 2, Santiago de Las Vegas, C. Habana, Cuba, C.P. 17200

CAROLINA SILVERA-SIMÓN

JOSEPA GENÉ & JOSEP GUARRO

mariacarolina.silvera@urv.cat

josepa.gene@ urv.cat & josep.guarro@urv.cat

Unitat de Microbiologia, Facultat de Medicina i Ciencies de la Salut Universitat Rovira i Virgili, 43201 Reus, Tarragona, Spain

DAVID W. MINTER

d.minter@cabi.org

CABI, Bakeham Lane, Egham, Surrey, TW20 9TY, United Kingdom

MARC STADLER

marc.stadler@t-online.de

InterMed Discovery GmbH, Otto-Hahn-str, 15, D-44227 Dortmund, Germany

MASATOSHI SAIKAWA

saikawa@u-gakugei.ac.jp

Department of Biology, Tokyo Gakugei University Nukuikita-machi, Koganei-shi, Tokyo 184-8501, Japan

Abstract — *Corynesporopsis iberica* sp. nov. found on the bark of an unidentified plant in Braganza, Portugal, is described and illustrated. It is characterized by an endogenous conidial ontogeny at the reduced internal area of inflated or globose bases of conidiophores, vase-shaped conidiogenous cells, and clavate to sub-cylindrical, (5–)7-septate, brown conidia with truncate bases and rounded apices. A key and illustrations to *Corynesporopsis* species is presented.

Key words — systematics, anamorphic fungi

Introduction

Kirk (1981) erected the genus *Corynesporopsis* for a taxon previously placed in *Corynespora* Güssow, *Corynesporopsis quercicola* (Borowska) P. M. Kirk

(type species). The author remarked as primary characteristics of the genus *Corynesporopsis* the terminal, determinate or rarely with enteroblastic percurrent proliferations, monotretic conidiogenous cells and cylindrical to ellipsoid, euseptate, catenate conidia. Subsequently, eight other species have been added to this genus: *Corynesporopsis antillana* R.F. Castañeda & W.B. Kendr., *C. biseptata* (M.B. Ellis) Morgan-Jones, *C. cylindrica* B. Sutton, *C. inaequiseptata* Matsush., *C. indica* P.M. Kirk, *C. isabelicae* Hol.-Jech., *C. rionensis* Hol.-Jech., and *C. uniseptata* P.M. Kirk. Kirk (1981), Morgan-Jones (1988), Siboe & Kirk (1999), Castañeda et al. (2004), Siqueira et al. (2008), and McKenzie (2010) have noted that the distoseptate, solitary or catenate conidia that are borne through a slightly depressed and evident apical pore of the monotretic conidiogenous cell are distinctive characters of *Corynespora cassiicola* (Berk. & M.A. Curtis) C.T. Wei (the most common species of *Corynespora*). Curiously, during direct isolation of *C. cassiicola* from common leaf lesions on several hosts (*Cucumis sativus* L., *Solanum lycopersicum* L., *Vigna unguiculata* (L.) Walp., and others) only solitary conidia have been observed when the samples are examined directly from the field, but in pure cultures or after incubation in damp chambers, mostly catenate conidia with several enteroblastic cylindrical to doliiform percurrent proliferations of the conidiogenous cells can be observed. In fact, *C. cassiicola* is a variable species that has been described several times as "new" based on small conidial size differences found on specimens collected on different hosts (Morgan-Jones 1988). However, these criteria are not sufficient to warrant recognition as novel species and the names should be reduced to synonyms of *C. cassiicola* (Morgan-Jones 1988). Four other genera — *Briansuttonia*, *Corynesporina*, *Hemicorynespora*, and *Solicorynespora* — that are closely related to *Corynesporopsis* and *Corynespora* based on conidium ontogeny development (monotretic, determinate or sometimes doliiform to percurrent) can be separated by conidial production (solitary, basocatenate, or blastocatenate) and type of septa as circumscribing characters as summarized by Siqueira et al. (2008). During a November 2007 "Flora Micológica Ibérica" survey of microfungi in the Montesinho and Douro Natural Park, Braganza, Portugal, a conspicuous fungus from the genus *Corynesporopsis* was collected. The specimen showed differences from previously described taxa.

Materials and methods

Samples of plant material were collected during a mycological survey in the Montesinho Natural Park, Braganza, Portugal. Individual collections were placed in paper and plastic bags taken to the laboratory and treated according to Castañeda (2005) and Castañeda et al. (2010). Mounts were prepared in polyvinyl alcohol-glycerol (8 g in 100 ml of water, plus 5 ml of glycerol) and measurements made at a magnification of × 1000. Micrographs were obtained with a Zeiss Axioskop 40, Leitz Dialux 20 and a Jeol

JSM-6400 scanning electron microscope using the techniques described previously by Figueras & Guarro (1988).

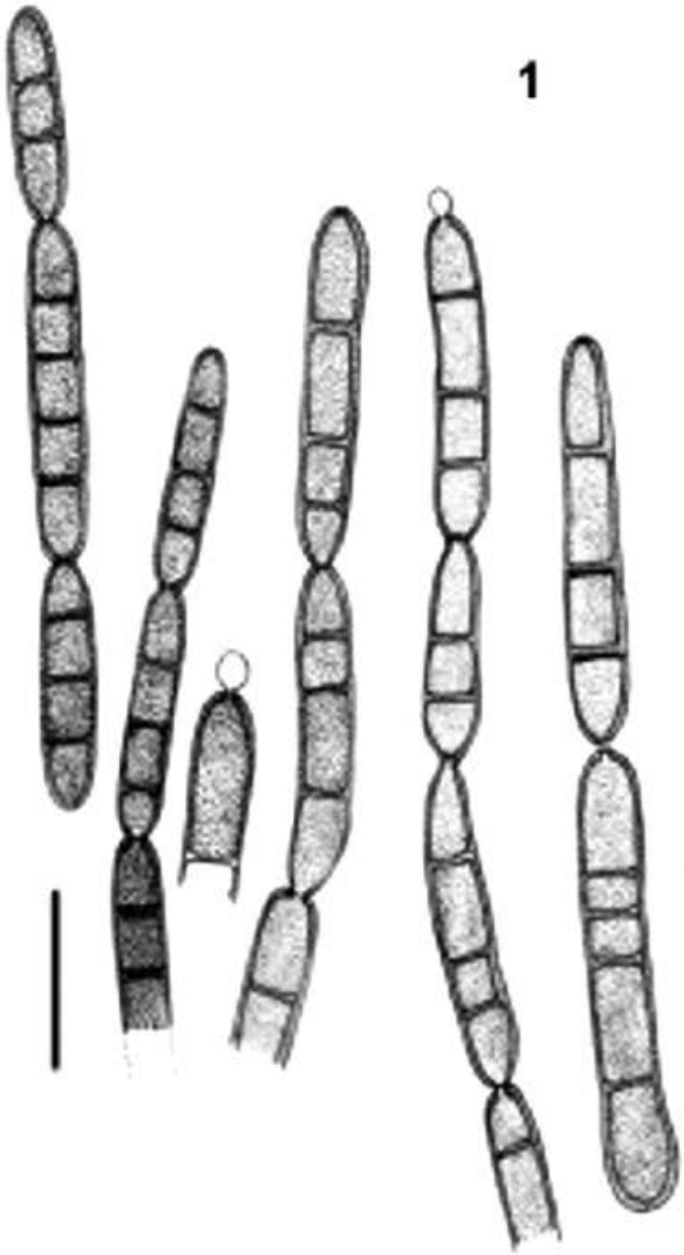


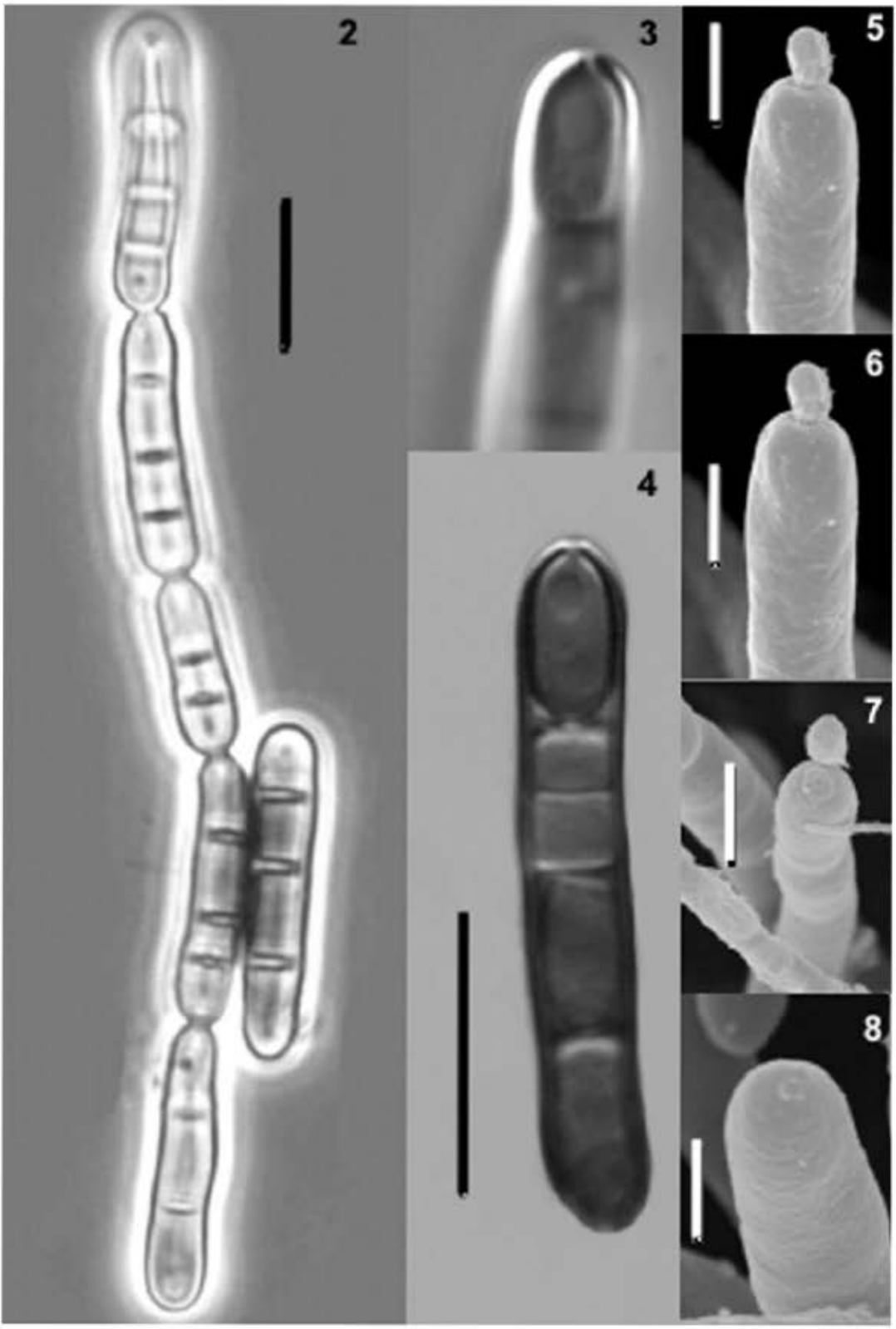
FIG. 1. *Corynesporopsis iberica*, drawings from holotype (IMI 398785). Conidiophores, conidiogenous cells, and conidia. Scale bar = 10 µm.

Taxonomy

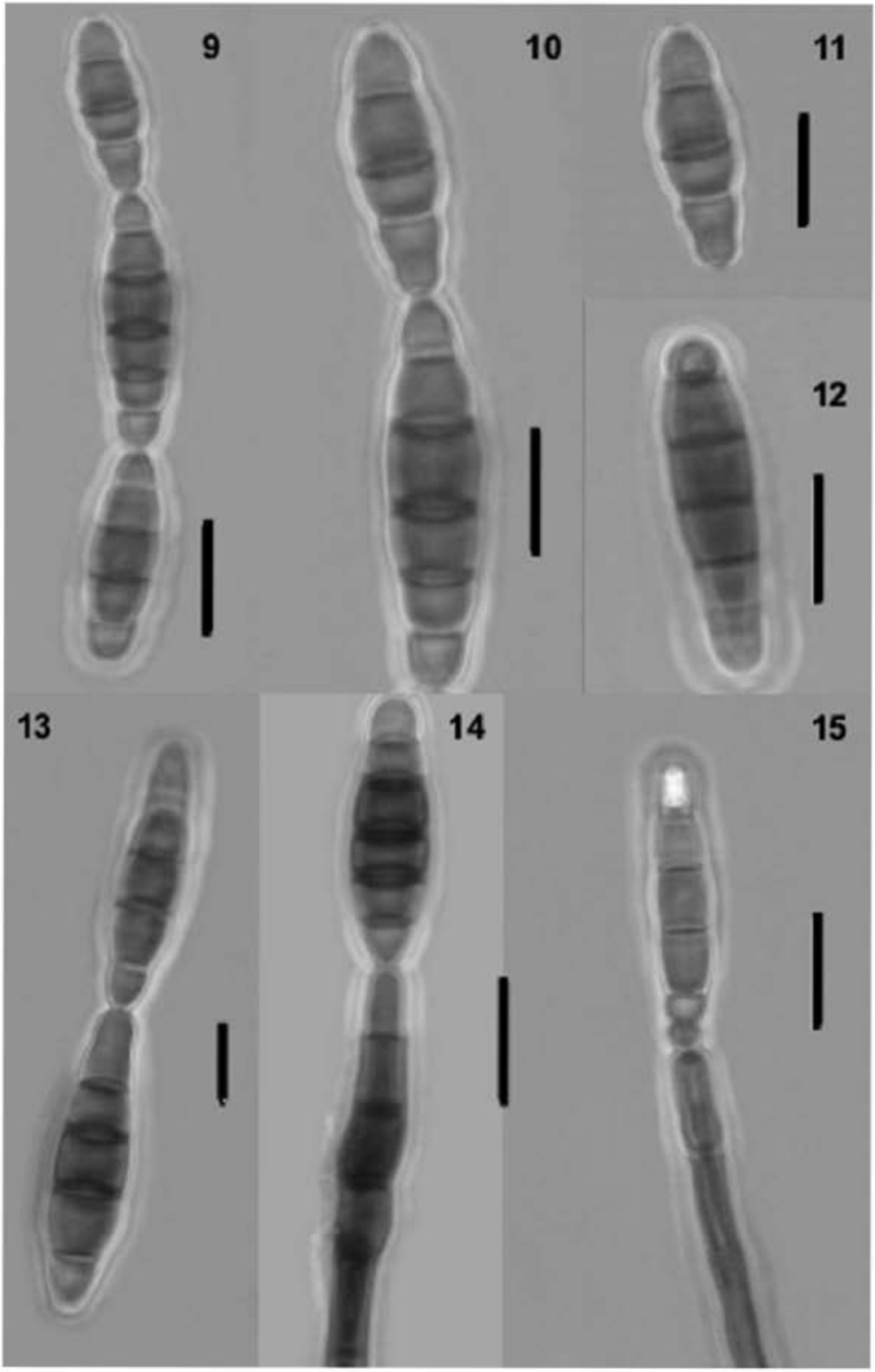
Corynesporopsis iberica R.F. Castañeda, Silvera, Gené & Guarro, **sp. nov.**

MYCOBANK MB 518642 FIGS 1–8

COLONIAE in substrato naturali effusae, pilosae, atrobrunneae vel nigrae. Mycelium plerumque in substrato immersum, ex hyphis septatis, cylindricis, aliquando cum cellulis inflatis, 1.5–2.5 µm diam., laevibus, atrobrunneis, compositum. CONIDIOPHORA



Figs. 2–8. *Corynesporopsis iberica*, photomicrographs from holotype (IMI 398785). 2. Conidia. 3–4. Conidiophores and conidiogenous cells. 5–8. photomicrographs (SEM) from culture derived from holotype. Conidiogenous cells and conidiogenous loci. Scale bars (1–4 = 10 µm; 5–8 = 3 µm).



FIGS. 9–15. *Corynesporopsis antillana*, photomicrographs from holotype (INIFAT C89/183). 9–13. Conidia. 14–15. Conidiophores and conidiogenous cells. Scale bars = 10 µm.

mononematosa, macronematosa, simplicia, erecta, recta, cylindrica, 4–7-septata, laevia, atrobrunnea, 30–100 × 6–10 µm. CELLULAE CONIDIOGENAE *monotreticae, terminal, determinatae, brunneae, 5–10 × 3.5–5.0 µm, cum parietibus incrassantis circa loco conidiogeno, praeditae.* CONIDIA, *cylindrica interdum leviter curvata, plus minusve utrimque rotundata, (2–)3–7-septata, atrobrunnea, laevia, sicca, 15–48(–59) × 3–4 µm, laevia, blastocatenulata. Teleomorphosis ignota.*

TYPE: PORTUGAL. BRAGANZA, MONTESINHO NATURAL PARK, on bark of an unidentified plant, 14.XI.2007. R.F. Castañeda, C. Silvera & J. Capilla (**Holotype:** IMI 398785; ex-type culture: FMR 9651, CBS).

ETYMOLOGY: Latin, iberica, in reference to Iberian Peninsula.

COLONIES on the natural substrate effuse, hairy, dark brown to black. Mycelium immersed; hyphae septate, branched, cylindrical and sometimes inflated, thickened cells, 1.5–2.5 µm diam., smooth-walled, dark brown. CONIDIOPHORES mononematous, macronematous, simple, erect, straight, cylindrical, 4–7-septate, smooth and thick-walled, 30–100 × 6–10 µm, dark brown. CONIDIOGENOUS CELLS monotretic, terminal, determinate, brown, 5–10 × 3.5–5.0 µm, markedly thick-walled around the conidiogenous loci. CONIDIA cylindrical, straight, sometimes slightly curved, more or less rounded at the ends, (2–)3–7-septate, with septa thick, smooth-walled, dark brown, 15–48(–59) × 3–4 µm, forming dark brown to black, acropetal, unbranched chains. Teleomorph unknown.

Culture from the holotype: COLONIES on corn meal agar mixed 1:1 with carrot extract, attaining 20–29 mm after 10 days at 25°C, floccose, pale brown. Reverse brown or cream-olivaceous. Hyphae thick-walled, septate, brown, 2–3 µm diam, smooth-walled. CONIDIOPHORES macronematous, cylindrical, multiseptate, smooth, brown, 3–8-septate, up to 160 µm tall, 5–8 µm wide. CONIDIA cylindrical, (2–)4–6-septate, dark brown to brown, smooth-walled, 15–48 × 3–4 µm, dry, blastocatenulate.

Corynesporopsis iberica slightly resembles *C. cylindrica*, but that species is easily differentiated by its shorter cylindrical conidiophores and brown, 1–2-septate, cylindrical, smooth, 12.5–20.5 × 6–7.5 µm conidia. Two other species with 3–5-septate conidia, *C. antillana* and *C. rionensis*, differ from *C. iberica* in shape and pigmentation.

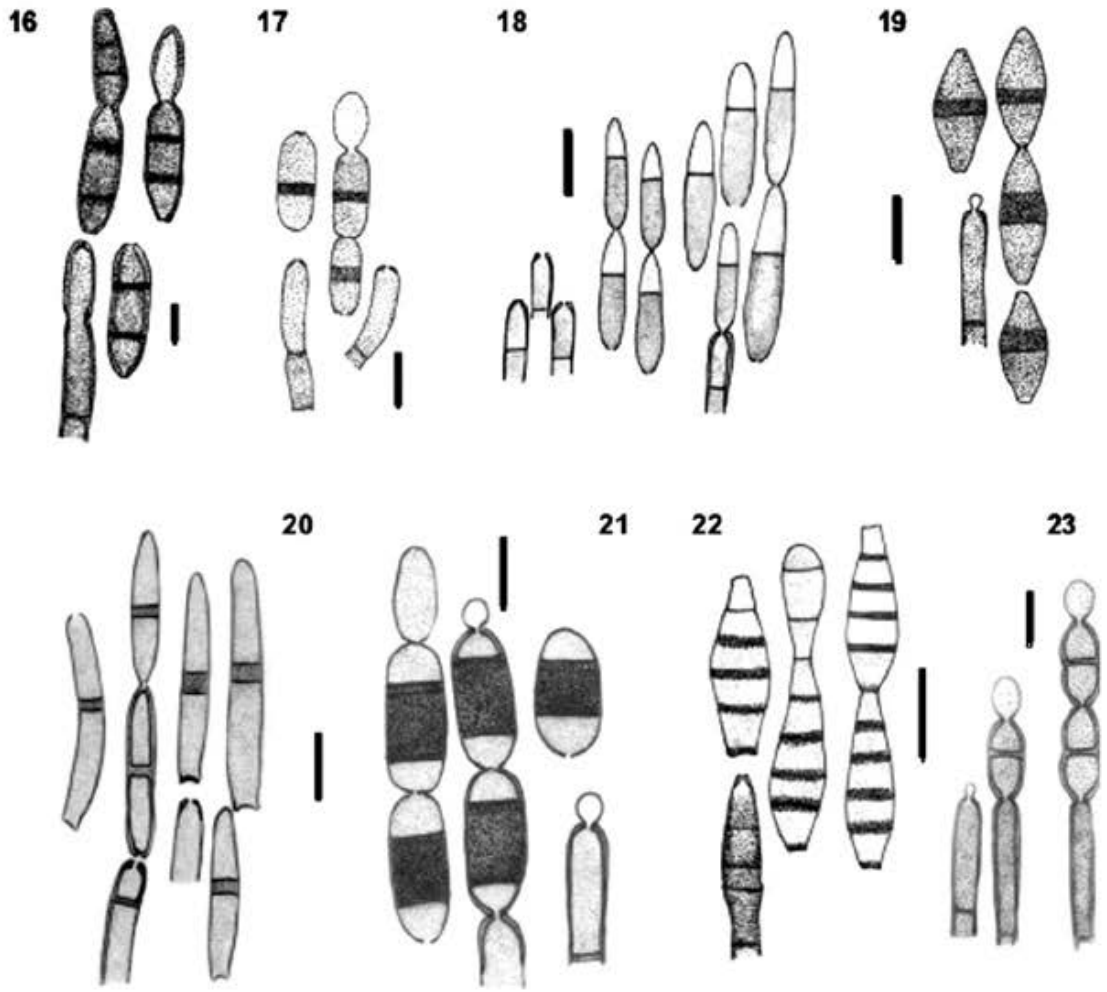
Key to *Corynesporopsis* species

1 Conidia 1-septate 2

Conidia 1-septate, rarely 2-septate, cylindrical, smooth, medium brown, guttulate, 12.5–20.5 × 6.0–7.5 µm ..... (FIG. 17) *C. cylindrica*

Conidia with more than 1 septa 3

2(1) Conidia elongate fusiform or navicular, smooth, brown, with the septum dark and thick, 24–43 × 4–6 µm ..... (FIG. 20) *C. isabelicae*



FIGS. 16–23. *Corynesporopsis* spp., conidiogenous cells and conidia redrawn from the original descriptions. 16. *C. biseptata*. 17. *C. cylindrica*. 18. *C. inaequiseptata*. 19. *C. indica*. 20. *C. isabelicae*. 21. *C. quercicola*. 22. *C. rionensis*. 23. *C. uniseptata*. Scale bars = 10 µm.

Conidia ellipsoid to broadly obovoid, sometimes somewhat biconic, smooth, dark brown to very dark brown, with the septum obscured by a dark band, 14–27 × 8–14 µm ..... (FIG. 19) *C. indica*

Conidia broadly ellipsoid, manifestly constricted at the septum, smooth, brown, often darker at the septum, 12–16 × 5–7 µm ..... (FIG. 23) *C. uniseptata*

Conidia narrowly obclavate, smooth, with brown basal cell and very pale brown apical cell, inequilateral, 17–25 × 4.0–5.5 µm..... ... (FIG. 18) *C. inaequiseptata*

3(1) Conidia usually 2-septate 4

Conidia usually with more than 2 septa.....5

4(3) Conidia broadly ellipsoid to cylindrical, smooth, end cells pale brown, middle cell dark brown, 12–22 × 6–9 µm ..... (FIG. 21) *C. quercicola*

Conidia cylindrical, straight or slightly curved, smooth, pale to mid-brown, with central cell usually slightly longer than end cells, 18–33 × 7–9 µm ..... (FIG. 16) *C. biseptata*

5(3) Conidia fusiform, broad fusiform or ellipsoidal, 3–4(–5)-septate, with septa dark and thick, distinctively truncate at the ends, smooth, brown or dark brown, apical cell pale brown or paler and apical cell of terminal conidium obtuse, 24–36 × 8–11 µm ..... (Fig. 22) *C. rionensis*

Conidia broadly ellipsoidal to navicular, (3–)5(–6)-septate, constricted at the septa, slightly truncate or rounded at the ends, smooth, 3–4 central cells dark brown, septa black, pale brown or colorless at the ends, 21–33 × 5–8 µm ..... (Figs. 9–15) *C. antillana*

Conidia cylindrical, straight, sometimes slightly curved, (2–)3–7-septate, with the septa thick, rounded at the ends, smooth, dark brown, 15–48(–59) × 3–4 µm ..... (Figs. 1–8) *C. iberica*

Acknowledgements

We are deeply indebted to Prof. Lori M. Carris (Washington State University) and Dr. De-Wei Li (The Connecticut Agricultural Experiment Station) for kindly reviewing the manuscript. This study was supported by the Ministry of Science and Innovation of Spain, grant CGL 2008-004226/BOS. We thank the Cuban Ministry of Agriculture for facilities. The author RFCR thanks Drs Uwe Braun, Lori Carris, De-Wei Li, Felipe Wartchow, Antonio Hernández-Gutiérrez, Melissa Mardones, Cony Decock, Shaun Pennycook, Walter Gams, Roland Kirschner, Gabriela Heredia, Rosa M. Arias, Antonio Hernández-Gutiérrez, Xiu Guo Zhang, D. J. Bhat, Mariana Capdet, Andrea I. Romero, Gregorio Delgado, Eric H.C. McKenzie for their generous and valued assistance with literature not otherwise available. We thank Beatriz Ramos, Mercé Moncusí, Mirtha Caraballo for technical assistance. We also acknowledge the facility provided by Dr. P.M. Kirk through the IndexFungorum website.

Literature cited

Castañeda Ruiz RF. 2005. Metodología en el estudio de los hongos anamorfos. 182–183, in: Anais do V Congresso Latino Americano de Micología. Brasilia.

Castañeda Ruiz RF, Heredia Abarca G, Arias Mota RM, Saikawa M, Minter DW, Stadler M, Guarro J, Decock C. 2004. Two new hyphomycetes from rainforest of Mexico, and *Briansuttonia*, a new genus to accommodate *Corynespora alternarioides*. Mycotaxon 89: 297–305.

Castañeda Ruiz RF, Heredia Abarca G, Arias Mota RM, Stadler M, Saikawa M, Minter DW. 2010. *Anaselenosporella sylvatica* gen. & sp. nov. and *Pseudoacrodictys aquatica* sp. nov., two new anamorphic fungi from Mexico. Mycotaxon 112: 65–74.

Figueras MJ, Guarro J. 1988. A scanning electron microscopic study of ascoma development in *Chaetomium malaysiense*. Mycologia 80: 298–306. doi:10.2307/3807625

Kirk PM. 1981. New or interesting microfungi II. Dematiaceous hyphomycetes from Esher Common, Surrey. Trans. Brit. Mycol. Soc. 77: 279–297. doi:10.1016/S0007-1536(81)80031-9

McKenzie EHC. 2010. Three new phragmosporous hyphomycetes on *Ripogonum* from an 'ecological island' in New Zealand. Mycotaxon 111: 183–496.

Morgan-Jones G. 1988. Notes on hyphomycetes. LX. *Corynespora matuszakii*, an undescribed species with narrow, cylindrical, catenate conidia and highly-reduced conidial cell lumina. Mycotaxon 33: 483–487.

Siboe GM, Kirk PM, Cannon PF. 1999. New dematiaceous hyphomycetes from Kenya rare plants. Mycotaxon 73: 283–302.

Siqueira VM, Braun U, Souza-Motta CM, Sutton BC, Pascoe IG. 2008. *Corynespora subcylindrica* sp. nov., a new hyphomycete species from Brazil and a discussion on the taxonomy of *Corynespora*-like genera. Sydowia 60: 113–122.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.417

Volume 114, pp. 417–421 October–December 2010

Taxonomic studies of *Ellisembia* from Hainan, China

JIAN MA, YI-DONG ZHANG, LI-GUO MA,
SHOU-CAI REN & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — Two new species of the anamorphic genus *Ellisembia* were collected from tropical forests in Hainan Province, China. *Ellisembia podocarpi* sp. nov. and *E. photiniae* sp. nov., occurring respectively on dead branches of *Podocarpus imbricatus* and *Photinia parvifolia*, are described and illustrated. They are compared with similar species.

Key words —anamorphic fungi, taxonomy

Introduction

The genus *Ellisembia* was introduced by Subramanian (1992) to accommodate *Sporidesmium*-like species that have determinate or irregularly percurrently extending conidiogenous cells that produce distoseptate conidia. Wu & Zhuang (2005) merged *Imicles* Shoemaker & Hambl. (Shoemaker & Hambleton 2001) into *Ellisembia*, and expanded the generic concept to include typically lageniform, ovoid or doliiform percurrently extending conidiogenous cells. Following the generic concept of Subramanian (1992) and Wu & Zhuang (2005), more than 40 species have been described under *Ellisembia*, most of which are saprobes on rotten wood and dead branches of various plants (Subramanian 1992, McKenzie 1995, 2010, Goh & Hyde 1999, Mena & Delgado 2000, Zhou & Hyde 2001, Wu & Zhuang 2005, Heuchert & Braun 2006, Ma et al. 2008).

The tropical forests of Hainan have a rich mycota, and many wood-inhabiting fungi have been discovered there (Dai & Cui 2006, Zhang et al. 2009, Dai & Li 2010). During an ongoing mycological survey in these forests, numerous conidial fungi were collected on dead branches. Among these were two species having the morphological characteristics of genus *Ellisembia*. They differ

*Corresponding author

significantly from previously described *Ellisembia* species and are therefore proposed as new taxa.

Taxonomy

Ellisembia podocarpi Jian Ma & X.G. Zhang, **sp. nov.** FIGS. 1–4

MycoBank MB 518837

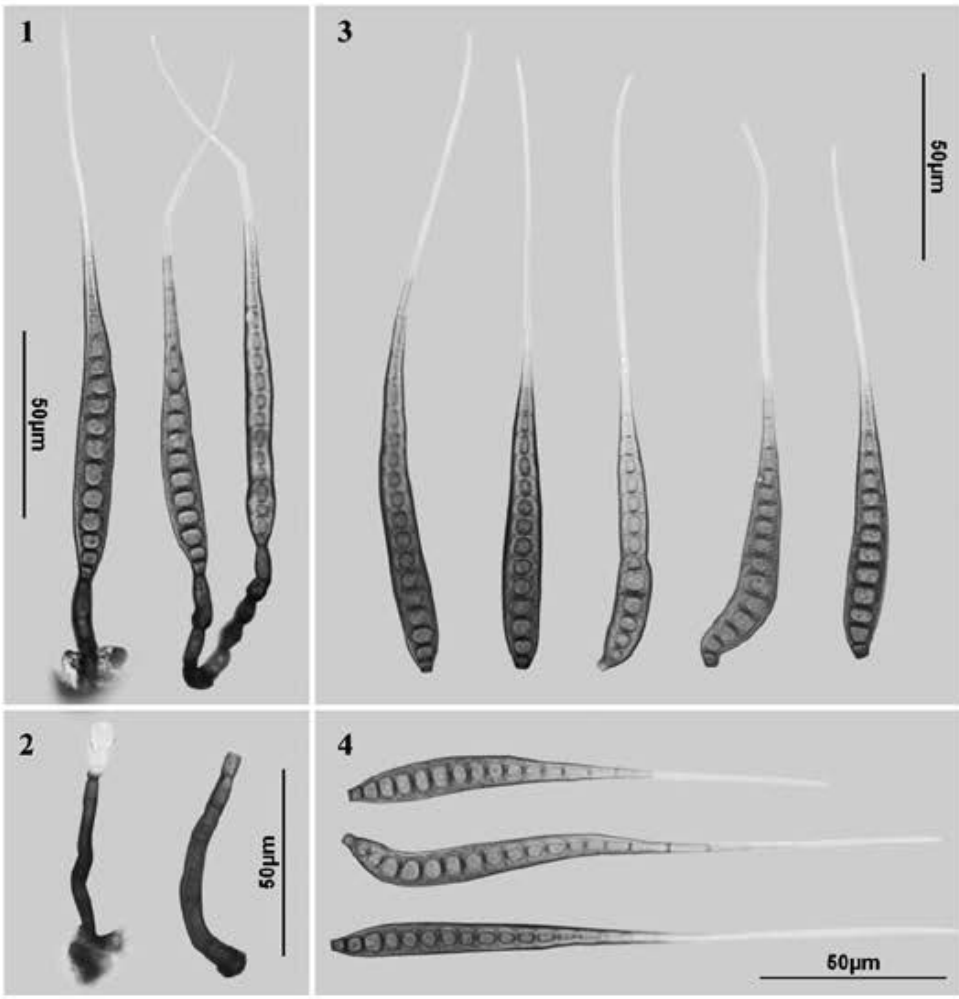
Fungus anamorphicus. Coloniae in substrato naturali effusae, brunneae, pilosae. Mycelium partim superficiale, partim immersum in substrato, ex hyphis ramosis, septatis, pallide brunneis, laevibus, 1.5–3 µm crassis compositum. Conidiophora macronemata, mononematica, singula vel fasciculata, erecta, nonramosa, recta vel flexuosa, cylindrica, brunnea, laevia, septata, 32–65 × 3–5.5 µm. Cellulae conidiogenae monoblasticae, integratae, terminales, lageniformes vel cylindricae, brunneae, laeves, 8–16 × 3–4.5 µm, ad usque 0–3 proliferationes lageniformes vel doliiformes percurrentes. Conidiorum secessio schizolytica. Conidia holoblastica, solitaria, acrogena, recta vel curvata, obclavata, ad longa rostrata, laevia, brunnea vel pallide brunnea, 13–19-distoseptata, 110–170 µm longa (rostro incluso), 7.5–10 µm crassa, basi truncata 2–4 µm lata, cellula apicali versus attenuate, pallide brunnea vel subhyalina, aseptata, laevia, rostro, ad usque 80 µm longo, 1–2.5 µm lato.

Holotype: on dead branches of *Podocarpus imbricatus* Blume (*Podocarpaceae*), tropical forest of Jianfengling, Hainan Province, China. 3 May 2007, J. Ma, HSAUP H5281 (isotype HMAS 146080).

Etymology: in reference to the host genus, *Podocarpus*.

Anamorphic fungi. Colonies on natural substrate effuse, brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown, smooth-walled hyphae, 1.5–3 µm thick. Conidiophores macronematous, mononematous, singly or in groups, erect, unbranched, straight or flexuous, cylindrical, brown, smooth, septate, 32–65 × 3–5.5 µm. Conidiogenous cells monoblastic, integrated, terminal, lageniform or cylindrical, brown, smooth, 8–16 × 3–4.5 µm, with 0–3 lageniform or doliiform percurrent proliferations. Conidial secession schizolytic. Conidia holoblastic, solitary, acrogenous, straight or curved, obclavate to long-rostrate, smooth-walled, brown to pale brown, 13–19-distoseptate, 110–170 µm long (rostrum included), 7.5–10 µm thick in the broadest part, 2–4 µm wide at the truncate base, apex extended into a pale brown to subhyaline, aseptate, smooth, rostrum, up to 80 µm long, 1–2.5 µm wide.

