MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

Volume 95 *January–March 2006*

CONTENTS

[Content continues inside front cover]

ISSN 0093-4666 MYXNAE 95: 1–350 (2006)

For subscription details, availability on microform, and availability of articles as photocopies or tear sheets, see back cover

[Content continued from front cover]

RECENT BOOKS FROM MYCOTAXON

Prices include surface mail shipment (*for more books see* **www.mycotaxon.com/books.html**)
Mycotaxon, Ltd., P. O. Box 264, Ithaca, NY 14851-0264, U.S.A.

Fungi of China, by S. C. Teng.

Mycotaxon, Ltd. 1996. Hardbound, xiv + 586 pp., 426 illustrations, map, portrait, index, 8-1/2x11 inches. $79.00.
Airmail price varies by country: enquire. ISBN 0-930845-05-6.
Edited by Richard P. Korf, with a foreword by Teng's daughter, Rosaline Z. Deng.
Proceeds from sales go to the Teng family.

Special for *Mycotaxon* subscribers: deduct $20 from regular price!

What reviewers say about Teng's Fungi of China:

"... one of the most valuable books on the fungi of China ever published in English." —*Mycologia* 90: 1091-1092, 1998.

"... a great big blue uncompromising brick of a book ... an instant classic. Anyone interested in identification of fungi, particularly in Asia, should get this book immediately. Mycology owes another debt to Dick Korf for his sympathetic and intelligent editing of this superb work." —*Bibliography of Systematic Mycology* 10(6): xlviii-xlix. 1998.

"The book is important for any researcher interested in the systematic relationships, diversity, and distribution of fungi on a global scale." - *New Zealand Journal of Botany* 35: 265-266. 1977.

Fungi of Northwestern China, edited by Wen-Ying Zhuang.

Mycotaxon, Ltd. 2005. Hardbound, 430 pp., 26 x 18.5 cm. US$40.00 plus postage. ISBN 0-930845-14-5.
(Please *order direct* from Wen-Ying Zhuang, PO Box 2714, Beijing 100080, China; zhuangwy@sun.im.ac.cn).

Some 3887 named species belonging to 759 genera of fungi (slime molds, plasmodiophoromycetes, chytrid, oomycetes, zygomycetes, lichens, non-lichenized ascomycetes, anamorphic fungi, rusts, smuts, and the basidiomycetous macrofungi) hitherto known from Gansu, Ningxia, Qinghai, Shaanxi and Xinjiang, China are listed. Useful references, detailed tropical distribution, and hosts or substrates are provided for each species. *Contributing authors:* Shuang-Lin Chen, Lin Guo, Shou-Yu Guo, Ying-Lan Guo, Shu-Xiao Sun, Shu-Xia Wei, Hua-An Wen, Xiao-Qing Zhang, Jian-Yun Zhuang, and Wen-Ying Zhuang.

Higher Fungi of Tropical China, edited by Wen-Ying Zhuang.

Mycotaxon, Ltd. 2001. Cloth bound, 485 pp., 26 x 18.5 cm. US$50.00 plus postage. ISBN 0-930845-13-7.
(Please *order direct* from Wen-Ying Zhuang, PO Box 2714, Beijing 100080, China; zhuangwy@sun.im.ac.cn).

Some 5056 named species belonging to 1192 genera of higher fungi hitherto known from tropical China are listed. Useful references, detailed tropical distribution, and hosts or substrates are provided for each species. *Contributing authors:* Lin Gou, Shou-Yu Guo, Ying-Lan Guo, Xiao-Lan Mao, Shu-Xiao Sun, Shu-Xia Wei, Hua-An Wen, Zhi-He Yu, Xiao-Qing Zhang, Jian-Yun Zhuang, and Wen-Ying Zhuang.

A Monograph of the Fungus Genus *Cercospora*, by Charles Chupp

Published by the author, Ithaca. 1953. Hardbound, 667 pp. 222 illustrations, octavo, $25.00. Airmail, $45.00
Proceeds from sales go to the Chupp family.
Still a classic after a half century.

Mycotaxon Cumulative Index for Volumes XLI-LX (1991-1996)

Karen D. Gettelman, Richard P. Korf, Susan C. Gruff & Ian P. Korf
Mycotaxon, Ltd. 1998. Softbound, 296 pp., 6x9 inches. $35.00. Airmail, $55.00. ISBN 0-930845-07-2.

Mycotaxon Cumulative Index for Volumes XXI-XL (1984-1991)

Richard P. Korf & Susan C. Gruff
Mycotaxon, Ltd. 1991. Softbound, 352 pp., 6x9 inches. $30.00. Airmail, $50.00. ISBN 0-930845-01-3.

Mycotaxon Cumulative Index for Volumes I-XX (1974-1984)

Richard P. Korf & Susan C. Gruff
Mycotaxon, Ltd. 1984. Softbound, 232 pp., 6x9 inches. $17.50. Airmail, $37.50.
ISBN 0-930845-00-5.

FUNGAL DIVERSITY RESEARCH SERIES (published in Hong Kong): Mycotaxon, Ltd. now ships rapidly from the U.S. to North American customers. All prices are *postpaid*. Titles include: **Marine Mycology—A Practical Approach**, Kevin D Hyde & Stephen B. Pointing (eds.), $100, 2000. **Genera of Ascomycetes from Palms**, by Kevin D. Hyde, Joanne E. Taylor & Jane Fröhlich, $100, 2000. **Palm Microfungi**, by Jane Frölich & Kevin D. Hyde, $100, 2000. **A World Monograph of *Anthostomellaa***, by Binsheng Lu & Kevin D. Hyde, $100, 2000. **Checklist of Hong Kong Fungi**, by B.S. Lu, K.D. Hyde, W.H. Ho, H.M. Tsui, M.K.M. Wong, Yanna & D.Q. Zhou, $20, 2000. **Bio-Exploitation of Filamentous Fungi**, Stephen B. Pointing & Kevin D. Hyde (eds.), $100, 2001. **Fungi in Marine Environments**, Kevin D. Hyde (ed.), $80, 2002. **Smut fungi from New Zealand—Fungi of New Zealand volume 2**, by Kálmán Vánky & Eric H.C. McKenzie, $50, 2002. **The Genus *Mycena* in South-Eastern Australia**, by Cheryl A. Grgurinovic, $80, 2002. **Freshwater Mycology**, by C.K.M. Tsui & K.D. Hyde, $80, 2003. **Myxomycetes of New Zealand—Fungi of New Zealand volume 3**, by Stephen L. Stephenson, $50, 2003. **Microfungi of Tropical and Temperate Palms**, by Joanne E. Taylor & Kevin D. Hyde, $80, 2003. **Revision of the genus *Amphisphaeria***, by Y.Z. Wang, André Aptroot & Kevin D. Hyde, $60, 2004. For details see the Hong Kong University website:
www.hku.hk/ecology/mycology/FDRS/index.htm

MYCOTAXON

THE INTERNATIONAL JOURNAL OF FUNGAL TAXONOMY & NOMENCLATURE

Volume 95, 2006

COMPLETE IN ONE VOLUME

CONSISTING OF VI + 350 PAGES INCLUDING FIGURES

EDITOR-IN-CHIEF

Lorelei L. Norvell
editor@mycotaxon.com
Pacific Northwest Mycology Service
6720 NW Skyline Boulevard
Portland, Oregon 97229-1309 USA

ASSOCIATE EDITORS

NOMENCLATURE EDITOR

Shaun R. Pennycook
PennycookS@LandcareResearch.co.nz
Manaaki Whenua Landcare Research
Auckland, New Zealand

BOOK REVIEW EDITOR

David L. Hawksworth
MycoNova, Calle Aguila 12
Colonia La Maliciosa, Mataelpino
ES-28411 Madrid, Spain

FRENCH LANGUAGE EDITOR

Grégoire Hennebert
32 Rue de l'Élevage
B-1340 Ottignies – LLN, Belgium

INDEX EDITOR

Karen D. Gettelman
510 Lake Blvd., Apt. 166
Davis, CA 95616 U.S.A.

EDITORIAL ADVISORY BOARD

Donald H. Pfister, Cambridge, Massachusetts, USA (1997-2007), Chair
Gary J. Samuels, Beltsville, Maryland, USA (1997-2006), Past Chair
Wen-Ying Zhuang, Beijing, China (2003-2008)
Carol A. Shearer, Urbana, Illinois, USA (1998-2009)
Shaun Ross Pennycook, Auckland, New Zealand (2005-2010)
Seppo Huhtinen, Turku, Finland (2006-2011)

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

www.mycotaxon.com

Printed in the United States of America

© Mycotaxon, Ltd, 2006

MYCOTAXON

VOLUME NINETY-FIVE TABLE OF CONTENTS

Indices & Information

PUBLICATION DATE FOR VOLUME NINETY-FOUR

MYCOTAXON *for* OCTOBER–DECEMBER, VOLUME 94 (1–412 + I–VI)

was issued on May 11, 2006

MYCOTAXON

Volume 95, pp. 1–65 *January–March 2006*

Taxonomic studies on Ustilaginomycetes - 26

KÁLMÁN VÁNKY

vanky.k@cityinfonetz.de
Herbarium Ustilaginales Vánky (HUV)
Gabriel-Biel-Str. 5, D-72076 Tübingen, Germany

Abstract—Fifteen new species of smut fungi are described: *Doassansiopsis tomasii, Microbotryum afromontanum, Pilocintractia adrianae, Sporisorium andropogonis-chinensis, S. andropogonis-eucomi, S. andropogonis-pumili, S. distachyum, S. ingoldii, S. livingstoneanum, S. scholzii, Ustanciosporium virginianum, Ustilago gabonensis, U. penniseti-purpurei, U. pentaschistidis, U. trichogena.* New names proposed are: *Sporisorium andropogonis-gabonensis* and *S. clintonianum.* New combinations are: *Heterodoassansia hygrophilae, Sporisorium andropteri, S. sanctae-catharinae, S. semisagittatum, S. sorghastri, S. zilligii, Ustilago jardineae.* Taxa placed in synonymy are: *Entyloma lavrovianum, Leucocintractia leucodermoides, Pericladium flavesci, Sorosporium chloridicola, S. platense, Sphacelotheca rhaphidis, Tilletia cynodontis, Ustilago andropogonis-hirtifolii, U. liebenbergii.* A lectotype is designated for *Ustilago chloridicola.* Keys are given to the species of *Pilocintractia* and to the smut fungi of *Andropogon, Chloris, Jardinea, Leptochloa, Nymphaea, Phacelurus, Rhytachne,* and *Sorghastrum.*

Key words—nomenclature, smut fungi, synonym, taxonomy

The smut fungi of *Andropogon* (*Poaceae*)

Andropogon L. is a genus with about 100 species in the tropics belonging to the subfam. *Panicoideae,* tribe *Andropogoneae,* subtribe *Andropogoninae* (Clayton & Renvoize, 1986:349). Numerous smut fungi have been described on it. Zundel (1930), in his monograph of the *Ustilaginales* attacking *Anropogon*, recognised 76 species. Since 1930, the classification of both the grasses and the smut fungi has changed considerably. Many "*Andropogon*" species in Zundel's paper do not belong to this genus any more, and many smut fungi do not belong to the genus under which they were treated by Zundel. On *Andropogon* s. str. 32 species of smut fungi could be distinguished, including 6 new species. At the same time, *Sorosporium platense* was found to be a synonym of *Sporisorium andropogonis*, and *Ustilago andropogonis-hirtifolii* a synonym of *Sporisorium stuhlmannii.*

The smut fungi of *Andropogon* were compared also with the six smut fungi described on the closely related *Schizachyrium* (comp. Vánky, 2003:36-43; 2004a:74). These six species proved to be distinct from the species on *Andropogon.* However, several smut fungi occur on both *Andropogon* and *Schizachyrium* species. The recognised smut fungi of *Andropogon* are:

1. *Jamesdicksonia brunkii* (Ellis & Galloway) J. Walker & R.G. Shivas, 1998:1212.

Ustilago brunkii Ellis & Galloway, March 1890:31. — *Tolyposporella brunkii* (Ellis & Galloway) G.P. Clinton, 1902:147. — *Tilletia brunkii* (Ellis & Galloway) Durán, 1972:2572 (invalid comb., no basionym and place of publication indicated; ICBN 33.2). — Type on *Andropogon argenteus* (= *A. ternarius*), USA, Texas, Brazos Co., College Station, 1890, H.S. Jennings, BPI 192453.

Ustilago apiculata Ellis & Galloway, in Jennings, May 1890:29. — Type on *Andropogon saccharoides*, USA, Texas, Brazos Co., College Station, 1890, H.S. Jennings, BPI 192453; isotype BPI 157287! (syn. by Clinton, 1902:129, confirmed).

Sori on the adaxial surface of the leaf sheaths, forming striae fusing into a blackish-brown, agglutinated to granular-powdery coat of spore masses, showing through the outer surface of the leaf sheaths, between the veins, as pale lead coloured striae of various length. *Spores* globose, subglobose to ovoid (in some specimens to subpolyhedrally irregular), extremely variable in size, 10-18 x 10-20(-24) µm in diameter, yellow to dark reddish-brown; wall 3-8 µm thick, composed of a homogenous, uniform endospore of 1-2 µm, and a multilayered, smooth exospore, sometimes with a short, hyaline papilla. (Spore measurements made in unheated lactophenol because in heated lactophenol or in water the spore wall and the spores swell considerably). *Spore germination* (Durán, 1972:2572, fig. 17; Bauer et al., 2001:420, fig. 9) results in holobasidia producing apically 4-8, allantoid, fusiform, symmetrical, septate basidiospores which do not fuse but germinate apically producing ballistoconidia. Asymmetrical ballisto basidiospores are also produced on the basidia on sterigmata.

On *Andropogon barbinodis* Lag. (*Bothriochloa barbinodis* (Lag.) Herter; *A. saccharoides* Sw. var. *barbinodis* (Lag.) Hack.; *A. saccharoides* Sw. var. *leucopogon* (Nees) Hack.), *A bicornis* L., *A. gerardii* Vitman, *A. hirtiflorus* (Nees) Kunth var. *pubiflorus* (Nees) Kunth, *A. perforatus* Trin. ex Fourn., *A. saccharoides* Sw. (*A. torreianus* Steud.; *Bothriochloa saccharoides* (Sw.) Rydb.), *A. ternarius* Michx. (*A. argenteus* Ell.; *A. argyraeus* Schult.), *Dichanthium sericeum* (R. Br.) A. Camus, *D. sericeum* subsp. *polystachyum* (Benth.) B.K. Simon, *Schizachyrium hirtiflorum* Nees (*Andropogon hirtiflorus* (Nees) Kunth; *S. sanguineum* (Retz.) Alston var. *hirtiflorum* (Nees) S.L. Hatch); Australia, N., C. & S. America, West Indian Antilles.

2. *Jamesdicksonia caribensis* M. Piepenbring, 2003:220.

Type on *Andropogon bicornis*, Dominican Republic, Azua Prov., Cordillera Central, La Cumbre, 3.III.1930, E.L. Ekman, S; isotype BPI 192463!

Sori forming striae on the leaves and leaf sheaths, linear, 0.2-0.5 x 1-5 mm, or longer by confluence, initially covered by the epidermis which ruptures longitudinally disclosing the black, agglutinated to granular spore mass. *Spores* very variable in shape and size, globose, ellipsoidal, lemon-shaped or irregular, often with appendages, 7-14 x 8-16(-18) µm, light to medium dark olivaceous-brown; wall uneven, 1.5-6.5 µm thick, including a thin, uniform endospore, and a multilayered, smooth exospore of variable thickness.

On *Andropogon bicornis* L.; West Indian Antilles (Dominican Rep., Puerto Rico).

Jamesdicksonia caribensis differs from *J. brunkii* in having smaller and more irregular spores and a thinner spore wall.

3. *Macalpinomyces ovariicolopsis* (Vánky) Vánky, 2002a:427.

Sporisorium ovariicolopsis Vánky, 2000:203. — Type on *Andropogon gayanus*, Zimbabwe, Matabeleland North Prov., 12 km N of Lusulu, alt. 1010 m, 16.III.1999, C. & K. Vánky, HUV 18903!; isotypes BPI 746891, IMI 380467, S.

Sori in sessile spikelets, infecting only a few in the inflorescence, leaving intact the outermost floral envelopes, lemon-shaped or obovoid with acute or subacute tip, 3-5 x 5-10 mm, covered by a thick, initially green later brown peridium of host and fungal origin which ruptures and opens irregularly disclosing the agglutinated to semi-powdery, dark brown mass of spores intermixed with sterile cells. The sori start to develop at the basal part of the ovaries. The distal part of the seeds may persist on the top of young sori as an acute tip. *Spores* single when mature, subglobose, ovoid or ellipsoidal, (5.5-)6.5-8(-9.5) x (6.5-)7-11 µm, yellowish-brown; wall even, 1-1.5 µm thick, prominently, rather densely echinulate. *Sterile cells* in loose, irregular groups or in short rows, single cells subglobose, ovoid or irregular, with one or two flattened sides, 5-9 x 6-11(-14) µm, hyaline; wall thin, c. 0.5 µm, smooth.

On *Andropogon gayanus* Kunth; Africa (Malawi, Zambia, Zimbabwe).

4. *Sporisorium andropogonis* (Opiz) Vánky, 1985:113.

Uredo (*Ustilago*) *andropogonis* Opiz, 1824:43 (as '*andropogi*'). — *Sphacelotheca andropogonis* (Opiz) Bubák, 1912:25. — *Cintractia andropogonis* (Opiz) Kochman, 1936:75. — Type on *Andropogon angustifolius* (= *Dichanthium ischaemum*), Czech Rep., Dablizerberg [Ďáblice] Mt., near Prague, F.M. Opiz.

For taxonomic synonyms such as *Ustilago ischaemi* Fuckel, *U. cylindrica* Peck, *U. bothriochloae-intermediae* Padwick, *Sphacelotheca chloridis* Mundk., *S. heteropogonis-triticei* L. Ling, *S. bothriochloae* Y.C. Wang, *Sorosporium baluchistani* S. Ahmad, see Vánky, 2004b:226-227.

Sorosporium platense Hirschhorn, 1941:348 (as '*platensis*'). — *Sphacelotheca platensis* (Hirschh.) Hirschhorn, 1986:129. — Type on *Andropogon saccharoides*, Argentina, Buenos Aires, Fac. de Agron. y Veter., XII.1936, E. Hirschhorn, Herb. Hirschhorn 363; isotype LPS 3057! (syn. nov.).

Sori usually destroying the entire inflorescence, rarely confined to the spikelets, cylindrical or bifurcate at their distal part, 1-10 mm wide, 1.5-7 cm long, partly hidden by the terminal leaf sheath, initially covered by a well developed, yellowish-brown peridium which ruptures irregularly and flakes away disclosing the dark brown, semiagglutinated to powdery mass of spore balls, spores and groups of sterile cells surrounding a simple or ramified, irregular columella of the length of the sorus, the remnants of the floral axis and branches. Infection systemic. *Spore balls* loose, subglobose, ellipsoidal, oblong or irregular, 20-100 x 40-160 µm, dark reddish-brown, composed of tens of spores which separate very easily. *Spores* single when mature, globose, ovoid, ellipsoidal to slightly irregular, (6.5-)7-10 x 7.5-11 µm, light olivaceous-brown; wall even, 0.5-1 µm thick, finely, densely punctate-verruculose, spore profile smooth to wavy, in SEM spores minutely echinulate, between the spines, finely and densely verruculose. *Spore germination* (Brefeld, 1883:96, Pl. XI, figs. 1-2; Vánky, Deml & Oberwinkler, 1988:185) results in four-celled basidia on which lateral and terminal basidiospores are produced. *Sterile cells* in irregular groups or chains among the spores and also forming the peridium, globose to irregularly polygonal, flattened on contact sides, 6-16(-22) µm

long, subhyaline to yellow tinted, with numerous droplets, collapsed in old specimens; wall even, 0.5-1 µm thick, smooth.

On *Andropogon arctatus* Chapm., *A. barbinodis* Lag., *A. chinensis* (Nees) Merr., *A. imperatoides* (Hack.) Lillo, *A. liebmannii* Hack., *Andropogon* sp., *Bothriochloa bladhii* (Retz.) S.T. Blake (*B. glabra* (Roxb.) A. Camus), *B. caucasica* (Trin.) C.E. Hubb., *B. decipiens* (Hack.) C.E. Hubb., *B. ewartiana* (Domin) C.E. Hubb., *B. intermedia* (R. Br.) A. Camus, *B. pertusa* (L.) A. Camus, *Dichanthium annulatum* (Forssk.) Stapf, *D. insculptum* (A. Richard) Clayton (*Andropogon pubescens* Vis.), *D. ischaemum* (L.) Roberty (*Andropogon angustifolius* Sibth. & Sm.; *A. ischaemum* L.; *B. ischaemum* (L.) Keng), *Diheteropogon amplectens* (Nees) Clayton (*Andropogon amplectens* Nees), *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult., *H. triticeus* (R. Br.) Stapf ex Craib; cosmopolitan (Europe, Africa, Asia, Australia, N., C. & S. America).

Fig. 1. Sori of *Sporisorium andropogonis-chinensis* in all sessile and pedicelled spikelets of *Andropogon chinensis* (type). Habit, and enlarged two infected spikelets. To the left a healthy inflorescence. Bars = 1 cm for habit, and 2 mm for the detail drawing.

5. *Sporisorium andropogonis-chinensis* Vánky, sp. nov.

Typus in matrice Andropogon chinensis *(Nees) Merr., Zambia, Eastern Prov., 407 km ENE urbe Lusaka, 14°16'54" S, 31°37'41" E, alt. 1070 m.s.m., 18.IV.2001, leg. C., T. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 21063!*

Sori *in spiculis et sessilibus et pedicellatis eiusdem inflorescentiae, longe ellipsoidales, cca. 1 x 3-5 mm, involucris floralibus plus-minus obtecti, peridio pallide brunneo cooperti, quo irregulariter rupto massam atrobrunneam, semiagglutinatam usque granuloso-pulveream glomerulorum sporarum et sporarum columellam compactam, attenuatam, saepe apice breviter bifurcatam circumdantium ostendentes.* Glomeruli sporarum *globosi, ovoidei usque late ellipsoidales, 20-30 x 25-40(-50) µm, flavidobrunnei, e 10-50(?) sporis leviter dissociabilibus compositi.* Sporae *dimorphae: externae earum globosae, subglobosae, ellipsoidales usque parum irregulares, 6,5-9 x 7,5-10,5 µm, flavidobrunneae; pariete inaequali, 0,5-1 µm crasso, in superficie externa crassiore, moderate dense prominenter verruculoso, imago obliqua eorum serrata. Sporae internae forma et magnitudine sporis externis cca. aequales, pallide flavidobrunneae; pariete aequali, 0,2-0.3 µm crasso, levi.* Cellulae steriles *absentes.*

Sori (Fig. 1) in all, sessile and pedicelled spikelets of an inflorescence, long ellipsoidal, c. 1 x 3-5 mm, more or less hidden by the floral envelopes and covered by a pale brown peridium which ruptures irregularly disclosing the dark brown, semiagglutinated to granular-powdery mass of spore balls and spores surrounding a stout, narrowing columella, often with a shortly bifurcate tip. *Spore balls* (Figs. 4, 5) globose, ovoid to broadly ellipsoidal, 20-30 x 25-40(-50) µm, yellowish-brown, composed of 10-50(?) spores which separate easily. *Spores* (Figs. 4, 5) dimorphic, outer spores globose, subglobose, ellipsoidal to slightly irregular, 6.5-9 x 7.5-10.5 µm, yellowish-brown; wall uneven, 0.5-1.5 µm, thicker on the free surface which is moderately densely, prominently verrucose, spore profile serrate. Inner spores about the shape and size of the outer spores, pale yellowish-brown; wall even, 0.2-0.3 µm thick, smooth. *Sterile cells* absent.

On *Andropogon chinensis* (Nees) Merr.; C. Africa. Known only from the type collection.

6. *Sporisorium andropogonis-eucomi* Vánky, sp. nov.

Typus in matrice Andropogon eucomus *Nees, South Africa, Mpumalanga Prov., 9 km NE urbe Graskop, via R534, 24°51'50" S, 30°51'21" E, alt. 1590 m.s.m., 22.I.1997, leg. C. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 21060; isotypi in BPI, BRIP, IMI, PREM.*

Sori *inflorescentiam totam destruentes, cylindrici, cca. 1 x 6-12 mm, vagina folii supremi obtecti, propter hoc tantum apicibus eorum protrudentes, primo peridio flavidobrunneo cooperti, quo irregulariter rupto massam semiagglutinatam usque granuloso-pulveream, nigram glomerulorum sporarum et columellarum nonnullarum filiformium, tenuium ostendentes.* Glomeruli sporarum *subglobosi, ovoidei, ellipsoidales, elongati vel parum irregulares, (20-)25-40 x (25-)30-50 µm, atro-rubrobrunnei, e sporis (2-)4-15(-20?) pressu separantibus compositi.* Sporae *in glomerulis magnis, dimorphae, externae earum subglobosae, ovoideae, ellipsoidales usque parum irregulares, 12-15 x 13,5-18.5(-20) µm, atro-rubrobrunneae; pariete inaequali, 0,8-2,5(-3) µm crasso, in superficie externa verrucis magnis moderate dense distributis, in lateribus contactis leniter verrucoso. Sporae internae subpolyedricae, magnitudine eadem sporarum externarum cca. aequales, sed colore pallidiores; pariete tenuiori, aequali vel inaequali, leniter punctato-verruculoso.* Cellulae steriles *absentes.*

2

Fig. 2. Sori of *Sporisorium andropogonis-eucomi* in all inflorescences of *Andropogon eucomus* (type). To the left some healthy inflorescences.

Bar = 1 cm.

Sori (Fig. 2) destroying the whole inflorescence, cylindrical, c. 1 x 6-12 mm, hidden by the uppermost leaf sheath from which only the tip of the sori protrudes, at first covered by a yellowish-brown peridium which ruptures irregularly disclosing the black, semiagglutinated to granular-powdery mass of spore balls and several filiform, slender columellae. *Spore balls* (Figs. 6, 7) subglobose, ovoid, ellipsoidal, elongate or slightly irregular, (20-)25-40 x (25-)30-50 µm, dark reddish-brown, composed of (2-)4-15(-20?) spores that separate by pressure. *Spores* (Figs. 6, 7) in larger balls dimorphic, outer spores subglobose, ovoid, ellipsoidal to slightly irregular, 12-15 x 13.5-18.5(-20) µm, dark reddish-brown; wall uneven, 0.8-2.5(-3) µm thick, with moderately densely situated, large warts on the free surface, finely verrucose on the contact sides. Inner spores subpolyhedral, about the size of the outer spores, paler coloured; wall thinner, even or uneven, finely punctate-verruculose. *Sterile cells* absent.

On *Andropogon eucomus* Nees; S. Africa. Known only from the type collection.

Sporisorium andropogonis-eucomi is closest to *S. pseudomaranguense* (type on *Andropogon* sp., South Africa), from which it differs especially by fewer spores in the balls and larger spores with thicker spore wall.

7. *Sporisorium andropogonis-gabonensis* Vánky, nom. nov.

Replacing *Sorosporium congoense* L. Ling, Lloydia 16:186, 1953a (not *Sporisorium congense* (Syd. & P. Syd.) Vánky, type on *Hyparrhenia diplandra*). — Type on *Andropogon gabonensis*, Congo, N. Dembo, VI.1906, H. Vanderyst B32, BR 339! Paratypes on *Andropogon gabonensis*, Congo, N. Dembo, 23.VI.1908, H. Vanderyst, BR 275; Congo, Kinshasa, 4.VI.1906, H. Vanderyst, BR 1326.

Sori in the spikelets protruding beyond the enveloping glumes, cylindrical, c. 1.5 x 7-18 mm, initially covered by a greyish-brown peridium which ruptures from its apex disclosing the dark brown, semiagglutinated to powdery mass of loose spore balls and spores surrounding several filiform columellae. *Spore balls* globose, ovoid, ellipsoidal, oblong or irregular, 30-75 x 30-100 µm, dark reddish-brown, composed of tens of spores which separate easily. *Spores* globose, subglobose, ovoid, ellipsoidal to slightly irregular, 6-9 x 7-10 µm, pale reddish-brown; wall uneven, 0.5-1 µm thick, sparsely, prominently, low verrucose, spore profile smooth to finely wavy. *Sterile cells* not seen.

On *Andropogon gabonensis* Stapf; C. Africa (Congo).

The specific epithets *congoense* and *congense* are confusingly similar and are considered as orthographic variants (homonyms), hence the proposed new name *andropogonis-gabonensis* (ICBN Art. 53.3).

8. *Sporisorium andropogonis-pumili* Vánky, sp. nov.

Typus in matrice Andropogon pumilus *Roxb., India, Maharashtra State, Pune (Poona), 2 km SW of M.A.C.S., 18°34' N, 73°58' E, alt. cca. 600 m, 23.X.1992, leg. C. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 21041! Paratypus: 15 km W urbe Pune, National Defence Academy, 18°34' N, 73°50' E, alt. cca. 720 m, 20.X.1992, leg. C. & K. Vánky, HUV 21040!*

Sori *in spiculis nonnullis et sessilibus et pedicellatis inflorescentiae eiusdem, cylindrici, saepe parum arcuati, 0,5-1 x 4-10 mm, involucris floralibus partim obtecti, primo peridio crasso, cremeo cooperti, quo ab apice eius irregulariter rupto massam glomerulorum sporarum nigrescentibrunneam primo agglutinatam, serius granulosopulveream, columellam centralem longam, filiformem, simplicem circumdantem ostendentes.* Glomeruli sporarum *forma et magnitudine varii, subpolyedrice irregulares, elongati,*

Fig. 3. Sori of *Sporisorium andropogonis-pumili* in some sessile and pedicelled spikelets of *Andropogon pumilus* (type). Bar = 1 cm.

rarius ovoidei vel ellipsoidales, 30-100 x 40-130 µm, atro-rubrobrunnei usque subopaci, permanentes, e pluribus decem sporis pressu difficiliter separabilibus compositi. Sporae *dimorphae: externas earum subglobosae, ellipsoidales usque subpolyedrice irregulares, 9-12,5 x 10,5-14,5 µm, uniformiter flavidobrunneae; pariete sine ornamentis aequaliter cca. 0,5 µm crasso, pariete libero cum ornamentis 1,5-3 µm crasso: etiam sub LM conspicue cum verrucis dense dispositis, filiformibus, 1-2,5 µm longis, in medio superficiei liberae altissimis, pariete contacto cca. 0,5 µm crasso apparenter levi, sub SEM valde leniter verruculoso. Sporae internae rotundae, subpolyedriciter irregulares, magnitudine cellulis externis cca. aequales, pallide flavidobrunneae; pariete aequali, tenui (cca. 0,3 µm), levi.* Cellulae steriles *absentes.*

Sori (Fig. 3) in some sessile and pedicelled spikelets of an inflorescence, cylindrical, often slightly bent, 0.5-1 x 4-10 mm, partly hidden by the floral envelopes, initially covered by a thick, cream coloured peridium which ruptures irregularly from its apex disclosing the blackish-brown, first agglutinated later granular-powdery mass of spore balls surrounding a long, filiform, simple, central columella. *Spore balls* (Figs. 8, 9) varying in shape and size, subpolyhedrally irregular, elongated, more rarely ovoid or ellipsoidal, 30-100 x 40-130 µm, dark reddish-brown to subopaque, permanent, composed of tens of spores separating with difficulty by pressure. *Spores* (Figs. 8, 9) dimorphic, outer spores subglobose, ellipsoidal to subpolyhedrally irregular, 9-12.5 x 10.5-14.5 µm, uniformly yellowish-brown; the wall without ornamentation is uniformly c. 0.5 µm thick, with ornamentation the free wall is 1.5-3 µm thick, as seen by LM provided with densely situated, filiform, 1-2.5 µm long warts, highest in the middle of the free surface, contact walls apparently smooth, in SEM very finely verruculose. Inner spores rounded, subpolyhedrally irregular, about the size of the outer spores, pale yellowish-brown; wall even, thin (c. 0.3 µm), smooth. *Sterile cells* absent.

On *Andropogon pumilus* Roxb.; S. Asia (India).

Sporisorium andropogonis-pumili is closest to *S. everhartii*, from which it differs especially by the morphology of the outer spores. In *S. everhartii* these are 8-15 µm long, medium dark reddish-brown with paler and darker areas, caused by the uneven, 0.5-1.5 (-2.5) µm thick wall, and the warts of the free surface are up to only 0.5 µm high.

9. *Sporisorium andropogonis-schirensis* (L. Ling) Vánky, 2005a:262.

Sphacelotheca andropogonis-schirensis L. Ling, 1953a:181. — Type on *Andropogon schirensis*, Congo, Bandundu, II.1914, H. Vanderyst 3555, BR 1349; isotypes in BPI 193953, K, HUV 18276!

Sori in all spikelets of an inflorescence, ellipsoidal, 1-1.5 x 2-3.5 mm, evident between the spreading glumes, initially covered by a brown, rather thick peridium which ruptures from its apex disclosing the dark brown, semiagglutinated to powdery mass of loose spore balls, spores and groups of sterile cells, surrounding a stout, tapering columella. *Spores* single when mature, subglobose, ellipsoidal, ovoid to slightly irregular, 6.5-9 x 7-10.5(-11) µm, yellowish-brown; wall even, 0.5-0.7 µm thick, finely, rather sparsely to moderately densely verruculose-echinulate, spore profile in LM smooth, in SEM, between the small spines finely, densely verruculose. *Sterile cells* in irregular groups, collapsed in old specimens, single cells 7-15.5 µm long, hyaline; wall thin (c. 0.5 µm), smooth.

On *Andropogon appendiculatus* Nees, *A. schirensis* A. Rich.; C. & S. Africa. (Congo, South Africa).

10. *Sporisorium andropogonis-tectorum* (L. Ling) Vánky, 2004a:106.

Ustilago andropogonis-tectorum L. Ling, 1953b:152. — Type on *Andropogon tectorum*, Sierra Leone, Hill Station, 27.VII.1941, F.C. Deighton M2302, IMI 10966; isotype BPI 157098. Paratype on *Andropogon tectorum*, Nigeria, 1936, J. West 69, IMI 44426; isoparatype HUV 17809!

Sori destroying the whole young floral shoots, transforming each into an elongated, somewhat curved, up to 20 cm long, whip-like structure, initially covered by the epidermis which flakes away disclosing the olivaceous-brown, semiagglutinated to powdery mass of spores intermixed with sterile cells, produced around a stout, narrowing columella with longitudinal furrows. *Spores* globose, subglobose, often flattened on one side, 7.5-9.5 x 8-10.5(-12) µm, yellowish-brown; wall slightly thinner on one side, 0.4-0.8 µm thick, finely, densely verrucose-echinulate, spore profile wavy to finely serrulate. *Sterile cells* in irregular groups, single sells 8-16 µm long, subhyaline, usually collapsed; wall c. 1 µm thick, smooth.

On *Andropogon tectorum* Schum.; Africa.

11. *Sporisorium bicornis* (Henn.) Vánky 1996:103.

Ustilago bicornis Henn., in Pazschke, 1896a:50. — *Sphacelotheca bicornis* (Henn.) Zundel, 1930:140. — Type on *Andropogon bicornis*, Brazil, Campo Bello, IV.1894, E. Ule 2079.

Sori in considerably swollen spikelets of a few racemes of an inflorescence, appearing as witches' brooms. Single sori long-cylindrical, 0.5-1 x 10-30 mm, curved, first covered by a thick, brown, fungal peridium which ruptures from its distal part disclosing the chocolate-brown, powdery mass of loose spore balls and spores surrounding a well developed central columella. *Spores* single when mature, globose, subglobose, ovoid, ellipsoidal or slightly irregular, 6-9.5 x 6.5-11(-12) µm yellowish-brown; wall even, 0.5-1 µm thick, moderately densely punctate to echinulate, spore profile smooth to finely wavy. *Sterile cells* few among the spores, varying in shape and size, 4-12 µm long, hyaline, thin-walled (c. 0.5 µm), smooth, forming shorter or longer chains.

On *Andropogon bicornis* L.; S. America (Brazil, Colombia).

In its appearance, *Sporisorium bicornis* resembles *S. holwayi* from which it differs especially by spore measurements, which in *S. holwayi* are 9-14 x 10-16(-18) µm.

12. *Sporisorium braziliense* (Zundel) M. Piepenbring, 2002a:54 (as '*braziliensis*').

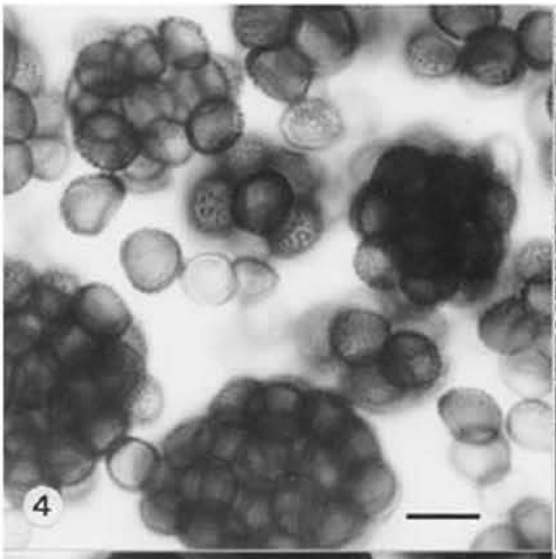
Sphacelotheca braziliensis Zundel, 1931:297. — Type on *Andropogon leucostachyus*, Brazil, State Minas Gerais, Serra do Cipo, 28.III.–1.IV.1925, A. Chase 9168, BPI 177294!; isotype BPI 177295!

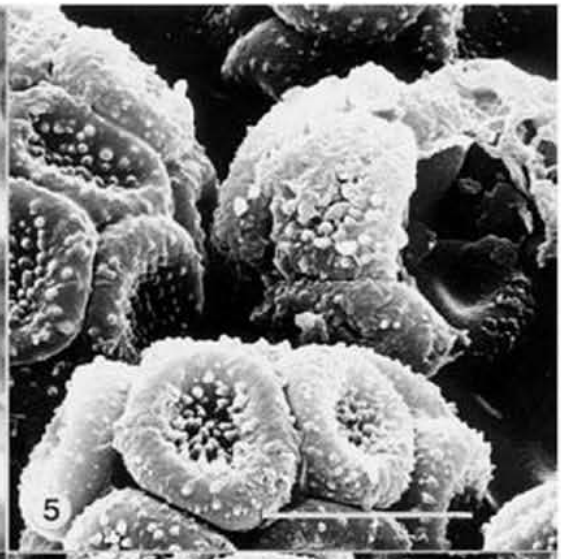
Sphacelotheca macrotrichis Zundel, 1933:354 (as '*macrothricis*'). — Type on *Andropogon macrothrix*, Brazil, State Minas Gerais, Uberlandia (Uberabinha), 15.III.1930, A. Chase 11253½, BPI 178070!; isotype BPI 178069! (syn. by Piepenbring, 2003:90).

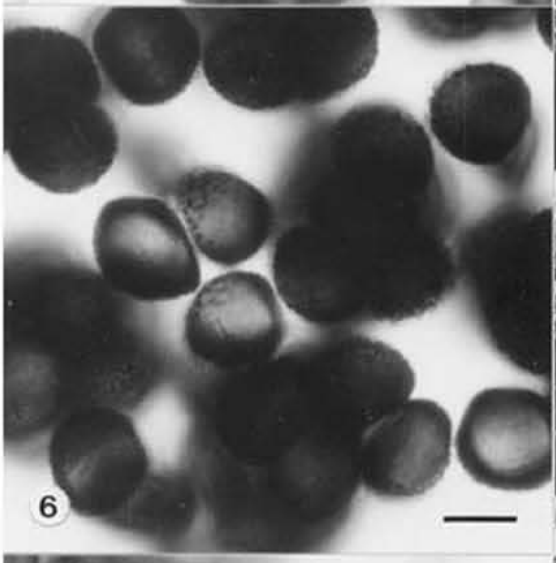
Figs. 4, 5. Spore balls and spores of *Sporisorium andropogonis-chinensis* on *Andropogon chinensis*, in LM and in SEM (type).

Figs. 6, 7. Spore balls and spores of *Sporisorium andropogonis-eucomi* on *Andropogon eucomus*, in LM and in SEM (type).

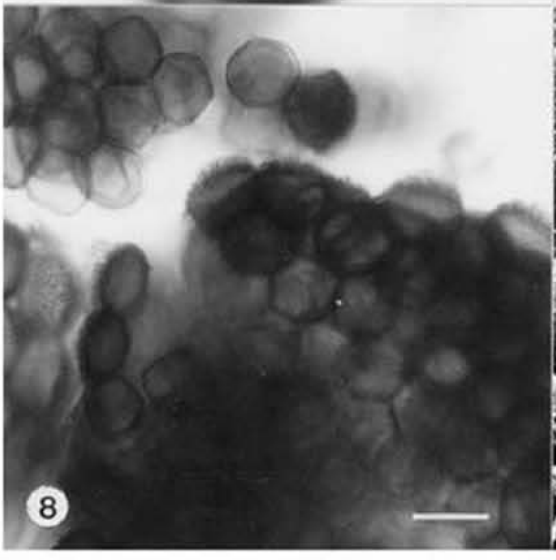
Figs. 8, 9. Spore balls and spores of *Sporisorium andropogonis-pumili* on *Andropogon pumilus*, in LM and in SEM (type). Bars = 10 µm.

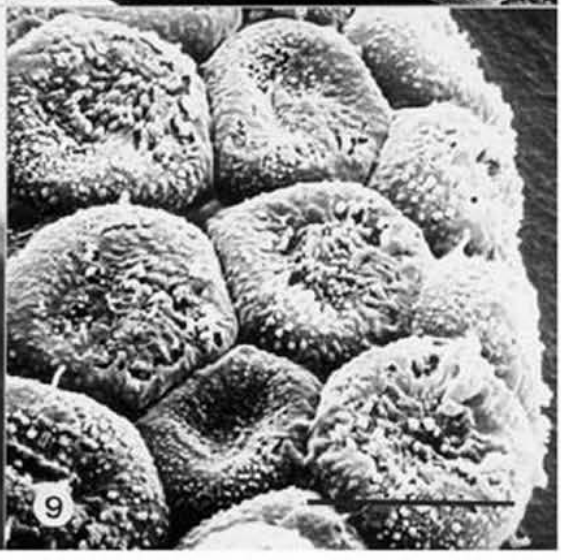

4


5


6


7


8


9

Sori in all spikelets of an inflorescence, cylindrical, 0.8-1.5 x 3-5 mm, first covered by a thin greyish peridium which ruptures irregularly disclosing the dark brown, powdery mass of loose spore balls and spores, surrounding a flagelliform central columella. *Spores* single when mature, globose, ovoid, ellipsoidal, slightly flattened on one side (6.5-9 µm wide), 8.5-12 x 9-14 µm, light to medium dark yellowish-brown; wall 0.5-1.2 µm thick, thinner on the flattened side, moderately densely verrucose-echinulate, spore profile wavy. *Sterile cells* among the spores not seen.

On *Andropogon leucostachyus* Kunth, *A. macrothrix* Trin., *Andropogon* sp.; S. America (Brazil).

13. *Sporisorium culmiperdum* (J. Schröt.) Vánky, 1993:40.

Ustilago culmiperda J. Schröt. in Hennings, 1896b:212. — *Sphacelotheca culmiperda* (J. Schröt.) G.P. Clinton, in Zundel, 1930:143. — Type on *Andropogon bicornis*, Brazil, Santa Catarina, near Joinville, V.1883, E. Ule 1627, BPI 159932; isotypes BPI 194444, 195257.

Sori in the whole inflorescence, long linear, 1-2 mm wide, 3-7 cm long, partly hidden by the terminal leaf sheath, first covered by a dark brown peridium which flakes away revealing a blackish-brown, dusty spore mass surrounding a well-developed, often bent columella. *Spores* globose, subglobose to ovoid, 12-18 x 14-19 µm, medium to dark reddish-brown with a paler, rounded area (germ pore) of 5-7 µm diameter; wall 1.5-2 µm thick, thinner at the paler areas, surface finely, densely verrucose-echinulate. *Spore germination* (Piepenbring, 1996:97) results in four- to several-celled basidia, producing basidiospores. *Sterile cells* absent.

On *Andropogon bicornis* L., *A. gerardii* Vitman var. *hondurensis* R.W. Pohl, *A. glomeratus* (Walter) Britton, Stern. & Poggenb.; N., C. & S. America.

14. *Sporisorium distachyum* Vánky, sp. nov.

Typus in matrice Andropogon distachyos *L., Ethiopia, Arsi Reg., 241 km SE urbe Addis Abeba, 77 km S pag. Asela, 07°22'57.3" N, 39°15'08.9" E, alt. 2985 m.s.m., 4.XI.2004, leg. T. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 20909; isotypi in Vánky, Ust. exs. no. 1286. Paratypus in matrice* Andropogon abyssinicus *Fresen., Ethiopia, Arsi Reg., 162 km SE urbe Addis Abeba, 2 km N pag. Asela, 07°59'14.9" N, 39°08'39.6" E, alt. 2345 m.s.m., 3.XI.2004, leg. T. & K. Vánky, HUV 20908; isoparatypi in Vánky, Ust. exs. no. 1287.*

Sori *in spiculis omnibus et sessilibus et pedicellatis inflorescentiae eiusdem, organa interna floralia destruentes, inter involucra distantia floralia prominentes, cilindrici, cca. 1 x 2-4 mm, primo peridio atrobrunneo cooperti, quo mature ab apice rupto massam glomerulorum sporarum nigram, semiagglutinatam usque pulveream et sporarum atque cellularum sterilium columellam brevem, simplicem, centralem circumdantem ostendentes.* Glomeruli sporarum *laxi, mature dissoluti.* Sporae *in maturitate earum singulae, globosae, subglobosae, ovoideae, ellipsoidales usque parum subpolyedrice irregulares, 9-12 x 10,5-13,5 µm, mediocriter atro-flavidobrunneae, cum poro germinationis leviter pallidiore, rotundo, diametro cca. 3 µm; pariete parum inaequali, 0,5-1(-1,5) µm crasso, ad poros germinationis tenuiore, leniter, dense verrucoso-echinulato, imago obliqua sporarum levis usque leniter serrulata.* Cellulae steriles *in catervis irregularibus, cellulae singulae forma et magnitudine variae, globoideae, ellipsoidales usque plerumque irregulares, latere uno vel lateribus nonnullis deplanatis, 4,5-14,5 x 6-16 µm, hyalinae; pariete aequali, 0,5-1 µm crasso, levi.*

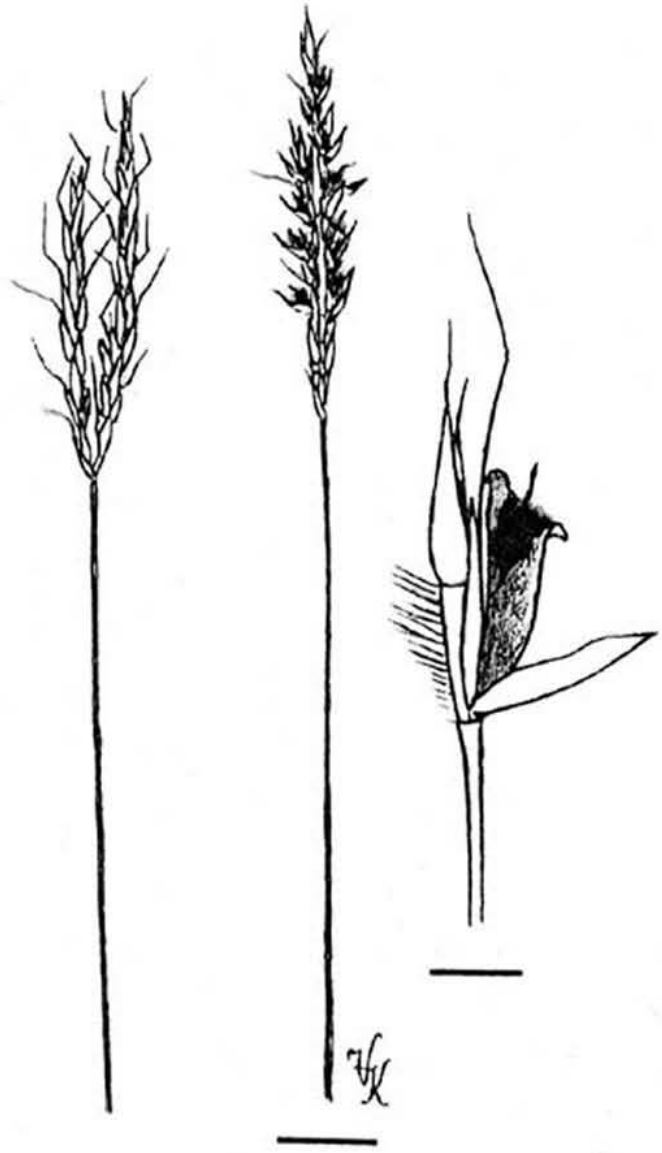


Fig. 10. Sori of *Sporisorium distachyum* in all sessile and pedicelled spikelets of *Andropogon distachyos* (type). Habit, and enlarged an infected spikelet. To the left a healthy inflorescence. Bars = 1 cm for habit, and 3 mm for the detail drawing.

Sori (Fig. 10) in all, both sessile and pedicelled spikelets of an inflorescence, destroying the inner floral organs, showing between the spreading floral envelopes, cylindrical, c. 1 x 2-4 mm, first covered by a dark brown peridium which early ruptures from its apex, disclosing the black, semiagglutinated to powdery mass of spore balls, spores and sterile cells surrounding a short, simple, central columella. *Spore balls* (Figs. 13, 14) loose, early disintegrating. *Spores* (Figs. 13, 14) single when mature, globose, subglobose, ovoid, ellipsoidal to subpolyhedrally slightly irregular, 9-12 x 10.5-13.5 µm, medium dark yellowish-brown, with a slightly paler, rounded germ pore of c. 3 µm diameter; wall slightly uneven, 0.5-1(-1.5) µm thick, thinner at the germ pores, finely, densely verrucose-echinulate, spore profile smooth to finely serrulate. *Sterile cells* (Figs. 13, 14) in irregular groups, single cells variable in shape and size, globoid, ellipsoidal to usually

irregular, with one or several flattened sides, 4.5-14.5 x 6-16 µm, hyaline; wall even, 0.5-1 µm thick, smooth.

On *Andropogon abyssinicus* Fresen., *A. distachyos* L.; Africa (Ethiopia).

15. *Sporisorium ellisii* (G. Winter) M. Piepenbring, 2003:103.

Sorosporium ellisii G. Winter, 1883a:2 (Jan.); 1883b:7 (Jan.). — Lectotype (design. by Jackson, 1908:148) on *Andropogon virginicus*, USA, New Jersey, Newfield, X.1880, J.B. Ellis, NY; isolectotypes in Ellis, N. Amer. Fgi. no. 1099, BPI 179797.

Sori destroying the whole inflorescence, long cylindrical, 1-2 x 10-50 mm, more or less hidden by leaf sheaths, initially covered by a pale brown, well-developed peridium which ruptures irregularly at maturity disclosing the blackish-brown, granular-powdery mass of spore balls and spores surrounding a long, thin columella often with bifurcate tip. Sori rarely confined to the spikelets only. *Spore balls* subglobose, ellipsoidal, oblong to irregular, 30-80 x 40-100 µm, dark reddish-brown, composed of tens of spores which separate easily by pressure. *Spores* subglobose, ellipsoidal to usually subpolyhedrally slightly irregular, 11-15 x 12-18.5(-20) µm, reddish-brown with irregular paler and darker areas; wall uneven, 1-2.5 µm thick, including an even, pale endospore and a pigmented, unevenly thickened, densely, prominently low verruculose-echinulate exospore, spore profile wavy to finely serrulate. *Sterile cells* not seen.

On *Andropogon elliottii* Chapm., *A. glomeratus* (Walter) Britton, Stern. & Poggenb., *A. virginicus* L., *Andropogon* sp., *Schizachyrium scoparium* (Michx.) Nash (*Andropogon scoparius* Michx.); N. America (USA).

Sporisorium ellisii is closest to *S. guaraniticum* (Speg.) Vánky, type on *Schizachyrium condensatum*, Paraguay, in which the spores are dimorphic, with smooth inner spores, the spore wall is thicker (2.5-4 µm) and more finely ornamented.

16. *Sporisorium everhartii* (Ellis & Galloway) M. Piepenbring, 1999:462.

Sorosporium everhartii Ellis & Galloway, 1890:32. — *Tolyposporium everhartii* (Ellis & Galloway) Dietel, in Engler & Prantl, 1897:14. — Type on *Andropogon virginicus*, USA, New Jersey, Newfield, X.1887, coll. N. A. F. 2265b, BPI 179946.

Sori in the sessile spikelets of all or of some spikelet pairs of an inflorescence, narrow cylindrical, 0.5-1 x 10-15(-20) mm, protruding between the outermost floral envelopes, first covered by a pale brown peridium which ruptures irregularly from its apex disclosing the blackish-brown, agglutinated to granular-powdery mass of spore balls surrounding a long, filiform, flattened central columella of the length of the sorus. The sori ripen from their apex which may be already empty of spores whereas their basal part is still unripe. *Spore balls* varying in shape and size, globose, ovoid, ellipsoidal, oblong to irregular, 30-100 x 50-130 µm, dark reddish-brown, composed of tens of firmly united spores which separate by hard pressure. *Spores* dimorphic. Outer spores ellipsoidal, tangentially elongated, slightly subpolyhedrally irregular or subcuneiform, 7-12 x 8-15 µm, medium dark reddish-brown with paler and darker areas, according to the unevenly thickened wall; wall 0.5-1.5 µm or up to 2.5 µm thick at the angles, free surface coarsely, moderately densely verrucose-echinulate, warts up to 0.5 µm high, spore profile wavy to serrulate. Inner spores rounded subpolyhedrally irregular, about the size of the outer spores, pale yellowish-brown; wall even or slightly uneven, c. 0.5 µm thick, smooth. *Spore germination* (Durán, 1987:65; Piepenbring, 1999:465) results in 4-7-celled, mononucleate basidia giving rise to ellipsoidal, mononucleate basidiospores.

Sterile cells not seen.

On *Andropogon brachystachyus* Chapm., *A. floridanus* Scribner, *A. gerardii* Vitman, *A. glomeratus* (Walter) Britton, Stern. & Poggenb. (*A. macrourus* Michx.), *A. microstachyus* Desv. ex Hamilt., *A. tener* (Nees) Kunth, *A. ternarius* Michx., *A. urcatus* Muhl., *A. virginicus* L., *A. virginicus* var. *hirsutior* (Hack.) Hitchc., *Schizachyrium hirtiflorum* Nees (*Andropogon hirtiflorus* (Nees) Kunth), *S. scoparium* (Michx.) Nash (*Andropogon scoparius* Michx.); N. America (USA, Mexico, Cuba).

Reports of this smut from Africa (comp. Zundel, 1938:304; 1953:59) refer to other smut fungi. That on *Hyparrhenia ruprechtii* (= *Hyperthelia dissoluta*), from S. Africa, is *Sporisorium ischaemoides* (Henn.) Vánky, PREM 7770! That on "*Andropogon diplandrus* Hack." (= *Hyparrhenia diplandra* (Hack.) Stapf), from Congo, is certainly one of the several *Sporisorium* species on this host plant, known from Africa. "*Sorosporium everhartii* on *Andropogon ischaemum* L." from South Africa (PREM 7770, BPI 179880) represents *Sporisorium ischaemoides* on *Hyperthelia dissoluta* (Nees ex Steud.) Clayton.

17. *Sporisorium fastigiatum* Vánky, 2000:206.

Type on *Andropogon fastigiatus*, Zimbabwe, Matabeleland North Prov., 25 km SE of Binga, alt. c. 690 m, 15.III.1999, C. & K. Vánky, HUV 18910!; isotypes BPI 746885 and in Vánky, Ust. exs. no. 1066. Paratype on *Andropogon fastigiatus*, Matabeleland North Prov., c. 50 km NW of Lusulu, alt. c. 970 m, 16.III.1999, C. & K. Vánky, HUV 18911!

Sori in all sessile and pedicelled spikelets of the inflorescence, completely destroying them, ovoid, 1-2 x 2-4 mm, first covered by a thick, pale yellowish-brown peridium which bears remnants of floral envelopes. At maturity, the peridium ruptures in several places disclosing the semi-agglutinated, blackish-brown mass of spores and sterile cells surrounding a stout, central columella, usually with short lateral branches. Rarely, the sori may comprise the whole inflorescence or a part of it. *Spores* when young in irregular, loose balls, single when mature, subglobose, ellipsoidal, usually rounded, subpolyhedrally irregular, 8-11 x 9-13.5 µm, reddish-brown; wall even or slightly uneven, 0.5-0.8 µm thick, apparently smooth to finely, densely punctate or punctate-echinulate, spore profile smooth to very finely serrulate. *Sterile cells* in compact, rounded or elongated groups, 15-25 x 20-35 µm, these may be agglutinated in short chains; single cells irregular, subpolyhedral with flattened sides, rarely ovoid, 5-13 µm long, subhyaline with homogenous content; wall 0.5-1 µm thick, smooth.

On *Andropogon angustatus* (Presl) Steud., *A. fastigiatus* Swartz (*Diectomis fastigiata* (Swartz) Kunth); Africa (Guinea, Zimbabwe), C. & S. America (Nicaragua, Venezuela).

18. *Sporisorium gayanum* Vánky & C. Vánky, in Vánky, 2000:205.

Type on *Andropogon gayanus*, Zimbabwe, Matabeleland North Prov., 12 km N of Lusulu, alt. c. 1010 m, 16.III.1999, C. & K. Vánky, HUV 18899!; isotypes BPI, IMI 380465, S, and in Vánky, Ust. exs. no. 1065.

Sori in all sessile and pedicelled spikelets of the inflorescence, leaving intact only the outermost floral envelopes, rarely also a few anthers, cylindrical with acute tip, c. 1 x 5-10 mm, covered by a pale yellowish-brown peridium which ruptures early from its apex and curls disclosing the blackish-brown, first agglutinated, later granular-powdery mass of spore balls and 3-6 filiform columellae. In young stage, the peridium often bears remnants of inner floral organs or aborted anthers. *Spore balls* varying in shape and size, broadly ellipsoidal, ovoid, oblong or irregular, 35-90 x 40-120(-140) µm, reddish-

brown to opaque, permanent, composed of tens to about a hundred tightly packed spores. *Spores* dimorphic. Outer spores subpolyhedrally irregular, 8-12 x 10.5-14.5 µm, dark reddish-brown with slightly uneven, 1-2 µm thick wall, prominently verruculose-echinulate on the free surface which appears finely serrulate in median view; inner spores subpolyhedrally or polyhedrally irregular, often elongated, tightly packed, the size of the outer spores or somewhat smaller, subhyaline or pale yellowish-brown; wall thin, c. 0.5 µm, even, smooth. *Sterile cells* few, in small groups or chains; single cells subglobose, oblong or irregular, with flattened sides, 5-13 µm long, hyaline; wall thin, c. 0.5 µm, smooth.

On *Andropogon chinensis* (Nees) Merr., *A. gayanus* Kunth; Africa (Malawi, Zambia, Zimbabwe).

19. *Sporisorium holwayi* (G.P. Clinton & Zundel) Vánky, 1993:40.

Sphacelotheca holwayi G.P. Clinton & Zundel, in Zundel, 1930:143. — Type on *Andropogon bicornis*, Bolivia, Prov. Sur Yungas, Villa Aspiazu, 31.V.1920, E.W.D. & M.M. Holway, BPI 177831.

Sphacelotheca kellermanii G.P. Clinton & Zundel, in Zundel, 1930:142. — Lectotype on *Andropogon leucostachyus* (det. A. Chase), Guatemala, Los Amates, 15.III.1905, W.A. Kellerman 7601-A (design. by Piepenbring, 2003:108) BPI 178042!; isolectotypes BPI 178041!, 178045! (syn. by Piepenbring, 2003:108).

Sori in groups of spikelets, bunched and forming witches' brooms. One or several witches' brooms of various sizes may occur in the same inflorescence. Individual sori linear, often curved, 0.7-1 x 10-40 mm, initially covered by a greyish-brown peridium which splits longitudinally exposing a blackish-brown mass of spores intermixed with few, irregular groups of sterile cells surrounding a well-developed, horn-shaped, central columella. *Spores* single when mature, subglobose, ovoid to irregularly oblong or subpolyhedral, 9-14 x 10-16(-18) µm, dark reddish-brown; wall even or slightly uneven, c. 1.5 µm thick, evidently, moderately densely echinulate, spore profile serrulate. *Sterile cells* varying in shape and size, smaller than the spores, subhyaline to light yellowish-brown, collapsed with age.

On *Andropogon bicornis* L., *A. leucostachyus* Kunth; C. & S. America.

Sporisorium holwayi differs from the similar *S. bicornis* especially in having much larger, darker, thick-walled spores.

20. *Sporisorium leucostachys* (Henn.) M. Piepenbring, 2003:110.

Ustilago leucostachys Henn., in Pazschke, 1896a:50. — *Sphacelotheca leucostachys* (Henn.) Zundel, 1930:144. — Type on *Andropogon leucostachyus*, Brazil, State Minas Gerais, Serra do Itatiaia, II.1894, E. Ule 2096, HBG; isotypes BPI 162412, HUV 17523!

Sori destroying the whole inflorescence, long linear, c. 2 mm wide, 5-7 cm long, partly enclosed by leaf sheaths, first covered by a thick, light brown peridium which ruptures irregularly disclosing the dark brown, granular powdery mass of spore balls surrounding a long, well-developed columella. *Spore balls* subglobose, ovoid, ellipsoidal, oblong to slightly irregular, 30-70 x 40-100 µm, dark reddish-brown, composed of tens of spores which separate by pressure. *Spores* subglobose, ovoid, ellipsoidal to usually rounded, subpolyhedrally slightly irregular, (10.5-)11-13.5 x 12-16 µm, medium dark reddish-brown, with paler and darker areas; wall uneven, 0.5-1.5 µm thick, moderately densely,

finely to prominently verrucose, especially on the free surface of the spores, spore profile smooth, wavy or serrulate. *Sterile cells* lacking.

On *Andropogon leucostachyus* Kunth; S. America (Brazil).

21. *Sporisorium livingstoneanum* Vánky, sp. nov.

Typus in matrice Andropogon gayanus *Kunth, Zambia, Southern Prov., 10 km N urbe Livingstone, 17°47'45" S, 25°51'10" E, alt. 960 m.s.m., 14.IV.2001, leg. T., C. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 21070!; isotypi in BPI, BRIP et IMI. Paratypi in matrice* Andropogon chinensis *(Nees) Merr., Zambia, Lusaka Prov., 169 km ENE urbe Lusaka, 15°04'10" S, 29°45'22" E, alt. 900 m.s.m., 17.IV.2001, leg. T., C. & K. Vánky, HUV 21072! et Lusaka Prov., 201 km E. urbe Lusaka, 15°00'18" S, 29°58'22" E, alt. 760 m.s.m., 27.IV.2001, leg. C. & K. Vánky, HUV 21073; isoparatypi in BPI, BRIP et IMI.*

Sori *in spiculis nonnullis et sessilibus et pedicellatis inflorescentiae eiusdem, longe cylindrici, arcuati vel torti, 1-1,5 x 5-20(-25) mm, primo peridio crasso, cremeo cooperti, quo ab apice eius irregulariter rupto massam nigrobrunneam, semiagglutinatam usque granuloso-pulveream glomerulorum sporarum et columellarum nonnullarum, filiformium plerumque partim vel omnio in columellam decrescentem, planam, taeniaeformem coalescentium ostendentes.* Glomeruli sporarum *forma et magnitudine varii, globosi, ovoidei, elongati, vel subpolyedrice irregulares, 30-140 x 30-150 µm, glomeruli globoidei diametro 30-140 µm, atro-rubrobrunnei, subopaci vel opaci, permanentes, e sporis pluribus decem usque pluribus centum, pressu valido difficiliter separabilibus compositi.* Sporae *dimorphae, externae earum subglobosae, ovoideae, ellipsoidales usque subpolyedrice parum irregulares, 7,5-10,5 x (8-)9-13(-14) µm, flavido- usque rubrobrunneae; pariete inaequali, 0,5-2 µm crasso, in lateribus contactis tenui, ad angulos et in superficie libera crassissimo, verrucis 0,5(-1) µm altis vel spinis moderate dense distributis inclusis, imago obliqua sporarum superficiei liberae undulata usque leniter serrulata, eadem in lateribus contactis levis. Sporae internae globoideae, ovoideae vel roundato-subpolyedricae, magnitudine sporis externis cca. aequales, pallide flavidobrunneae; pariete aequali, cca. 0,4-0,8 µm crasso, levi, sub SEM ruguloso.* Cellulae steriles *absentes.*

Sori (Fig. 11) in some sessile and pedicelled spikelets of an inflorescence, long cylindrical, bent or curled, 1-1.5 x 5-20(-25) mm, first covered by a thick, cream coloured peridium which ruptures irregularly from its apex disclosing the blackish-brown, semiagglutinated to granular-powdery mass of spore balls and several long, filiform columellae, which usually partly or completely fuse into a narrowing, flat, band-like columella. *Spore balls* (Figs. 15, 16) varying in shape and size, globose, ovoid, elongated or subpolyhedrally irregular, 30-140 x 30-150 µm, globoid balls 30-140 in diameter, dark reddish-brown, subopaque or opaque, permanent, composed of tens to hundreds of spores which separate with difficultly by hard pressure. *Spores* (Figs. 15, 16) dimorphic, outer spores subglobose, ovoid, ellipsoidal to subpolyhedrally slightly irregular, 7.5-10.5 x (8-)9-13(-14) µm, yellowish- to reddish-brown; wall uneven, 0.5-2 µm thick, thin on the contact sides, thickest at the angles and on the free surface, including the moderately densely situated, 0.5(-1) µm high warts or spines. Spore profile on the free surface wavy to finely serrulate, on the contact sides smooth. Inner spores globoid, ovoid or rounded subpolyhedral, about the size of the outer spores, pale yellowish-brown; wall even, c. 0.4-0.8 µm thick, smooth. *Sterile cells* absent.

On *Andropogon gayanus* Kunth, *A. chinesis* (Nees) Merr.; C. Africa (Zambia).

Etymology: This species is named after the Zambian city Livingstone, close to the Victoria Falls, where this smut was first collected.

Fig. 11. Sori of *Sporisorium livingstoneanum* in some sessile and pedicelled spikelets of *Andropogon gayanus* (type). Habit. To the left a healthy inflorescence. Bar = 1 cm.

22. *Sporisorium mexicanum* (Vánky) Vánky & Cunnington, in Cunnington, Vánky & Shivas, 2005:98.

Lundquistia mexicana Vánky, 2004c:161. — Type on *Andropogon gerardii*, Mexico, Durango State, 57 km WSW of Durango, Hwy no. 48, alt. 2538 m, 19.XI.2003, T. & K. Vánky, HUV 20498; isotypes in Vánky, Ust. exs. no. 1202. Paratype on *Schizachyrium mexicanum*, Mexico, Mexico State, 18.5 km W of Toluca, Hwy no. 1, alt. 2812 m, 6.XII.2003, C. & K. Vánky, HUV 20526; isoparatypi in BPI and IMI.

Sori on the top of sterile shoots as dark, long, slender, bent bodies composed of numerous vascular bundles and among them spore masses and sterile cells destroying the parenchymatous tissues. At maturity the host tissue disintegrates and the dark brown, semiagglutinated to powdery mass of spores and sterile cells is successively liberated leaving behind a 2-5 mm wide, 15-40 cm long, twisted and curled fascicle of numerous, filiform columellae. *Spores* globose to subglobose, 8-10.5 × 8-11 µm, medium dark yellowish-brown; wall 2-2.5 µm thick including the 1.5-2 µm high, anastomosing warts which form an irregular, labyrinthiform or incompletely and irregularly reticulate pattern. Warts in optical median view acute. *Sterile cells* single, in short chains or in small, irregular groups. Single cells subglobose or ellipsoidal with flattened contact sides, 7-13 µm long, subhyaline to pale yellowish-brown; wall even, c. 0.5 µm thick, smooth. *Spore germination* (Vánky, 2004c:161 + fig. 2) results in 4-celled basidia (often in 3+1 arrangement), measuring 2-2.5 × 15-25 µm. On the basidia, laterally and terminally, ovoid basidiospores measuring 1.5-2.5 × 4-5.5 µm are produced on sterigmata. The basidiospores bud like yeast cells giving rise to yeast colonies.

On *Andropogon gerardii* Vitman, *Schizachyrium mexicanum* (Hitchc.) A. Camus; N. America (Mexico). Known only from the type collections.

23. *Sporisorium occidentale* (Seym. ex G.P. Clinton) Vánky & Snets., in Vánky, 1990:270.

Sphacelotheca occidentalis Seymour ex G.P. Clinton, 1902:141, nom. nud.; 1904:389. — Type on *Andropogon furcatus* (= *A. gerardii*), USA, North Dakota, Bismarck, 30.VIII.1884, A.B. Seymour, BPI 69513; isotypes HUV 1980, Ellis & Ev., N. Amer. fgi. no. 2265/a, HUV 12914!

Sori in all sessile and pedicelled spikelets of an inflorescence, cylindrical, 1-1.5 x 5-10 mm, initially covered by a thick, light brown, fungal peridium which ruptures irregularly at maturity disclosing the blackish-brown, semiagglutinated mass of spore balls, spores and sterile cells surrounding a simple, narrowing, central columella. *Spore balls* loose, early disintegrating. *Spores* slightly irregular, subpolyhedral, ovoid to oblong, 12-16 x 13.5-18 µm, yellowish-brown; wall uniform, thin, c. 0.5 µm, finely and densely punctate-echinulate, spore profile finely serrulate. *Spore germination* (on MYP, at room temp., in 4 days) results in 4-celled basidia the cells of which give rise to long, septate, ramifying hyphae. *Sterile cells* in groups or chains, very variable in shape and size, usually smaller than the spores, 8-15 µm long, rarely up to 22 µm long, collapsed in old specimens, hyaline, with a few oil droplets; wall thin, c. 0.5 µm, smooth.

On *Andropogon gerardii* Vitman (*A. furcatus* Muhl.; *A. provincialis* Lam. not Retz.), *A. glomeratus* (Walter) Britton, Stern. & Poggenb., *A. hallii* Hack., *A. virginicus* L., *Schizachyrium scoparium* (Michx.) Nash (*Andropogon scoparius* Michx.); N. America (Canada, USA).

24. *Sporisorium polliniae* (Magnus) Vánky, 1983:331.

Sorosporium polliniae Magnus, 1900:433 (as '*Sorisporium*'). — Type on *Pollinia distachya* (= *Andropogon distachyos*), Judaea [= Israel], Jaffa Distr., Bab-el-Wad, 15.V.1897, J. Bornmüller 1015; isotypes in Bornmüller, Iter syriacum 1897, no. 1015, BPI 180134!

Sorosporium icosiense Maire, 1917:145. — Type on *Andropogon distachyos*, Algeria, near Icosium, Télemly, El-Biar, coll. R. Maire. (syn. by Ling, 1951:47).

Sori in all, both sessile and pedicelled spikelets of an inflorescence, destroying the innermost floral organs, cylindrical or corniculate, 1-1.5 x 7-10 mm, partly hidden by the glumes, covered by a yellowish-brown peridium which splits longitudinally in several places exposing the blackish-brown, granular-powdery mass of spore balls and a central, filiform, sometimes apically bifurcate columella. *Spore balls* subglobose, ellipsoidal to irregular, 20-40 x 25-55 µm, reddish-brown, composed of few to many (10-40 or more?) spores, initially firm but disintegrating readily at maturity. *Spores* subglobose, ellipsoidal, usually slightly subpolyhedrally irregular, 7-11 x 8-14 µm, yellowish- to reddish-brown, verrucose to echinulate on the free surface, punctate to apparently smooth on the contact sides; wall uneven, 1-2 µm thick, thickest at the angles and on the free surface, inner spores pale yellowish-brown, wall even, c. 0.5 µm thick, smooth. *Spore germination* (on potatoglucoseagar, at room temp., in 2 days) results in long, 4-celled basidia with fusiform basidiospores on short sterigmata at the septa and on the apex of the basidium. *Sterile cells* absent. The peridium is composed of long chains of hyaline, thin-walled, elongated or irregular cells (8-16(-20) µm long), with 1(-2) oil droplets.

On *Andropogon abyssinicus* Fresen., *A. distachyos* L. (*Pollinia distachya* (L.) Spreng.; *Chrysopogon distachyos* (L.) Rossi); Mediterranean region (S. Europe, N. & NE. Africa, incl. Ethiopia, Asia).

Specimens collected in Ethiopia have larger and more compact spore balls. In other respects they are identical with the type.

25. *Sporisorium provinciale* (Ellis & Galloway) Vánky & Snets., in Vánky, 1990:271.

Sorosporium ellisii var. *provinciale* Ellis & Galloway, 1890:31. — *Sorosporium provinciale* (Ellis & Galloway) G.P. Clinton, 1902:145. — Lectotype on *Andropogon provincialis* (= *A. gerardii*), USA, (design. by Clinton, 1902:145) Montana, Saline Co., near Emma, 3.VI.1889, C.H. Demetrio, BPI 179762; isolectotypes in Ellis & Ev., N. Amer. fgi. no. 2425, HUV 5231! Syntype BPI 179759.

Sori on the top of shoots comprising the whole inflorescence and inflorescence axis, cylindrical, 2-5 mm wide, up to 12 cm long, sometimes bearing remnants of inflorescence branches or spikelets distally, partly enclosed by the leaf sheath, first covered by a light brown peridium which lacerates at maturity disclosing the blackish-brown, granular-powdery mass of spore balls and the interwoven and interconnected, filiform columellae of remnants of host vascular tissue. *Spore balls* globoid to oblong or somewhat irregular, 25-55 x 30-75 µm, medium dark yellowish-brown, composed of 5-35 (or more?), loosely connected spores. *Spores* rather uniform, globose, ovoid or slightly irregularly subpolyhedral, 12-16 x 13-19 µm, yellowish-brown; wall 3-4 µm thick, minutely, sparsely to moderately densely verrucose, spore profile finely wavy. *Spore germination* (on MYP, at room temp., in one week) results in 4-celled basidia on which long, cylindrical or naviculiform basidiospores are produced on well developed sterigmata. The basidiospores become multiseptate and produce small, slightly bent secondary sporidia. *Sterile cells* in groups or chains, single cells varying in shape and

size, usually smaller than the spores, 8-15, rarely up to 22 µm long, collapsed in old specimens, hyaline, with a few oil droplets; wall thin, c. 0.5 µm, smooth.

On *Andropogon gerardii* Vitm an (*A. provincialis* Lam.; *A. furcatus* Muhl.), *A. hallii* Hack., *A. microstachyus* Desv., *A. virginicus* L., *Schizachyrium hirtiflorum* Nees (*Andropogon hirtiflorus* (Nees) Kunth), *S. scoparium* (Michx.) Nash (*Andropogon scoparius* Michx.); N. America (Mexico, USA).

26. *Sporisorium pseudomaranguense* (Zundel) Vánky, 2005a:262.

Sorosporium pseudomaranguense Zundel, 1938:309. - Type on *Andropogon* sp. (det. A. Chase), South Africa, Natal, Mooi River, 21.III.1917, A.O.D. Mogg, PREM 10073; isotype HUV 18007!

Sori destroying the whole inflorescence, long linear, c. 2 mm wide, 3-5 cm long, hidden by the uppermost leaf sheath from which only the tips of the sori protrude, initially covered by a thick, yellowish-brown peridium which ruptures irregularly liberating the dark brown, granular-powdery mass of spore balls and groups of sterile cells surrounding numerous, long, filiform, slender columellae. *Spore balls* subglobose, ovoid, ellipsoidal, oblong or slightly irregular, 30-70 x 40-130 µm, dark reddish-brown to subopaque, composed of tens of spores that separate by pressure. *Spores* varying in shape and size, subglobose, ellipsoidal to subpolyhedrally irregular, 8-12 x 9-14.5 µm, dimorphic. Outer spores rounded, larger, dark yellowish- to reddish-brown; wall irregular, 0.8-1.2 µm thick, prominently, moderately densely verrucose-echinulate, spore profile serrulate. Inner spores subpolyhedral, smaller, pale yellowish-brown; wall even, c. 0.5 µm thick, finely punctate-verruculose. *Sterile cells* few, in irregular groups or short chains, single cells ellipsoidal to usually irregular with flattened sides, 8-12 µm long, hyaline; wall c. 0.5 µm thick, smooth.

On *Andropogon* sp.; S. Africa. Known only from the type collection.

27. *Sporisorium sanctae-catharinae* (Zundel) Vánky, comb. nov.

Basionym: *Ustilago sanctae-catharinae* Zundel, Mycologia 43:268, 1951 (nom. nov.). — *Ustilago occulta* Hennings, 1897:212 (later homonym, not *U. occulta* (Wallr.) Rabenh., Herb. viv. myc. no. 1898, 1874). — Type on *Andropogon* sp., Brazil, Santa Catarina, Caraça, III.1892, E. Ule 1888, HBG!

Sori on the top of sterile shoots including also the uppermost leaves and leaf sheaths, transforming them into slender, bent, cylindrical, distally narrowing bodies, up to 5 mm wide and 10 cm long, initially covered by host epidermis which ruptures longitudinally in many places disclosing the dark brown, semiagglutinated to powdery mass of spores, sterile cells and numerous filiform columellae of vascular bundles. *Spores* globose, subglobose, broadly ellipsoidal, 5.5-7(-8) x 6.5-9 µm, dark yellowish-brown; wall 1-1.5 µm thick including the cylindrical, often anastomosing, labyrinthiform warts, with flattened tip; in SEM the spore surface appears cerebriform. *Sterile cells* in small groups, single cells subglobose, ellipsoidal or slightly irregular, 10-15 µm long, yellowish-brown, collapsed in old specimen; wall even, c. 0.5 µm thick, finely punctate-echinulate, profile smooth to finely wavy.

On *Andropogon* sp.; S. America (Brazil). Known only from the type locality.

Sporisorium sanctae-catharinae is closest to *S. mexicanum* (type on *Andropogon gerardii*), from which it differs by smaller spores and lower warts with flattened tip.

28. *Sporisorium scholzii* Vánky, sp. nov.

Typus in matrice Andropogon schirensis *A. Rich., Zambia, Eastern Prov., 407 km ENE urbe Lusaka, 14°16'54" S, 31°37'41" E, alt. 1070 m.s.m., 18.IV.2001, leg. C., T. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 21062! Paratypus in matrice* Andropogon schirensis, *Zambia, Lusaka Prov., 124 km ENE urbe Lusaka, 15°08'59" S, 29°21'45" E, alt. 1035 m.s.m., 17.IV.2001, leg. T., C. & K. Vánky, HUV 21065!*

Sori *in spiculis nonnullis sessilibus inflorescentiae eiusdem, longe cylindrici, 1-1,5 x 7-15 mm, primo peridio crasso, cremeo cooperti, quo apice eius irregulariter rupto massam nigram, granuloso-pulveream glomerulorum sporarum et columellarum nonnullarum, longarum filiformium ostendentes.* Glomeruli sporarum *forma et magnitudine varii, subpolyedrice irregulares, interdum elongati, raro globosi, 70-140 x 80-180(-200) µm, atro-rubrobrunnei usque plerumque opaci, permanentes, e sporis pluries decem vel pluries centum pressu valido tantum difficiliter separatis compositi.* Sporae *dimorphae, externae earum globosae, subglobosae, ellipsoidales usque rotundato-subpolyedricae, 9-10,5 x 9-11(-12) µm, mediocriter atro-olivaceobrunneae; pariete inaequali, 0,5-1 µm crasso, in superficie libera valde leniter punctato-verruculoso, imago obliqua sporarum levis. Sporae internae rotundate subpolyedricae vel polyedricae, magnitudine sporis externis cca. aequales, pallide olivaceobrunneae; pariete aequali, 0,3-0,5 µm crasso, levi, sub SEM ruguloso.* Cellulae steriles *absentes.*

Sori (Fig. 12) in some sessile spikelets of an inflorescence, long cylindrical, 1-1.5 x 7-15 mm, initially covered by a thick, cream coloured peridium which ruptures irregularly from its apex disclosing the black, granular-powdery mass of spore balls and several long, filiform, columellae. *Spore balls* (Figs. 17, 18) varying in shape and size, subpolyhedrally irregular, sometimes elongated, rarely globose, 70-140 x 80-180(-200) µm, dark reddish-brown to usually opaque, permanent, composed of tens or hundreds of spores which separate with difficultly by hard pressure. *Spores* (Figs. 17, 18) dimorphic, outer spores globose, subglobose, ellipsoidal to rounded subpolyhedral, 9-10.5 x 9-11(-12) µm, medium dark olivaceous-brown; wall uneven, 0.5-1 µm thick, finely punctate-verruculose on the free surface, spore profile smooth. Inner spores rounded subpolyhedral or polyhedral, about the size of the outer spores, pale olivaceous-brown; wall even, 0.3-0.5 µm thick, smooth, in SEM appearing wrinkled. *Sterile cells* absent.

On *Andropogon schirensis* A. Rich.; C. Africa. Known only from the type collections.

Sporisorium scholzii differs from *S. andropogonis-pumili* in which the spore balls are larger and darker, and the outer spores of the balls are provided with densely situated, 1-2.5 µm long, filiform warts. It differs also from *S. livingstoneanum* in which the columellae are often band-like, the spore balls are smaller, and the outer spores of the balls are provided with moderately densely situated, 0.5(-1) µm high warts or spines.

Etymology: This species is named in the honour of Professor Hildemar Scholz (Berlin, Germany), an excellent and helpful person, outstanding specialist of the *Poaceae* of the world, and also of the smut fungi, author of several books on grasses and on the smut fungi of Germany (1988a, b, 2000, 2004).

29. *Sporisorium seymourianum* (G.P. Clinton) M. Piepenbring, 2003:89.

Sphacelotheca seymouriana G.P. Clinton, 1904:387. — Lectotype on *Andropogon virginicus*, USA, Alabama, Auburn, 14.X.1897, Earle & Baker, (design. by Piepenbring, 2003:89) BPI 193990; isolectotypes BPI 193989, Seymour & Earle, Econ. Fgi., Suppl. C. no. 531, HUV 17711!, Syd. Ust. no. 189, HUV 1660! Syntypes in Seymour & Earle, Econ. Fgi., Suppl. C. no. 122, HUV 9710!

Fig. 12. Sori of *Sporisorium scholzii* in some sessile spikelets of *Andropogon schirensis* (type). Habit. Bar = 1 cm.

Sori in all sessile and pedicelled spikelets of an inflorescence, cylindrical, 0.5-1 x 3-7 mm, partly hidden by floral envelopes, first covered by a pale brown peridium which ruptures from its apex disclosing the dark brown, agglutinated to powdery mass of spore balls, spores and sterile cells surrounding a simple, narrowing, central columella. *Spore balls* irregular, early disintegrating. *Spores* rounded, subpolyhedrally slightly irregular, 7-11 x 8-13.5 µm, yellowish-brown; wall even, c. 0.5 µm thick, finely, densely punctate-verruculose, spore profile smooth. *Sterile cells* in irregular groups, single cells about the size of the spores, hyaline, collapsed in old specimens; wall c. 0.5 µm thick, smooth.

On *Andropogon gerardii* Vitman, *A. ternarius* Michx., *A. virginicus* L., *Schizachyrium scoparium* (Michx.) Nash (*Andropogon scoparius* Michx.); N. America (USA).

30. *Sporisorium stuhlmannii* (Henn.) Vánky, 2004a:107.

Ustilago stuhlmannii Hennings, 1893:3. — *Sphacelotheca stuhlmannii* (Henn.) Zundel, 1930:136. — Type on *Andropogon* sp., "Central Afrikan. Seengebiet" (Central African Lakes Territory), Ukami, Mrogoro, 18.V.1890, F. Stuhlmann 63, "Emin Pascha Expedition", BPI 198126!

Ustilago andropogonis-hirtifolii Henn., in Holway, 1899:274 (as '*andropogonis-hirtefolii*'). — *Sphacelotheca andropogonis-hirtifolii* (Henn.) G.P. Clinton, 1902:141. — *Sporisorium andropogonis-hirtifolii* (Henn.) M. Piepenbring, 2003:88. — Type on *Andropogon hirtifolius* var. *pubiflorus*, Mexico, Michoacán, Patzcuaro, 20.X.1898, E.W.D. Holway 3216, B; isotypes BPI 157091, 157093, HBG, Sydow, Ust. no. 201, HUV 9766! (syn. nov.)

Ustilago andropogonis-saccharoidis Henn., in P. Sydow, Ustilagineen no. 251 (nom. nud.). — *Sphacelotheca andropogonis-saccharoidis* (Henn.) Cif., in Ciferri & Herter, 1932:531 (comb. invalid.). — Type on *Andropogon saccharoides*, Mexico, Jalisco, Chapala, 17.IX.1899, E.W.D. Holway; isotypes in Syd. Ustil. no. 251, HUV 3154! (syn. by Clinton, 1902:129). The host plant in the HUV copy of Syd. Ustil. no. 251 is *Andropogon perforatus* (det. K. Vánky).

Sori comprising the entire inflorescence, elongate, 1-3 mm wide, 5-10 cm long, partly enclosed by leaf sheaths, initially covered by a thick, brown peridium which flakes away disclosing the semiagglutinated to powdery, dark olivaceous-brown mass of spores and sterile cells surrounding a long, sometimes bifurcate columella often with short lateral branches. Sori rarely restricted to the spikelets, then c. 1 x 5-10 mm. *Spores* subglobose, ellipsoidal to usually rounded, subpolyhedrally slightly irregular, 8-12 x 9-13.5 µm, yellowish-brown; wall even, c. 0.5 µm thick, finely, densely punctate to verruculose-echinulate, spore profile smooth, finely wavy to finely serrulate. *Spore germination* (Durán, 1987:87 & 102) results in 4-5-celled basidia producing basidiospores. *Sterile cells* in irregular groups, single cells 6.5-13 µm long, subhyaline; wall thin, c. 0.5 µm, smooth, collapsed in old specimens.

On *Andropogon barbinodis* Lag. (*Bothriochloa barbinodis* (Lag.) Herter), *A. hallii* Hack., *A. hirtifolius* J. Presl var. *pubiflorus* Hack., *A. lateralis* Nees, *A. perforatus* Trin. ex Fourn., *A. saccharoides* Sw. (*Bothriochloa saccharoides* (Sw.) Rydb.), *A. wrightii* Hack., *Andropogon* sp.; Africa, N. America (Mexico, USA), Caribic Islands (Dominican Rep.).

The sori, spores and sterile cells of the types of *Ustilago andropogonis-hirtifolii* and those of *U. stuhlmannii* are identical hence they are considered to be synonyms.

31. *Sporisorium zilligii* (Zundel) Vánky, **comb. nov.**

Basionym: *Sphacelotheca zilligii* Zundel, Mycologia 22:142, 1930. — Type on *Andropogon* sp., South Africa, Cape Province, Vryburg, 25.III.1921, A.O.D. Mogg, PREM 20666; isotypes BPI 192099, BPI 195088, HUV 18128!

Sori destroying the whole inflorescence, long linear, 1-2 x 10-30 mm, partly hidden by leaf sheaths, initially covered by a thick, brown peridium which flakes away disclosing the dark brown, semiagglutinated to powdery mass of spore balls, spores and sterile cells surrounding a stout, bifurcate or much ramifying columella. *Spore balls* loose, composed of tens or a hundred of easily separating spores. *Spores* globose, ovoid, ellipsoidal to slightly irregular, varying in size, 5.5-9.5(-10.5) x 6-13(-16) µm, yellowish-brown; wall even, c. 0.5 µm thick, finely, densely punctate-verruculose, spore profile smooth. *Sterile cells* in irregular groups, single cells subglobose, ellipsoidal, irregular, 8-16(-18) µm long, subhyaline to pale yellowish-brown tinted, collapsed in old specimen; wall c. 1 µm thick, smooth.

On *Andropogon* sp.; S. Africa. Known only from the type collection.

Doidge (1950:384), and after her Zundel (1953:115), stated that the host plant is a *Cymbopogon* sp., not *Andropogon* as originally given. Unfortunately, no healthy host plant is preserved. Judged from the sori, I doubt that the host is a *Cymbopogon* (comp. Vánky, 2003:31).

32. *Ustilago andropogonis-tuberculati* Brefeld, 1895:108.

Type on *Andropogon tuberculatus*, India, Simla, comm. Barclay (type where?).

Sori in the ovaries, compact, hard, black. *Spores* remarkably variable, rounded, 10-13 µm in diameter, dark brown. *Spore germination* (Brefeld, 1895:108, Plate VI, figs. 24, 25) results in long, narrow, 4-celled basidia on which long ellipsoidal basidiospores are produced.

On *Andropogon tuberculatus* Hack.; S. Asia (India).

No specimen was available for study. Description taken from the original. Collection and study of this species is desired as the generic position is uncertain.

Invalid names, uncertain, excluded and undescribed species

Sphacelotheca furcata var. ***congoensis*** Zambettakis, 1979(1980):410.

Invalid name, no Latin diagnosis, and no type designated (ICBN 36.1 & 37.1).

On *Andropogon* sp., Congo, BR.

Sphacelotheca tonkinensis (Henn.) Zundel, 1930:134.

Uredo tonkinensis Hennings, 1895a:11. — Type on *Andropogon* sp., N. Vietnam, Tonkin, Hanoi (type where?).

Sori destroying the ovaries, 2-3 mm long, at first concealed by the glumes, covered by a brown peridium, which dehisces from the apex revealing a brown spore mass surrounding a well-developed columella. *Spores* globose to subglobose, regular, 9-12 µm in diameter, reddish-brown; wall thick, two-layered, smooth. Spore content granular-vacuolate.

Type not seen. Description taken from Zundel (1930:134). This species belongs to the genus *Sporisorium*. However, the short and incomplete description does not allow a sure identification.

Sporisorium moniliferum (Ellis & Everh.) L. Guo, 1990:82.

Type on *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult., USA.

Zundel (1953:100) mentions this smut also on *Andropogon glomeratus* (Walter) Britton, Stern. & Poggenb. from the USA, Va. The specimen in BPI 178090! (USA, Va., Williamsburg, 28.VI.1921, E.J. Grimes) represents another, probably an undescribed species.

Ustilago amadelpha is *Ustilago scitaminea*

Ustilago amadelpha Syd., P. Syd. & E.J. Butler, 1912:249. — Type on "*Andropogon* sp." (= misnamed *Saccharum* sp.), India.

It is identical with the later published *Ustilago scitaminea* Syd. on *Saccharum officinarum* L., India (Vánky, 2004a:114), a name that was proposed for conservation (Vánky & Shivas, 2005:180).

Sporisorium sp. nov.

On *Andropogon gayanus* Kunth, Nigeria, Prov. Zaria, Samaru, 20.II.1961, E. Harris, IMI 87111!

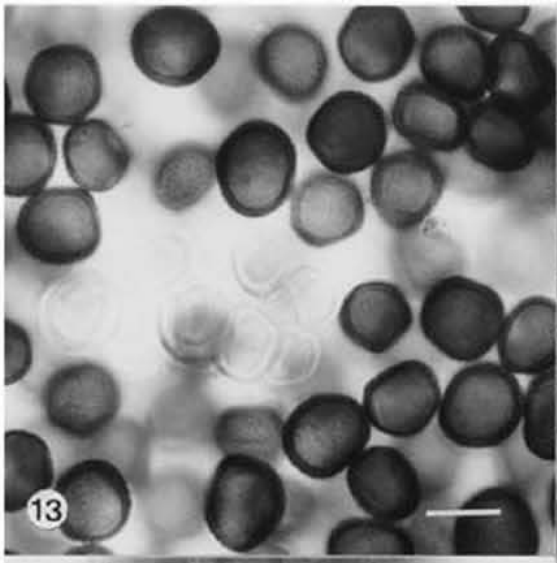
Sori in the spikelets, cylindrical, up to 2 cm long, covered by a peridium which ruptures disclosing the dark brown, granular powdery mass of spore balls surrounding a central columella. *Spore balls* variable in shape and size, ovoid, usually oblong or irregular, 40-120 x 50-180(-210) µm, olivaceous brown, rather permanent, composed of tens to hundreds of spores. *Spores* dimorphic, outer spores ellipsoidal, 6.5-9 x 6.5-10(-11) µm, brown; wall c. 1 µm thick, on the free surface prominently verrucose. Inner spores subpolyhedrally irregular, subhyaline with c. 0.5 µm thick, smooth wall. *Sterile cells* not seen

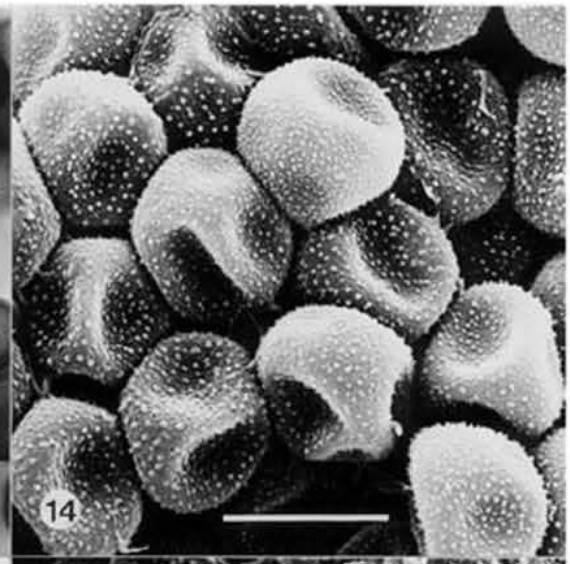
It differs from all known *Sporisorium* species on *Andropogon*. However, the IMI specimen I have seen is too scanty to be designated as the type of a new species. It is presented here to call attention to it.

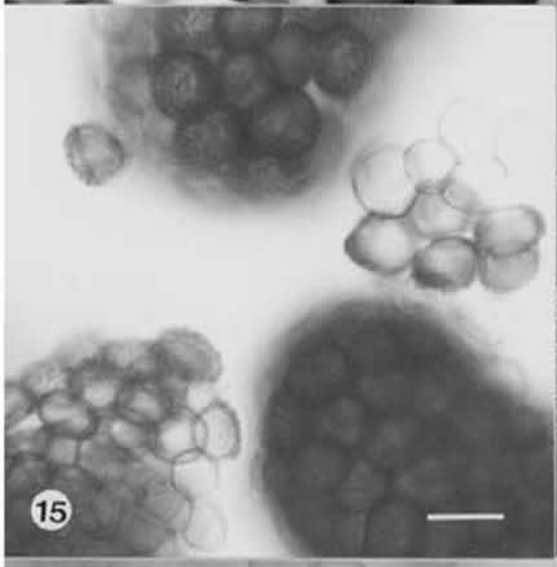
Figs. 13, 14. Spores and sterile cells of *Sporisorium distachyum* on *Andropogon distachyos*, in LM and in SEM (type).

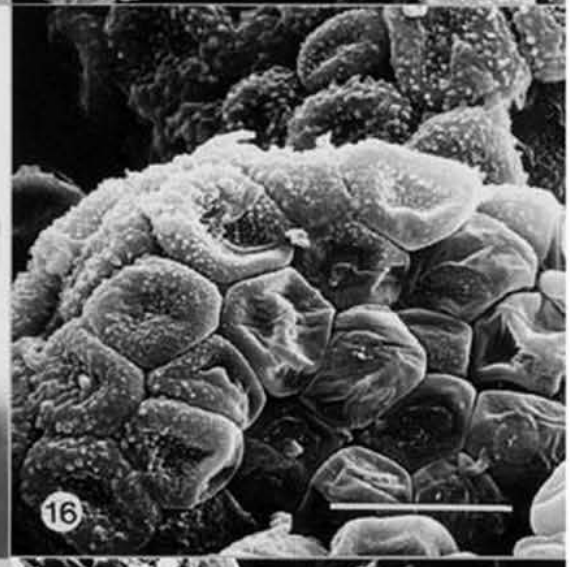
Figs. 15, 16. Spore balls and spores of *Sporisorium livingstoneanum* on *Andropogon gayanus*, in LM and in SEM (type).

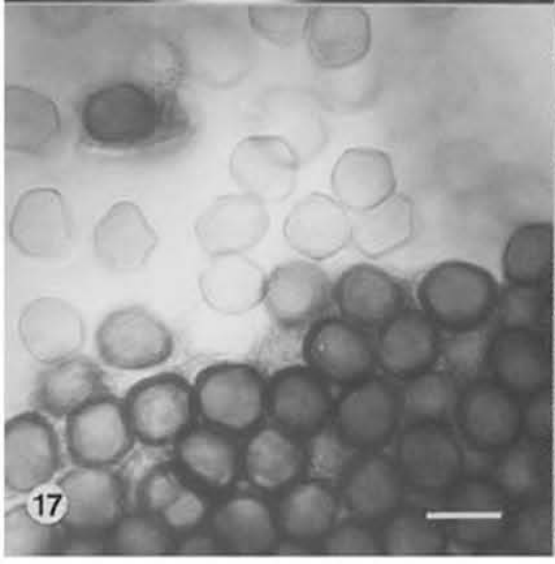
Figs. 17, 18. Spore balls and spores of *Sporisorium scholzii* on *Andropogon schirensis*, in LM and in SEM (type). Bars = 10 µm.

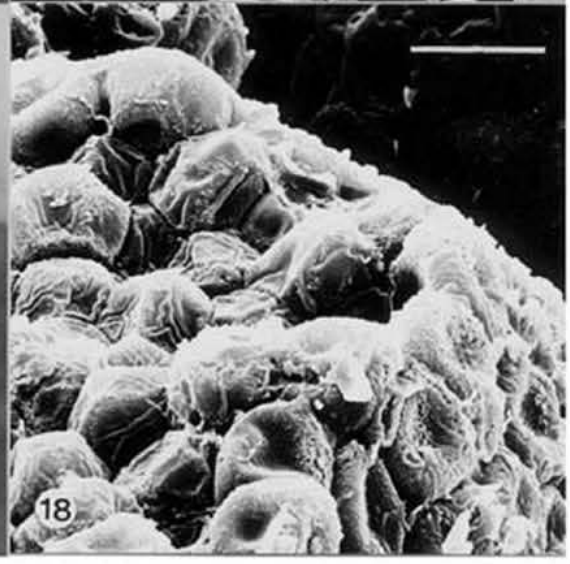

13


14


15


16


17


18

Key to the smut fungi of *Andropogon* and *Schizachyrium*

(S. = Sporisorium)

1. Sori on the leaves or leaf sheaths as striae. Spore wall thick, multilayered 2
— Sori and spore wall not so 3
2. Spores 10-20(-24) µm long; wall 3-8 µm thick ..... ***Jamesdicksonia brunkii***
— Spores 8-16(-18) µm long; wall 1.5-6.5 µm thick ..... ***Jamesdicksonia caribensis***
3. Sori on the top of shoots as whip-like structures 4
— Sori not so 7
4. Columella one, stout, with longitudinal furrows. Spore wall 0.4-0.8 µm thick, thinner on one side ..... ***S. andropogonis-tectorum***
— Columellae several, filiform. Spore wall thicker, not thinner on one side 5
5. Spores 13-19 µm long; wall 3-4 µm thick, minutely verruculose ..... ***S. provinciale***
— Spores smaller; wall thinner 6
6. Spores 8-11 µm long; wall 2-2.5 µm thick, including the 1.5-2 µm high, anastomosing warts ..... ***S. mexicanum***
— Spores 6.5-9 µm long; wall 1-1.5 µm thick, including the cylindrical, single or anastomosing, labyrinthiform or cerebriform warts ..... ***S. sanctae-catharinae***
7(3). Sori destroying the whole inflorescence 8
— Sori restricted to the spikelets or ovaries 19
8. Spores dimorphic. Columella filiform, one or numerous. 9
— Spores not dimorphic. Columella stout, one, sometimes branching 14
9. Columella one 10
— Columellae numerous 13
10. Spore balls persistent 11
— Spore balls easily separating 12
11. Spores 10.5-13.5 µm long ..... ***S. absconditum***
— Spores 15-20(-21.5) µm long ..... ***S. blakeanum***
12. Spores 10.5-17 µm long, free surface coarsely echinulate ..... ***S. zambianum***
— Spores 13-20 µm long, free surface finely verrucose ..... ***S. guaraniticum***
13. Spores 13.5-18.5(-20) µm long. Sterile cells absent ..... ***S. andropogonis-eucomi***
— Spores 9-14.5 µm long. Sterile cells present ..... ***S. pseudomaranguense***
14. Spores very variable in size, 6-13(-16) µm long ..... ***S. zilligii***
— Spores less variable in size 15
15. Spores up to 20 µm long 16
— Spores smaller 17
16. Spores regular, with a rounded paler area ..... ***S. culmiperdum***
— Spores mostly slightly irregular, with irregular, paler and darker areas ..... ***S. ellisii***
17. Spores 7.5-11 µm long ..... ***S. andropogonis***
— Spores larger 18
18. Spores 9-13.5 µm long; wall even, 0.5 µm thick ..... ***S. stuhlmannii***
— Spores 12-16 µm long; wall uneven, 0.5-1.5 µm thick ..... ***S. leucostachys***
19(7). Sori in the ovaries, compact, hard, black ..... ***Ustilago andropogonis-tuberculati***
— Sori in the spikelets, not hard and black 20

20. Sori in some spikelets of an inflorescence 21
— Sori in all spikelets, both sessile and pedicelled, or only sessile ones of an inflorescence (excepting sometimes *S. everhartii*) 27
21. Sori producing groups of witches' brooms in the inflorescence 22
— Sori not producing witches' brooms 23
22. Spores 10-16(-18) µm long ..... ***S. holwayi***
— Spores 6.5-11(-12) µm long ..... ***S. bicornis***
23. Spores not in permanent balls, not dimorphic 24
— Spores in permanent balls, dimorphic 25
24. Spores prominently echinulate, single ..... ***Macalpinomyces ovariicolopsis***
— Spores finely punctate-verruculose, in loose balls ..... ***S. berndtii***
25. Columella one, simple. Warts 1-2.5 µm long, filiform ..... ***S. andropogonis-pumili***
— Columellae several, or one, fused, band-like. Warts shorter, not filiform 26
26. Columellae several. Outer spores finely punctate-verruculose ..... ***S. scholzii***
— Columella often band-like. Outer spores with 0.5(-1) µm high warts or spines ..... ***S. livingstoneanum***

27(20). Columellae several, filiform (or one, filiform in *S. schizachyrii*) 28
— Columella one, flagelliform or stout, simple or with branches 30
28. Spores not dimorphic, 7-10 µm long ..... ***S. andropogonis-gabonensis***
— Spores dimorphic, larger 29
29. Spores 8-10.5 µm long. Sterile cells absent ..... ***S. schizachyrii***
— Spores 10.5-14.5 µm long. Sterile cells present ..... ***S. gayanum***
30. Spores dimorphic 31
— Spores not dimorphic. Spore balls ephemeral or very loose 33
31. Spore balls loose, 25-40(-50) µm long ..... ***S. andropogonis-chinensis***
— Spore balls permanent, longer 32
32. Spore balls 50-130 µm long. Outer spores 8-15 µm long ..... ***S. everhartii***
— Spore balls 50-180(-210) µm long. Outer spores 6.5-10 µm long ..... S. sp.
33. Spores 13.5-18 µm long ..... ***S. occidentale***
— Spores smaller 34
34. Sterile cells absent 35
— Sterile cells present 36
35. Spore wall 0.5-1.2 µm thick, thinner on one side ..... ***S. braziliense***
— Spore wall 1-2 µm thick, uneven, thickest at the angles ..... ***S. polliniae***
35. Spores 7-10.5(-11) µm long ..... ***S. andropogonis-schirensis***
— Spores larger, up to 13.5 µm long 37
37. Spore wall 0.5-1(-1.5) µm thick, with a paler, thinner germ pore, finely, densely verrucose-echinulate ..... ***S. distachyum***
— Spore wall thinner, germ pore lacking, more finely ornamented 38
38. Sori completely destroying the spikelets. Spore wall 0.5-0.8 µm thick. Sterile cells in compact, rounded or elongated groups ..... ***S. fastigiatum***
— Sori not so. Spore wall c. 0.5 µm thick. Sterile cells not so ..... ***S. seymourianum***

The smut fungi of *Sorghastrum* (*Poaceae*)

Sorghastrum Nash, in the subfam. *Panicoideae*, tribe *Andropogoneae*, subtribe *Sorghinae*, is a genus of about 16 species in Africa and tropical America. It is a relative of *Sorghum* (Clayton & Renvoize, 1986:341). Five smut fungi could be recognised on *Sorghastrum:*

1. *Macalpinomyces ugandensis* Vánky, 2003:50.

Type on *Sorghastrum stipoides*, Uganda, Rakai Distr., 40 km SW. of Masaka, 6 km NE. of Kyotera, alt. 1190 m, 27.II.2002, T., C. & K. Vánky, HUV 19992; isotypes BPI, MHU, Vánky, Ust. exs. no. 1177. Paratype on *Loudetia phragmitoides*, HUV 19993; isoparatypes BPI, K, MHU.