Ellisembia podocarpi is morphologically most similar to *E. filia* W.P. Wu (Wu & Zhuang 2005) and *E. maungatautari* McKenzie (McKenzie 2010), but differs from *E. filia* (conidia 40–50 µm long, 7–9-distoseptate) in having longer conidia with more numerous distosepta, and from *E. maungatautari* (conidia 13–15 µm wide, 17–23-distoseptate) in having narrower conidia with fewer distosepta. In addition, conidiophores of *E. podocarpi* extend percurrently up to 3 times while *E. filia* and *E. maungatautari* conidiophores do not extend.



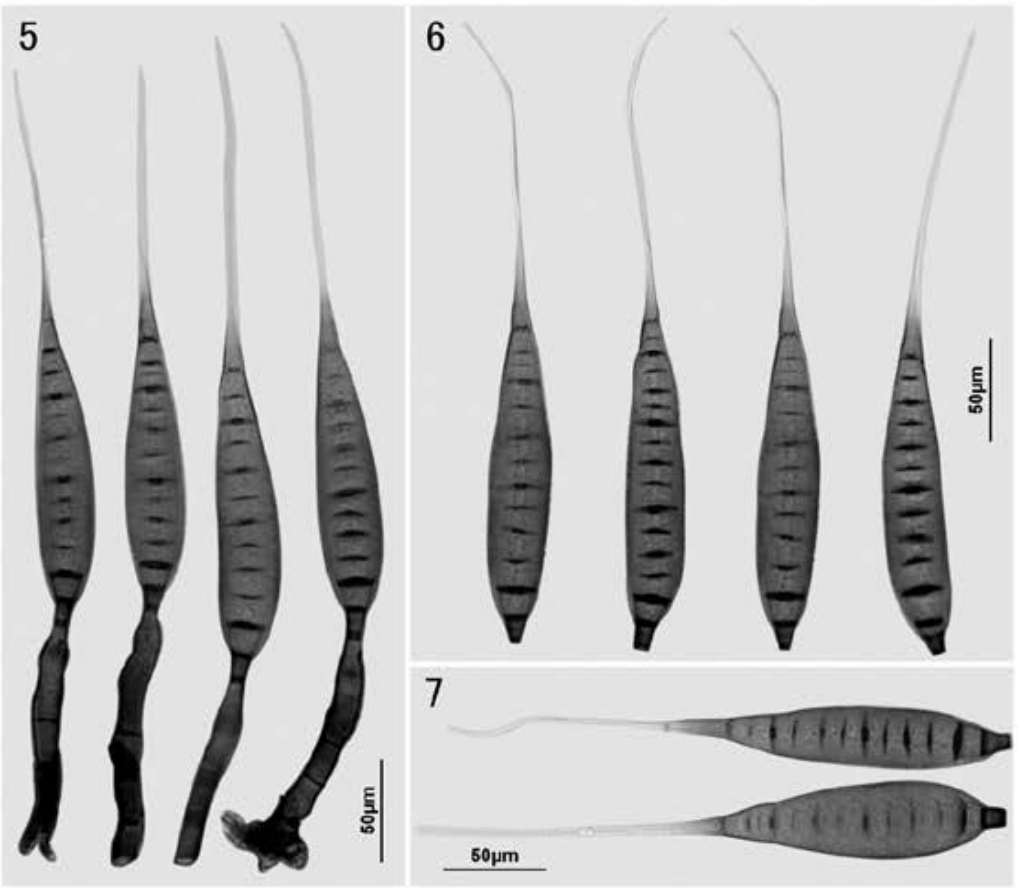
FIGS. 1–4. *Ellisembia podocarpi*. 1, 2. Conidiophores with terminal conidia. 3, 4. Conidia.

Ellisembia photiniae Jian Ma & X.G. Zhang, **sp. nov.** FIGS. 5–7

MYCOBANK MB 518838

Fungus anamorphicus. COLONIAE *in substrato naturali effusae, brunneae, pilosae. Mycelium partim superficiale, partim immersum in substrato, ex hyphis ramosis, septatis, pallide brunneis, laevibus, 1.5–2.5 µm crassis compositum.* CONIDIOPHORA *macronemata, mononematica, singula vel fasciculata, erecta, nonramosa, recta vel flexuosa, cylindrica, brunnea vel atrobrunnea, laevia, septata, 8.5–32 × 5.5–7.5 µm.* CELLULAE CONIDIOGENAE *monoblasticae, integratae, terminales, lageniformes vel cylindricae, brunneae, laeves, 27–30 × 6.5–7.5 µm, ad usque 0–1 proliferationes cylindricaes percurrentes. Conidiorum secessio schizolytica.* CONIDIA *holoblastica, solitaria, acrogena, recta vel leviter curvata, obclavata, ad longa rostrata, laevia, brunnea vel pallide brunnea, 10–16-distoseptata, 92–170 µm longa (rostro incluso), 13–16 µm crassa, basi truncata 3–5 µm lata, cellula apicali versus attenuate, pallide brunnea vel subhyalina, aseptata, laevia, rostro 43–90 × 1–1.5 µm.*

HOLOTYPE: on dead branches of *Photinia parvifolia* C.K. Schneid. (*Rosaceae*), tropical forest of Bawangling, Hainan Province, China. 10 Dec 2009, J. Ma, HSAUP H5189–4 (isotype HMAS 146081).



FIGS. 5–7. *Ellisembia photiniae*. 5. Conidiophores with terminal conidia. 6, 7. Conidia.

ETYMOLOGY: in reference to the host genus, *Photinia*.

Anamorphic fungi. COLONIES on natural substrate effuse, brown, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown, smooth-walled hyphae, 1.5–2.5 µm thick. CONIDIOPHORES macronematous, mononematous, singly or in groups, erect, unbranched, straight or flexuous, cylindrical, brown to dark brown, smooth, septate, 8.5–32 × 5.5–7.5 µm. CONIDIOGENOUS CELLS monoblastic, integrated, terminal, lageniform or cylindrical, brown, smooth, 27–30 × 6.5–7.5 µm wide, with 0–1 cylindrical percurrent proliferations. Conidial secession schizolytic. CONIDIA holoblastic, solitary, acrogenous, straight or slightly curved, obclavate to long-rostrate, smooth-walled, brown to pale brown, 10–16-distoseptate, 92–170 µm long (rostrum included), 13–16 µm thick in the broadest part, 3–5 µm wide at the truncate base, apex extended into a pale brown to subhyaline, aseptate, smooth, rostrum 43–90 × 1–1.5 µm.

Ellisembia photiniae bears some resemblances to *E. filia* (Wu & Zhuang 2005) and *E. maungatautari* (McKenzie 2010) in conidial shape. However, conidia of *E. photiniae* are distinctly larger than those of *E. filia* (conidia 40–50 × 7–8

µm), and shorter than those of *E. maungatautari* (conidia 85–125 µm long). In addition, conidia of *E. photiniae* have 10–16 distosepta, while those of *E. filia* and *E. maungatautari* have 7–9 and 17–23 distosepta, respectively.

Acknowledgments

The authors express gratitude to Dr W.B. Kendrick and Dr R.F. Castañeda Ruíz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (Nos. 30499340, 30770015) and the Ministry of Science and Technology of the People's Republic of China (Nos. 2006FY120100, 2006FY110500–5).

Literature cited

Dai YC, Cui BK. 2006. Two new species of *Wrightoporia* (Basidiomycota, *Aphyllophorales*) from southern China. Mycotaxon 96: 199–206.

Dai YC, Li HJ. 2010. Notes on *Hydnochaete* (*Hymenochaetales*) with a seta-less new species discovered in China. Mycotaxon 111: 481–487. doi:10.5248/111.481.

Goh TK, Hyde KD. 1999. Fungi on submerged wood and bamboo in the Plover Cove Reservoir, Hong Kong. Fungal Diversity 3: 57–85.

Heuchert B, Braun U. 2006. On some dematiaceous lichenicolous hyphomycetes. Herzogia 19: 11–21.

Ma J, Zhang K, Zhang XG. 2008. Two new *Ellisembia* species from Hainan, China. Mycotaxon 104: 141–145.

McKenzie EHC. 1995. Dematiaceous hyphomycetes on *Pandanaceae*. 5. *Sporidesmium* sensu lato. Mycotaxon 56: 9–29.

McKenzie EHC. 2010. Three new phragmosporous hyphomycetes on *Ripogonum* from an 'ecological island' in New Zealand. Mycotaxon 111: 183–196. doi:10.5248/111.183.

Mena-Portales J, Delgado-Rodríguez G, Heredia-Abarca G. 2000. Nuevas combinaciones para especies de *Sporidesmium* sens. lat.. Boletín de la Sociedad Micológica de Madrid 25: 265–269.

Shoemaker RA, Hambleton S. 2001. "*Helminthosporium*" *asterinum*, *Polydesmus elegans*, *Imimyces*, and allies. Canadian Journal of Botany 79(5): 592–599. doi:10.1139/cjb-79-5-592.

Subramanian CV. 1992. A reassessment of *Sporidesmium* (hyphomycetes) and some related taxa. Proceedings of the Indian National Science Academy B 58(4): 179–190.

Wu WP, Zhuang WY. 2005. *Sporidesmium*, *Endophragmiella* and related genera from China. Fungal Diversity Research Series 15: 1–351.

Zhang K, Fu HB, Zhang XG. 2009. Taxonomic studies of *Corynespora* from Hainan, China. Mycotaxon 109: 85–93.

Zhou DQ, Hyde KD, Wu XL. 2001. New records of *Ellisembia*, *Penzigomyces*, *Sporidesmium* and *Repetophragma* species on bamboo from China. Acta Botanica Yunnanica 23(1): 45–51.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.423

Volume 114, pp. 423–428 *October–December 2010*

New records of *Corynesporopsis* from China

JIAN MA, SHOU-CAI REN, LI-GUO MA,
YI-DONG ZHANG & XIU-GUO ZHANG*

zhxg@sdau.edu.cn, sdau613@163.com
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — Three species of *Corynesporopsis* — *C. uniseptata*, *C. quercicola*, and *C. indica* — are recorded for the first time from China. They are described and illustrated from specimens collected on dead branches of unidentified plants. The specimens are deposited in Herbarium of Shandong Agricultural University, Plant Pathology (HSAUP) and Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences (HMAS).

Key words —hyphomycetes, taxonomy

Introduction

Kirk (1981a) established the genus *Corynesporopsis* for the single species previously known as *Corynespora quercicola*. It is characterized by single, differentiated, sometimes percurrent, conidiophores and integrated, terminal, monotretic conidiogenous cells that produce short acropetal chains of ellipsoid to cylindrical euseptate conidia. These characters separate *Corynesporopsis* P.M. Kirk from other similar genera including *Corynespora* Güssow (Güssow 1906), *Corynesporella* Munjal & H.S. Gill (Munjal & Gill 1961), *Hemicorynespora* M.B. Ellis (Ellis 1972), and *Solicorynespora* R.F. Castañeda & W.B. Kendr. (Castañeda & Kendrick 1990). Nine species are currently included in this genus, of which *Corynesporopsis quercicola* and *C. biseptata* (M.B. Ellis) Morgan-Jones were transferred from *Corynespora* (Kirk 1981a,b, 1983, Holubová-Jechová & Mercado 1986, Holubová-Jechová 1987, Morgan-Jones 1988, Sutton 1989, Castañeda Ruíz & Kendrick 1990, Matsushima 1993). Only *Corynesporopsis isabelicae* Hol.-Jech. has previously been reported from China (Lu et al. 2000). Most species are reported to survive saprophytically on dead branches, twigs,

*Corresponding author

and decaying leaves of various plants. During a continuing survey of tropical microfungi from the forests of Hainan Province of southern China, three species of *Corynesporopsis* were collected on dead branches. They are introduced as new records for China.

Taxonomy

Corynesporopsis uniseptata P.M. Kirk, Trans. Br. Mycol. Soc. 77(3): 463 (1981) FIG. 1

SPECIMEN EXAMINED: on dead branches of unidentified plant, tropical forest of Bawangling, Hainan Province, China. 12 Dec 2009, J. Ma, HSAUP H5137 (duplicate HMAS 146082).

FIG. 1. *Corynesporopsis uniseptata*. Conidiophores and conidia.

ANAMORPHIC FUNGI. Colonies effuse, blackish brown to black, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae, 2–4.5 µm wide. Conidiophores differentiated, arising single or in groups on the haphae, erect, straight or flexuous, unbranched, brown, smooth, septate, up to 160 µm long, 3.5–5 µm wide. Conidiogenous cells monotretic, integrated, terminal, determinate, cylindrical, brown, smooth, 16–35 µm long, 4.5–6 µm wide. Conidia acrogenous, dry, in acropetal chains of up to 10, ellipsoid to cylindrical, 1-euseptate, constricted at the septum, smooth, brown, often with darker pigmentation at the septum, 14–21 µm long, 6–8 µm wide in the widest part.

NOTES: *Corynesporopsis uniseptata* is reported for the first time from China. Compared with the morphology of the type specimen described by Kirk (1981b), the conidia of our collection are longer (14–21 µm vs. 12–16 µm) and the conidiophores are also longer (up to 160 µm vs. 60–100 µm), but we believe they are basically the same species. *Corynesporopsis uniseptata* most closely resembles *C. cylindrica* B. Sutton (Sutton 1989) in conidial shape and size range but differs in having didymospores with a median constriction at the septum. Moreover, the conidia of *C. cylindrica* are guttulate while *C. uniseptata* conidia are not.

Corynesporopsis quercicola (Borowska) P.M. Kirk, Trans. Br. Mycol. Soc. 77(2):284 (1981) FIG. 2

≡ *Corynespora quercicola* Borowska, Acta Mycol. 11(1): 60 (1975)

SPECIMEN EXAMINED: on dead branches of unidentified plant, tropical forest of Bawangling, Hainan Province, China. 10 Dec 2009, J. Ma, HSAUP H5082 (duplicate HMAS 146083).

ANAMORPHIC FUNGI. Colonies effuse, blackish brown to black, hairy. Mycelium partly superficial, partly immersed in the substratum, composed of branched, septate, pale brown, smooth-walled hyphae, 2–4.5 µm wide. Conidiophores differentiated, arising single or in groups, erect, straight or flexuous, unbranched, brown to dark brown, smooth, septate, 45–114 µm long, 3–4 µm wide, sometimes once or twice percurrent. Conidiogenous cells monotretic, integrated, terminal, cylindrical, brown, smooth. Conidia acrogenous, dry, in short acropetal chains, broadly ellipsoid to oblong, mainly 2-euseptate, rarely 1-euseptate, sometimes slightly constricted at the septum, smooth, polar cells pale brown, middle cell brown to dark brown, 13–21 µm long, 6–7 µm wide in the widest part.

NOTES: This is the first report of this species in China. The conidia of the specimen examined are somewhat longer (13–21 µm vs. 12–18 µm) than those

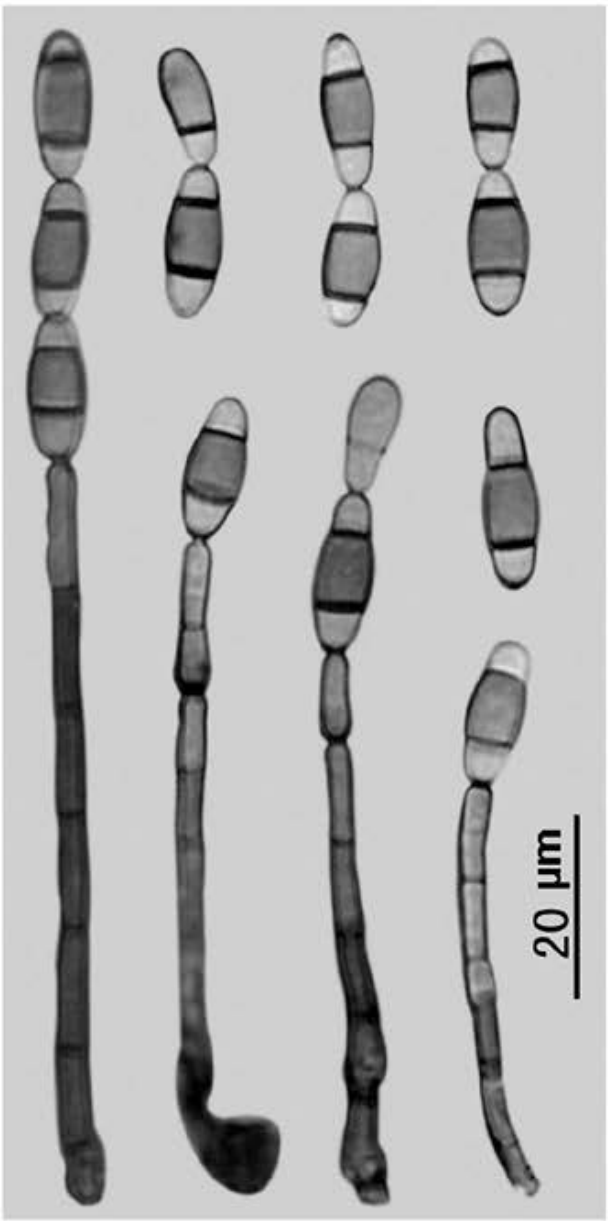


FIG. 2. *Corynesporopsis quercicola*. Conidiophores and conidia.

of the type specimen described by Kirk (1981a). This species has been recorded from Russia, Poland, United Kingdom, and Cuba. *Corynesporopsis quercicola* somewhat resembles *C. biseptata* (Morgan-Jones 1988) in conidial shape and septation but has smaller (13–21 × 6–7 µm vs. 18–33 × 7–9 µm) versicolored conidia.

Corynesporopsis indica P.M. Kirk, Mycotaxon 17: 405 (1983) FIG. 3

SPECIMEN EXAMINED: on dead branches of unidentified plant, tropical forest of Baomeiling, Hainan Province, China. 9 Dec 2009, J. Ma, HSAUP H5274–1 (duplicate HMAS 146084).

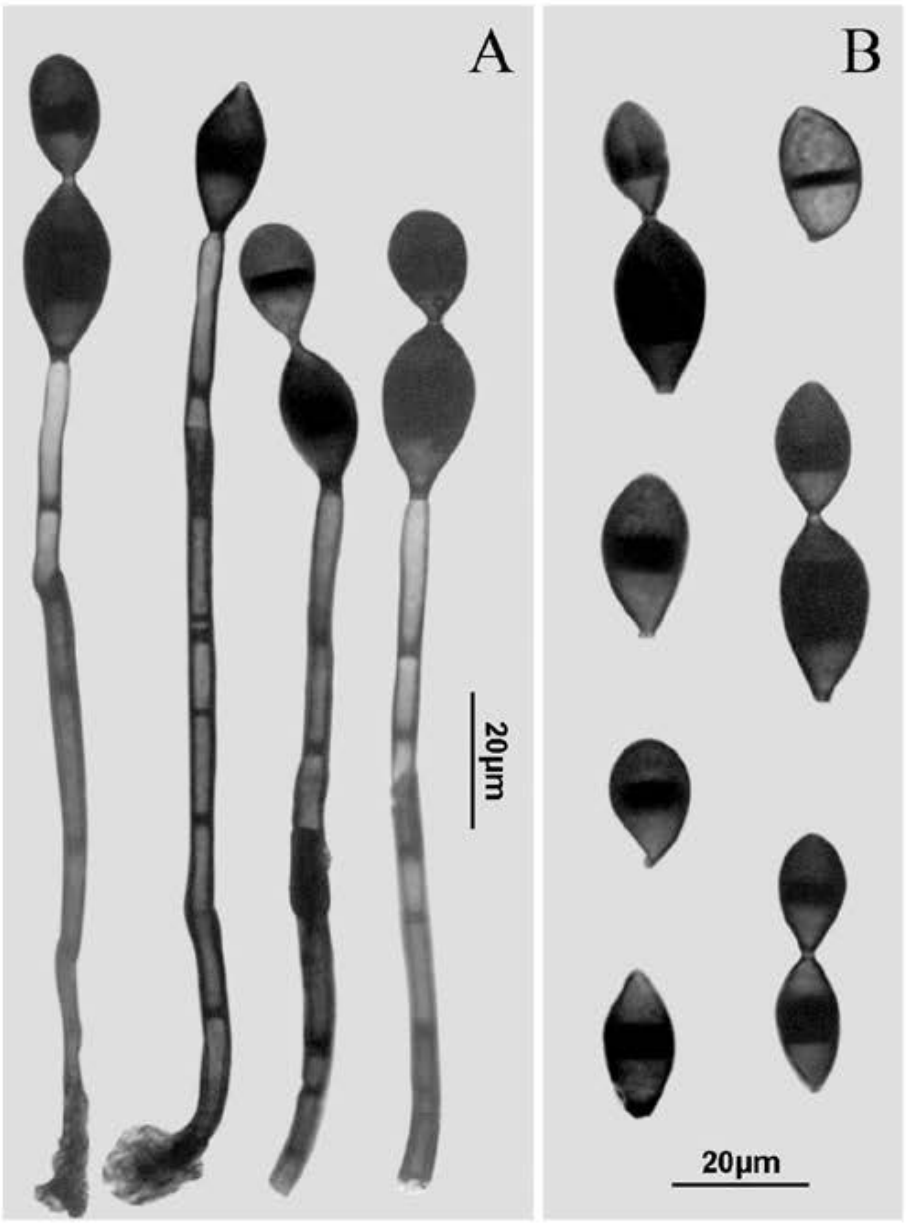


FIG. 3. *Corynesporopsis indica*. A. Conidiophores and conidia. B. Conidia.

ANAMORPHIC FUNGI. Colonies effuse, blackish brown to black, hairy. Mycelium mostly immersed in the substratum, composed of branched, septate, pale brown to brown, smooth-walled hyphae, 1.5–3 μm wide. Conidiophores differentiated, single or in groups, erect, straight or slightly flexuous, unbranched, brown to dark brown, smooth, septate, 67–172 μm long, 3–5.5 μm wide, sometimes swollen at the base. Conidiogenous cells integrated, terminal, monotretic, cylindrical, brown, smooth, sometimes with percurrent proliferation. Conidia acrogenous, dry, solitary or in acropetal chains of 2 or 3, ellipsoid to broadly obovoid, sometimes somewhat biconic, i with one indistinct median euseptum,

the septum usually obscured by a darkly pigmented band, smooth, dark brown to blackish brown, 16–27 µm long, 8–13.5 µm wide in the widest part.

NOTES: This species has not been previously recorded in China. The size range of conidia and conidiophores in our specimen overlaps well with that of the type specimen described by Kirk (1983), and other features of this taxon also match those of the original species. *Corynesporopsis indica* is unique within the genus in its ellipsoid to obovoid, 1-septate conidia with the septum usually obscured by a band of pigment.

Acknowledgments

The authors express gratitude to Dr W.B. Kendrick and Dr R.F. Castañeda Ruíz for serving as pre-submission reviewers and for their valuable comments and suggestions. This project was supported by the National Natural Science Foundation of China (Nos. 30499340, 30770015) and the Ministry of Science and Technology of the People's Republic of China (Nos. 2006FY120100, 2006FY110500–5).

Literature cited

Castañeda Ruíz RF, Kendrick B. 1990. Conidial fungi from Cuba: II. Univ Waterloo Biol Ser 33: 1–61.

Ellis MB. 1972. Dematiaceous hyphomycetes. XI. Mycological Papers 131: 1–25.

Güssow HT. 1906. Über eine neue Krankheit an Gurken in England (*Corynespora mazei*, Güssow gen. et sp. nov.). Zeitschrift für Pflanzenkrankheiten16: 10–13.

Holubová-Jechová V. 1987. Studies on hyphomycetes from Cuba VI. New and rare species with tretic and phialidic conidiogenous cells. Česká Mykologie 41(2): 107–114.

Holubová-Jechová V, Mercado SA. 1986. Studies on hyphomycetes from Cuba IV. Dematiaceous hyphomycetes from the Province Pinar del Rio. Česká Mykologie 40(3): 142–164.

Kirk PM. 1981a. New or interesting microfungi II. Dematiaceous hyphomycetes from Esher Common, Surrey. Transactions of the British Mycological Society 77(2): 279–297. doi:10.1016/S0007-1536(81)80031-9.

Kirk PM. 1981b. New or interesting microfungi III. A preliminary account of microfungi colonizing *Laurus nobilis* leaf litter. Transactions of the British Mycological Society 77(3): 457–473. doi:10.1016/S0007-1536(81)80093-9.

Kirk PM. 1983. New or interesting microfungi VIII. *Corynesporopsis indica* sp. nov.. Mycotaxon 17: 405–408.

Lu BH, Hyde KD, Ho WH, Tsui K., Taylor JE, Wong KM, Yanna, Zhou DQ. 2000. Checklist of Hong Kong Fungi. Fungal Diversity Research Series 5: 1–207.

Matsushima T. 1993. Matsushima Mycological Memoirs No. 7. Published by the author, Kobe, Japan.

Morgan-Jones G. 1988. Notes on hyphomycetes. LVII. *Corynespora biseptata*, reclassified in *Corynesporopsis*. Mycotaxon 31(2): 511–515.

Munjal RL, Gill HS. 1961. *Corynesporella*: a new genus of hyphomycetes. Indian Phytopathology 14(1): 6–9.

Sutton BC. 1989. Notes on deuteromycetes. II. Sydowia 41: 330–343.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.429

Volume 114, pp. 429–437 October–December 2010

Black mildew fungi (*Meliolaceae*) associated with *Schinus terebinthifolius* (Brazilian pepper tree) in Brazil

DAVI M. DE MACEDO[1], DANILO. B PINHO[1], ROBERT W. BARRETO[1*], OLINTO L. PEREIRA[1] & JAMES P. CUDA[2]

*rbarreto@ufv.br

[1]*Departamento de Fitopatologia, Universidade Federal de Viçosa Viçosa CEP 36570-000 Minas Gerais Brazil*

[2]*Biological Weed Control, UF/IFAS Entomology & Nematology Dept Bldg. 970, Natural Area Drive, P.O. Box 110620, Gainesville, FL 32611-0620 USA*

Abstract —*Meliola chilensis, M. rhois* var. *africana,* and *Irenopsis schini-terebinthifolii* sp. nov. are described from the leaves of *Schinus terebinthifolius* (*Anacardiaceae*). Illustrations and a key to all *Meliolaceae* known to associate with species belonging to the genus *Schinus* are provided.

Key words — *Ascomycetes*, Atlantic forest, biodiversity, taxonomy, tropical fungi

Introduction

Schinus terebinthifolius Raddi (*Anacardiaceae*), the Brazilian pepper tree (known in Brazil as "aroeira"), is a small sized plant widely distributed in Brazil, Argentina, and Paraguay. Introduced to many other tropical and sub-tropical regions as an ornamental or spice source, the Brazilian pepper has invaded natural ecosystems and provoked serious disruptions of such natural areas. Now regarded as one of the worst invasive plant species in Florida, Hawaii, and New Zealand (Ferriter 1997), for several decades it has been a target of biological control programs by using insects as its natural enemies (Cuda et al. 2006).

Surveys of and research on fungal pathogens of *S. terebinthifolius* have been only recently initiated in Brazil. A partial result of such surveys published by Faria et al. (2008) has revealed a significant diversity of pathogenic or purported pathogenic fungi associating with *S. terebinthifolius*. Some of these, such as *Septoria* sp., have clear potential for use in biological control of the

Brazilian pepper tree (Faria et al. 2008). The present publication deals with a group of species in the fungal family *Meliolaceae* collected on *S. terebinthifolius*. Although they clearly show no potential for biocontrol, they do represent mycological novelties.

The *Meliolaceae* includes approximately 1980 species, of which most are from the tropics (Kirk 2008). The main genera in this family are *Amazonia* Theiss., *Appendiculella* Höhn., *Asteridiella* McAlpine, *Irenopsis* F. Stevens, and *Meliola* Fr. (Hansford 1961). Meliolaceous fungi produce black colonies on the host surface and hence are known as black mildews. They have little economic importance even when attacking cultivated plants since the disease severity is generally low (Sabulal et al. 2006, Hosagoudar et al. 1997). In some cases, particularly when the host-species is an ornamental plant and black mildew colonies are abundant on it, this may harm the appearance of the plant as reported for *Asteridiella pittieri* (Toro) Hansf. attacking *Duranta repens* L. (Pereira et al. 2006).

Three distinct black mildew taxa were found during the survey of the mycobiota on *S. terebinthifolius*. Even not useful for biocontrol, their potential as scientific novelties justified further investigation. There is an obvious need to broaden the knowledge of the *Meliolaceae* in Brazil, as the group has been largely neglected by Brazilian mycologists and little has been published on this fungal group in Brazil in contrast to the large number of novel taxa in the *Meliolaceae* described from other tropical countries (Crane & Jones 2001, Hosagoudar & Shiburaj 2002, Song & Li 2004, Biju et al. 2005, Rodriguez & Piepenbring 2007).

Materials and methods

The mycobiota on *S. terebinthifolius* was intensively surveyed during two different periods from September 2001 to May 2003, concentrated at first in a small part of southeastern Brazil in areas of the states of Rio de Janeiro, São Paulo, and Minas Gerais and later expanding to include also Espírito Santo, Paraná, Santa Catarina, and Rio Grande do Sul and additional ad hoc collections in the state of Pernambuco from 2008 to 2010. Foliage of *S. terebinthifolius* bearing black mildew colonies was collected, observed while still fresh, and then dried in a plant press. Samples were examined under an Olympus SZX7 stereomicroscope. Representative structures were either scraped with a scalpel or removed with an adhesive tape and mounted in lactophenol. Fungal structures were measured, photographed, and drawn using an Olympus BX 51 light microscope equipped with an Olympus e-volt 330 digital camera and a drawing tube. Representative specimens were deposited in the local herbarium at the Universidade Federal de Viçosa (Herbarium VIC).

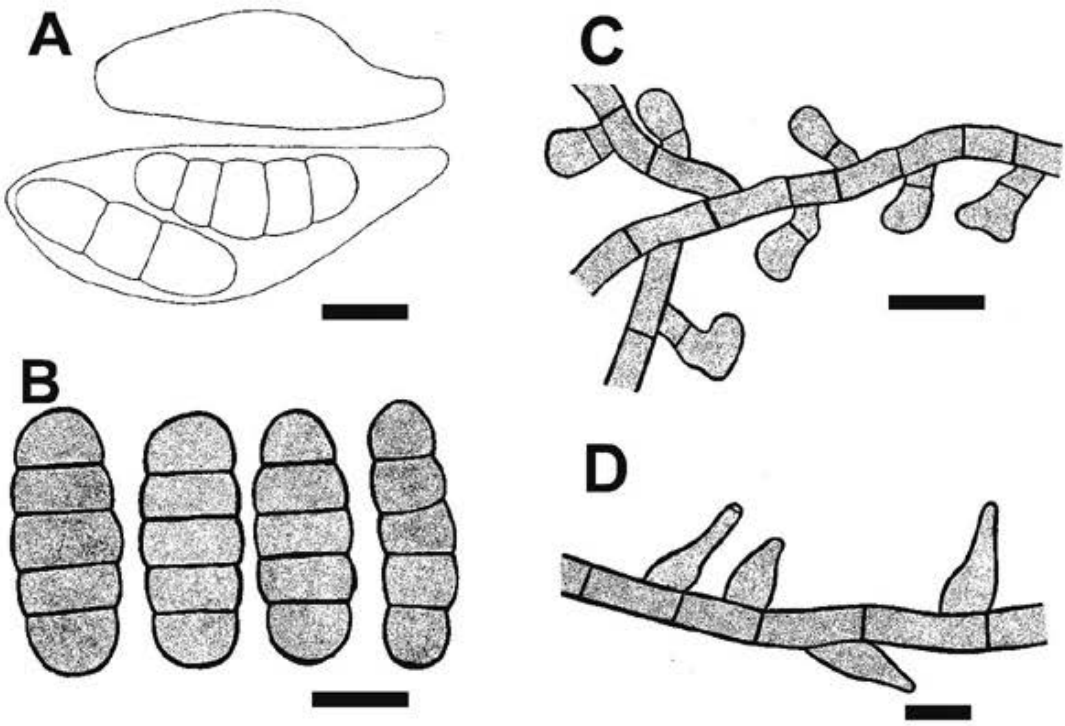


PLATE 1. *Meliola chilensis*. A. Asci and immature ascospores. B. Ascospores. (Bar = 20µm). C. Appressoria on hypha. D. Conidiogenous cells on hypha. (Bar = 20µm).

Taxonomy

Meliola chilensis Speg., Bol. Acad. Nac. Ci. 25: 41 (1921) PLATE 1

SPECIMENS EXAMINATED: on leaves of *Schinus terebinthifolius*, **BRAZIL, Minas Gerais,** Heliodora, 08 July 2008, D.M. Macedo (VIC 31323); São Brás do Suaçuí, 28 October 2009, D.M. Macedo (VIC 31336); Barbacena, 28 October 2009, D.M. Macedo (VIC 31337); **Paraná,** Bacaetava, 09 July 2008, D.M. Macedo (VIC 31322).

Colonies amphigenous, mostly epiphyllous, black, dense, subvelvety, 0.6–2.7 mm diam. Hyphae crooked, composed of dark brown septate hyphae, cells 15–26.5 × 7.5–9 µm, branching alternate to irregular at acute to irregular angles, producing appressoria and conidiogenous cells. Appressoria alternate, sub-antrorse, straight to bent; stalk cells cylindrical to cuneate, brown, 7.5–10 × 7.5–9 µm; head cell cylindric-clavate, straight to bent, entire, sometimes rounded-angulose to sublobate, brown or reddish brown, 14–20 × 13–19 µm. Conidiogenous cells (phialides) borne on a separate mycelia branch, opposite to alternate, ampulliform, brown, 11–15 × 5–7 µm. Mycelial setae numerous, scattered, straight to slightly flexuous, 7–12 septate, simple, apex obtuse, dark brown, 332–550 × 7.5–10 µm. Perithecia in a central group, black, globose, verrucose, 213–345 µm diam. Asci evanescent. Ascospores oblong, hyaline

when inside the ascus, becoming brown with age, rounded at the tips, 4-septate, constricted at the septa, dark brown, 46–52 × 15–20 µm.

ADDITIONAL DESCRIPTION: Hansford (1961: 470).

BRAZILIAN DISTRIBUTION: Paraná and Minas Gerais (Brazil).