For description and illustrations see Vánky, 2003:50-52 & 55.

On *Sorghastrum stipoides* (Kunth) Nash, and *Loudetia phragmitoides* (Peter) C.E. Hubb.; C. Africa (Uganda).

2. *Sporisorium clintonianum* Vánky, **nom. nov.**

Replacing *Sphacelotheca chrysopogonis* G.P. Clinton, Proc. Boston Soc. Nat. Hist. 31:387, 1904 (not *Sporisorium chrysopogonis* Vánky, 1983:327). — Type on *Chrysopogon nutans* (= *Sorghastrum nutans*), Mexico, Chapala, 1901, E.W.D. Holway, BPI 177307; isotopotypes in Seymour & Earle, Econ. fgi., Suppl. C, no. 118, HUV 9706!

Sori in all ovaries of an inflorescence, c. 3-5 mm long, showing between the spreading floral envelopes, initially covered by a thin peridium which ruptures disclosing the blackish-brown, semiagglutinated to powdery mass of spores and sterile cells, surrounding a simple, central columella. *Spores* single when mature, subglobose, ellipsoidal to usually slightly irregular, 7-9.5 x 7.5-10.5 µm, light yellowish-brown; wall even, c. 0.5 µm thick, finely, densely punctate, spore profile smooth. *Sterile cells* in large, irregular groups, single cells globoid, ellipsoidal or irregular, with flattened contact sides, 6.5-12 x 6.5-13 µm, subhyaline; wall c. 1 µm thick, smooth, collapsed in old specimens.

On *Sorghastrum nutans* (L.) Nash (*Chrysopogon nutans* (L.) Benth.); N. America (Mexico, USA).

Fischer (1953:134) considered *Sphacelotheca chrysopogonis* to be a synonym of *S. cruenta* (J.G. Kühn) Potter (= *Sporisorium cruentum* (J.G. Kühn.) Vánky, type on *Sorghum saccharatum* (L.) Pers.). However, the two differ in sorus, spore and sterile cell morphology which, in my opinion, is sufficient to treat them as two separate species.

3. *Sporisorium sorghastri* (Zundel) Vánky, **comb. nov.**

Basionym: *Sphacelotheca sorghastri* Zundel, in Massey & Zundel, Phytopathology 32:545, 1942. — Type on *Sorghastrum elliottii*, USA, Virginia, Pittsylvania Co., 2 miles W of Chatham, Moses Mill Pond, 4.IX.1941, A.B. Massey 5059, BPI 193999!

Sori destroying the whole inflorescence, long linear, 2-4 mm wide, 7-10 cm long, at first covered by a thick, pale brown peridium that ruptures irregularly, flakes away, exposing the dark brown, semiagglutinated to powdery mass of spores and sterile cells surrounding a central columella with several long, filiform branches. *Spores* single when mature, subglobose, ovoid, ellipsoidal to slightly irregular, 7-10(-11) x 8-11(-12) µm, yellowish-brown; wall even, c. 0.5 µm thick, finely, densely punctate-verruculose, spore profile smooth. *Sterile cells* in irregular groups or chains, single cells ellipsoidal or irregular, with flattened contact sides, 7-12 x 8-16 µm, hyaline; wall thin, c. 0.5 µm, smooth, collapsed in old specimens.

On *Sorghastrum elliottii* (Mohr) Nash; N. America (USA).

4. *Sporisorium tepicense* (Durán) M. Piepenbring, 2003:129.

Sphacelotheca tepicensis Durán, 1970:1098. — Type on *Sorghastrum incompletum*, Mexico, Nayarit State, 38.6 km SE of Tepic, Hwy. Mex. no. 15, 29.X.1969, R. Durán, WSP 58550; isotype HUV 14419!

Sori in all ovaries of an inflorescence, ovoid or ellipsoidal, 0.5-0.8 x 1-2 mm, showing between the spreading floral envelopes, first covered by a thin, fragile, dark brown peridium which ruptures irregularly at maturity disclosing the blackish-brown, semiagglutinated mass of spores and sterile cells surrounding a thin, central columella of the length of the sorus. *Spores* single when mature, globose, ovoid or ellipsoidal, 6.5-9 x 7-11 µm, medium dark reddish-brown; wall even, 0.5-1 µm thick, densely, coarsely verrucose, spore profile wavy to finely serrulate. *Sterile cells* in short chains, or in small groups, single cells globoid, ellipsoidal to usually irregular with flattened contact sides, 5.5-12 x 5.5-15 µm, pale yellowish-brown; wall c. 1 µm thick, smooth.

On *Sorghastrum incompletum* (J. Presl) Nash; N. America (Mexico). Known only from the type collection.

5. *Tolyposporella chrysopogonis* G.F. Atkinson, 1897:16.

Type on *Chrysopogon nutans* (= *Sorghastrum nutans*), USA, Alabama, Auburn, autumn, Duggar, no special collection designated.

Sori on inner surface of leaf sheaths, by which they are concealed, forming linear, more or less confluent, initially subepidermal, later bursting striae filled with black, granular-agglutinated masses of spore balls. *Spore balls* subglobose, oblong, subpolyhedral, usually more or less irregular, 40-80 x 50-175 µm, reddish- to blackish-brown, opaque, composed of numerous, firmly agglutinated spores, separating with difficulty. *Spores* subglobose, ovoid, usually irregular, (7-)8-9.5 x 8-13(-15) µm including the thin (c. 1 µm), dark endospore but excluding the irregularly thickened (2.5-8(-14) µm), laminated, light yellowish-brown, smooth exospore which, on the outer spores of the ball may be excessively thickened forming long (up to 14 µm), often bent appendages; with such thickenings of the spore wall the spores may reach 30 µm in length. Spores "germinating by a delicate promycelium which becomes branched, septate. Sporidia borne laterally, single, subclavate or fusoid, 2-2.5 x 9-12 µm" (Atkinson, 1897:16).

On *Sorghastrum nutans* (L.) Nash (*Chrysopogon nutans* (L.) Benth.; *C. avenaceus* (Michx.) Benth.; *S. avenaceum* (Michx.) Nash), *S. stipoides* (Kunth) Nash; C. Africa (Uganda), N. America (USA).

Key to the smut fungi of *Sorghastrum*

1. Sori on the inner surface of leaf sheaths. Spore wall 3-9(-15) µm thick ..... ***Tolyposporella chrysopogonis***
– Sori elsewhere. Spore wall 0.5-1 µm thick 2
2. Sori on the top of shoots forming up to 1 m long, flagelliform tubes ..... ***Macalpinomyces ugandensis***
– Sori not so 3
3. Sori in the whole inflorescence ..... ***Sporisorium sorghastri***
– Sori in the ovaries 4
4. Spores densely, coarsely verrucose ..... ***Sporisorium tepicense***
– Spores densely, finely punctate ..... ***Sporisorium clintonianum***

The smut fungi of *Leptochloa* (*Poaceae*)

Leptochloa P. Beauv. (including *Diplachne* P. Beauv.), in the subfam. *Chloridoideae*, tribe *Eragrostideae*, subtribe *Eleusinae*, is a genus of 40 species throughout the tropics, warm temperate parts of America and Australia (Clayton & Renvoize, 1986:208). On *Leptochloa* and *Diplachne* seven smut fungi are recognised:

1. *Tilletia leptochloae* Thirumalachar & Pavgi, 1968(1969):253.

Type on *Leptochloa filiformis* (= *L. panicea*), India, Rajasthan, Ajmer, X.1955, P.N. Mathur 1259, HCIO(?).

According to the original description, *sori* in the ovaries, few ovaries in the panicle attacked to form dirty green, minute, round bodies up to 1 mm in diameter, half enclosed by the glumes and rupturing irregularly to expose black, dusty spore mass. *Spores* globose, subglobose, ovoid, 12.9-17.2 µm in diameter; wall medium thick, ornamented with short, blunt, triangular processes. *Sterile cells* numerous, globose to subglobose, occasionally irregular, about the size of the spores, hyaline, thick-walled, smooth.

On *Leptochloa panicea* (Retz.) Ohwi (*L. filiformis* Nees), *L. uniflora* A. Rich; S. Asia (India).

2. *Tilletia salzmannii* Maire, in Maire & Werner, 1937:47.

Type on *Koeleria salzmannii* (= *Leptochloa salzmannii*), Morocco, Moyen-Atlas, Plateau d'Ito, alt. 1450 m, VII.1921, R. Maire, MPU; isotype HUV 13106!

Sori in the ovaries, ovoid or lemon-shaped, 0.5-0.8 x 1-1.5 mm, hidden by the floral envelopes, dark brown, covered by a thin membrane of the pericarp which ruptures irregularly disclosing the dark brown, semiagglutinated to powdery mass of spores and sterile cells. *Spores* globose to broadly ellipsoidal, 18-24(-28) x 18.5-26.5(-28) µm, pale to medium yellowish-brown; wall 2.5-3.5 µm thick, usually completely, rarely incompletely reticulate, 6-10 meshes per spore diameter, muri 1-2(-2.5) µm high. *Sterile cells* globose, ovoid to irregular, 10-17 µm long, hyaline; wall even, c. 1 µm thick, smooth, content homogeneous.

On *Lophochloa salzmannii* (Boiss. & Reuter) H. Scholz (*Koeleria salzmannii* Boiss. & Reuter); N. Africa (Morocco), S. Asia (Iran).

In the original description of *T. salzmannii*, the spores were cited as 14-18 µm. These results could not be confirmed by study of the type specimen under standard conditions (spores in lactophenol, gently heated to boiling point).

3. *Tranzscheliella amplexa* (Syd.) Vánky, 2004a:109.

Ustilago amplexa Sydow, 1924:278. — Type on *Diplachne fusca*, Egypt, Belbes in the delta of Nile River, V.1880, G. Schweinfurth; isotypes Thümen, Mycoth. univ. no. 1818, HUV 3854!

Sori surrounding the upper internodes of sterile shoots, 0.2-0.3 x 10-15 cm, partly hidden by leaf sheaths, initially covered by a thin, greyish peridium which flakes away disclosing the olivaceous-brown, powdery mass of spores. *Spores* globose, subglobose, rarely ovoid or broadly ellipsoidal, flattened, in side view 4-5 µm wide, in plane view 5.5-6.5(-7) x 6-7(-7.5) µm, medium yellowish-brown; wall even, c. 0.5 µm thick, slightly thinner on the flattened sides, in LM smooth, in SEM finely, moderately densely verruculose.

On *Diplachne fusca* P. Beauv. ex Roem. & Schult.; N. Africa (Egypt).

4. *Tranzscheliella serena* (Syd.) Vánky, 2004a:109.

Ustilago serena Sydow, 1937:24. — Type on *Diplachne fusca*, Australia, New South Wales, between Warren and Collie, I.1936, L. Fraser 195; isotypes IMI 44656, HUV 17815!

Sori surrounding the uppermost culms, partly hidden by leaf-sheaths, initially covered by a delicate, grey or lead-coloured peridium which flakes away disclosing the olivaceous-brown, powdery mass of spores. *Spores* globose to broadly ellipsoidal, 6.5-8 x 7-10 µm, pale yellowish-brown; wall even, c. 0.5 µm thick, smooth in LM, finely, sparsely verruculose in SEM.

On *Diplachne fusca* P. Beauv. ex Roem. & Schult.; Australia. Known only from the type collection.

T. serena differs from *T. amplexa* especially in the larger, paler spores.

5. *Ustilago heterogena* Hennings, 1904:155.

Type on *Leptochloa virgata*, Brazil, Rio Juruá, Bom Fim, X.1900, E. Ule 2675. Topotype: 1901, E. Ule, in Mycoth. brasil. no. 3, HUV 3712!

Sori in various parts of the host plants, forming conspicuous galls or fusiform swellings on stems, leaves, inflorescence, often about 15 x 40 mm or larger, up to 2 x 12 cm, or restricted to the spikelets and as small as 0.5-1 mm in diameter, first covered by a thick, brown peridium of host tissues which ruptures irregularly at maturity disclosing the dark chocolate-brown, semiagglutinated to powdery mass of spores. *Spores* varying in shape and size, globose, subglobose, ellipsoidal, oblong, irregular, occasionally bent or with an acute tip, (7-)8-13 x 9-13.5(-15) µm, medium dark reddish-brown; wall even, c. 1 µm thick, densely low echinulate, spore profile finely serrulate.

On *Leptochloa filiformis* (Lam.) P. Beauv. (*L. mucronata* Kunth), *L. scabra* Nees, *L. virgata* (L.) P. Beauv., *L. viscida* (Scribner) Beal; N. America (Mexico, USA), S. America (Brazil).

6. *Ustilago ornata* Tracy & Earle, 1895:175.

Type on *Leptochloa mucronata* (= *L. filiformis*), USA, Mississippi, Starkville, I.X.1894, S.M. Tracy, BPI 164358, 164361; isotypes in Ellis & Ev., N. Amer. fgi. no. 3340, HUV 9325!, HUV 4257! Topotype: 27.VIII.1895, S.M. Tracy; isotopotypes in Seymour & Earle, Econ. fgi. no. 542, HUV 7306!, and Reliquiae Seymourianae, HUV 9931!

Sori in ovaries, infecting only some in the inflorescence, ovoid, often with a short, acute tip, 0.7-1 x 1-1.8 mm, initially covered by a thin layer of the pericarp which ruptures irregularly disclosing the dark brown, semi-powdery mass of spores, or the sori fall off the plant entirely. *Spores* varying in size, globose, ovoid, ellipsoidal, rarely oblong or irregular, 9-14.5 x 10-16 µm, yellowish-brown; wall even, c. 0.5 µm thick, prominently, moderately densely echinulate, spines up to 1.5 µm high, in SEM between the spines finely verrucose.

On *Leptochloa filiformis* (Lam.) P. Beauv. (*L. mucronata* Kunth), *L. uninervia* (Presl) Hitchc. & Chase (*L. imbricata* Turb.); N. America (USA).

7. *Ustilago thaxteri* Zundel, 1939:579.

Type on *Leptochloa uninervia* (det. A. Chase), Argentina, Buenos Aires, 29.IX.1905, R. Thaxter, BPI 168169!; isotypes FH 7899, 7907, 7911, HUV 18704!

Sori destroying the whole inflorescence and extending down to and surrounding the upper portions of the stem, long cylindrical, 1-3 mm in width, 10 cm or more in length,

at first partly hidden by leaf sheaths and covered by a greyish-silvery delicate membrane which flakes away revealing a semiagglutinated to powdery, olivaceous-brown spore mass. *Spores* globose, ovoid to ellipsoidal or slightly irregular, (7-)8-10.5 x 8-11(-12) µm, light olivaceous-brown; wall even, c. 0.5 µm thick, apparently smooth to very finely punctate, in SEM finely, moderately densely verrucose.

On *Leptochloa uninervia* (Presl) Hitchc. & Chase; S. America (Argentina).

A *Tilletia*, collected on *Leptochloa uniflora* A. Rich in Nyasaland (= Malawi), N.A., Kalembo, 8.VI.1955, C. Jackson 1684, represents a new species. Unfortunately, the IMI 60435 specimen contains only some spores on the envelope. Because of the paucity of the specimen, no formal description was made, only an informative one, to call attention to this bunt.

"*Tilletia leptochloae-uniflorae*" nom. prov.

Sori in the ovaries(?). *Spores* globose, subglobose, rarely ellipsoidal, 19-25 x 19-25 µm, medium to dark olivaceous-brown, provided with 2-3 µm high, cylindrical warts with flattened top, in surface view showing as darker, irregular groups, 5-8 per spore diameter, each group composed of 3-10 punctiform elements, in optical median view 18-24 warts on the equatorial circumference. *Sterile cells* globose, ellipsoidal to irregular, variable in size, 12-26 x 13.5-30 µm, pale olivaceous-brown; wall 1.5-2.5 µm thick, smooth, content granular.

Key to the smut fungi of *Leptochloa*

1.	Sori in ovaries	2
–	Sori elsewhere	5
2.	Spores reticulate	***Tilletia salzmannii***
–	Spores with other ornament	3
3.	Spores prominently echinulate. Sterile cells absent	***Ustilago ornata***
–	Spores with blunt or flattened warts. Sterile cells present	4
4.	Spores 19-25 µm long, with cylindrical warts	"***Tilletia leptochloae-uniflorae***"
–	Spores 13-17.5 µm long, with subconical warts	***Tilletia leptochloae***
5(1).	Sori surrounding upper internodes	6
–	Sori otherwise	7
6.	Spores 6-7(-7.5) µm long	***Tranzscheliella amplexa***
–	Spores 7-10 µm long	***Tranzscheliella serena***
7.	Sori forming conspicuous galls in various parts of the host. Spores densely low echinulate	***Ustilago heterogena***
–	Sori in the whole inflorescence, long cylindrical. Spores apparently smooth to very finely punctate	***Ustilago thaxteri***

The smut fungi of *Chloris* (*Poaceae*)

Chloris Sw., in the subfam. *Chloridoideae*, tribe *Cynodonteae*, subtribe *Chloridinae*, has about 55 species in tropical and warm temperate regions of both hemispheres (Clayton & Renvoize, 1986:236). On *Chloris* at least 13 smut fungi have been described. Of these, *Tolyposporium chloridis* is a hyphomycete, *Sphacelotheca chloridis* is *Sporisorium andropogonis* on *Bothriochloa pertusa*, *Ustilago liebenbergii* is a synonym of *U. elegans*,

and *Sorosporium chloridicola* is identical with *Ustilago induta*. The recognised nine species, some of them doubtful, are:

1. "*Entyloma*" *chloridis* Thirumalachar & Pavgi, 1968(1969):251.

Type on *Chloris barbata*, India, Poona, at Pimpri, 8.X.1955, M.J. Thirumalachar 1253, HCIO(?)

Sori in the leaves and leaf sheaths forming blackish, slightly raised, often coalescent, 0.5-5 mm long streaks along the veins. *Spores* agglutinated, single spores globose, subglobose, ovoid or irregularly polyhedral, 10-14.3 µm in diameter, dark olive-brown; wall thick, smooth.

On *Chloris barbata* Sw.; S. Asia (India).

This is one of the dark-spored "*Entyloma*" species on *Poaceae*, which belongs either to the genus *Jamesdicksonia*, *Phragmotaenium* or *Eballistra*, depending on spore germination and/or molecular characters. No specimen was available for study. Description taken from the original.

2. *Tilletia chloridicola* Ciferri, 1928:10.

Type on *Chloris paraguaiensis* (= *C. inflata*), Dominican Republic, Distrito Nacional, Haina, IX.1925, R. Ciferri (type where?).

Sori in the flowers and ovaries, inflated and twisted. Spore mass chestnut-brown, odourless. *Spores* globose, rarely ovoid, 12.5-15(-18) µm, brown; wall thick, densely covered with conical, pointed to subacuminate spines, 0.8-1 µm high.

On *Chloris inflata* Link (*C. paraguaiensis* Steud.); West Indies (Dominican Republic).

No material was available for study. Description taken from the original. Based on the short description, most probably it is not a *Tilletia*. It could be a *Ustilago* or a *Macalpinomyces* species.

3. *Ustilago chloridicola* Hennings, 1898:267.

Lectotype on *Chloris* sp., USA, California, Mendocino Co., Potter Valley, IV.1894, A. Purpus, (designated here) BPI 159608!; isotypes BPI 159609 & 196337.

Sori destroying the distal part of the culms including the inflorescence, 2-5 x 10-20(-30) mm, dark brown, powdery, causing shredding of the infected tissues. *Spores* variable in shape and size, globose, ovoid, long ellipsoidal, sometimes lacrymiform, (5.5-)6-9 x 6.5-11(-12) µm, olivaceous-brown; wall even, c. 1 µm thick, densely verrucose, several warts fuse, giving the spore surface an irregular pattern, spore profile wavy.

On *Chloris verticillata* Nutt., *Chloris* sp.; N. America (USA).

4. *Ustilago chloridis* Vánky, C. Vánky & R.G. Shivas, in Vánky & Shivas, 2001:171.

Type on *Chloris lobata*, Australia, Queensland, 51 km S of Lakeland, 5.III.2000, C. & K. Vánky, BRIP 27016; isotypes HUV 19177 and in Vánky, Ust. exs. no. 1084.

Sori in some ovaries of an inflorescence, lemon-shaped, 2-3 mm long. *Spores* subglobose to ellipsoidal, 9.5-13 x (10-)11-13.5(-15) µm, slightly flattened (8-11 µm wide); wall uneven, 0.5-1 µm thick, sparsely low verruculose, spore profile smooth to very finely serrulate.

On *Chloris divaricata* R. Br., *C. lobata* Lazarides, *C. truncata* R. Br.; Australia.

5. *Ustilago deserticola* Spegazzini, 1899:209.

Type on *Chloris* sp., Argentina, Salta Prov., near Amblaio, I.1897, C. Spegazzini (type where?).

Sori on the stems (internodes) and rhizomes, blackish-brown, narrow, subepidermal, causing no deformation. *Spores* globose, subpolyhedrally irregular, often compressed, 5-7 µm in diameter, blackish-brown; wall thick, smooth.

On *Chloris* sp.; S. America (Argentina). Known only from the type collection.

No material was available for study. Description taken from the original. I suspect that this is not a smut fungus.

6. *Ustilago elegans* Griffiths, 1902:292.

Type on *Chloris elegans* (= *C. virgata*), USA, Arizona, Cochise, X.1900, D. Griffiths, BPI 160338!; isotypes in Griff., W. Amer. fgi. no. 309, HUV 19955!

Ustilago liebenbergii Zundel, 1943:165. — Type on *Chloris virgata*, South Africa, Transvaal, Wolmaransstad Distr., Vlakfontein, VII.1932, L.C.C. Liebenberg, PREM 26412 & 24412; isotypes BPI 162512, HUV 15374! (syn. nov.).

Sori destroying the inflorescence, and also present within the upper 1-3 leaf sheaths (probably in induced, young inflorescence), more or less hidden by leaves and leaf sheaths, dark brown, powdery. *Spores* globose, subglobose to broadly ellipsoidal, 9.5-13 x 10-14.5 µm, laterally compressed, 7-10.5 µm wide, yellowish- to reddish-brown; wall even, 0.5-1 µm thick, moderately densely verrucose-echinulate, which just affects the spore profile. *Spore germination* (Durán, 1987:231) results in phragmobasidia with 4-5 or more cells producing hyphae.

On *Chloris submutica* H. B. K., *C. virgata* Sw. (*C. elegans* H. B. K.); Africa (South Africa), E. Asia (China), N. America (Mexico, USA).

According to Piepenbring (2003:165) probably also on *Chloris beyrichiana* Kunth (*C. radiata* Sw.) in Bolivia but the sori are forming pustules on the leaves.

No difference in the sorus and spore morphology of *Ustilago liebenbergii* and *U. elegans* could be found, hence they are considered to be synonyms.

7. *Ustilago induta* Sydow, 1939:199.

Type on *Chloris breviseta*, Sierra Leone, Njala, 12.XI.1930, F.C. Deighton 311, IMI 43068!, BPI 162017!

Sorosporium chloridicola Beeli, 1922:7 (not *Ustilago chloridicola* Henn., 1898). — Type on *Chloris polydactyla* (L.) Sw. (= misnamed *Chloris virgata*, det. J. Bosser, BR), Congo, Kinshasa, 1.VI.1916, H. Vanderyst, BR 1328!; isotype BPI 195122! (syn. nov.).

Sori in some ovaries of an inflorescence, ovoid, c. 1.5 x 2 mm, hardly evident and only slightly protruding, first covered by a leather-brown peridium enclosing a dark olivaceous-brown, powdery mass of spores. *Spores* globose, subglobose to ellipsoidal, 7.5-11 x 8-12 µm, yellowish-brown; wall even, c. 1 µm thick, sparsely verrucose, spore profile smooth to finely wavy.

On *Chloris breviseta* Benth., *C. virgata* Sw.; C. & W. Africa (Congo, Sierra Leone).

Spore balls in *Sorosporium chloridicola*, reported by Beeli (1922:7), are the result of insect work!

8. *Ustilago ulei* Hennings, 1895b:88.

Type on *Chloris* sp., Brazil, Goyaz Prov., Bom Frio, VII.1892, E. Ule 1955, HBG!; isotypes BPI 168674, BPI 168677.

Sori forming striae on the leaves, 0.5-1 x 1-30 mm, grey, covered by the epidermis which ruptures longitudinally and the dark brown, powdery mass of spores is scattered leaving behind the perforated or shredded leaves. *Spores* globose, subglobose, ellipsoidal or slightly irregular, 8-10.5 x 8-11 µm, laterally compressed, 5.5-8 µm wide, yellowish-brown; wall even, 0.5-1 µm thick, finely, moderately densely punctate-verruculose, spore profile smooth. *Spore germination* (Durán, 1987:256) results in hyphae or in 2-3-celled basidia producing basidiospores.

On *Chloris submutica* H. B. K., *C. virgata* Sw., *Chloris* sp.; N. & S. America (Mexico, Argentina, Brazil).

9. *Ustilago valentula* Sydow, 1937:24.

Type on *Chloris acicularis* (= *Enteropogon acicularis*), Australia, New South Wales, between Warren and Collie, I.1936, L.R. Fraser 194, MEL; isotypes BPI 169382, BRIP 8041, HUV 17962!, IMI 44467.

Ustilago enteropogonis Vánky, 2002a:378. — Type on *Enteropogon ramosus*, Australia, New South Wales, Bedgerebong, 'Tresta', 26.III.1982, J. Bollinger & I. McGowen, DAR 41433; isotype HUV 19540! (syn. by Vánky, 2005a:264).

Sori destroying the inflorescence, 4-8 x 15-20 mm, initially covered by a thin, greyish peridium which flakes away disclosing the dark brown, powdery mass of spores. *Spores* subglobose, ellipsoidal to slightly irregular, 9-13 x 10-14.5 µm, yellowish-brown; wall even, c. 1 µm thick, densely, minutely verruculose-echinulate, spore profile finely serrulate.

On *Chloris bournei* Rang. & Tadul., *C. pycnothrix* Trin., *Enteropogon acicularis* (Lindl.) Lazarides (*Chloris acicularis* Lindl.), *E. ramosus* B.K. Simon; NE Africa (Ethiopia), Asia, Australia.

Excluded species or not on *Chloris*

Tolyposporium chloridis is a hyphomycete

Tolyposporium chloridis Henn., in Engler, 1895c:49. — *Tolyposporidium chloridis* (Henn.) Thirumalachar & Neergaard, 1977(1978):180. — Type on *Chloris abyssinica* Hochst., Africa, "Steppe am Papyrussumpf", coll. Volkens 456.

According to Zundel, 1938:319, this is a hyphomycete.

Sphacelotheca chloridis is *Sporisorium andropogonis*

Sphacelotheca chloridis Mundkur, 1944:50. — Type on "*Chloris barbata* Sw." = misnamed *Bothriochloa pertusa* (L.) A. Camus (teste K. Vánky), India, Mysore, Bangalore, Karnataka, 20.VIII.1942, M.J. Thirumalachar, HCIO 10000; isotypes BPI 195098, HUV 17273. It is *Sporisorium andropogonis*. (syn. by Vánky, 2004b:226).

On the label of the type specimen, the original name of *Sphacelotheca bothriochloae* on *Bothriochloa pertusa* was crossed out and changed into *Sphacelotheca chloridis* on *Chloris barbata* Sw. However, study of some remnants of an infected inflorescence in the type collection revealed that the host is *Bothriochloa pertusa*, with a deep, circular pit on the lower glume of the sessile spikelet.

Key to the smut fungi of *Chloris*

(U. = Ustilago)

1. Sori on the stems or leaves forming striae 2
– Sori in the ovaries, flowers or inflorescence 4
2. Spores embedded in the host tissue, agglutinated ..... ***"Entyloma" chloridis***
– Spores not so 3
3. Spores 5-7 µm long, smooth ..... ***U. deserticola***
– Spores 8-11 µm long, punctate-verruculose ..... ***U. ulei***
4. Sori in the ovaries 5
– Sori in the inflorescence 7
5. Spores 12.5-15(-18) µm long, with conical spines ..... ***"Tilletia" chloridicola***
– Spores smaller, sparsely verruculose 6
6. Spores 8-12 µm long ..... ***U. induta***
– Spores (10-)11-13.5(-15) µm long ..... ***U. chloridis***
7. Spores 6.5-11(-12) µm long, irregularly verrucose ..... ***U. chloridicola***
– Spores 10-14.5 µm long, regularly ornamented 8
8. Spores echinulate, spore profile serrulate ..... ***U. valentula***
– Spores finely verruculose-echinulate, spore profile smooth or nearly so ***U. elegans***

The smut fungi of *Jardinea, Phacelurus* and *Rhytachne* (*Poaceae*)

Jardinea Steud. (1 sp.), *Phacelurus* Grieseb. (9 spp.) and *Rhytachne* Desv. (12 spp.) belong to the subfam. *Andropogoneae*, tribe *Rottboelliinae*. Actually, *Jardinea* is considered a synonym of *Phacelurus* (Clayton and Renvoize, 1986:363). On members of these genera five smut fungi are known. A sixth one is described below.

1. *Franzpetrakia microstegii* Thirum. & Pavgi, in Pavgi & Thirumalachar, 1957:2.

Type on *Microstegium* sp., India, Uttar Pradesh, Mussoorie Hills, IX.1954, M.S. Pavgi (type where?).

Sori destroying the whole inflorescence. The spores are mixed with long, slender, fungal filaments.

For a detailed description and illustration see Guo, Vánky & Mordue, 1990:58-62, or Vánky, 2002b:66-67.

On *Microstegium* sp. and *Phacelurus latifolius* (Steud.) Ohwi var. *monostachyus* Keng; S & SE Asia (India, China).

2. *Sporisorium rhytachnes* (Syd.) Vánky, 2000:171.

Sphacelotheca rhytachnes Sydow, 1939:202. — Type on *Rhytachne triaristata*, Sierra Leone, Mama Beach near Kent 3.XII.1936, E.C. Deighton 1109, IMI 43050!; isotypes BPI 113630, BPI 95072, HUV 17496.

The sori destroying the whole racemes, columella present. The spores are finely to prominently verruculose-echinulate.

For a detailed description see Vánky, 2000:171.

On *Rhytachne triaristata* Stapf; W Africa (Sierra Leone). Known only from the type locality.

3. *Sporisorium rhytachnes-rottboellioidis* Vánky, 2003:54.

Type on *Rhytachne rottboellioides*, Uganda, Masaka Distr., 13 km E Masaka, alt. 1140 m, 17.II.2002, C., T. & K. Vánky, HUV 19994; isotype in MHU, BPI, IMI, K.

Sori in all ovaries of an inflorescence, columella present. Spores finely, densely punctate.

For a detailed description and illustration see Vánky, 2003:54-55 + fig. 41.

On *Rhytachne rottboellioides* Stapf; Africa (Uganda). Known only from the type locality.

4. *Tolyposporella rhytachnes* Viennot-Bourgin, 1958:167.

Type on *Rhytachne minor*, Guinea (French), near Kindia, Foulaya, I.1957, G. Viennot-Bourgin, PC; isotype in HUV 15804!

Sori on the adaxial side of the rolled, tube-like leaves. Spores 9-25 µm long, wall multilayered, 2-8 µm thick, smooth. For a detailed description see Vánky, 2000:172.

On *Rhytachne minor* Pilger; W Africa. Known only from the type locality.

Amongst specimens obtained in exchange from the late Prof. Ch. Zambettakis, there is an unnamed smut fungus collected in Gabon, on *Phacelurus gabonensis*, which represents a new species:

5. *Ustilago gabonensis* Vánky, **sp. nov.**

Typus in matrice Phacelurus gabonensis *(Steud.) Clayton, Gabon, Moyen Ogooué, oppid. Ndjolé, c. 100 km SW Libreville, 0°07' S, 10°45' E, 10.I.1972, leg. M.G. Gilles, HUV 20999!; isotypus in BPI.*

Sori *in spiculis nonnullis sessilibus inflorescentiae eiusdem, elongate cylindrici, torti, 1-2 x 10-30 mm, plerumque 3 in eadem spicula, peridio pallide brunneo cooperti, quo longitudinaliter in locis nonnullis rupto massam sporarum mediocriter atrobrunneam, pulverescentem ostendentes. Columella nulla.* Sporae *singulae, globosae, subglobosae, ovoideae, ellipsoidales, raro elongatae vel parum irregulares, 8-11 x 8-13(-14) µm, pallide flavidobrunneae; pariete aequali, 0,5-0,8 µm crasso, verrucis vel spinis paulo sparse distributis, latis, humilibus, imago obliqua sporarum undulata vel leniter, sparse serrulata. Cellulae setriles absentes.*

Sori (Fig. 19) in some sessile spikelets of an inflorescence, long cylindrical, twisted, 1-2 x 10-30 mm, usually three in each spikelet, covered by a pale brown peridium which splits longitudinally in several places disclosing the medium dark brown, dusty mass of spores. No columella. *Spores* (Figs. 22, 23) single, globose, subglobose, ovoid, ellipsoidal, rarely elongate or slightly irregular, 8-11 x 8-13(-14) µm, pale yellowish-brown; wall even, 0.5-0.8 µm thick, provided with rather sparsely situated, wide, low warts or spines, spore profile wavy or finely, distantly serrulate. *Sterile cells* absent.

On *Poaceae: Phacelurus gabonensis* (Steud.) Clayton (*Jardinea gabonensis* Steud.; *Rhytachne gabonensis* (Steud.) Hack.); Africa (Gabon). Known only from the type collection.

At first sight, this smut appears to be a *Sporisorium*. However, because of the lack of columella/ae, spore balls and sterile cells, it is placed in the genus *Ustilago*.

6. *Ustilago jardineae* (Zambett.) Vánky, **comb. nov.**

Basionym: *Cintractia jardineae* Zambettakis, Bull. Soc. Mycol. France 95:408, 1979(1980). — Type on *Jardinea gabonensis* (= *Phacelurus gabonensis*), Congo, "Mission Congo Belge". No further data. Type BR 258 (lost).

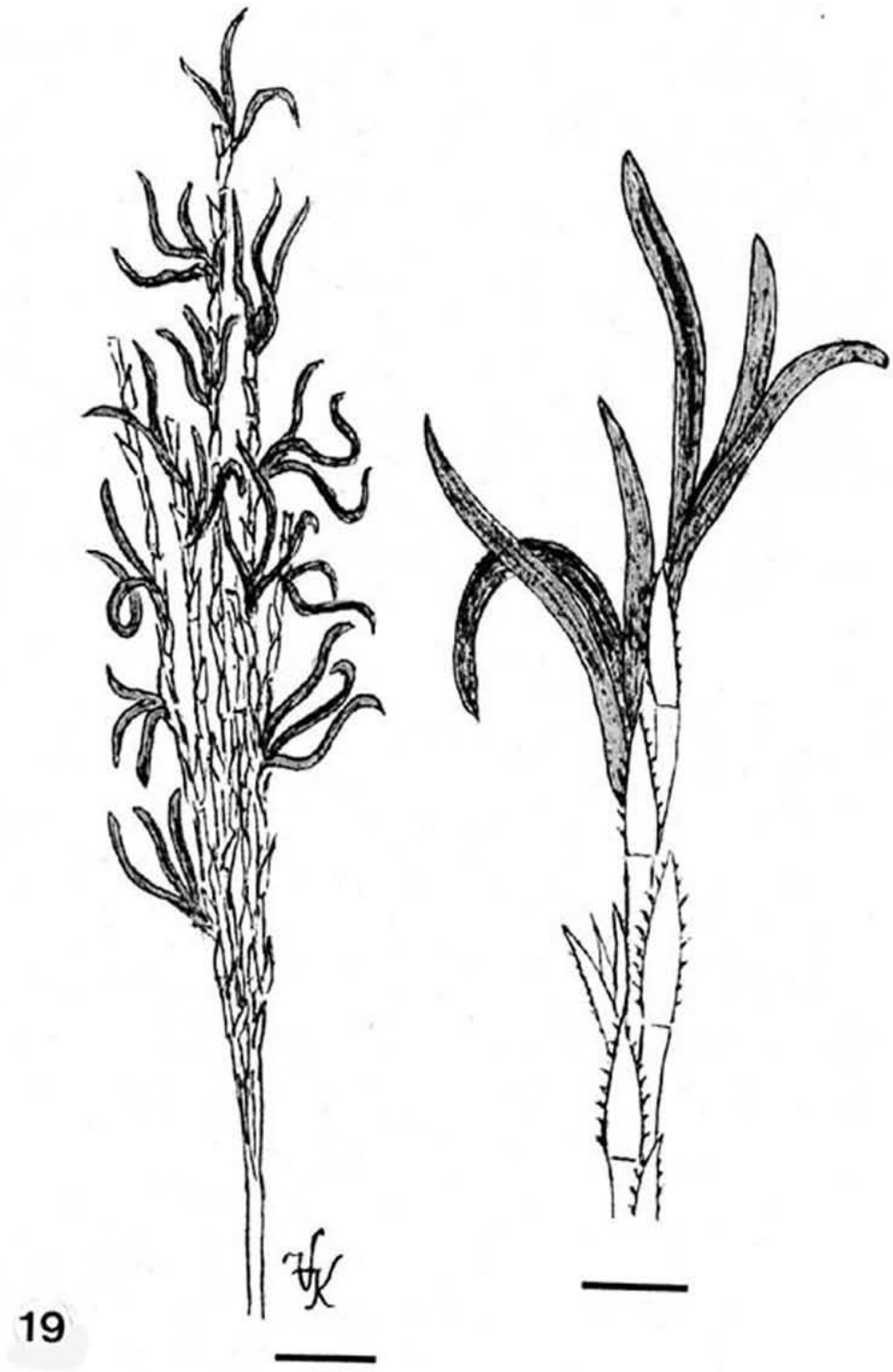


Fig. 19. Sori of *Ustilago gabonensis* in some sessile spikelets of *Phacelurus gabonensis* (type). Habit, and enlarged some infected and healthy spikelets.

Bars = 1 cm for habit, and 3 mm for the detail drawing.

Sori in ovaries, small, completely hidden by the glumes, ovoid or elongated, brown, agglutinated. Spore mass powdery. *Spores* globose, blackish-brown, 15-18 µm in diameter; wall 1.5-2 µm thick, granular or punctate.

Phacelurus gabonensis (Steud.) Clayton (*Jardinea gabonensis* Steud.; *Rhytachne gabonensis* (Steud.) Hack.); Africa (Congo). Known only from the type description.

No specimen was seen. The type (BR 258) is lost. It is not in BR or PC. Description based on the original and on fig. 1. in Zambettakis, 1979(1980):395. The short and incomplete original description does not allow a sure generic placement. It is certainly not a *Cintractia*, which is restricted to host plants in the *Cyperaceae*. Because no peridium, columella/ae, spore balls or sterile cells were mentioned by Zambettakis, it is recombined into the genus *Ustilago*.

Key to the smut fungi of *Jardinea, Phacelurus* and *Rhytachne*

1. Sori on the leaves. Spore wall 2-8 µm thick ..... ***Tolyposporella rhytachnes***
– Sori elsewhere. Spore wall thinner 2
2. Spores intermixed with long, slender, fungal filaments. ***Franzpetrakia microstegii***
– Spores not intermixed with fungal filaments. 3
3. Sori destroying the whole racemes ..... ***Sporisorium rhytachnes***
– Sori not destroying the whole racemes 4
4. Spores 15-18 µm long ..... ***Ustilago jardineae***
– Spores 7.5-13(-14) µm long 5
5. Sori in all ovaries. Columella present ..... ***Sporisorium rhytachnes-rottboellioidis***
– Sori in some spikelets. Columella absent ..... ***Ustilago gabonensis***

Two synonyms

Pericladium flavesci is considered to be *P. grewiae*

Prasad & Tyagi (1961:500) described *Pericladium flavesci*, based on minor differences in sorus and spore germination characters compared with the common and polyphagous *P. grewiae*. According to the original description, *P flavesci* has somewhat larger and sparsely distributed sori, somewhat lower optimal temperature of spore germination, longer basidia and more globose basidiospores than *P. grewiae*. In my opinion, these differences do not justify the recognition of a separate species. Consequently, I consider *P. flavesci* a synonym of *P. grewiae*.

Pericladium grewiae Passerini, 1875:185.

Ustilago grewiae (Pass.) Hennings, 1900:(75). — Type on *Grewia* cf. *mollis*, Eritrea, near Sciotel, Zedamba, VI.1870, O. Beccari.

Pericladium flavesci Prasad & Tyagi, 1961:500. — Type on *Grewia flavescens*, India, Rajasthan, Bagdara, Udaipur, 6.XI.1958, J. Abraham., K.L. Kothari & R.N.S. Tyagi, HCIO 27004; isotype HUV 15507! (syn. nov.).

For description and illustration, including spore germination, see Vánky, 2002b:122-123.

On Tiliaceae: *Grewia asiatica* L., *G. breviflora* Benth., *G. carpinifolia* Juss., *G. columnaris* Sm., *G. flavescens* Juss., *G. microcarpa* Schum., *G. mollis* Juss., *G. orbiculata* Rottl., *G. retusifolia* Kurz, *G. venusta* Fresen, *G. villosa* Willd., *Grewia* sp.; Africa, S. Asia, Australia.

Sphacelotheca rhaphidis is *Sporisorium tumefaciens*

Sphacelotheca rhaphidis was described on *Rhaphis aciculatus*, which is a synonym of *Chrysopogon aciculatus*. On *C. aciculatus* two smut fungi are known: *Sporisorium andropogonis-aciculati* (Petch) Vánky, and *S. tumefaciens*. A comparison of the types revealed that *Sphacelotheca rhaphidis* is a synonym of *Sporisorium tumefaciens*, on *Chrysopogon pallidus*.

Sporisorium tumefaciens (McAlpine) Vánky, 1983:328.

Lectotype (designated by Vánky, 2005b:182) on "*Stipa pubescens* R. Br." = misnamed *Chrysopogon* sp. (teste S.T. Blake, in Herbert & Langdon, 1941:2, confirmed), Australia, Queensland, 40 miles S of Cloncurry, 10.V.1909, G.H. Robinson, VPRI!

Sphacelotheca rhaphidis L. Ling, 1949:128. — Type on *Rhaphis aciculatus* Retz. (= *Chrysopogon aciculatus* (Retz.) Trin.), Philippine Islands, Luzon, Manila, Wack-Wack Country Club, 10.IX.1945, C.T. Rogerson 662, BPI 113317!; isotype BPI 195059! (syn. nov.).

For its description see Vánky, 2005b:182.

On ***Gramineae:*** *Chrysopogon aciculatus* (Retz.) Trin., *C. caeruleus* (Steud.) Watson, *C. fallax* S.T. Blake, *C. latifolius* S.T. Blake, *C. pallidus* (R. Br.) Trin. ex Steud., *Chrysopogon* sp.; S. Asia, Philippines, Australia.

Miscellaneous new species

A NEW *USTILAGO* ON *PENTASCHISTIS* (*POACEAE*)

Ustilago pentaschistidis Vánky, **sp. nov.**

Typus in matrice Pentaschistis pallida *(Thunb.) Linder, South Africa, Western Cape Prov., Cederberg Mts., Driehoek, 32°26'21" S, 19°11'13" E, alt. 915 m, 12.X.2004, leg. R. Berndt [within the "BIOTA Southern Africa Project (SO3)"], holotypus in PREM; isotypi in HUV 20880 et in ZA ZT.*

Ustilago pentaschistidis *distincta a specie* Ustilago dregeana *L.-R. & C. Tulasne (Ann. Sci. Nat. Bot., Sér. 3, 7:83, 1847, typus in matrice* Danthonia *sp.) et a specie* Ustilago dregeanoides *K. & C. Vánky (in Vánky, Mycotaxon 65:177, 1997b, typus in matrice* Merxmuellera stricta*) imprimis teliosporis minoribus (4-5,5 µm longis), minus prominenter (leniter, humiliter tuberculatis) ornatis. Distincta etiam a specie* Ustilago sladenii *Pole-Evans (Ann. Bolus Herb. 1:115, 1915, typus in matrice* Ehrharta *sp.) imprimis teliosporis magis evidenter ornatis et plantis eius nutrientibus ad subfamiliam alteram pertinentibus.*

Sori (Fig. 20) in the whole inflorescence as naked, dark brown, powdery spore masses on the surface of short inflorescence branches, 4-5 x 20-30 mm, partly enclosed by the uppermost leaf sheath. *Spores* (Figs. 24, 25) globose, subglobose to broadly ellipsoidal, 4-5 x 4-5.5 µm, olivaceous-brown; wall c. 0.5 µm thick, slightly uneven, with two, somewhat thinner polar areas, surface finely low-tuberculate, spore profile finely to evidently wavy, more evidently at the polar areas.

On *Poaceae: Pentaschistis pallida* (Thunb.) Linder, South Africa. Known only from the type collection.

Ustilago pentaschistidis differs from *U. dregeana* and *U. dregeanoides* especially by smaller, less prominently ornamented spores. It differs from *U. sladenii*, on *Ehrharta*, especially by larger, more evidently ornamented spores and also by host plants belonging to different subfamilies.

Fig. 20. Sori of *Ustilago pentaschistidis* in the inflorescence of *Pentaschistis pallida* (type). Habit. To the left a healthy inflorscence. Bar = 1 cm.

Fig. 21. A sorus of *Ustilago penniseti-purpurei* in the ovary of *Pennisetum purpureum* (type). Bar = 2 mm.

A NEW *USTILAGO* ON *PENNISETUM* (*POACEAE*)

I revised the smut fungi of *Pennisetum* (Vánky, 2003:8-20) and recognised thirteen species. I also revised the smut fungi of other genera of the tribe *Cenchrinae*, such as *Anthephora*, *Cenchrus* and *Pseudochaetochloa* (Vánky, 2002a:391-398) and recognised eight species. Scrutinising herbarium specimens, obtained from the late Prof. Zambettakis, I found an unnamed smut fungus on *Pennisetum* "*benthamii*", which is distinct from all known smut fungi on *Cenchrinae*. It is described as:

Ustilago penniseti-purpurei Vánky, **sp. nov.**

Typus in matrice Pennisetum purpureum *Schumach., Congo, c. 100 km S urbe Kinshasa (Leopoldville), oppid. Kisantu, 5°08' S, 15°09' E, 8.V.1913, H. Vanderyst 376, BR; isotypus in Herbario Ustil. Vánky, HUV 21039!*

Sori *in ovariis nonnullis inflorescentiae eiusdem, longe ellipsoidales, cum apice uno acuto, cca. 1 x 2-4 mm, inter involucris floralibus prominentes, primo pericarpio sicut peridio tenui, brunneo cooperti, quo mature irregulariter rupto massam sporarum nigrescentibrunneam, semiagglutinatam usque pulveream ostendentes.* Sporae *globosae, subglobosae, ellipsoidales, saepe reniformes, 5-9 x 6,5-13,5 µm, flavidobrunneae; pariete inaequali, plerumque 0,5 µm crasso, sed in medio lateris concavi sporarum reniformium multo tenuiore, subtiliter moderate dense verruculoso-echinulato; imago obliqua sporae levis, subtiliter undulata vel ad partes tenues subtiliter serrulata.*

Sori (Fig. 21) in some ovaries of an inflorescence, long ellipsoidal with an acute tip, c. 1 x 2-4 mm, showing between the spreading floral envelopes, at first covered by the pericarp as a thin, brown peridium which ruptures irregularly at maturity disclosing the blackish-brown, semiagglutinated to powdery mass of spores. *Spores* (Figs. 26, 27) globose, subglobose, ellipsoidal, often kidney-shaped, 5-9 x 6.5-13.5 µm, yellowish-brown; wall uneven, mostly 0.5 µm thick but on the middle of the concave side of kidney-shaped spores much thinner, finely, moderately densely verruculose-echinulate, spore profile smooth, finely wavy or, on the thin-walled parts, finely serrulate.

On *Poaceae: Pennisetum purpureum* Schumach. (*P. benthamii* Steud.); C. Africa (Congo). Known only from the type collection.

A NEW *DOASSANSIOPSIS* ON *NYMPHAEA* (*NYMPHAEACEAE*)

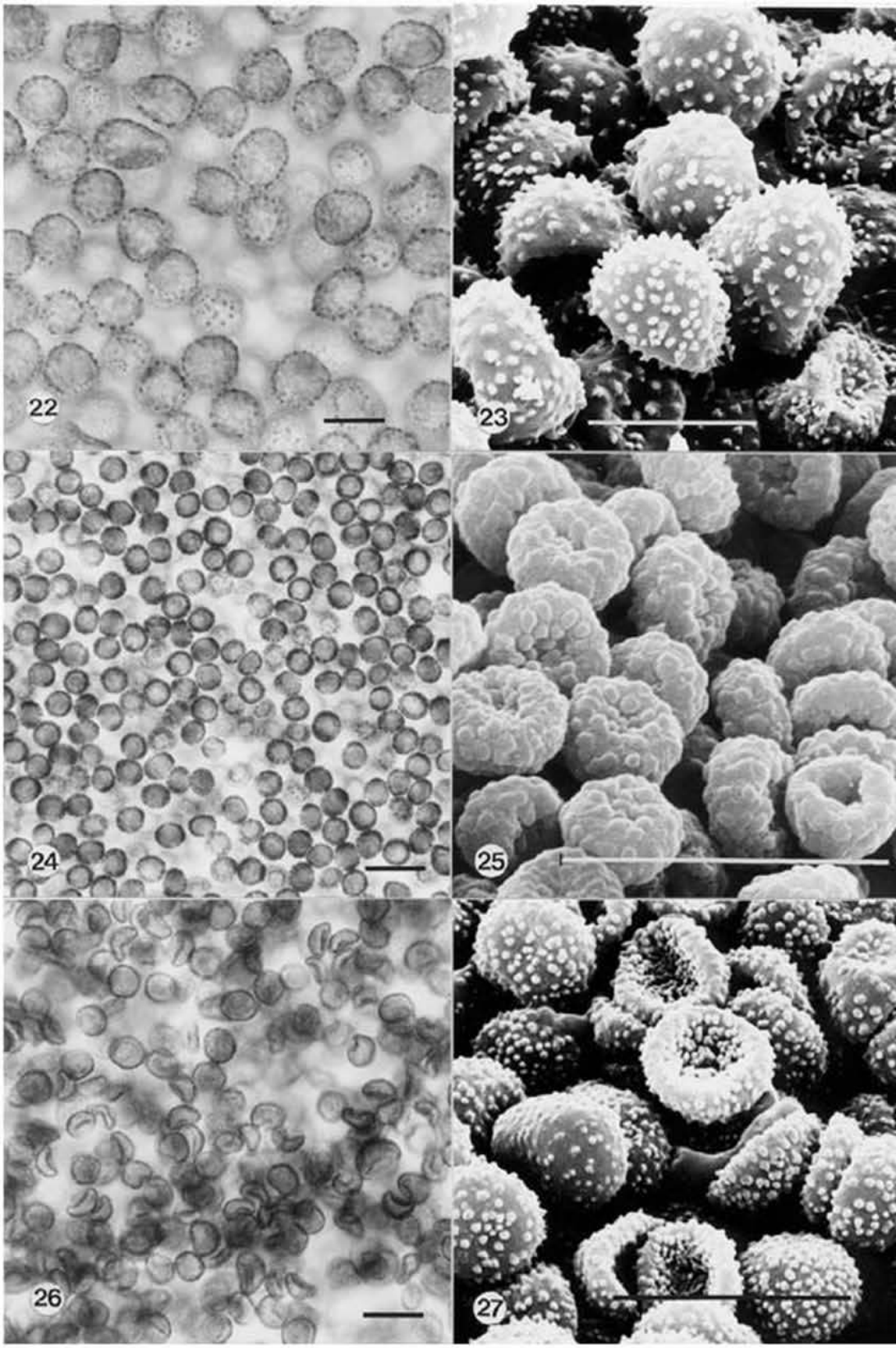
On the 50 species of *Nymphaea* of the world, three smut fungi are known: 1. ***Rhamphospora nymphaeae*** D.D. Cunn. (type on *N. stellata* Willd., India), possessing solitary, lemon-shaped, hyaline spores embedded in the leaf tissue; 2. ***Doassansiopsis nymphaeae*** (type on *N. stellata*, India), forming conspicuous galls on the petioles, with spore balls embedded in the host tissue; and 3. ***D. ticonis*** (type on *N. blanda* G.F.W. Meyer, Costa Rica), producing flat leaf spots, containing spore balls.

A smut fungus was collected in Ethiopia on the leaves of *Nymphaea nouchali*, producing thickened, moderately hypertrophied, wart-like or typically cup-shaped leaf spots, containing persistent spore balls. These show the typical structure of a *Doassansiopsis*, i.e., composed of a central mass of parenchymatous sterile cells surrounded by a layer of oblong, usually radially arranged, firmly adhering spores. The whole is covered by a thin cortical layer of more or less flattened, relatively small, empty fungal cells (comp. Vánky, 2002b:9, fig. 3). It is described as:

Figs. 22, 23. Spores of *Ustilago gabonensis* on *Phacelurus gabonensis*, in LM and in SEM (type).

Figs. 24, 25. Spores of *Ustilago pentaschistidis* on *Pentaschistis pallida*, in LM and in SEM (type).

Figs. 26, 27. Spores of *Ustilago penniseti-purpurei* on *Pennisetum purpureum*, in LM and in SEM (type). Bars = 10 µm.


22
23
24
25
26
27

Doassansiopsis tomasii Vánky, **sp. nov.**

Typus in matrice Nymphaea nouchali *Burm. f., Ethiopia, Gojam Reg., 17 km S urbe Bahar Dahr, haud procul Blue Nile Falls, 11°30'48.7" N, 37°29'31.6" E, alt. 1712 m.s.m., 22.X.2004, leg. T. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 20840!; isotypi in BPI 863739; BRIP, S et in Vánky, Ust. exs. no. 1259.*

Dassansiopsis tomasii ab utraque specie cognita generis Doassansiopsis matricis Nymphaeae distincta: D. ticonis M. Piepenbring (Mycol. Res. 99:783, 1995) et D. nymphaeae (Syd. & P. Syd.) Thirumalachar (Mycologia 39:604, 1947), basisnomine Doassansia nymphaeae H. & P. Sydow (Ann. Mycol. 10:406, 1912). A prima specie praecipue per maculas foliorum hypertrophicas productas et glomerulos sporarum maiores irregularesque, a secunda soris laminae foliorum non petiolorum et magnitudine glomerulorum sporarum distincta (cf. descriptionem accuratiorem et clavem determinationis in sequentibus).

Sori (Fig. 28) on the leaves forming rounded, thickened, slightly hypertrophied, wart-like or cup-shaped leaf spots, evident especially on fresh material, on the abaxial side, from 1-2 mm to 5-6 mm in diameter, when dried wart-like. The spots are initially yellow, later brown, with numerous, tightly packed, pale brown (beige) spore balls embedded in the host tissue. In old sori, the necrotic host tissue is decomposed, the spore balls liberated and the leaves appear perforated. *Spore balls* varying in shape and size, globose, subglobose, ovoid, ellipsoidal, oblong or irregular, with one or several flattened sides, 130-310 x 140-400 µm, dark brown, subopaque, composed of a central mass of parenchymatous, sterile fungal cells surrounded by a layer of spores and an external, thin cortex of sterile cells. *Spores* (Fig. 31) variable in shape and size, mostly radially elongated, subpolyhedral, sometimes subcuneiform with narrowing proximal or distal part, rarely ellipsoidal, (6-)8-10.5 x (11-)13.5-21.5 µm, pale yellowish-brown, arranged in one layer, rarely two spores form the layer; wall thin, c. 0.3-0.4 µm, smooth, content homogenous. *Central parenchymatous sterile cells* (Fig. 31) extremely variable in shape and size, irregularly polyhedral with flattened contact sides, rarely ovoid or ellipsoidal, 4-21.5 x 7-32 µm, hyaline, empty; wall thin, 0.3-0.4 µm, smooth. *Cortical sterile cells* (Fig. 31) variable in form and size, irregular, radially more or less flattened, tangentially elongated, with flattened contact sides and flat, convex or hemiglobose free surface, 4-8 x 5-12 µm, subhyaline, wall 0.3-0.4 µm thick, smooth.

On *Nymphaeaceae: Nymphaea nouchali* Burm. f. (*N. caerulea* Savigny; *N. stellata* Willd.); NE Africa. Known only from the type collection in Ethiopia, not far from the Blue Nile Falls.

Piepenbring (1995:784) describing the new species *D. ticonis*, compared it with the type of *D. nymphaeae* and wrote: "The corresponding measurements for *D. ticonis* would not provide sufficient evidence to define a new species because the size of spores and its cells tends to be rather variable in species of *Doassansiopsis*. However, the characteristics of the infected part of the host and the lack of gall growth are considered distinct enough to treat the Costa Rican collection as a new species". This statement refers also to the Ethiopian collection, a statement to which maybe geographical distribution, host plant spectrum, and some morphological differences of the spore balls and their components of the three *Doassansiopsis* species of *Nymphaea* could also be added (comp. the key below).

Etymology: This fungus is named after my son, Tomas Vánky (42), physician, but an ardent and the best collector of smut fungi in the world, who found and collected so many known and unknown smuts (see HUV no. 1-21120 and the labels of Vánky, Ust. exs. no. 1-1300). He also found this new species.

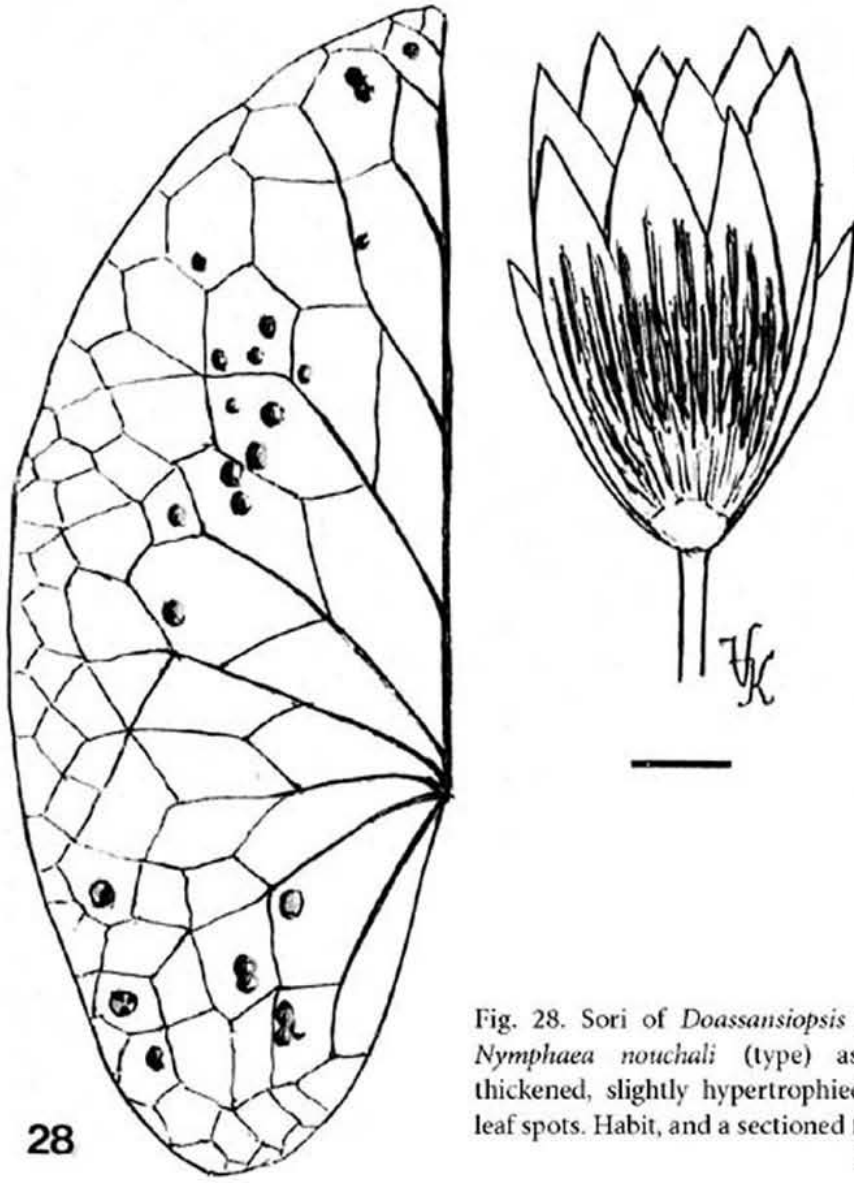


Fig. 28. Sori of *Doassansiopsis tomasii* on *Nymphaea nouchali* (type) as rounded, thickened, slightly hypertrophied, wart-like leaf spots. Habit, and a sectioned flower.
Bar = 1 cm.

Key to the smut fungi of *Nymphaeaceae*

1. On *Euryale*. Spores 16-30 µm long ..... ***Doassansiopsis euryalis***
– On *Nymphaea*. Spores shorter 2
2. Spores solitary, lemon-shaped ..... ***Rhamphospora nymphaeae***
– Spores in spore balls, not lemon-shaped 3
3. Sori as flat leaf spots, not producing hypertrophy. Spore balls globose or subglobose, 120-250 µm long. Spores 12-16 µm long. ..... ***Doassansiopsis ticonis***
– Sori producing hypertrophy. Spore balls irregular, larger. Spores longer 4
4. Sori as conspicuous swellings on the petioles. Spore balls 150-285 µm long. Spores 17-25 µm long ..... ***Doassansiopsis nymphaeae***
– Sori as thickened, wart-like or cup-shaped leaf spots. Spore balls 140-400 µm long. Spores 11-21.5 µm long ..... ***Doassansiopsis tomasii***

A NEW *USTANCIOSPORIUM* ON *RHYNCHOSPORA* (*CYPERACEAE*)

Of the 25 known species of *Ustanciosporium*, 17 are found on *Rhynchospora*. A distinct species was collected recently in the USA:

Ustanciosporium virginianum Vánky, **sp. nov.**

Typus in matrice Rhynchospora capitellata *(Michx.) Vahl (det. T.F. Wieboldt, VPI), USA, Virginia, Giles Co., Appalachian Mts., Stony Creek Valley, via no. 635, locus dictus "Interior", 37°24'53.0" N, 80°34'51.2" W, alt. 753 m.s.m, 25.VIII.2004, leg. C. et K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 20782; isotypi in Vánky, Ust. exs. no. 1251.*

Sori *in omnibus floribus inflorescentiae aliquantum congestae, massa nigra, conglutinata usque granuloso-pulverea glomerulorum sporarum atque sporarum completi, omnio glumis maxime externis occulti. Peridium et stroma sterile absentes.* Glomeruli sporarum *globosi, ovoidei, ellipsoidales, elongati vel irregulares, 25-50 x 25-80 µm, atro-rufobrunnei usque opaci, e paucis vel pluries decem sporis, pressu facile separabilibus compositi.* Sporae *parum complanatae, in visu laterali ellipticae, 7-9,5 µm latae, sine appendicibus hyalinis, in visu plano subcirculares, ovatae, ellipticae usque plerumque irregulares vel angulares, 9-13,5 x 9,5-15(-16) µm, rufobrunneae; pariete inaequali, 0,5-1(-1,5) µm crasso, leniter, dense foveolato; imago obliqua sporae levis.*

Sori (Fig. 29) in all spikelets of a somewhat congested inflorescence, completely hidden by the outermost glumes, filled with a black, granular-powdery mass of spore balls and spores. Peridium and sterile stroma lacking. *Spore balls* (Figs. 32, 34) globose, ovoid, ellipsoidal, elongated or irregular, 25-50 x 25-80 µm, dark reddish-brown to opaque, composed of a few to tens of spores which separate easily by pressure. *Spores* (Figs. 33, 34) laterally slightly compressed, in side view ellipsoidal, 7-9.5 µm, hyaline appendage lacking, in face view subcircular, ovoid, elliptic to usually irregular and angular, 9-13.5 x 9.5-15(-16) µm, reddish-brown; wall uneven, 0.5-1(-1.5) µm thick, finely, densely foveolate, spore profile smooth.

On *Cyperaceae: Rhynchospora capitellata*; N. America (USA). Known only from the type collection.

Ustanciosporium virginianum belongs to a group of smut fungi with many unsolved problems. The high frequency of "mixed" collections of diseased *Rhynchospora*, in which several „species" or „varieties" of *Ustanciosporium* are present concomitantly is surprising. The reason for this phenomenon is not clear. It caused numerous taxonomic and nomenclatorial problems and contradictions in the literature (comp. Ling, 1950, Nannfeldt, in Lindeberg, 1959:156).

The combined study of morphological and molecular characters of the genus *Cintractia* by Piepenbring, Begerow & Oberwinkler (1999), and Piepenbring (2000), resulted in the recognition of several new genera and also in a better knowledge and delimitation of numerous species. Similar investigations should be continued with as many as possible types and other specimens within the *Ustanciosporium montagnei* complex. These often differ only very little morphologically from each other. Do they represent several „small" species on the way to speciation, or one (or a few) species with high morphological variability due to hybridization, genetic variability, recombinations, segregation? A similar, unexplained case was observed by me (Vánky, 2004a:112) in a specimen of *Farysia ugandana* Zundel (= *F. butleri* (Syd. & P. Syd.) Syd. & P. Syd.) in which a part of one sorus contains much darker, somewhat agglutinated, almost smooth to finely punctate spores instead of the typical olive-brown, dusty, finely, distinctly verruculose spores of the species.

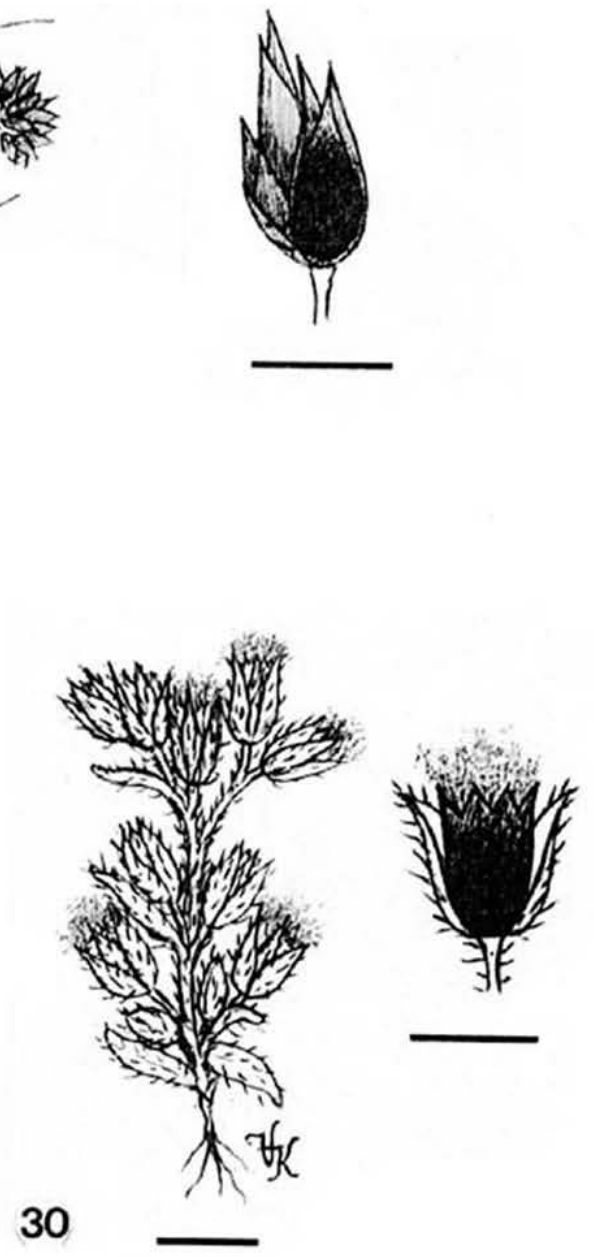


Fig. 29. Sori of *Ustanciosporium virginianum* in all spikelets of *Rhynchospora capitellata* (type). Habit, and enlarged a longitudinally sectioned spiklet. Bars = 1 cm for habit, and 2 mm for the detail drawing.

Fig. 30. Sori of *Microbotryum afromontanum* in the capsules of *Cerastium afromontanum* (type). Habit, and enlarged a longitudinally sectioned capsule. Bars = 5 mm for habit, and 3 mm for the detail drawing.

A NEW *MICROBOTRYUM* ON *CERASTIUM* (*CARYOPYLLACEAE*)

Microbotryum afromontanum Vánky, sp. nov.

Typus in matrice Cerastium afromontanum *T.C.E. Fr. & Weimark, Ethiopia, Gondar Reg., 62 km NE pag. Debart, Simien Mountains, 13°15'29.1" N, 38°12'58.1" E, alt. 4060 m.s.m., 25.X.2004, leg. T. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 20888; isotypi in BPI 863704, S et in Vánky, Ust. exs. no. 1265.*

Sori *ovula destruentes, capsulas massa sporarum purpurascentibrunnea, primo agglutinata serius pulverea implentes. Infectio systemica, capsulas omnes plantae eiusdem inficiens.* Sporae *globosae, subglobosae usque late ellipsoidales, 11-14,5 x 12-16 µm, pallide flavidobrunneae, pallide violaceo tinctae; pariete subtiliter, dense, nonnunquam incomplete reticulato, (5-)6-9 maculis in diametro sporae, muri earum 0,8-1,5 µm alti, acuti, subacuti vel obtusi, 21-30 in circumferentia aequatoriali.*

Sori (Fig. 30) destroying the ovules filling the capsules with a purplish-brown, at first agglutinated, later powdery spore mass. Infection systemic, all capsules of a plant being infected. *Spores* (Figs. 35, 36) globose, subglobose to broadly ellipsoidal, 11-14.5 x 12-16 µm, light yellowish-brown with a pale violet tint; wall finely, densely, sometimes incompletely reticulate, (5-)6-9 meshes per spore diameter, muri 0.8-1.5 µm high, acute, subacute or blunt, 21-30 on the equatorial circumference.

On *Caryophyllaceae* (subfam. *Alsinoideae*): *Cerastium afromontanum* T.C.E. Fr. & Weimark, NE. Africa (Ethiopia). Known only from the type collection.

Microbotryum afromontanum differs from *M. duriaeanum* (Tul. & C. Tul.) Vánky (type on *Cerastium glomeratum* Thuill., Algeria) especially in spores having more and smaller meshes and lower muri. *M. duriaeanum* (on *Cerastium brachypetalum* Pers., Vánky, Ust. exs. no. 112) has 4-7 meshes per spore diameter, muri 1-2.5 µm high, acute or subacute, 16-22 on the equatorial circumference.

A NEW *SPORISORIUM* SPECIES ON *ECHINOCHLOA* (*POACEAE*)

Ingold (1996) demonstrated that five collections of smut fungi, identified as *Ustilago trichophora* on *Echinochloa* spp., originating from HUV, show two different types of spore germination. Since then, I intended to find out the cause of this phenomenon. In my efforts to identify a specimen recently collected in Ethiopia on *E. colona*, I investigated all 63 collections of *U. trichophora* in HUV. The result is that besides *U. trichophora*, there is an apparently very similar but distinct species belonging to the genus *Sporisorium* which is described as:

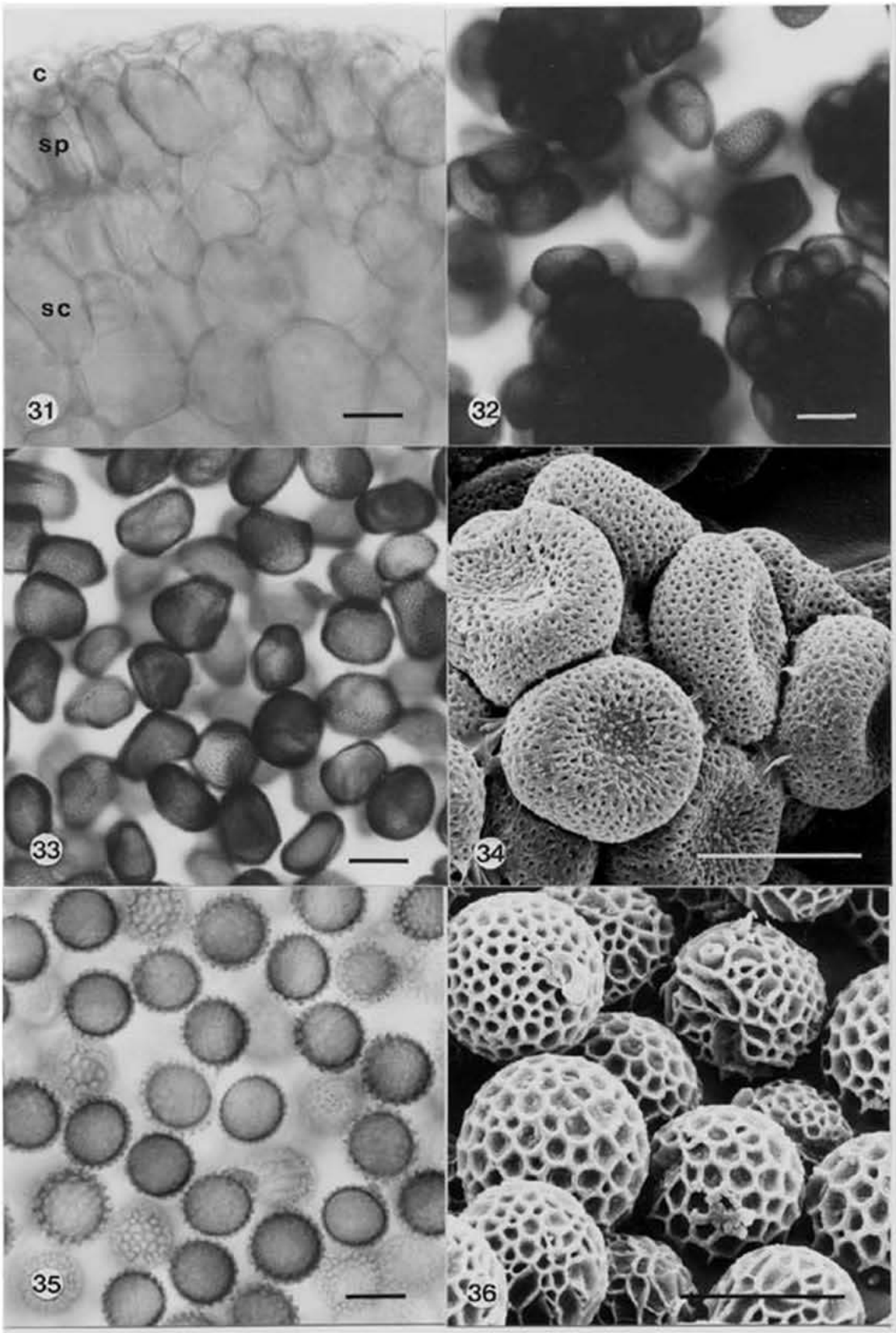
Sporisorium ingoldii Vánky, sp. nov.

Typus in matrice Echinochloa colona *(L.) Link, India, Uttar Pradesh, Varanasi, Banaras Hindu University Campus, 25°20' N, 83°00" E, alt. cca. 100 m.s.m., 4.X.1992, leg. C. & K. Vánky. Holotypus in Herbario Ustil. Vánky, HUV 15764; isotypi in Vánky, Ust. exs. no. 948 (ut* Ustilago trichophora*). Paratypi in matrice E. colona, India, Madhya Pradesh, 21*

Fig. 31. Part of a spore ball with spores (sp), sterile cells (sc) and cortex (c) of *Doassansiopsis tomasii* on *Nymphaea nouchalii*, in LM (type).

Figs. 32, 33, 34. Spore balls and spores of *Ustanciosporium virginianum* on *Rhynchospora capitellata* in LM and in SEM (type).

Figs. 35, 36. Spores of *Microbotryum afromontanum* on *Cerastium afromontanum*, in LM and in SEM (type). Bars = 10 µm.


c
sp
sc
31
32
33
34
35
36

km NW urbe Jabalpur, 15.X.1992, N.D. Sharma, R.S. Singh & K. Vánky, HUV 15587. E. colona, *Ethiopia, Gondar Reg., supra Blue Nile Falls, 11°30'48" N, 37°29'30" E, alt. 1710 m.s.m., 22.X.2004, leg. T. & K. Vánky, HUV 20936; isoparatypi in Vánky, Ust. exs. no. 1270.*

Sporisorium ingoldii *distinctum a specie manifeste simili* Caeoma trichophorum *Link (in Linné's Species Plantarum, Ed. 4, 6(2):3, 1825,* = Ustilago trichophora *(Link) Körn.) imprimis characteribus soralibus et typo germinationis sporarum. In specie* Sporisorium ingoldii *plerumque spiculi omnes eiusdem inflorescentiae affecti, peridium in maturitate cito ruptum, columella brevis, crassa praesens, et saepe etiam catervae cellularum sterilium praesentes. In specie* Ustilago trichophora *spiculae singulae vel catervae earum affectae, peridium satis persistens, columella et cellulae steriles absentes. Praeterea sori speciei* Sporisorium ingoldii *spiculis restricti, sed illi speciei* Ustilago trichophora *saepe etiam in culmis evoluti. Distinctiones in germinatione sporarum a C.T. Ingold (1996:418-420, fig. 1-7) descriptae et illustratae.*

Sori (Fig. 37) usually in all spikelets of an inflorescence, globoid or rarely bilobed, 1-2 mm in diameter, partly hidden by floral envelopes, first covered by a thick, hispid peridium which ruptures irregularly at maturity disclosing the dark brown, semiagglutinated to powdery mass of spores and sterile cells surrounding a thick, short, simple columella with longitudinal furrows. *Spores* (Figs. 40, 41) single when mature, globose, subglobose, ovoid to broadly ellipsoidal, 8-10.5 x 9-12 µm, yellowish-brown; wall even, c. 0.5 µm thick, sparsely low echinulate, spore profile wavy to finely, distantly low serrulate. *Sterile cells* few or lacking, when present in small, irregular groups, single cells globoid, ellipsoidal to irregular, with one or several flattened sides, 4.5-9 x 5.5-12 µm, hyaline; wall c. 0.5 µm thick, smooth. *Spore germination* (Ingold, 1996) results in a long, slender, 4-celled basidium measuring 1.5-2 x 40-60 µm, laterally and terminally giving rise to ovoid or cylindrical basidiospores on short sterigmata.

On *Echinochloa colona* (L.) Link; Africa (Ethiopia, S. Africa, Zimbabwe), S. Asia (India, Pakistan). Probably more common but overlooked or identified as *Ustilago trichophora*.

Sporisorium ingoldii is apparently similar to *Ustilago trichophora*. The most evident difference lies in the sorus characters and in the spore germination. In both species the sori are covered by a hispid peridium. However, in *S. ingoldii* usually all spikelets of an inflorescence are affected (systemic infection?), the peridium ruptures early at maturity, there is a short, stout columella and often also groups of sterile cells, whereas in *U. trichophora* only single spikelets or groups of spikelets are affected, the peridium is rather persistent, a columella is lacking (rarely, irregular host tissue remnants may give the appearance of a columella) and no sterile cells are present. In addition, in *S. ingoldii* the sori are restricted to the spikelets only whereas in *U. trichophora* they can be present also on the stems and leaves. The spores in both species look very similar but in *U. trichophora* they are slightly smaller (6-11 x 7-12 µm). Differences in spore germination are described and illustrated by Ingold (1996:418-420, figs. 1-7). It seems, that *S. ingoldii* is restricted to *Echinochloa colona*, whereas *U. trichophora* infects many *Echinochloa* species, including *E. colona*.

Etymology: This species is dedicated to Professor C. Terence Ingold, at the occasion of his 100th birthday (3 July 2005), a many-sided, most outstanding contemporary mycologist, scientist, teacher and a warm-hearted, inspiring human being and friend. I am happy for the privilege of the over 20 years of correspondence and co-operation with him.

Fig. 37. Sori of *Sporisorium ingoldii* in all spikelets of *Echinochloa colona* (type). Habit, and enlarged some sori in diverse developmental stages. Bars = 1 cm for habit, and 2 mm for the detail drawings.

A new *Ustilago* on *Setaria* (*Poaceae*)

Ustilago trichogena Vánky, sp. nov.

Typus in matrice Setaria setosa *var.* leiantha *Hack., Bolivia, Dept. Tarija, Tarija, 21°33' S, 64°45' W, 6.II.1902, leg. R.E. Fries 271, S; isotypus in HUV 5214!*

Ustilago trichogena *a* Caeoma trichophorum *Link, in Linnés Species Plantarum, Ed. 4, 6(2):3, 1825 [= U. trichophora (Link) Körn., typus in matrice* Panicum colonum *L., Egypt], distincta soris acutis, sporis irregularibus longioribusque, 5,5-8(-9) x 6,5-16 µm, et superficie sporarum levi vel valde leniter, parce granulosa inter verrucas humiles vel spinas in SEM conspicuas.*

Sori (Fig. 38) in some flowers of an inflorescence, transforming the ovaries and filaments into fusiform or ovoid bodies with acute tip, 1-2 x 2-3 mm, covered by a thick, brown, hairy peridium, protruding between the floral envelopes, of which the glumes are intact, the other ones are often more or less hairy. At maturity the peridium ruptures irregularly disclosing the dark brown, semiagglutinate to powdery mass of spores. *Spores* (Figs. 42, 43) rarely subglobose, usually slightly irregular, ovoid, ellipsoidal, often considerably elongated, sometimes even slightly bent, 5.5-8(-9) x 6.5-16 µm, yellowish-brown; wall even, c. 0.5 µm thick, sparsely, finely verrucose-echinulate, spore profile smooth to finely wavy; in SEM, between the low warts or spines the surface is smooth or very finely, sparsely granular. *Sterile cells* absent.

On *Setaria setosa* var. *leiantha*; S. America (Bolivia). Known only from the type collection.

Ustilago trichogena is close to *U. trichophora*, type on *Panicum colonum* L. (= *Echinochloa colona* (L.) Link), Egypt. In both species the sori are hispid. However, in *U. trichophora* the sori are more globose, and often appear also on the stems, the spores are more regular, rounded, measuring 6-11 x 7-12 µm, and the surface between the spines is sparsely verruculose as seen in SEM.

Etymology: trichogena from Greece *thrix* = hair, and –genes = producing, referring to the hairy soral membrane, produced by the fungus.

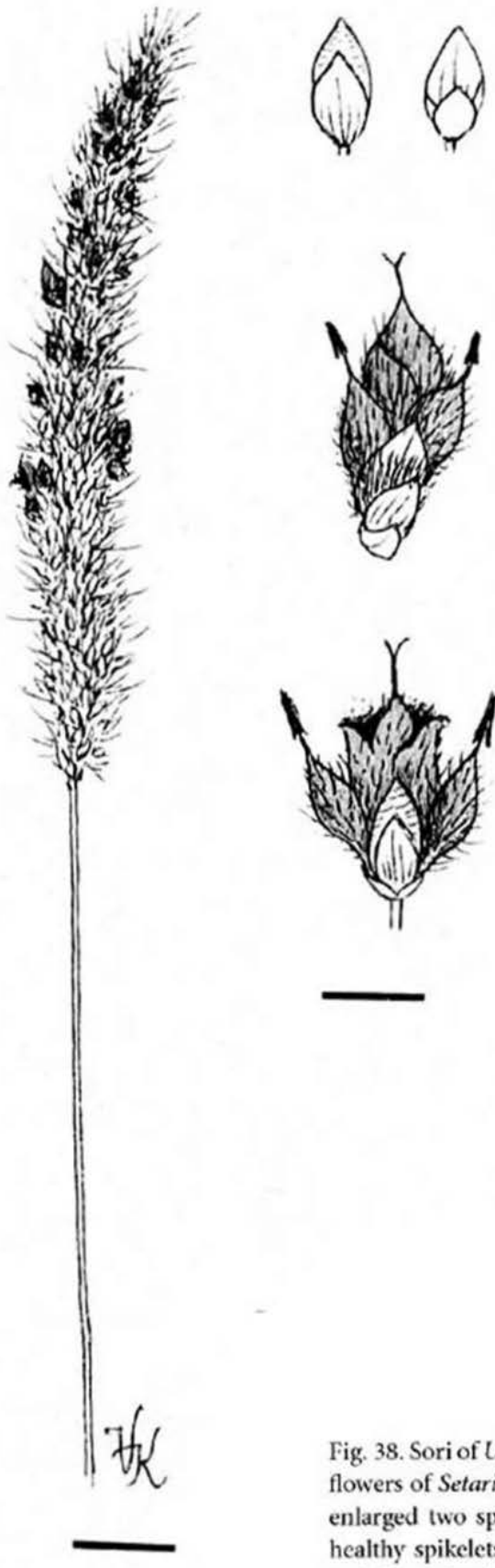
A second species of *Pilocintractia* on *Fimbristylis*

The genus *Pilocintractia* Vánky (2004d:172) was erected for *Cintractia fimbristylidicola* Pavgi & Mundk. (type on *Fimbristylis complanata* Link, India), based on molecular biological data and the peculiar soral structure. A smut fungus, collected by Dr. N.D. Sharma (Jabalpur, India), and another one, obtained in exchange from HCIO, under the name of *Cintractia indica* Pavgi & Mundk., nom. herb., on „*Fimbristylis aestivalis*" (Retz.) Vahl (= misnamed *F. miliacea*), have similar soral structure but larger spores. They both represent the same species and are described as:

Pilocintractia adrianae Vánky, sp. nov.

Typus in matrice Fimbristylis miliacea *(L.) Vahl (det. K. Vánky), India, Madhya Pradesh, cca. 115 km W urbe Jabalpur, pag. Bohani, X.1977, leg. N.D. Sharma, HUV 20947!; isotypi in BPI et HCIO. Paratypus in matrice* Fimbristylis miliacea *(det. K. Vánky, conf. K.A. Lye, NLH), India, Punjab, Amritsar, 31°35' N, 74°56' E, 12.X.1907, leg. A. Hafiz Khan, HUV 15463!; isoparatypus in HCIO 1437.*

Sori *corpora atrobrunnea, globoidea, ovoidea, compacta, dura, diametro 1-1,5 mm circa nuces nonnullas spiculorum aliquorum eiusdem inflorescentiae formantes. Peridium*



38

Fig. 38. Sori of *Ustilago trichogena* in some flowers of *Setaria setosa* (type). Habit and enlarged two spikelets with sori and two healthy spikelets. Bars = 1 cm for habit, and 2 mm for the detail drawings.

eorum deest, superficie non pulverei. Sori maturi in unum continentes a planta nutrienti decidentes. Sporae *complanatae, a latere ellipticae, 8-10,5 µm latae, sine appendicibus hyalinis, in aspectu plano circulares, subcirculares, ellipticae usque parum irregulares, 11-14,5 x 11.5-16(-17) µm, rubrobrunneae; pariete aequali, cca. 0,5 µm crasso, conspicue levi usque valde subtiliter, dense punctato-verruculoso. Sporae in marsupiis cupulatis formatae. Inter sporis filamenta fungalia, hyalina, sterilia, cum muris gelatinosis praesentes, sporas maturas conglutinantia. Germinatio sporarum non cognita.*

Sori (Fig. 39) forming dark brown, globoid, ovoid, compact, hard bodies around some nuts in several spikelets of an inflorescence, 1-1.5 mm in diameter. Peridium lacking, surface not powdery. Mature sori fall off the plants in one piece. *Spores* (Figs. 44, 45) flattened, in side view elliptic, 8-10.5 µm wide, no hyaline appendages, in plane view circular, subcircular, elliptic to slightly irregular, 11-14.5 x 11.5-16(-17) µm, reddish-brown; wall even, c. 0.5 µm thick, apparently smooth to very finely, densely punctate-verruculose. The spores are formed in cup-shaped pockets. Among the spores hyaline, sterile, fungal filaments with gelatinised wall are present, gluing the spores together. *Spore germination* unknown.

On *Cyperaceae: Fimbristylis miliacea*; S. Asia (India). Known only from the type collections.

Etymology: This species is named in the memory of the young, talented, Colombian biologist, Adriana Mercedes Gill Correa, married in Germany, collector of numerous interesting, rare and also new neotropical smut fungi (comp. Piepenbring, 2002b, 2003), whose lost fight against a malignant tumour that prevented her making a great mycological career.

Key to the *Pilocintractia* species

- Spores 9-12(-13) µm long, finely granular-verruculose..... ***P. fimbristylidicola***
- Spores 11.5-16(-17) µm long, apparently smooth to finely punctate..... ***P. adrianae***

New combinations

A further member of the genus *Heterodoassansia* (*Doassansiaceae*)

Heterodoassansia Vánky (1993:28) differs from the genus *Doassansia* Cornu (1883:283) in the heterogeneity of the cortical sterile cells of the spore balls (see below). It has five known species. Recently, smutted leaves of *Hygrophila auriculata* were collected in Ethiopia, with spore balls embedded in the host tissue. Study of thin, hand-cut slices of the spore balls revealed that they represent the same species which was known only from India, under the name of *Doassansia hygrophilae*. It turned out also, that this species belongs to the genus *Heterodoassansia*:

Heterodoassansia hygrophilae (Thirum.) Vánky, **comb. nov.**

Basionym: *Doassansia hygrophilae* Thirumalachar, Lloydia 9:29, 1946. — Type on *Hygrophila* sp. (= *H.* cf. *auriculata*, teste K. Vánky), India, Mysore, Nandi Hills, 5.XI.1944, M.J. Thirumalachar, HCIO 10692; isotypes BPI 178386, 178388, 195045, IMI, HUV 15470!

Sori on leaves forming initially yellow, later brown, circular spots, 2-10 mm in diameter or larger by confluence, with permanent spore balls embedded in the host tissue as minute, dark brown, raised, mainly hypophyllous dots. Later the leaves may be perforated. *Spore*

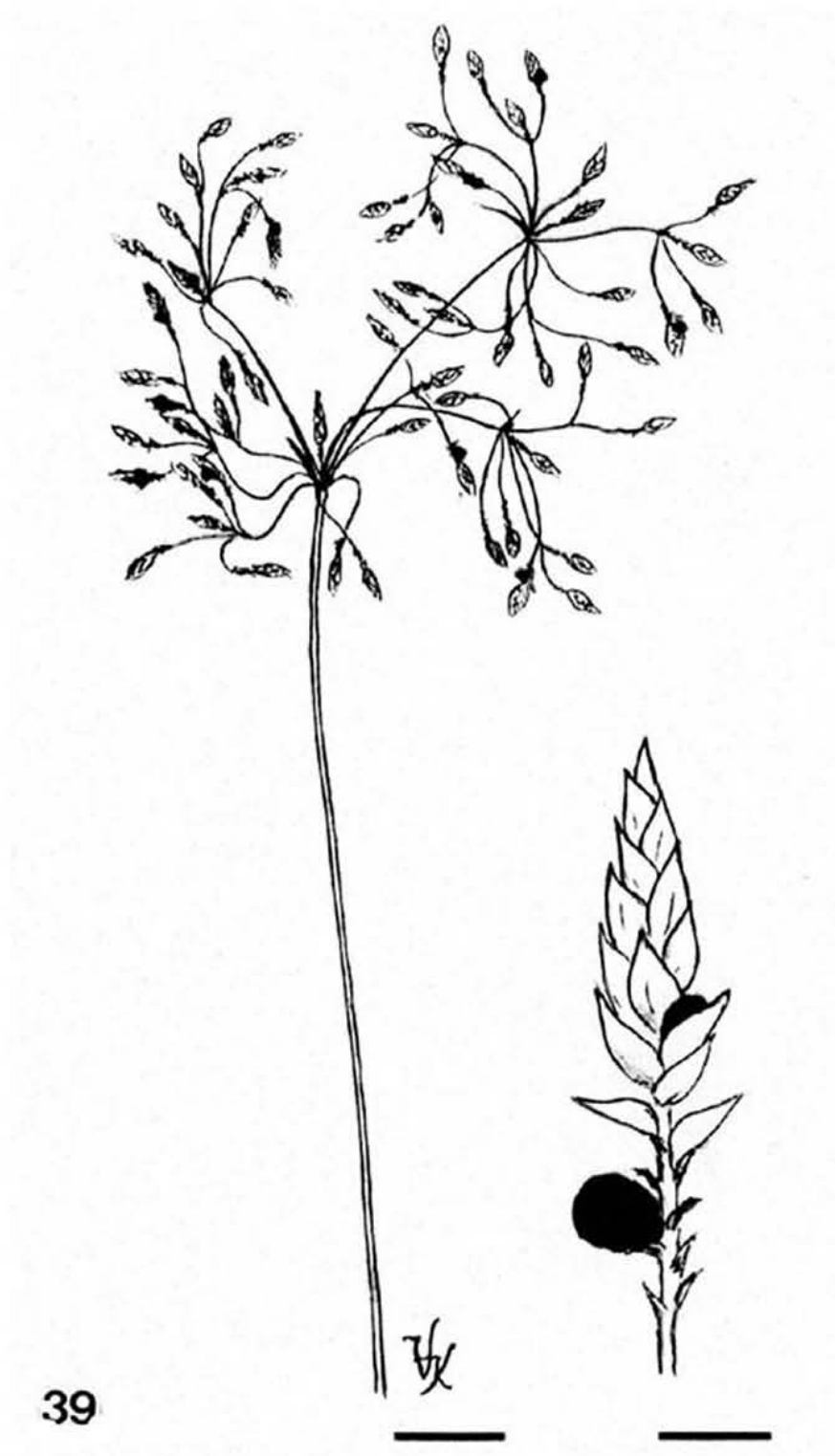
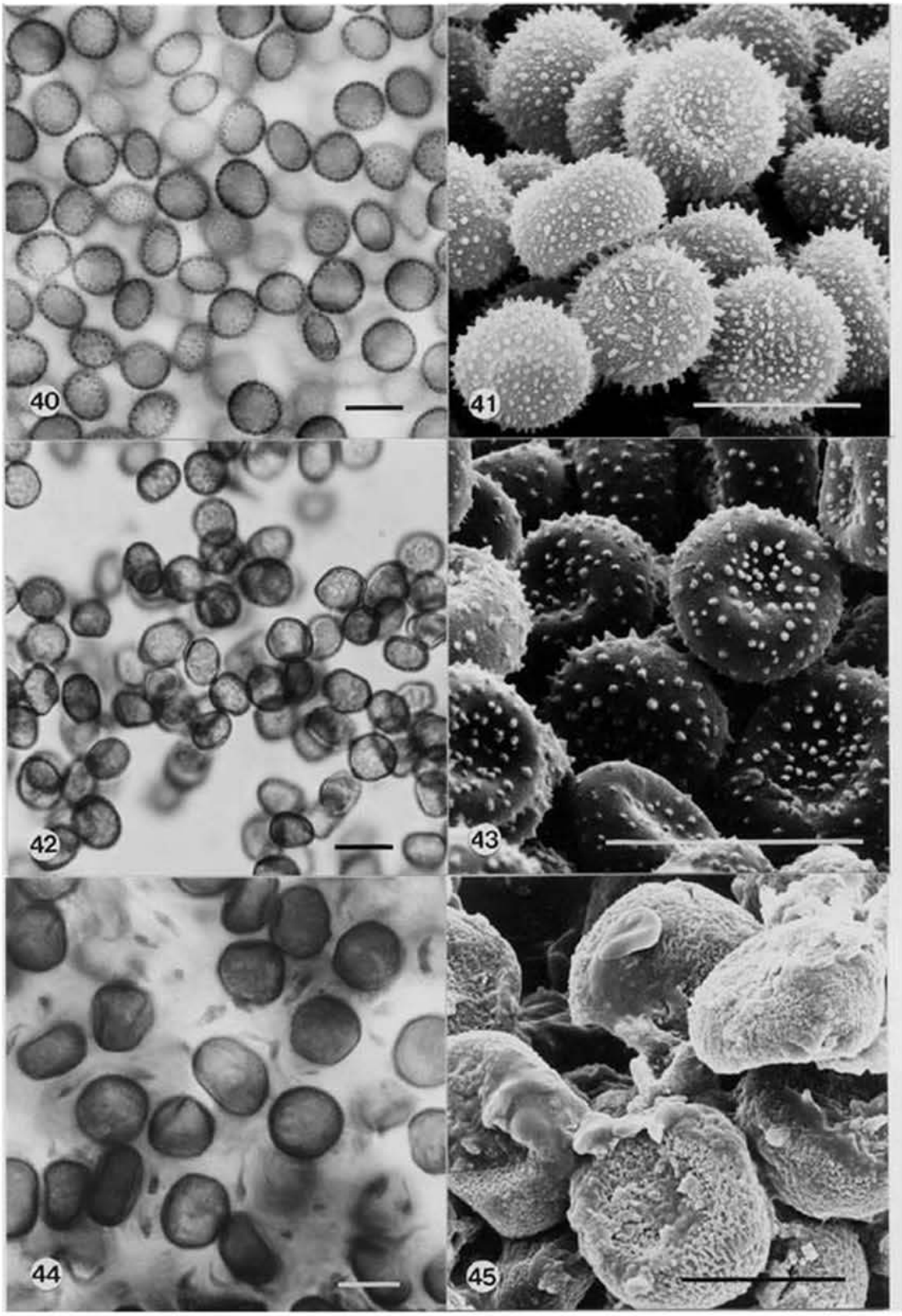


Fig. 39. Sori of *Pilocintractia adrianae* around some nuts of *Fimbristylis miliacea* (type). Habit and enlarged a spikelet with two sori. Bars = 1 cm for habit, and 1 mm for the detail drawing.


40
41
42
43
44
45

balls globose, subglobose, ovoid to slightly irregular, 100-170 x 110-200 µm, beige-brown, composed of a central mass of loosely aggregated spores surrounded by a firm cortex of two different kinds of sterile cells. *Spores* subglobose, ellipsoidal to slightly irregular, 7-12 x 9-16 µm, subhyaline, easily separating by pressure; wall even, thin (c. 0.5 µm), smooth. *Cortex* composed of an inner layer of radially oblong, tightly adhering, relatively large, irregularly subpolyangular, empty cells measuring 6-18 x 7-25 µm, pale yellowish-brown; wall even, c. 0.5 µm thick, ornamented on its inner surface (towards the empty lumen) by moderately densely situated, thin, 0.5-1.5 µm high spines. These cells are arranged in one layer, which in some places is formed by two smaller cells. The outer layer of the cortex is the last-formed component of the spore balls. It differentiates from tangentially elongated, thin-walled, septate, plasmatic fungal filaments. When mature, this thin covering layer is formed of small, irregularly polyangular, often radially flattened, 5-12 µm long, pale yellow, empty cells with c. 0.4 µm thick wall, smooth on the inner and outer surface. *Spore germination* (Thirumalachar, 1946) results in holobasidia bearing an apical whorl of 5-7, fusiform, slightly asymmetrical basidiospores measuring 1-1.2 x 14-15 µm. These conjugate two by two forming binucleate infection hyphae. On the hyphae, on well-developed sterigmata, short, slightly bent ballistospores can be produced.

On *Acanthaceae: Hygrophila auriculata* (Schumach.) Heine (*H. spinosa* T. Anders.; *Asteracantha longifolia* (L.) Nees); Africa (Ethiopia), Asia (India).

Some *Sporisorium* species

Andropterum Stapf is a unispecific genus in the subfam. *Andropogoneae*, tribe *Ischaeminae*, with the type *A. variegatum* Stapf (= *A. stolzii* (Pilger) C.E. Hubb.), in Central Africa (Clayton & Renvoize, 1986:348). Scrutinising herbarium specimens obtained from the late Prof. Zambettakis, I found two sori of an unnamed smut fungus, originating from BR. It turned out to be the isotype of *Sphacelotheca andropteri*, which belongs to the genus *Sporisorium*.

Sporisorium andropteri (Zambett.) Vánky, comb. nov.

Basionym: *Sphacelotheca andropteri* Zambettakis, Bull. Soc. Mycol. France 95:410, 1979(1980). — Type on *Andropterum stolzii*, Congo, S of Boudouinville, Mission St. Martin, Valley of Cumons, leg. Boudewyn 51, BR 2!

Sori in sessile and pedicelled spikelets, cylindrical, 0.8-1 x 3-5 mm, partly hidden by the floral envelopes, covered by a thick, brown peridium which ruptures irregularly disclosing the blackish-brown, first agglutinated later dusty mass of spores and groups of sterile cells surrounding a simple, stout, narrowing central columella. *Spores* single when mature, globose, subglobose, ovoid or broadly ellipsoidal, 4.5-5.5 x 4.5-6.5 µm, yellowish-brown; wall uneven, c. 0.5 µm thick with a thinner part on one side, in LM apparently smooth to very finely punctate, in SEM moderately densely low verrucose. *Sterile cells* in irregular groups or chains, rarely solitary, single cells subglobose, ellipsoidal

---

Figs. 40, 41. Spores and sterile cells of *Sporisorium ingoldii* on *Echinochloa colona*, in LM and in SEM (type).

Figs. 42, 43. Spores of *Ustilago trichogena* on *Setaria setosa*, in LM and in SEM (type).

Figs. 44, 45. Spores and gelatinised fungal filaments of *Pilocintractia adrianae* on *Fimbristylis miliacea*, in LM and in SEM (type). Bars = 10 µm.

to usually irregular, with one or several flattened sides, 8-14 µm long, subhyaline to pale yellowish-brown; wall 0.8-1.5 µm thick, smooth.

On *Poaceae: Andropterum stolzii* (Pilger) C.E. Hubb.; Africa (Congo). Known only from the type collection.

Revising the smut fungi of *Ischaemum* (Vánky, 2004a:94-102), I recognised 11 species. A further species, *Sorosporium semisagittatum*, was also given with its original description, because no material of it was available for study (the type probably being lost). Identifying smut fungi of *Ischaemum indicum*, collected in India, Madhya Pradesh, Kundam, 11.X.1992, leg. N.D. Sharma, C. & K. Vánky (HUV 21078), and Maharashtra State, near Khandala, 25.X.1992, leg. C. & K. Vánky (HUV 21077), it turned out that these specimens represent *S. semisagittatum*, which belongs to the genus *Sporisorium*. The second collection is also distributed in Vánky, Ust. exs. no. 1290.

Sporisorium semisagittatum (Thirum. & Pavgi) Vánky, **comb. nov.**

Basionym: *Sorosporium semisagittatum* Thirum. & Pavgi, Sydowia 20:22, 1967(1968). — Type on *Ischaemum semisagittatum*, India, Maharashtra State, Poona, Khandala, 14.XI.1954, M.J. Thirumalachar 1235 (type where?).

Sori in some spikelets of an inflorescence, ellipsoidal or short cylindrical, 0.8-1.5 x 3-5 mm, showing between the spreading floral envelopes, initially covered by a thick, pale brown peridium which ruptures irregularly from its apex disclosing the blackish-brown, first agglutinated later dusty mass of spore balls, spores and groups of sterile cells surrounding a stout, narrowing central columella, often with shortly bi- or trifurcate tip or with short lateral branches. *Spore balls* subglobose, ellipsoidal, oblong or irregular, of varying size, 30-90 x 35-120 µm, dark reddish-brown to opaque, composed of tens to hundreds of spores which separate easily by pressure. *Spores* globose, subglobose, ovoid ellipsoidal, oblong or rounded subpolyhedrally irregular, 7-9 x 8-11(-12) µm, yellowish-brown; wall slightly uneven, 0.5-0.8 µm thick, densely verrucose-echinulate, spore profile smooth, finely wavy to finely serrulate. *Sterile cells* rather few, usually in rounded, compact groups of (3-)5-10(-15?), single cells irregular, with one or several flattened sides, 5-11 µm long, subhyaline to pale yellowish-brown; wall c. 0.5 µm thick, smooth.

On *Poaceae: Ischaemum indicum* (Houtt.) Merr. (*I. ciliare* Retz.), *I. semisagittatum* Roxb.; S. Asia (India).

Three additional synonyms

Entyloma lavrovianum is a synonym of *E. hieracii*

Entyloma lavrovianum Schwarzman (1960:297) was described from Kazakhstan on several collections of two *Hieracium* species (no type designated). Two syntypes, one on *H. ganeschinii* Zahn, another on *H. korshinskyi* Zahn, both from Alma-Ata Region, Zailijskij Alatau, Great Alma-Ata Gorge, 19.VIII.1958, C. Schwarzman, AA, HUV 12112! & HUV 12113!, were compared with the lectotype of *Entyloma hieracii* Syd. & P. Syd. ex Cif., on *Hieracium murorum* L., Germany, HUV 1174! No differences in spore morphology (shape, size, wall thickness) could be evidentiated, excepting a somewhat darker colour of the spores of *E. lavrovianum*, namely pale yellow to very pale yellowish-brown. The spores of the type of *E. hieracii* are subhyaline to pale yellow. Therefore, I am considering the two names synonyms.

Leucocintractia leucodermoides is considered to be *L. leucoderma*

Leucocintractia leucodermoides M. Piepenbr. & Begerow, was described in Piepenbring (2000:315), based on some differences in spore measurements, spore wall thickness and colour of the spores as compared with the similar *L. leucoderma* (Berk.) M. Piepenbr. A comparison of the types could reveal only minor differences, less than was given in the original description. For the length of the spores of *L. leucoderma* I obtained 14.5-21 µm (instead of 17-19(-21) µm), and for the spore wall thickness 1.5-3 µm. For *L. leucodermoides* these were 13-20(-21) µm (instead of (14-)15-18(-19 µm), and 1.5-2.5 µm, respectively. The difference of the spore ornamentation between these two species, seen in SEM, was also minimal. Consequently, I am considering these two species to represent only variation within the same species, *L. leucoderma.* (syn. nov.).