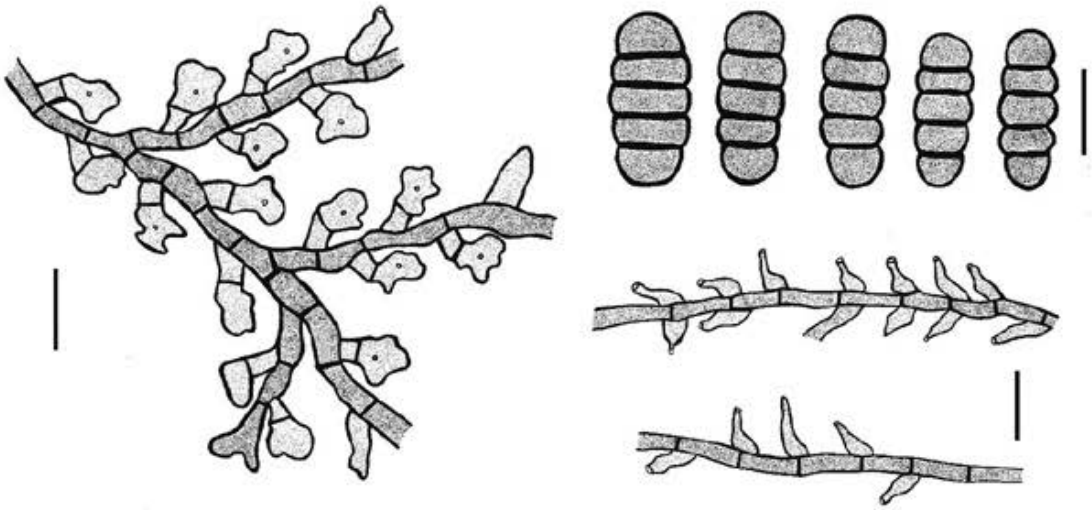


PLATE 2. *Meliola rhois* var. *africana*. A. Ascospores (Bar = 20µm). B. Appressoria on hypha (Bar = 20 µm). C. Conidiogenous cells on hyphae (Bar = 30µm).

Meliola rhois var. ***africana*** Hansf., Sydowia 9: 75, 1955 PLATE 2

SPECIMEN EXAMINED: on living leaves of *Schinus terebinthifolius*, **BRAZIL, Rio de Janeiro,** Mury, 11 April 2008, D.M. Macedo (VIC 31320).

Colonies amphigenous, mostly epiphyllous, black, dense, velvety, cells 3–26 mm diam. Hyphae almost straight to sinuous, composed of dark brown septate hyphae, cells 12.5–25 × 7.5–9 µm, branching usually alternate at acute angles, producing appressoria and conidiogenous cells. Appressoria alternate, more or less antrorse, straight or bent; stalk cells cylindrical to cuneate, brown, 6–10 × 6–7.5 µm, head cell irregularly lobate, versiform, from elongate-clavate to broader than long, straight to variously bent, brown, 12.5–22.5 × 12.5–17.5 µm. Conidiogenous cells (phialides) separate, opposite to alternate, ampulliform, brown, 17.5–25 × 7.5–9 µm. Mycelial setae numerous, scattered, straight, 6–12 septate, simple, apex acute, dark brown, 314–527 × 8.5–10 µm. Perithecia in a central group, black, globose, verrucose, 243–354 µm diam. Asci evanescent. Ascospores oblong to subellipsoid, hyaline when inside the ascus, becoming brown with age, rounded at the tips, 4 septate, constricted at the septa, dark brown, 45–52.5 × 14–19 µm.

ADDITIONAL DESCRIPTION: Hansford (1961: 469).

BRAZILIAN DISTRIBUTION: Rio de Janeiro

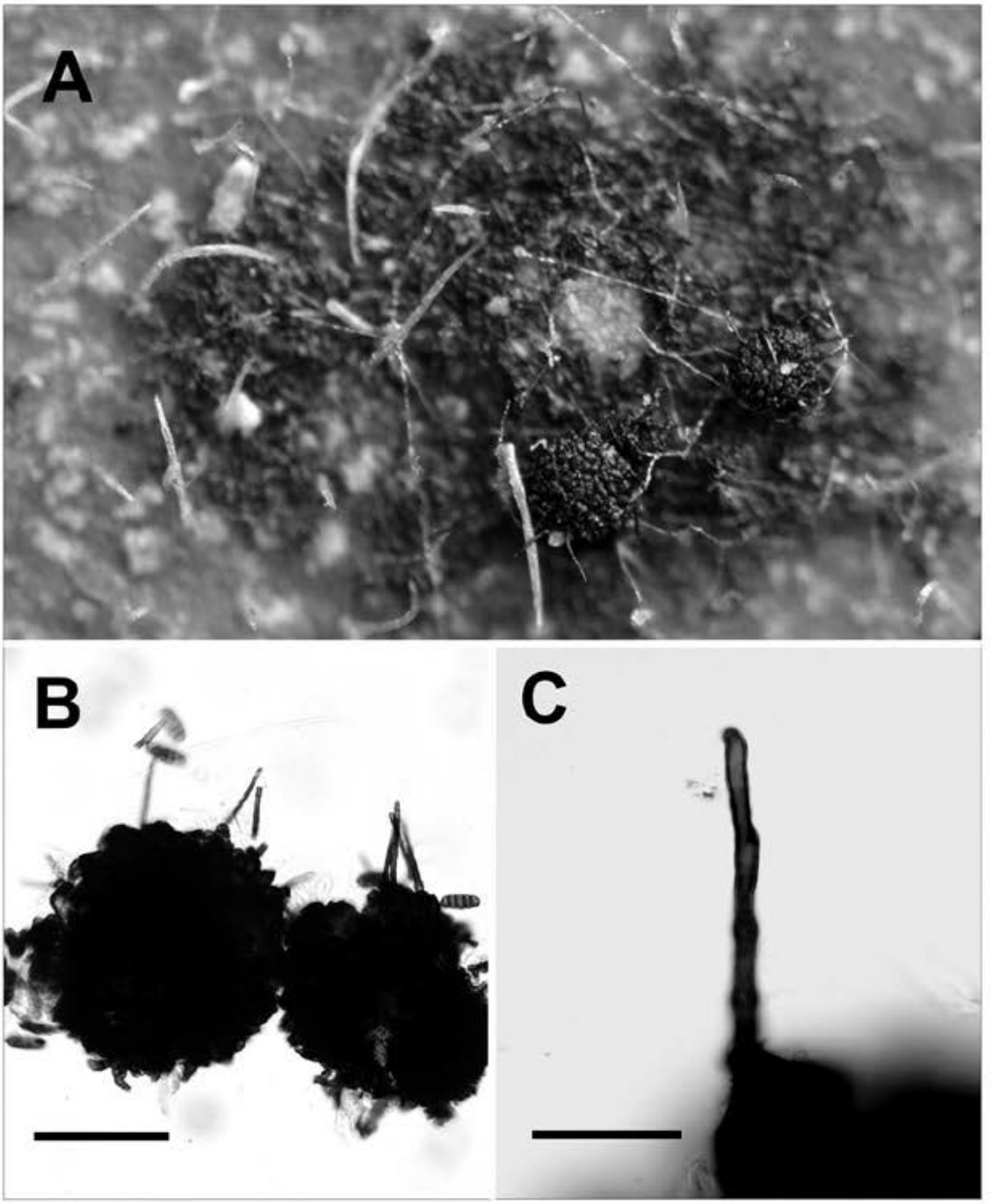


Plate 3. *Irenopsis schini-terebinthifolii.* Plate 3. A. Colony on leaf of *Schinus terebinthifolius.* B. Setose perithecia. C. Close-up of perithecial seta. (Bar = 25 µm).

Irenopsis schini-terebinthifolii D.M. Macedo & R.W. Barreto, **sp. nov.**

MycoBank 18069 Plates 3–4

Differt a I. comocladiae *coloniae 0.4–2.1 cm; cellulae hyphales 15–40 × 7–9 µm. cellulae basalis appressoriis 6–11 × 6–10 µm; cellulae apicalis 12–19 × 11–16 µm. Cellulae conidiogenae oppositae, 19–21 × 6–8 µm. Perithecia 168–300 µm diam; setae peritheciales, 1–2 septatae, 64–140 × 5–7 µm; Ascosporae 40–50 × 15–23 µm.*

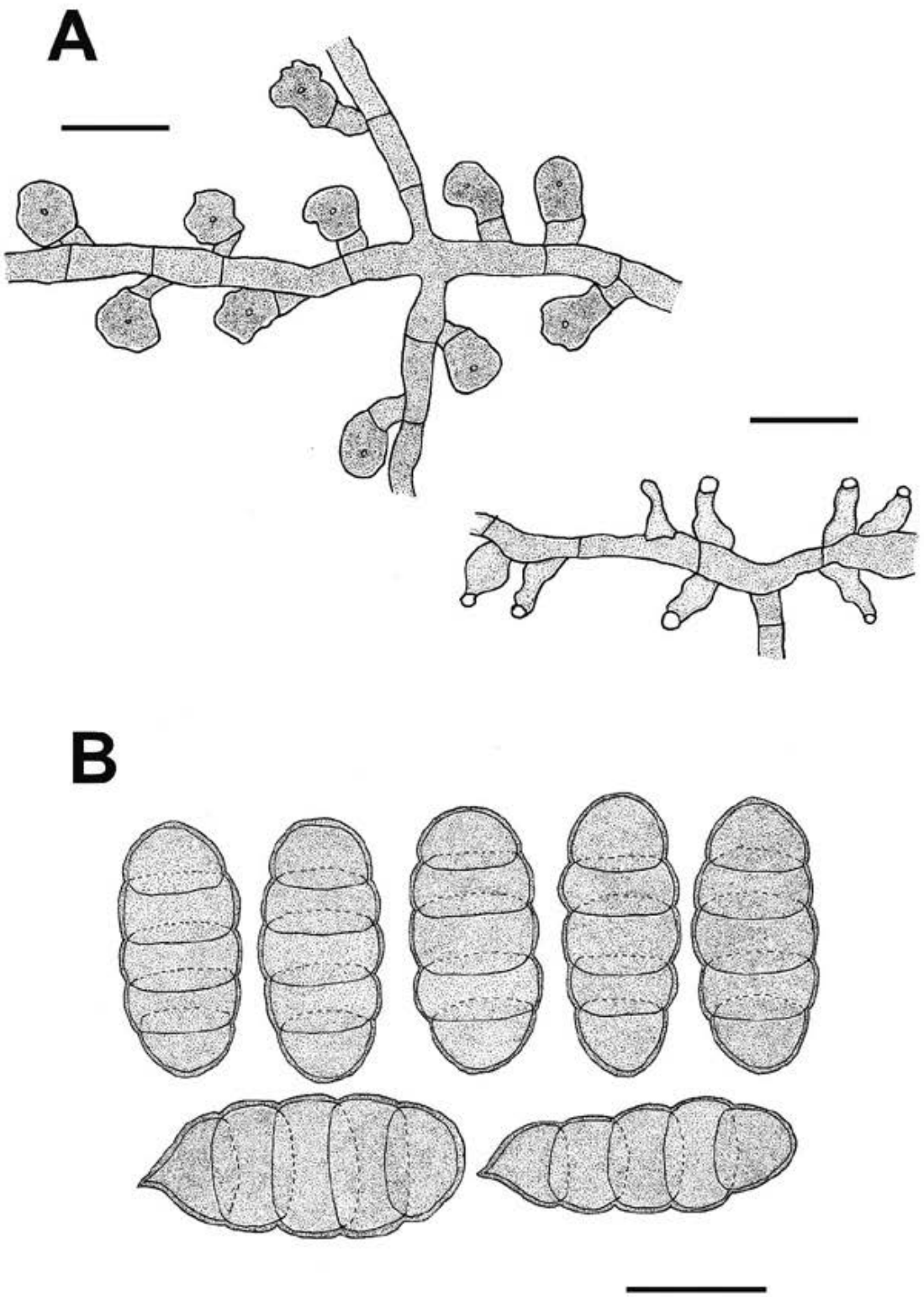


PLATE 4. *Irenopsis schini-terebinthifolii*. PLATE 4. A. Appressoria and conidiogenous cells on hyphae (Bar= 20 µm). B. Ascospores (note two spores bearing pointed cells on left (Bar = 45 µm).

TYPE: on living leaves *Schinus terebinthifolius* (*Anacardiaceae*), D. M. Macedo, Casimiro de Abreu, Rio de Janeiro, Brasil (**holotype** - VIC 31318).

ETYMOLOGY: The epithet refers to the host plant, *Schinus terebinthifolius*

Colonies amphigenous, mostly hypophyllous, confluent, black, dense, scattered, cells 0.4–2.1 mm diam. Hyphae straight, almost straight to undulate, composed of dark brown septate hyphae, cells 15–40 × 7–9 µm, branching opposite at acute or wide angles, producing appressoria and conidiogenous cells. Appressoria alternate, antrorse, bent, 18–30 µm long; stalk cells cylindrical to cuneate, brown, 6–11 × 6–10 µm, head cell irregular, entire to rounded-angulose, brown to reddish brown, 12–19 × 11–16 µm. Conidiogenous cells (phialides) mixed with appressoria, opposite, conoid to ampulliform, brown, 19–21 × 6–8 µm. Perithecial setae straight, 1–2 septate, simple, apex obtuse, dark brown, 64–140 × 5–7 µm. Perithecia black, scattered, globose, 168–300 µm diam. Asci evanescent. Ascospores oblong to subellipsoid, end cells often pointed at apex, hyaline when inside the ascus, becoming brown with age, rounded at the tips, 4-septate, constricted at the septa, dark brown, 40–50 × 15–23 µm.

DISTRIBUTION: Rio de Janeiro and Minas Gerais (Brazil).

ADDITIONAL SPECIMENS EXAMINED: on living leaves of *Schinus terebinthifolius*, **BRAZIL, Rio de Janeiro,** parque Nacional de Jurubatiba, 9 April 2008, D.M. Macedo (VIC 31319); Casimiro de Abreu, 11 April 2009, D.M. Macedo (VIC 31321); **Minas Gerais,** Ponte Nova, 22 August 2008, D.M. Macedo (VIC 31325); Padre Viegas, 22 August 2008, D.M. Macedo (VIC 31326); Catas Altas, 24 August 2008, D.M. Macedo (VIC 31226); Antonio Pereira, 23 August 2008, D.M. Macedo (VIC 31340); Lambari, 23 March 2009, D.M. Macedo (VIC 31334).

COMMENTS – The three meliolaceous fungi collected on *S. terebinthifolius* clearly belong to *Irenopsis* and *Meliola*. The latter is easily separated from *Appendiculella*, *Asteridiella*, and *Irenopsis* by mycelial setae; *Asteridiella* has no setae, *Appendiculella* has perithecia bearing larviform appendages, and *Irenopsis* has setose perithecia (Hansford, 1961).

Forty-two species and 7 infraspecific taxa of *Meliolaceae* are known on members of *Anacardiaceae*. Of these, 38 species and 7 infraspecific taxa belong to *Meliola* (Hansford 1961, Hosagoudar 1996, Hosagoudar & Archana 2009). The following *Meliolaceae* taxa have been reported in association with members of *Schinus*: *Meliola chilensis*, *M. lanigera* Speg., *M. rhoina* Doidge, *M. rhoina* var. *schini* Hansf., *M. rhois* var. *africana* and *M. rhois* var. *lithraeae* Hansf. (Hansford 1961, Mafia et al. 2004, Farr & Rossman 2010, Mendes & Urben 2010). With the exception of *M. chilensis*, all have been reported from Brazil, but only *M. lanigera* was reported in association with *S. terebinthifolius*.

The first fungus described above fits well within the description of *M. chilensis*, a fungus originally known on *Schinus latifolius* (Gillies ex Lindl.) Engl. and *Schinus latifolius* var. *tomentosus* Fenzl from Chile. The second fungus clearly belongs to *M. rhois* var. *africana*, which has been reported on *Rhus glaucescens*

A. Rich. in Uganda and Congo, on *Protorhus longifolia* (Bernh.) Engl. in South Africa, on *Schinus dependens* Ortega in Brazil, and on *Schinus molle* L. in Argentina, Brazil, and Paraguay. Therefore, the two *Meliola* taxa described above represent first reports on *S. terebinthifolius*. There are often more than one species of black mildew associated with plants in the *Anacardiaceae*. For instance, *S. latifolius* is a host for both *M. chilensis* and *M. rhoina* var. *schini*, while *S. dependens* serves as host for *M. lanigera*, *M. rhoina*, and *M. rhois* var. *africana* (Hansford, 1961).

Only two *Irenopsis* species have been described on members of the *Anacardiaceae*: *I. comocladiae* (F. Stevens) F. Stevens and *I. portoricensis* F. Stevens (Hansford 1961, Farr & Rossman 2010, Mendes & Urben 2010). The new specimen referred to *S. terebinthifolius* is the first time an *Irenopsis* species has been reported on a member of the genus *Schinus*. *Irenopsis schini-terebinthifolii* is distinguished from *I. comocladiae* and *I. portoricensis* by its simple and straight perithecial setae, longer cells at the appressoria bases and larger ascospores.

Key to *Meliolaceae* taxa associated with *Schinus* spp.

1. Mycelium not setose ..... *Irenopsis schini-terebinthifolii*
1'. Mycelium setose 2
2. Perithecia dispersed over colony ..... *Meliola rhois* var. *lithraeae*
2'. Perithecia in a central group on colony 3
3. Setae grouped around perithecia ..... *M. rhoina* var. *schini*
3'. Setae scattered over colony 4
4. Setae broadly arcuate to flexuous ..... *M. lanigera*
4'. Setae straight 5
5. Appressoria cylindrical-clavate. ..... *M. chilensis*
5'. Appressoria otherwise 6
6. Ascospores 33–45 × 14–18 µm ..... *M. rhoina*
6'. Ascospores 45–50 × 20–22 µm ..... *M. rhois* var. *africana*

Acknowledgments

This study is part of a DS thesis presented by D.M. Macedo to the Departamento de Fitopatologia/Universidade Federal de Viçosa and was performed with financial support from the University of Florida and the United States Department of Agriculture. The first author acknowledges Fundação de Amparo à Pesquisa de Minas Gerais (FAPEMIG) for the scholarship. R.W. Barreto and O.L. Pereira acknowledge financial support from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). Dr. Virupakshagouda B. Hosagoudar (Tropical Botanic Garden and Research Institute, Palode 695562, Thiruvananthaparum, Kerala, India), and Dr José L. Bezerra

(Universidade Estadual de Santa Cruz, Ilhéus, Bahia, Brazil) for reviewing the manuscript and for their valuable suggestions.

Literature cited

Biju CK, Hosagoudar VB, Abraham TK. 2005. *Meliolaceae* of Kerala, India – XV. Nova Hedwigia 80(3–4): 465–502. doi: 10.1127/0029-5035.

Crane JL, Jones AG. 2001. Nomenclatural and taxonomic revisions in the *Meliolaceae*. Mycotaxon 77: 145–151.

Cuda JP, Ferriter AP, Manrique V, Medal JC. 2006. Florida's Brazilian peppertree management plan: recommendations from the Brazilian pepper Task Force & Florida Exotic Pest Council. 81 p.

Faria ABV, Barreto RW, Cuda J. 2008. Fungal pathogens of *Schinus terebinthifolius* from Brazil as potential biocontrol agents. pp. 270–277 in: Julien MH, Sforza R, Bon MC, Evans HC, Hatcher PE, Hinz HL, Rector BG (eds), XII International Symposium on Biological Control of Weeds, Proceedings of the XII International Symposium on Biological Control of Weeds. Wallingford, CAB International.

Farr DF, Rossman AY. 2010. Fungal Databases, Systematic Mycology and Microbiology Laboratory, ARS, USDA. Available at: http://nt.ars-grin.gov/fungaldatabases/ [Verified 22 February 2010]

Ferriter A. 1997. Brazilian pepper management plan for Florida recommendations from Brazilian pepper task force & Florida pest council. Brazilian pepper task force chairman. 26 p.

Hansford CG. 1961. The *Melioneae*. A Monograph. Beiheth. Sydowia 2: 1–806.

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

Hosagoudar VB, Abraham TK, Krishnan PN, Vijayakumar K. 1997. Biochemical changes in the leaves of ebony tree affected with black mildew. Indian Phytopathology 50: 439–440.

Hosagoudar VB, Shiburaj S. 2002. *Meliola gamsii* sp. nov. (*Ascomycetes*, *Meliolales*) from Kerala, India. Nova Hedwigia 74(3–4): 411–413. doi: 10.1127/0029-5035/2002/0074-0411

Hosagoudar VB, Archana GR. 2009. Host range of meliolaceous fungi in India. Journal of Threatened Taxa 1: 269–282

Kirk PM, Cannon PF, MinterJA, Stalpers JA. 2008. Dictionary of Fungi. 10th ed. Wallingford, UK, CAB International. 771 p.

Mafia RG, Alfenas AC, Andrade GCG, Neves DA, Graça RN, Alonso SK. 2004. Incidência de *Meliola rhoina* como fator limitante à produção de mudas de *Schinus molle* para fins de arborização. Fitopatologia Brasileira 29: 224.

Mendes MAS, Urben AF. 2010. Fungos relatados em plantas no Brasil, Laboratório de Quarentena Vegetal. Brasília, DF: Embrapa Recursos Genéticos e Biotecnologia. Available at: http://pragawall.cenargen.embrapa.br/aiqweb/michtml/fgbanco01.asp [Verified 22 february 2010].

Pereira OL, Soares DJ, Barreto RW. 2006. First report of *Asteridiella pittieri* on golden dewdrop *Duranta repens* var. *aurea* in Brazil. Australasian Plant Disease Notes 1: 17–18. doi:10.1071/DN06008

Rodriguez D, Piepenbring M. 2007. Two new species of *Appendiculella* (*Meliolaceae*) from Panama. Mycologia 99(4): 544–552. doi:10.3852/mycologia.99.4.544

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

Song B, Li TH. 2004. Studies on the genus *Asteridiella* of China 2. Mycotaxon 89(1): 201–204.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.439

Volume 114, pp. 439–451 October–December 2010

Morphology: still essential in a molecular world

KEVIN D. HYDE[1,2], KAMEL ABD-ELSALAM[2,3] & LEI CAI[4*]

** mrcailei@gmail.com*

[1]*School of Science, Mae Fah Luang University, Thasud, Chiang Rai 57100, Thailand*

[2]*King Saud University, College of Science, Botany and Microbiology Department P.O. Box: 2455, Riyadh 1145, Saudi Arabia*

[3]*Agricultural Research Center, Plant Pathology Research Institute Giza, Egypt*

[4]*Key Laboratory of Systematic Mycology & Lichenology, Institute of Microbiology Chinese Academy of Sciences, Beijing 100190, P.R. China*

Abstract — Morphological characters have long served as the basis for mycological taxonomy. But with the advent of DNA sequence data, is morphology still useful? Will barcoding replace visual identification? Taxa in the *Dothideomycetes* serve to illustrate how molecular analyses have revised species relationships and higher-level systematics. *Aspergillus* species are now defined using a polyphasic approach with morphology assuming a lesser role. Sequence analyses likewise reveal that *Colletotrichum* species complexes once considered good morphological species now comprise many phylogenetically distinct species. Although *Phyllosticta* species concepts are less advanced, sequence data are expected to reveal new species in that genus as well. Molecularly supported higher taxa in *Dothideomycetes* often differ from those circumscribed by morphological characters. However, DNA barcodes, recently applauded as a magic formula for species identification, are yet to be determined for many genera, and too many GenBank sequences are wrongly named or contain sequencing errors. Thus, despite recent molecular advances, there is an unprecedented need for mycologists to return to the field, recollect species, and re-typify taxa with living cultures. Only after we obtain sequences from species and genera linked to properly named taxa will barcoding become successful.

Key words — anamorph, molecular phylogenetics, teleomorph, traditional taxonomy, typification

Introduction

Morphology has been the basis of nearly all fungal taxonomic studies. Numerous books and monographs use morphology alone to separate families, genera,

and species. Classical texts such as MARINE MYCOLOGY, THE HIGHER FUNGI (Kohlmeyer & Kohlmeyer 1969), GENERA OF HYPHOMYCETES (Carmichael et al. 1980), and THE COELOMYCETES (Sutton 1980) are archetypal examples. Numerous important higher-level taxonomic texts have also been published using morphology for all class, ordinal, and familial placements. Texts such as A RE-EVALUATION OF THE BITUNICATE ASCOMYCETES WITH KEYS TO FAMILIES AND GENERA (von Arx & Müller 1975) and PRODROMUS TO CLASS *LOCULOASCOMYCETES* (Barr 1987) are classic examples.

Clearly morphology has underpinned taxonomic studies. In many other areas of fungal biology, it is essential to establish correct names and until recently there has been no way to identify a fungus without using morphological characters. Thus most fungal biochemistry, biotechnology, bioremediation, physiology, and plant pathology studies have cited species named after the fungi were identified through morphology (e.g. novel compounds — Evidente et al. 2008; chitinase production — Souza et al. 2003; bioremediation — Launen et al. 1995; physiology of *Colletotrichum graminicola* — Ali 1962; checklist of disease associated microorganisms in northern Australia — Hyde & Alcorn 1993). Similarly, most ecological studies relied on morphology to identify fungal communities (e.g. soil fungi communities — Ali-Shtayeh & Jamous 2000; fungal succession — Duong et al. 2008; endophytes — Hyde & Soytong 2008).

The situation however, is rapidly changing. Monographs of many genera now almost entirely rely on molecular data, and increasingly more often morphology is being replaced by molecular study (e.g. Tejesvi et al. 2007, Aveskamp et al. 2010). Ecological studies may now completely ignore morphology and fungal communities are identified through analysis of environmental DNA (Seena et al. 2008, Curlevski et al. 2010). The identities of fungi used in population genetics, biotechnology, and even biochemical studies are now often checked using sequence data only.

The results of these changes are rarely questioned, let alone discussed, yet most mycologists would agree that these changes should be advantageous. In this paper we explore *Aspergillus, Colletotrichum,* and *Phyllosticta,* genera where sequence data have to some extent profoundly affected species understanding. Below we discuss the effect of sequence data on understanding higher taxonomic levels in the *Dothideomycetes* and illustrate some unsolved problems in the new system. The aim is neither to criticize the studies nor to degrade the outcome, but to point out the resulting changes and confusion so that the mycological community can deliberate how best to manage such changes to everyone's benefit.

Phylogenetic methodology

Sequences were downloaded from GenBank and aligned using Clustal X. The alignment was optimized manually to allow maximum alignment and maximum sequence similarity. Gaps were treated as missing data. Phylogenetic analysis was carried out based on the aligned dataset by PAUP* 4.0b10 (Swofford 2002). Ambiguously aligned regions were excluded from all analyses. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Maxtrees were unlimited, branches of zero length were collapsed, and all multiple parsimonious trees were saved. Trees were figured in TreeView (Page 1996).

Discussion

Aspergillus, Colletotrichum and *Phyllosticta* – the process towards understanding a species

In many genera understanding what delimits a species has typically evolved from 1) a basic and relatively stable morphological concept (possibly including other characters such as cultural, growth rates, or mating), which often comprised species complexes, to 2) molecular revision where the morphological system starts to disintegrate and needs rethinking, and 3) a stabilized system based on molecular data with morphology taking a lesser role. Although eventually taxa may be identified solely using molecular data, in most genera this is decades away.

Aspergillus is advanced with respect to species delineation, mainly because it produces post harvest mycotoxins and valuable industrial chemicals (Geiser et al. 2007, Samson & Varga 2007). There has been a substantial increase in numbers of accepted taxa, with Rapier & Fennell (1965) recognizing 132 species, Geiser et al. (2008) estimating ~250 species, and Kirk et al. (2010) 266 species. Species delineation is based on a polyphasic approach with molecular data taking primary importance (Geiser et al. 2007). Multiple independent loci are now recommended when describing new species, particularly loci for which large datasets already exist, such as ITS, β-tubulin, calmodulin, actin, and RNA polymerase (Samson et al. 2007). All types are available in culture collections (Pitt & Samson 2000). Many species have now been sequenced for multiple genes and the understanding of species concepts in *Aspergillus* is advanced. Whole genomes have also been sequenced for at least eleven strains of nine species, with several others in the pipeline (Geiser et al. 2007; Samson, pers. comm.).

Sutton (1980) provided a practical key to 40 *Colletotrichum* species that provided a basic species identification text. Although often difficult to decide whether to key a fungus to one or another species, the key was convenient and

descriptions brief. Even after 27 years and >4000 *Colletotrichum* publications, Sutton's text served as a necessary and convenient tool for placing names on taxa. The first molecular data on *Colletotrichum* were published after 1990 (e.g. Bailey et al. 1996, Correll et al. 1993, Fabre et al. 1995); although the results were revealing, the data began to complicate species identification (Hyde et al. 2009a, b). There was, however, no attempt to stabilize species concepts in a formal way, so that sequences deposited in GenBank were unknowingly often wrongly named. Not until 2007–2008 were several *Colletotrichum* species epitypified (Shenoy et al. 2007, Cannon et al. 2008), thereby enabling comparisons of reference sequence data against data from fresh collections. This commenced the period of reconciling *Colletotrichum* species, especially in the difficult complexes. Recent studies have introduced 15 new species (most in the "gloeosporioides" species complex), epitypification of 14 *Colletotrichum* species, and generation of sequence data for ex-type cultures of 46 species (Hyde et al. 2009b; Damm et al. 2009; Prihastuti et al. 2009, 2010; Shivas & Yu 2009; Phoulivong et al. 2010; Yang et al. 2009, 2010; Wikee et al. 2011).

FIGURE 1 provides an example of the confusion that molecular data can produce. We generated the phylogram by downloading 41 GenBank ITS sequences, of which 25 were labeled *Colletotrichum gloeosporioides*. In FIG. 1 *C. gloeosporioides* epitype sequences cluster at the top of the tree, while clades containing putative *C. gloeosporioides* strains — some representing very distantly related species —are scattered throughout, illustrating the diversity of one species name in GenBank. Cai et al. (2009a) have estimated that >86% of the *C. gloeosporioides* names in GenBank considerably diverge from the epitype and are likely to represent other *Colletotrichum* species. As *C. gloeosporioides* represents a species complex comprising numerous diverse species, great care must be used when downloading sequences labeled as 'gloeosporioides' from GenBank. Ultimately, only sequence data from the epitype strain should be used to characterize the species.

Compared with *Aspergillus* and *Colletotrichum*, understanding *Guignardia* and its *Phyllosticta* anamorphs is less advanced. *Guignardia* comprises 335 records (Index Fungorum) and has no monograph, although species from various hosts have been reviewed (e.g. palms — Hyde 1995; *Podocarpus* — Crous et al. 1996). Van der Aa & Vanev (2002) accepted 141 species based on cultural and morphological characteristics in their monograph on *Phyllosticta*. As very few living types appear to exist in these genera, Wulandari et al. (2009) compared their new species causing tan spot of pomelo in Asia with many questionably labeled *Phyllosticta* sequences from GenBank. D.M. Lam & N. Wulandari (unpublished) also sequenced many *Guignardia* and *Phyllosticta* strains from CBS, but as few represented type strains, their conclusions were limited and may never be published. There is a need to designate epitypes

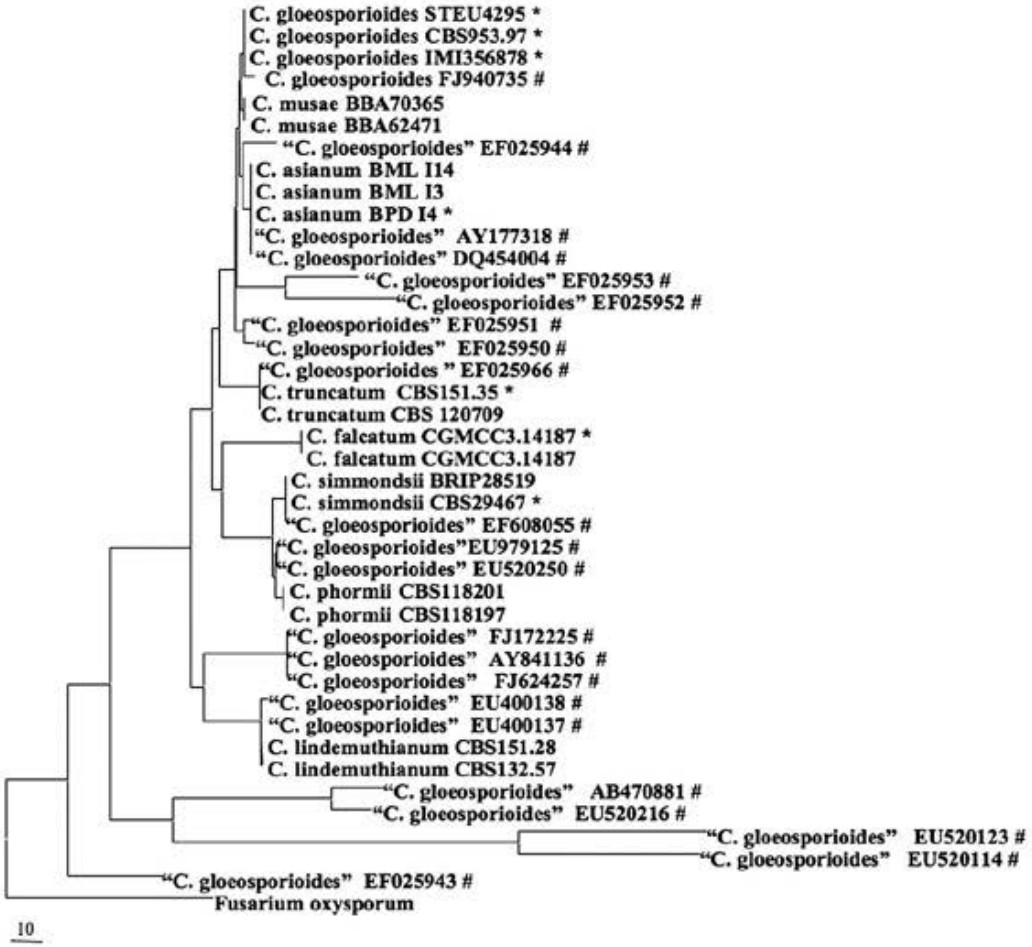


FIG. 1. Maximum parsimony phylogram generated from ITS sequence analysis of "*Colletotrichum gloeosporioides*" downloaded from GenBank with other related taxa. Data were analysed with random addition sequence, unweighted parsimony, and treating gaps as missing data. # indicates ITS sequences of "*Colletotrichum gloeosporioides*" downloaded from GenBank; * indicates sequences derived from ex-type cultures.

for species of *Phyllosticta* and the teleomorph *Guignardia*, so that a clear understanding of the status of species and their biological relationships can be obtained.

Guignardia mangiferae A.J. Roy offers a second example of confusion resulting from molecular data (FIG 2). This name has been extensively applied to an endophyte isolated by Rodrigues et al. (2004); many putative *G. mangiferae* strains were used by Wulandari et al. (2009). However, no type of *G. mangiferae* can be found (Wulandari, pers comm.) nor has it ever been epitypified. Thus this recent name has been used arbitrarily for endophytic strains producing obtrullate ascospores. The obtrullate ascospore type, however, can be found in numerous species (e.g. *G. eucalyptorum* Crous, *G. smilacis* A.J. Roy, *G. graminea* Lobik) and most likely comprises a species complex that could

have a much older name. In FIG. 2 we downloaded a selection of *G. mangiferae* labeled strains from GenBank to illustrate the diversity the name represents. It is therefore unwise to name a *Guignardia* or *Phyllosticta* species based solely on sequence similarity with a GenBank sequence.

The above examples serve to illustrate how molecular data can resolve species understanding in some plant pathogenic genera yet pose challenges in interpretation. We should remember that many previous studies likely applied incorrect names to their organisms. Type cultures must be sequenced, and where no such cultures exist, fresh collections are needed. Both type cultures and fresh collections should be fully characterized using morphology, sequence analyses, and other polyphasic approaches. Only by using such methods can we begin to understand genera and their individual species complexes. Such understanding now exists for *Aspergillus* and *Penicillium*, is advanced in *Fusarium*, is progressing in *Colletotrichum*, and has only begun in *Guignardia*/*Phyllosticta* and *Pestalotiopsis*. The simple message is that although molecular data may eventually identify taxa in these genera, an enormous concerted effort is needed to recollect, morphologically characterize, epitypify, sequence, analyze, and combine all data with other polyphasic characters before we will make any real progress in understanding species in these important genera. It is also suggested that NCBI should rename an entry if there are sufficient evidences supporting to do so.