Tilletia cynodontis is a synonym of *T. montemartinii*

Tilletia montemartinii Canonaco (1936:35) was described on *Cynodon glabratus* Steud. (= *C. dactylon* (L.) Pers.) from Erythrea. It was forgotten and did not appear in recent literature. I described *T. cynodontis* Vánky (2001:294) on *Cynodon plectostachyus* (K. Schum.) Stapf from Ethiopia. No specimen of *T. montemertinii* was available for study but based on the description, I consider the two names to by synonyms. For description and illustration (as *T. cynodontis*) see Vánky, 2001:294, fig. 26, and figs. 24, 25, p. 291.

Acknowledgements

I am grateful to S. Tóth (Gödöllő, Hungary) for preparing the Latin diagnoses, to E.H.C. McKenzie (Auckland, New Zealand), and R. Berndt (Zürich, Switzerland) for reading the manuscript and serving as pre-submission reviewers. Many thanks to N.D. Sharma (Jabalpur, India) for smut fungus specimens, to K.A. Lye (NLH, Norway), H. Scholz (B, Germany) and T.F. Wieboldt (VPI, USA) for identifying host plants. Thanks are also due to the Directors and Curators of the Herbaria BPI, BR, BRIP, HCIO, IMI, PREM and S for loans and/or exchange of specimens.

Literature Cited

Atkinson GF. 1897. Some fungi from Alabama. Cornell Univ. Sci. Bull. 3:1-50.

Bauer R, Begerow D, Nagler A, Oberwinkler F. 2001. The Georgefischeriales: a phylogenetic hypothesis. Mycol. Res. 105:416-424.

Beeli M. 1922. Notes mycologiques. Bull. Jard. Bot. État 8:1-22.

Brefeld O. 1883. Botanische Untersuchungen über Hefenpilze. 5. Die Brandpilze I (Ustilagineen). Leipzig, Verlag v. A. Felix, VI + 220 pp. + Pls. I-XIII.

Brefeld O. 1895. Untersuchungen aus dem Gesammtgebiete der Mykologie. XII. Hemibasidii. Brandpilze III. Münster i. W., Commissions-Verlag v. H. Schöningh. IV + 99-236 pp. + Pls. VI-XII.

Bubák F. 1912. Houby České. Díl II. Sněti (Hemibasidii). Arch. Přír. Výzk. Čech. 15(3):1-84.

Canonaco A. 1937. Contributo alla flora micologica dell'Africa Orientale Italiana. Boll. Stud. Inform. Reale Giardino Colon. 14:33-37 + Pl.

Ciferri R.1928. Quarta contribuzione allo studio degli *Ustilaginales*. Ann. Mycol. 26:1-68 + Pl.

Ciferri R, Herter WG. 1932. *Ustilaginales* Uruguayenses; Itinera Herteriana. Bot. Arch. 34:527-540.

Clayton WD, Renvoize SA. 1986. Genera graminum. Grasses of the world. Kew Bulletin Additional Series XIII. London, UK, 389 pp.

Clinton GP. 1902. North American *Ustilagineae*. J. Mycol. 8:128-156.

Clinton GP. 1904. North American *Ustilagineae*. Proc. Boston Soc. Nat. Hist. 31:329-529.

Cornu M. 1883. Sur quelques Ustilaginées nouvelles ou peu connues. Ann. Sci. Nat. Bot., Sér. 6, 15:269-296.

Cunnington J, Vánky K, Shivas RG. 2005. *Lundquistia* is a synonym of *Sporisorium* (Ustilaginomycetes). Mycol. Balcan. 2:95-99.

Dietel P. 1897. Hemibasidii (*Ustilagineae* und *Tilletiineae*). In Engler & Prantl, Die Natürlichen Pflanzenfamilien. I(1)**:2-24.

Doidge EM. 1950. The South African fungi and lichens to the end of 1945. Bothalia 5:1-1045. (*Ustilaginales* pp. 377-393).

Durán R. 1970. Hosts and distribution records of Mexican smut fungi. Mycologia 62:1094-1105.

Durán R. 1972. Aspects of teliospore germination in North American smut fungi. II. Canad. J. Bot. 50:2569-2573 + Pls. I-IV.

Durán R. 1987. *Ustilaginales* of Mexico. Taxonomy, symptomatology, spore germination, and basidial cytology. Washington State University, Pullman, USA, 331 pp.

Ellis JB, Galloway BT. 1890. New species of fungi. J. Mycol. 6:31-33.

Fischer GW. 1953. Manual of the North American smut fungi. New York, Ronald Press Co.

Griffiths DG. 1902. Concerning some West American fungi. Bull. Torrey Bot. Club 29:290-301.

Guo L. 1990. The genera *Sorosporium* and *Sporisorium* in China. Mycosystema 3:67-88.

Guo L, Vánky K, Mordue JE. 1990. The genus *Franzpetrakia* (*Ustilaginales*). Mycosystema 3:57-66.

Hennings P. 1893. Fungi africani, II. Bot. Jahrb. Syst. 17:1-42.

Hennings P. 1895a. Neue und interessante Pilze aus dem Königl. botanischen Museum in Berlin. III. Hedwigia 34:10-13.

Hennings P. 1895b. Fungi goyazenses. Hedwigia 34:88-116.

Hennings P. 1895c. *Ustilagineae*. Brandpilze. In Engler, A. (ed.). Die Pflanzenwelt Ost-Afrikas und der Nachbargebiete. Teil C. Berlin, pp. 48-49.

Hennings P. 1896a. Ustilaginaceen. In Pazschke O., II. Verzeichniss brasilianischer von E. Ule gesammelter Pilze. Hedwigia 35:50-51.

Hennings P. 1896b. Beiträge zur Pilzflora Südamerikas I. Myxomycetes, Phycomycetes, *Ustilagineae* und *Uredineae*. Hedwigia 35:207-262.

Hennings P. 1897. Beiträge zur Pilzflora Südamerikas II. Hedwigia 36:190-246.

Hennings P. 1898. Fungi americani-boreales. Hedwigia 37:267-276.

Hennings P. 1900. Die Gattung *Pericladium* Passer. Hedwigia, Beibl. 39:(75)-(76).

Hennings P. 1904. Fungi amazonici I. Hedwigia 43:154-186.

Herbert DA, Langdon RFN. 1941. Records of Queensland fungi, III. Univ. Queensland Dept. Biol. Pap. 2:1-6.

Hirschhorn E. 1941. Las especies de *Sorosporium* de la flora Argentina. Revista Mus. La Plata, N.S., Secc. Bot. 3:335-354 + Pls. I-IV.

Hirschhorn E. 1986. Las *Ustilaginales* de la flora Argentina. La Plata, CIC, 530 pp.

Holway EWD. 1899. Mexican fungi. II. Bot. Gaz. 28:273-274.

Ingold CT. 1996. Different patterns of teliospore germination in *Ustilago trichophora*. Mycol. Res. 100:418-420.

Jackson HS. 1908. *Sorosporium ellisii* Winter, a composite species. Bull. Torrey Bot. Club 35:147-149.

Jennings HS. 1890. Some parasitic fungi of Texas. Texas Agric. Exp. Sta. Bull. 9:23-29.

Kochman J. 1936. Grzyby Głowniowe Polski. *Ustilaginales* Poloniae. Planta Polonica. 4:1-161.

Lindeberg B. 1959. *Ustilaginales* of Sweden (exclusive of the *Cintractias* on Caricoideae). Acta Univ. Upsal., Symb. Bot. Upsal. 16(2):1-175.

Ling L. 1949. Taxonomic notes on Asiatic smuts. I. Sydowia 3:123-134.

Ling L. 1950. Studies in the genus *Cintractia*. I. *Cintractia montagnei* and related species. Mycologia 42:503-513.

Ling L. 1951.Taxonomic notes on Asiatic smuts. III. Sydowia 5:40-48.

Ling L. 1953a. Taxonomic notes on the *Ustilaginales*. II. Lloydia 16:180-192.

Ling L. 1953b. Taxonomic notes on the *Ustilaginales*. III. Sydowia 7:151-157.

Magnus P. 1900. J. Bornmüller, Iter Syriacum 1897. Fungi. Weiterer Beitrag zur Kenntnis der Pilze des Orients. Verh. K. K. Zool.-Bot. Ges. Wien 50:432-449 + Pls. II-III.

Maire R. 1917. Champignons nord-africains nouveaux ou peu connus. Bull. Soc. Hist. Nat. Afrique N. 8:134-200.

Maire R, Werner RG. 1937. Fungi Maroccani. Mém. Soc. Sci. Nat. Maroc. 45:1-147.

Massey AB, Zundel GL. 1942. *Sorghastrum*, host of an undescribed smut. Phytopathology 32:544-546.

Mundkur BB. 1944. Some rare and new smuts from India. Indian J. Agric. Sci. 14:49-52.

Opiz PM. 1823-25. Naturalientausch. No. 1-10. Prag. Sechstes Verzeichniss 1924:37-52.

Passerini G. 1875. Funghi raccolti in Abissinia dal Signor O. Beccari, esaminati dal Prof. G. Passerini. Nuovo Giorn. Bot. Ital. 7:180-192.

Pavgi MS, Thirumalachar MJ. 1957. *Franzpetrakia*, a new genus of the *Ustilaginales*. Sydowia, Beih. 1:1-3 + Pl. 1.

Piepenbring M. 1995. Taxonomic studies on *Ustilaginales* from Costa Rica. Mycol. Res. 99:783-788.

Piepenbring M. 1996. Smut fungi (*Ustilaginales* and *Tilletiales*) in Costa Rica. Beih. Nova Hedwigia 113:1-155.

Piepenbring M. 1999. New and poorly known smut fungi in Cuba. Mycol. Res. 103:459-467.

Piepenbring M. 2000. The species of *Cintractia* s. l. (*Ustilaginales*, Basidiomycota). Nova Hedwigia 70:289-372.

Piepenbring M. 2002a. Diversity, taxonomy, and ecology of plant parasitic smut fungi in Bolivia. Ecologia en Bolivia 37:49-58.

Piepenbring M. 2002b. Annotated checklist and key for smut fungi in Colombia. Caldasia 24:103-119.

Piepenbring M. 2003. Smut fungi (Ustilaginomycetes p.p. and *Microbotryales*, Basidiomycota). Flora Neotropica. Monograph 86. The New York Botanical Garden Press, New York.

Piepenbring M, Begerow D, Oberwinkler F. 1999. Molecular sequence data assess the value of morphological characteristics for a phylogenetic classification of species of *Cintractia*. Mycologia 91:485-498.

Pole-Evans IB. 1915. Three fungi collected on the Percy Sladen Memorial Expeditions of 1910-11 and 1912-13. Ann. Bolus Herb. 1:115.

Prasad N, Tyagi RNS. 1961. A new species of *Pericladium* causing stem galls on *Grewia flavescens* Juss. J. Indian Bot. Soc. 40:497-501.

Scholz H, Scholz I. 1988a. Die Brandpilze Deutschlands (*Ustilaginales*). Englera 8:1-691.

Scholz H, Scholz I. 1988b. Taxonomische Erkenntnisse bei der Erarbeitung einer Brandpilzflora von Deutschland (*Ustilaginales*). Nova Hedwigia 47:69-79.

Scholz H, Scholz I. 2000. Die Brandpilze Deutschlands (*Ustilaginales*), Nachtrag. Verh. Bot. Vereins Berlin Brandenburg 133:343-398.

Scholz H, Scholz I. 2004. Die Brandpilze Deutschlands, 2. Nachtrag. Verh. Bot. Vereins Berlin Brandenburg 137:441-487.

Schwarzman SR. 1960. Golovnevye griby. (Smut fungi; in Russian). Flora sporovych rastenij Kazachstana 2. Alma Ata.

Spegazzini C. 1899. Fungi argentini novi vel critici. Anales Mus. Nac. Buenos Aires, Ser. 2, 6:81-367 + 2 Pls.

Sydow H. 1924. Notizen über Ustilagineen. Ann. Mycol. 22:277-291.

Sydow H. 1937. Neue oder bemerkenswerte australische Micromyceten. I. Ann. Mycol. 35:22-49.

Sydow H. 1939. Novae fungorum species. XXVII. Ann. Mycol. 37:197-253.

Sydow H, Sydow P. 1912. Novae fungorum species. VIII. Ann. Mycol. 10:405-410.

Sydow H, Sydow P, Butler EJ. 1912. Fungi Indiae orientalis. Pars IV. Ann. Mycol. 10:243-280.

Thirumalachar MJ. 1946. Nuclear cycle and life history of a new species of *Doassansia* (*Ustilaginales*). Lloydia 9:24-30.

Thirumalachar MJ. 1947. Species of the genera *Doassansia, Doassansiopsis,* and *Burrillia* in India. Mycologia 39:602-611.

Thirumalachar MJ, Neergaard, P. 1977(1978). Studies on the genus *Tolyposporium*. *Tolyposporidium* gen. nov. Friesia 11:177-192.

Thirumalachar MJ, Pavgi MS. 1967(1968). Notes on some Indian *Ustilagineae*. IX. Sydowia 20:21-27 + Pl. I.

Thirumalachar MJ, Pavgi MS. 1968(1969). Notes on some Indian *Ustilagineae*. X. Sydowia 22:250-253 + Pls. XV-XVI.

Tracy SM, Earle FS. 1895. New species of parasitic fungi. Bull. Torrey Bot. Club 22:174-179.

Tulasne L-R, Tulasne C. 1847. Mémoire sur les Ustilaginées comparées aux Urédinées. Ann. Sci. Nat. Bot., Sér. 3, 7:12-127 + Pls. 2-7.

Vánky K. 1983. Ten new species of *Ustilaginales*. Mycotaxon 18:319-336.

Vánky K. 1985. Carpathian *Ustilaginales*. Acta Univ. Upsal., Symb. Bot. Upsal. 24(2):1-309.

Vánky K. 1990. Taxonomical studies on *Ustilaginales*. VI. Mycotaxon 38:267-278.

Vánky K. 1993. Taxonomical studies on *Ustilaginales*. X. Mycotaxon 48:27-44.

Vánky K. 1996. Taxonomical studies on *Ustilaginales*. XIV. Mycotaxon 59:89-113.

Vánky K. 1997a. Taxonomical studies on *Ustilaginales*. XVI. Mycotaxon 65:133-158.

Vánky K. 1997b. Taxonomical studies on *Ustilaginales*. XVII. Mycotaxon 65:159-182.

Vánky K. 2000. Taxonomical studies on *Ustilaginales*. XX. Mycotaxon 74:161-215.

Vánky K. 2001. Taxonomical studies on *Ustilaginales*. XXI. Mycotaxon 78:265-326.

Vánky K. 2002a. Taxonomical studies on *Ustilaginales*. XXII. Mycotaxon 81:367-430.

Vánky K. 2002b. Illustrated Genera of Smut Fungi. 2nd. Ed. APS Press, 238 pp.

Vánky K. 2003. Taxonomical studies on *Ustilaginales*. XXIII. Mycotaxon 85:1-65.

Vánky K. 2004a. Taxonomic studies on Ustilaginomycetes - 24. Mycotaxon 89:55-118.

Vánky K. 2004b. The smut fungi (Ustilaginomycetes) of *Bothriochloa, Capillipedium* and *Dichanthium* (*Poaceae*). Fungal Diversity 15:221-246.

Vánky K. 2004c. New smut fungi (Ustilaginomycetes) from Mexico, and the genus *Lundquistia*. Fungal Diversity 17:159-190.

Vánky K. 2004d. *Pilocintractia* gen. nov. (Ustilaginomycetes). Mycol. Balcan. 1:169-174.

Vánky K. 2005a. Taxonomic studies on Ustilaginomycetes - 25. Mycotaxon 91:217-272.

Vánky K. 2005b. The smut fungi (Ustilaginomycetes) of *Chrysopogon* (Poaceae). Fungal Diversity 18:177-187.

Vánky K, Deml G, Oberwinkler F. 1988. The smut fungi of *Hyparrhenia hirta* (Gramineae). J. Phytopathology 121:181-191.

Vánky K, Shivas RG. 2001. New smut fungi (Ustilaginomycetes) from Australia. Fungal Diversity 7:145-174. note). Rev. Pathol. Vég. Entomol. Agric. France 37:167-178.

Vánky K, Shivas RG. 2005. (1655) Proposal to conserve the name of *Ustilago scitaminea* against *Ustilago amadelpha* (Fungi, Ustilaginomycetes, *Ustilaginaceae*). Taxon 54:180.

Viennot-Bourgin G. 1958. *Ustilaginales* nouvelles de Guinée française. (Deuxième note). Rev. Pathol. Vég. Entomol. Agric. France 37:167-178.

Walker J, Shivas RG. 1998. Two species of *Sporisorium* on *Chionachne* in tropical Australia, the first Australian record of *Ustilago brunkii* and its transfer to *Jamesdicksonia*. Mycol. Res. 102:1203-1214.

Winter G. 1883a. Fungi nonnulli novi. Hedwigia 22:1-3.

Winter G. 1883b. New North American fungi. Bull. Torrey Bot. Club 10:7.

Zambettakis C. 1979(1980). Recherches sur les *Ustilaginales*. (Supplément sur les espèces africaines). Bull. Soc. Mycol. France 95:393-443.

Zundel GL. 1930. Monographic studies on the *Ustilaginales* attacking *Andropogon*. Mycologia 22:125-158.

Zundel GL. 1931. Notes on new species of *Ustilaginales*. Mycologia 23:296-299.

Zundel GL. 1933. New and rare North and South American *Ustilaginales*. Mycologia 25:349-355.

Zundel GL. 1938. The *Ustilaginales* of South Africa. Bothalia 3:283-330.

Zundel GL. 1939. Studies on the *Ustilaginales* of the world. Mycologia 31:572-589.

Zundel GL. 1943. Notes on the *Ustilaginales* of the world. III. Mycologia 35:164-184.

Zundel GL. 1951. Notes on the *Ustilaginales* of the world. V. Mycologia 43:267-270.

Zundel GL. 1953. The *Ustilaginales* of the World. Pennsylvania State Coll. School Agric. Dept. Bot. Contrib. 176:XI + 1-410.

MYCOTAXON

Volume 95, pp. 67–69 *January–March 2006*

Kalmusia amphiloga comb. nov. on *Bambusa*

OVE E. ERIKSSON

ove.eriksson@emg.umu.se
Department of Ecology and Environmental Science, Umeå University
SE 90187 Umeå, Sweden

Abstract—*Leptosphaeria amphiloga* is transferred to the genus *Kalmusia*. It differs from *K. scabrispora*, another bambusicolous species, in smaller ascomata, asci and ascospores.

Key words—bambusicolous, pyrenomycete, morphology

Introduction

Tanaka et al. (2005: 110) recently transferred *Leptosphaeria scabrispora* Teng to the genus *Kalmusia* Niessl. That species occurs on *Phyllostachys* and is certainly closely related to another bambusicolous species, *Leptosphaeria amphiloga*, which is transferred here to *Kalmusia*.

Kalmusia amphiloga (Petr.) O. E. Eriks., **comb. nov.** **Fig. 1ab**

Basionym: *Leptosphaeria amphiloga* Petr., in Sydow & Petrak, *Ann. Mycol.* 29: 202 (1931).

The presence of this fungus on old bamboo culms is indicated only by the epidermis being raised by the ascomata over small scattered areas, c. 10-40 x 10 mm, up to c. 150 µm high. There are several densely aggregated ascomata within each elevated area, which may have several, narrow, longitudinal cracks, but the ascomata are not visible, only the minute, ascomal pores may be visible.

Pseudostroma subepidermal and visible only if the epidermis is removed, forming a thin, dark brown layer in small, scattered, circular areas on the wood; hyphae intermingled with the uppermost cell layer of the wood, and not distinctly visible as discrete hyphae, irregularly dark reddish brown, turning greenish brown with NaClO or KOH.

Ascomata subepidermal, several densely aggregated in one layer on each pseudostroma (Fig. 1a), flattened subglobose or of more irregular shape from mutual pressure, c. 200-300 µm across; wall c. 10-12 µm thick, pale brown to hyaline.

Hamathecium of numerous, parallel hyphae (pseudoparaphyses?) between and above asci, and here with few branches and anastomoses; cells hyaline, rather thick-walled, most of them c. 25-35 µm long and c. 2 µm wide, with most of the protoplasm (1.5-3 µm) near the septa, slightly constricted at some septa; in the periphery hyphae with more anastomoses and shorter cells.

Asci c. 85-100 x 14-17 µm, clavate, bitunicate; ectotunica thin, endotunica thin (also in asci with broken ectotunica), with a small ocular chamber, but no ring structures; with 8 spores, the two lowermost overlapping uniseriate, the others biseriate.

Ascospores (Fig. 1b) 26-31 x 8-9 µm, fusiform, lower hemispore often with more rounded end, inequilateral, (2-)3-5-septate, very seldom with a longitudinal septum in one of the segments, pale brown, with dark brown, coarse verrucae, and a hyaline sheath (width could not be measured safely, as the material is old and the ascospores do not readily leave the asci).

Anamorph not seen.

Habitat: old culms of *Bambusa* sp.

Known distribution: Asia (Philippines).

Material studied: Philippines, Luzon, Pampanga Prov., Stotsenberg, on *Bambusa* sp., iii.1923, leg. Mary Strong Clemens, n. 1632 (W 11891, holotype).

Discussion

Ascomata of *Leptosphaeria* species have walls with scleroplectenchymatous cells (Holm 1957). *Leptosphaeria amphiloga* differs in that respect from typical members of the genus. It resembles very much another bambusicolous species, *Leptosphaeria scabrispora*, which recently was transferred to *Kalmusia* by Tanaka et al. (2005: 110), and *L. amphiloga* is now placed in the same genus. *Kalmusia scabrispora* (Teng) Tanaka et al. and *K. amphiloga* both have ascomata that are densely aggregated under the epidermis in elevated areas of bark on bamboo stems. The ascomata, asci and ascospores of the former species are larger. In *K. scabrispora*, the ascomata measure 250-400 µm, the asci 124-153(-160) x (15.5-) 17-21 µm, and the ascospores (29-)31-40.5 x (7-)8-10 µm (Tanaka et al., l.c.), whereas in *K. amphiloga*, the ascomata measure c. 200-300 µm, the asci c. 85-100 x 14-17 µm, and the ascospores c. 26-31 x 8-9 µm.

Kalmusia is currently accommodated in the *Montagnulaceae* (Eriksson 2006: 7), but there are no sequences in GenBank from any member of the genus, and its position is uncertain.

Acknowledgements

I am grateful to the Curator of W for the loan of the type material of *Leptosphaeria amphiloga*, to Dr Jingzhu Pearl Yue (San Francisco) for preparing a drawing of a bamboo twig with immersed ascomata of the species, and to the reviewers Prof. L. Holm and Prof. N. Lundqvist (Uppsala) for examining this paper.

Literature Cited

Eriksson O.E. (ed.). 2006. Outline of the Ascomycota – 2006. Myconet 12: 1-82.

Holm L. 1957. Études taxonomiques sur les Pléosporacées. - Symbolae Botanicae Upsalienses 14(3): 1-188.

Sydow H. & Petrak F. 1931. Micromycetes philippinenses. Series secunda. Ann. Mycol. 29: 145-279.

Tanaka K, Harada Y, Barr ME 2005. Bambusicolous fungi in Japan (3): a new combination, *Kalmusia scabrispora*. Mycoscience 46: 110-113.

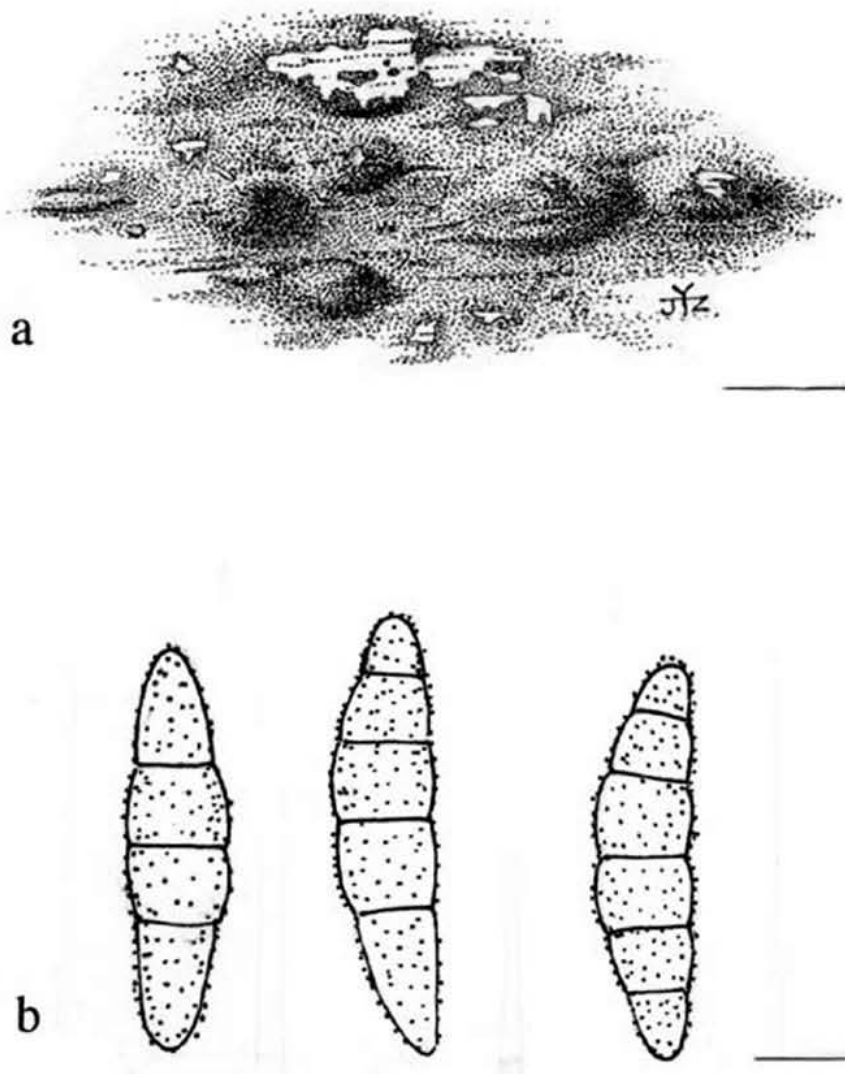


Fig. 1 a-b. *Kalmusia amphiloga*. a. Bark with bulges, each containing several ascomata (del. J.-Z. Yue). b. ascospores. Scale: a. 1 mm, b. 10 µm. – Material: a-b. W11891.

MYCOTAXON

Volume 95, pp. 71–79 *January–March 2006*

A new species and new records of *Rhytismatales* from Taiwan

CHENG-LIN HOU[1] ROLAND KIRSCHNER[2] CHEE-JEN CHEN[3]

houchenglincn@yahoo.com
[1]College of Life Science, Capital Normal University
Beijing 100037, China

kirschner@em.uni-frankfurt.de
[2]Botanisches Institut, Johann Wolfgang Goethe-Universität
Frankfurt am Main, 60054 Frankfurt/M., Germany

C5200999@mail.stut.edu.tw
[3]Department of Biotechnology, Southern Taiwan University of Technology
1 Nan-Tai street, Yung-kang City, Tainan County, Taiwan 71043

Abstract—Of nine names of the *Rhytismatales* reported for Taiwan, only five, *Coccomyces foliicola*, *Lophodermium mangiferae*, *L. pinastri*, *Rhytisma placenta*, and *Vladracula annuliformis*, are retained. The other four are either invalid or incorrect. Recently, additional specimens were collected and identified. They include a new species, *Coccomyces taiwanensis* on fallen twigs of an unknown angiosperm host, and three species reported for the first time for Taiwan, *Coccomyces multangularis* on *Machilus thunbergii*, *Lophodermium conigenum* on *Pinus* sp. and *Lophodermium petrakii* on *Cunninghamia lanceolata*.

Key words—Ascomycota, *Rhytismataceae*, taxonomy

Introduction

Until now, nine names of the *Rhytismatales* (Ascomycota) have been reported for Taiwan. Some of them, however, are invalid or incorrect. *Lophodermium rottboelliae* Sawada ('*rottobaelliae*'), *Rhytisma ilicis* Sawada, and *R. rhododendri-oldhamii* Sawada are invalidly published since Sawada did not provide Latin diagnoses for them (Hou 2004, Sawada 1943, 1944, 1959), and *Coccomyces mussaendae* Sawada is a synonym of *Biostictis tjibodensis* (Racib.) Sherwood (*Ostropales*) (Sherwood 1980).

Therefore, there are only five correctly applied names of the *Rhytismatales* in Taiwan, i.e. *C. foliicola* (Dennis & Spooner) Sherwood, *L. mangiferae* Koord., *L. pinastri* (Schrad.) Chevall., *R. placenta* Berk. & Broome, and *Vladracula annuliformis* (Syd. et al.) P.F. Cannon et al. (Sawada 1959, Sivanesan & Hsieh 1989, Li & Hsieh 1991, Chen & Hsieh 1994, Wu & Wang 2000). The present study, which is based on specimens recently collected by the second and third authors from Taiwan, includes one new species and three species previously unknown from Taiwan.

* *Author for correspondence*

Materials and methods

Sections of different thickness of ascomata were made by hand using a razor blade. Microscopic preparations were made in water, Melzer's reagent, 5% KOH, or 0.1% (w/v) cotton blue in lactic acid. For observation of ascomatal outlines in vertical section, sections were mounted in lactic acid or cotton blue with pretreatment in water. Gelatinous sheaths surrounding ascospores and paraphyses were observed in water or cotton blue in lactic acid. Ascospore contents are drawn based on observations in water. Measurements were made using material mounted in 5% KOH or Melzer's reagent and from 20 ascospores and asci for each specimen.

Taxonomy

Coccomyces multangularis Y.R. Lin & Z.Z. Li Mycosystema 20: 1, 2001

FIGURES 1-5

Holotype. On *Litsea coreana* var. *sinensis* (Allen) Yang & P. H. Huang, China, Anhui, Huangshan, Zuishi, 12 VIII 1995, Y. R. Lin et al. L1621a (AAUF 67729a).

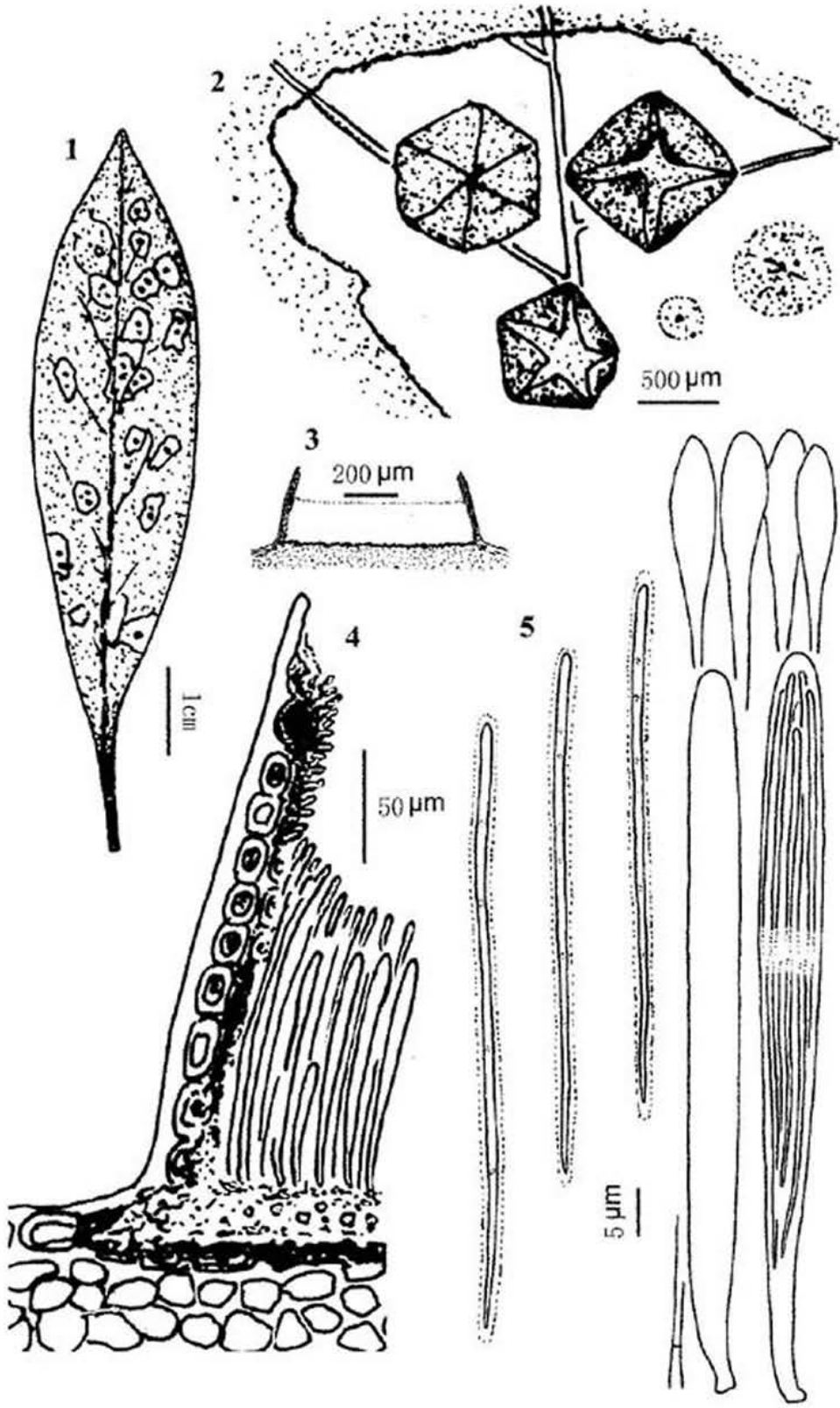
Ascomata developing on both sides of fallen leaves, in small, bleached or pale brown lesions, angular, 4-6-sided, occasionally triangular, round when young, (500-)600-1100 μm diam., black, shiny on the upper side of the leaf, and less shiny on the lower side of the leaf, strongly raising above the surface of the host at maturity, with obvious, preformed lines of dehiscence, lips absent, opening by 4-6 teeth. In median vertical section, ascomata intraepidermal at ascomatal edges, subepidermal to intra-hypodermal near the middle part of covering stroma, and intraepidermal to cuticular near the opening, 220-320 μm deep, covering stroma poorly developed, 20-35 μm thick, consisting of textura angularis and hyphae with thick-walled, dark brown fungal cells. Epidermal and remained hypodermal cells in covering stroma filled with dark brown fungal cells of different size. Periphyses short cylindrical, hyaline, thin-walled, 3-5 × 1-2 μm. Basal stroma medium developed, flat, composed of two layers of dark brown, thick-walled angular cells, 10-13 μm thick. Excipulum present, 20-30 μm wide, arising from the marginal paraphyses. Excipular elements similar to paraphyses. Subhymenium consisting of textura intricata, 15-20 μm thick, with many crystals of different shape and size. Paraphyses 100-120 × 1.5-2 μm, filiform, aseptate, not branched, swollen up to 4-5 μm diam. at the apex. Asci ripening sequentially, 80-110 × 4-5 μm, cylindrical, thin-walled, J−, without circumapical thickening at the apex, 8-spored. Ascospores filiform, 40-65 × 0.8 μm, rounded at the apex and slightly tapering towards the base, hyaline, aseptate, multiguttulate, with a thin gelatinous sheath.

Structures resembling conidiomata of *Rhytismatales* in pale areas near ascomata, pale brown to concolorous with the host tissue, round, 180-240 μm diam., opening by an ostiole. In vertical section, conidiomata epidermal. Conidiogenous cells and conidia not seen.

Specimen examined: TAIWAN, Taipei, Yangmingshan, alt. ca. 900 m, on fallen leaves of *Machilus thunbergii* Sieb. & Zucc. (*Lauraceae*), 27 VIII 2004, Roland Kirschner (TNM).

Known distribution: Anhui (Lin et al. 2001) and Taiwan.

Known Host species: *Litsea coreana* var. *sinensis*, *Machilus thunbergii*. (Lin et al. 2001).



Figs. 1-5. *Coccomyces multangularis* on fallen leaves of *Machilus thunbergii*. 1. A leaf bearing ascomata. 2. Ascomata as seen under a dissecting microscope. 3. Ascoma in vertical section. 4. Detail of an ascoma in vertical section. 5. Paraphyses, a mature ascus with ascospores, an ascus after the liberation of the ascospores, and liberated ascospores with gelatinous sheaths.

Notes: The morphological features, ecology and host of the specimen are very similar to the type specimen of *Coccomyces multangularis* described by Lin et al. (2001). Depth of ascomata inserting the host of *C. multangularis* is similar to that of *C. mucronatus* Korf & W. Y. Zhuang on fallen leaves of *Fagaceae* (Korf & Zhuang 1985). *C. mucronatus* is easily distinguished from *C. multangularis* by its mucronate tip of the paraphyses.

Coccomyces taiwanensis C.L. Hou, R. Kirschner & Chee J. Chen, **sp. nov.**

FIGURES **6-11**

Ascomata (1200-)1500 × 2500 µm, nigra, elliptica, intraepidermalia; paraphyses filiformes; asci (150-)180-220 × 8-10 µm, clavati; ascosporae 100-150 × 1-1.5 µm, filiformes.

Etymology: referring to the place where the specimen was collected.

HOLOTYPE: On twigs of unknown angiosperm host, TAIWAN, Yilan, Taipingshan, alt. ca. 1500 m, 24 V 2000, R. Kirschner & Chee. J. Chen 662 (TNM).

Ascomata developing on fallen twigs, not associated with bleached areas. Ascomata irregularly rounded or slightly triangular, occasionally elliptical, (1200-)1500 × 2500 µm diam., black, strongly raising above the surface of the host at maturity, without preformed lines of dehiscence, lips absent, opening by irregular splits. In median vertical section, ascomata deep in host tissue, 300-450 µm deep, covering stroma up to 75-120 µm thick near the centre of the ascomata (not including host tissue), slightly thinner towards the edges, extending to the basal stroma, consisting of an outer layer of host tissue and an inner layer of black textura angularis and short hyphae.

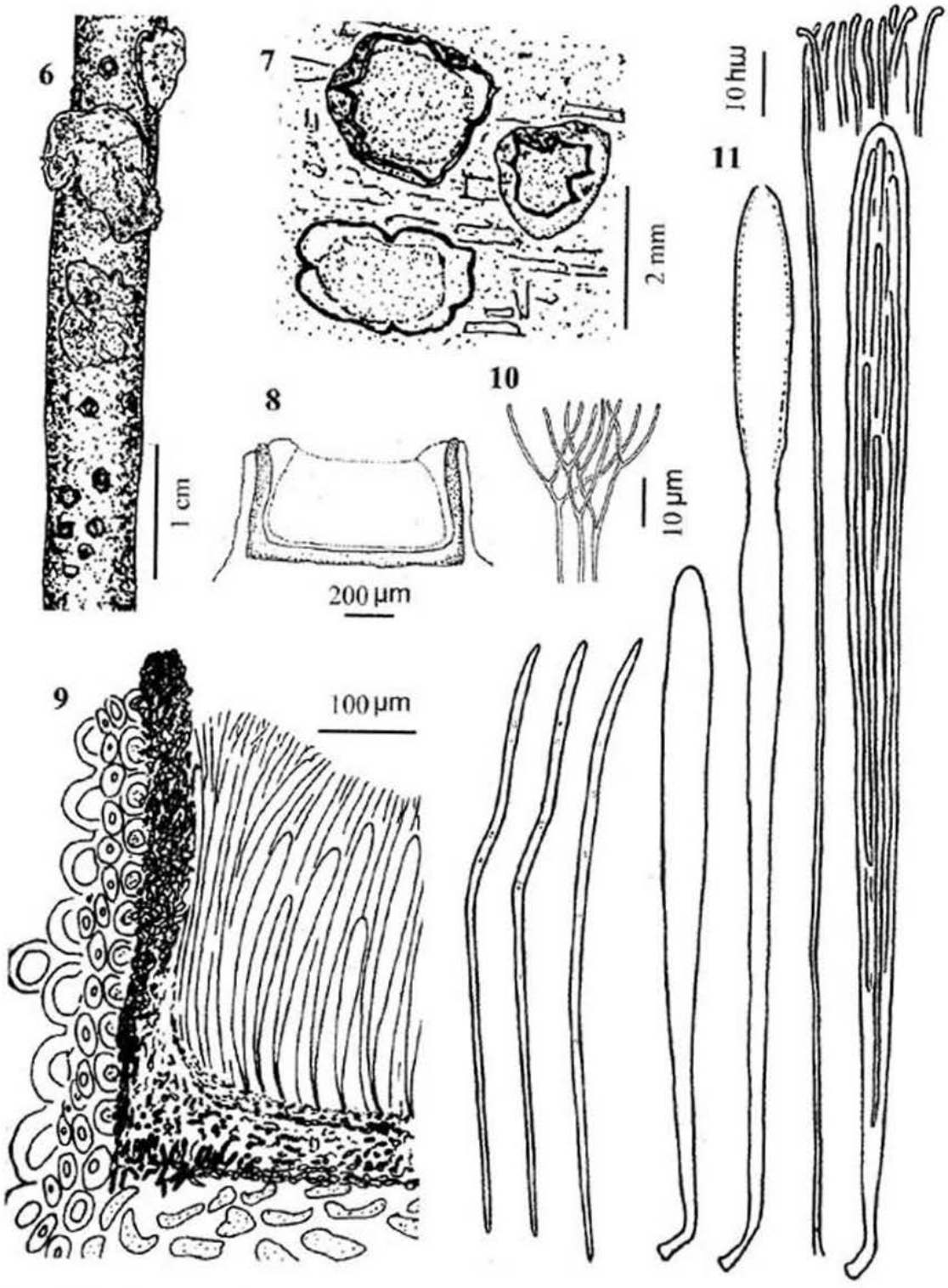
Periphysoids absent. Basal stroma flat, 30-50 µm thick, composed of an outer layer of dark brown short hyphae or textura angularis and an inner layer of pale brown to hyaline short hyphae. *Excipulum* well developed, 80-120 µm wide, arising from the marginal paraphyses. Excipular elements branching two times near the apices. Subhymenium consisting of textura intricate, 10-15 µm thick. Paraphyses 200-250 × 1 µm, filiform, unbranched, simple, slightly hooked at the apex. Asci ripening sequentially, (150-)180-220 × 8-10 µm, long cylindrical-clavate, with a conspicuous stalk, thin-walled, J–, without circumapical thickening, 8-spored. Ascospores fasciculate, 100-150 × 1-1.5 µm, filiform, tapering at the both ends, hyaline, aseptate, gelatinous sheaths not seen.

Conidiomata and zone lines not observed.

Known distribution: Only from the type locality.

Habitat: *C. taiwanensis* was collected from twigs in litter.

Notes: Microscopical investigations of wood anatomy of the substrate of *C. taiwanensis* revealed the presence of pitted vessels, indicating that the host belongs to angiosperm. *Coccomyces taiwanensis* is ecologically and macroscopically similar to some *Coccomyces* species on bark, such as *C. boydii* A. L. Sm. on *Myrica gale* L., *C. juniperi* (P. Karst.) P. Karst. on *Juniperus* spp., and *C. strobi* J. Reid & Cain on *Pinus* spp. (Sherwood 1980). However, *C. taiwanensis* has a very well developed excipulum and excipular elements branching two times near the apices, while *C. boydii*, *C. juniperi*, and *C. strobi* do not have an excipulum (Sherwood 1980). In addition, shape and size of ascospores as well as lacking of gelatinous sheaths surrounding the ascospores of the new taxon are quite different from those of the species mentioned above (Sherwood 1980). The shape of the



Figs. 6-11. *Coccomyces taiwanensis* on twigs of unknown angiosperm host. 6. A twig bearing ascomata. 7. Ascomata as seen under a dissecting microscope. 8. Ascoma in vertical section. 9. Detail of an ascoma in vertical section. 10. Detail of the top of excipular elements. 11. Paraphyses, a young ascus, a mature ascus with ascospores, an ascus after the liberation of the ascospores, and liberated ascospores.

released ascospores of *C. taiwanensis* is reminiscent of the species of *Lophodermium unciniae* and *L. brunneolum* (Johnston 1994) where the ascospore has a slight bend along its length. For the new taxon, however, no a small gelatinous appendage at the point where the ascospore is bent is observed.

Lophodermium conigenum (Brunaud) Hilitzer, Věd. Spisy čsl. Akad. zeměd. 3: 76, 1929.

Lophodermium pinastri forma *conigena* Brunaud, 1888; *Lophodermina conigena* (Brunaud) Tehon, 1935. Neotype. On *Pinus sylvestris* L., Scotland, Glentanar, Aberdeenshire, 5 IX 1975, C. S. Millar s. n. IMI 231805.

For description and figures of *L. conigenum* see Minter (1981, 1985).

Specimen examined: TAIWAN, Nantou, Huisunlinchang, ca. 800 m, on fallen needles of *Pinus* sp., 11 VIII 2004, R. Kirschner & C. J. Chen 2015 (TNM).

Known distribution: Europe, North America, Asia, Australia, Africa (Minter 1981).

Host species: *Pinus* sp. (*Pinaceae*). For further host species see Minter (1981).

Habitat: *L. conigenum* was collected from needles that were still attached to twigs or fallen on the ground.

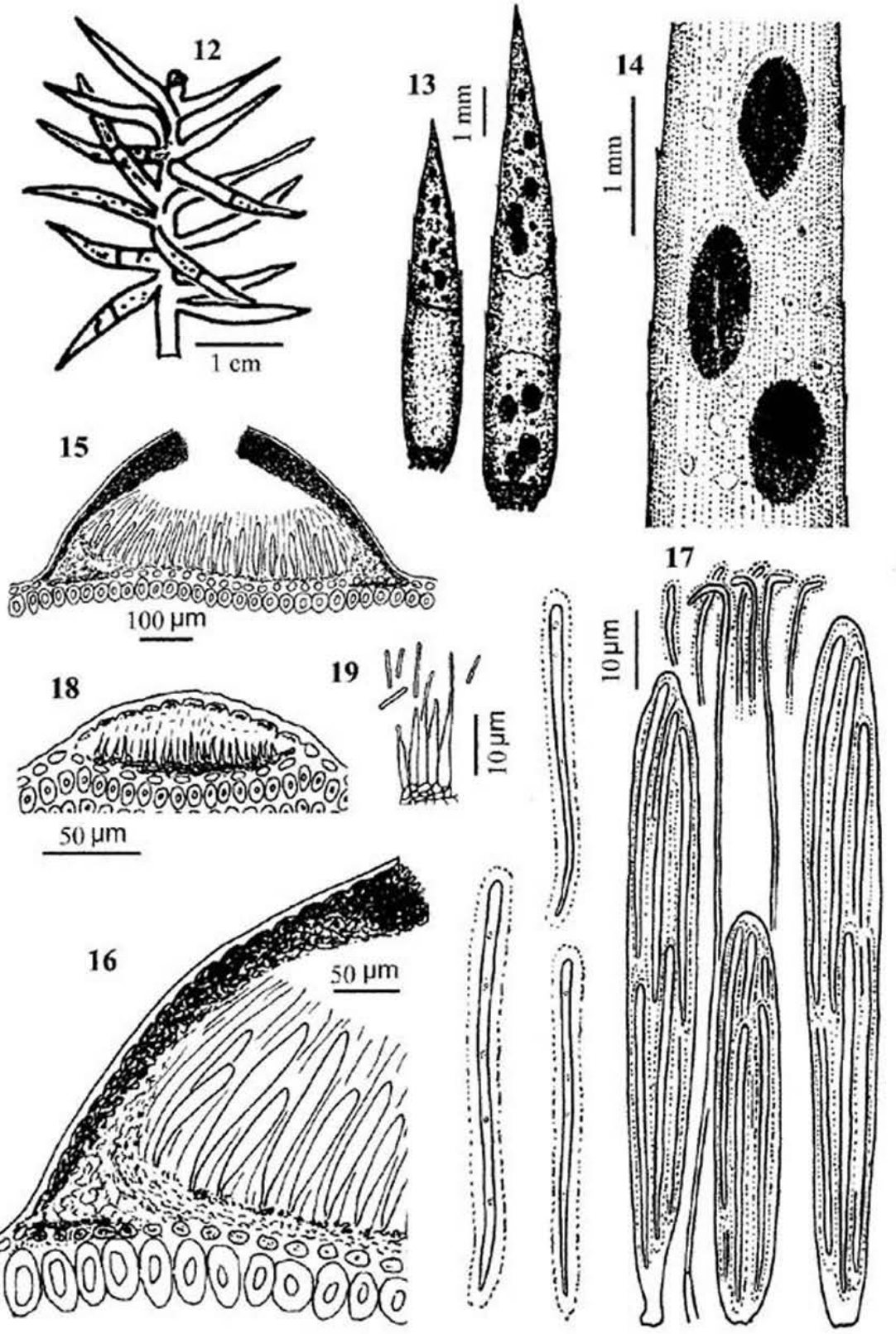
Notes: *Lophodermium conigenum* is morphologically similar to *L. australe* Dearn., and Minter (1985) considered that they might be conspecific. The specimen we checked matches the description of *L. conigenum* by Minter (1981) except that the dimensions of the ascomata and ascospores are somewhat smaller. Our collection differs from Minter's concept of *L. australe* by its wider ascomata which partly insert epidermal cells of host.

The nucleotide sequences of the internal transcribed spacer (ITS) show that specimens identified as both these species are genetically very similar (Ortiz-Garcia et al. 2003). However, unpublished ITS sequence data of the first author shows that there may be several genetically distinct but morphologically very similar *L. conigenum*-like species. DNA sequences were not obtained for the Taiwanese specimen.

Lophodermium petrakii Durrieu, Sydowia Beih. 1: 355, 1957. FIGURES 12-19

Type. On *Cunninghamia lanceolata* (Lamb.) Hook., France, Arboretum Henri Gaussen du Laboratoire forestier de Toulouse, á Jouéou prés Luchon, IX 1955, Herbier du Laboratoire Botanique Appliquée, Toulouse (TLA 1822).

Ascomata on both sides of needles, scattered, sometimes two ascomata confluent. In surface view ascomata dark brown, shiny, perimeter line inconspicuous or absent, elliptical, 700-1100 × 420-580 µm, slightly raising above the surface of the substrate, opening by a single longitudinal split. Lips inconspicuous. In median vertical section ascomata subcuticular, 220-280 µm deep. Covering stroma up to 40-65 µm thick near the centre of the ascomata, thinner towards the edges, not extending to or slightly to the basal stroma, consisting of an outer layer of host cuticle, a layer of textura angularis but textura epidermoidea with thick-walled, dark brown cells near the inner part of the covering layer. A triangular space between the covering stroma and the basal stroma filled with thin-walled, hyaline cells. Lip cells sparse, disappearing at maturity. Basal stroma poorly developed or absent, the epidermal cells underneath basal stroma tinted. Subhymenium 8-15 µm thick, composed of textura intricata. Paraphyses 120-150 ×



Figs. 12-19. *Lophodermium petrakii* on *Cunninghamia lanceolata*. 12, 13. Needles bearing ascomata. 14. Ascomata as seen under a dissecting microscope. 15. Ascoma in vertical section. 16. Detail of an ascoma in vertical section. 17. Paraphyses, mature asci with ascospores, and liberated ascospores with gelatinous sheaths. 18. Conidioma in vertical section. 19. Conidiogenous cells and conidia.

2-3 µm, filiform, septate, not branched, slightly swollen at the apex, the paraphyses covered by gelatinous sheaths. Asci ripening sequentially, (60-)80-140 × 10-13 µm, cylindrical, thin-walled, sometimes rostrate at the apex at maturity, J-, without circumapical thickening. Ascospores 50-75 × 1.5-2 µm, filiform, slightly tapering near the base, hyaline, aseptate, with a 1-2 µm thick gelatinous sheath.

Conidiomata on both sides of needles. In surface view conidiomata 100-250 µm diam., elliptical or slightly irregular, concolorous with the substrate or slightly brown, dark brown when old, opening by one to several ostioles. In vertical section conidiomata subcuticular, 23-35 µm deep, upper layer composed of host cuticle and undistinguishable fungal tissue. Basal layer poorly developed. Conidiogenous cells 8-15 × 1-2 µm, cylindrical, tapering towards the tip. Conidia 4-7 × 0.8-1 µm, bacilliform, hyaline.

Zone lines present, frequent, black.