The *Loculoascomycetes*

AFTOL (All Fungi Tree of Life) aimed to find natural classifications for fungi based on multi-locus phylogeny, rather than visual, relationships (Schoch et al. 2006). The project made considerable progress towards understanding fungi at the higher levels, particularly in the basidiomycetes. Classes of fungi are similarly better resolved in the ascomycetes, although the *Dothideomycetes* offer a good example where molecular analyses have resulted in uncertainty, especially at the family level.

The issue of STUDIES IN MYCOLOGY (Schoch et al. 2009) devoted to the *Dothideomycetes* resolved many problems at the higher taxonomic levels (order, family) but may have created more confusion than intended. What classical mycologists such as J.A. von Arx, E. Müller, and M.E. Barr previously considered to be orders and families and the characters they used to diagnose such (von Arx & Müller 1975; Barr 1987) are, in many cases, no longer usable. Unfortunately, although molecular data can place taxa at the family and in some cases generic levels, there has been little effort made in attempting to correlate phylogeny with phenotypes (Suetrong et al. 2009, Zhang et al. 2009a).

For example, the *Lophiostomataceae* and *Trematosphaeriaceae* cluster as separate families and contain elements that can be linked by very few characters

FIG. 2. Maximum parsimony phylogram generated from ITS sequence analysis of "*Guignardia mangiferae*" downloaded from GenBank with other related taxa. Data were analysed with random addition sequence, unweighted parsimony, and treating gaps as missing data. # indicates ITS sequences of "*Guignardia mangiferae*" downloaded from GenBank; * indicates sequences derived from ex-type cultures.

— the same characters found in other families. The *Lophiostomataceae* include *Lophiostoma,* some species placed in *Thyridaria,* and a new genus *Misturatosphaeria* (Mugambi & Huhndorf 2009; Zhang et al. 2009a,b). *Lophiostoma* species are characterized by ascomata that are erumpent with slot- or slit-like ostioles and may have raised flanges (Holm & Holm 1988), while in *Misturatosphaeria* ascomata are erumpent to superficial with often raised rounded apices and ascospores are phragmosporous or dictyosporous (Mugambi & Huhndorf 2009). Dictyosporous ascospore types are found throughout the

Dothideomycetes but not — until now — within *Lophiostomataceae*. At the moment, there is a distinct lack of defining characters that can be used for this family. Mugambi & Huhndorf (2009) themselves state, "despite morphological differences of *Misturatosphaeria* from other lophiostomataceous fungi, we feel justified in placing it in *Lophiostomataceae* at this point due to the strong support received in their analysis."

Tetraplosphaeriaceae (Tanaka et al. 2009) is basal to most families in *Pleosporales* and yet previous classification systems would have probably placed the species in *Astrosphaeriella* (Hyde et al. 2000). The main distinguishing characters of the family are the *Tetraploa*-like anamorphs; however the ascomata (immersed or superficial), pseudoparaphyses (cellular or trabecular), and ascospore (fusiform to cylindrical, 1–3-septate, hyaline or pale brown) forms are found throughout the *Dothideomycetes*. Therefore if a researcher encounters the teleomorph stage only, it would be difficult to use morphology to place the taxon, even at the family level, unless the characters are identical to an existing species in the literature.

In other groups in the *Dothideomycetes* there are so few sequences available that phylograms reveal very little information concerning the species at any level. This is true of taxa in the *Capnodiaceae* and *Microthyriaceae* and in numerous genera (e.g *Muyocopron*, *Trichodelitschia*) (see Boehm et al. 2009, Schoch et al. 2009).

What is the way forward? Many sequences used in the issue of STUDIES IN MYCOLOGY on the *Dothideomycetes* are linked to cultures from poorly documented taxa while only a few are linked to type material. This will create doubt in the minds of readers because generic types must be used in such analyses. Again, a concerted effort is needed to recollect, document characters, isolate, and deposit herbarium materials and/or living cultures. In this way we will have accurately documented morphological characters that are linked to sequence data of accurately named species; only then can we confidently start to understand relationships in *Dothideomycetes* and be confident in the conclusions arising from combined morphological and molecular classifications.

Linking anamorphs to teleomorphs

There has been much expectation amongst mycologists that molecular analyses of anamorphic fungi will be able to link them to teleomorphs or at least provide an idea of their positions in the *Ascomycota* (Shenoy et al. 2006, 2007). Several studies have shown that morphological characters traditionally used to delimit anamorphic fungi are less informative in inferring fungal phylogenies. For example, in traditional taxonomy morphologically well-defined genera such as *Chalara* and *Sporidesmium* appear to be highly polyphasic (Shenoy et al. 2006, Cai et al. 2009b). Re-evaluation of the evolutionary significance of anamorphic

characters should therefore be carried out to 'rebuild' morphological classification. Morphology will then once again become important for identifying species, provided type specimens and derived cultures have been used in the reconstruction. If unavailable, the fungus should be interpreted by a freshly collected material from original hosts and localities, accurate documentation, isolation, sequencing, and deposition in herbaria as epitypes with living ex-type cultures. Only in this way will an accurate understanding of the natural placement of anamorphs in the teleomorphic scheme be achieved.

Barcoding and GenBank difficulties and solutions

There are important initiatives to barcode the fungi (Santamaria et al. 2009, Seifert 2009). However, we feel that the benefit gained from large scale sequencing of fungal isolates will be diluted if sequence data from too few properly named taxa or types are deposited in public databases. As illustrated by Figs 1–2, the lack of sequences with reliably applied names in public databases would make barcoding currently unworkable. This deficiency must be corrected at the same time as barcoding takes place. As the type specimens and derived type cultures are not always available, there needs to be a concerted effort by mycologists to go back to the field and recollect the fungi. Taxonomic experts must carefully name those fungi and where possible designate epitypes with derived living cultures. Once we obtain sequences from species and genera that are linked to properly characterized taxa, we can really start to understand the fungi. Only then will barcoding work. These approaches will be useful in a few fungal studies as data obtained from molecular analysis of environmental samples, linking of anamorphs and teleomorphs, and the proper naming of species in biochemistry, pathology, and biotechnology research publications become precise.

Concluding remarks

Fungal systematics has irreversibly stepped into the phylogenetics era. Molecular diagnosis through barcoding is favored by most researchers because it seemingly provides an easy and quick assessment of the fungus at hand and does not require years of training. This, however, does not exclude morphology from modern systematics, as morphological characters are the most easily accessible. The characters used to define species, genera, families, and orders nonetheless need reevaluation in light of sequence generated phylogenetic relationships. Morphological characters would then be used in agreement with new classification schemes and thus correspond to the natural phylogeny. The success of molecular diagnosis and barcoding, however, largely depends on comparing sequence data from type specimens. Most fungal names lack living type specimens and cannot be sequenced. There is consequently an

urgent need to epitypify all such fungi and deposit living ex-type cultures and derived sequence data in public culture collections and databases. Mycologists must go back to field and recollect important species and generic types and re-characterize these taxa using a polyphasic approach. Incorporating morphology is essential for establishing species concepts and higher taxonomic frameworks. Until much more data has been generated from types and many more accurately named species are deposited in public databases, confusion will remain. To eliminate the confusion, morphology is not only not outdated but is a necessity.

Acknowledgements

This study was supported by research grants 51101010029 and 52101010002 awarded by Mae Fah Luang University Chiang Rai, Thailand and a research grant Biodiversity Research and Training Program (BRT R253012) and The Thailand Research Fund (BRG 5280002), which are gratefully acknowledged. This research was also funded by the Knowledge Innovation Program of the Chinese Academy of Sciences, No. KSCX2-YW-Z-1026 and National Natural Science Foundation of China (NSFC 31070020). Damodar Shenoy, Edward Liew, and Zhang Ying, plus many other students of the first author are thanked for providing inspiration and ideas for the opinions stated in this paper. Dimuthu Manamgoda is thanked for technical assistance. Drs. Lorelei L. Norvell, Richard P. Korf, and Shaun Pennycook are thanked for their critical reviews of this manuscript and providing valuable comments.

Literature cited

Ali MM. 1962. Comparison of the physiology of three isolates of *Colletotrichum graminicola*. Mycopathologia et Mycologia Applicata 17: 261–268. doi:10.1007/BF02279299

Ali-Shtayeh MS, Jamous RMF. 2000. Keratinophilic fungi and related dermatophytes in polluted soil and water habitats. Revista Iberoamericana de Micologia 17 (Suppl.): 51–59.

Arx JA von, Müller E. 1975. A re-evaluation of the bitunicate ascomycetes with keys to families and genera. Stud. Mycol. 9: 1–159.

Aveskamp MM, Gruyter J de, Woudenberg JHC, Verkley GJM, Crous PW. 2010. Highlights of the *Didymellaceae*: A polyphasic approach to characterise *Phoma* and related pleosporalean genera. Stud. Mycol. 65: 1–60. doi:10.3114/sim.2010.65.01

Barr ME1987. Prodromus to Class *Loculoascomycetes*. M.E. Barr Bigelow, Amherst, Massachusetts.

Bailey JA, Nash C, Morgan LW, O'Connell RJ, TeBeest DO. 1996. Molecular taxonomy of *Colletotrichum* species causing anthracnose on the Malvaceae. Phytopathology 86: 1076–1083. doi:10.1094/Phyto-86-1076

Boehm EWA, Mugambi GK, Miller AN, Huhndorf SM, Marincowitz S, Spatafora JW, Schoch C. 2009. A molecular phylogenetic reappraisal of the *Hysteriaceae*, *Mytilinidiaceae* and *Gloniaceae* (*Pleosporomycetidae, Dothideomycetes*) with keys to world species. Stud. Mycol. 64: 49–83. doi:10.3114/sim.2009.64.03

Cai L, Hyde KD, Taylor PWJ, Weir B, Waller J, Abang MM, Zhang JZ, Yang YL, Phoulivong S, Liu ZY, Prihastuti H, Shivas RG, McKenzie EHC, Johnston PR. 2009a. A polyphasic approach for studying *Colletotrichum*. Fungal Divers. 39: 183–204.

Cai L, Wu WP, Hyde KD. 2009b. Phylogenetic relationships of *Chalara* and allied species inferred from ribosomal DNA sequences. Mycological Progress 8: 133–143. doi:10.1007/s11557-009-0585-5

Cannon PF, Buddie AG, Bridge PD. 2008. The typification of *Colletotrichum gloeosporioides*. Mycotaxon 104: 189–204.

Carmichael JW, Kendrick WB, Corners IL, Sigler L1980. Genera of Hyphomycetes. University of Alberta Press

Correll JC, Rohoads, DD, Guerber JC. 1993. Examination of mitochondrial DNA restriction fragment lengh polymorphisms, DNA fingerprints, and randomly amplified polymorphic DNA of *Colletotrichum orbiculare*. Phytopathology 83: 1199–1204. doi:10.1094/Phyto-83-1199

Crous PW, Seifert KA, Castañeda Ruiz RF. 1996. Microfungi associated with *Podocarpus* leaf litter in South Africa. S. Afr. J. Bot. 62 : 89–98.

Curlevski NJA, Xu ZH, Anderson IC, Cairney JWG. 2010. Diversity of soil and rhizosphere fungi under *Araucaria bidwillii* (Bunya pine) at an Australian tropical montane rainforest site. Fungal Divers. 40: 1–11. doi:10.1007/s13225-009-0001-0

Damm U, Woudenberg JHC, Cannon PF, Crous PW. 2009. *Colletotrichum* species with curved conidia from herbaceous hosts. Fungal Divers. 39: 45–87.

Duong LM, McKenzie EHC, Lumyong S, Hyde KD. 2008. Fungal succession on senescent leaves of *Castanopsis diversifolia* in Doi Suthep-Pui National Park, Thailand. Fungal Divers. 30: 23–36.

Evidente A, Cimmino A, Andolfi A, Vurro M, Zonno MC, Motta A. 2008. Phyllostoxin and phyllostin, bioactive metabolites produced by *Phyllosticta cirsii*, a potential mycoherbicide for *Cirsium arvense* biocontrol. J. Agr. Food Chem. 56: 884–888. doi:10.1021/jf0731301

Fabre JV, Julien J, Parisot D, Dron M. 1995. Analysis of diverse isolates of *Colletotrichum lindemuthianum* infecting common bean using molecular markers. Mycol. Res. 99: 429–435. doi:10.1016/S0953-7562(09)80640-0

Geiser DM, Klich MA, Frisvad JC, Peterson SW, Varga J, Samson RA. 2007. The current status of species recognition and identification in *Aspergillus*. Stud. Mycol. 59: 1–10. doi:10.3114/sim.2007.59.01

Geiser DM, Samson RA, Varga J, Rokas A, Witiak SM. 2008. A review of molecular phylogenetics in *Aspergillus*, and prospects for a robust genus-wide phylogeny. In: Varga J, Samson RA (eds) *Aspergillus* in the Genomic Era. Netherlands: Wageningen Academic Publishers. 17–32.

Holm L, Holm K. 1988. Studies in the *Lophiostmataceae* with emphasis on the Swedish species. Symbolae Botanicae Upsalienses 28: 1–50.

Hyde KD. 1995. Fungi from palms. XX. The genus *Guignardia*. Sydowia 47: 180–198.

Hyde KD, Alcorn JL. 1993. Some disease-associated microorganisms on plants of Cape York Peninsula and Torres Strait Islands. Australian Plant Pathol. 22: 73–83. doi:10.1071/APP9930073

Hyde KD, Soytong K. 2008. The fungal endophyte dilemma. Fungal Divers. 33: 163–173.

Hyde KD, Aptroot A, Fröhlich J, Taylor JE. 2000. Fungi from palms. XLIII. *Lophiostoma* and *Astrosphaeriella* species with slit-like ostioles. Nova Hedwigia 70: 143–160.

Hyde KD, Cai L, McKenzie EHC, Yang YL, Zhang JZ, Prihastuti H. 2009a. *Colletotrichum*: a catalogue of confusion. Fungal Divers. 39: 1–17.

Hyde KD, Cai L, Cannon PF, Crouch JA, Crous PW, Damm U, Goodwin PH, Chen H, Johnston PR, Jones EBG, Liu ZY, McKenzie EHC, Moriwaki J, Noireung P, Pennycook SR, Pfenning LH, Prihastuti H, Sato T, Shivas RG, Taylor PWJ, Tan YP, Weir BS, Yang YL, Zhang JZ. 2009b. *Colletotrichum* – names in current use. Fungal Divers. 39: 147–182.

Kirk PM, Cannon PF, David JC, Stalpers JA (2008). Dictionary of the Fungi. 10th edn. CABI International, UK.

Kohlmeyer J, Kohlmeyer E. 1969. Marine mycology – the higher fungi. Cambridge University Press, UK.

Launen L, Pinto L, Wiebe C, Kiehlmann E, Moore M. 1995. The oxidation of pyrene and benzo[a]pyrene by nonbasidiomycete soil fungi. Can. J. Microbiol. 41: 477–488. doi:10.1139/m95-064

Mugambi GK, Huhndorf SM. 2009. Molecular phylogenetics of *Pleosporales*: *Melanommataceae* and *Lophiostomataceae* re-circumscribed (*Pleosporomycetidae, Dothideomycetes, Ascomycota*). Stud. Mycol. 64: 103 –121. doi:10.3114/sim.2009.64.05

Page RDM. 1996. TREEVIEW: An application to display phylogenetic trees on personal computers. Computer Applications in the Biosciences 12: 357–358.

Pitt JI, Samson RA. 2000. Types for accepted species in *Penicillium*, *Aspergillus* and their teleomorphs In: Integration of modern taxonomic methods for *Penicillium* and *Aspergillus* classification (eds. RA Samson, JI Pitt). Harwood Publishers, Amsterdam: 51–72.

Phoulivong S, Cai L, Noireung P, Chen H, Abdelsalam K, Chukeatirote E, Hyde KD. 2010. A new species of *Colletotrichum* from *Cordyline fruticosa* and *Eugenia javanica* causing anthracnose disease. Mycotaxon (in press).

Prihastuti H, Cai L, Chen H, McKenzie EHC, Hyde KD. 2009. Characterization of *Colletotrichum* species associated with coffee berries in northern Thailand. Fungal Divers. 39: 89–109.

Prihastuti H, Cai L, Chen H, McKenzie EHC, Hyde KD. 2010. *Colletotrichum gloeosporioides* is not a common pathogen on tropical fruits. Fungal Diversity. doi 10.1007/s13225-010-00-0046-0-

Rapier KB, Fennell DI. 1965. The Genus *Aspergillus*. Baltimore: Williams & Wilkins.

Rodrigues KF, Sieber TN, Grünig CR, Holdenrieder O. 2004. Characterization of *Guignardia mangiferae* isolated from tropical plants based on morphology, ISSR-PCR amplifications and ITS1-5.8S-ITS2 sequences. Mycological Research. 108: 45–52. doi:10.1017/S0953756203008840

Samson RA, Varga J. 2007. *Aspergillus* systematics in the genomic era. Stud. Mycol. 59: 1–203.

Samson RA, Noonim P, Meijer M, Houbraken J, Frisvad JC, Varga J. 2007. Diagnostic tools to identify black aspergilli. Stud. Mycol. 59: 129–145. doi:10.3114/sim.2007.59.13

Santamaria M, Vicario S, Pappadà G, Scioscia G, Scazzocchio C, Saccone C. 2009. Towards barcode markers in Fungi: an intron map of Ascomycota mitochondria. BMC Bioinformatics. 10(Suppl 6): S15 doi:10.1186/1471-2105-10-S6-S15.

Schoch CL, Shoemaker RA, Seifert KA, Hambleton S, Spatafora JW, Crous PW. 2006. A multigene phylogeny of the *Dothideomycetes* using four nuclear loci. Mycologia 98: 1041–1052. doi:10.3852/mycologia.98.6.1041

Schoch CL, Crous PW, Groenewald JZ, Boehm EWA, Burgess TI, de Gruyter J, de Hoog GS, Dixon LJ, Grube M, Gueidan C, Harada Y, Hatakeyama S, Hirayama K, Hosoya T, Huhndorf SM, Hyde KD, Jones EBG, Kohlmeyer J, Kruys A, Li YM, Lucking R, Lumbsch HT, Marvanova L, Mbatchou JS, Mcvay AH, Miller AN, Mugambi GK, Muggia L, Nelsen MP, Nelson P, Owensby CA, Phillips AJL, Phongpaichit S, Pointing SB, Pujade-Renaud V, Raja HA, Plata ER, Robbertse B, Ruibal C, Sakayaroj J, Sano T, Selbmann L, Shearer CA, Shirouzu T, Slippers B, Suetrong S, Tanaka K, Volkmann-Kohlmeyer B, Wingfield MJ, Wood AR, Woudenberg JHC, Yonezawa H, Zhang Y, Spatafora JW. 2009b. A class-wide phylogenetic assessment of *Dothideomycetes*. Stud. Mycol. 64: 1–15. doi:10.3114/sim.2009.64.01

Seena S, Wynberg N, Bärlocher F. 2008. Fungal diversity during leaf decomposition in a stream assessed through clone libraries. Fungal Divers. 30: 1–14.

Seifert K. 2009. Progress towards DNA barcoding of fungi. Molecular Ecology Resources 9: 83–89. doi:10.1111/j.1755-0998.2009.02635.x

Shenoy BD, Jeewon R, Wu WP, Bhat DJ, Hyde KD. 2006. Ribosomal and RPB2 DNA sequence analyses suggest that *Sporidesmium* and morphologically similar genera are polyphyletic. Mycol. Res. 110: 916–928. doi:10.1016/j.mycres.2006.06.004

Shenoy BD, Jeewon R, Lam WH, Bhat DJ, Than PP, Taylor PWJ, Hyde KD. 2007. Morpho-molecular characterization and epitypificatin of *Colletotrichum capsici* (*Glomerellaceae, Sordariomycetes*), the causative agent of anthracnose in chilli. Fungal Divers. 27: 197–211.

Shivas RG, Yu YP. 2009. A taxonomic re-assessment of *Colletotrichum acutatum*, introducing *C. fioriniae* comb. et stat. nov. and *C. simmondsii* sp. nov. Fungal Diversity 39: 111–122.

Souza RF, Gomes RC, Coelho RRR, Alviano CS, Soares RMA. 2003. Purification and characterization of an endochitinase produced by Colletotrichum gloeosporioides. FEMS Microbiology Letters 222: 45–50. doi:10.1016/S0378-1097(03)00220-9

Suetrong S, Schoch CL, Spatafora JW, Kohlmeyer J, Volkmann-Kohlmeyer B, Sakayaroj J, Phongpaichit S, Tanaka K, Hirayama K, Jones EBG. 2009. Molecular systematics of the marine *Dothideomycetes*. Studies in Mycology 64: 155-173.

Sutton BC. 1980. The Coelomycetes. Commonwealth Mycological Institute, Kew, London.

Swofford DL. 2002. PAUP* 4.0: phylogenetic analysis using parsimony (* and other methods). Sinauer Associates, Sunderland, MA.

Tanaka K, Hirayama K, Yonezawa H, Hatakeyama S, Harada Y, Sano T, Shirouzu T, Hosoya T. 2009. Molecular taxonomy of bambusicolous fungi: *Tetraplosphaeriaceae*, a new pleosporalean family with *Tetraploa*-like anamorphs, and notes on the phylogeny of selected species from bamboo. Stud. Mycol. 64: 175–209. doi:10.3114/sim.2009.64.10

Tejesvi MV, Kini KR, Prakash HS, Ven Subbiah, Shetty HS. 2007. Genetic diversity and antifungal activity of species of *Pestalotiopsis* isolated as endophytes from medicinal plants. Fungal Divers. 24: 37–54.

Van der Aa HA, Vanev S. 2002. A revision of the species described in *Phyllosticta*. Centraalbureau voor schimmelcultures- Utrecht, Natherlands.

Wikee S, Cai L, Noireung P, McKenzie EHC, Su Yuan-Ying, Chukeatirote E, Thi HN, Bahkali AH, Moslem MA, Abdelsalam K, Hyde KD. 2011. *Colletotrichum* species from Jasmine (*Jasminum sambac*). Fungal Divers. doi:10.1007/s13225-010-0049-x

Wulandari NF, To-Anun C, Hyde KD, Duong LM, de Gruyter J, Meffert JP, Groenewald JZ, Crous PW. 2009. *Phyllosticta citriasiana* sp nov., the cause of Citrus tan spot of *Citrus maxima* in Asia. Fungal Divers. 34: 23–39.

Yang YL, Liu ZY, Cai L, Hyde KD, Yu ZN, McKenzie EHC. 2009. *Colletotrichum* anthracnose of *Amaryllidaceae*. Fungal Divers. 39: 123–146.

Yang YL, Cai L, Yu ZN, Liu ZY, Hyde KD. 2010. *Colletotrichum* species on *Orchidaceae* in southwest China. Mycological progress submitted.

Zhang Y, Schoch CL, Fournier J, Crous PW, de Gruyter J, Woudenberg JHC, Hirayama K, Tanaka K, Pointing SB, Spatafora JW, Hyde KD. 2009a. Multi-locus phylogeny of *Pleosporales:* a taxonomic, ecological and evolutionary re-evaluation. Stud. Mycol.: 85-102. doi:10.3114/sim.2009.64.04

Zhang Y, Wang HK, Fournier J, Crous PW, Jeewon R, Pointing SB, Hyde KD. 2009b. Towards a phylogenetic clarification of *Lophiostoma / Massarina* and morphologically similar genera in the *Pleosporales*. Fungal Divers. 38: 225–251.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.453

Volume 114, pp. 453–457 October–December 2010

Masseeella flueggeae on *Flueggea virosa*, a new record for Pakistan

A. N. KHALID[1], N. S. AFSHAN[2]* & H. ELAHI[1]

drankhalid@gmail.com
[1]*Department of Botany, University of the Punjab*
Quaid-e-Azam Campus, Lahore, 54590, Pakistan

**pakrust@gmail.com*
[2]*Centre for Undergraduate studies, University of the Punjab*
Quaid-e-Azam Campus, Lahore, 54590, Pakistan

Abstract — *Masseeella flueggeae* on *Flueggea virosa* is reported as a new record for Pakistan. This is the first report of the genus *Masseeella* from this country, raising the number of rust genera known from Pakistan to twenty-two.

Key words — *Euphorbiaceae*, macrocyclic rust, Neelum valley

Introduction

Flueggea virosa is a dioecious, multi-stemmed, fast-growing bushy shrub in the *Euphorbiaceae*. It is common in deciduous woodlands and on forest margins, along rivers, and in rocky areas and is widely distributed in Asia, Africa, and Australia. In Pakistan, *it is found in Sindh, the Kaghan Valley, and Kashmir (Stewart 1972)*. In the Neelum Valley, Azad Kashmir, this plant was found heavily infected by a rust fungus that belongs to an interesting rust genus, *Masseeella* Dietel.

Masseeella was erected by Dietel (1895) based on *M. capparis* (Cooke) Dietel [as "*capparidis*"] to accommodate a rust on *Flueggea virosa* in India and named after the famous English mycologist G.E. Massee (Cummins & Hiratsuka 2003). This genus is subtropical in distribution and restricted to the warm regions of Asia in the Philippines as well as South Africa. All species of *Masseeella* parasitize members of the family *Euphorbiaceae* and are macrocyclic and autoecious (Thirumalachar 1943, Singh & Singh 1967). *Masseeella flueggeae* on *Flueggea virosa* was described from the Philippines by Sydow & Petrak (1928)

* Corresponding author

and has since been reported in Myanmar (Thaung 2005) and South Africa (Doidge 1950). This rust has pycnidia, aecidia, and uredosori that are unknown in the type species of the genus (Sydow & Petrak 1928, Cummins 1937). The present paper reports the occurrence of *Masseeella flueggeae* on *Flueggea virosa* for the first time in Pakistan. In addition, a noteworthy rust, *Pucciniastrum pyrolae* on *Pyrola rotundifolia* subsp. *karakoramica,* is reported here as a new host record in Pakistan.

Materials and methods

Rusted specimens were collected in Azad Kashmir, Neelum Valley, Lawat and northern areas, Fairy Meadows, Pakistan. Freehand sections of infected tissues and spores were mounted in lactophenol and gently heated to a boiling point. The preparations were observed under a NIKON YS 100 microscope. Spores and sori were drawn using a camera lucida (Ernst Leitz Wetzlar, Germany). Spores were measured with an ocular micrometer. At least 25 spores were measured for each spore state. The specimens were deposited in the Herbarium of the Botany Department, University of the Punjab, Lahore (LAH).

Recorded species

Masseeella flueggeae Syd., Ann. Mycol. 26: 424 (1928). FIG. 1

MATERIAL EXAMINED: Pakistan, Azad Kashmir, Neelum valley, Lawat, on *Flueggea virosa* (Willd.) Voigt (*Euphorbiaceae*), 16 Aug 2009, Abdul Nasir Khalid 130 (LAH 1130).

SPERMOGONIA and AECIA unknown. UREDINIA amphigenous, forming groups, yellow to yellowish orange, subepidermal, mostly intermixed with telia. UREDINIOSPORES ellipsoid to obovoid, hyaline to yellow, 15–19 × 18–27 µm, wall 1.5–2 µm thick, echinulate to verrucose, germ pores obscure. TELIA amphigenous, crowded, mostly along veins or margins of leaf, causing malformations, subepidermal, arising in uredosori, becoming erumpent as hair-like columns, orange to yellowish brown or chestnut brown. TELIOSPORES one-celled, sessile with hyphal attachment organs resembling pedicels, up to 34 µm long, ellipsoid to broadly ellipsoid or cylindric to angular, 16–24 × 23–47 µm, embedded in mucilaginous mass, germ pore apical, wall striate, yellowish brown to chestnut brown, 4–6 µm thick at sides and 4–7 µm thick apically.

Pucciniastrum pyrolae Arthur, North Amer. Fl. 7: 108 (1907). FIG. 2

MATERIAL EXAMINED: Pakistan, Northern Areas of Pakistan, Fairy Meadows, Bial Camp, at 3,036 m a.s.l., On *Pyrola rotundifolia* subsp. *karakoramica* (Křísa) Y.J. Nasir (*Ericaceae*), with II stage, 11 Aug 2007. Najam-ul-Sehar Afshan G07 (LAH NSA 1119).

SPERMOGONIA, AECIA, and TELIA unknown. UREDINIA hypophyllous, covered by epidermis, yellowish orange, rounded, minute, in form of group, covered

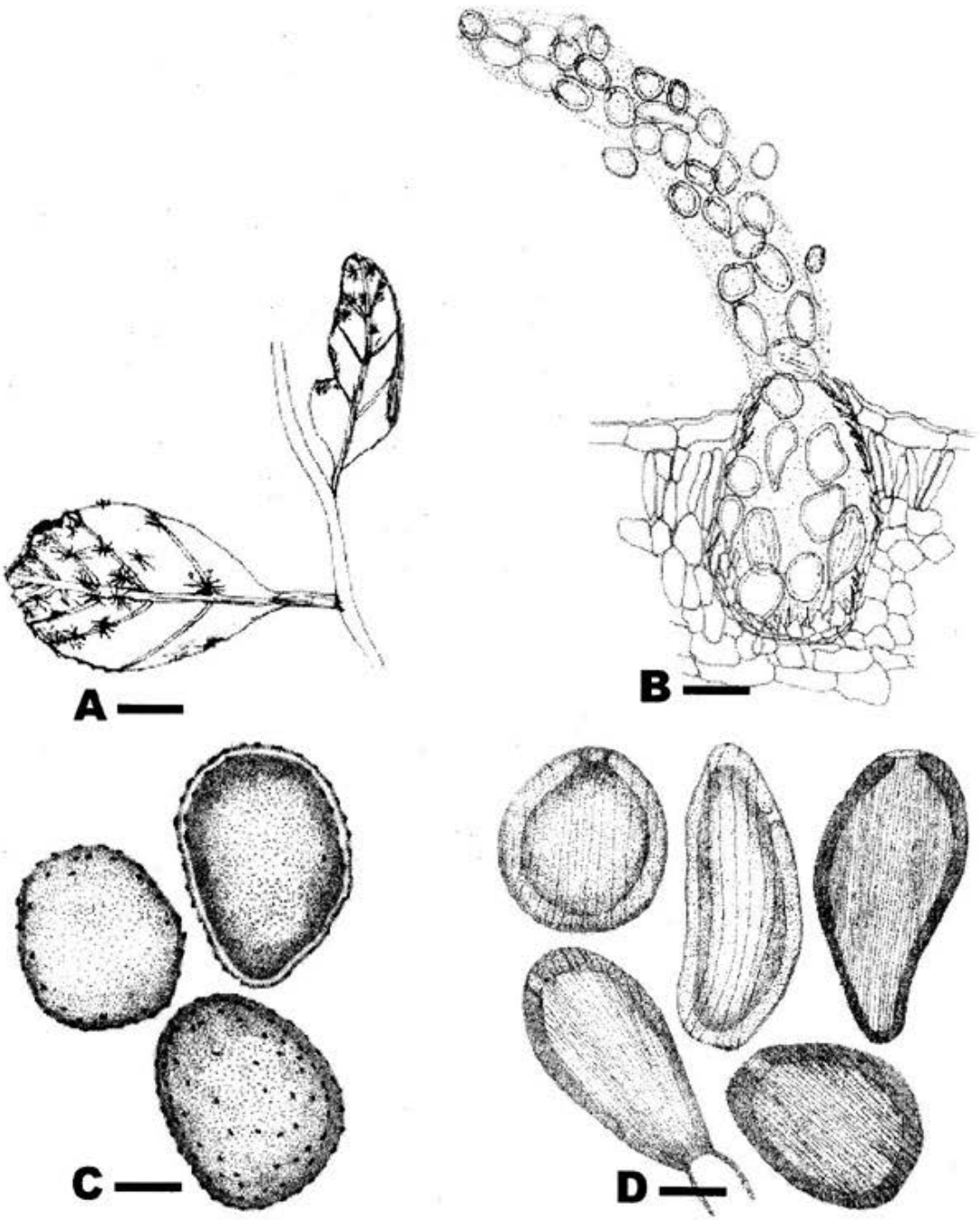


FIG. 1. *Masseeella flueggeae.*
A. Drawing of host plant showing infected parts.
B. A telial sorus showing the development of spore column and mucilage-secreting hyphae.
C. Urediniospores with echinulate to verrucose wall ornamentation.
D. Mature teliospores with striate walls.
Scale bars = 10 µm.

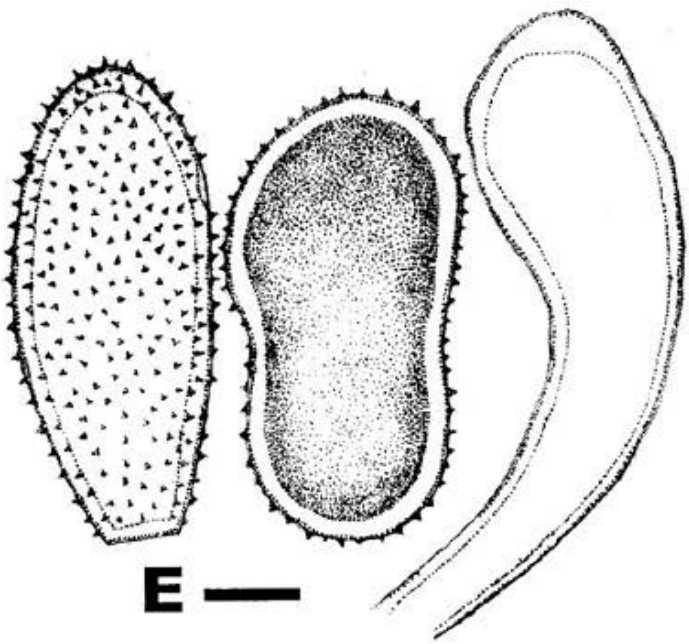


FIG. 2. *Pucciniastrum pyrolae.*
Drawings of mature urediniospores and apex of a paraphysis. Scale bar = 8 µm.

by a peridium of hyphal cells, releasing spores by an ostiolar opening, 0.1–0.2 × 0.2–0.4 mm. UREDINIOSPORES ovoid to obovoid or ellipsoid, 13–18 × 26–37 µm (mean = 16.0 × 32.0 µm); wall 1.8–3 µm thick, hyaline to yellow, echinulate; germ pores obscure. Paraphyses clavate, hyaline or yellowish, 13–15 × 47–71 µm.

Pucciniastrum pyrolae has previously been reported on leaves of *Pyrola secunda* L. from Fairy Meadows and Gilgit by Kaneko (1993). *Pyrola rotundifolia* subsp. *karakoramica* is a new host for this rust fungus in Pakistan.

Acknowledgments

We sincerely thank Dr. Amy Rossman, Systematic Mycology and Microbiology Laboratory, USDA-ARS, Beltsville, and Omar Paíno Perdomo, Dominican Mycological Society, Santo Domingo, for their valuable suggestions to improve the manuscript and acting as presubmission reviewers. We sincerely thank Dr. Abdul Rehman Niazi for help in the field. We are greatly obliged to the Pakistan Science Foundation (PSF) and Higher Education Commission (HEC) of Pakistan for providing financial support for research work.

Literature cited

Cummins GB. 1937. Studies in the *Uredinales* of the Philippines. *Ann. Mycol.* 35: 98–105.
Cummins GB, Hiratsuka Y. 2003. Illustrated genera of rust fungi, third edition. APS, St. Paul.

Dietel P. 1895. Drei neue Uredineen Gattungen, *Masseeella, Phakospora* und *Schizospora*. Ber. deutsch. bot. Ges. 13: 332–335.

Doidge EM. 1950. The South African fungi and lichens to the end of 1945. Bothalia 5: 1-1094.

Kaneko S. 1993. Parasitic fungi on woody plants from Pakistan. 149–168, in: Nakaike T, Malik S (eds), Cryptogamic flora of Pakistan, vol. 2. Nat. Sci. Mus., Tokyo. .

Singh H, Singh BV. 1967. On some Indian species of *Masseeella*. Mycopathologia 33: 193–199. doi:10.1007/BF02053451

Stewart RR. 1972. An annotated catalogue of the vascular plants of West Pakistan and Kashmir. In: Nasir E, Ali SI (eds), Flora of Pakistan. Fakhri Printing Press, Karachi.

Sydow H, Petrak F. 1928. Micromycetes Philippinenses. Ann. Mycol. 26: 414–446

Thaung MM. 2005. Rusts, smuts and their allies in Burma. Australas. Mycol. 24: 29–46.

Thirumalachar MJ. 1943. *Masseeella breyniae*, a new species of rust, New Phytologist 42: 45–48. doi:10.1111/j.1469-8137.1943.tb04984.x

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.459

Volume 114, pp. 459–462 October–December 2010

Two new species of *Stachybotrys* from soil

YUE-MING WU & TIAN-YU ZHANG*

tyzhang1937@yahoo.com.cn
Department of Plant Pathology, Shandong Agricultural University
Taian, 271018, China

Abstract — Two new species are described and illustrated: *Stachybotrys jiangziensis* and *S. xigazenensis*, both from soil in China. The type specimens (dried cultures) and living cultures are deposited in the Herbarium of Shandong Agricultural University Plant Pathology (HSAUP). Isotypes are kept in the Herbarium of Institute of Microbiology, Academia Sinica (HMAS).

Key words — taxonomy, soil fungi, dematiaceous hyphomycetes

Introduction

Stachybotrys Corda was erected in 1837, and since then 96 epithets have been proposed in the genus (Index Fungorum 2010). This genus is characterized by distinct, mononematous conidiophores bearing an apical cluster of several swollen phialides producing unicellular phialoconidia that become aggregated in globose masses. In the course of a survey of soil dematiaceous hyphomycetes in China, several unusual species of *Stachybotrys* were collected. Two of them are described as new species, *S. jiangziensis* and *S. xigazenensis*.

Taxonomy

Stachybotrys jiangziensis Y.M. Wu & T.Y. Zhang, **sp. nov.** FIG. 1

MYCOBANK MB 518786

Coloniae in CMA effusae, atrogriseae vel nigrae. Hyphis ramosis, septatis, laevibus, hyalinis vel subhyalinis, 1.5–3 µm crassis. Conidiophora erecta, 2–4-septata, basim versus subhyalina, supra griseo-brunnea, levia, 60–80 µm longa, ad basim 4–5 µm diam. Phialides 6–8 ad apicem conidiophori productae, pallide brunneae, leves, 8–10 × 5–7 µm. Conidia tuberculata, globosa vel subglobosa, brunnea vel atrobrunnea, 6–9 µm diam.

HOLOTYPE: China. Tibet, Jiangzi, from a grassland soil, altitude 4050 m, 9 Sept. 2007, Y.M. Wu, HSAUPII$_{07}$0881, **holotype**; HMAS 196256, **isotype**.

ETYMOLOGY: in reference to the type locality.

*Corresponding author: Tian-Yu Zhang

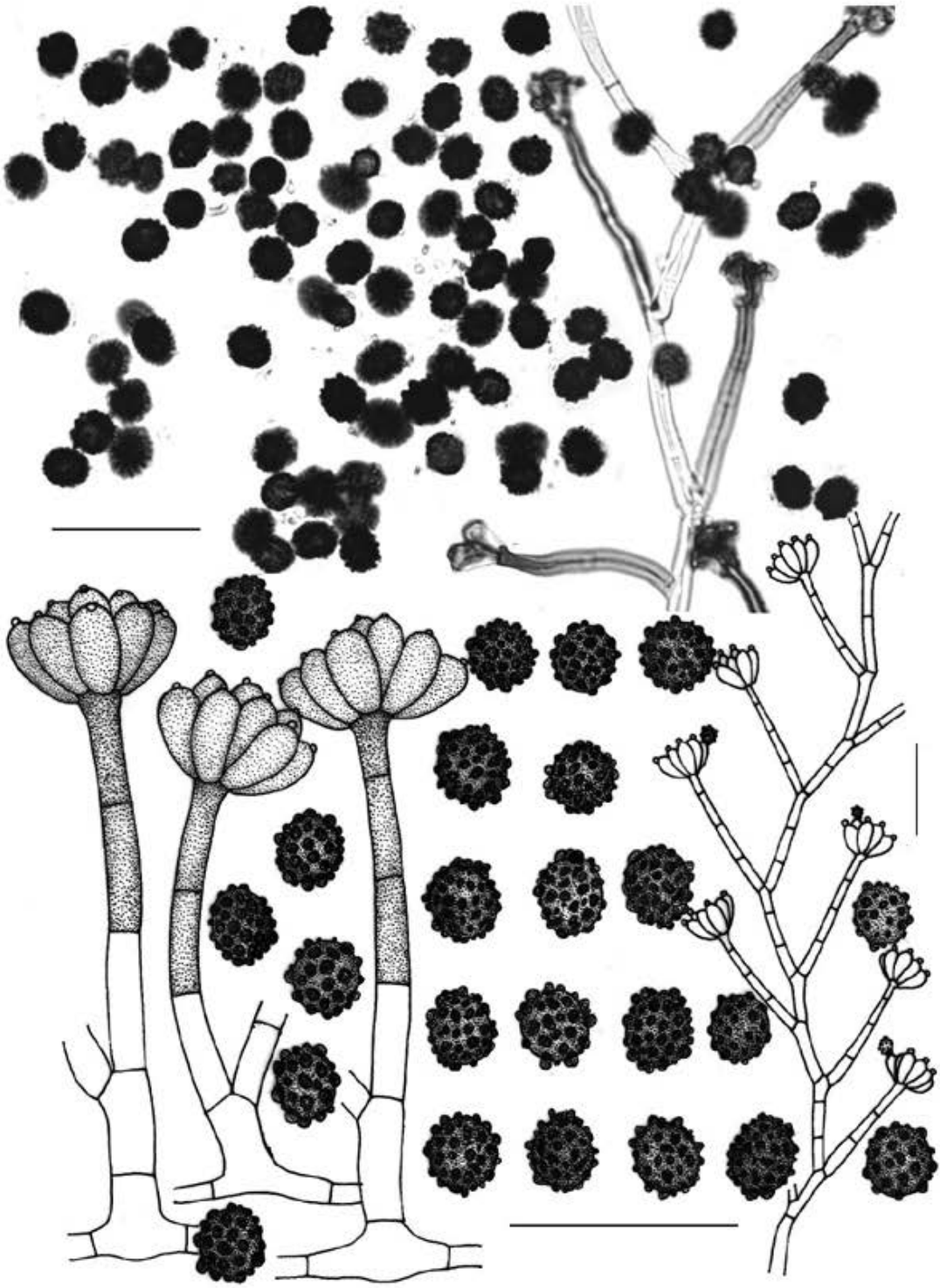


FIG. 1. *Stachybotrys jiangziensis* (ex holotype). Conidia, conidiophores, and conidiogenous cells. Above: photomicrographs. Below: drawings. (Bars = 25 μm).

Colonies on CMA (cornmeal agar) at 25°C for 21 days 4–6 cm diam., effuse, darkish grey to black. Mycelium mostly superficial, partly immersed. Hyphae branched, septate, smooth, hyaline to subhyaline, 1.5–3 μm wide. Conidiophores

erect, branched, 2–4-septate, subhyaline near the base, greylish brown above, smooth, 60–80 µm long, 4–5 µm wide near base. Phialides borne in groups of 6–8 at the apices of conidiophores, pale brown, smooth, 8–10 × 5–7 µm. Conidia globose to subglobose, tuberculate, brown to dark brown, 6–9 µm in diameter.

In conidial morphology this fungus somewhat resembles *Stachybotrys nilagirica* Subram. (Subramanian 1957) and *S. sphaerospora* Morgan-Jones & R.C. Sinclair (Morgan-Jones & Sinclair 1980). However *S. nilagrica* has larger conidia (16–20 µm diam.) and *S. sphaerospora* larger (11–12 µm diam.), ridged conidia than *S. jiangziensis*.

Stachybotrys xigazenensis Y.M. Wu & T.Y. Zhang, **sp. nov.** FIG. 2

MycoBank MB 518787

Coloniae in CMA effusae, atrogriseae vel nigrae. Hyphis ramosis, septatis, laevibus, hyalinis vel subhyalinis, 2–3 µm crassis. Conidiophora erecta, 1–4-septata, basim versus subhyalina, supra griseo-brunnea, verrucosa, interdum granulis magnis tecta, 60–100 µm longa, ad basim 4–6 µm diam. Phialides 6–8 ad apicem conidiophori productae, pallide brunneae, leves, 7–10 × 5–8 µm. Conidia ovoidea, ellipsoidea vel oblonga, tuberculata, brunnea vel atrobrunnea, 9–12.5 × 7.5–10 µm.

FIG. 2. *Stachybotrys xigazensis* (ex holotype). Conidia, conidiophores, and conidiogenous cells. Left: photomicrographs. Right: drawings. (Bars = 25 µm).

HOLOTYPE: China. Tibet, Xigazen, from a grassland soil, altitude 4150 m, 19 Sept. 2007, Y.M. Wu, $HSAUPII_{07}1450$, **holotype**; HMAS 196257, **isotype**.

ETYMOLOGY: in reference to the type locality.

Colonies on CMA at 25°C for 21 days 5–8 cm diam., effuse, darkish grey to black. Mycelium mostly superficial, partly immersed. Hyphae branched, septate, smooth, hyaline to subhyaline, 2–3 µm wide. Conidiophores erect, sympodially branched, 1–4-septate, subhyaline near the base, greyish brown above, verrucose, sometime covered with large granules, 60–100 µm long, 4–6 µm wide near base. Phialides borne in groups of 6–8 at the apices of conidiophores, pale brown, smooth, 7–10 × 5–8 µm. Conidia ovoid, ellipsoid or oblong, tuberculate, brown to dark brown, 9–12.5 × 7.5–10 µm.

This fungus somewhat resembles *Stachybotrys chartarum* (Ehrenb.) S. Hughes (Hughes 1958) and *S. microspora* (B.L. Mathur & Sankhla) S.C. Jong & E.E. Davis (Jong & Davis 1976) in conidial colour and size, but *S. xigazensis* has more obviously tuberculate conidia. In addition, the conidia of *S. xigazensis* are larger than those of *S. microspora* (6–8 × 4–5 µm) and wider than those of *S. chartarum* (7–12 × 4–6 µm).

Acknowledgments

The authors are grateful for pre-submission comments and suggestions provided by Dr. Eric McKenzie, Prof. Y.L. Guo, and Dr. Shaun Pennycook. This project was supported by the National Science Foundation of China (no. 30670014 & 30499340).

Literature cited

Hughes SJ. 1958. Revisiones Hyphomycetum aliquot cum appendice de nominbus rejiciendis. Canadian Journal of Botany 36: 727–836. doi: 10.1139/ b58-067.

Index Fungorum. 2010. http://www.indexfungorum.org/Names/Names.asp; accessed 28 August 2010.

Jong SC, Davis EE. 1976. Contribution to the knowledge of *Stachybotrys* and *Memnoniella* in culture. Mycotaxon 3: 409–485.

Morgan-Jones G, Sinclair RC. 1980. Notes on Hyphomycetes. XXXIII. *Stachybotrys sphaerospora* sp. nov. from South Africa. Mycotaxon 10: 372–374.

Subramanian CV. 1957. Hyphomycetes–IV. Proceedings of the Indian Academy of Sciences B. 46: 330–331.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.463

Volume 114, pp. 463–472 *October–December 2010*

The genus *Placidiopsis* in the Iberian Peninsula and the Balearic Islands

María Prieto*, Isabel Martínez & Gregorio Aragón

* *Maria.Prieto@nrm.se*

Cryptogamic Botany, Swedish Museum of Natural History

P.O. Box 50007, SE-104 05, Stockholm, Sweden

Abstract — A taxonomic revision of the genus *Placidiopsis* in the Iberian Peninsula and the Balearic Islands is provided. A total of 500 specimens were studied. A detailed description of the morphology, anatomy, ecology, and distributional rank is presented for each species. Additionally, a key to *Placidiopsis* species is included. The genus is represented by four species in the studied region, with *P. cavicola* and *P. cinereoides* known only from the type localities and *P. cinerascens* and *P. custnani* common in the eastern half of the region. These data expand considerably the ecological and distributional range of these species in the Iberian Peninsula.

Key words — catapyrenioid lichens, distribution, Spain, Portugal, *Verrucariaceae*

Introduction

Placidiopsis Beltr. (*Verrucariaceae*) is a genus of squamulose lichens closely related to *Catapyrenium* s. str., although recent phylogenetic analyses (Gueidan et al. 2007, 2009; Prieto et al. 2010) concluded that both genera were different entities. The two genera are morphologically differentiated by uniseptate ascospores in *Placidiopsis* and simple ascospores in *Catapyrenium* s. str. *Placidiopsis* species are characterized by squamulose thalli attached to the substrate by a rhizohyphal web, a central bundle of rhizohyphae, or rhizines. The upper cortex is either absent or *cinereum*–type (Breuss 1996, 2002; Prieto et al. 2010), the photobiont is a chlorococcoid alga (Breuss 2002), the medulla is proso– or subparaplechtenchymatous, and the lower cortex is (sub)paraplect enchymatous when present. Perithecia are immersed, with or without an apical involucrellum, asci are clavate with an ocular chamber, and pycnidia have never been observed (Breuss 2002).

Members of the group inhabit arid, semiarid, and arctic–alpine regions in the Northern Hemisphere (Breuss 2002). Ecological preferences of the genus

include soil, rock, detritus, or bryophytes occurring in calciferous or acid substrates. *Placidiopsis* comprises 12 species world-wide (Breuss 2010), many of which appear rare and restricted either to their type localities (e.g. *P. cavicola*, *P. cervinula* (Nyl.) Vain., *P. cinereoides*) or to very small areas (e.g. *P. hamadicola* Bredkina, *P. tiroliensis* Breuss).

Breuss (1996), who until now has published the only complete treatment of the genus, reported few specimens for the Iberian Peninsula. Therefore exhaustive collection and more in-depth research of *Placidiopsis* species was necessary in order to establish the true extent of the genus in the Iberian Peninsula and the Balearic Islands. The current research is part of the project Spanish Lichenological Flora.

Materials & methods

This study is mainly based on material collected by the authors in the Iberian Peninsula and the Balearic Islands during 2005–2009. The specimens are deposited in MA herbarium. In addition, collections in Iberia (BCC, BCN, LEB, LISU, MA, MACB, MAF, SANT, VAL, VIT), other European and North American herbaria (ABL, ARIZ, ASU, B, BM, COLO, GB, H, HAL, L, LI, NY, PRM, S, TUR), and personal herbaria (C. Keller, G. Aragón) were revised. Approximately 500 specimens in total were studied.

Observations and measurements were made using a Nikon SMZ-800 dissecting microscope and an Olympus BX 51 microscope. Thallus cross-sections (14–20 µm thick) were made with a Leica CM 1850 UV freezing microtome. Sections were observed and measured in water or occasionally lactophenol cotton blue. For anatomical studies, ten specimens per species were analysed (when available), and ten measurements of each specimen on different squamules were carried out. The limited material of some species and the poor condition of others led to a lower number of measurements in some cases. Measurements are expressed as the mean ± standard deviation (SD) with the extremes within parentheses; length/wide ratios (l/w) were calculated for ascospores. Distributional maps were drawn with ArcView GIS 3.1, based on UTM coordinates (WGS84 Datum).

For each taxon, we cite the basionym, type specimen, and type location, but not previously published synonyms (see Breuss 1996).

Results

Of the four *Placidiopsis* species found in the Iberian Peninsula and the Balearic Islands, two — *P. cavicola, P. cinereoides* — are known only from their type localities and two — *P. cinerascens, P. custnani* — are more common than previously believed and found throughout the studied area.

Key to the known *Placidiopsis* species in the Iberian Peninsula

1. On rocks, squamules up to 0.5 mm ..... *P. cavicola*
1. On soil, squamules up to 2–3 mm 2

2. Rhizohyphae colourless ..... *P. cinerascens*
2. Rhizohyphae dark 3
3. Squamules with down-rolled margins, rhizohyphae attached in a central holdfast (looking like a rhizine), ascospores 15–22 × 5–7 µm ..... *P. custnani*
3. Squamules without downrolled margins, central holdfast absent, ascospores 22–28 × 7–8 µm ..... *P. cinereoides*

Placidiopsis cavicola Etayo & Breuss, Österr. Z. Pilzk. 3: 21 (1994) FIGS. 1A, 2A

[TYPE: Spain, Navarra, Larra, Isaba, Añelarra, cave A-50, 5 m depth, on calcareous flagstone, 2154 m, J. Etayo & J.I. Calvo, 19/08/1992 (Herb. Etayo, HOLOTYPE; LI 271012, ISOTYPE!).]

MORPHOLOGY— Thallus squamulose, composed of very small squamules, ≤ 0.5 mm broad, flat, crenulate, adjacent to slightly overlapping. Upper surface green to light brown; lower surface brown, with colourless to brown rhizohyphae.

ANATOMY— Thallus 100–150(–250) µm thick, upper cortex 10–20 µm thick, with cells of 4–6 µm diam, epinecral layer lacking. Algal layer distributed over nearly the entire thallus, with algal cells of 5–9 µm; lower cortex not clearly delimited. Rhizohyphae colourless to brownish, ca. 4 µm thick.

Perithecia 150–250 µm wide, with a colourless exciple. Asci clavate, 45–55 × 15–20 µm, ascospores septate, 13–17 × 6–7 µm (Etayo & Breuss 1994). Pycnidia absent.

ECOLOGY & DISTRIBUTION — *Placidiopsis cavicola* was collected on rock, growing over a thin algal or debris layer in a calcareous cave in the subalpine belt of the Pyrenees, over 2100–2200 m altitude (Etayo & Breuss 1994).

The species is known only from the type locality in Navarra, Spain; it may be more widely distributed, however, as it has probably been overlooked due to its small size.

COMMENTS— *Placidiopsis cavicola* resembles *P. minor* R.C. Harris in that both species have small squamules (no more than 1 mm) and grow on rocks. However, *P. cavicola* has crenulated and non-pruinose squamules, while *P. minor* has roundish to slightly lobed and pruinose squamules; moreover, the spores are bigger in *P. cavicola* (8–10 × 4–5 µm in *P. minor*). *Placidiopsis minor* has not been found until now in the Iberian Peninsula and has previously been known only from North America and Greenland (Breuss 1996).

Placidiopsis cinerascens (Nyl.) Breuss, Plant Syst. Evol. 148: 315 (1985) FIGS. 1B, 2A

[TYPE: Gallia merid., Beaucaire, W. Nylander (H-NYL 4021, HOLOTYPE!).]

= *Placidiopsis tenella* (Nyl.) Zahlbr., Catal. Lich. Univ. 1: 240 (1921)

[TYPE: Oran, Balansa (H-NYL 3944!, LECTOTYPE, designated by Cl. Roux in herbarium).]

MORPHOLOGY— Thallus squamulose, squamules up to 3 mm wide, scattered to contiguous, flattened to slightly convex, rounded to lobed or crenate. Upper surface whitish, greenish grey or brownish grey, pruinose or not; lower surface pale with colourless rhizohyphae.

ANATOMY— Thallus (110–) 226 ± 48.9 (–320) µm thick, with or without epinecral layer, up to 50 µm when present; upper cortex (5–) 19.1 ± 8.1 (–37.5) µm thick, paraplectenchymatous, with roundish-subangular cells of (4–) 7.1 ± 1.4 (–11) µm diam. Algal layer distributed over almost the entire thallus, 50–175 µm thick, with cells (3–) 6.5 ± 1.7 (–12) µm diam. Medulla not clearly delimited from the algal layer, composed of globular cells (4–) 7.5 ± 1.5 (–11) µm diam; lower cortex lacking. Rhizohyphae colourless, (2.5–) 3.2 ± 0.4 (–4) µm.

Perithecia slightly pyriform to globose, up to 300 µm wide, exciple hyaline to brownish, up to ca. 30 µm thick, darker in the ostiole, with or without a small apical involucrellum. Asci clavate, 55–65 × 11–16 µm (Breuss 1996), with a small ocular chamber; ascospores biseriate, hyaline, septate (occasionally simple), (12–) 16.4 ± 1.9 (–21) × (5–) 6.2 ± 0.5 (–7) µm, l/w ratio (1.7–) 2.6 ± 0.4 (–3.3). Pycnidia absent.

ECOLOGY & DISTRIBUTION—The species shows preferences for soil and rock ledges on calcareous and gypsiferous substrates. It was found in shrublands with *Buxus sempervirens* L., *Lavandula latifolia* Medik., *Lycium* sp., *Rosmarinus officinalis* L., and *Thymus* sp. in dry and open habitats, but also collected in *Pinus halepensis* Mill., *Juniperus thurifera* L. and *Quercus ilex* subsp. *ballota* (Desf.) Samp. forests. *Placidiopsis cinerascens* has been frequently found together with *Anthracocarpon virescens* (Zahlbr.) Breuss, *Endocarpon pusillum* Hedw., *Placidiopsis custnani,* or *Placidium pilosellum* (Breuss) Breuss. In the studied area, *P. cinerascens* was found between the sea level and 1300(–1800) m altitude.

Until now, *P. cinerascens* was little collected in the Iberian Peninsula and recorded from only 5 southern and eastern provinces of Spain although also known from Portugal (Barreno et al. 1989, Breuss 1996, Etayo & Breuss 1996). There are few records of *P. cinerascens* reported as *P. tenella* in Spain (Boom & Gómez-Bolea 1991, Etayo 1992, Gutierrez & Casares 1994, Guerra et al. 1995); as these specimens could not be examined, their data are not included in the maps.

Our data indicate that *P. cinerascens,* relatively abundant in the Iberian Peninsula, is more common than previously thought. New data extend the known distribution of the species in the Iberian Peninsula, mainly from central, southern and southeastern Spain, with many collections constituting first provincial records. Although present throughout the Iberian Peninsula with

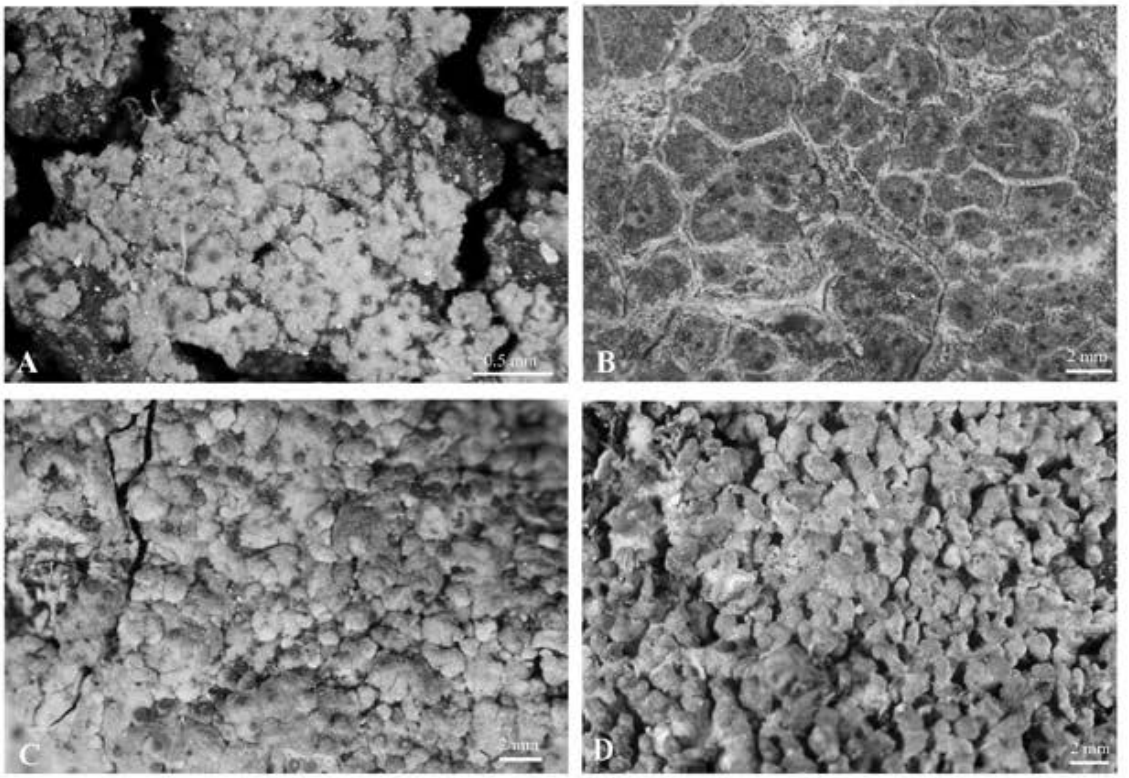


FIGURE 1. Habit of species of *Placidiopsis*.
A, *P. cavicola*; B, *P. cinerascens*; C, *P. cinereoides*; D, *P. custnani*.

some occurrence in the west, the species is especially prevalent in the eastern half; it is relatively common in the Balearic Islands.

Placidiopsis cinerascens is widely distributed in Mediterranean and arid climates throughout the European mediterranean region as well as in central Asia, Mexico, northern Africa, and SW North America (Breuss 2002).

COMMENTS— *Placidiopsis cinerascens* was synonymized with *P. tenella* based on morphological and genetic similarities (Prieto et al. 2010). The presence of an involucrellum in *P. tenella* is not a valid character state, because it does not appear in all ascomata within the same specimen or even in the same squamule. Therefore, *Placidiopsis tenella* cannot be distinguished from *P. cinerascens* using this character.

REPRESENTATIVE SPECIMENS — **SPAIN. ALBACETE:** Riópar, Calar del Mundo, subida por la Fuente de las Raigadas, 549451 E, 4256284 N, 1320 m, G. Aragón, R. Belinchón & M. Prieto, 31/01/2007, M. Prieto 664b. **ALICANTE:** Orihuela, 680582 E, 4218299 N, suelos calizos, 35 m, M. Prieto, 11/04/2006, M. Prieto 589b. **ALMERÍA:** Turrillas, Sierra Alhamilla, 565453 E, 4098680 N, 1300 m, suelos calizos, I. Martínez, M.A.G. Otálora & M. Prieto, 29/11/2005, M. Prieto 515. **BARCELONA:** Can Grau, Sierra del Garraf, 403256 E, 4573874 N, 279 m, M. Prieto, 08/07/2004, M. Prieto 1654. **BURGOS:** Oña, carretera hacia Villanueva de los Montes, Sierra de Tesla, 466595 E, 4733638 N, repisas calizas, 590 m, I. Martínez & M. Prieto, 23/08/2007, M. Prieto 1166. **CÁCERES:** Torrejón El Rubio, castillo de Monfragüe, 244525 E, 4414075 N, sobre mortero de un muro,

661 m, M. Prieto, 14/01/2007, M. Prieto 662 (MA 16302). CÁDIZ: Grazalema, Sierra de Grazalema, carretera hacia Zahara de la Sierra, antes del Puerto de los Acebuches, 287604 E, 4075692 N, 870 m, oquedades de rocas calizas, R. Belinchón, I. Martínez & M. Prieto, 13/06/2008, M. Prieto 1474. CASTELLÓN: Cabanes, dessert de les Palmes, 248364 E, 4448733 N, fisuras calizas, 290 m, M. Prieto, 14/03/2008, M. Prieto 1410, 1411 (MA 16302). CUENCA: Poyatos, 582121 E, 4474336 N; repisas de rocas calizas en pinar, 1046 m, M. Prieto, 05/04/2007, M. Prieto 942. GRANADA: Sierra Nevada, antes de Prado Llano, 460330 E, 4107723 N, suelo calizo, 1880 m, M. Prieto, 26/06/2008, M. Prieto 1523. LA RIOJA: Foncea, 497345 E, 4718904 N, suelo entre rocas calizas, 860 m, I. Martínez & M. Prieto, 27/08/2007, M. Prieto 1154, 1160. LEÓN: Miñera de Luna, 267275 E, 4751065 N, suelos calizos en sabinar, 1130 m, M. Prieto, 18/05/2006, M. Prieto 617. LÉRIDA: Alfés, Timoneda, aeròdrom d´Alfés, 30TCG00, terrícola, 240 m, J. Perez-Redondo, 12/01/1992, BCC 12680. MADRID: Patones de Arriba, 459550 E, 4524950 N, 834 m, M. Prieto, 01/05/2008, M. Prieto 1520. MÁLAGA: Parauta, Sierra de las Nieves, estribaciones del pinsapar de cerro Alcojona, cerca del pinsapo de la Escalereta, 318103 E, 4060026 N, 1164 m, R. Belinchón, I. Martínez & M. Prieto, 12/06/2008, M. Prieto 1454b. MALLORCA: Caimari, Sierra de Tramuntana, 681883 E, 4759848 N, fisuras calizas, 500 m, M. Prieto, 15/04/2007, M. Prieto 904 (MA 16304). NAVARRA: Rada, Bárdenas Reales, 616320 E, 4686664 N, suelo calizo, I. Martínez & M. Prieto, 22/08/2007, M. Prieto 1131. PALENCIA: Piedrasluengas, Puerto de Piedrasluengas, 381275 N, 4767675 E, fisuras calizas, 1355 m, G. Aragón, A. García & M. Prieto, 21/07/2005, M. Prieto 108 (MA 16397). TOLEDO: carretera hacia Villacañas, 476725 E, 4378425 N, M. Prieto, 21/01/2007, M Prieto 657. VALENCIA: carretera de Utiel a Estenas, Sierra de Juan Navarro, 659189 N, 4384368 E, suelos calizos en coscojar, 892 m, M. Prieto, 22/02/2008, M. Prieto 1328, 1330. ZARAGOZA: Calcena, 606269 E, 4610745 N, repisas calizas, 890 m, I. Martínez & M. Prieto, 21/08/2007, M. Prieto 1116. PORTUGAL. Alvados, Serra de Aire e os Candeiros, grutas, 521231 E, 4376584 N, suelos calizos, 445 m, M.A.G. Otálora & M. Prieto, 27/09/2007, M. Prieto 1257 (MA 16309), 1263, 1266.

Placidiopsis cinereoides Breuss, Österr. Z. Pilzk. 5: 84 (1996) FIGS. 1C, 2B

[TYPE: España, Palencia, Pico Curavacas, sobre conglomerado silíceo, 1900–2100 m, M.E. López de Silanes, 09/09/1990 (SANT 7072, HOLOTYPE!; LI 271013, ISOTYPE!).]

MORPHOLOGY— Thallus squamulose, composed of contiguous to slightly overlapping squamules, forming a compact rosette; squamules finely lobulate to crenate, flat to slightly convex, up to 2 mm wide; upper surface whitish to greenish grey-brown; lower surface dark with brown rhizohyphae.

ANATOMY— Thallus 200–400 µm thick; upper cortex up to 20 µm thick, with roundish-subangular cells of 5–8 µm diam; with or without epinecral layer, up to 50 µm when present. Algal layer filling almost half of the thallus, with cells (3) 5 ± 1.3 (6) µm diam. Medulla subparaplectenchymatous with globular cells of 8–11 µm diam, brownish in the lower zone; lower cortex paraplectenchymatous, of more densely aggregated cells. Rhizohyphae brown, ca. 4 µm.

Perithecia globose, 200–400 µm wide, exciple colourless to brownish; asci 65–80 × 16–20 µm (Breuss 1996), ascospores biseriate, hyaline, septate (occasionally simple), (20) 22–28 (30) × (6.5) 7–8 (8.5) µm. Pycnidia absent.

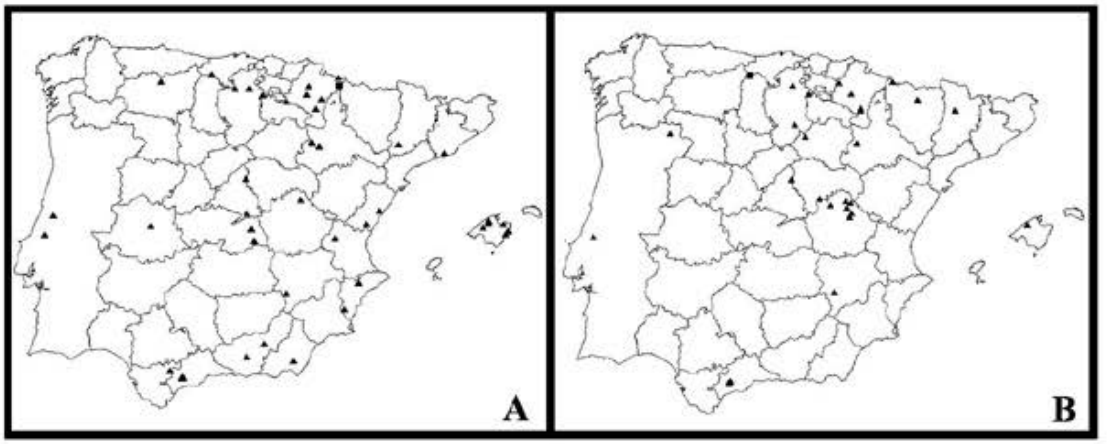


FIGURE 2. Distribution of *Placidiopsis* species in the Iberian Peninsula and the Balearic Islands. A, *P. cinerascens* (▲) and *P. cavicola* (■); B, *P. custnani* (▲) and *P. cinereoides* (■).

ECOLOGY & DISTRIBUTION—The species was found growing in a cave over siliceous substrate, in the northern slope, at 1900–2100 m altitude. *Placidiopsis cinereoides* is known only from the type locality in the north half of the Iberian Peninsula.

COMMENTS— The species is well recognized by the presence of larger ascospores and the rosette-like growth.

Placidiopsis custnani (A. Massal.) Körb., Parerga Lichenol. 305 (1863) FIGS. 1D, 2B

[TYPE: in opp. Scorgano (Custnano), Verona, A. Massalongo. (A. Massal., Lich exs. Ital. 187, M LECTOTYPE, GE, L, M, W! ISOLECTOTYPES).]

MORPHOLOGY— Thallus squamulose, composed of scattered to contiguous squamules; squamules lobulate to crenate, up to 2(–3) mm wide, with margins ascending and down-rolled; upper surface olive green to brownish or greyish, pruinose or not; lower surface dark brown to black or carbonaceous but pale at margins; attached by a central holdfast of dark rhizohyphae, forming a rhizine-like structure.

ANATOMY— Thallus (180) 262.1 ± 51.7 (380) µm thick, upper cortex (7.5) 25.1 ± 9.6 (50) µm thick, paraplectenchymatous, with roundish-subangular cells of (3) 6.4 ± 1.7 (10) µm diam; with or without epinecral layer, up to 50 µm when present. Algal layer 55–175 µm thick, with cells (5) 7.1 ± 1.2 (11) µm diam. Medulla (37.5) 89.5 ± 31.2 (150) µm, composed mainly of globular cells, (4) 6.7 ± 1.3 (10) µm diam; lower cortex not clearly delimited. Rhizohyphae colourless, (3) 3.5 ± 0.5 (4) µm.