Specimen examined: TAIWAN, alt. ca. 400 m, 20 III 2001, R. Kirschner (s. n.) (AAUF), TAIWAN, Nantou, Huisunlinchang, ca. 800 m, 12 VIII 2004, R. Kirschner & C. J. Chen 2053 (TNM).

Host species: *Cunninghamia lanceolata* (Lamb.) Hook. (*Taxodiaceae*).

Known distribution: Europe (Durrieu 1957), Anhui, Jiangxi, Sichuan, Guizhou, Jiangsu, Hunan, Fujian, Guangxi, Shandong, Henan, Shanxi (Hou 2000, Lin et al. 1993), Taiwan.

Habitat: *L. petrakii* was collected from needles that were still attached to living and dead twig and shoot.

Notes: *Lophodermium petrakii* was often incorrectly described as *L. pinastri* or *L. uncinatum* Darker in China (Hou 2000, Teng 1996). However, *L. pinastri* only occurs on *Pinus* spp. (Minter 1981) and *L. uncinatum* is only known on *Abies* spp. in North America. They are morphologically quite different from *L. petrakii*.

Acknowledgements

We are grateful to Dr. W.Y. Zhuang and Dr. P.R Johnston for critically reading the manuscript, to T. Trampe for assisting in the wood anatomy of the substrate of *C. taiwanensis*, and to Dr. Y. Z. Wang for providing literature on ascomycetes from Taiwan. The study was supported by the National Science Council (NSC 93-2745-B-218-001-URD) of Taiwan, Deutscher Akademischer Austauschdienst of Germany (DAAD), and the National Natural Science Foundation of China (NSFC).

Literature Cited

Chen CY, Hsieh WH. 1994. Some new ascomycetous fungi for Taiwan. Trans. Mycol. Soc. R. O. C. 9: 39-54.

Durrieu G. 1957. Deux *Hypodermataceae* nouvelles sur conifers. Sydowia Beih. 1: 355-358.

Hou CL. 2000. The pathogenic fungi of *Rhytismataceae* on Chinese fir. Forest Pest and Disease. 19: 3-5. (in Chinese)

Hou CL. 2004. *Rhytismatales* (Ascomycota) in China-Ecology, Morphology, and Systematics [Dissertation]. Frankfurt am Main: J. W. Goethe-Universität Frankfurt, 2004. 279 pp.

Korf RP, Zhuang, WY. 1985. Some new species and new records of discomycetes in China. Mycotaxon 22: 483-514.

Johnston PR. 1994. Ascospore sheaths of some *Coccomyces*, *Hypoderma*, and *Lophodermium* species (*Rhytismataceae*). Mycotaxon 52: 221-239.

Li I.T, Hsieh WH. 1991. Two new species and 13 new records of ascomycetes from Taiwan. Trans. mycol. Soc. R. O. C. 6: 57-71.

Lin YR, Tang YP, Liu HY. 1993. Some members of the *Rhytismataceae* on conifers in the southern part of China. Acta Mycol. Sin. 12: 93-98. (in Chinese)

Lin YR, Li ZZ, Xu ZS, Wang JR, Yu SM. 2001. Studies on the genus *Coccomyces* from China IV. Mycosystema 20: 1-7. (in Chinese)

Minter DW 1981. *Lophodermium* on pines. Mycol. Pap. 147: 1-54.

Minter DW. 1985. Some members of the *Rhytismataceae* (Ascomycetes) on conifer needles from Central and North America. Pp. 71-106. In Peterson, G. W. Recent research on conifer needles diseases conference proceedings. Gen. Techn. Rep., WO-50, U. S. Forest Serv.

Ortiz-García S, Gernandt DS, Stone JK, Johnston PR, Chapela IH, Salas-Lizana R, Alvarez-Buylla ER. 2003. Phylogenetics of *Lophodermium* from pines. Mycologia 95: 846-859.

Sawada K. 1943. Descriptive catalogue of the Formosan fungi. Part VIII. Rep. Dept. Agric. Gov. Res. Inst. Formosa 85: 1-130, in: Anonymous. 1999. List of the Fungi in Taiwan. Council of Agriculture, Executive Yuan, Taipei, 289 pp.

Sawada K. 1944. Descriptive Catalogue of Formosan Fungi. Part X. Rep. Dept. Agric. Gov. Res. Inst. Formosa 87: 1-97, in: Anonymous. 1999. List of the Fungi in Taiwan. Council of Agriculture, Executive Yuan, Taipei, 289 pp.

Sawada K. 1959. Descriptive Catalogue of Taiwan (Formosan) Fungi. XI. College of Agriculture, National Taiwan University, Taipei, Taiwan: 1-268 + plates I-XII.

Sherwood MA. 1980. Taxonomic studies in *Phacidiales*: the genus *Coccomyces* (*Rhytismataceae*). Occ. Pap. Farlow Herb. Crypt. Bot. 15: 1-120.

Sivanesan A, Hsieh WH. 1989. New species and records of ascomycetes from Taiwan. Mycol. Res. 93: 340-351.

Teng SC. 1996. Fungi of China. Mycotaxon, Ltd., Ithaca, N.Y. 586 pp.

Wu ML, Wang YZ. 2000. Mycological resources of saprophytic ascomycetes in Fushan Forest. Fung. Sci. 15: 1-14.

MYCOTAXON

Volume 95, pp. 81–90 *January–March 2006*

Macromycetes of Pinacate and Great Altar Desert biosphere reserve, Sonora, Mexico

MARTÍN ESQUEDA[1*], MARTHA CORONADO[2], ALFONSO SÁNCHEZ[1], EVANGELINA PÉREZ-SILVA[3] & TEÓFILO HERRERA[3]

**esqueda@cascabel.ciad.mx*

[1]Centro de Investigación en Alimentación y Desarrollo A.C. Apartado Postal 1735, Hermosillo 83000, Sonora. México

[2]Centro de Estudios Superiores del Estado de Sonora Apartado Postal 11, Admón. 11, Hermosillo 83000, Sonora. México

[3]Laboratorio de Micología, Instituto de Biología, UNAM Apartado Postal 70-233, Coyoacán 04510, México D.F. México

Abstract—Macromycetes associated with four different vegetation types in the Pinacate and Great Altar Desert biosphere reserve were studied over a one-year period. Twenty-seven taxa representing the *Phallales* and *Agaricales* were determined. Families represented include the *Geastraceae* (4), *Agaricaceae* (5), *Phelloriniaceae* (1), *Lycoperdaceae* (4), *Schizophyllaceae* (1), and *Tulostomataceae* (12). Of these, *Montagnea arenaria* and *Podaxis pistillaris*, which produced the highest number of collections, were the most widely distributed; species belonging to the *Geastraceae* and *Lycoperdaceae* showed a more restricted distribution. The most species-rich genus was *Tulostoma* with 12 taxa. *Geastrum berkeleyi, G. schmidelii* and *Tulostoma mohavei* are new records for México. Chorology and phenology of all species are outlined, and SEM micrographs of basidiospores representing six species are provided.

Key words—Gasteromycetes, taxonomy, chorology, phenology, SEM

Introduction

Mexico ranks among the first three places in the world as far as biological wealth is concerned, with over 12% of the world's biota. In general, its topography and geographical location on the boundaries of confluence of the neo-arctic and neo-tropical zones explain the large variety of ecosystems and resultant biological diversity. The Pinacate and Great Altar Desert biosphere reserve, which is located 31°30'-32°30' N and 113°00'-114°30' W, comprises an area of 714,556.5 ha. The core area includes two discontinuous regions: the Sierra del Rosario in the reserve's northwestern edge (with 41,392.5 ha) and the Sierra El Pinacate in the reserve center and eastern portion (with 228,112.75 ha). The buffer zone comprises 445,051.25 ha.

Over 50% of Sonora's area, 185,431 km^2, corresponds to the Sonoran Desert, from which the remainder covers a portion of Baja California Sur in Mexico and Arizona and

California in the United States. This region is considered a tropical-subtropical desert with bi-modal rain patterns. Its climate, physiography, edaphology, and hydrography favor the establishment of a large diversity of species (Shreve & Wiggins 1975). The Sonoran Desert has four subdivisions, each of which has very particular features: the central gulf coast, the Sonoran plains, the Arizona high plateau, and the lower Colorado river valley.

The biological diversity thus far catalogued for the biosphere reserve is represented by the following species: 41 mammals, 184 birds, 43 reptiles, 4 amphibians, 2 native fresh water fish, 560 vascular plants, and 11 fungi, including six Myxomycetes—*Didymium dubium* Rostaf., *Badhamia melanospora* Speg., *Fuligo intermedia* T. Macbr., *Physarum notabile* T. Macbr., *P. robustum* (Lister) Nann.-Bremek. and *P. straminipes* Lister (Moreno et al. 2004)—and five Gasteromycetes—*Battarreoides diguetii* (Pérez-Silva et al. 1994), *Dictyocephalos attenuatus* (Peck) Long & Plunkett (Esqueda et al. 1998), *Tulostoma cretaceum*, *T. fimbriatum*, and *T. leiosporum* (Esqueda et al. 2004).

Our study expanded what is known about macromycetes diversity in the Pinacate and Great Altar Desert Biosphere Reserve. We report below on the 27 species recorded during our survey, of which 23 are new to the reserve and three are new to the Mexican mycobiota.

Materials and methods

The survey was conducted at Pinacate and Great Altar Desert biosphere reserve. Four types of vegetation were sampled seasonally from fall 2003 to summer 2004: microphyllous desert scrub, sandy desert vegetation, mezquital, and sarcocaule scrub. The 10 sites studied were geo-referenced with a Magellan GPS ProMark X (Magellan System Corp., San Dimas, CA) (Table 1).

The sites have a dry type climate of the very dry, semi-warm sub-type, which is bi-modal: November to April and May to October with temperatures of 6 to 21°C and 18 to 36°C, and rainfalls from 0 to 100 mm and 50 to 100 mm, respectively. The areas are located within the Sonoran plain, Altar Desert sub-province, Sonoran mountain range (sierra) and plain. Topographically, the sites correspond to sierra (Los Tanques), sandy zones (Ejidos of Punta Peñasco, Los Norteños, Sierra Blanca and Cerro Lava), sierras and small hills (Papalote), and badlands (Ejido of San Juanico; Celaya, El Colorado and El Elegante Craters).

Taxonomic classification follows Kirk et al. (2001). Specimens were collected and conserved following conventional mycological techniques. Spores of most of the species were observed under a Jeol, JSM-5200 scanning electron microscope (SEM). Samples were studied after a treatment in a Polaron E-2000 equipment for 60 seconds at 1.2 Kv and 20 mA in an argon atmosphere until a 500 Å gold cover was obtained. Specimens are kept in the macromycetes collection of the Centro de Estudios Superiores del Estado de Sonora (CESUES) with some duplicates at the National Herbarium (MEXU).

This work was presented at the "Fungal Biodiversity Symposium", realized on March 4th, 2005 to commemorate the 60th anniversary as researcher of the Emeritus Professor Dr. Teófilo Herrera at the Institute of Biology, UNAM.

Table 1. Sampling localities in Pinacate and Great Altar Desert biosphere reserve

Localities	N	W	Altitude	Vegetation
Municipality of Sonoyta				
I. Sierra Los Tanques	31°46'12"	113°00'48"	371 m	MDS
II. Ejido Punta Peñasco	31°45'41"	113°15'57"	154 m	SDV
III. Papalote	31°55'44"	113°01'40"	307 m	M
IV. Crater Celaya	31°59'17"	113°27'20"	277 m	SS
V. Crater El Colorado	31°55'04"	113°18'44"	201 m	SS
Municipality of San Luis Rio Colorado				
VI. Cerro Lava	32°03'02"	113°33'33"	229 m	SDV
Municipality of Puerto Peñasco				
VII. Crater El Elegante	31°51'34"	113°22'55"	252 m	SS
VIII. San Juanico	31°50'01"	113°20'13"	198 m	SS
IX. Ejido Los Norteños	31°39'36"	113°19'37"	132 m	SDV
X. Sierra Blanca	31°31'32"	113°25'28"	60 m	SDV

Vegetation types: Microphyllous Desert Scrub (MDS); Sandy Desert Vegetation (SDV); Mezquital (M); Sarcocaule Scrub (SS).

Results and discussion

Phallales: Geastraceae—The family is characterized by gastrocarps with peridia that split into stellate rays, unbranched capillitia, and warty spores. Four taxa were determined within *Geastrum*, three of them found in the mezquital: *G. berkeleyi*, *G. kotlabae* and *G. schmidelii* (Table 2). *Geastrum berkeleyi,* which is close to *G. campestre* Morgan, *G. kotlabae,* and *G. pseudolimbatum* Hollós, was diagnosed based on the following features: a conical, plicate peristome, a coarse endoperidium, a short stalk and a non-hygroscopic exoperidium. Spores measure 5–6 µm diam.; SEM micrographs indicate that the epispore is composed of columnar processes with truncated apices that are about 0.7 µm high and occasionally confluent (Fig. 1). *G. berkeleyi* is a first record for Mexico.

Macroscopically, *Geastrum kotlabae* is similar to *G. campestre* and *G. pouzarii* V.J. Staněk, but differs by having a sessile spore sac in contrast to the stalked endoperidial sac in the other two species. In Mexico, it is known to grow in arid areas of Baja California, Tlaxcala and Sonora (Guzmán & Herrera 1969, Esqueda et al. 2003, Calonge et al. 2004). *G. kotlabae* was the only species collected throughout the year (Table 2). Within the Sonoran Desert, *G. minimum* has been found to grow in microphyllous desert scrub, tropical thorn forest, spiny scrubland and tropical deciduous forest (Pérez-Silva et al. 1999, Esqueda et al. 2003). In this specific study, it was collected from sarcocaule scrubland in spring.

The gastrocarp of *Geastrum schmidelii* resembles that of *G. pectinatum* Pers. but is smaller and has a short-stalked endoperidial sac covered by a thin powdery layer (this

Table 2. Distribution of macromycetes species in the Pinacate and Great Altar Desert biosphere reserve

SPECIES	LOCALITIES									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Phallales, Geastraceae										
**Geastrum berkeleyi* Massee			4							
Geastrum kotlabae V.J. Staněk	2		1,2,3,4							
Geastrum minimum Schwein.							1			
**Geastrum schmidelii* Vittad.			3,4							
Agaricales, Agaricaceae										
Longula texensis (Berk. & M.A. Curtis) Zeller	2	3				3				
Chlorophyllum molybdites (G. Mey.) Massee			3							
Endoptychum arizonicum (Shear & Griffiths) Singer & A.H. Sm.		1							1	
Montagnea arenaria (DC.) Zeller	1,2,4	1,2,3,4	1,2,3,4	1,2,3,4	1,4	1,2,3	1	2	3,4	3,4
Podaxis pistillaris (L.) Fr.	2,3,4	1,2,4	1,2,3,4	4	1,2,4	1	1,2,4	3,4	1,2,3,4	1
Phelloriniaceae										
Phellorinia herculeana (Pall.) Kreisel emend. Demoulin	4									
Lycoperdaceae										
Abstoma stuckertii (Speg.) J.E. Wright & V.L. Suárez			2							
Calvatia pygmaea (R.E. Fr.) Kreisel et al.		1,2,4							2	

Season: 1 (Spring); 2 (Summer); 3 (Autumn); 4 (Winter). * New records for the Mexican mycobiota. See Table 1 for locality data.

Table 2 (Reserve macromycete distribution), concluded

SPECIES	LOCALITIES									
	I	II	III	IV	V	VI	VII	VIII	IX	X
Disciseda hyalothrix (Cooke & Massee) Hollós	2									
Disciseda verrucosa G. Cunn.			2,4							
Schizophyllaceae										
Schizophyllum commune Fr.			1,2,3,4							
Tulostomataceae										
Battarreoides diguetii (Pat. & Har.) R. Heim & T. Herrera					2				4	
Schizostoma laceratum Ehrenb.	1,2,4	1,2,4	2,3		4	1,4	1	1	1	
Tulostoma albicans V.S. White	2									
Tulostoma cretaceum Long		2				2			1	
Tulostoma fimbriatum Fr.			1,2,3						1	
Tulostoma involucratum Long							2			
Tulostoma leiosporum R.E. Fr.	4	2	1,4	2		1,4			1	
**Tulostoma mohavei* Lloyd	2									
Tulostoma nanum (Pat.) J.E. Wright		2		1			1,4		1	
Tulostoma obesum Cooke & Ellis		1	2	2,4	1	1,4	1,4	2,4	1	1,4
Tulostoma pygmaeum Lloyd	2									
Tulostoma xerophilum Long	2			1						

Season: 1 (Spring); 2 (Summer); 3 (Autumn); 4 (Winter). * New records for the Mexican mycobiota. See Table 1 for locality data.

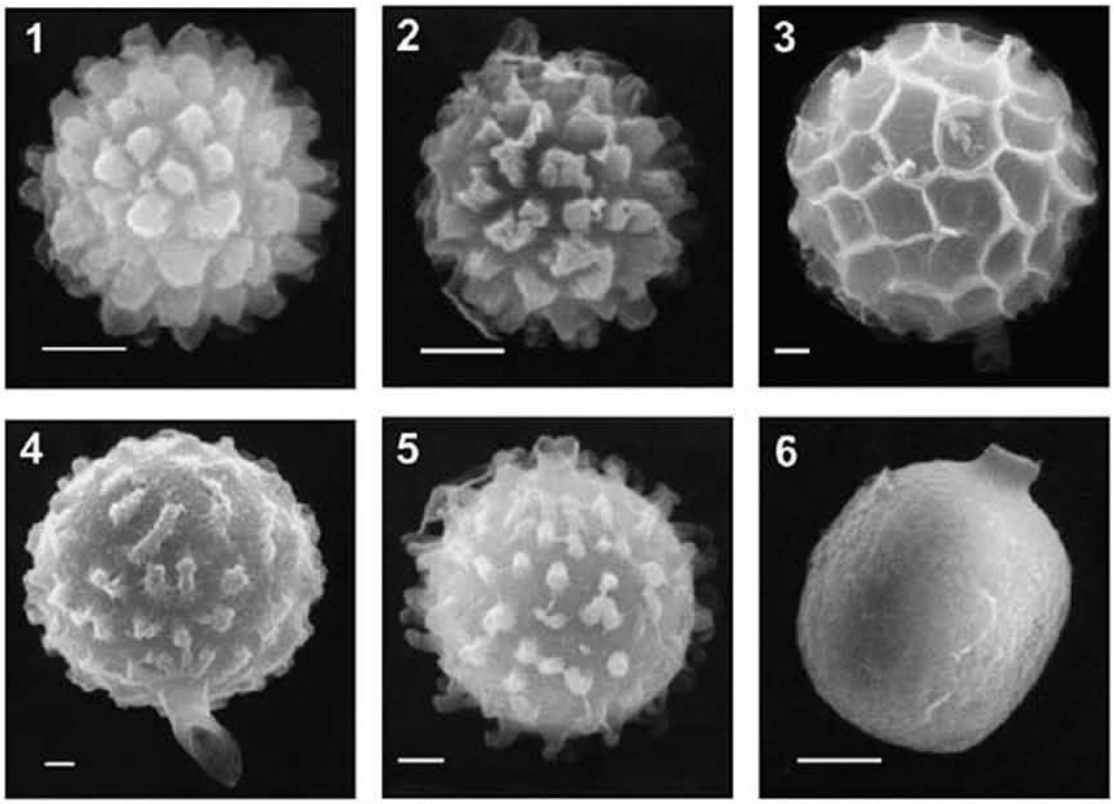
crystalline pruina is occasionally absent). Spores measure from 4.5 to 5.5 µm; SEM microphotos reveal an epispore formed of warts and columnar processes that are about 0.5 µm high and occasionally coalescent (Fig. 2). In Northwestern Europe, it grows in association with scrubland vegetation in open areas on well-drained sandy, slightly alkaline and calcareous soils (Sunhede 1989). These features are similar to those of the site, where it was collected in mesquite tree vegetation in the Sonoran reserve (Table 2). It is recorded for the first time in Mexico.

Agaricales: Agaricaceae—This family comprises 51 genera and 918 species. It is characterized by basidiomes with velar structures and spores of variable color but never rusty-brown or cinnamon-brown (Kirk et al. 2001). Five taxa were determined for *Agaricaceae*, with *Montagnea arenaria* and *Podaxis pistillaris* outstanding as they were present in all sites and found throughout the year at several sites. Both have smooth, thick-walled pigmented spores. These characteristics help to explain its wide distribution throughout the reserve under extreme conditions, as they are commonly found in areas with no vegetation at all. Apparently these fungi, together with species that belong to the *Tulostoma obesum* complex, are the best adapted in this ecological reserve. They have been registered for several xeric regions of Sonora (Aparicio-Navarro et al. 1994, Pérez-Silva et al. 1994, Esqueda et al. 1998).

Longula texensis, *Chlorophyllum molybdites* and *Endoptychum arizonicum* had a more restricted distribution. *Longula texensis*, which is similar to *Gyrophragmium dunalii* (Fr.) Zeller, is considered uncommon in Mexico (Ochoa 1993). Recently Geml et al. (2004), based on the sequence of internal transcription spacers (ITS) and largest partial sub-unit of ribosomal ADN, confirmed that these species are valid since they evolved from different *Agaricus* taxa. *Chlorophyllum molybdites* is widely distributed throughout Mexico and can cause gastrointestinal distress (Pérez-Silva 2004). It was restricted to areas of mezquital at the end of the rainy season during fall. Although *Endoptychum arizonicum* has been frequently collected in arid areas of Sonora (Esqueda et al. 1990, 1998), distribution in the reserve was restricted to two sites with sandy desert vegetation. This secotioid fungus with smooth and thick-walled spores is well-adapted to xeric environments.

Agaricales: Phelloriniaceae—Diagnostic characters of this family include stipitate gastrocarps and basidia that persist in bundles in the mature gleba. Although *Phellorinia herculeana* is widely distributed throughout the world's arid regions, it is uncommon. In fact, this is the third record for Sonora: *P. herculeana* was previously cited for the microphyllous desert scrub (Aparicio-Navarro et al. 1994) and in spiny scrubland (Esqueda et al. 1998). Recordings for Mexico are scarce: San Luis Potosí, Sinaloa (Guzmán & Herrera 1969), Nuevo León and Tamaulipas (Urista et al. 1985). It was the only species observed growing in the microphyllous desert scrub, solitary during winter in the Pinacate (Table 2).

Agaricales: Lycoperdaceae—Family features include epigeous gasterocarps with apical openings, hyphae lacking clamp connections, and powdery gleba. The four representatives of the *Lycoperdaceae* that were determined had a restricted distribution and fruited during summer (Table 2). *Abstoma stuckertii* was found in association with



Figs. 1–6. SEM micrographs of basidiospores. Fig. 1. *Geastrum berkeleyi* (CESUES 5111). Fig. 2. *Geastrum schmidelii* (CESUES 5108). Fig. 3. *Abstoma stuckertii* (CESUES 5232). Fig. 4. *Disciseda hyalothrix* (CESUES 5208). Fig. 5. *Disciseda verrucosa* (CESUES 5226). Fig. 6. *Tulostoma mohavei* (CESUES 5209). Scale bar = 1 µm.

mezquital. The size and ornamentation of spores (Fig. 3) allow it to be easily identified. It is known to the United States, Argentina, and Australia (Suárez & Wright 1990).

Disciseda hyalothrix was only collected in microphyllous desert scrub. Gastrocarps of *Disciseda* taxa are similar and can be recognized by their distinctive spore ornamentation. *D. hyalothrix* is characterized by an epispore forming columnar processes that have flattened and confluent tips (Fig. 4). In Mexico, it has been recorded for xeric regions in Chihuahua (Laferriere & Gilbertson 1992), Sonora (Esqueda et al. 1995a) and Baja California (Ochoa et al. 2000).

The known distribution of *Disciseda verrucosa* on the American continent is restricted to Sonora, Mexico, where it is associated with microphyllous desert scrub (Aparicio-Navarro et al. 1994), spiny scrubland, and the low deciduous forest (Pérez-Silva et al. 2000). Spore ornamentation is very characteristic under SEM with an epispore composed of small warts and obtuse finger-like processes (Fig. 5). In the reserve, it was seen in mezquital during summer and winter.

Calvatia pygmaea is a xerophilous bovistoid species that belongs to *Calvatia* Section *Lanopila* (Fr.) Kreisel and is the only taxon in this group that has smooth spores under both LM and SEM. Worldwide, it is only known from Argentina and Bolivia (Fries 1909) and Baja California Sur, Mexico (Ochoa et al. 1998). It was restricted to sandy desert vegetation with gastrocarps collected in all seasons except autumn in the reserve (Table 2).

Agaricales: Tulostomaceae—Family characters include stipitate gasterocarps having long stalks with globose heads, peridia with apical pores, and pleurosporous basidia. *Battarreoides diguetii* has been previously registered for several sites in the Sonoran Desert (Pérez-Silva et al. 1994, Esqueda et al. 1995b). In the Pinacate, it was observed to grow in sarcocaule scrubland and sandy desert vegetation in summer and winter, respectively.

Schizostoma laceratum is only known to grow in Northwestern Mexico in Baja California (Moreno et al. 1995) and Sonora (Esqueda et al. 1995b). It showed a wide distribution within the reserve, growing in all types of vegetation, bearing gastrocarps mainly during spring (Table 2).

Different species of *Tulostoma* showed a restricted distribution: *T. albicans, T. mohavei* and *T. pygmaeum* were all found in microphyllous desert scrubland, and *T. involucratum* was found in sarcocaule scrubland (Table 2). In contrast, *T. leiosporum* and *T. obesum*, characterized by their subsmooth (rugose) and smooth spores under SEM, respectively, which have a thick and pigmented wall, had a wider distribution. *Tulostoma fimbriatum* was collected throughout the year, except for winter, while growing in mezquital. *Tulostoma mohavei* is similar to *T. obesum*, its difference being the ferruginous ochre colored gleba and the dark ferruginous to chocolate colored gleba, respectively. This is the first report for Mexico of *T. mohavei*, which previously had been cited in North America only from Arizona and California in the United States. The distribution of *Tulostoma pygmaeum* in Mexico was only known to Veracruz, Oaxaca (Wright 1987) and Baja California (Moreno et al. 1995). This is the first record for the Sonoran mycota.

Agaricales: Schizophyllaceae—This family comprises 5 genera and 43 taxa characterized by pleurotoid basidiomes with split-lamellate hymenophores (Kirk et al. 2001). *Schizophyllum commune* is widely distributed throughout Mexico from arid to template zones, occasionally in cold areas (Olivo & Herrera 1994). In the Pinacate, it was collected throughout the year only in mesquite tree vegetation (Table 2).

Acknowledgments

The authors thank SEMARNAT-CONACYT (Grant 2002-C01-0409) and DGAPA (Grant IN206901 (México). Our gratitude is to M.B. Mendoza-Garfias (UNAM) for her assistance with SEM. We are grateful to Prof. H. Kreisel and Prof. F.D. Calonge for the critical revision of the manuscript.

Literature Cited

Aparicio-Navarro A, Quijada A, Quintero T, Búrquez A. 1994. Nuevos Gasteromicetos para la micobiota de Sonora, México. Ecológica 3: 11-14.

Calonge FD, Guzmán G, Ramírez F. 2004. Observaciones sobre los Gasteromycetes de México depositados en los herbarios XAL y XALU. Boletín de la Sociedad Micológica de Madrid 28: 337-371.

Esqueda M, Quintero T, Pérez-Silva E, Aparicio A. 1990. Nuevos registros de Gasteromycetes de Sonora. México. Revista Mexicana de Micología 6: 91-104.

Esqueda M, Pérez-Silva E, Herrera T. 1995a. New records of Gasteromycetes for Mexico. Documents Mycologiques 98-100: 151-160.

Esqueda M, Pérez-Silva E, Villegas RE, Araujo V. 1995b. Macromicetos de zonas urbanas, II: Hermosillo, Sonora, México. Revista Mexicana de Micología 11: 123-132.

Esqueda M, Pérez-Silva E, Herrera T, Moreno G. 1998. Adiciones al conocimiento de los Gasteromicetos de Sonora, México. Revista Mexicana de Micología 14: 41-52.

Esqueda M, Herrera T, Pérez-Silva E, Sánchez A. 2003. Distribution of *Geastrum* species from some priority regions for conservation of biodiversity of Sonora, Mexico. Mycotaxon 87: 445-456.

Esqueda M, Moreno G, Pérez-Silva E, Sánchez A, Altés A. 2004. The genus *Tulostoma* in Sonora, Mexico. Mycotaxon 90: 409-422.

Fries RE. 1909. Über einige Gasteromyceten aus Bolivia and Argentinien. Arkiv for Botanik 8: 1-34.

Geml J, Geiser DM, Royse DJ. 2004. Molecular evolution of *Agaricus* species based on ITS and LSU rDNA sequences. Mycological Progress 3: 157-176.

Guzmán G, Herrera T. 1969. Macromicetos de las zonas áridas de México, II. Gasteromicetos. Anales del Instituto de Biología de la Universidad Nacional Autónoma de México, Serie Botánica 40: 1-92.

Kirk PM, Cannon PF, David JC, Stalpers JA. 2001. Ainsworth and Bisby's dictionary of the fungi. 9th ed. CAB International, Wallingford-Oxon.

Laferriere JE, Gilbertson RL. 1992. Fungi of Nabogame, Chihuahua, Mexico. Mycotaxon 44: 73-87.

Moreno G, Altés A, Ochoa C, Wright JE. 1995. Contribution to the study of the Tulostomataceae in Baja California, Mexico. I. Mycologia 87: 96-120.

Moreno G, Illana C, Esqueda M, Castillo A, Pérez-Silva E. 2004. Notes on Myxomycetes from Mexico II. Boletín de la Sociedad Micológica de Madrid 28: 55-63.

Ochoa C. 1993. Contribución al estudio taxonómico, ecológico y corológico de la clase Gasteromycetes *sensu lato* en Baja California, México. Doctoral Thesis. Universidad de Alcalá, Alcalá de Henares.

Ochoa C, Moreno G, Altés A, Kreisel H. 1998. *Calvatia pygmaea* (Gasteromycetes) in the deserts of Baja California Sur (Mexico). Cryptogamie Mycologie 19: 131-137.

Ochoa C, Moreno G, Altés A, Aguilar-Rodríguez JL. 2000. Gasteromycetes de Sierra Juárez, Baja California, México. I. Boletín de la Sociedad Micológica de Madrid 25: 157-166.

Olivo F, Herrera T. 1994. Las especies de *Schizophyllum* en México, su distribución ecológica e importancia etnomicológica. Revista Mexicana de Micología 10: 21-32.

Pérez-Silva, E. 2004. Intoxicación por hongos. 305-329, in OB Martínez (ed.), Intoxicaciones. México, McGraw-Hill-Interamericana.

Pérez-Silva E, Esqueda M, Herrera T. 1994. Contribución al conocimiento de los Gasteromicetos de Sonora. Revista Mexicana de Micología 10: 77-101.

Pérez-Silva E, Herrera T, Esqueda M. 1999. Species of Geastrum (Basidiomycotina: Geastraceae) from Mexico. Revista Mexicana de Micología 15: 89-104.

Pérez-Silva E, Esqueda M, Herrera T, Moreno G, Altés A. 2000. *Disciseda verrucosa* (Gasteromycetes) in Mexico. Mycotaxon 76: 337--341.

Shreve F, Wiggins IL. 1975. Vegetation and flora of the Sonoran Desert. Stanford University Press, Stanford.

Suárez V, Wright JE. 1990. South American Gasteromycetes IV. The genus *Abstoma*. International Journal of Cryptogamic Botany 1: 372-383.

Sunhede S. 1989. *Geastraceae* (Basidiomycotina). Morphology, ecology, and systematics with special emphasis on the North European species. Synopsis Fungorum 1. Fungiflora. Grønlands Grafiske A/S, Oslo.

Urista E, García J, Castillo J. 1985. Algunas especies de Gasteromicetos del Norte de México. Revista Mexicana de Micología 1: 471-523.

Wright JE. 1987. The genus *Tulostoma* (Gasteromycetes). A world monograph. J. Cramer, Berlin-Stuttgart.

MYCOTAXON

Volume 95, pp. 91–96 *January–March 2006*

A new species and a new record of *Lycoperdaceae* from India

DIPIKA BISHT[1], J.R. SHARMA[1], HANNS KREISEL[2] & KANAD DAS[3*]

[1]*Botanical Survey of India*
192, Kaulagarh Road, Dehradun 248195, India

[2]*Zur Schwedenschanze 4, D-17498 Potthagen, Germany*

[*]*daskanad@yahoo.co.in*
[3]*Mycology Group, Agharkar Research Institute*
G.G. Agarkar Road, Pune 411004, India

Abstract—A new species, *Lycoperdon ovalicaudatum* and a new record, *Calvatia longicauda*, are described and illustrated in detail from Western Himalaya, India.

Key words—macrofungi, Gasteromycetes, *Lycoperdales*, taxonomy

Introduction

During the macrofungal investigation in Western Himalaya, authors collected some interesting specimens belonging to *Lycoperdon* Tourn.:Pers. and *Calvatia* Fr. Macroscopic and microscopic studies followed by literature survey revealed them as an undescribed species proposed herein as *Lycoperdon ovalicaudatum*, and *Calvatia longicauda* reported for the first time from India. The genus *Lycoperdon* is characterized by having basidiomata with more or less distinct pseudostipe, opening by apical pore and branched, rarely septate, capillitial hyphae. Out of ca 50 species known from the world over (Kirk et al. 2001), only a few have pedicellate spores. The genus *Calvatia* characterized by irregular dehiscence of peridium and regularly septate capillitium, comprises ca 36 species world wide (Kreisel 1994). Preliminary surveys have revealed rich representation of these genera in the Himalayan forests (Ahmad 1941, Gupta et al. 1974, Khare 1976, Thind & Thind 1982).

Materials and Methods

The present communication is based on the surveys undertaken to different localities of Uttaranchal during June–October in 2004 and 2005. Morphological characters were noted from the fresh specimens in the field. Microscopic anatomical details were studied from the dried material mounted in 5% KOH, lactophenol–cotton blue and lactic acid. Line drawings were prepared with the aid of camera lucida attachment at original magnification of 1500x for basidiospores, 500x for peridial structures and 500x or 1000x for capillitial hyphae. A total of 25 basidiospores were measured from

the holotype. Colour terminology follows Kelly & Judd (1955). Herbarium name used follow Holmgren et al. (1990). Kr. refers to the personal herbarium of H. Kreisel.

Description of the species

Lycoperdon ovalicaudatum D. Bisht, J.R. Sharma & Kreisel, **sp. nov.**

Fig. 1

Etymology: The name refers to the ovate, pedicellate spores of this taxon.

Basidiomata pyriformia-turbinata, 18–22 mm lata, 20–24 mm alta. Pseudostipes praesens. Exoperidium griseofuscum, spinosum, spinae densae in parte superiori, sparsae in parte inferiori. Endoperidium pallide flavum, brunneum. Gleba griseofusca, pulverulenta. Pseudocolumella indistincta. Subgleba loculata. Basidiosporae ovales, 5.4–5.7 x 3.7–3.9µm, glabrae, guttulatae, pedicelli hyalini, recti, ad 22µm longi. Capillitium 4–6µm latum, fuscogriseum, crassitunicatum, non septatum, glabrum, ramosum, parietes non perforatae. Paracapillitium 3–4µm latum, hyalinum, septatum, tenuitunicatum. Exoperidium 500µm crassum. Endoperidium 60µm crassum, hyphis 2µm crassis, non septatis. ***Holotypus:*** *INDIA, Uttaranchal, Nainital, Sheetla, August 23, 2004, leg. D. Bisht, DB514 (HOLOTYPUS, BSD; ISOTYPUS, Kr.).*

Basidiomata scattered or gregarious, pyriform to turbinate, 18–22 mm broad, 20–24 mm high. Rhizomorphs poorly branched. Pseudostipe present. Exoperidium dark greyish brown, spinose, spines up to 0.5 mm, dense, prominent on the upper part, scattered, blunt on pseudostipe. Endoperidium light yellowish brown, rough, opens by apical aperture. Gleba greyish brown, pulverulent at maturity. Pseudocolumella indistinct. Subgleba chambered, one- quarter of basidiomata in length, tapering towards base.

Basidiospores ovate, 5.4–5.7 x 3.7–3.9 µm, Q=1.5, smooth , guttulate, pedicellate, pedicels hyaline, long , curved, up to 22 µm in length. Capillitium greyish brown, 4–6 µm wide, smooth, aseptate, branched, thick-walled, wall more than 1µm thick, not pitted. Paracapillitium hyaline, 3–4 µm wide, smooth, septate, unbranched, thin-walled. Exoperidium pseudoparenchymatous, up to 500 µm thick, cells subglobose–oval, 20–40 x 14–32 µm in diameter, thin-walled. Endoperidium hyphal, up to 60 µm thick, hyphae narrow, up to 2 µm wide, aseptate, unbranched, thin-walled.

COLLECTIONS EXAMINED—**INDIA, Uttaranchal,** NAINITAL, Sheetla, on soil, August 23, 2004, leg. D. Bisht, DB514 (BSD).

Comments—*Lycoperdon ovalicaudatum* can be distinguished by comparatively smaller basidiomata, prominent spiny warts on the upper part, chambered subgleba and ovate, smooth, pedicellate spores. The shape and surface of basidiospores are unique which make this species distinct. The present taxon is close to *L. mundkurii* S. Ahmad but the latter has comparatively larger basidiomata with spines on exoperidium forming a dark central patch at the apical part. Further, *L. mundkurii* has verruculose spores with longer (30 µm) pedicels and much branched and wider (up to 10 µm wide) capillitial hyphae. *L. asperum* (Lév.) Speg. which also appears closer to the present taxon morphologically, has globose-subglobose spores and rudimentary subgleba (Bottomley 1948, Dissing & Lange 1962, Kreisel & Hausknecht 2002).

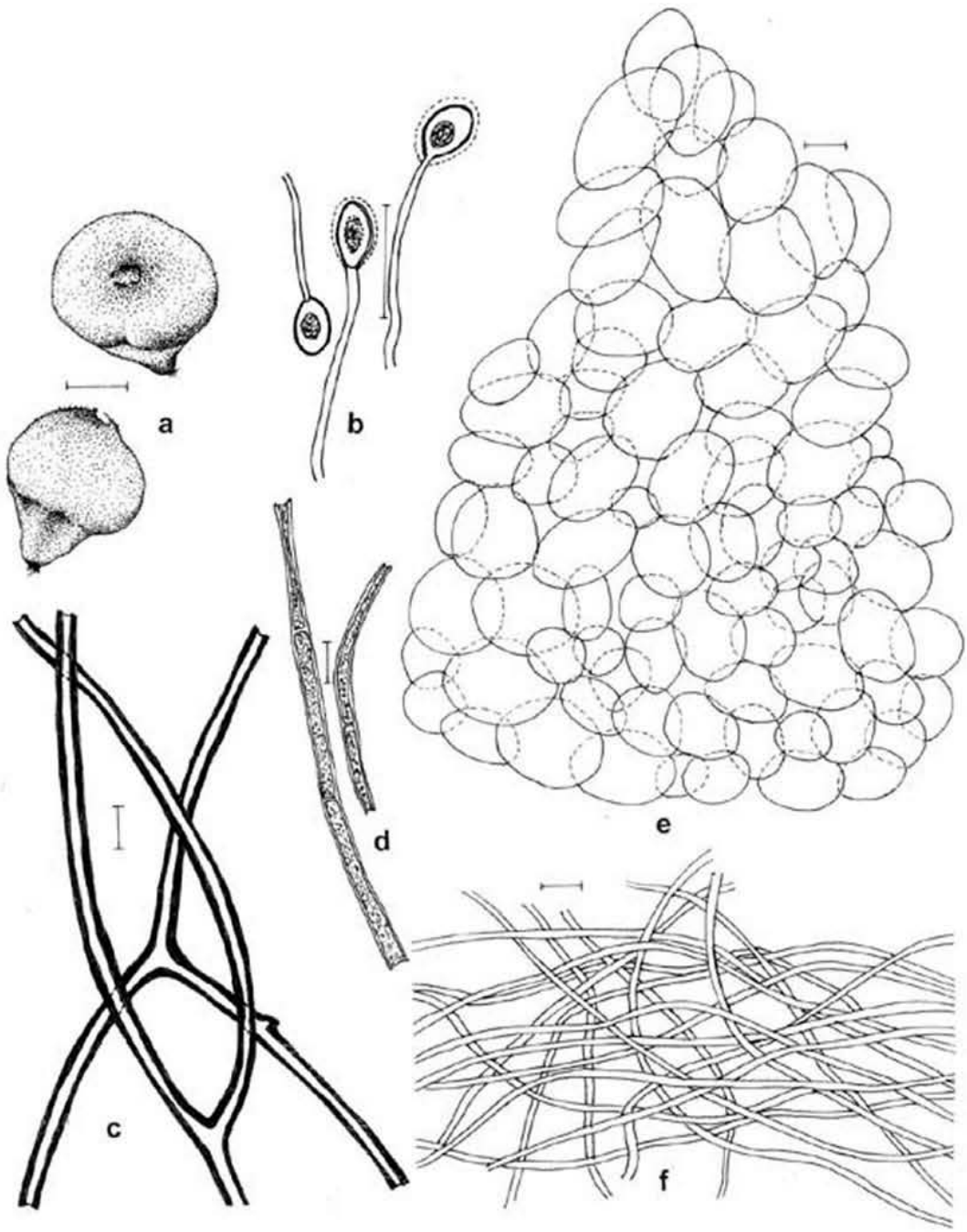


Fig. 1. *Lycoperdon ovalicaudatum* (from holotype): a. Basidiomata b. Basidiospores c. Capillitium d. Paracapillitium e. Exoperidium f. Endoperidium. Bars: a = 10 mm; b-f = 10 µm.

Calvatia longicauda (Henn.) Lloyd, Mycol. Writ. 2 (Letter 21): 3. 1908

=*Lycoperdon longicaudum* Henn., Botan. Jahrb. Syst. 23: 556. 1897

Fig. 2

Basidiomata scattered on leaf litter, turbinate-agaricoid, 4–8 cm broad, up to 7 cm high, distinctly lobed, irregular, flattened head with a long pseudostipe, fragile-brittle after drying. Rhizomorphs whitish, fine, profusely branched. Pseudostipe curved, up to 5 cm in length, tapering towards base. Exoperidium dark brown, verrucose with prominent verrucae on upper portion, shed off at maturity. Endoperidium light orange yellow, rough, peeling off in irregular flakes at maturity. Gleba medium yellow brown at centre, dark yellow brown beneath peridium, very persistent. Pseudocolumella indistinct. Subgleba dark yellowish brown, chambered.

Basidiospores globose-subglobose, 3.3–4.0 x 3.3–3.9 µm, verruculose, guttulate, apedicellate. Capillitium olivaceous yellow, up to 4 µm wide, lumen hyaline, septate, dichotomously branched, tapering towards ends, pitted, wall up to 1µm thick. Paracapillitium absent. Exoperidium pseudoparenchymatous, up to 625 µm thick, cells 10–25 x 7–15 µm, cylindrical, arranged in irregular chains on upper part, gradually subglobose, compact on lower part. Endoperidium hyphal, up to 125 µm thick, hyphae 2–4.5 µm wide, septate, branched, thin-walled.

COLLECTIONS EXAMINED—**INDIA, Uttaranchal,** DEHRADUN, Forest Research Institute campus (700 m), on soil, June 26, 2004, leg. D. Bisht & K. Das, DB1005 (BSD); ibid. Botanical Survey of India campus (700 m), on soil, October 8, 2005, leg. D. Bisht, DB605 (BSD).

Comments—The agaricoid basidiomata, ruptured peridium after drying and persistent gleba are the main determining features of this species. *Calvatia gardneri* (Berk.) Lloyd can be confused with this species in the field, but the earlier one lacks the persistent gleba and agaricoid basidiomata (Dring & Rayner 1967). *C. craniiformis* (Schwein.) Fr. resembles the present species in the manner of rupturing the peridium and in size and shape of basidiospores but differs in having wider (up to 7.7 µm) capillitial hyphae (Zeller & Smith 1964). Unlike *C. longicauda*, *C. candida* (Rostk.) Hollós has pulverulent gleba and pseudoparenchymatous exoperidium with cells not arranged in chains (Thind & Thind 1982).

Acknowledgements

The authors are thankful to the Director, Botanical Survey of India, Kolkata and Joint Director, Northern Circle, Dehradun for providing facilities during the present study. Prof. F.D. Calonge (Real Jardin Botánico, Madrid, Spain) and Prof. Gabriel Moreno (University of Alcalá de Henares, Spain) are duly acknowledged for critically reviewing the manuscript. Financial assistance to one of the authors (DB) is provided by Botanical Survey of India.

Literature Cited

Ahmad S. 1941. Higher Fungi of the Panjab Plains III. The Gasteromycetes. Jour. Ind. Bot. Soc. 20: 135–143.

Bottomley A.M. 1948. Gasteromycetes of South Africa. Bothalia 4: 473–810.

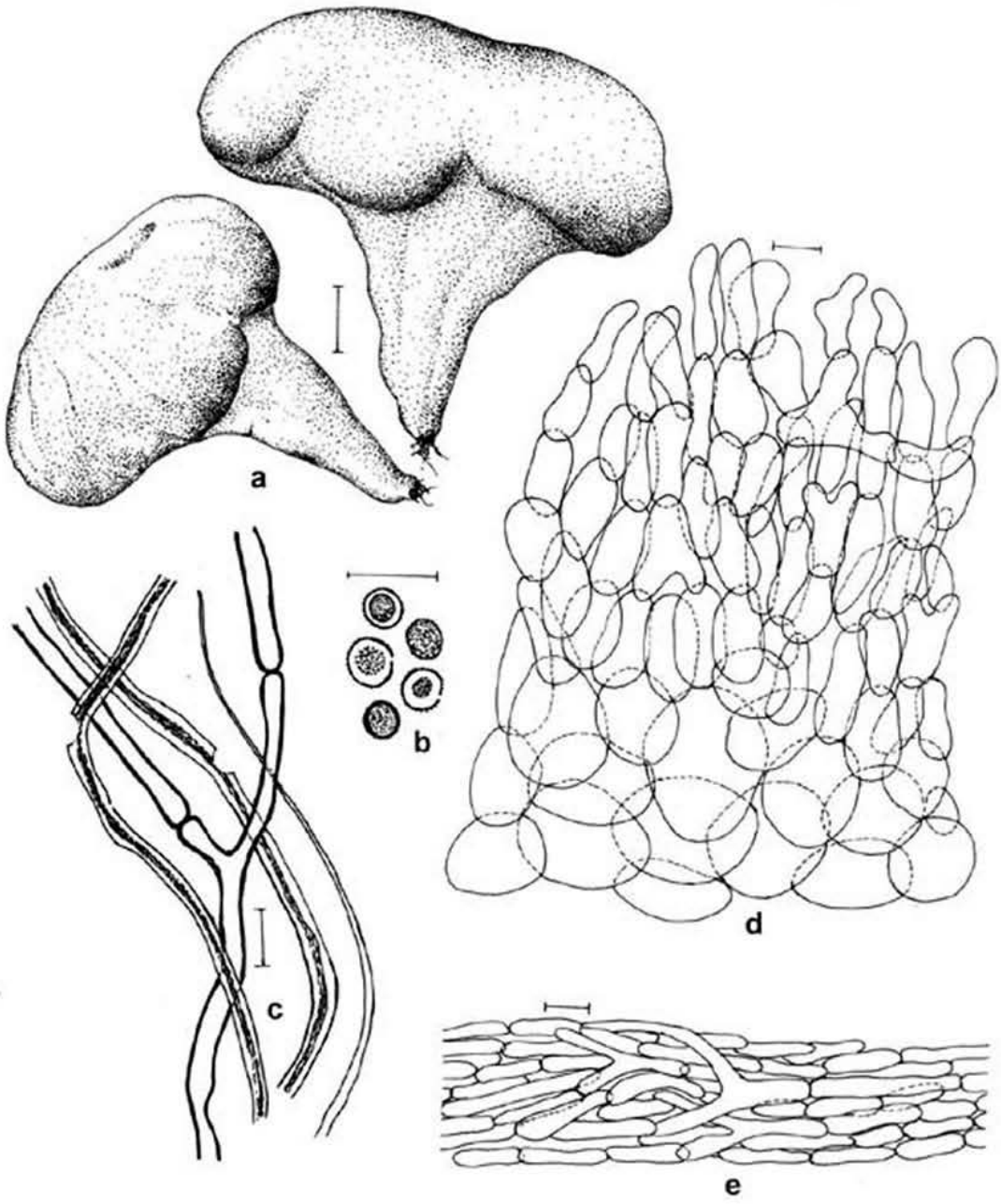


Fig. 2. *Calvatia longicauda*: a. Basidiomata b. Basidiospores c. Capillitium d. Exoperidium e. Endoperidium. Bars: a = 10 mm; b-e = 10 µm.

Dissing H, Lange M. 1962. Gasteromycetes of Congo. Bull. Jard. Bot. l'Etat 32(4): 325–416.

Dring DM, Rayner RW. 1967. Some Gasteromycetes from Eastern Africa. J. E. Afr. Nat. Hist. Soc. 26 no 2(114): 5–46.

Gupta KK, Agarwal RK, Kumar S, Seth PK. 1974. Gasteromycetes of Himachal Pradesh. Ind. Phytopath. 27(1): 45–48.

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index Herbariorum. Part 1: Herbaria of the world, 86th ed. Brox: New York Botanical Garden.

Kelly KL, Judd DB. 1955. The ISCC-NBS Method of Designating Colors and a Dictionary of Colour Names. ISCC-NBS Color-Name Charts Illustrated with Centroid Colors. National Bureau of Standards Circular 553. U.S. Government Printing Office, Washington, DC.

Khare KB. 1976. Some Gasteromycetes from Uttar Pradesh. Ind. Phytopath. 29: 34–38.

Kirk PM, Canon PF, David IC, Stalpers JA. 2001. Ainsworth & Bisby's Dictionary of the Fungi. 9th edition, CAB International, Wallinford, 655pp.

Kreisel H. 1994. Studies in the *Calvatia* complex (Basidiomycetes) 2. Feddes Repertorium 105(5–6): 369–376.

Kreisel H, Hausknecht A. 2002. The gasteral Basidiomycetes of Mascarenes and Seychelles. Österr. Z. Pilzk. 11: 191–211.

Thind KS, Thind IPS. 1982. The Gasteromycetes of the Himalayas II. Jour. Ind. Bot. Soc. 61: 19–32.

Zeller SM, Smith AH. 1964. The Genus *Calvatia* in North America. Lloydia 27(3): 148–186.

MYCOTAXON

Volume 95, pp. 97–112 *January–March 2006*

Notes on the type, synonyms, and other specimens of the balansioid fungus, *Nigrocornus scleroticus*

MALCOLM J. RYLEY*

malcolm.ryley@dpi.qld.gov.au
Department of Primary Industries and Fisheries
PO Box 102, Toowoomba Qld, 4350 Australia

Abstract—The type, and other specimens of the balansioid fungus, *Nigrocornus scleroticus*, its synonyms, and similar fungi studied during extensive research on the taxonomy and biology of the fungus, are described. Two hypocrealean fungi found parasitising the ascostromata of *N. scleroticus* are also discussed.

Key words—*Balansia sclerotica, Ephelis, Nectriella, Bionectria*

Introduction

Ryley (2003) erected the genus *Nigrocornus* Ryley & Langdon, with *Nigrocornus scleroticus* as the type and only species, to accommodate a balansioid fungus formerly known as *Balansia sclerotica*. Both the teleomorph and anamorph of this fungus differ significantly from all other members of the tribe *Balansieae*. The teleomorph consists of perithecia immersed in a black, corniform, papillate stroma, composed of hyphae and the protophyll of the axillary bud, at the nodes of tillers of its grass hosts. The dimensions of the ascostromata vary considerably from host to host. The cylindrical, unitunicate asci within the perithecia have a hemispherical cap perforated by a fine pore, and contain eight filiform, 7-septate ascospores. Upon discharge from the asci, the ascospores produce short germtubes from each cell, and break into two 3-septate part-spores. The anamorphic conidia develop holoblastically on short, indeterminate conidiophores which are on an effuse hyphal layer covering the abaxial surfaces of the upper leaves on tillers bearing the teleomorph. Both the morphology and ontogeny of the anamorphic conidia of *N. scleroticus* are identical to those described for *Ephelis* Fr., which is the anamorph of the balansioid genera, *Balansia* Speg., *Dothichloë* G.F. Atk., and *Myriogenospora* G.F. Atk., and one of the two anamorphs of *Atkinsonella* Diehl (White, 1997; Hodge, 2003). *Nigrocornus scleroticus*, whose *Ephelis* fructification and sexual state are spatially separated, differs from all other described balansioid fungi. The anamorph(s) and teleomorphs of these fungi develop in succession on the same stroma (White, 1997).