Perithecia pyriform to globose, up to ca. 200 µm wide, exciple hyaline to brown or black, darker on the ostiole, up to ca. 20 µm thick; asci clavate, 50–70 × 10–14 µm (Breuss 1996), with a small ocular chamber; ascospores biseriate,

hyaline, septate, (15) 18.2 ± 1.6 (22) × (5) 6.1 ± 0.5 (7.2) µm, l/w ratio (2.3) 3 ± 0.3 (3.8). Pycnidia absent.

Ecology & Distribution — *Placidiopsis custnani* shows preferences for calcareous soils. We have found it mainly in *Pinus halepensis*, *Juniperus thurifera*, and *Quercus ilex* subsp. *ballota* forests; it was found together with *Placidium pilosellum* and sometimes with *Placidiopsis cinerascens*, usually mixed with bryophytes. In the studied area, *P. custnani* was found between 300 and ca. 1500 m altitude.

Placidiopsis custnani has been very infrequently recorded in the Iberian Peninsula. Paz-Bermúdez et al. (2009) reported the second record of the species in the studied region, previously cited from Mallorca (Breuss 1996); this specimen constituted the first record from Portugal. Nevertheless, there are two more records in Spain from 1994 (Hladun & Llimona 2002–07).

Our data considerably extend the known distribution of *P. custnani* in the Iberian Peninsula and the Balearic Islands, with many of the collections constituting first provincial records. The species has been found mainly in central and northern Spain, although there are some localities in southern Spain. In general, the species inhabits colder places than *P. cinerascens*.

Worldwide distribution of *Placidiopsis custnani* includes central Europe reaching northern Europe and the Mediterranean Region (Breuss 1996).

Comments— *Placidiopsis custnani* is easily identified by the presence of ascending squamules with down-rolled margins.

Representative specimens — **SPAIN. Albacete**: Riópar, Sierra de Alcaraz, Calar del Mundo, 555692 E, 426654N, suelo y fisuras calizas, 1530 m, G. Aragón, R. Belinchón y M. Prieto, 01/02/2007, M. Prieto 672, 674. **Burgos**: Contreras, pista hacia Santo Domingo de Silos, Sabinares del Arlanza, 465731 E, 4648768 N, 1276 m, suelo entre musgos, I. Martínez & M. Prieto, 23/08/2007, M. Prieto 1190. Panizares, Sierra de Tesla, 461124 E, 4738773 N, 641 m, suelo entre matorral con boj, I. Martínez & M. Prieto, 23/08/2007, M. Prieto 1168, 1169. **Cuenca**: Las Majadas, Los Callejones, 584688 E, 4459765 N, suelo limoso, 1410 m, M. Prieto, 05/04/2007, M. Prieto 964, 980. **Guadalajara**: Sacedón, carretera hacia Auñón, embalse de Buendía, 521366 E, 4481909 N, 752 m, suelos calizos, M. Prieto, 31/03/2007, M. Prieto 790. **Huesca**: Laguarta, carretera hacia Sabiñánigo, 746634 E, 4706241 N, suelos calizos, 600-700 m, M. Prieto, 04/03/2007, M. Prieto 709 (MA 16303). **La Rioja**: Foncea, 497345 E, 4718904 N, suelos calizos entre matorral con boj, sabina y encinas, 860 m, I. Martínez & M. Prieto, 23/08/2007, M. Prieto 1151 (MA 16310). **Lérida**: Abella de la Conca, Sierra de Carreu, camí Herba-Savina, 832233 E, 4681537 N, suelo entre encinar, 831 m, M. Prieto, 12/08/2008, M. Prieto 1590. **Madrid**: Patones de Arriba, 459550 E, 4524950 N, suelos calizos, 834 m, M. Prieto, 01/05/2008, M. Prieto 1521. **Málaga**: Parauta, Sierra de las Nieves, estribaciones del pinsapar de cerro Alcojona, cerca del pinsapo de la Escalereta, 318103 E, 4060026 N, repisa caliza, 1164 m, I. Martínez & M. Prieto, 12/06/2008, M. Prieto 1452. **Mallorca**: umgebung von Soller, Hohe im Ort, betretener Boden, C. & J. Poelt, 07/04/1964, M. **Navarra**: Bárdenas Reales, hacia el embalse de El Ferial, 616227 E, 4681607 N, suelos yesíferos,

Juniperus phoenicea y *Quercus coccifera*, 362 m, I. Martínez & M. Prieto, 22/08/2007, M. Prieto 1128. **Soria**: Santa María de las Hoyas, monte "Sierra, Jabinada y otros", 489656 E, 4621980 N, suelos calizos en sabinar de *Juniperus thurifera*, 1069 m, R. Belinchón & M. Prieto, 25/05/2006, M. Prieto 633. **Zaragoza**: Oseja, 607653 E, 4606638 N, sustrato yesíferos, suelo entre musgos, 837 m, I. Martínez & M. Prieto, 21/08/2007, M. Prieto 1090. **PORTUGAL.** Bragança, 29TPG799245, rocas básicas, anfibolitas, 955 m, I. Martínez & M. Prieto, 06/09/2006, M. Prieto 838 (MA 16174).

Acknowledgments

We sincerely thank R. Belinchón, M.A.G. Otálora, D. Martínez, and J. Torres for helping with fieldwork. The first author also thanks O. Breuss for interesting discussions, A.R. Burgaz and H. Mayrhofer for helpful comments and revision of the manuscript, and Shaun Pennycook for nomenclature review. The project has been financed by the Spanish Ministry of Science (CGL2004-04795-C04-04) as part of the project "Spanish Lichenological Flora" and a PhD grant from Universidad Rey Juan Carlos to M. Prieto.

Literature cited

Barreno E, Atienza V, Sanz M. J. 1989. Catálogo de los líquenes epífitos y terrícolas de la Font Roja (Alicante, España). Instituto de Cultura "Juan Gil-Albert". Dip. Alicante.

Boom PPG van den, Gómez-Bolea A. 1991. Contribution to the lichen flora of Spain. Nova Hedwigia 53: 497–505.

Breuss O. 1996. Revision der Flechtengattung *Placidiopsis* (*Verrucariaceae*). Österreichische Zeitschrift für Pilzkunde 5: 65–94.

Breuss O. 2002. *Placidiopsis*. 383–384, in: TH Nash III, BD Ryan, C Gries, F Bungartz (eds.): Lichen Flora of the Greater Sonoran Desert Region. I. Lichens Unlimited, Arizona State University, Tempe, Arizona.

Breuss O. 2010. An updated world-wide key to the catapyrenioid lichens (*Verrucariaceae*). Herzogia 23:205–216.

Etayo J. 1992. Fragmenta chorologica occidentalia, lichenes, 3935–4012. Anales del Jardín Botánico de Madrid 50: 85–89.

Etayo J, Breuss O. 1994. *Placidiopsis cavicola*, a new lichen species (*Verrucariaceae*) from the Pyrenees. Österreichische Zeitschrift für Pilzkunde 3: 21–24.

Etayo J, Breuss O. 1996. Líquenes y hongos liquenícolas de los Pirineos occidentales y norte de la Península Ibérica, IV. Cryptogamie, Bryologie–Lichénologie 17: 213–230.

Gueidan C, Roux C, Lutzoni F. 2007. Using a multigene phylogenetic analysis to assess generic delineation and character evolution in *Verrucariaceae* (*Verrucariales*, *Ascomycota*). Mycological Research 111: 1145–1168. doi:10.1016/j.mycres.2007.08.010

Gueidan C, Savić S, Thüs H, Roux C, Keller C, Tibell L, Prieto M, Heiðmarsson S, Breuss O, Orange A, Fröberg L, Amtoft Wynns A, Navarro-Rosinés P, Krzewicka B, Pykälä J, Grube M, Lutzoni F. 2009. Generic classification of the *Verrucariaceae* (*Ascomycota*) based on molecular and morphological evidence: recent progress and remaining challenges. Taxon 58: 184–208.

Guerra J, Ros RM, Cano MJ, Casares M. 1995. Gypsiferous outcrops in SE Spain, refuges of rare, vulnerable and endangered bryophytes and lichens. Cryptogamie, Bryologie–Lichénologie 16: 125–135.

Gutiérrez L, Casares M. 1994. Flora liquénica de los yesos miocénicos de la provincia de Almería (España). Candollea 49: 343–358.

Hladun N, Llimona X. 2002–07. Checklist of the lichens and lichenicolous fungi of the Iberian Peninsula and Balearic Islands. http://botanica.bio.ub.es/checklist/checklist.htm

Paz-Bermúdez G, López de Silanes ME, Terrón A, Arroyo R, Atienza V, Brime SF, Burgaz AR, Carvalho P, Figueras G, Llop E, Marcos B, Pino-Bodas R, Prieto M, Rico VJ, Fernández-Salegui AB, Seriñá E. 2009. Lichens and lichenicolous fungi in the Montesinho Natural Park, the Serra da Nogueira and the Río Sabor Valley (Portugal). Cryptogamie, Mycologie 30: 279–303.

Prieto M, Martínez I, Aragón G, Otálora MAG, Lutzoni F. 2010. Phylogenetic study of *Catapyrenium* s.str. (*Verrucariaceae*, lichen-forming *Ascomycota*) and related genus *Placidiopsis*. Mycologia 102: 291–304. doi:10.3852/09-168

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.473

Volume 114, pp. 473–479 October–December 2010

A new species of *Paradendryphiopsis* from Portugal

CAROLINA SILVERA-SIMÓN, JOSEPA GENÉ & JOSEP GUARRO

carolina.silvera@urv.cat, josepa.gene@ urv.cat & josep.guarro@urv.cat
Unitat de Micologia, Facultat de Medicina i Ciéncies de la Salut
Universitat Rovira i Virgili, 43201 Reus, Tarragona, Spain

RAFAEL F. CASTAÑEDA RUIZ

rfcastaneda@inifat.co.cu
Instituto de Investigaciones Fundamentales en Agricultura Tropical "Alejandro de Humboldt" (INIFAT), Calle 1 Esq. 2, Santiago de Las Vegas, C. Habana, Cuba, C.P. 17200

DAVID W. MINTER

d.minter@cabi.org
CABI, Bakeham Lane, Egham, Surrey, TW20 9TY, United Kingdom

MARC STADLER

marc.stadler@t-online.de
InterMed Discovery GmbH, Otto-Hahn-Strasse 15, D-44227 Dortmund, Germany

Abstract — *Paradendryphiopsis pleiomorpha* sp. nov., found on the bark of an unidentified plant in Braganza, Portugal, is described and illustrated. It is distinguished by conidia that are catenulate, mostly 1–3-septate, usually ellipsoid or obclavate, navicular to oblong, smooth, with pale brown ends and brown at the middle, formed by blastic mode through the conidiogenous locus on unbranched, macronematous conidiophores and by a "thallic-arthric" *Bahusakala*-like synanamorph, which arises from the same conidiophores and vegetative hyphae. A key to *Paradendryphiopsis* species is presented.

Key words — systematics, anamorphic fungi

Introduction

Ellis (1976) erected the genus *Paradendryphiopsis* for *P. cambrensis* M.B. Ellis (type species), found on dead wood of *Quercus* sp. in Wales. The author remarked that primary characteristics of the genus are monotretic conidiogenous cells and thin-walled, catenulate conidia. Hughes (1979) added a second species, *P. laxa* (H.J. Huds.) S. Hughes, and provided several illustrations and commentaries on

conidium ontogeny in *P. cambrensis*. Regarding *P. cambrensis*, Hughes (1979) wrote,

> "Conidia are blastic rather than tretic as described, the deeply pigmented and conspicuous outer wall of the conidiogenous cell is constricted at its apex but entirely continuous with that of the conidium. Acropetal chains of two or three conidia are produced. When the conidium is mature the inner wall of the conidiogenous cell retreats somewhat from the apex and appears as a convex dome. Sometimes the base of the conidium may be temporarily attached, by means of a short denticle, to the retreated inner wall after the outer wall has already ruptured".

Morgan-Jones et al. (1983) followed the same criteria when they described the third species, *Paradendryphiopsis anomala* Morgan-Jones et al., and treated the conidiogenous cells as monoblastic rather than tretic since continuity is clear between the wall of the conidiogenous cell and that of the conidium. During a November 2007 survey of microfungi in the Montesinho and Douro Natural Park (Portugal) as part of a mycological survey called "Flora Micológica Ibérica," a conspicuous fungus from the genus *Paradendryphiopsis* was collected. The specimen showed differences from previously described taxa and is proposed as new to science.

Materials and methods

Plant material was sampled during a mycological survey in the Montesinho Natural Park, Braganza, Portugal. Individual collections were placed in paper and plastic bags, taken to the laboratory, and treated according to Castañeda (2005) and Castañeda et al. (2010). Mounts were prepared in polyvinyl alcohol-glycerol (8 g in 100 ml of water + 5 ml of glycerol) and measurements made at 1000× magnification. Micrographs were obtained with a Zeiss Axio-Imager M1 light microscope.

Taxonomy

Paradendryphiopsis pleiomorpha R.F. Castañeda, Silvera, Gené & Guarro, **sp. nov.**
MycoBank MB 518830 Figs 1–14

Coloniae in substrato naturali effusae, pilosae et funiculosae et interdum granulosae, atrobrunneae. Mycelium partim superficial et partim in substrato immersum, ex hyphis septatis, ramosis, subhyalinis vel dilute brunneis, laevibus, 3–5 µm diam., compositum. Conidiophora mononematosa, macronematosa, simplicia, erecta, recta, cylindrica, 2–6-septata, laevia, irregulartim pigmentata, subhyalina vel dilute brunnea ad basim et brunnea vel dilute brunnea ad apicem, interdum fumoso-brunnea vel atrofumoso-brunnea, 40–150 × 4–6 µm. Cellulae conidiogenae monoblasticae, terminales, determinatae, brunneae vel dilute brunneae, interdum fumoso-brunneae vel atrofumoso-brunneae, 25–40 × 4–5µm. Conidia ellipsoidea, aliquot obclavata, ad usque oblonga, raro navicularia, blasto-catenulata, 1–3 septata, plerumque 2- septata, laevia, 17–30 × 6–9 µm, sicca, utrimque

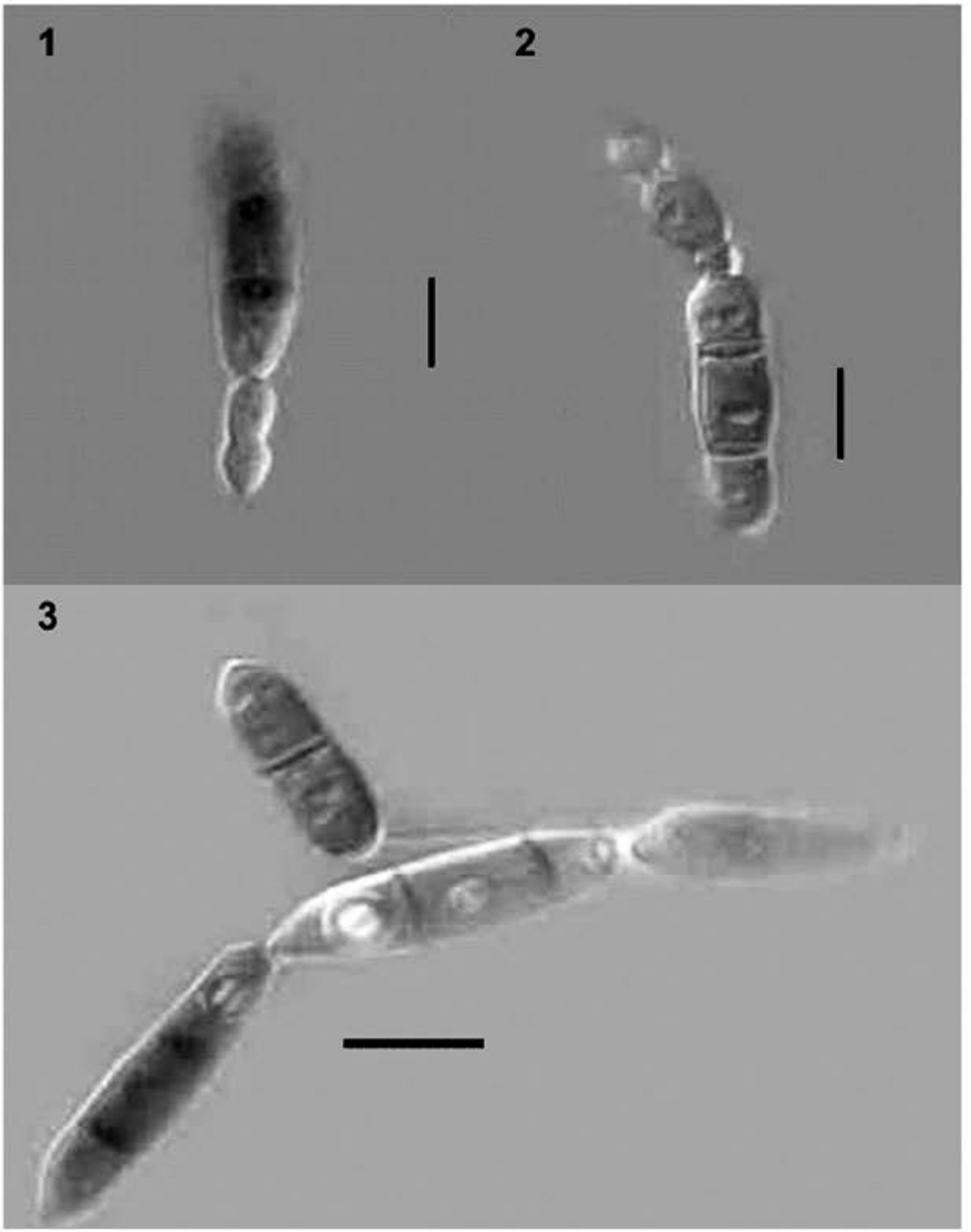
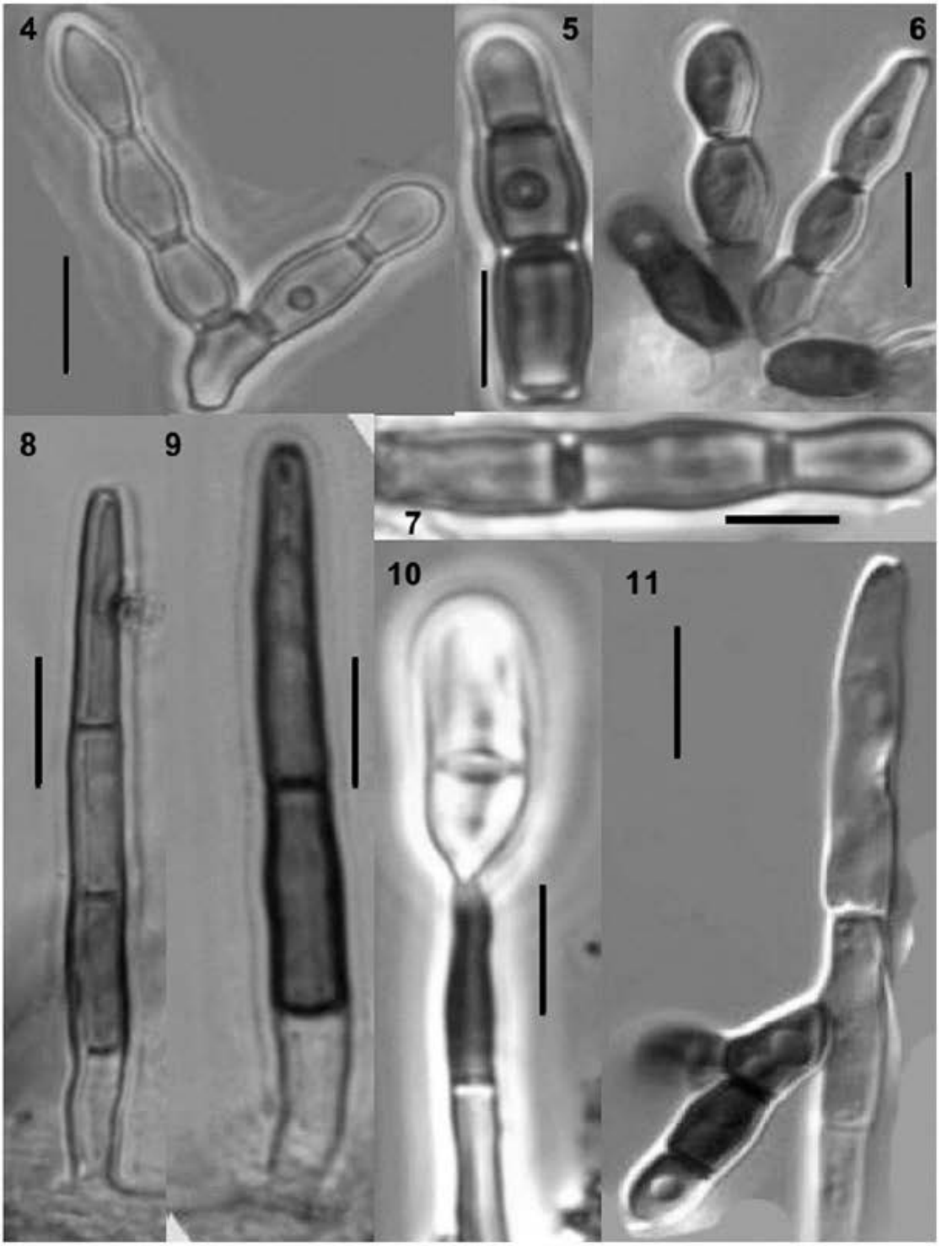


FIG. 1-3. *Paradendryphiopsis pleiomorpha* photomicrographs from holotype (IMI 398786). Conidia and conidial chain. Scale bars = 10 µm.

dilute brunnea et cellula centralis atrobrunnea, interdum irregulartim pigmentata cum unica cellula basalis vel apicalis dilute brunnea et cetero atrobrunnea vel atrofumoso-brunnea, praedita. SYNANAMORPHA *ad genus Bahusakala similis, nonnumquam ipsis ex hyphis et conidiophoris exoriens cum conidiophoris micronematis, ramosis et irregulartim fasciculatis, ramoconidia et conidia "thallica-arthrica", catenulata, per disarticulationem*



Figs. 4–11. *Paradendryphiopsis pleiomorpha*, photomicrographs from holotype (IMI 398786). 4-7. Conidia of the *Bahusakala*-like synanamorph. 8–11. Conidiophores and conidiogenous cells, young attached conidium and *Bahusakala*-like synanamorph arising laterally from a conidiophore. Scale bars = 10 µm.

ramorum producto, oblonga, doliiformia vel in forma plus minusve litterae Graecae upsilon, ex unicellularia, atrofumoso-brunnea vel atrobrunnea, laevia, sicca, 4–17 × 4–7 µm. Teleomorphosis ignota.

TYPE: Portugal. Braganza, Montesinho Natural Park, on bark of an unidentified plant, 14.XI.2007. R.F. Castañeda, C. Silvera & J. Capilla (HOLOTYPE: IMI 398786; ISOTYPE: FMR 10132).

ETYMOLOGY: Greek, *pleio-*, meaning more than usual; *-morpha*, referring to existing forms of conidium ontogeny.

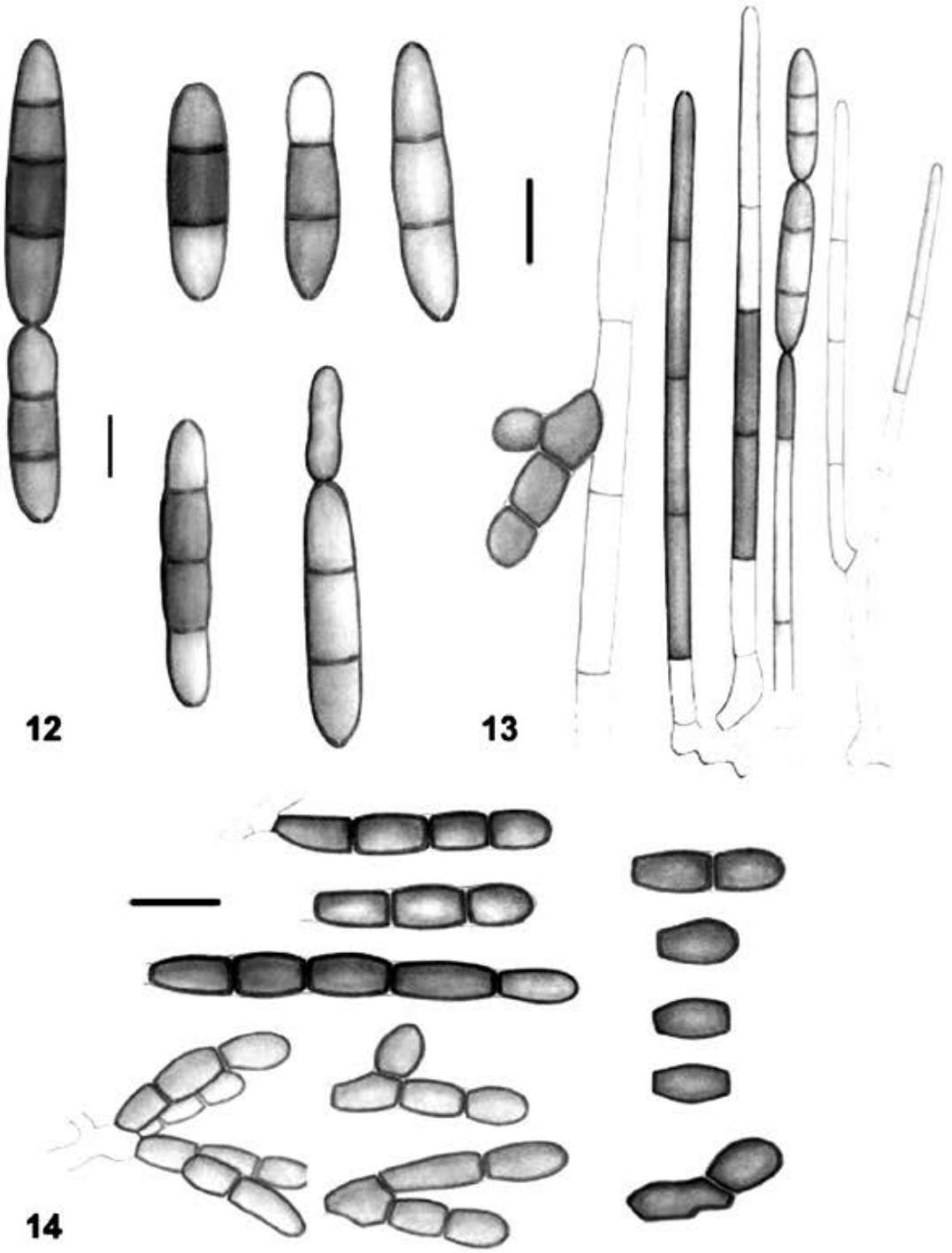
COLONIES on the natural substrate effuse, hairy and funiculose, sometimes granular, dark brown. Mycelium superficial and immersed; hyphae septate, branched, 3–5 µm diam., smooth-walled, subhyaline or pale brown. CONIDIOPHORES mononematous, macronematous, simple, erect, straight, cylindrical, 2–6-septate, smooth, subhyaline or pale brown at the base and brown or pale brown towards the apex, but sometimes irregularly pigmented grayish brown or dark grayish brown, 40–150 × 4–6 µm. CONIDIOGENOUS CELLS monoblastic, integrated, terminal, determinate, brown or pale brown, sometimes grayish brown to dark grayish brown, 25–40 × 4–5 µm. CONIDIA ellipsoid, somewhat obclavate, rarely navicular or oblong, blastocatenulate, 1–3-septate, mostly 2-septate, smooth-walled, 17–30 × 6–9 µm, dry, usually pale brown at the ends (sometimes only one end paler than the rest) and dark brown to dark grayish brown at the middle. SYNANAMORPH *Bahusakala*-like, arising from the same vegetative hyphae and conidiophores. Conidiophores micronematous, branched, irregularly fasciculate, dark brown to dark grayish brown. RAMOCONIDIA AND CONIDIA "thallic-arthric", catenulate, oblong, doliiform, broadly Y-shaped, unicellular, dark gray-brown or dark brown, smooth, dry, 4–17 × 4–7 µm, forming by disarticulation of the conidiogenous branches. Teleomorph unknown.

Paradendryphiopsis pleiomorpha slightly resembles *P. cambrensis*, but that species has discrete conidiogenous cells and lacks a *Bahusakala*-like synanamorph. The pigment distribution in the conidiophores and conidia in that species is also quite distinct from *P. pleiomorpha* and can be easily differentiated (see key below).

Key to *Paradendryphiopsis* species

1 Conidiogenous cells discrete 2
Conidiogenous cells integrated 3

2(1) Conidia ellipsoid, 3-septate, with end cells pale brown to subhyaline and intermediates ones brown, smooth, dry, blastocatenulate, 12–19 × 4–5 µm ..... *P. cambrensis*
Conidia ellipsoid to clavate or turbinate, narrowed to truncate base, 2–3-septate, mid to dark brown, end cells pale, with dark brown bands at the septa, smooth, blastocatenulate dry, 16–30 × 8–12 µm ..... *P. laxa*



Figs. 12–14. *Paradendryphiopsis pleiomorpha*, drawings from holotype (IMI 398786). 12. Conidia. 13. Conidiophores, conidiogenous cells, conidia, and *Bahusakala*-like synanamorph arising from a conidiophore.14. Conidiophores and conidia of the *Bahusakala*-like synanamorph. Scale bars = 10 µm.

3(1) Conidia blastocatenulate, ellipsoid, somewhat obclavate, rare navicular or oblong, 1–3-septate, mostly 2-septate, smooth-walled, dry, pale brown at the ends, dark brown at the middle, sometimes irregularly pigmented, with basal or apical cell pale brown and dark brown to dark grayish-brown the rest, 17–30 × 6–9 µm ..... *P. pleiomorpha*
Conidia solitary, ellipsoid, smooth, 3–4-septate, brown, with the outer cells paler, usually slightly constricted at the end septa, dry, slightly truncated at the base, 24–26 × 11–13 µm ..... *P. anomala*

Acknowledgements

We are deeply indebted to Prof. Lori M. Carris (Washington State University) and Dr. De-Wei Li (The Connecticut Agricultural Experiment Station) for kindly reviewing the manuscript. This study was supported by the Ministry of Science and Innovation of Spain, grant CGL 2008-04226/BOS. We thank the Cuban Ministry of Agriculture for facilities. The author RFCR thanks Drs Uwe Braun, Lori Carris, De-Wei Li, Felipe Wartchow, Antonio Hernández-Gutiérrez, Melissa Mardones, Cony Decock, Shaun Pennycook, Walter Gams, Roland Kirschner, Gabriela Heredia, Xiu Guo Zhang, D.J. Bhat, Gregorio Delgado, Eric H.C. McKenzie, and Pedro Crous for their generous and valued assistance with literature not otherwise available. We also acknowledge the facility provided by Dr. P.M. Kirk through the IndexFungorum website.

Literature cited

Castañeda Ruiz RF. 2005. Metodología en el estudio de los hongos anamorfos. 182–183, in: Anais do V Congresso Latino Americano de Micología. Brasilia.

Castañeda Ruiz RF, Heredia Abarca G, Arias Mota RM, Stadler M, Saikawa M, Minter DW. 2010. *Anaselenosporella sylvatica* gen. & sp. nov. and *Pseudoacrodictys aquatica* sp. nov., two new anamorphic fungi from Mexico. Mycotaxon 112: 65–74. doi: 10.5248/112.65

Ellis MB. 1976. More dematiaceous hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.

Hughes SJ. 1979. Relocation of species of *Endophragmia* auct. with notes on relevant generic names. New Zeal. J. Bot. 17: 139–188.

Morgan-Jones G, Sinclair RC, Eicker A. 1983. Notes on hyphomycetes. XLIV. New and rare dematiaceous species from the Transvaal. Mycotaxon 17: 301–316.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.481

Volume 114, pp. 481–484 *October–December 2010*

New records and checklist of corticioid *Basidiomycota* from Uruguay

SEBASTIÁN MARTÍNEZ[1] & KAREN K. NAKASONE[2]

[1]*sebamart@fing.edu.uy*
Laboratorio de Micología Facultad de Ingeniería/ Ciencias, J. Herrera y Reissig 565, C. P. 11300 Montevideo, Uruguay

[2] *Center for Forest Mycology Research, Northern Research Station, US Forest Service, One Gifford Pinchot Drive, Madison, Wisconsin, USA 53726–2398*

Abstract — Twenty-eight corticioid basidiomycete species are reported from Uruguay for the first time. An annotated checklist with 110 species of corticioid *Basidiomycota* recorded from Uruguay is presented based on these new records and an intensive literature search. These species are distributed in 49 genera and 10 orders. The order *Polyporales* is represented by the most species (40) and the genus *Phanerochaete* has the most species (11). *Hjortstamia fuscomarginata, Hyphoderma rimosum, Phlebia lividina,* and *P. subserialis* are recorded for the first time from South America. For the complete checklist see http://www.mycotaxon.com/resources/weblists.html.

Key words — biodiversity, *Homobasidiomycetes*, taxonomy, wood-rot

Introduction

Uruguay is located in southeast South America between 30° and 35°S and 53.5° and 58.5°W, covering around 178,000 km². The mean temperature is 17.5°C varying from 16°C in the southeastern Atlantic coast to 19°C in the northwest. The mean annual precipitation is 1300 mm, ranging from 1100 mm in southern Uruguay to 1600 mm in the north (Dirección Nacional de Meteorología 2009). The climate in Uruguay is rainy, without a dry season, but with a wide annual variation in precipitation. The Uruguayan climate is temperate and wet (type "C") with precipitation throughout the year (type "f"); in the hottest month the temperature is over 22°C (type "a") (Dirección Nacional de Meteorología 2009). These characteristics correspond with the Cfa climate type of the Köppen-Geiger classification (Peel et al. 2007).

In Uruguay, 7% is forested and 80% is grasslands (Carrere 2001). About 750000 ha are covered by native forests and an additional 670,000 ha consist

of nonnative forests of mostly *Eucalyptus* and *Pinus* species for the pulp and sawmill industries (Anon. 2005). The native vascular flora of Uruguay consists of approximately 2500 to 2750 species (Marchesi 2005, Alonso-Paz & Bassagoda 2002) including 302 indigenous tree and shrub species (Brussa & Grela 2007). According to Alonso-Paz & Bassagoda (2002), the Uruguayan vascular flora is composed of 150 families and 859 genera, which is high if measured by unit area. The families with the highest number of species are *Asteraceae*, *Poaceae*, *Fabaceae*, *Cyperaceae*, and *Euphorbiaceae* (Marchesi 2005, Alonso-Paz & Bassagoda 2002). This diversity of woody native and introduced plant species suggest a corresponding high level of fungal diversity.

The corticioid Basidiomycetes of Uruguay are poorly known. Felippone (1928) was the first to record corticioid species from Uruguay. He recorded four species of *Thelephora* and eight in *Stereum*. Herter (1933) reported six species of *Thelephoraceae*, including one species of *Hymenochaete* and two species in *Irpex* and *Merulius*. Koch et al. (1981) recorded eight species in the genera *Corticium*, *Stereum* and *Thelephora*, as related to plant pathology. In a series of papers, Gazzano (1987, 1988, 1990, 1992, 1994, 1996, 1998, 2000, 2001, 2002, 2007) reported on various polyporoid and corticioid species from Uruguay, including many new records. In total, there are about 70 species of corticioid fungi reported from various sources. Recent collections from throughout Uruguay on native and exotic trees yielded new records of corticioid basidiomycetes. In this study, we report an additional 28 new records of corticioid species. The aim of the present work is to establish a baseline of knowledge of the diversity of corticioid basidiomycetes in Uruguay by providing a checklist of the recorded species.

Materials and methods

The checklist is based on data obtained from an intensive search of literature records of corticioid fungi from Uruguay. Genera and species are listed alphabetically within each accepted order according with the proposed nomenclature of Hibbett et al. (2007) and Larsson (2007). Data on substrate and nutritional strategies are provided for each species. The new species records in this study were collected in native and nonnative, planted forests, urban areas, or retrieved from the herbarium of the Facultad de Ciencias, Montevideo, Uruguay (MVHC). Microscopic examinations were made from freehand sections mounted in 5% aqueous KOH and 1% aqueous phloxine solutions, 5% cotton blue in 25% lactophenol, and Melzer's reagent (Kirk et al. 2008). Specimens were deposited at MVHC. Author abbreviations follow Kirk & Ansell (1992). Cortbase version 2.1 (Parmasto et al. 2004) and Index Fungorum (www.indexfungorum.org) were consulted for current names of species and synonyms.

Results

The corticioid basidiomycetes of Uruguay consist of 110 recorded species, including the present additions. Ninety-nine species are here taxonomically or nomenclaturally accepted and eleven are listed as doubtful. These are distributed in 10 orders according with the modern classification based on molecular studies (Hibbett et al. 2007, Larsson 2007). Among them, only three species belonging to the *Boletales* are brown-rot decay fungi. The orders with the highest number of species present in Uruguay are *Polyporales* (40 species), *Hymenochaetales* (25 species), and *Russulales* (16 species). The remaining seven orders are represented by five or fewer species. The genera with the highest number of recorded species are *Phanerochaete* (11 species), *Phlebia* (8 species) and *Hyphodontia* (7 species) from a total of 49 genera represented in the Uruguayan checklist. *Hjortstamia fuscomarginata* (Burt) Hjortstam & Ryvarden, *Hyphoderma rimosum* Burds. & Nakasone, *Phlebia lividina* Hjortstam and *P. subserialis* (Bourdot & Galzin) Donk are recorded for the first time from South America. For the complete checklist see http://www.mycotaxon.com/resources/weblists.html.

Acknowledgments

We thank Drs. Beatriz Ortiz-Santana and E. Setliff for reviewing this manuscript multiple times and providing many useful comments and corrections.

Literature cited

Alonso-Paz E, Bassagoda MJ. 2002. La biodiversidad asociada a los bosques del Uruguay. Ciencia & Ambiente 24: 35–50.

Anon. 2005. Boletín Estadístico: Diciembre 2005. Dirección General Forestal. Ministerio de Ganadería Agricultura y Pesca. Uruguay. 44 pp.

Brussa CA, Grela IA. 2007. Flora arbórea del Uruguay. Con énfasis en las especies de Rivera y Tacuarembó. Empresa Gráfica Mosca. Montevideo (Uruguay). 544 pp.

Carrere R. 2001. Monte indígena. Mucho más que un conjunto de árboles. Nordán. Montevideo (Uruguay). 152 pp.

Dirección Nacional de Meteorología. 2009. El clima de Uruguay (http://www.meteorologia.com.uy/caract_climat.htm).

Felippone F. 1928. Contribution á la flore mycologique de l'Uruguay. Ann. Cryptog. Exotique. 1(4): 338–348.

Gazzano S. 1987. Notas sobre *Basidiomycetes* xilófilos del Uruguay. II. Nuevos registros de *Polyporaceae* s. str. Comun. Bot. Mus. Hist. Nat. Montevideo 4(79): 1–4.

Gazzano S. 1988. Notas sobre *Basidiomycetes* xilófilos del Uruguay. III. Nuevos registros de *Corticiaceae* s.l. y *Polyporaceae* s.l. (*Aphyllophorales*). Comun. Bot. Mus. Hist. Nat. Montevideo 5(87): 1–3.

Gazzano S. 1990. Notas sobre *Basidiomycetes* xilófilos del Uruguay. IV. *Polyporaceae* s. l. e *Hymenochaetaceae* de un monte indígena del Departamento de Montevideo. Comun. Bot. Mus. Hist. Nat. Montevideo 5(95): 1–4.

Gazzano S. 1992. Notas sobre *Basidiomycetes* xilófilos del Uruguay. V. Nuevos registros de *Corticiaceae* s.l. (*Aphyllophorales*) de la Región Litoral Platense. Comun. Bot. Mus. Hist. Nat. Montevideo 5(99): 1–7.

Gazzano S. 1994. Notas sobre *Basidiomycetes* xilófilos del Uruguay. VI. Nuevos registros. Comun. Bot. Mus. Hist. Nat. Montevideo 5(102): 1–9.

Gazzano S. 1996. Notas sobre Basidiomycetes xilófilos del Uruguay. VII. Nuevos registros de *Aphyllophorales* resupinados (*Corticiaceae* y *Polyporaceae*). Comun. Bot. Mus. Hist. Nat. Montevideo 6(106): 1–8.

Gazzano S. 1998. Notas sobre *Basidiomycetes* xilófilos del Uruguay. VIII. Registro de *Aphyllophorales* y sus sustratos arbóreos. Comun. Bot. Mus. Hist. Nat. Montevideo 6(109): 1–12.

Gazzano S. 2000. Notas sobre *Basidiomycetes* xilófilos del Uruguay. IX. Nuevos registros de *Corticiaceae* y poroides (*Aphyllophorales*). Comun. Bot. Mus. Hist. Nat. Montevideo 6(115): 1–7.

Gazzano S. 2001. Notas sobre *Basidiomycetes* xilófilos del Uruguay. X. Hongos *Aphyllophorales* de la Región E y NE (Departamentos de Cerro Largo, Rivera y Treinta y Tres). Comun. Bot. Mus. Hist. Nat. Montevideo 6(119): 1–10.

Gazzano S. 2002. Notas sobre Basidiomycetes xilófilos del Uruguay. XI. Nuevos registros en hongos corticioides (*Aphyllophorales*: *Coniophoraceae*, *Corticiaceae*, *Hericiaceae* e *Hymenochaetaceae*). Comun. Bot. Mus. Hist. Nat. Montevideo 6(124): 1–8.

Gazzano S. 2007. Notas sobre *Basidiomycetes* xilófilos del Uruguay. XII. Nuevos registros en hongos corticioides (*Aphyllophorales*, *Eumycota*). Comun. Bot. Mus. Hist. Nat. Montevideo 6(132): 1–8.

Herter G. 1933. Florula Uruguayensis. Plantae Avasculares. Ostenia. Montevideo. 364 pp.

Hibbett DS, Binder M, Bischoff, JF, Blackwell M, Cannon PF, Eriksson OE, Huhndorf S, James T, Kirk PM, Lücking R, Lumbsch, HT, Lutzoni F, Matheny PB, McLaughlin DJ, Powell MJ, Redhead S, Schoch CL, Spatafora JW, Stalpers JA, Vilgalys R, Aime MC, Aptroot A, Bauer R, Begerow D, Benny GL, Castlebury LA, Crous PW, Dai Y-C, Gams W, Geiser DM, Griffith GW, Gueidan C, Hawksworth DL, Hestmark G, Hosaka K, Humber RA, Hyde KD, Ironside JE, Kõljalg U, Kurtzman CP, Larsson K-H, Lichtwardt R, Longcore J, Miądlikowska J, Miller A, Moncalvo J-M, Mozley-Standridge S, Oberwinkler F, Parmasto E, Reeb V, Rogers JD, Roux C, Ryvarden L, Sampaio JP, Schüßler A, Sugiyama, J, Thorn RG, Tibell, L, Untereiner WA, Walker C, Wang Z, Weir A, Weiss, M, White MM, Winka K, Yao Y-J, Zhang N. 2007. A higher-level phylogenetic classification of the fungi. Myc. Research 111: 509–547. doi:10.1016/j.mycres.2007.03.004

Kirk PM, Ansell AE. 1992. Authors of fungal names. Index of fungi supplement. CAB International: Wallingford (United Kingdom). 104 pp.

Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008. Ainsworth & Bisby's Dictionary of the fungi. 10th ed. CAB International: Wallingford (United Kingdom). 771 pp.

Koch L, Boasso C, Riccio O, Gandolfo C. 1981. Enfermedades de las plantas, hongos superiores y saprófitas en el Uruguay. Departamento de Comunicaciones. Dirección de Sanidad Vegetal. Ministério de Agricultura y Pesca.

Larsson KH. 2007. Re-thinking the classification of corticioid fungi. Mycol. Res. 111: 1040–1063. doi:10.1016/j.mycres.2007.08.001

Marchesi E. 2005. Flora y vegetación del Uruguay. Project Orion. Environmental Impact Assessment. Capítulo 5: Características del ambiente receptor, IFC.

Parmasto E, Nilsson RH, Larsson KH. 2004. Cortbase version 2 – extensive updates of a nomenclatural database for corticioid fungi (*Hymenomycetes*). Phyloinformatics 5: 1–7. (http://andromeda.botinst.gu.se/cortbase.html)

Peel MC, Finlayson BL, McMahon TA. 2007. Updated world map of the Köppen–Geiger climate classification. Hydrol. Earth Syst. Sci. 11: 1633–1644. doi:10.5194/hess-11-1633-2007.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.485

Volume 114, p. 485 *October–December 2010*

Cautionary advice to authors who alter their reprints in any way from the original publication

RICHARD P. KORF[1*] & LORELEI L. NORVELL[2]

** info@mycotaxon.com*
[1]Plant Pathology Herbarium, Cornell University
Ithaca, NY 14853, USA

[2]Pacific Northwest Mycological Service
6720 NW Skyline Blvd, Portland, OR 97229, USA

ABSTRACT — When authors print out reprints, if they change their article by correcting errors or substituting color illustrations for ones published in black and white, they should be aware that they have essentially published a new article, with a new copyright date, and that the date of making such changes should appear on their doctored reprints.

KEY WORDS — copyright, errata, publication date, color

We call attention to a frequent failure of authors to recognize that when they produce offprints of their journal articles or chapters of books for distribution and in that process make any changes, no matter how small, they are thereby changing the copyright status of their reprints. Permission to make such changes should be sought from the person or organization that holds the copyright.

In the case of this journal, although the copyright is nominally in the name of the publishing corporation, Mycotaxon, Ltd., since its beginnings MYCOTAXON has granted full copyright ownership to each senior author.

All authors who produce offprints from the articles published in MYCOTAXON should be aware that correcting even minor typographical errors or substituting color illustrations for those published in black and white constitutes a change in the copyright status, such that a new copyright date is automatically created. Moreover, that date and the extent of such changes should be clearly identified in the printouts. We suggest that a notice, similar to the hypothetical example below, would ideally appear at the bottom of the first page of such offprints and be printed preferably in color (red) to call attention to post-publication revisions:

This reprint varies from the version originally published on 15 October 2010 in presenting a corrected legend on page 533, corrected "Literature cited" entries on page 538, and the substitution of color plates for those rendered originally in black and white for figs. 1, 3, 4, and 7. This amended version was first printed and distributed (and thus copyrighted) on 22 January 2011 by the senior author.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.487

Volume 114, pp. 487–500 *October–December 2011*

BOOK REVIEWS AND NOTICES

Compiled by

ELSE C. VELLINGA[1]

bookreviews@mycotaxon.com
861 Keeler Avenue, Berkeley CA 94708 U.S.A.

INTRODUCTION

Monographic systematic treatments of diverse fungal groups are the focus of this installment of BOOK REVIEWS AND NOTICES. The first four reviews cover four volumes in the series STUDIES IN MYCOLOGY that focus on different groups of *Ascomycota*. The other five publications have *Agaricales* and *Russulales* as the subject. A worldwide overview of the species and genera in the *Xerula/Oudemansiella* complex, *Lactarius* in Africa, and European representatives of the genera *Hygrocybe*, *Conocybe* and *Pholiotina*, and *Agaricus* are reviewed. These books, although with a regional approach, have a much wider usability than only for the region for which they were researched and written. Most of these books are lavishly illustrated with colour pictures, thanks to today's digital cameras and the modern printing techniques. The Internet with its resources and digitalized texts means that mycology is no longer only a privilege for those with access to well-stocked libraries. The two books in the series FUNGI EUROPAEI that are reviewed here are examples of this democratization process, as both authors are not mycologists by profession: the author of the *Agaricus* book is a practicing veterinarian. It seems fitting that he explicitly acknowledges the on-line sources for old(er) mycological literature.

This contribution concludes with a list of newly published books to be included in upcoming BOOK REVIEWS AND NOTICES.

[1] Books for consideration for coverage in this column should be mailed to the Book Review Editor at the address above. All unsigned entries are by the Book Review Editor.

Ascomycetes

A phylogenetic re-evaluation of *Dothideomycetes*. By C.L. Schoch, J.W. Spatafora, H.T. Lumbsch, S.M. Huhndorf, K.D. Hyde, J.Z. Groenewald & P.W. Crous. 2009. Studies in Mycology no. 64. CBS Fungal Diversity Centre, PO Box 85167, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. vi + 220, illustr. ISBN 978-90-70351-78-6. Price: 65 €.

The taxonomy of the dothideomycetous fungi, i.e. most of those with bitunicate asci, has been in a state of continuous flux for over a century, with vastly different systems being proposed by some and then overturned by others. Part of this difficulty has been a consequence of how particular characters should be interpreted and weighted, but even more of a problem has been the vastness of the group, which makes it difficult for a single mycologist to appreciate the breadth and complexity of the included fungi – both morphologically and biologically. The most significant morphologically based works on the group in the last quarter of the 20th century have been the generic keys and compilation of synonyms by von Arx & Müller (1975), the critical studies on the types of family names by Eriksson (1981), and the illustrated overview of families and genera by Barr (1987). The present issue is fittingly dedicated to the three of those now deceased. However, all these authors adopted different systems of orders and families, and development of a robust classification has only become feasible with the advent of molecular phylogenetic methods. In such a complex group, inadequate sampling, even at the ordinal level, has meant that molecular phylogenies have also been in flux. Indeed, it is only in the last few five years that a more stable backbone has started to emerge as the representation of families and genera has improved. The present volume evidences the enormous and exciting progress that has been made, but simultaneously reveals areas of continuing uncertainty and instability where yet more work is required.

The scene is set by a five-gene phylogeny derived from 356 isolates representing 41 families (of which six are newly described elsewhere in the volume) and all currently accepted orders. Prepared by Schoch and 53 co-authors, this also includes an analysis of the biology of the taxa, leading to the somewhat contentious view that there have been numerous transitions from saprobic to plant-associated and lichenized life-styles. However, a genome-level comparison revealed a high level of unique protein coding genes in the class compared with other fungi, supporting the recognition of *Dothideomycetes* as a distinct class. The major part of the volume, however, is devoted to more detailed studies of particular orders, families, or representatives with different biologies or ecologies.

The monophyly and family structure in *Capnodiales* is addressed by Crous et al., where the main surprise is the placement of *Piedraiaceae* inside *Teratosphaeriacee*; the new family *Dissoconiaceae* is also proposed. The families and genera of the former *Hysteriales* are revisited in a multi-gene phylogeny by Boehm et al.; *Hysteriales* is supported as sister to *Pleosporales*, while *Mytilinidiales* (including *Gloniaceae*) is sister to both. Here a particularly surprising find was that the asexual *Cenococcum geophilum* falls in *Gloniaceae* – a result that may merit more critical scrutiny. In the case of *Pleosporales*, Zhang et al. compared five loci in representatives of 59 genera and 15 families; two new families (*Amniculicolaceae, Lentitheciaceae*) are introduced, *Pleomassariaceae* is included in *Melanommataceae*, and the familial positions of several genera are clarified. Mugambi & Huhndorf revisit the *Melanommataceae* and *Lophiostomataceae* issue; while both families and *Hypostromataceae* were recovered, *Melanommataceae* and, in particular, *Melanomma* remain polyphyletic — however, *Bertiella* and *Herpotrichia* did belong to that family, and an atypical new genus *Misturatosphaeria* is described.

The problem of unnamed lineages recovered from rock is explored further by Ruibal et al., who again emphasize the phylogenetically diverse positions of these superficially rather similar fungi; they include representatives of four dothideomycete orders but one lineage appears closer to *Arthoniomycetes* — many more of these rock-inhabiting fungi clearly remain to be found, and at least the main lineages will eventually have to be named as new genera, even in the absence of either a sexual or an asexual stage, if no already named fungi sequenced continue to prove to be distinct. Nelsen et al. treat the lichenized representatives of *Dothideomycota* based on nuLSU and mtSSU sequence data; *Arthoniomycetes* and *Dothideomycetes* are supported as separate classes; the study shows that in several cases generic concepts require revision, while *Mycomicrothelia* (a genus which includes both lichenized and non-lichenized species) is found to be sister to *Trypetheliaceae* rather than a member of *Arthopyreniaceae*. Shearer et al. studied 169 freshwater isolates, of which 84 belonged in *Dothideomycetes;* within the four clades including only freshwater species — *Jahnulales* the largest (the others being *Lingoldiomycetaceae, Amniculicolaceae,* and *Tingoldiago* + allies) — the aquatic habit is regarded as secondary, all having terrestrial ancestors. Suetrong et al. reached similar conclusions for marine *Dothideomycetes*, which were found to be dispersed through 12 families in six orders in a four-gene phylogeny; most occur on intertidal plants and are tropical, with novel taxa continuing to be recognized, which include two new families (*Aigialaceae, Morosphaeriaceae*) and three new genera introduced here. Finally, Tanaka et al. propose the new family *Teratosphaeriaceae* for five new genera of *Massarina*-like bambusicolous fungi

with *Tetraploa* and *Tetraploa*-like anamorphs or which only produce conidia; here the beautiful *Quadricrura* has species with 1–2 long apical and 4–5 short more basal setae.

The whole issue is illustrated by stunning top-quality and artistically composed colour photomicrographs, and also colour-coded phylograms, which greatly facilitates their interpretation. There is no doubt that this will be regarded as a classic work on the class (!), but I was disappointed that only one chapter (Boehm et al.'s on the hysterioid groups) included any keys. Keys to families, and at least the genera and species treated in detail, would have made the work much more accessible to those wishing to use this volume in making identifications using microscopic characters. Mycologists with access to superbly equipped and resourced molecular laboratories, supported by skilled technicians, should not forget that they represent a privileged section of the potential user-community of systematic works.

Arx JA von, Müller E. 1975. A re-evaluation of the bitunicate ascomycetes with keys to families and genera. Studies in Mycology 9: 1–159.

Barr ME. 1987. Prodromus to Class *Loculoascomycetes*. Amherst, MA: ME Barr.

Eriksson OE. 1981. The families of bitunicate ascomycetes. Opera Botanica 60: 1–220.

DAVID L HAWKSWORTH
Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, Plaza Ramón y Cajal, 28040 Madrid, Spain
davidh@farm.ucm.es

Highlights of the *Didymellaceae*: a polyphasic approach to characterise *Phoma* and related pleosporalean genera. By M. Aveskamp, H. de Gruyter, J. Woudenberg, G. Verkley & P.W. Crous. 2010. STUDIES IN MYCOLOGY no. 65. CBS Fungal Diversity Centre, PO Box 85167, 3508 AD Utrecht, The Netherlands. <info@cbs.knaw.nl>. Pp. iv + 64, illustr. ISBN 978-90-70351-79-3. Price: 40 €.

With over 3200 species names in Index Fungorum/MycoBank, *Phoma* is surely one of the largest morasses requiring resolution amongst the microfungi. This slim volume does not have all the answers, but makes important inroads into identifying the directions of future work by re-assessing the nine-section morphology based system of Boerema et al. (2004; see MYCOTAXON 90: 487–492, 2004); the sections in that system were separated by differences in pycnidial wall anatomy, the occurrence of setae, conidium size, and the presence of chlamydospores. In this issue of STUDIES, a commendable 324 strains are compared by molecular phylogenetic methods, representing 206 taxa of which 159 are *Phoma*-like. Eighteen clades are recognized which, perhaps not surprisingly, do not correlate with the earlier sectional system. Just four of those clades — ones that could be separated morphologically

— are named here: *Didymella* (incl. *Phoma herbarum*, the type species of *Phoma*), *Boeremia* gen. nov. (for *P. exigua* and allied species), *Peyronella* (with teleomorphs formerly in *Didymella* and *Mycosphaerella* — controversially combined under the anamorphic name), and *Stagonosporopsis* (for the former *Phoma* sect. *Heterospora*). In addition, the anamorphs of *Leptosphaerulina* and *Macroventuria* came together in another of the 18 clades. No links with any true *Mycosphaerellaceae*, or indeed any group in *Capnodiales*, were upheld. Sixty-one new combinations are made, and eight new species and two new varieties are described in addition to the new genus.

In view of the limited representation of the treated species, almost all of which are from plants and known in culture, it will be interesting to see whether there is any change in the support for the clades found here when specimens from other host plants, and such disparate hosts as lichens, can be incorporated into the analysis. In the meantime, those working with the untreated species will have to be content to continue to use the current morphology based circumscription of *Phoma*, but in doing so should also appreciate that they are being pragmatic and using the name ad interim in a polyphyletic sense.

Boerema GH, de Gruyter J, Noordeloos ME, Hames MEC. 2004. *Phoma* Identification Manual: differentiation of specific and infra-specific taxa in culture. CABI Publishing, Wallingford.

DAVID L HAWKSWORTH
Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, Plaza Ramón y Cajal, 28040 Madrid, Spain
davidh@farm.ucm.es

Systematics of *Calonectria*: a genus of root, shoot and foliar pathogens. By L. Lorenzo, P.W. Crous, B.D. Wingfield & M.J. Wingfield, 2010. STUDIES IN MYCOLOGY 66. CBS Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT, Utrecht, the Netherlands. <info@cbs.knaw.nl>. Pp. iv + 71, illustr. ISBN 978-90-70351-81-6. Price: 40 €.

The approach taken in this taxonomic revision may be controversial for nomenclatural pedants, but it is pragmatic in a time when changes in the International Code of Botanical Nomenclature relating to the separate naming of states of pleomorphic fungi may be imminent. They treat the generic name *Cylindrocladium*, which is typified by a conidial state fungus, as a regular synonym of *Calonectria*, which is based on a sexual state; i.e. they apply the one-name-for-one-fungus approach, which can only be welcomed by those working with these fungi. The proclamation that "new species should be described in *Calonectria* irrespective of whether the teleomorph is known or not" (p. 3) is pragmatic in this case, where there is a complete congruence between the circumscriptions of the two genera.

The issue comprises three contributions. First is a discussion of species concepts and the nomenclatural approaches adopted, also emphasizing the importance of the genus as plant pathogens. Second is what might be seen as an exemplar study of the plant pathogenic *Calonectria pauciramosa* s. lat. in which a multigene phylogeny and mating tests demonstrate the occurrence of three previously unrecognized cryptic species, which are here described as new. But it is the third that will be of especial interest to those concerned with identification of fungi in the genus – a multigene phylogeny and synopsis that accepts a total of 68 species, of which seven are new to science, and 18 new combinations (all with basionyms in *Cylindrocladium*). Diagnostic characters of the conidial states are illustrated by photomicrographs, and most pleasing are the synoptic and dichotomous keys to the 68 species now accepted under *Calonectria* (i.e. including *Cylindrocladium*). While this is no monograph with detailed descriptions and information on hosts and distributions (as the authors recognize on p. 10), the issue will facilitate the accurate identification of these fungi by plant pathologists and citizen scientists. All concerned with these fungi will need to have this to hand, at least until a full monographic treatment becomes available.

DAVID L HAWKSWORTH
Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, Plaza Ramón y Cajal, 28040 Madrid, Spain
davidh@farm.ucm.es

Species and ecological diversity within the *Cladosporium cladosporioides* complex (*Davidiellaceae, Capnodiales*). By K. Bensch, J.Z. Groenewald, J. Dijksterhuis, M. Starink-Willemse, B. Andersen, B.A. Summerell, H-D Shin, F.M. Dugan, H-J Schroers, U. Braun & P.W. Crous, 2010. STUDIES IN MYCOLOGY 67. CBS Fungal Biodiversity Centre, Uppsalalaan 8, 3584 CT, Utrecht, the Netherlands. <info@cbs.knaw.nl>. Pp. iv + 96, illustr. ISBN 978-90-70351-83-0. Price: 50 €.

Our understanding of the taxonomy of the remarkably successful fungi referred to *Cladosporium* has advanced dramatically over the last few years as more and yet more isolates have been studied by molecular phylogenetic methods – as witnessed by a previous number of STUDIES devoted to the genus, its dismemberment, and also revisions of species concepts in *C. herbarum* and *C. sphaerospermum* (Crous et al. 2007; see MYCOTAXON 107: 507–509, 2009). This new number of the STUDIES might be viewed as a continuation or supplement to that of 2007 in addressing *C. cladosporioides* — a name widely used for saprobic fungi of the genus occurring on decaying or diseased plant parts and well-known as a spoilage and indoor mould growing on materials such as damp plasterwork. Now, over 200 isolates of the complex have been

analyzed by a multigene approach — resulting in an explosive expansion of the group. While the precise application of the name *C. cladosporioides* is fixed here by neo- and epitypification, a staggering 22 species are described as new to science. Although recognized as a result of molecular studies, diagnostic micromorphological features were found: differences in the shape, width, length, septation, and surface ornamentation of the conidia and conidiophores; the length and branching patterns of conidial chains; and hyphal shape, width, and arrangement. The surface features of the conidia were examined using Cryo-SEM and the conidia were found to have a characteristic reticular or embossed striped ornamentation. All these features are seen in the superb photomicrographs provided, which leave no doubt that there are non-molecular characters of value, even though very careful comparisons will often be required.

I was very pleased to see that a dichotomous key had been provided, and that the couplet characters were almost all morphological or micromorphological. However, variability has necessitated that several species were keyed out more than once and, somewhat frustratingly, no micromorphological features were found to distinguish some of the novel phylogenetic species closest to *C. cladosporioides* s. str., so that after the couplet leading to that name placed in parenthesis is "(including morphologically indistinguishable but phylogenetically distinct lineages)." The implication of this is that, without molecular sequence data, it is no longer possible to recognize *C. cladosporioides* s. str., which means that morphological identifications will have to have appended "complex" or "s. lat." A further complication is that instances were found where several isolates from a single location and precise substratum (e.g., an individual plant) yielded more than one widely separated species of the complex. The phenomenon of co-occurrence of different species of *Mycosphaerella* and *Teratosphaeria* in the same leaf lesions has previously been documented, so this result is perhaps not surprising, but it does mean that enormous care is needed in isolating these fungi from natural habitats to be confident that representative lineages have been obtained. This revision has consequently elegantly clarified the species concepts in this group of economically important fungi, but simultaneously made it more difficult for some of the members now known to be in the complex to be identified in the absence of molecular data.

Crous PW, Braun U, Schubert K & Groenewald JZ (2007) The genus *Cladosporium* and similar dematiaceous hyphomycetes. Studies in Mycology 58: 1–253.

David L Hawksworth
Departamento de Biología Vegetal II, Facultad de Farmacia, Universidad Complutense de Madrid, Plaza Ramón y Cajal, 28040 Madrid, Spain
davidh@farm.ucm.es

AGARICALES AND RUSSULALES

The *Xerula/Oudemansiella* complex (*Agaricales*). By R.H. Petersen & K.W. Hughes. 2010. BEIHEFTE NOVA HEDWIGIA 137. J. Cramer in der Gebr. Borntraeger Verlagsbuchhandlung, Johannesstraße 3A, 70176 Stuttgart, Germany. <mail@schweizerbart.de>. Pp. 625, plates 31, figs 576. No ISBN number. Price 179.00 €

The complex of the agaricoid genera *Xerula* and *Oudemansiella* (*Physalacriaceae*, *Agaricales*) is unraveled in great detail in this taxonomic treatment by Ron Petersen and Karen Hughes. The 625-page thick book reveals a much greater complexity than ever imagined. The complex is morphologically studied, and ITS and LSU phylogenies are constructed.

Let us first look at the contents of the book. After a general introduction with a history of the genera/genus and its classifications, material and methods for the research are given, followed by a chapter on the DNA-based phylogenies. 330 pages are devoted to genus and species descriptions, keys to the species, line drawings, and photographs. The next 200 or so pages contain the type studies, and finally a list of new taxa and new combinations, indices, and literature references fill the rest of the pages.

A big problem faced by the authors was how to name the supraspecific taxa, and whether to recognize one genus or name the separate clades. The choice was made to split the group and to recognize seven genera, four of them newly described here, some of them distinctly not monophyletic, but morphologically distinct and homogeneous. The two genera with non-rooting fruitbodies that grow directly on wood are *Oudemansiella*, restricted to tropical species without a persistent annulus, and *Mucidula* as the temperate counterpart with a persistent annulus. Although the two look very much alike, they are not sister groups. The other five genera all have a 'rooting' stipe connected to subterraneous wood or tree roots. The old *Xerula* is redistributed into *Xerula* (in the strict sense) for species with thick-walled setae on the pileus; *Paraxerula* harbours species with thin-walled setae on the pileus; *Hymenopellis*, with the highest number of species, is characterized by a moist to glutinous pileus; *Protoxerula* species, also with a sticky pileus, occur in Australia and have green colours; species with spiny spores are accommodated in the genus *Dactylosporina*; and *Ponticulomyces* (which did not make it into the general key) is an Asian clade of two species with characters in between *Hymenopellis* and *Oudemansiella*. *Hymenopellis* is not a monophyletic unit, and several other genera are nested within it; which genera depend on which gene region the phylogeny is based. The position of *Mucidula* in the middle of *Hymenopellis* was not expected. It is surprising that the authors have not tried to show more support for these decisions by either analyzing the data with topological constraints (such as a

monophyletic *Hymenopellis*) or adding data from protein coding genes. Another solution might be to recognize three genera — *Xerula* s. str. and *Paraxerula* as defined above plus *Oudemansiella* containing all other taxa, including the secotioid genus *Cribbea*. All three form well supported monophyletic clades in the ITS and the LSU phylogenies. Personally, I find the recognition of non-monophyletic genera very problematic, and this is my main critique on this book.

Besides the four new genera, four new species are described, one from Guyana, one from the USA, a third from India, and the fourth from eastern Russia.

The value of this monograph lies in the very thorough descriptions, not only of all accepted taxa, but also and especially of all the type specimens that could be studied. It is also extremely pleasant to have all this information in one place, and not scattered over various publications in a diverse set of journals. However, the information on the type collections should be searchable on the web, ideally linked to nomenclatural data, such as in Index Fungorum or Mycobank. On the negative side is of course the cost of this book, a high price that will certainly deter people in less developed countries from purchasing. This is very infelicitous, as the highest diversity of these taxa is in Asia.

The quality of the photos is variable, and some have been reproduced in a strange way. Unfortunately, but understandably, not all taxa are depicted with a colour plate.

With a book of this size it is inevitable that details have been overlooked; one Latin description never got beyond the first phase of some jotted down characteristics, the epithet 'kuehneri' is consistently misspelled as 'kuehnerii', and diacritical signs in non-English article titles and publications are not or wrongly applied.

This book should nonetheless find a wide audience due to its thorough descriptions and worldwide coverage.

***Agaricus* L. *Allopsalliota* Nauta & Bas.** FUNGI EUROPAEI 1. 2nd Ed. By L. A. Parra Sánchez. 2008. Edizioni Candusso, Via Ottone Primo 90, 17021 Alassio SV, Italy. <maxcandusso@libero.it>. Pp. 824, Plates 396 + 42, figs 114. ISBN 88-901057-7-1. Price 75.00 €.

This new book in the series FUNGI EUROPAEI replaces the 1984 and first volume on the genus *Agaricus* in the series on European fungi. This volume consists of a thorough and well-illustrated introduction to the genus, keys to the subsections, and extensive descriptions of and notes on the 35 species and varieties in sections *Agaricus*, *Bivelares*, *Chitonioides*, *Sanguinolenti*, and *Spissicaules*. The other two sections, viz. *Minores* (with subsections *Minores* and *Arvenses*) and

Xanthodermatei, the subgenus *Lanagaricus*, and the genus *Allopsalliota* will be covered in Part 2 that was scheduled to appear in 2009/2010, but one which we are still eagerly awaiting.

The book was written in Spanish with an English translation, and an Italian translation of the keys is also provided, which partly explains the volume of it. It is lavishly illustrated, with line drawings of the microscopical characters, numerous photos — always several per species showing the variability and changes the fruitbodies go through during maturation, and photos of micromorphological characters. Important characters are often separately illustrated, and photos of spot tests made with various chemicals are given as well.

The introduction alone is reason to buy this book: all you ever wanted to know about *Agaricus*, and much more, is covered. The overview of the characters that are used in *Agaricus* classifications and species recognition is excellent, with many colour photos to illustrate them.

Original diagnoses and plates are reproduced, either in black and white in the text or at the end as colour plates. This is a very valuable asset of this whole series.

Tables compare spore sizes by different authors for the taxa or give comparisons of closely related species.

This book is extremely well researched and executed. Although the European taxa are the focus of the book, its usage exceeds this area, for several reasons. First of all, it provides a clear concept of the European species, and secondly, mushroom species do not read maps and are not constrained by political boundaries. It is also very fortunate that the author has teamed up with those *Agaricus* researchers who apply molecular-phylogenetic methods to the genus for species recognition and circumscription.

A small comment I have is that it would have helped the user to have headers with the species names on top of the pages.

The happy spores on page 367 reflect my feelings when browsing through this book. The only thing missing is the mushroom smells...

Cappelli, A., 1984. *Agaricus* L. : Fr. (*Psalliota* Fr.) Fungi Europaei 1. Libreria editrice Biella Giovanna, Saronno.

***Conocybe* Fayod. *Pholiotina* Fayod.** FUNGI EUROPAEI 11. By A. Hausknecht. 2009. Edizioni Candusso, Via Ottone Primo 90, 17021 Alassio SV, Italy. <maxcandusso@libero.it>. Pp. 968, plates 46 + 403, figs 150, maps 154. ISBN 88-901057-8-X. Price 79.00 €.

Another thorough and excellent monograph in the FUNGI EUROPAEI series, volume 11 harbours all European taxa of *Conocybe* and *Pholiotina*. After the classic but of course heavily outdated 1935 book on the genus *Galera* by Kühner

and the much more recent work on the Dutch species by Arnolds (2005), this will be the book for the future on all aspects of these two genera. In almost 1000 pages, the 101 *Conocybe*, and 26 *Pholiotina* species are described, compared with each other, and illustrated with colour photos, watercolours, and black-and-white microdrawings. Little maps show in which European countries the species were found. As in the other volumes in the series, the original descriptions are reproduced and type studies are provided. The book starts out with an extensive introduction to the two genera, covering the history, classifications, and an overview of the main characters. This introductory text is in three languages: English, Italian, and German. The keys and descriptions of the supra-specific taxa are also trilingual, species descriptions are in English, and comments are in English and German. The list of examined collections also notes whether that particular collection is depicted in the literature, a feature I have not seen elsewhere.

Thickness and colour of the spore wall turn out to be very important in the identification, and it is a pity that those characters are not depicted. The line drawings fall short here (the ones in Arnold's work are of better quality), and colour photos would have been more helpful.

The author also contributed to the sections on the two genera in FUNGA NORDICA (2008), but the present work covers a much wider area and more species. With the relatively low cost of this book, it should find its way to many mycologists' bookshelves.