*Formerly of the Department of Botany, University of Queensland, St. Lucia Qld 4072, Australia

Ryley (2003) has described, in detail, the development and morphology of *N. scleroticus*, host symptomatology, the fungus' relationships with other balansioid genera, and has formally erected the new genus. In this paper I provide information on specimens of the synonyms and other collections of *N. scleroticus*. In addition, the features of two hyperparasitic hypocrealean fungi, found on some ascostromata of *N. scleroticus*, are described and their identity is discussed.

Examination of herbarium specimens

All herbarium specimens were examined in a similar manner. The dimensions, shape and other aspects of the morphology of papillate ascostromata were ascertained, and where possible a single ascostroma was removed from the host and soaked for 24 hours in lactophenol. Sections 1-2 mm thick were taken from the ascostroma, and perithecia teased from the stromatic hyphae. Data were gathered on the morphology of perithecia, asci and ascospores. The uppermost leaves of the specimens, where present, were examined for the presence of effuse conidial fructifications. When such a fructification was found, a portion was mounted in lactophenol-trypan blue for 2 hours before examination.

The type specimen of *N. scleroticus*

Epichloë sclerotica Pat., J. Bot. (Morot) 4: 65 (1890)

Synonyms: *Ophiodothis sclerotica* (Pat.) Henn., Ann. Naturhist. Mus. Wien 15: 2 (1900).
Balansia sclerotica (Pat.) Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 120: 449 (1911).
Parepichloë sclerotica (Pat.) J.F. White & P.V. Reddy, Mycologia 90: 231 (1998).
Nigrocornus scleroticus (Pat.) Ryley, Clavicipitalean Fungi: Evolutionary Biology, Chemistry, Biocontrol, and Cultural Impacts. pp. 267-268 (2003).

SPECIMEN EXAMINED–VIETNAM (as TONKIN). On ?*Cymbopogon* sp.: FAC-BIN 11.XI.1887 Balansa *FH* (**NEOTYPE**). Fig 1A.

Nigrocornus scleroticus is based on *Epichloë sclerotica*, which was described by Patouillard (1890) from a specimen collected in Tonkin, now Vietnam. The holotype of *E. sclerotica* could not be obtained from any herbarium, so the specimen listed above was designated as the neotype (see Ryley, 2003 for details). A complete description of Patouillard's original specimen is given by Ryley (2003). My observations on the teleomorph were almost identical with those of Patouillard (1890) except in some minor details. While Patouillard (1890), Hennings (1900), and Höhnel (1911) did not describe an anamorph for this species, Ryley (2003) found it to be present on the adaxial surfaces of the upper leaves of the neotype, and although in poor condition, to agree well with observations of the anamorph on fresh material of the fungus.

The type specimens of the synonyms and possible synonyms of *N. scleroticus*

1. *Hypocrella axillaris* Cooke, Grevillea 20: 4 (1891)

Synonyms: *Hypocrea axillaris* (Cooke) Massee, J. Bot. 34: 152 (1896).
Balansia axillaris (Cooke) Petch, Ann. Roy. Bot. Gard. (Peradeniya) 6: 171 (1916).

SPECIMENS EXAMINED–AUSTRALIA. **QUEENSLAND.** On Gramineae: BRISBANE FM Bailey *K ex Herb. FM Bailey 897&898*. On *Eragrostis pubescens* (R.Br.) Steud. (as *Eragrostis stricta* Cke.): WALSH R T Barclay-Millar *VPRI437 ex. Qld Herb.* (as *Eragrostis stricta*), .III.1891 T Barclay-Millar *DAR69754 ex Herb. FM Bailey 897 & 898* **(here designated LECTOTYPE). NORTHERN TERRITORY.** On *Chrysopogon violascens* Trin. (not a valid name; no known synonym): 20.IV.1916 GF Hill *VPRI438*.

Hypocrella axillaris was described by Cooke (1892) on grasses from Brisbane, Queensland, Australia, which had been collected by F.M. Bailey. The following description was provided by Cooke (1892): "Stroma obturbinate or obclavate, seated in the upper axils (5 mm long, 2-3 broad), black, opaque, minutely granular with the ostiola; substance white. Perithecia very minute, immersed in the periphery. Asci cylindrical, 120 µm long. Sporidia filiform, at length multiseptate (about 100 µ long), hyaline. On grasses, Brisbane (F.M. Bailey 897, 898)". Massee (1896) transferred the fungus to *Hypocrea* and considered that it was identical with *Hypocrea* (*Hypocrella*) *bambusae* Berk. & Broome. Some years later, Petch (1916) provided evidence by which the species *axillaris* and *bambusae* could be separated, and transferred both to *Balansia*. Petch (1916) added the following information on the morphology of the fungus – the stroma was adnate to the leaf (of the lateral shoot), the perithecia were flask-shaped, 0.15 mm deep and 0.15 mm diameter, and the asci were about 180 µm x 5 µm.

My examination of the specimens labelled F.M. Bailey 897 and 898 from several herbaria (*K, DAR*) has shown that the characteristics of that fungus published by Cooke (1892) and Petch (1916) were accurate, although the asci were closer to Petch's (1916) dimensions. On all specimens, a white flaky deposit was present on the adaxial surfaces of the uppermost leaves, but no acicular conidia were found. Some differences were observed in the stromata from material in the two specimens from Kew. In specimen number 897 the protophyll of the axillary bud at each node is attached to the stroma, whereas in number 898 the protophyll is not adnate to the stroma.

There is some evidence that Cooke's material was collected from at least two grass species. Firstly, Cooke (1892) described *H. axillaris* on "grasses". Secondly, large spines up to 1 mm long are present around the margin of the leaf blade on the host material in specimen 898, ex *K*. The spines are absent from leaf blades of the material in specimen 897 from that herbarium. The material in both specimens consists of only vegetative portions of the host, so the identity of the grasses cannot be ascertained with any certainty. One of the specimens in *DAR69754* consists of two short sections of culm held on a piece of card by a paper strap with the annotation "897 & 898". On each culm there is a single ascostroma, and a thin, dried, effuse hyphal sheet on the abaxial surfaces of the upper leaves. The long spines found in the Kew specimen 898 are absent from the leaves on both sections of culm, and the protophyll is adnate with stromal tissue on both ascostromata.

One of the hosts of this fungus is probably *Eragrostis pubescens* (R.Br.) Steud. (syn. *Eragrostis stricta* F.M. Bailey), because (i) Bailey (1913) listed it as the host of *Hypocrea axillaris*, (ii) in *VPRI437*, *E. stricta* is listed as the host of *Hypocrea* (*Hypocrella*) *axillaris* on a mounting board displaying a short length of a single culm with several ascostromata and the annotation "898" (iii) the annotation "Hypocrea (Hypocrella) axillaris on a grass (Eragrostis stricta) Walsh R, T.B. Millar" is on a specimen packet containing short sections of stem each with a single ascostroma in *DAR69754* and (iv) *Eragrostis stricta* was described

by Bailey (1891) from material collected at Walsh River, north-eastern Queensland. Palmer et al., (2005) listed *E. stricta* as a synonym of *E. pubescens*. The locality on *VPRI437* and *DAR69754* is also given as Walsh River.

Taking these facts into consideration, it is likely that *VPRI437, DAR69754,* and the two specimens originally from F.M. Bailey's herbarium (897, 898) and now deposited at Kew, were collected at the same time near Walsh River in north-eastern Queensland by Barclay-Millar and examined by Bailey in Brisbane. One of the grasses is *E. pubescens*, but the other is unknown. Because the type specimen(s) of *B. axillaris* contains ascostromata on two different species of grasses, one of them must be designated as the lectotype. Cooke listed the specimens F.M. Bailey 897 and 898 as the specimens he examined to typify the fungus, and neither Massee (1896) nor Petch (1916) designated a type specimen. Specimen *DAR69754* is here designated as the lectotype because it is most representative of Cooke's original description.

The fungus called *B. axillaris* is very similar to *N. scleroticus*. The ascospores are somewhat shorter than those of the type of *N. scleroticus*, but in material which may possibly have been collected while immature, the significance of disparities in dimensions is probably less than the mere figures might suggest.

2. *Epichloë oplismeni* Henn., Bot. Jahrb. Syst. 22: 76 (1895)

Synonyms: *Ophiodothis oplismeni* (Henn.) Henn., Ann. Naturhist. Mus. Wien 15: 2 (1900).
Parepichloë oplismeni (Henn.) J.F.White & P.V.Reddy, Mycologia 90: 231 (1998).

SPECIMEN EXAMINED–CAMEROON (as KAMEROUN). On *Oplismenus* sp.: VICTORIA 25.III.1894 Preuss *B ex Preuss No.1153* (HOLOTYPE).

In his description of *Epichloë oplismeni*, Hennings (1895a) noted that the stromata were curved, black, 3-4 mm long and 1 mm wide. The asci were 180-220 x 5-5.5 µm, and the ascospores were 90-110 x 0.3-0.5 µm, aseptate and hyaline. Examination of the type specimen revealed that the ascospores are 7-septate, and 180-220 x 3-5 µm. During preparation of the teleomorph for microscopic examination the ascospores easily fragmented into 3-septate part-ascospores, as do those of *N. scleroticus*. No conidia were found on the upper leaves of the specimen, but hyphal sheets, similar to those found on many specimens of *N. scleroticus*, were present. The lack of conidia on the type specimen of *O. oplismeni* may be due to the weathered state of the specimen at the time of collection. I consider that *O. oplismeni* is a synonym of *N. scleroticus*.

3. *Epichloë schumanniana* Henn., Pflanzenw. Ost-Afrikas, C: 32 (1895)

Synonyms: *Ophiodothis schumanniana* (Henn.) Henn., Ann. Naturhist. Mus. Wien 15: 2 (1900).
Balansiopsis schumanniana (Henn.) Höhn., Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 119: 61 (1910).

SPECIMENS EXAMINED–CONGO (as BELGIAN CONGO). On *Schizachyrium brevifolium* (Sw.) Nees: Holst *B ex. Holst n. 3110* (HOLOTYPE) [No host name or locality was given on the type specimen packet, but in his original description Hennings (1895a) called the host *Schizachyrium brevifolium*, and gave the locality as East Africa]. On *Andropogon* sp.: .1913 T Enlleb *B*. On *Andropogon* sp.: Warnorki *B*.

Hennings (1895b) described the fungus as having curved stromata, 3-5 x 1 mm, asci 150-210 x 2-4 µm with an obtuse to rotund apex, and filiform, multiguttulate ascospores, 120-

180 x 0.5-1.0 µm. Höhnel (1910) considered that *O. schumanniana* should be transferred to *Balansiopsis* Höhn., an opinion based on the similarity of the development of the ascostromata of *Epichloë schumanniana* with that of *Balansiopsis gaduae* (Rehm.) Höhn., the type species of *Balansiopsis*. An important taxonomic criterion of the fungi assigned to *Balansiopsis* was the lack of an anamorph. However, that genus is no longer valid because *Ephelis* anamorphs have been described for all the fungi placed in *Balansiopsis* (White, 1997). My examination of the type specimen showed that Hennings' (1895b) description of the ascostromata and asci was accurate. The ascospores are 7-septate and 120-180 µm long. Conidia, 14-21 µm long and identical in all other respects with those of the type specimen of *N. scleroticus*, were found on the upper leaves of this specimen. Both the ascal and conidial states found on the type specimen of *B. schumanniana* are very similar to the corresponding states on *N. scleroticus*, so it can be considered to be conspecific with the latter. White & Reddy (1998) considered that *Epichloë sclerotica* (sic) and *Epichloë schumanniana* were identical, based on ascostroma morphology and ITS1 sequences.

4. *Epichloë volkensii* Henn., Pflanzenw. Ost-Afrikas, C: 32 (1895)

Synonyms: *Ophiodothis volkensii* (Henn.) Sacc., Bull. Soc. Roy. Bot. Belg. 38: 161 (1899).
Balansia volkensii (Henn.) E.Castell. & Cif., Prod. Mycofl. Afr. Or. p. 20 (1937).
Parepichloë volkensii (Henn.) J.F.White & P.V.Reddy, Mycologia 90: 231 (1998).

SPECIMENS EXAMINED–AFRICA. On *Andropogon* sp.: KILO? G Volkens *B* (HOLOTYPE). **CENTRAL AFRICA?** On *Anthephora* sp.: DJUR IX.1867 G Schweisfurth? *B*. **CENTRAL AFRICAN REPUBLIC (as FRENCH CONGO).** On grasses: KOUTI REGION (NEAR NDÉLE) 15.XI.1891 J Dybowski *F6844 ex Patouillard Herb. 597* (as *Hyalodothis clavus*).

Hennings (1895b) reported that the host of *Epichloë volkensii* was *Andropogon exothecus* Hack. On the packet containing the type specimen, and in the description of *Ophiodothis volkensii* (Bresadola & Saccardo, 1899), the host is given as *Andropogon* sp. In his paper, Hennings provided the following description: "Stromatibus vaginas ramulorum ambientibus subcylindraceis, curvatis, corniformibus, semini cornuto similibus, duris, atris, rugulosis, minute papillatis, usque ad 1 cm longis, 2 mm crassis, apicibus plerumque elongatis: peritheciis subglobosis; ascis cylindraceis, 8-sporis; sporidiis filiformibus. auf *Andropogon exothecus* - Volk.n.988". Castellani & Ciferri (1937) transferred the fungus to *Balansia*, but provided no reasons for their action. Roger (1953) reported that the perithecia of *B. volkensii* measured 225-375 x 90-135 µm and that 'Les asques cylindriques, octospores, diffluent tôt et contiennent des spores filiformes très allongées (90-150 µm) et fortement guttulées'. He gave no indication of the specimen he examined, so the validity of his report is questionable.

My examination of the type material confirmed much of Hennings' (1895b) data. Transverse sections of a stroma revealed that it has a structure similar to that of ascostromata of *N. scleroticus*. Immersed in the stroma are locules 360-390 x 120-150 µm which were empty of asci. No asci or ascospores were found in the type material, a situation which was undoubtedly influenced by the weathered nature of the ascostromata. The type specimen of *B. volkensii* lacks the upper portions of the tillers where an anamorph might possibly have developed on the unfolding leaves. Due to the inability to determine the morphology of both the anamorph and teleomorph of *E. volkensii*, it is here considered to be a tentative synonym of *N. scleroticus*.

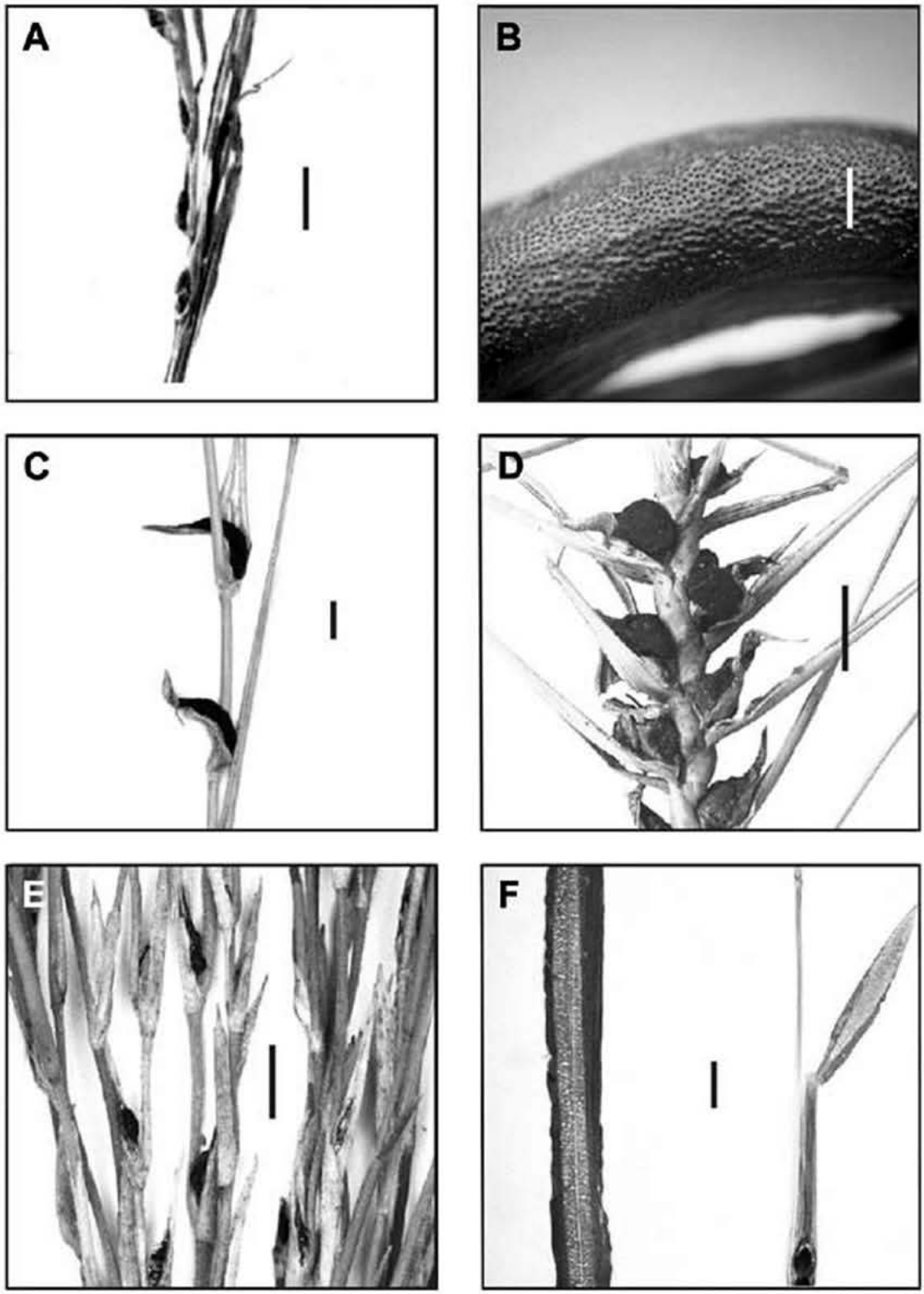


Figure 1. *Nigrocornus scleroticus.* A Portion of neotype with ascostromata (*FH*) (bar = 5 mm); B Papillate surface of ascostroma on *Sarga leiocladum* (*BRIP13402*) (bar = 1 mm); C–E Ascostromata on C *Sarga leiocladum* (*BRIP13402*) (bar = 5 mm), D *Triodia epactia* (*BRIP27802*) (bar = 10mm), and E *Entolasia stricta* (*BRIP13389*) (bar = 5 mm); F *Ephelis* anamorph on leaves of *Digitaria biformis* (*IMI123627*) (bar = 5 mm)

5. *Ophiodothis vorax* var. *paspali* Henn., Bot. Jahrb. Syst. 28: 274 (1901)

Probable synonym: *Balansia vorax* var. *paspali* (Henn.) Tesdoro (?)

SPECIMEN EXAMINED–JAPAN. SURUGA PROVINCE. On *Paspalum scrobiculatum* L. (as *Paspalum filiculare* Nees on specimen packet): 18.X.1921 K Hara *L W ex Sydow fungi exotici exsiccati No. 520.*

Ophiodothis Sacc., type species *O. vorax* (Berk. & M.A. Curtis) Sacc., was based on *Dothidea vorax* Berk. & M.A.Curtis (Berkeley & Curtis, 1883). *Ophiodothis vorax* var. *paspali* was described by Hennings (1901) on *Paspalum filiculare* Nees from Japan with the following characteristics: Stromata in the axils of the culms, corniform, black, about 2 cm long, 2 mm wide; asci cylindrical, apex rotund, 8-spored, 90-120 x 5-6 µm; spores filiform, multiguttulate, 0.6-0.7 µm wide. Although the name *Balansia vorax* var. *paspali* (Henn.) Tesdoro is listed in Index Fungorum (www.indexfungorum.org/Names/Names.asp), no reference to a formal description could be found. A specimen labelled *Ophiodothis vorax* var. *paspali* was examined, but the type specimen was unobtainable from any of the many herbaria to which requests were directed. My examination of the available specimen revealed that the stromata are 12-20 x 1.5-2.0 mm, the asci 168-220 x 4-6 µm, and the ascospores filiform, 144-180 x 1.0-1.5 µm and 7-septate. However, no conidia typical of *N. scleroticus* were found on the upper leaves of the specimens. On ascal characters alone, this fungus closely resembles *N. scleroticus*.

6. *Ophiodothis arundinellae* Henn., Bot. Jahrb. Syst. 37: 162 (1906)

SPECIMEN EXAMINED–JAPAN. On *Arundinella anomala* Steud.: UMAJIMURA .X.1904 Yoshinaga *S* (HOLOTYPE).

Hennings (1906) described *O. arundinellae* with the following characteristics: Stroma in the leaf axils, corniform, cylindrical, obtuse, black ca. 5 x 2 mm, verrucose-rugulose; perithecia densely crowded, ovoid to ellipsoidal; asci cylindrical, apex rounded-capitate, 8-spored, 120-150 x 4-6 µm; spores arranged in a parallel manner, filiform, multiguttulate or septate, hyaline, 1.5-2 µm wide. Hab. on culms of *Arundinella anomola* (sic; = *anamola*).

The type specimen of this fungus consists of a short section of tiller on which there are two black, curved ascostromata, 4-5 x 1.5-2.0 mm. The morphology of the ascus and of the ascospores could not be ascertained due to the weathered nature of the ascostromata. The specimen did not include any leaves from upper parts of tillers where an anamorph might possibly be found. The characteristics of the sexual state of *O. arundinellae* as described by Hennings (1906) are similar in most respects to those of *N. scleroticus*. Unfortunately, no information on the dimensions and septation of the ascospores or on the characteristics of a possible anamorph could be obtained, so this fungus can be considered to be a tentative synonym of *N. scleroticus*.

7. *Ophiodothis paspali* Henn., Bot. Jahrb. Syst. 37: 162 (1906) (nomen nudum)

SPECIMEN EXAMINED–JAPAN. On *Paspalum thunbergii* Kunth ex. Steud.: TOKYO BOTANICAL GARDENS TOKYO 6.IX.1899 Kusano *S.*

Despite an extensive literature search, no formal description of this fungus was found. *O. paspali* appears here because it was mentioned in a short discussion at the end of the

formal description of *Ophiodothis arundinellae*: "Die Art steht der *O. paspali* P. Henn. nahe, ist aber durch die kürzeren, von den Blattscheiden umschlossenen Stromaten, die längeren Asken und die viel breiteren Sporen genugsam verschieden" (Hennings, 1906).

A specimen bearing this name was obtained from an herbarium (*S*). The ascostromata are black, curved, and 7-12 x 1.5-2.0 mm, but the morphology of the asci and ascospores could not be determined due to the weathered nature of the stromata. Conidia identical to those of *N. scleroticus* were found on the upper leaves of this specimen. The name *Ophiodothis paspali* Henn. can be considered a nomen nudum under Article 34 of the International Code of Botanical Nomenclature. The specimen may be an authentic collection of the fungus described by Hennings (1901) as *Ophiodothis vorax* var. *paspali*.

8. *Balansia cynodontis* Syd., Ann. mycol. 33: 234 (1935)

Synonym: *Parepichloë cynodontis* (Syd.) J.F. White & P.V. Reddy, Mycologia 90: 231 (1998).

> **SPECIMENS EXAMINED–SOUTH AFRICA.** On *Cynodon dactylon* (L.) Pers.: HARTEBEESTPORT DAM 25.V.1928 AM Bottomley *PREM23473* (HOLOTYPE); BUFFELSPOORT .III.1938 EM Doidge & Turner *BPI ex Sydow Fungi exotici exsiccati No. 996.*

Balansia cynodontis was described on a South African specimen of *Cynodon dactylon* by Sydow (1935). The following summary of the characteristics of this fungus has been derived from Sydow's data: ascostromata straight or curved, 5.0-10.0 x 0.5-0.75 mm, papillate part covering outer surface is of variable extent; perithecia oblong lageniform, 175-200 x 70-90 µm; asci 110-130 x 5.5-6.0 µm containing eight filiform spores about 1 µm in diameter.

My examination of the type material revealed that on most ascostromata there are several papillate portions separated from each other by non-papillate areas. A similar condition is found on some ascostromata of *N. scleroticus* on *Paspalidium criniforme* S.T. Blake collected in southern Queensland. The asci are 135-170 x 5-6 µm and have a hemisperical apical thickening, 3 x 3 µm, perforated by a fine pore. Only a few ascospores could be measured due to the weathered nature of most of the ascostromata, but the ascospores observed were 120-160 µm long and 7-septate. Hyaline, acicular, aseptate conidia 10-23 µm long were found on the adaxial surfaces of the uppermost leaves on infected tillers.

The teleomorph and anamorph of *B. cynodontis* are very similar to those of *N. scleroticus* in the following characteristics: ascostroma shape, perithecium morphology, ascus morphology, ascospore septation, and conidium morphology. The non-papillate areas on the ascostromata of the holotype may be due to differential maturation, because the entire surfaces of mature ascostromata of a recent collection of *N. scleroticus* from Zimbabwe (*BRIP39212*) were papillate. However the upper and lower limits of the ranges of both ascus length and ascospore length for *B. cynodontis* are less than the corresponding values for *N. scleroticus*. These differences may be due to the immature nature of the specimen or to genetic differences between the fungi. I consider that this taxon is conspecific with *N. scleroticus*, but examination of fresh material collected from *Cynodon dactylon* is warranted.

9. *Balansia trachypogonis* Doidge, Bothalia 4: 854 (1948)

SPECIMENS EXAMINED–SOUTH AFRICA. On *Trachypogon plumosus* Nees: KAALFONTEIN 9.III.1916 IB Pole-Evans *PREM9543b* (HOLOTYPE), 2.II.1916 IB Pole-Evans *PREM9435* (PARATYPE), 9.III.1916 IB Pole-Evans *PREM28581* (PARATYPE), 27.III.1917 IB Pole-Evans *PREM10082* (PARATYPE); JOHANNESBURG DISTRICT, III.1931, AM Bottomley *PREM26607* (PARATYPE).

The characteristics of *Balansia trachypogonis* as described by Doidge (1948) are summarised as follows: ascostromata straight-curved, 1-3 cm x 2-3 mm, perithecia 300-480 x 70-120 µm; asci 150-200 x 5 µm; ascospores hyaline, filiform, multiseptate, almost equalling the ascus in length, 1.25-2.5 µm wide. My examination of the holotype and paratypes of *B. trachypogonis* confirmed the data given by Doidge (1948) as well as revealing previously undescribed characteristics. The apical thickening of asci of this fungus is not hemispherical as in *N. scleroticus*, but is in the form of a slight thickening of the ascus wall. As a consequence, the apical pore is much wider than on asci of *N. scleroticus*. The ascospores are 144-180 µm long, 1.0-1.5 µm wide, and 7-septate. On the upper, unfolding leaves, there are conidia, 13-23 µm long and 1.0-1.5 µm wide. Both the anamorph and teleomorph of *B. trachypogonis* are very similar to those of *N. scleroticus*. The ascostromata of *B. trachypogonis* are longer than those of the type specimen of *N. scleroticus*, that difference probably being influenced by the host. Although the ranges of ascospore length and conidium length of the former fungus lie within the corresponding ranges of *N. scleroticus*, the characteristics of the apical thickening of the asci closely resemble that described for *Myriogenospora* (Luttrell & Bacon, 1977; Bischoff & White, 2003). However, *B. trachypogonis* cannot be transferred to *Myriogenospora* because the stromata of the species in that genus develop in the rolled or folded leaves of grasses (Luttrell & Bacon, 1977; Bischoff & White, 2003). On this basis, *B. trachypogonis* is considered to be a tentative synonym of *N. scleroticus*, whose taxonomic status may change after examination of additional specimens.

10. *Balansia sclerotica* var. ***deformans*** Govindu & Thirum., Mycopathol. Mycol. Appl. 20: 300 (1963)

Govindu & Thirumalachar (1963) erected *Balansia sclerotica* var. *deformans* based solely on differences in symptomatology between *B. sclerotica*-infected hosts; on *Cymbopogon caesius* culms bearing ascostromata were shorter than healthy culms, while infected culms on other hosts were longer than normal. Such diversity in symptomatology between hosts infected by *N. scleroticus* is discussed in length by Ryley (2003). Although the type specimen of this taxon was not examined, the variety *deformans* is here considered to be synonymous with *N. scleroticus*.

11. *Balansia madagascariensis* Vienn.-Bourg., Ann. Inst. Natl. Agron., Sér. 3, 2: 25 (1964)

SPECIMEN EXAMINED–MADAGASCAR. On *Paecilostachys* sp.: RANOMAFANA .I.1964 J Bosser *P* (HOLOTYPE).

The stromata on the type specimen are straight, black, 2.5-4.0 x 1.0 mm, surrounding the axillary buds on the culms. Asci (as measured by me) are 144-180 x 3-6 µm, but

Viennot-Bourgin (1964) described the asci as being 60-90 x 6-10 µm, perhaps because he measured immature asci. No intact ascospores were seen, all having broken while being teased from the asci. The fracturing of the ascospore to give part-ascospores is typical of *N. scleroticus*, as discussed in earlier sections. The part-ascospores, 60-72 x 1.0-1.5 µm, are pointed at one end and blunt at the other, and appear to be aseptate. The septum at the blunt end of the part-ascospores and the fracturing of the ascospores indicates that at least the thick central septum typical of ascospores of *N. scleroticus* was present. In addition, the material may not have been mature at the time of collection, and for that reason the thin septa of the part-ascospores were not in evidence. Hyphae similar to those found on many specimens of *N. scleroticus* were present on the adaxial surfaces of the uppermost unfolding leaves, but no conidia were found on these hyphae.

Although the teleomorph of *B. madagascariensis* is very similar to that of *N. scleroticus*, the lack of conidia on the upper leaves and the uncertainty of the ascospore septation make the reduction of that taxon to synonymy with *N. scleroticus* tenuous.

12. *Balansia triraphidis* (herbarium name)

SPECIMENS EXAMINED–AUSTRALIA. NORTHERN TERRITORY. On *Triodia bitextura* Lazarides (as *Triraphis pungens* R.Br. on specimen packet): 34 MILE SIDING ON NT RAILWAY 15.1.1913 GF Hill *VPRI 439*.

Brittlebank (1940) listed *Balansia* sp. as a pathogen of *Triraphis* in his "Australian Fungi Index", citing the source of the record as *VPRI* (Pascoe, pers. comm.). The specimen received from that herbarium had *Balansia triraphidis* on the packet, and despite an intensive literature search no formal description has been found. The specimen consists of one badly weathered, black ascostroma, 4 x 3 mm, surrounding an axillary bud. Although the morphology of the teleomorph could not be determined, handwritten notes in the specimen packet provide the following information: perithecia 370 x 140 µm, asci 190-210 x 6 µm, ascospores 8 per ascus, 96 x 1-1¼ µm and 120 x 1-1¼ µm, multiseptate. Until evidence to the contrary is found, this specimen is considered to be *N. scleroticus*.

Summary of the synonyms of *Nigrocornus scleroticus*

Nigrocornus scleroticus (Pat.) Ryley

- ≡ *Epichloë sclerotica* Pat.
- ≡ *Ophiodothis sclerotica* (Pat.) Henn.
- ≡ *Balansia sclerotica* (Pat.) Höhn.
- ≡ *Parepichloë sclerotica* (Pat.) J.F.White & P.V.Reddy
  - = *Hypocrella axillaris* Cooke
  - = *Epichloë oplismeni* Henn.
  - = *Epichloë schumanniana* Henn.
  - = *Ophiodothis paspali* Henn. (nomen nudum)
  - = *Balansia cynodontis* Syd.
  - = *Balansia sclerotica* var. *deformans* Govindu & Thirum.
  - = *Balansia triraphidis* (herbarium name)

?= *Epichloë volkensii* Henn.

?= *Ophiodothis vorax* var. *paspali* Henn.

?= *Ophiodothis arundinellae* Henn.

?= *Balansia trachypogonis* Doidge

?= *Balansia madagascariensis* Vienn.-Bourg.

Other specimens of *Nigrocornus scleroticus* examined

SPECIMENS EXAMINED–*ASIA AND PACIFIC REGION*: AUSTRALIA. NEW SOUTH WALES. On *Entolasia stricta* (R.Br.) Hughes: GLENBROOK 9.XII.1933 LR Fraser *DAR29874*; MOUNT TOMAH 21.V.1977 C Nuzum *DAR28740*, 9.VI.1977 J Walker *DAR30009*, 9.VI.1977 C Nuzum *DAR30011* (As *Hypocrella* sp. on all specimen packets). On *Entolasia marginata* (R.Br.) Hughes: GLENBROOK 09.XII.1933 L Fraser *DAR29874*. On *Oplismenus imbecillis* (R.Br.) Roem. & Schult.: MOUNT TOMAH 6.IV.1977 R Keogh *DAR28742*, 21.V.1977 C Nuzum *DAR28741* (As *Hypocrella* sp. on both specimen packets). On *Triodia* sp.: PILLIGA SCRUB 8.X.1918 JB Cleland *DAR256* (As *Epichloë typhina* on specimen packet). NORTHERN TERRITORY. On *Eriachne mucronata* R.Br.: BICKERTON ISLAND 17.VI.1948 RL Specht *BRIP2817*; CORKSCREW PASS 4.VII.1948 ST Blake *BRIP2811 DAR21400* (as *Balansia* sp.). On *Sarga plumosum* (R.Br.) R.E.Spangler [as *Sorghum plumosum* (R.Br.) P.Beauv.]: STUART HIGHWAY 30 KM N DALY WATERS, 17.III.2000 RG Shivas IT Riley C&K Vanky *BRIP26983*. On *Schizachyrium pachyarthron* C.Gardner: FLORENCE FALLS (LITCHFIELD) 13.III.2000 RG Shivas *BRIP27878*. On *Sorghum* sp.: KATHERINE 17.III.2000 RG Shivas *BRIP27702*. On *Triodia basedowii* Pritzel: FINKE R 02.IV.2002 P Latz *DAR60915*. On *Triodia burbidgeana* S.W.L.Jacobs: PORT BRADSHAW 18.XII.1998 RG Shivas *BRIP25528*. On *Triodia procera* R.Br.: GROOTE EYLANDT 7.V.1948 RL Specht *BRIP2818*. On *Triodia pungens* R.Br.: ULURU 26.V.1979 P Latz *DAR61057*. On *Triodia shinzii* (Henrard) Lazarides: NNW ALICE SPRINGS 26.III.2000 C&K Vánky *BRIP27466*. QUEENSLAND. On *Bothriochloa ewartiana* (Domin.) C.E.Hubb.: KIDSTON VIII.1954 SL Everist *BRIP2808 DAR 21409* (as *Balansia* sp.). On *Chrysopogon fallax* S.T.Blake: 10 KM S GLADSTONE 25.IV.2004 RG Shivas *BRIP39883*; KANGAROO HILLS (INGHAM) 27.V.1965 IC Tommerup *BRIP2809 DAR 23783* (as *Balansia* sp.); E MAREEBA 24.III.2005 TS Marney *BRIP46794*; 24 KM N MT MOLLOY 02.V.2005 TS Marney *BRIP45836*. On *Cymbopogon refractus* (R.Br.) A.Camus: (KENMORE) BRISBANE 15.III.1981 MJ Ryley *BRIP13388**. On *Eremochloa bimaculata* Hack.: GEEBUNG (BRISBANE) 05.IV.2003 RG Shivas *BRIP39619*. On *Entolasia stricta* (R.Br.) Hughes: BRISBANE VI.1968 R Creagh *BRIP2810*; CHAPEL HILL (BRISBANE) 3.IX.1980 MJ Ryley *BRIP13389**. On *Eragrostis pubescens* (R.Br.) Steud. (as *Eragrostis oxylepis* Torr.): WALSH R .III.1891 T Barclay-Millar *DAR69754* (see *Hypocrella axillaris* above). On *Panicum* sp.: BEATRICE R (PALMERSTON) 9.III.1941 LG Miles *BRIP2813 DAR 21408* (as *Balansia* sp.). On *Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult: 20 KM N GIN GIN, 25.IV.2003 MDE & RG Shivas *BRIP47180*. On *Paspalidium criniforme* S.T.Blake: HIRSTGLEN 8.III.1979 MJ Ryley *BRIP13390**, 26.VIII.1980 MJ Ryley *BRIP13391**, 9.IV.1981 MJ Ryley *BRIP 13392*, 11.IV.2003 MJ Ryley *BRIP39912*, .2003 MJ Ryley *BRIP45139*. On ? *Paspalidium distans* (Trin.) Hughes: JULATTEN 30.IV.1987 JL Alcorn *BRIP15816*. On *Paspalum scrobiculatum* L.: MT COTTON (BRISBANE) 6.I.1980 MJ Ryley *BRIP13393**, 4.II.1981 MJ Ryley *BRIP13394*. On *Paspalidium* sp.: MAREEBA WETLANDS (NEAR MAREEBA) 01.V.2004 MDE Shivas *BRIP44114*. On *Sarga leiocladum* (Hack.) R.E.Spangler [as *Sorghum leiocladum* (Hack.) C.E.Hubb.]: BLACKBUTT CK (BLACKBUTT) 1.IV.1979 MJ Ryley *BRIP13399*; COOYAR 1.IV.1979 MJ Ryley *BRIP 13400**, 2.III.1991 M Ryley *BRIP17463*; CROWS NEST 22.IX.1977 MJ Ryley *BRIP13396*; HIRSTGLEN 9.IX.1977 MJ Ryley *BRIP13395*, 19.XII.1977 RF Langdon *IMI 224366*, 10.XI.1978 MJ Ryley *BRIP13398*,

29.XI.1979 MJ Ryley *BRIP13401*, 28.III.1980 MJ Ryley *BRIP 13403**, 9.IV.1981, MJ Ryley *BRIP 13404**; KENMORE (BRISBANE) EX HIRSTGLEN 1.IX.1977 MJ Ryley *BRIP 15373*; J BJELKE-PETERSEN RESEARCH STATION (KINGAROY) 7.XII.2000 M Ryley *BRIP27613*; MAIDENWELL 13.XII.2000 RG Shivas MJ Ryley *BRIP27596*; MAPLETON 6.XI.1978 MJ Ryley *BRIP13397*; ST LUCIA (BRISBANE) EX HIRSTGLEN 27.III.1980 MJ Ryley *BRIP13402**. On *Sarga plumosum* (R.Br.) R.E.Spangler [as *Sorghum plumosum* (R.Br.) P.Beauv.]: ATHERTON .IV.1960 G Keefer *BRIP2815 DAR 21411* (as *Balansia* sp.). On *Themeda triandra* Forssk. [as *Themeda australis* (R.Br.) Stapf]: BULLERINGA NEAR CHILLAGOE 24.V.2002 PR Trevorrow PR O'Keefe *BRIP29111*; MT NEBO 10.II.1981 MJ Ryley *BRIP13405**; MT TAMBORINE 21.IV.1962 DK Campbell *BRIP2816 DAR 21412* (as *Balansia* sp.). On *Triodia* sp.: 266 KM N CHARTERS TOWERS .V.2004 TS Marney *BRIP44584*; 40 KM W OF JERICHO 24.II2004 DR Beasley *BRIP43737*; TORRENS CK 26.III.1980 P Curran *BRIP13406*. On ? *Bothriochloa* sp.: 150 KM NW CHARTERS TOWERS .IV.1989 J&O Matthews *BRIP16640**. On unknown hosts: 241 KM N CHARTERS TOWERS 06.V.2004 TS Marney *BRIP44582*; MUSGRAVE 15.VII.1999 M Gunther *BRIP26753*; RIFLE CK (NEAR MT MOLLOY) 30.IV.1987 JL Alcorn *BRIP15784*. **WESTERN AUSTRALIA.** On *Sarga timorense* (Kunth.) R.E.Spangler [as *Sorghum stipoideum* (Ewart & White) Gardner & C.E.Hubb.]: POINT SPRINGS (NEAR KUNUNURRA) 8.X.1996 AA Mitchell *BRIP27800*, AA Mitchell *BRIP28853*. On *Triodia bynoei* (C.E.Hubb.) Lazarides: MITCHELL PLATEAU 10.II.1986 R Shivas *PERTH741884*. On *Triodia epactia* S.W.L.Jacobs: ONSLO(W) 18.V.1997 AA Mitchell *BRIP27802*. On *Triodia* sp.: BEAGLE BAY 1.III.2001 AA Mitchell *BRIP39323*; KARIJINI 11.VIII.2005 MJ Ryley *BRIP46838*, KARRATHA 09.VIII.2005 MJ Ryley *BRIP46839*; OOGALANOONGOO 3.VI.1996 AA Mitchell *BRIP27801*. **CHINA. YUNNAN.** On *Andropogon* sp.: .1919 AV Brooks *IMI182686**. On *Pogantherum crinitum* (Thunb.) Kunth [as *Pogantherum paniceum* (Lam.) Hack.]: TENGUYEH .X.1919 G Forrest *IMI4388 ex G. Forrest No. 18549*. **JAPAN.** On *Paspalum thunbergii* Kunth ex Steud.: SHIZOUKA 18.X.1921 K Hara *IMI4367 IMI22213 ex Sydow Fungi exotici exsiccata** (as *Ophiodothis vorax* var. *paspali* on specimen packet). **NEW GUINEA.** On *Themeda triandra* Forssk. [as *Themeda australis* (R.Br.) Stapf]: DARU ISLAND 5.VI.1957 F Kleckham *IMI74093*. **TONGA.** On *Cyrtococcum oxyphyllum* (Hochst. ex Steud.) Stapf: WA Sykes *PDD47078**. ***INDIAN SUBCONTINENT.*** **INDIA.** On *Andropogon* sp.: DHERWAR .XI.1964 VS Seshadri *IMI116178**; NAGPUR 1.X.1922 RM Pearl *IARI21105*. On *Brachiaria distachya* (L.) Stapf: EX BANARAS HINDU UNIVERSITY .IX.1962 RA Singh *IMI123625**. On *Cymbopogon martinii* (Roxb.) J.F.Watson: EX URKRAM UNIVERSITY (UJJAIN) 27.II.1979 BS Sharma *IMI235875**. On *Dichanthium caricosum* (L.) A.Camus: EX BANARAS HINDU UNIVERSITY .X.1965 RA Singh *IMI123626**. On *Digitaria biformis* Willd.: EX BANARAS HINDU UNIVERSITY .IX.1963 RA Singh *IMI123627**. On *Ischaemum* sp.: MUNNAR KERALA DISTRICT 17.I.1965 T Raghunatti *IMI116179**. On *Setaria pumila* sub sp. *pallide-fusca* (Schum.) B.K.Simon [as *Setaria pallide-fusca* (Schum.) Stapf & C.E.Hubb.]: EX BANARAS HINDU UNIVERSITY .IX.1963 RA Singh *IMI123629*. On *Themeda* sp.: ORISSA 3.IX.1949 HF Mooney *IMI44594**. ***AFRICA:*** **GHANA (AS GOLD COAST COLONY).** On *Anadelphia* sp.: AYIKUMA 2.VI.1949 GJ Hughes *IMI46347**. **MALAWI (AS NYASALAND ON SOME).** On *Hyparrhenia dissoluta* (Nees) C.E.Hubb.: NENO 2.VII.1949 PJ Wuhl? *IMI38763*; ZOMBA 7.V.1949 PJ Wuhl? *IMI35550**. On *Hyparrhenia* sp.: LILONGWE 11.III.1964 DCM Corbett *IMI114417**; ZOMBA 19.III.1927 EJ Rutter? *IMI75064**. **NIGERIA.** On *Andropogon* sp.: OYO PROVINCE 6.VI.1954 RM Jarbron? *IMI56874**. **SIERRA LEONE.** On *Andropogon gabonensis* Stapf: NEWTON 6.VIII.1939 FC Deighton *IMI4385**. On *Andropogon tectorum* Schum. & Thonn.: NEWTON 6.VIII.1939 FC Deighton *IMI 4384**; HILL STATION 27.VII.1941 FC Deighton *IMI10965**; KEINADUGU DISTRICT .VIII.1963 H Mead *IMI112570**; MUSAIA 1.VII.1948 FC Deighton *IMI32562**; REGENT 11.VIII.1955 CT Pyle *IMI61714**; ROKUPR 25.VII.1939 FC Deighton *IMI4383**. On *Oplismenus hirtellus* (L.) P.Beauv.: KORTRIGHT 17.VIII.1958 FA Melville & T

Horker *IMI77026;* NJALA 18.VII.1927 FC Deighton *IMI4607* * (As *Epichloë oplismeni* on both specimen packets). **TANZANIA.** On ? *Hyparrhenia* sp.: PONGWE TANGA .IV.1970 DJ Allen *IMI158973**. **ZAMBIA (AS NORTHERN RHODESIA ON SOME).** On *Diheteropogon amplectens* (Nees) W.D.Clayt. (as *Andropogon amplectens* Nees): CHILANGA 4.III.1963 A Angus *IMI112416**; KAFUE GAME RESERVE 27.IV.1962 A Angus *IMI100139;* KASAMA 24.III.1960 A Angus *IMI119807.* On *Digitaria* sp.: MAZABUKA 2.IV.1962 A Angus *IMI100111.* **ZIMBABWE (AS RHODESIA ON *IMI 182949*).** On *Cynodon dactylon* (L.) Pers.: MATOPOS RESEARCH STATION .II.2002 DA Frederickson *BRIP39212**. On *Setaria pumila* sub sp. *pallide-fusca* (Schum.) B.K.Simon [as *Setaria pallide-fusca* (Schum.) Stapf & C.E.Hubb.]: QUE QUE 19.I.1974 A Rothwell *IMI182949.* **UNKNOWN.** On *Brachiaria distachya* (L.) Stapf: *IMI 4387.*

On these specimens the ascostromata are black, corniform, curved or straight, papillate, and variable in length and width (Figs. 1B-E). At one extreme are ascostromata on *Themeda triandra* (*IMI74093*) which measure 15-17 x 3-4 mm and at the other are those on *Oplismenus hirtellus* (*IMI4607*), being 2-3 x 1.0-1.5 mm. For most specimens the length:width ratio of ascostromata is >2:1, but on the specimens of *Triodia* species collected in Australia the ratio is very close to 1:1. The characteristics of the perithecia, asci and ascospores on ascostromata which could be examined are, in most cases, identical to those of the corresponding characteristics of the type specimen. For three specimens, *IMI4367, IMI22213* (both on *Paspalum thunbergii* from Japan), and *IMI114417* (on *Hyparrhenia* sp. from Malawi), the ranges of ascospore length (160-280 µm) are different to that of the type specimen (140-220 µm). A dried hyphal matrix was found covering the abaxial surfaces of the uppermost leaves on most specimens (Fig. 1F), and on some of these (marked * in the specimen list above) there were conidia identical in all respects to those found in the hyphal matrix on the type specimen.

Other specimens received as *Balansia sclerotica*

A number of specimens received as *Balansia sclerotica* from IMI were not conspecific with *N. scleroticus.* Specimens *IMI4449, IMI4478,* and *IMI4481* were prepared slides consisting of transverse sections of immature ascostromata with characteristics similar to *N. scleroticus.* The specimen packet of *IMI4478* indicates that the slide was made from specimen number 18549 of the collection of George Forrest; ascostromata of that specimen are deposited as *IMI4388* (see specimen list above). *IMI118290* and *IMI138634* were dried cultures from which conidia, 13-15 x 1.0-1.5 µm and with characteristics similar to those of the anamorph of *N. scleroticus,* were gathered. *IMI112156* consists of a conidiostroma of *Ephelis* sp. *IMI75075* is a smut fungus, while the other three (*IMI48964, IMI48969* and *IMI98181*), all collected on *Panicum congoense* Franch. from western Africa, have characteristics typical of *Parepichloë cinerea* (Berk. & Broome) J.F. White & P.V. Reddy (1998).

SPECIMENS EXAMINED–CHINA. YUNNAN PROVINCE. On *Pogantherum crinitum* (Thunb.) Kunth [as *Pogantherum paniceum* (Lam.) Hack.]: .1917-1919 *IMI4478 ex G. Forrest No. 18549.* **INDIA.** On *Cymbopogon martinii* (Roxb.) J.F. Watson: 20.IV.1966 MJ Thirumalachar *IMI118290.* On unidentified host: POONA MJ Thirumalachar *IMI138634.* **MALAYSIA.** On *Brachiaria mutica* (Forssk.) Stapf: SELANGOR .1897 Ridley *IMI4481* (As *Epichloë volkensii* on specimen packet). **NEW GUINEA.** On *Digitaria smutsii* Stent: AIYURA 19.II.1965 D Petty *IMI112156.* **REPUBLIC OF GUINEA.** On *Panicum congoense* Franch.: PELLEL KOURA

6.XI.1962 P Adames *IMI98181*. **SIERRA LEONE.** On *Panicum congoense* Franch.: GHAP? 12.X.1951, HD Jordan *IMI48964*, KASANKO 24.X.1951 HD Jordan *IMI48969*. **THAILAND (AS SIAM).** On *Cymbopogon nardus* (L.) Rendle: 3.VIII.1925 Garret *IMI4449*. **UGANDA.** On *Hyparrhenia cymbaria* Stapf: KAWANDA .VI.1944 CG Hansford *IMI75075*.

Hypocrealean fungi associated with *Nigrocornus* ascostromata

1. *Nectriella balansiae* R.H.Arnold, Mycologia 59: 248 (1967)

SPECIMENS EXAMINED–AUSTRALIA. QUEENSLAND. On ascostromata of *Nigrocornus scleroticus:* KENMORE (BRISBANE) 15.III.1981 MJ Ryley *BRIP13495* (On *Cymbopogon refractus*). **CONGO.** On ascostromata of *Nigrocornus scleroticus:* 15.XI.1891 J. Dybowski (as *Hyalodothis clavus*: **HOLOTYPE** *F 6844 ex Patouillard Herb. 597*) (grass host unknown).

Hyalodothis Pat. & Har. was described by Patouillard & Hariot (1893) with *H. clavus* Pat. & Har. as the type, and only, species. Diehl (1950) examined the type specimen of *H. clavus* and considered it to be "a species of *Balansia* identical with the African *Epichloë volkensii* P. Henn.". As a consequence he reduced *Hyalodothis* to synonymy with *Balansia*. Later, Arnold (1967) examined the type specimen of *H. clavus* and found small (100-165 x 60-100 µm), spherical-ovoid perithecia immersed in the ascostromata, where they were scattered between those of the *Balansia* species. She also rejected *Hyalodothis* and *H. clavus* on the grounds that the original descriptions included elements of *Balansia volkensii* and another fungus, and named the latter *Nectriella balansiae* R.H.Arnold, without describing an anamorph. Rossman et al., (1999) re-examined the type specimen and confirmed Arnold's description, with only minor modifications. During this study, perithecia which matched the description of *N. balansiae* were found in ascostromata on the type specimen of *H. clavus* and on an Australian specimen of *N. scleroticus* (*BRIP13495*), but no mature asci or ascospores were found in either.

Until evidence to the contrary is found, the Australian specimen is designated as *Nectriella balansiae*.

2. *Bionectria* sp.

SPECIMENS EXAMINED–AUSTRALIA. NEW SOUTH WALES. On ascostromata of *Nigrocornus scleroticus* (all as *Hypocrella axillaris*): MOUNT TOMAH 21.V.1977 C Nuzum *DAR28740* (On *Entolasia stricta*), 9.VI.1977 J Walker *DAR30009* (On *Entolasia stricta*), 9.VI.1977, C Nuzum *DAR 30011* (On *Entolasia stricta*), 6.IV.1977 R Keogh *DAR28742* (On *Oplismenus imbecillis*), 21.V.1977 C Nuzum *DAR28741* (On *Oplismenus imbecillis*).

Walker (from annotations, slides and cultures in specimen packets) found light yellow, raised, solitary or gregarious, dome-shaped perithecia of a *Nectria*-like species on some *Nigrocornus* ascostromata on the specimens listed above. On all of these specimens except *DAR30011* he also found the sporodochia of a fungus which he ascribed to *Myrothecium* Tode. My examination of the specimens showed that the conidia of the latter fungus are hyaline, thin-walled, aseptate, ellipsoidal, straight or slightly curved, with a distinctive hilum and 10-15 x 2.2-2.5 µm. The conidiophores are penicillate with two phialides arising from the supporting cell, each phialide being 3-4 µm wide at the widest point, narrowing to approx. 2 µm at the tip. On a 1-month-old culture of *DAR28741(b)* there are discrete, raised sporodochia with a dark green spore mass. The conidia are more variable than those on the host tissue, being cylindrical-ovate, 10-15 x 3-4 µm, but with

a prominent protruding hilum. The asci in the *Nectria*-like perithecia are clavate, thin-walled, unitunicate, and lack any apparent apical thickening. There were 8 ascospores per ascus, the ascospores being hyaline, thin- and smooth-walled, 1-septate, fusiform, 10-15 x 2.5-3 µm, and with a slight constriction at the septum of some.