Arnolds E. 2005. *Conocybe. Pholiotina*. In Noordeloos ME, Kuyper ThW, Vellinga EC (eds). Flora agaricina neerlandica 6: 120–203. Taylor & Francis, Boca Raton, etc.

Hausknecht A, Vesterholt J. 2008. *Conocybe; Pholiotina*. In Knudsen H, Vesterholt J (eds). Funga Nordica: 626–645; 651–657. Nordsvamp, Copenhagen.

Kühner R. 1935. Le genre *Galera* (Fries) Quélet. Lechevalier, Paris.

The genus *Hygrocybe*. 2nd revised edition. FUNGI OF NORTHERN EUROPE Vol. 1. By D. Boertmann, 2010. Danish Mycological Society, Søvænget 9, 3100 Hornbæk, Denmark. <svampetryk@webspeed.dk>. Pp 200, colour plates, line drawings, distribution maps. ISBN 978-87-983581-7-6. Price DKK 280

The second edition of this handsome book, in which the *Hygrocybe* species form northern Europe are depicted and described, shows some significant changes in comparison with the first (Boertmann 1995), now out of print: it is in hardcover, and three additional taxa are treated, many new colour plates of these bright and beautiful fungi are added showing more than ever the extreme colour variability, and the introduction and references are updated. Not yet updated are the genus names that might have to be adopted because of the progress in phylogenetic studies based on DNA comparisons. *Hygrocybe* in the sense presented here is not monophyletic. Some species are better placed in

Omphalina/Arrhenia, outside the *Hygrophoraceae*, *Cuphophyllus* (also known as *Camarophyllus*) and *Gliophorus* are well characterized genera within the *Hygrophoraceae*, but as there is not yet a thorough molecular-phylogenetic analysis of the family as a whole, these decisions have been postponed. Three new combinations that were invalidly introduced in FUNGA NORDICA (Boertmann 2008) are here validated.

The photos are just plain beautiful and in themselves a reason to buy this book. This book is particularly valuable for all who are trying to survey, manage and conserve the vulnerable unfertilized grasslands in (northern) Europe, and the author mentions, with pride, a British court case in which the presence of wax caps stood in the way of building developments. Of course, this book can be used in a much larger area than just northern Europe; it gives well-illustrated descriptions of the European species whose names are widely applied elsewhere.

Boertmann D. The genus *Hygrocybe*. Fungi of northern Europe vol. 1. The Danish Mycological Society.

Boertmann D. 2008. *Hygrocybe* (Fr.) P. Kumm. In Knudsen H, Vesterholt J (eds). Funga Nordica: 194–212. Nordsvamp, Copenhagen.

Fungus flora of tropical Africa. Volume 2. Monograph of *Lactarius* in tropical Africa. By A. Verbeken & R. Walleyn. 2010. National Botanic Garden of Belgium, Nieuwelaan 38, 1860 Meise, Belgium, <sales@br.fgov.be>. Pp. 151, plates 54. ISBN 978-90-726-1981-5. Price 50.00 €.

Isolated early from the other continents and bounded to the north by the Sahara Desert, the African tropical forests possess an ectomycorrhizal mycota that is largely — perhaps completely — endemic (Verbeken & Buyck 2002). For over three-quarters of a century, the National Botanical Garden of Belgium has fostered the scientific knowledge of ectomycorrhizal and other macromycetes in central Africa through collecting expeditions and the publication series FLORE ICONOGRAPHIQUE DES CHAMPIGNONS DU CONGO (18 volumes; 1935-1972) and FLORE ILLUSTRÉE DES CHAMPIGNONS D'AFRIQUE CENTRALE (17 volumes; 1972-1997). A new series, the FUNGUS FLORA OF TROPICAL AFRICA (2007-present), represents a continuation of the two previous series. In the second volume of the FUNGUS FLORA OF TROPICAL AFRICA, Professor Annemieke Verbeken of Ghent University (Belgium) and the late Ruben Walleyn (1966-2008) present a monographic study of the genus *Lactarius* (*Basidiomycota*, *Russulales*) in tropical Africa.

Outside of Heim's (1938, 1955a, b) studies in Madagascar, Congo, and Western Africa, studies of *Lactarius* in tropical Africa were restricted to scattered species

descriptions until the early 1990s. In 1993, the authors began focused studies on *Lactarius* in this region, and the present volume compiles a substantial amount of knowledge about the topic. Verbeken and Walleyn present descriptions of 96 species and 2 accepted varieties within 17 subgeneric sections, with taxonomic keys to tropical African species provided for each section. A detailed, 20-page section describing taxonomically valuable characters is richly illustrated with line drawings of micromorphological features. Species descriptions are detailed and accompanied by exceptional line drawings. Eighty of the species are represented within the 54 full-page color plates by photographs, watercolors by M. Goosens-Fontana (whose striking watercolors appear in the previous two publication series), or both. The color photographs (mostly by the authors, B. Buyck, or A. De Kesel) are impressively large (most are half-page scale – significantly larger than those in most field guides, not to mention other monographs) and nearly all of them are of excellent quality; both characteristics combine to make the plates a valuable source of visual information. References, a taxonomic index, and French translations of the taxonomic keys are provided. At a list price of 50 € ($68 US), this volume is quite reasonably priced given the number of photographs, and demonstrates that it is indeed possible to publish richly illustrated yet affordable taxonomic texts.

Though recent molecular systematic studies have established the non-monophyly of *Lactarius*, a phylogenetic classification at the sectional and species levels has not yet been achieved; therefore, the authors adhere to a more traditional, morphology-based concept in the classification used in this book, with the exception of including the sequestrate genera *Arcangeliella*, *Zelleromyces*, and *Gastrolactarius* that have previously been shown to be synonymous with *Lactarius*.

The authors note that approximately 25% of the species described in this volume are known only from the type locality, highlighting the fragmentary state of knowledge about *Lactarius* (the same could be said of most other genera) in tropical Africa; at the same time, however, the present volume makes an extremely valuable contribution toward reducing the size of this problem. While the high endemicity of the African mycota reduces somewhat the utility of this monograph for identifying species found elsewhere, the data and specimens represented therein provide a critical component for understanding the biogeography of *Russulaceae* and tropical ectomycorrhizal fungi in general. The detailed introductory section on taxonomically valuable characters alone is an important enough resource that researchers and students of *Lactarius* should own a copy of this book. This impressive volume excels both in terms of scientific value and aesthetic quality, and I highly recommend it not only to

persons with a specific interest in *Lactarius* or the African mycota, but to any amateur or professional mycologist who wishes to be inspired by an outstanding example of taxonomic mycology.

Heim R. 1938. Les lactario-russulés du domaine oriental de Madagascar. Prodr. Fl. Mycol. Madagascar Dépendances 1: 1–196.

Heim R. 1955a. Les lactaires d'Afrique intertropicale (Congo belge et Afrique noire française). Bull. Jard. Bot. Etat Bx. 25: 1–91.

Heim R. 1955b. *Lactarius*. Flore Iconographique des Champignons du Congo 4: 81-97.

Verbeken A, Buyck B. 2002. Diversity and ecology of tropical ectomycorrhizal fungi in Africa. In: Watling R, Frankland JC, Ainsworth AM, Isaac S, Robinson CH. (eds). Tropical Mycology, Volume 1: Macromycetes: 11–24. Wallingford, CABI Publishing.

TODD W. OSMUNDSON
Berkeley Natural History Museums and
Department of Environmental Science, Policy & Management
University of California, Berkeley, CA, USA
toddo@berkeley.edu

BOOK ANNOUNCEMENTS

***Corticiaceae* s.l. Fungi Europaei 12.** By A. Bernicchia & S.P. Gorjón. 2010. Edizioni Candusso, Via Ottone Primo 90, 17021 Alassio SV, Italy. <maxcandusso@libero.it>. Pp. 1008, plates 427, figs 455. ISBN 978-88-901057-9-1. Price: 77.00 €.

Rare and interesting species of heterobasidiomycetes from Russia. Fungi non delineati 53. By V.F. Malysheva, 2010. Edizioni Candusso, Via Ottone Primo 90, 17021 Alassio SV, Italy. <maxcandusso@libero.it>. Pp. 90, plates 52, figs 43. Price: 12.00 €.

The Lichen Genus *Rinodina* (*Lecanoromycetidae, Physciaceae*) in North America, North of Mexico. By J. Sheard, 2010. NRC Research Press, 1200 Montreal Rd, Bldg M-55, Ottawa, ON K1A 0R6, Canada. <pubs@nrcresearchpress.com>. Pp. 246. ISBN-139780660199412. Price: US$89.95.

ISSN 0093-4666 © 2010. Mycotaxon, Ltd. ISSB 2154-8889

MYCOTAXON

DOI: 10.5248/114.501

Volume 114, pp. 501–505 *October–November 2011*

Fungal nomenclature. Summary of recent decisions by the Nomenclature Committee for Fungi

LORELEI L. NORVELL

llnorvell@pnw-ms.com

Secretary, IAPT Permanent Nomenclature Committee for Fungi

Abstract — Recent decisions made by the IAPT permanent Nomenclature Committee for Fungi (NCF) cover 17 proposals to conserve or protect fungal names. Recommendations on 10 sets of proposals to amend the International Code of Botanical Nomenclature (including the governance of fungal nomenclature, name deposition, electronic publication, sanctiotypification, and Art. 59) and decisions on two cases of near homonymy and one of orthography are also reported.

In preparation for IBC2011 (the XVIII International Botanical Congress, Melbourne, Australia, 23–30 July, 2011), the IAPT permanent Nomenclature Committee for Fungi (NCF) reports on votes from two ballots on proposals to conserve or reject fungal names and announces recommendations on proposals to amend the INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE to help guide non-mycologists during the pre-Congress paper ballot and final voting at the July 18–22 Nomenclature Section.

The 14 voting NCF members are Lee Crane (Urbana-Champaign IL), Chairman Vincent Demoulin (Liege), David Hawksworth (Madrid/London), Teresa Iturriaga (Caracas), Paul Kirk (Egham), Pei-Gui Liu (Kunming), Tom May (Melbourne), Jacques Melot (Reykjavík), Secretary Lorelei Norvell (Portland OR), Shaun Pennycook (Auckland), Christian Printzen (Frankfurt), Scott Redhead (Ottawa), Svengunnar Ryman (Uppsala), and Dagmar Triebel (München). As a 9-vote minimum is required for the NCF to recommend or reject a conservation proposal, only those proposals showing a greater than 60% majority can be considered to have passed out of Committee.

Published nomenclatural proposals and NCF reports can be downloaded from [www.ingentaconnect.com/content/iapt/tax] (the TAXON website),

while all previous and current NCF commentaries, important committee correspondence, and interim reports are available via the International Mycological Association website [http://www.ima-mycology.org/CFF].

Proposals to conserve or reject fungal names

* = proposal decisions detailed in Norvell (2011: Taxon 60(1) in press).

The Committee recommends the following proposals:

*Prop. 1810, to conserve the name *Hemipholiota* against *Nemecomyces* (*Agaricales, Basidiomycota*) [Jacobsson & Holec 2008; Taxon 57: 641-642]
— 86% support

*Prop. 1828, to conserve the name *Aspicilia aquatica* against *Lichen mazarinus* (*Ascomycota*: *Pertusariales*: *Megasporaceae*) [Nordin & Jørgensen 2008; Taxon 57: 989]
—86% support

*Prop. 1831, to conserve the name *Mixia* against *Phytoceratiomyxa* (*Basidiomycota*) [Sugiyama & Katumoto 2008: Taxon 57: 991–992]
— 86% support

Prop. 1852, to conserve the name *Olivea tectonae* (T.S. Ramakr. & K. Ramakr.) R.L. Mulder against *Olivea tectonae* (Racib.) Thirum. (*Basidiomycota*). [Minnis & al. 2008: Taxon 57: 1355–1356]
— 93% support

*Prop. 1862, to conserve the name *Psoroma versicolor* (*Degeliella versicolor*) against *Psoroma subdescendens* (lichenized *Ascomycota*, *Pannariaceae*) [Fryday & Coppins 2009: Taxon 58: 293]
— 86% support

Prop. 1863, to conserve the name *Craterellus cinereus* (Pers. : Fr.) Donk with a conserved type against *Craterellus cinereus* Pers. (*Basidiomycota*) [Olariaga & al. 2009: Taxon 58: 294–295]
— 93% support

Prop. 1896, to conserve the name *Lichen lichenoides* (*Leptogium lichenoides*) against *Lichen tremelloides* and *L. tremella* (lichenized *Ascomycota*) [Jørgensen 2009, Taxon 58: 1002–1003]
— 71% support

*Prop. 1897, Proposal to reject the name *Lecidea epiploica* (lichenized *Ascomycota*) [Jørgensen & Nordin 2009: Taxon 58: 1003–1004]
— 93% support

*Prop. 1898, to conserve *Stirtonia* A.L. Sm, (lichenized *Ascomycota, Arthoniales*) against *Stirtonia* R. Gr. bis (*Bryophyta, Dicranales*) [Frisch & Thor 2009: Taxon 58: 1004]
— 86% support)

*Prop. 1899, to conserve the name *Hebeloma cylindrosporum* against *Hebeloma angustispermum* (*Basidiomycota*) [Vesterholt & al. 2009:Taxon 58: 1005]
— 93% support

*Prop. 1918, to conserve the name *Dermatocarpon* (*Placopyrenium*) *bucekii* against *Placidium steineri* (lichenized *Ascomycota, Verrucariaceae*) [Senkardesler 2010: Taxon 59: 294]
— 86% support

*Prop. 1919, to conserve *Lactarius* (*Basidiomycota*) with a conserved type [Buyck & al. 2010: Taxon 59: 295–296]
— 79% support

*Prop. 1926, to conserve *Cladia* against *Heterodea* (*Ascomycota*) [Lumbsch & al. 2010: Taxon 59: 643]
— 86% support

*Prop. 1945, to conserve the name *Thelephora comedens* (*Vuilleminia comedens*) with a conserved type (*Basidiomycota*) [Ghobad-Nejhad & Hallenberg 2010: Taxon 59: 1277–1278]
— 100% support

The Committee does not recommend the following proposals:

Prop. 1769, to conserve the name *Cortinarius speciosissimus* against *C. rubellus*. [Gasparini & al. 2007: Taxon 56: 596–597]
— 86% oppose

*Prop. 1829–30, to reject the names *Verrucaria thelostoma* (1829) and *Pyrenula umbonata* (1830) (lichenized *Ascomycota*) [Jørgensen 2008: Taxon 57: 990–991]
— Both opposed: (1829) by 71%; (1830) by 79%

The Committee is still considering the following proposals:

Prop. 1861, to conserve the name *Aspicilia farinosa* (*Ascomycota*: *Pertusariales*: *Megasporaceae*) with a conserved type [Nordin & Roux 2009: Taxon 58: 292]

Prop. 1888, to conserve the name *Glomus* (*Fungi, Glomeromycota, Glomerales*) as being of neuter gender [Kuyper 2009: Taxon 58: 647]
—Note: 93% support the proposal, which is retained for further discussion by request of Chair Demoulin.

Prop. 1927, to conserve the name *Agaricus rachodes* (*Basidiomycota*) with that spelling [Vellinga & Pennycook 2010: Taxon 59: 644]

Proposals to amend the International Code of Botanical Nomenclature

The following recommendations cover proposals unrelated to Art. 59:

Props. 16–20, to make clear that the *Code* covers the nomenclature of fungi, and to modify its governance with respect to names of organisms treated as fungi

[Hawksworth & al. 2009: Taxon 58: 658–659]

— 78% support (16—changing the title to the International Code of Botanical and Mycological Nomenclature) and 71% support Props. (17—replacing "plant/s" by "plant/s or fungus/i" throughout) and (18—provide for election of the NCF by an International Mycological Congress). At the moment simple majorities do not support either (19—to permit decisions on fungal proposals to be taken at an IMC) or (20—to make such decisions binding on the subsequent IBC Nomenclature section.)

Props. 48–51, to exclude the phylum *Microsporidia* from the *Code* [Redhead & al. 2009: Taxon 58: 669]

— 86% support all three proposals.

Props. 117–119, to make the pre-publication deposit of key nomenclatural information in a recognized repository a requirement for valid publication of organisms treated as fungi under the Code [Hawksworth & al. 2010: Taxon 59: 1297]

— 79% support all three proposals.

Props. 183–184, to require deposition of information concerning typification of names of fungal taxa, with an associated Recommendation [Gams 2010: Taxon 59: 1626–1627]

— 72% support both proposals

Props. 185–190, to amend Art. 15 (185—to clarify what is meant by sanctioning), Art. 36 (185–189—to permit the use of either Latin or English for valid publication), and to amend Art. 45 (190—to make Art. 45 applicable to groups similar to the *Microsporidia* but which are not covered by Props. 48–51) [Demoulin 2010, Taxon 59: 1627–1628]

— All supported: (185) by 86%; (186–189) by 79%; (190) by 71%.

Props. 203–213, to permit electronic publications to be effectively published under specified conditions [Special Committee on Electronic Publication 2010: Taxon 59: 1907]

— 79% support

Prop. 223–232, to amend articles regulating the typification of names in sanctioning works [Redhead & al. 2010: Taxon 59: 1910–1913]

— 71% do not support (223—delete Art. 7.8); a 57% simple majority supports (223–232—amend Art. 7.8) .

The following recommendations cover Art. 59 proposals:

Props. 172–174, to amend Article 59 concerning teleotypification of fungal names. [Gams & al. 2010: Taxon 59: 1297]

— 71% do not recommend (172) to delete Art. 59.7 and 64% do not support (174) to add Rec. 59A4 to classify a new anamorph under a teleomorph-typified generic name only when no suitable anamorph-typified generic name is available; (173), to alter Art. 59.7 so that teleomorph-typified names

in anamorphic genera need not be changed, is still under consideration with 57% currently opposing.

PROPS. 294–306, to define the new term 'teleotype' (294–5), to rename Chapter VI (306), and to modify Art. 59 to limit dual nomenclature and to remove conflicting examples and recommendations (296–305) [Redhead 2010: TAXON 59: 1927–1929]

— A strong majority (64–86%) supports all except 298, 300, and 303; the last three show majority (57%) support.

PROPS. 307–313, to harmonize Art. 59 in order to harmonize it with present practice, by raising the status of anamorph names (307–309), clarify the status of teleomorph- and anamorph-typified genera (310–311), and recommend that teleomorph-typified genera should be reserved to teleomorph-typified species and vice versa for anamorphs (312–313) [Gams & al. 2010: TAXON 1929–1930]

— All proposals are still under consideration. simple majorities support (307—57%) and do not support (308, 310–313—50%); there is no agreement on (309).

Other recommendations

The following recommendations cover near homonymy according to Art. 53.5 (1–2) and orthography (3).

(1) ***Calongea*** Healey & al. in Anales Jard. Bot. Madrid 66(51): 27. 2009 (*Pezizaceae*) and ***Calongia*** D. Hawksw. & Etayo in Lichenologist 42: 355-359. 2010 (mitosporic fungi).

— 93% considered the names are sufficiently alike to be confusable, and so they should be treated as homonyms, with priority granted to *Calongea* Healey & al.

(2) ***Phyllocratera*** Sérus. & Aptroot in Aptroot & al., Biblioth. Lichenol. 64: 132. 1997 (*Phyllobatheliaceae*) and ***Phyllocrater*** Wernham in J. Linn. Soc., Bot. 42: 90. 1914 (*Dicotyledones, Rubiaceae*).

— 64% considered the names are sufficiently alike to be confusable, and so they should be treated as homonyms, with priority granted to *Phyllocrater* Wernham. (The lower support in case (2) is attributable that two different kingdoms (*Fungi* vs. *Plantae*) are represented.

(3) Regarding the applicability of Art. 60.1 to the elements 'rhiz,' 'rrhiz,' 'riz,' or 'rriz' within a name:

—86% considered that the element should be spelled as written by the original author. Demoulin's Prop. 185 to amend the Code is an outgrowth of this discussion.

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.507

Volume 114, pp. 507–508 *October–December 2010*

NOMENCLATURAL NOVELTIES AND TYPIFICATIONS PROPOSED IN MYCOTAXON 114

Alboleptonia angustospora Largent, Aime & T.W. Henkel, p. 116

Alboleptonia cystidiosa Largent & Aime, p. 120

Alboleptonia minima Largent & T.W. Henkel, p. 122

Alternaria silybi Gannibal, p.110

Alternaria simmonsii Gannibal, p. 112

Anthracoidea arnelli Denchev, T. Denchev & Karatygin, p. 68

Apiognomonia duschekiae Lar.N. Vassiljeva & S.L. Stephenson, p. 300

Asterostroma boninense Suhara & N. Maek., p. 198

Biscogniauxia alnophila Lar.N. Vassiljeva & S.L. Stephenson, p. 300
≡ *Biscogniauxia mediterranea* var. *microspora* (J.H. Mill.) Y.M. Ju & J.D. Rogers 1998

Caloplaca tianshanensis Xahidin, A. Abbas & J.C. Wei, p. 3

Cetraspora helvetica Oehl, Jansa, F.A. Souza, G.A. Silva, p. 74

Colletotrichum cordylinicola Phoulivong, L. Cai & K.D. Hyde, p. 251

Conocybe volviradicata Watling, Işıloğlu & Baş Sermenli, p.146

Coprinellus allovelus (Uljé) Doveri & Sarrocco, p. 358

Coprinellus canistri (Uljé & Verbeken) Doveri & Sarrocco, p. 359

Coprinellus limicola (Uljé) Doveri & Sarrocco, p. 358

Coprinellus minutisporus (Uljé) Doveri & Sarrocco, p. 359

Coprinellus mitrinodulisporus Doveri & Sarrocco, p. 353

Coprinellus pseudoamphithallus (Uljé) Doveri & Sarrocco, p. 359

Corynesporopsis iberica R.F. Castañeda, Silvera, Gené & Guarro, p. 409

Dactylella yoaniae Y.D. Zhang & X.G. Zhang, p. 260

Ellisembia photiniae Jian Ma & X.G. Zhang, p. 419

Ellisembia podocarpi Jian Ma & X.G. Zhang, p. 418

Entoloma vittalii Senthil., Kumaresan & S.K. Singh, p. 62

Exobasidium rhododendri-siderophylli ZhenYing Li & L. Guo, p. 271

Galerella nigeriensis Tkalčec, Mešić & Čerkez, p. 266

Heteroconium schimae Y.D. Zhang & X.G. Zhang, p. 316

ISSN (print) 0093-4666 ISSN (online) 2154-8889

MYCOTAXON

DOI: 10.5248/114.509

Volume 114, pp. 509–520 *October–December 2010*

From the *Editor-in-Chief*

Farewell to Hard Copy — It is with a certain amount of regret I close Mycotaxon 114 — a volume delayed by a perfect storm of computer and other problems. Ever since I saw my first volume in the 1970's, I have loved the 'book' feel of these brightly colored volumes dedicated solely to fungal nomenclature and taxonomy. While I will not miss compiling author indices or explaining for the umpteenth time why a line drawing must have 900-1200 dpi resolution (or why color — which conveys so much more than halftones ever can — costs so much), I will definitely miss the solid thump of a newly arrived volume on my desktop and sitting down to read all of its pages over again in one continuous flow.

Fortunately, the searchability, versatility, and immediacy of an online journal will more than make up for the sound of that gratifying thump, just as the free and unlimited number of color plates on the 'inside' pages will more than compensate for a book bound in color. For Mycotaxon, "Print is dead. Long live the pixel!"

Open Access — "Knowledge is power. Knowledge shared is power multiplied," wrote the late "mayor of Silicon Valley" (Robert Noyce). For that reason Mycotaxon feels strongly that all scientific papers should be available to everyone at no charge. Although we cannot cover our costs by making all papers freely available at the outset, through Cyberliber and soon Ingenta we do release all papers to the Internet for free access after two years. Nonetheless, we urge authors who can afford our modest and reasonable fee of $20/page to pay for immediate "Open Access."

Web-list innovations: farewell to the 4-page summary — As it makes no sense whatsoever to post online a summary of a longer annotated species distribution list ("web-list") also posted online, we no longer require authors to prepare both a summary for inclusion within the journal and a longer annotated list for posting to the Mycotaxon website. Instead, we now ask that each annotated web-list undergo vigorous and thorough reviews by at least

three experts, one of whom is a native English-speaker. After three experts have returned favorable reviews (accompanied by a special 'list' review form) to both authors and *Editor-in-Chief,* the authors may prepare their document using whatever format and size they prefer before submitting it to the *Nomenclature Editor* for accessioning and approval (but not review). Authors then submit their approved, final list (as document or pdf file) + new "list submission form" to the *Editor-in-Chief.* The authors and title of a finally approved list will be cited on a free access summary page within the online volume. The page will list all newly uploaded weblists, each of which will be 'hot-linked' to the Mycotaxon weblist page. Our weblist upload fee remains $40. We now also charge $40 to replace a previously posted species list with an updated and revised version.

New instructions — With the delay of Mycotaxon 114 and additional time needed to prepare for an online Mycotaxon 115, I have not yet had time to revise the Instructions to Authors pdf posted on Mycotaxon website. I have, however, been able to prepare newly revised templates, a sample manuscript, and forms, all of which can be downloaded from the author downloads page on our website. As noted above, we now require separate weblist review and submission forms. Also, all illustration files should be submitted in jpg (or tif) format and all should have 300 dpi resolution for a 4.33 page width. Only plates intended to display color should be submitted in color mode.

Warm (if seriously belated) regards,

Lorelei Norvell,
Mycotaxon *Editor-in-Chief*
24 January 2011

AUTHOR INDEX—VOLUME ONE HUNDRED FOURTEEN

REVIEWERS, VOLUME ONE HUNDRED FOURTEEN

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this volume.

Eef Arnolds
Timothy J. Baroni
Scott Thomas Bates
Dominik Begerow
José Luiz Bezerra
D.J. Bhat
María Virginia Bianchinotti
Irwin M. Brodo
Harold H. Burdsall, Jr.
Ana Rosa Burgaz
Lei Cai
Paul Francis Cannon
Lori Carris
Rafael F. Castañeda Ruiz
Michael Castellano
Gerard Chevalier
Kanad Das
Vagner Gularte Cortez
Wolfgang Dämon
Yu-Cheng Da
Cony Decock
Paul Diederich
Paolo Giordani
Aristóteles Góes-Neto
Bruno Tomio Goto
Shouyu Guo
Ying-Lan Guo
Laura Guzmán-Dávalos
Nils Hallenberg
Richard C. Harris
Tsutomu Hattori
Anton Hausknecht
Shuanghui He
V.B. Hosagoudar
Kentaro Hosaka
E.B. Gareth Jones
W.B. Kendrick
Paul M. Kirk
Henning Knudsen
Kerry Knudsen
Richard P. Korf
Carlos Lado
De-Wei Li
Zongqi Liang
Marcos Lizárraga E.
D. Jean Lodge
Clarice Loguercio-Leite
Juan Luis Mata
Patrick Brandon Matheny
Helmut Mayrhofer
Andrew S. Methven
Eric H.C. McKenzie
Vadim A. Mel'nik
Leticia Montoya
László Nagy
Karen Nakasone
George Newcombe
Machiel E. Noordeloos
Anders Nordin
Lorelei L. Norvell
Nichole R. O'Neill
Omar Paíno Perdomo E.
Javier Palenzuela Jiménez
Shaun R. Pennycook
Sergio Pérez-Ortega
Beatriz Ortiz-Santana
Ronald H. Petersen
Michele D. Piercey-Normore
Huzefa A. Raja
Scott A. Redhead
Amy Y. Rossman
Leif Ryvarden
Derek J. Schafer
Keith A. Seifert
Edward C. Setliff
Roger G. Shivas
Emory G. Simmons
Harrie J.M. Sipman
Leo Spier
Wjacheslav Spirin
Steven L. Stephenson
Dagmar Triebel
Alexander Urban
Kálmán Vánky
Long Wang
Zheng Wang
Jinze Zhang
Tian-Yu Zhang
Xiu-Guo Zhang
Dequn Zhou
Wen-Ying Zhuang

Errata

Volume 110

p. 257, line 7	for: *Dac. phymatopagum*	read: *Dac. phymatopaga*
line 10	for: *Dac. ellipsosporum*	read: *Dac. ellipsospora*
line 11	for: *Dac. haptotylum*	read: *Dac. haptotyla*
p. 285, line 12	for: *Crepidotus betula*	read: *Crepidotus betulae*
p. 333. line 36	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*
p. 336, line 25	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*
p. 337, line 34	for: *vesparia*	read: *vesparium*
p. 338, line 48	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*
p. 340, line 48	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*
p. 348, line 6	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*
p. 350, line 6	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*
p. 352, line 15	for: *Metatrichia vesparia*	read: *Metatrichia vesparium*

Volume 111

p. 455, tab 3	for: *Xeroceps peckianus*	read: *Xanthoporus peckianus*
	for: *Xeroceps syringae*	read: *Xanthoporus syringae*

Volume 113

p. 14, line 2	*for:* nine	*read:* eight
p. 58, lines 25 & 28	*for:* Botanik	*read:* Botanisk
p. 248, line 6	for: *B. zelandiaenovae*	read: *B. zelandiae-novae*
p. 393, right_line 4	*for:* Hyphodiscus-Catinifera	*read:* Hyphodiscus-Catenulifera
p.468, Fig. 1, line 5	*for:* culture on wood; show the ...	*read:* culture on wood show the ...
p.468, bottom line	*for:* 12 µm long); 1.5 µm wide	*read:* 12 µm long; 1.5 µm wide
p.469, line 8	*for:* droplets). Ascospores ...	*read:* droplets. Ascospores ...
p. 505, 5th from bottom	*for:* Index of Fungi	*read:* Index Fungorum
p.505, 2nd from bottom	*for:* Rec. 88B.3	*read:* Rec. 8B.3

FOUR EASY STEPS TO SUCCESSFUL MYCOTAXON PUBLICATION IN 2011

MYCOTAXON's complete instructions, last updated in January, 2010, are posted on the INSTRUCTIONS TO AUTHORS page on the MYCOTAXON website listed below. Prospective authors should download instructions PDF, expert reviewer comment and submission forms, and helpful templates by clicking the 'file download page' link on the instructions page before preparing a paper intending for the journal. The newly revised MYCOTAXON template shows the new style and should be followed until the revised Instructions are posted. Below is a summary of our simple '4-step' publication process.

Step 1—PEER REVIEW: Authors send a formatted text document with illustration files and MYCOTAXON Reviewer Comments Form to 2–3 experts for peer review. Authors should (i) ask peer reviewers to Email the revised manuscripts and comment forms to both authors and the *Editor-in-Chief* <editor@mycotaxon.com> and (ii) revise their manuscript according to reviewer suggestions **before** submitting all text files to the *Nomenclature Editor* for nomenclatural review. NEW: doi reference numbers must be added to cited references prior to sending a manuscript out for review. (See MYCOTAXON 112: 514–515.)

Step 2—NOMENCLATURAL REVIEW: Authors next Email their revised master text file (containing footnotes, tables and captions but ***NO*** illustrations) to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz> for accession and pre-submission review. The Email message *MUST* include the word 'MYCOTAXON' on the subject line and *MUST* include names **and** Email addresses of all peer reviewers. The Nomenclature Editor will return annotated files with a list of needed corrections to the authors and *Editor-in-Chief.*

Step 3—FINAL SUBMISSION: After authors receive their manuscript accession number and make revisions requested during nomenclatural review, they should send (i) a completed MYCOTAXON submission form; (ii) separate text files for main text, tables, and legends; and (iii) art files to the *Editor-in-Chief* <editor@mycotaxon.com>. Only text and image files considered ready for immediate publication should be sent at this time. The *Editor-in-Chief* will try to acknowledge receipt of files within two weeks. Authors are asked to wait at least 14 days before sending a follow-up query, to avoid unnecessary Email traffic near publication deadlines or during temporary closures of the editorial office.

Step 4—PRESS PREPARATION: After preparing a PDF from the author's text and art files, the *Editor-in-Chief* sends journal entries for the nomenclatural novelties with the PDF proof to all coauthors for approval. Editorial errors are always corrected free of charge, but authors who ask the *Editor-in-Chief* to correct errors present in their original files will be charged $10 per correction

(minimum charge of $40). Payment arrangements for all fees should be made by writing the *Business Manager* <subscriptions@mycotaxon.com>.

Mycotaxon frequently updates its webpages and regularly posts abstracts, table of contents, book reviews, indices, distributional checklists, and revised instructions and forms on its website. We invite all of you to browse our website frequently for updated journal and other interesting mycological news.

www.mycotaxon.com

www.ingentaconnect.com/content/mtax/mt

MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

MYCOTAXON is a quarterly, peer-reviewed journal devoted to mycological taxonomy and nomenclature. All articles are reviewed by specialists prior to submission. Publication is open to everyone. Papers are in English, with summaries in any additional languages desired by the authors given for longer articles. Authors prepare their own files after having received critical comments from pre-submission reviewers and nomenclatural review by the Nomenclature Editor. *Instructions to Authors* and *Guidelines for Reviewers* are updated and can be downloaded from our website at <WWW.MYCOTAXON.COM/AUTHORS/DOWNLOADS.HTML>. Submission procedures are presented in the last pages of each volume.

ALERT — ATTENTION ALL SUBSCRIBERS: IMPORTANT NEWS!

MYCOTAXON is evolving!

In January 2011, we will convert to an online format and will no longer offer a printed version of the journal, except to selected libraries for nomenclatural purposes. MYCOTAXON has, from its inception, worked at being a fast and affordable means of sharing taxonomic and nomenclatural discoveries. Rising postage costs and our efforts to "go green" convinced us that moving to an online format offers subscribers and authors numerous advantages. Keep up to date on this changeover at:

www.mycotaxon.com/gogreen.html

ALERT — ATTENTION AUTHORS: ADDITIONAL NEWS!

Among the many advantages an online MYCOTAXON offers authors is the opportunity to publish an unlimited number of pages and color illustrations, both at NO COST! All articles submitted to MYCOTAXON now require authors to provide Digital Object Identifiers (DOIs) in their cited references. More information on this new process is available at:

www.mycotaxon.com/authors/doi.html

CUMULATIVE INDICES

Printed versions of the *Mycotaxon Cumulative Indices* for Volumes 1-20 (ISBN 0-930845-00-5), Volumes 21-40 (ISBN 0-930845-01-03), and Volumes 41-60 (ISBN 0-930845-07-02) are available (see descriptions at <WWW.MYCOTAXON.COM> and order there or through your local bookstore's listings under "Books in Print"). An online *Cumulative Index to Taxa in Volumes 61-ff.* and the *Cumulative Author Index to Volumes 61-ff.* are posted at <WWW.MYCOTAXON.COM>.

AVAILABILITY IN ELECTRONIC VERSIONS

Back volumes through 2007 are available as downloads through Cyberliber <WWW.CYBERTRUEFELE.ORG.UK/CYBERLIBER/INDEX.HTM> under 'Journals.'

CONTACTING MYCOTAXON'S EDITOR-IN-CHIEF

To reach the *Editor-in-Chief* regarding manuscripts, E-mail to <EDITOR@MYCOTAXON.COM>
or post to Lorelei L. Norvell, 6720 NW Skyline Boulevard, Portland, OR 97229-1309, USA

CONTACTING MYCOTAXON'S ORDER DEPARTMENT

To reach the Order Department for information or placing orders, you may
E-mail to <SUBSCRIPTIONS@MYCOTAXON.COM> or
Fax to Orders, Mycotaxon, Ltd. at +1.607.273.4357.

VISIT MYCOTAXON ONLINE AT <WWW.MYCOTAXON.COM>