The orange perithecia place this fungus in the *Bionectriaceae* rather than in the *Nectriaceae*, where it is most closely aligned with *Bionectria* Speg. (Schroers, 2001), and its anamorph has characteristics which would place it in *Clonostachys* Corda, the anamorph of *Bionectria*. This fungus closely resembles *Bionectria epichloë* (Speg.) Schroers [syn. *Nectriopsis epichloë* (Speg.) Samuels], which has been found on the stromata of species of *Epichloë* and *Balansia* in the Americas (Samuels, 1988; Schroers, 2001). However, although the dimensions of the ascospores in the Australian specimens lie within the ranges for those of *N. epichloë*, its conidia are longer than those provided in Samuels' and Schroer's descriptions (5-8 x 2.5-5 µm and 4.8-9.6 x 2.2-3.6 µm, respectively). *Nectriopsis macroepichloë* Samuels was described as colonising ascostromata of *Balansia cyperacearum* (Berk. & M.A. Curtis) Diehl in Venezuela, but its ascospores are considerably longer than those of *B. epichloë* and the *Bionectria* species on *N. sclerotica* ascostromata (Samuels, 1988). It is possible that the specimens of *Bionectria* found on some ascostromata of *N. sclerotica* in Australia represent a new species.

Acknowledgments

I thank Dr Ray Langdon, former Reader in Botany, University of Queensland, for his guidance and patience during my postgraduate studies, and for his esteemed and enduring friendship since then. I also thank the curators of herbaria for loans of type and other specimens listed in this paper. Thanks also to Dr Michael Priest, Dr Ian Pascoe, and Dr Shaun Pennycook for reviewing this paper.

Literature Cited

Arnold RH. 1967. The *Nectriella* element of '*Hyalodothis*'. Mycologia 59: 246-254.

Bailey FM. 1891. Contributions to the Queensland flora. Bot. Bull. Dep. Agric Qd 3.

Bailey FM. 1913. Comprehensive Catalogue of Queensland Plants. Government Printer, Brisbane.

Berkeley MJ, Curtis, MA. 1883. Sylloge Fungorum 2: 652.

Bischoff J.F., White JF Jr. 2003. The Plant-infecting Clavicipitaleans. *In* Clavicipitalean Fungi: Evolutionary Biology, Chemistry, Biocontrol, and Cultural Impacts (Eds. J White Jr, CW Bacon, NL Hywel-Jones, JW Spatafora), pp. 125-149. Marcel Dekker Inc., New York NY, USA.

Bresadola G, Saccardo PA. 1899. Fungi Congoenses enumerati I. Bull. Soc. Roy. Bot. Belg. 38: 161.

Brittlebank CC. 1940. The Brittlebank Catalogue of Fungi and Bacteria Causing Plant Diseases in Australia (unpublished, held in the National Herbarium of Victoria).

Castellani E, Ciferri R. 1937. Prod. Mycofl. Afr. Or. Ist. Agr. Coloniale Italiano, Firenze.

Cooke MC. 1892. Australian fungi. Grevillea 20: 4-7.

Diehl WW. 1950. *Balansia* and the *Balansiae* in America. Agriculture Monograph No. 4. United States Department of Agriculture, Washington DC.

Doidge EM. 1948. South African ascomycetes in the national herbarium. Part 4. Bothalia 4: 837-880.

Govindu HC, Thirumalachar MJ. 1963. Studies on some species of *Ephelis* and *Balansia* occurring in India. II Morphological and taxonomic status of *Balansia*. Mycopathol. Mycol. Appl. 20: 297-306.

Hennings P. 1895a. Fungi kamerunenses I. Bot. Jahrb. Syst. 22: 72-111.

Hennings P. 1895b. Pilze Ostafrikas in Deutsch-Ost Afrika. Band II. In Pflanzenw. Ost-Afrikas (Ed. A. Engler), Teil C, pp. 30-35. D. Reimer, Berlin.

Hennings P. 1900. Fungi in Zahlbrückner plantae pentherianae. Ann. Naturhist. Mus. Wien 15: 1-3.

Hennings P. 1901. Fungi japonici. Bot. Jahrb. Syst. 28: 274-275.

Hennings P. 1906. Fungi japonici VI. Bot. Jahrb. Syst. 37: 162.

Hodge KT. 2003. Clavicipitaceous anamorphs. In Clavicipitalean Fungi: Evolutionary Biology, Chemistry, Biocontrol, and Cultural Impacts (eds J White Jr, CW Bacon, NL Hywel-Jones, JW Spatafora), pp. 75-123. Marcel Dekker Inc., New York NY, USA.

Höhnel F Von. 1910. Fragmente zur Mykologie No. 630. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 119: 57-65.

Höhnel F Von 1911. Fragmente zur Mykologie No. 704. Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1, 120: 449.

Luttrell ES, Bacon CW. 1977. Classification of *Myriogenospora* in the Clavicipitaceae. Can. J. Bot. 55: 2090-2097.

Massee G. 1896. New or critical fungi. J. Bot. 34: 145-154.

Palmer J, Lazarides M, McCusker A, Weiller CM. 2005. *Eragrostis*. In Flora of Australia Vol. 44B Poaceae 3 (ed K Mallett), pp. 346-409. ABRS/CSIRO Publishing, Melbourne, Australia.

Patouillard N. 1890. Contribution à la flore mycologique du Tonkin. VI. Pyrenomycetes. J. Bot. (Morot) 4: 61-67.

Patouillard N, Hariot P. 1893. Fungos aliquot novos in regione congoana collectos. Bull. Soc. mycol. Fr. 9: 206-211.

Petch T. 1916. Revisions of Ceylon fungi (Part IV). Ann. Roy. Bot. Gard. (Peradeniya) 6: 153-183.

Roger L. 1953. Phytopathologie des pays chauds. Tome II. Etude descriptive des Maladies parasitaires des plantes des pays chauds. Hypocréacées genre *Balansia* Speg. Encycl. mycol. 18: 1537.

Rossman A, Samuels GJ, Rogerson CT, Lowen R. 1999. Genera of *Bionectriaceae, Hypocreaceae* and *Nectriaceae* (*Hypocreales*, Ascomycetes). Studies in Mycology 42. Centraalbureau voor Schimmelcultures, Baarn/Delft, The Netherlands.

Ryley MJ. 2003. *Nigrocornus sclerotícus*, a common Old World balansioid fungus. In Clavicipitalean Fungi: Evolutionary Biology, Chemistry, Biocontrol, and Cultural Impacts (eds J White Jr, CW Bacon, NL Hywel-Jones, JW Spatafora), pp. 247-271. Marcel Dekker Inc., New York NY, USA.

Samuels GJ. 1988. Fungicolous, Lichenicolous, and Myxomyceticolous Species of *Hypocreopsis*, *Nectriopsis*, *Nectria*, *Peristomialis*, and *Trichonectria*. Mem. New York Bot. Grdn. 48. Bronx, New York Botanical Garden.

Schroers H-J. 2001. A Monograph of *Bionectria* (Ascomycota, *Hypocreales, Bionectriaceae*) and its *Clonostachys* anamorph. Studies in Mycology 46. Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands.

Sydow H Von. 1935. Beschreibungen neuer sudafrikanischer pilze VI. Annls mycol. 33: 230-237.

Viennot-Bourgin G. 1964. Étude de micromycètes parasites récoltés a Madagascar, 3° Ascomycetes et Imperfecti. *Balansia madagascariensis* n.sp. Annls Inst. natn. agron., Paris, Ser. 2, 2: 16-25.

White JF Jr. 1997. Systematics of the graminicolous clavicipitaceae. In Neotyphodium/Grass Interactions (eds CW Bacon, NS Hill), pp. 27-39. Plenum Press, New York.

White JF Jr, Reddy PV. 1998. Examination of structure and molecular genetic phylogenetic relationships of some graminicolous symbionts in genera *Epichloë* and *Parepichloë*. Mycologia 90: 226-234.

MYCOTAXON

Volume 95, pp. 113–116 *January–March 2006*

Rick's species revision: *Mitremyces zanchianus* versus *Calostoma zanchianum*

IURI G. BASEIA[1], VAGNER G. CORTEZ[2] & FRANCISCO D.CALONGE[3]

baseia@cb.ufrn.br
[1]*Universidade Federal do Rio Grande do Norte, CB*
Depto. Botânica, Ecologia e Zoologia, 59072-970, Natal, RN, Brazil

cortezvg@yahoo.com.br
[2]*Universidade Federal do Rio Grande do Sul*
Depto. Botânica, 91501-970, Porto Alegre, RS, Brazil

calonge@ma-rjb.csic.es
[3]*Real Jardín Botánico, CSIC*
Plaza de Murillo 2, 28014 Madrid, Spain

Abstract — After the revision of *Mitremyces zanchianus* we confirm this species as a valid name in the *Sclerodermataceae* and propose a new combination to the genus *Calostoma*. Description and illustrations of the type and SEM images of the basidiospores are given.

Key words — *Agaricomycetidae*, *Sclerodermataceae*, Gasteromycetes, taxonomy, neotropics

Introduction

The role played by Rick in the development of Brazilian mycology is not measured by his numerous works alone (for a full list see Fidalgo, 1962), but by his collaboration with foreign mycologists (e.g. Lloyd, Rehm, Bresadola, Sydow), which furthered the study the Brazilian fungi. In addition, it is worth emphasizing that Rick influenced and encouraged fellow mycologists, such as Theissen and Torrend (Fidalgo 1962). A representative part of the Rick's collection in Brazil is preserved in the Herbarium Anchieta (PACA), located in the State of Rio Grande do Sul.

The genus *Calostoma*, which was established by Desvaux in 1809, has priority over *Mitremyces*, a synonym erected by Nees in 1817. According to Kirk et al. (2001), *Calostoma* comprises about 15 species and is currently included in the family *Sclerodermataceae* Corda (= *Calostomaceae* E. Fisch.). *Calostoma* species are characterized by the pseudostipitate basidioma with a peridium composed of two to four layers and opening by only one apical star-like pore, and basidiospores that are globose to elliptic with reticulate or pitted ornamentation (Miller & Miller 1988).

At present, no representatives of the *Calostoma* have been reported for Brazil except for *Mitremyces zanchianus*, a rare species described by Rick (1961, but see comments

below). Our primary goal is to determine whether Rick's species should be placed in *Calostoma*.

Materials and methods

Macroscopic characters were examined following usual techniques utilized in taxonomic studies of gasteroid fungi including a detailed description from the fresh specimen. Microscopic characters were determined according to Miller & Miller (1988). Basidiospores were examined using a Philips XL20 Scanning Electron Microscope (SEM).

Results

Calostoma zanchianum (Rick) Baseia & Calonge, **nov. comb.** **Figs. 1-3**

Basionym: *Mitremyces zanchianus* Rick in Iheringia Sér. Bot..9: 456, 1961.

Basidiomata stalked, head egg-shaped, 1.3 cm long, 1 cm broad; exoperidium white silky, rather thick, gelatinous, rugose surface ruptured by the growth of fruitbody. Endoperidium pinkish white, cartilaginous, smooth. Mouth regularly star-shaped consisting of 4 long slits, splitting at maturity; stalk strongly dilated, subglobose, 1.2 cm long, 1.3 cm broad. Spores 30-35 x 15-20 µm, fusiform to elliptic, smooth, colourless to pale yellowish, provided with a longitudinal groove.

MATERIAL EXAMINED – *Holotypus* of Herbarium Anchieta (PACA 19.673), collected by Father Rômulo Zanchi in March 1943 from the current municipality of São João do Polesine (formerly Polesine, municipality of Cachoeira do Sul, as indicated in the herbarium notes), central part of Rio Grande do Sul State, Brazil.

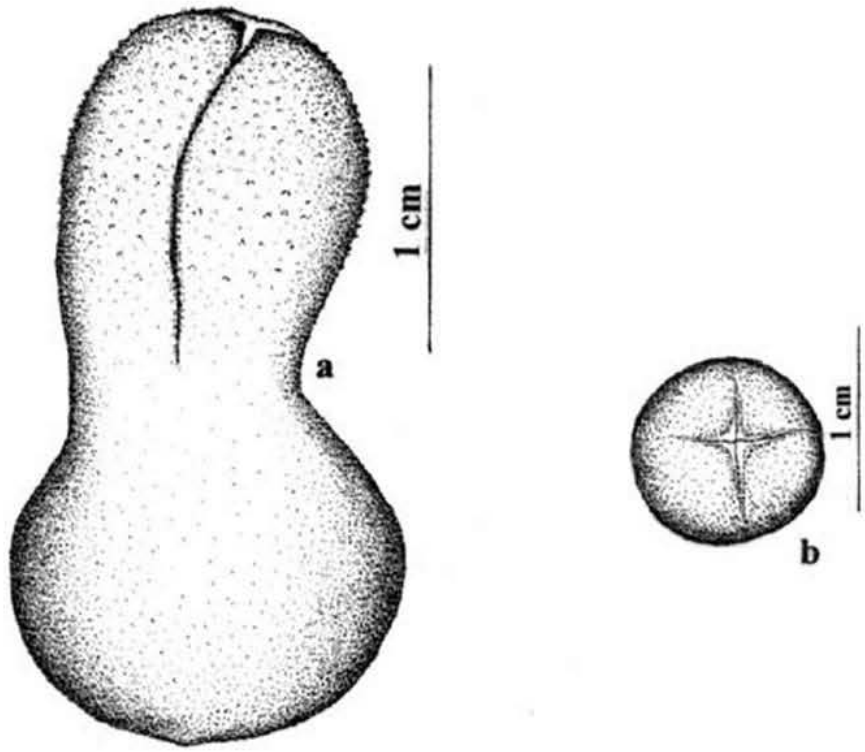


Fig. 1 ***Calostoma zanchianum*** (holotypus) **a**: Mature basidioma. **b**: Top view

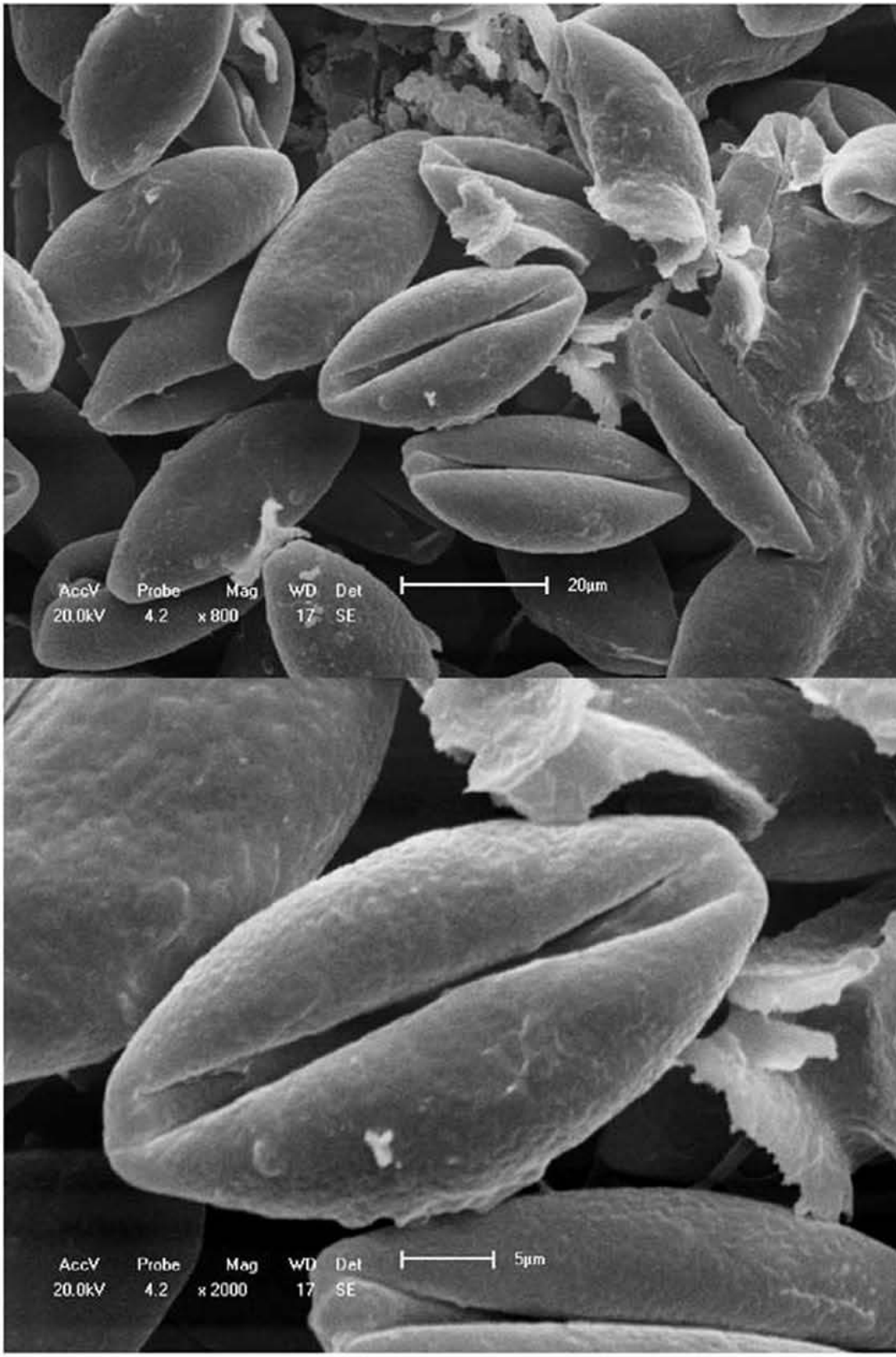


Fig. 2-3: *Calostoma zanchianum* (holotypus). Basidiospores under SEM

Discussion

This species is easily recognized by several distinct characters: a stalk strongly dilated at the base, a mouth consisting of four long slits, and elliptic to fusiform basidiospores with a longitudinal groove. Those singular characters separate *Calostoma zanchianum* from other *Calostoma* species. This taxon also has some interesting ecological data: Zanchi's notes cite that it was found growing on roots of an unknown native tree.

In fact, Rick himself never published the collection as a new species. The species was published in a posthumous series (i.e., Basidiomycetes Eubasidii in Rio Grande do Sul – Brasilia) by Father Balduíno Rambo, another noteworthy botanist who compiled all fungi studied and collected by Rick, including several non-published taxa. Thus, *Mitremyces zanchianus* was only validly published 15 years after Rick's death in 1946.

Unfortunately, the only known material of this species is the holotype. Efforts are underway to collect new material so as to document the morphological variation and biology of this unusual species.

Acknowledgments

We express our sincere gratitude to the curator of Anchieta Herbarium (PACA) for the loaned material. Thanks are also given to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for financial support; and to Tereza Cristina de Oliveira Galvão for the illustrations. We are grateful to Prof. H. Kreisel, Prof. G. Moreno and Dr. P. M. Kirk for the critical revision of the manuscript and checking of the English text.

References

Desvaux NA. 1809. Observations sur quelques genres à établir dans la famille dês Champignons. Journal de Botanique 2: 38-105.

Fidalgo O. 1962. Rick, o Pai da Micologia Brasileira. Rickia 1: 3-11.

Kirk PM, Cannon PF, David JC, Stalpers JA. 2001. Ainsworth & Bisby's Dictionary of the Fungi. 9th ed. CABI Int. Publ., UK.

Miller OK, Miller HH. 1988. Gasteromycetes: Morphology and Developmental Features. Mad River, Eureka, CA, 156 pp.

Nees v. Essenbeck CG. 1817. Das System der Pilze und Schwämme. Würzburg, p. 136.

Rick J. 1961. Basidiomycetes Eubasidii in Rio Grande do Sul. Iheringia, Ser. Bot. 9: 451-490.

MYCOTAXON

Volume 95, pp. 117–131 *January–March 2006*

Taxonomic studies on Indian *Phellinus* s.l. species: parsimony analysis using morphological characters

PRASAD LAMROOD

pylamrood@yahoo.com
Department of Botany, Modern College
Ganeshkhind, Pune - 411 053, Maharashtra, India

ARISTÓTELES GÓES-NETO

agoesnt@uefs.br
Laboratório de Pesquisa em Microbiologia (LAPEM),
Depto. de Ciências Biológicas, Universidade Estadual de Feira de Santana (UEFS)
Km 3, BR-116 (norte), Feira de Santana, Bahia, 44.031-460, Brazil

Abstract — Parsimony analysis of Indian *Phellinus* s.l. species based on basidiomata morphological characters was carried out. Fifty-four samples belonging to 23 species collected from different hosts were used. Trees were produced using parsimony analysis, heuristics search with random taxon addition sequences, tree-bisection-reconnection branch swapping without topological constraints. Out of 84 morphological characters used in the present analysis, 35 characters were binary and 49 were multistate and treated as non-additive. Parsimony analysis revealed that most of the studied specimens could be assigned to *P. rimosus* complex (*Fulvifomes*), *P. pini* complex (*Porodaedalea*), and *P. igniarius* complex (*Phellinus* s.s.).

Key words — basidiomata morphology, cladistic analysis, *Hymenochaetaceae*, South Asia, tropical rain forest

Introduction

The circumscription of genera in the *Hymenochaetaceae* is imprecise, even in the field of traditional systematics (Corner, 1991). The same situation occurs at generic level, notably in *Phellinus* Quél., which accounts for more than half of the total number of species of Hymenochaetales. The genus *Phellinus* includes several species complexes, and is generally regarded as polyphyletic (Ryvarden 1991, Fischer 1996ab, Wagner & Fischer 2002). *Phellinus* s.l. is worldwide in distribution (Lloyd 1915, Bondarzew 1953, Overholts 1929, 1953, Lowe 1957, Cunningham 1965, Fidalgo 1968, Niemelä 1972, Ryvarden 1972, Donk 1974, Gilbertson & Ryvarden 1987, Rajchenberg 1989, Larsen & Cobb-Poulle 1990). A survey of the world taxa of *Phellinus* resulted in the recognition of 154 species and 67 forms and varieties (Larsen & Cobb-Poulle 1990, Rabba 1994, Fischer 1996ab).

Species of *Phellinus* are parasitic, perthophytic and/or saprobic causing white rot that degrades both lignin and cellulose (Rabba 1994, Vaidya 1995, Fischer 1996ab). They dwell on a wide variety of angiosperms and/or gymnosperms (Wagner & Fischer 2002) causing heart rot disease in live standing trees. Besides being a wood decaying fungus, *Phellinus* serves as a medicine in the western part of India (Vaidya & Bhor 1991, Vaidya & Rabba 1993, Vaidya & Lamrood 2000) and also in traditional Chinese and Korean medicine (Mizuno 2000, Smith et al. 2002).

Species are characterized by poroid basidiomata with variable shape that even between closely related species may range from resupinate, effused-reflexed, pileate, and substipitate to stipitate (Wagner & Fischer 2002). The generic concepts of *Phellinus* and its closest relative *Inonotus* P. Karst. have been traditionally based on mitism of the hyphal system and consistency of the fruit body (i.e. *Phellinus*: dimitic and perennial; *Inonotus*: monomitic and annual) but this has been repeatedly demonstrated as artificial (Fiasson & Niemelä 1984, Corner 1991, Dai 1999, Fischer 1996ab, Wagner & Fischer 2002), and inconsistent in *Phellinus* (Fischer 1996ab). In several taxa, the dimitic hyphal system is vague or lacking, e.g. members of *P. robustus* complex and *P. sulphurascens* Pilát (Fischer 1996b). Intermediate forms occur as in *P. discipes* (Berk.) Ryvarden, *P. erectus* A. David et al., and *P. gilvus* (Schwein.) Pat., in which the fruit bodies are annual and have dimitic hyphal system. On the other hand, species like *P. pachyphloeus* (Pat.) Pat., *P. poeltii* Ryvarden, *P. robustus* (P. Karst.) Bourdot & Galzin and *P. sulphurascens* have perennial fruit bodies but have monomitic hyphal system or show transitions between monomitic and dimitic hyphal systems (Domanski et al. 1973, Jahn 1981, Fiasson & Niemelä 1984, Corner 1991, Ryvarden & Gilbertson 1994, Wagner & Fischer 2002).

Extensive studies on the occurrence and systematics of *Phellinus* have been carried out for European and North American taxa (Jahn 1981, Ryvarden 1978, Fiasson & Niemelä 1984, Jülich 1984, Gilbertson & Ryvarden, 1986, 1987, Ryvarden & Gilbertson, 1994). As stated by numerous authors (Bondarzew 1953, Niemelä 1972, 1975, Domanski et al. 1973, Kotlaba & Pouzar 1978, Ryvarden 1978, Fiasson & Niemelä 1984, Parmasto 1988, Ryvarden & Gilbertson 1994, Fischer 1996b) the European taxa of *Phellinus* can be divided into a number of groups. Besides the type species, *Phellinus* contains a varying number of closely related taxa, which, in many cases, were originally considered as varieties or forms of the type species. The species complexes that are recognized for Europe are: *P. igniarius* complex, *P. pini* complex (Fischer 1996ab), and *P. robustus* complex. Three additional groups with *P. ferrugineofuscus* (P. Karst.) Bourdot & Galzin, *P. ferruginosus* (Schrad.) Pat., and *P. rimosus* (Berk.) Pilát are also recognized (Fischer 1996b). The *P. igniarius* and *P. robustus* complexes are also mentioned for North America (Gilbertson 1979).

Numerous characters from morphology, anatomy, sexuality, nuclear behaviour, pigmentation and ecology would suggest that *Phellinus* is heterogeneous (Fiasson 1982, Fiasson & Niemelä 1984, Dai 1999, Fischer 1996b). Because of the uncertainty of the concept of *Phellinus*, as well as recognized divergences within the genus, the species complexes have repeatedly been acknowledged as separate genera. Based upon the examination of mostly North American and European collections, several attempts were made to split *Phellinus* into smaller, more natural genera. As a result *Phellinus* s.l. comprises numerous generic notions (Fiasson & Niemelä 1984, Wagner & Fischer 2002)

made up of *Fomitiporella* Murrill, *Fomitiporia* Murrill, *Fulvifomes* Murrill, *Fuscoporella* Murrill, *Fuscoporia* Murrill, *Ochroporus* J. Schröt., *Phaeoporus* J. Schröt., *Phellinidium* (Kotl.) Fiasson & Niemelä, *Phellopilus* Niemelä et al., *Phylloporia* Murrill, *Porodaedalea* Murrill, *Pseudofomes* Lázaro Ibiza, *Pyropolyporus* Murrill, and *Scalaria* Lázaro Ibiza (Wagner & Fischer 2002).

The comprehensive study of Fiasson & Niemelä (1984) was mostly based on morphology, anatomy, pigmentation, protein pattern, cultural type and nuclear behaviour. Based on the characters derived from this study, Fiasson & Niemelä (1984) revised the taxonomy of the European poroid Hymenchaetales and proposed to split the Hymenchaetales into two families, Phellinaceae, composed of *Fomitiporia*, *Fulvifomes*, *Fuscoporia*, *Inonotopsis* Parmasto, *Ochroporus*, *Onnia* P. Karst., *Phellinidium*, *Phellinus* s.s., and *Porodaedalea*, and a newly described Inonotaceae, composed of *Inonotus* s.s., *Inocutis* Fiasson & Niemelä, and *Phylloporia* (Wagner & Fischer 2002). Since the study of Fiasson & Niemelä was mostly based on European material, neglecting the numerous tropical species, this suggested splitting concept was not followed subsequently (Gilbertson & Ryvarden 1986, 1987, Parmasto 1988, Larsen & Cobb-Poulle 1990, Ryvarden & Gilbertson 1994). The generic splitting has been accepted in only a few studies such as Nuss (1986) and Hansen & Knudsen (1997). Dai (1999) also accepted genera like *Fomitiporia* and *Phellinidium* but granted subgeneric level to *Fulvifomes*, *Fuscoporia*, *Phellinidiopsis*, *Phellinus* s.s., and *Porodaedalea* (Wagner & Fischer 2002).

As extensive phylogenetic data are still missing for non-European taxa, which make up approximately two thirds of the presently known species, the generic concept of *Phellinus* is mostly based on the European taxa (Wagner & Fischer 2002). However, fragmentary work has been done in India, mainly pertaining to Himalaya and a few parts of the central Peninsula (Bagchee & Bakshi 1950, Bagchee 1961, Singh 1966, Bakshi 1958, 1971, Thind & Chatrath 1957, Thind & Dhanda 1980, Roy 1979, Tiwari et al. 1989, Sharma, 1993), as well as in southern parts (Ganesh & Leelavathy 1986, Natarajan & Kolanduvelu 1985). The most comprehensive account on this genus in Maharashtra is the work of Rabba (1994). Before Rabba (1994) and Rabba et al. (1994) only nine species were known from Maharashtra and 50 species from India (as *Fomes*). High rainfall, high humidity and hot temperature favour the growth of many species of *Phellinus* in the forests of Maharashtra. Neither the species (Parmasto 1985) nor the generic concepts in *Phellinus* are stable and will only become more concise when species from all parts of the globe are included in an analysis of the genus (Wagner & Fischer 2002). Towards this end, a study was undertaken of *Phellinus* s.l. found in Maharashtra.

Materials and methods

Collection of samples

Fifty-four samples of *Phellinus* were collected in India, mainly during the monsoon season. Six samples were collected in 1987-92 while the other samples were collected during 1998-2002. Collections were made in various regions of western Maharashtra (i.e. Konkan region), including in and around Pune city (Pune University Campus (PUC), Amba valley, and Simhagarh fort) on various plant hosts (Table 1).

The samples were kept in clean polythene bags with a label indicating the date and place of collection, name of the collector, name of the host (in case of field collection), name of the shop and shop owner (in case of market collection), type of fruiting body and a brief description of the specimen. Specimens were then taken to the laboratory.

Spore prints, obtained from fresh basidiomata on cellophane paper, were maintained in airtight plastic bags. After drying in a oven at 40°-45°C the basidiomata were stored in cardboard boxes and deposited in Herbaria Poonensis, Department of Botany, University of Pune under the accession number 'PH'. All the characters used in the analysis were evaluated in dried basidiomata.

Identification

Specimens were identified following a study of external and internal morphology. The color, texture, type of attachment of the basidiomata, hymenial and pileal surface of the basidiomata, margin, pore morphology, and dissepiment were observed and noted. Measurements of basidiomata were taken as in Ryvarden & Johansen (1980). Detailed microscopic examinations were carried out by cutting freehand longitudinal thin sections of basidiomata, passing through hymenia. Sections were first treated with absolute alcohol for a few seconds and then transferred to a solution of 10% KOH to allow the swelling of different hymenial structures. Sections were washed two to three times with distilled water (1 minute per washing), then stained with 1% phloxine (for visualization of basidia), and teased apart in lactoglycerine with 1% cotton blue (for visualization of setae, hyphal tips, hyphae, etc.). Semipermanent slides were prepared in lactoglycerine. Permanent slides were prepared in polyvinyl alcohol (PVA) medium (Omar et al. 1979) and observed under a bright field microscope (Olympus BX 40) with an attached color camera (Hamamatsu 3CCD C6157 and UVP).

The identification of specimens was done using a key (Larsen & Cobb-Poulle 1990). The color scheme of Jordan & David (1995) was used to describe color of morphological structures.

Morphological Characters

Eighty-four morphological characters were used in the analysis. The list of characters and character states (Table 2) was prepared according to Góes-Neto et al. (2001) and Kim & Jung (2002). A character state matrix was then prepared accordingly.

The characters of *Phellinus merrillii* and *P. linteus* were compared with the descriptions given by Larsen & Cobb-Poulle (1990), Rabba (1994), Dai & Xu (1998) and Lim et al. (2003), abbreviated as LCP, R, D, Y, respectively. Similarly, the description of *P. baumii* Pilát was compared with those in Larsen & Cobb-Poulle (1990), Dai & Xu (1998) and Lim et al. (2003).

Parsimony analysis

The character code for any character 'not determined' was coded as (?) and any character that was absent in a particular species was coded as missing (–). The newly generated data matrix was analyzed with PAUP 4.0 (Swofford 1999). Unrooted trees were produced using parsimony analysis, heuristics search with random taxon addition sequences, tree-bisection-reconnection branch swapping without topological constraints.

Results

Fifty-four samples belonging to 23 species were collected from 18 different plant hosts. Parsimony analysis conducted in PAUP resulted in 12 most parsimonious trees of 291 steps in length with CI = 0.38 and RI = 0.43. The strict consensus tree is represented in Fig. 1. Three retrieved clades are consistent with proposed *Phellinus* species complexes (or genera).

Clade 1 comprised *P. torulosus*, *P. baumii* (LCP), *P. conchatus*, *P. baumii* (D), *P. baumii* (Y), *P. linteus* (D), *P. linteus* (Y), *P. linteus*, *P. linteus* (LCP), and *P. linteus* (R), species that have hymenial setae, hyaline to brown spores, pileate basidiomata, and skeletal hyphae that are brown, thick-walled, septate, and rarely branched.

Furthermore, *P. baumii* (D) and *P. baumii* (Y) are closer to each other than to *P. baumii* (LCP), which grouped with *P. conchatus*. These two taxa are similar with respect to many characters but have distinct setal characters. *P. baumii* (LCP) has only hymenial setae while *P. conchatus* has both hymenial and tramal setae. These taxa have hyaline spores while most of the characters of generative and skeletal hyphae are missing in the case of *P. baumii* (LCP). Although *P. baumii* is usually treated as akin to *P. linteus*, it was observed that *P. linteus* forms a less inclusive clade sharing characters like presence of hymenial setae and brown spores, but the spores of *P. linteus* are slightly thick-walled. Also, the spores of *P. baumii* are ellipsoid while *P. linteus* has ovoid spores. Moreover, *P. linteus* as described by Dai & Xu (1998) and Lim et al. (2003) was not similar to the *P. linteus* described by Larsen & Cobb-Poulle (1990), Rabba (1994), and the sample of the present study. This could be attributed to the fact that many characters are missing.

Clade 2 is composed of *P. rickii*, *P.* sp., *P. lamaensis* and *P. orientalis*. Although all these taxa have subglobose, thin-walled and hyaline basidiospores, the former two have only hymenial setae while the latter two have tramal and hymenial setae.

Clade 3 is formed by the species *P. coffeatoporus*, *P. pappianus*, *P. badius*, *P. macgregorii*, *P. stratosus*, *P. fastuosus*, *P. lloydii*, *P. merrillii* (R), *P. merrillii* and *P. merrillii* (LCP). All these species lack setae, and have slightly thick or thick-walled, brown basidiospores.

Discussion

This is the first attempt to analyze the species concept of Indian species of *Phellinus*. In this study, character evolution was not considered and the study was entirely based on the morphological characters.

Because of the complexity in the family as well as in the genera of *Hymenochaetaceae*, mycologists have divided the family and even genera into smaller taxa. This has resulted in several species complexes especially within the genus *Phellinus*, e.g. *P. rimosus* complex, *P. pini* complex, *P. igniarius* complex, etc. The parsimony analysis revealed that many of the studied specimens could be assigned to at least three of these complexes.

P. conchatus, for example, was previously regarded as a member of *P. pini* complex. Fiasson & Niemelä (1984) proposed a new combination for this species using *Porodaedalea* as a generic name, i.e. *Porodaedalea conchata* instead of *Phellinus conchatus*. *P. conchatus*, however, was regarded as a member of *P. igniarius* complex by Fischer (1987). In the present study *P. conchatus* grouped together with *P. baumii* (LCP).

However, *P. baumii* was treated as a close member of *P. linteus*. In addition, *P. torulosus* also grouped together with these species.

P. igniarius complex is recognized by the species having well developed dimitic hyphal system, setae always present, and non-dextrinoid and hyaline basidiospores becoming brown or yellow with age. Both *P. conchatus* and *P. baumii* (LCP) comply with the characters of this complex but *P. conchatus* has both tramal and hymenial setae while *P. baumii* has only hymenial setae. Moreover, *P. conchatus* is oligonucleate, haploid, and bipolar heterothallic while *P. torulosus* is binucleate (Fischer 1996b). Furthermore, *P. torulosus* shares characters of several complexes within *Phellinus* and seems to be closer to *P. ferreus* and *P. pini* (Fiasson and Niemelä 1984). The taxonomic position of *P. torulosus* is rather isolated in Europe and more closely related to taxa occurring in North America (*P. gilvus*) or the tropics (*P. licnoides* (Mont.) Pat.). In the present study *P. torulosus* shares characters of *P. iginarius* complex along with *P. conchatus* and *P. baumii* (LCP).

P. baumii and *P. linteus* can be distinguished on morphological features. *P. baumii* has long been regarded as a synonym of *P. linteus*, owing to morphological similarities, until Dai & Xu (1998) discriminated them (Lim et al. 2003). These species are well separated from each other in Clade 1. Moreover, although *P. baumii* is closer to *P. linteus*, it grouped with other *Phellinus* spp. of a major '*P. igniarius* complex' clade. The Indian specimen of *P. linteus*, *P. linteus* (LCP) and *P. linteus* (R) were closer to each other than to *P. linteus* (D) and *P. linteus* (Y). It is suggested that *P. linteus* might have intermediate forms and these taxa, especially those from India, need further evaluation using other data sets.

Taxa of the *P. pini* complex are apparently restricted to Europe (Fischer 1996a). However, Overholts (1953), Owens (1936), and Parmasto (1985), based on morphology, suggested the existence of undescribed taxa within *P. pini* complex.

The *P. pini* complex is characterized by species with dimitic hyphal system with skeletal hyphae, annual or perennial basidiomata, presence of setae, and basidiospores with variable morphology that are hyaline, becoming slightly yellow with age, and nondextrinoid. The basidiospores and host specificity to conifers distinguishes the *P. pini* complex from other groups. In the present analysis, taxa like *P. rickii*, *P.* sp. (probably a new species), *P. lamaensis* and *P. orientalis* were observed to share the characters of the complex. *P.* sp., *P. lamaensis* and *P. orientalis* have resupinate to effused-reflex basidiomata. Amongst these three species, *P.* sp. has annual basidiomata and host specificity. It was found only on *Broussonetia papyrifera*, while only *P. rickii* has pileate, applanate basidiomata. In basidiospore morphology, all species of this clade except for *P. rickii*, have hyaline, thin-walled, subglobose basidiospores; *P. rickii* has brown thin-walled spores. Both hymenial and tramal setae were observed in *P. lamaensis* and *P. orientalis*, and only hymenial setae were observed in *P. rickii* and *P.* sp.

The *P. rimosus* complex has been recognized as a unique group with similar rusty brown spores, absence of setae, and ungulate basidiomata rapidly becoming black and rimose. Murrill proposed a new name *Fulvifomes* Murrill 1914, for this group. Ryvarden (1987) included *P. badius*, *P. caryophylii*, *P. fastuosus*, *P. nilgheriensis*, *P. robiniae* and *P. rimosus* in this complex. During the present study it was observed that a large clade shares these characters. Along with *P. badius* and *P. fastuosus*, species like *P. coffeatoporus*, *P. pappianus*, *P. macgregorii*, *P. stratosus*, *P. lloydii*, *P. merrillii* (R), *P. merrillii* (LCP), and *P. merrillii* (specimens of present study) agree with the characters of *P. rimosus* complex.

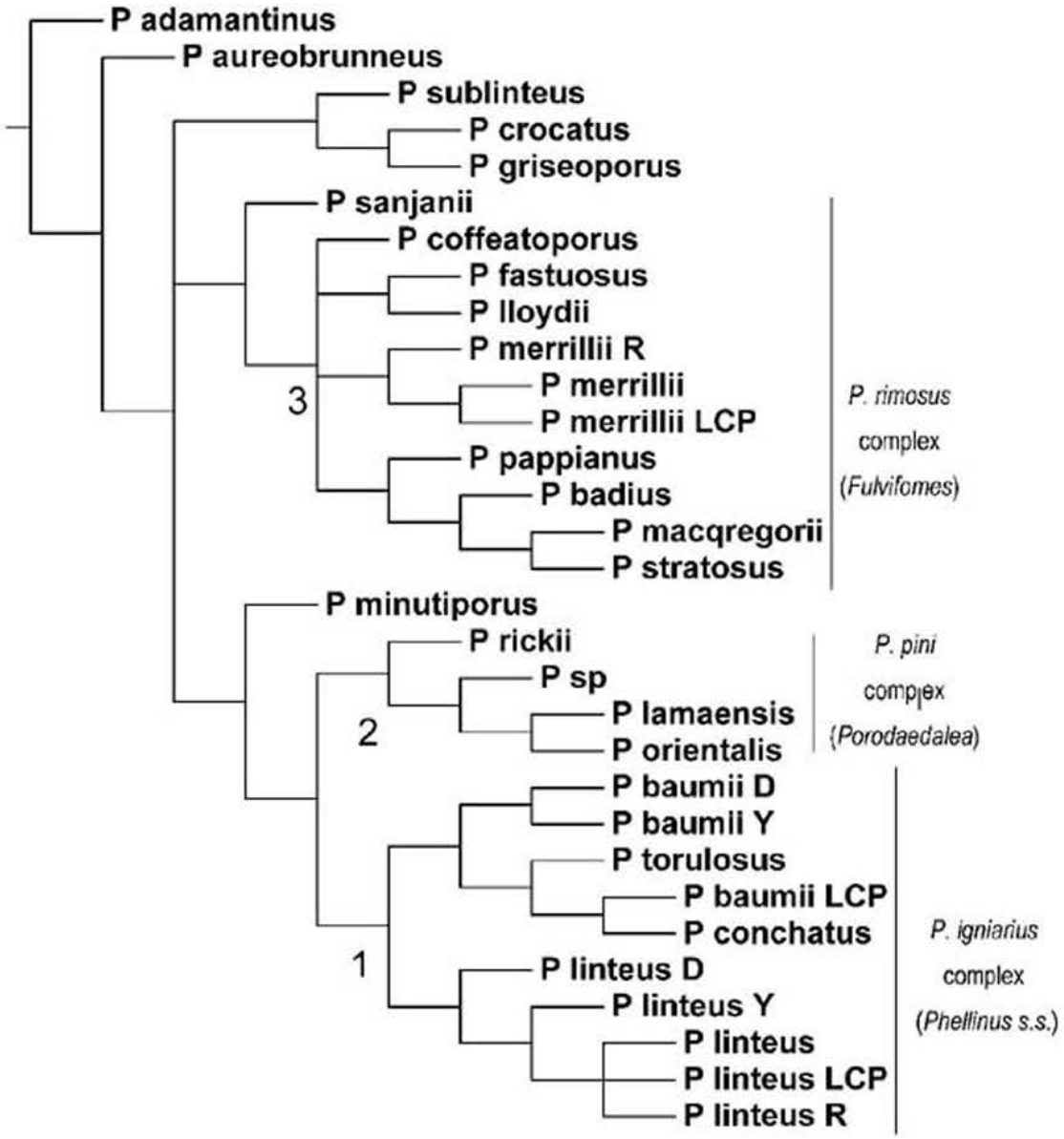


Fig. 1. Strict consensus tree for 23 *Phellinus* species in India.
Note: (Description of species according to LCP = Larsen and Cobb- Poulle 1990, D = Dai and Xu 1998, R = Rabba 1994, Y = Y. Lim et al. 2003.).

These species have pigmented brown spores, lack setae, and have pileate, perennial basidiomata.

P. sublinteus, *P. griseoporus*, and *P. crocatus* have varying basidioma morphology, and basidiospore shape and color. All, however, have thick-walled basidiospores. This clade was observed to be somewhat isolated from the rest of the main clades and the species within the clade could not be assigned to any particular species complex, and thus need further evaluation.

P. minutiporus showed rather close association with the taxa belonging to *P. iginarius* complex while *P. sanjanii* were closer to *P. rimosus* complex than the other studied taxa. Both *P. adamantinus* and *P. aureobrunneus* formed residual taxa in the tree and could not be assigned to any particular species complex.

Table 1: *Phellinus* collections studied and their collection data.

Species	Host	Site	Date	Sample
P. adamantinus (Berk.) Ryvarden	*Albizia lebbeck* (L.) Benth.	Near Kothi Gate (PUC)	2.VIII.2000	PH5A
	Eucalyptus globulus Labill.	Alice Garden (PUC)	27.VII.2000	PH3
	Tamarindus indica L.	Bremen Square, Aundh, Pune	5.VI.2001	PH20
P. aureobrunneus J.E. Wright & Blumenf.	*Albizia lebbeck*	Near Kothi Gate (PUC)	2.VIII.2000	PH4
P. badius (Berk.) G. Cunn.	*Acacia nilotica* (L) Delile	Lake side of Pashan	VI.1999	PH12
P. coffeatoporus Kotl. & Pouzar	*Acacia nilotica*	In front of Botany Department (PUC)	2.VIII.2000	PH13
P. conchatus (Pers.) Quél.	*Actinodaphne angustifolia* (Blume) Nees	Bhimashankar	27.IX.1987	VA-252
P. crocatus (Fr.) Ryvarden	*Acacia nilotica*	Alice Garden (PUC)	21.VII.2000	PH7
P. fastuosus (Lév.) Ryvarden	*Artocarpus integrifolius* L.f.	Sandu Brothers, Nerul, Navi Mumbai	III.2000	PH34S1
		Adali, Sawantwadi, Sindhudurg	VII.1988	Adali20
P. griseoporus D.A. Reid	*Albizia lebbeck*	Near Kothi Gate (PUC)	2.VIII.2000	PH5
		Near Kothi Gate (PUC)	2.VIII.2000	PH6
P. lamaensis (Murrill) Sacc. & Trotter	*Olea dioica* Roxb.	Bhimashankar	25.XII.2001	PH41
P. linteus (Berk. & M.A. Curtis) Teng.	*Mangifera indica* L.	Amba Valley	25.XII.2000	PH24
	Olea dioica	Karnala Bird Sanctury	19.IX.2000	PH30
	Pongamia glabra Vent.	Karnala Bird Sanctury	19.IX.2000	PH29
	Tamarindus indica	Alibaugh	14.IX.2000	PH18
P. lloydii (Cleland) G. Cunn.	*Artocarpus integrifolius*	Base of Sinhagad Fort	1.VII.2000	PH9
		Seetabai cha Dara Sinhagad Fort	1.VII.2000	PH9A
		Lokhande Aushadhalaya (LA), Ravivar Peth, Pune	IV.1999	PH33L2
P. merrillii (Murrill) Ryvarden	*Acacia leucophloea* Willd.	Anthropology Dept. (PUC)	17.VII.2000	PH15
		Anthropology Dept. (PUC)	17.VII.2000	PH15A
	Acacia nilotica	Lake side of Pashan	13.VIII.2001	PH17
	Artocarpus integrifolius	Lokhande Aushadhalaya, (LA), Ravivar Peth, Pune	IV.1999	PH32L1
		Sandu Brothers, Nerul, Navi Mumbai	III.2000	PH35S2
		Bhakti Cha Mala, Dapoli	IX.1998	PH36B1
		Bhakti Cha Mala, Dapoli	IX.1998	PH37B2

Table 1. (cont.).

Species	Host	Site	Date	Sample
P. merrillii (cont.)	*Artocarpus integrifolius* (cont.)	Nardave, Kankavali, Sindhudurg	XII.2001	PH47A
		Nardave, Kankavali, Sindhudurg	XII.2001	PH47B
		Nardave, Kankavali, Sindhudurg	XII.2001	PH47C
		Nardave, Kankavali, Sindhudurg	XII.2001	PH47D
		Adali, Sawantwadi, Sindhudurg	VII.1988	Adali21
		Deorukh, Ratnagiri	V.2002	M2
		Deorukh, Ratnagiri	V.2002	M4
	Azadirachta indica A. Juss.	Near Arts Faculty (PUC)	15.VII.2000	PH10
	Caesalpinia coriaria (Jacq.) Willd.	Near Examination Section (PUC)	15.VII.2000	PH16
	Gliricidia sepium (Jacq.) Kunth ex Walp.	Pune University Campus (PUC)	2.VIII.2000	PH2
		Near Post Office (PUC)	21.VII.2000	PH8
		Near S.T.P. (PUC)	2.VIII.2000	PH43
		Near S.T.P. (PUC)	15.VIII.2000	PH21
P. macgregorii (Bres.) Ryvarden	*Acacia nilotica*	Pune University Campus	26.XI.1992	VA-117
P. minutiporus Bondartseva & S. Herrera	*Albizia lebbeck*	Aundh Gate, (PUC)	2.VIII. 2000	PH31
P. orientalis Bondartseva & S. Herrera	*Thespesia populnea* (L.) Sol. ex Correa	Harihareshwar	19.IX.2000	PH1
P. pappianus (Bres.) Ryvarden	*Acacia nilotica*	Near Examination Section	2.VIII.2000	PH22
P. rickii Teixeira	*Swietenia mahagoni* (L.) Jacq.	Alice Garden (PUC)	17.VII.2000	PH14
P. sanjanii (Lloyd) Ryvarden	*Tamarindus indica*	Pune University Campus (PUC)	24.IX.1988	VA-354
P. stratosus Pat.	*Tamarindus indica*	Pune University Campus (PUC)	15.III.1992	VA-287
P. sublinteus (Murrill) Ryvarden	*Azadirachta indica*	Between S.T.P. and E.M.R.C. (PUC)	2.VIII.2000	PH23
	Gliricidia sepium	Between S.T.P. and E.M.R.C. (PUC)	2.VIII.2000	PH19
	Mangifera indica	Radhanagari	XI.2000	PH42
	Peltophorum ferrugineum Benth.	Alice Garden (PUC)	27.VII.2000	PH25
		Rear of Main Building (PUC)	IX.1999	PH26
P. torulosus (Pers.) Bourdot & Galzin	*Cassia fistula* L.	Central Bee Research Station, Pune	VI.2000	PH27
Phellinus sp.	*Broussonetia papyrifera* (L.) Vent.	Botanical Garden, Botany Dept. (PUC)	VI.2002	PH44

Table 2. List of characters and character states.

Character No.	CHARACTER	Character State
1	Life strategy	0 = annual, 1 = perennial
2	Basidioma morphology	0 = resupinate, 1 = effused-reflex, 2 = pileate
3	Basidioma	0 = sessile, 1 = spurious stipitate
4	Type of basidioma	0 = confluent, 1 = applanate, 2 = ungulate, 3 = imbricate, 4 = triquetrous, 5 = bracket, 6 = semi ungulate, 7 = pendent, 8 = convex
5	Attachment of pilei	0 = semicircular, 1 = dimidiate, 2 = lobate
6	Base of pilei	0 = attached by broad base, 1 = attached by narrow base, 2 = attached laterally
7	Consistency of basidioma	0 = brittle, 1 = corky, 2 = woody hard, 3 = pulvinate
8	Weight of basidioma	0 = light, 1 = medium, 2 = heavy
9	Separability from host	0 = easily, 1 = not easily
10	Basidioma gregariousness	0 = solitary, 1 = grouped
11	Color of pileal surface	0 = yellow, 1 = brown, 2 = red, 3 = black
12	Texture of pileal surface	0 = glabrous, 1 = velvety, 2 = tomentose, 3 = velutinate, 4 = pruinose
13	Zonation of pileal surface	0 = azonate, 1 = zonate
14	Sulcation of pileal surface	0 = sulcate, 1 = non sulcate
15	Cracks in pileal surface	0 = cracking, 1 = not cracking
16	Warts in pileal surface	0 = warty, 1 = not warty
17	Rimosity of pileal surface	0 = rimose, 1 = not rimose
18	Nodosity of pileal surface	0 = nodose, 1 = not nodose
19	Rugosity of pileal surface	0 = rugose, 1 = not rugose
20	Ridges in pileal surface	0 = ridged, 1 = not ridged
21	Induration of pileal surface	0 = indurate, 1 = not indurate
22	Shape of pileal surface	0 = flat, 1 = rounded
23	Moss covered	0 = yes, 1 = no
24	Margin	0 = entire, 1 = lobed
25	Thickness of margin	0 = thin, 1 = thick
26	Shape of margin	0 = acute, 1 = obtuse, 2 = blunt, 3 = rounded, 4 = nodular
27	Fertility of margin	0 = sterile, 1 = fertile
28	Texture of margin	0 = glabrous, 1 = tomentose, 2 = velutinate
29	Color of margin	0 = yellow, 1 = brown
30	Color of margin compared to pore surface	0 = paler than pore surface, 1 = darker than pore surface, 2 = concolorous
31	Consistency of margin	0 = brittle, 1 = firm
32	Morphology of margin	0 = soft, 1 = rough, 2 = sulcate
33	Size of margin	0 = below 2.5 mm, 1 = above 2.5 mm, 2 = more that 5 mm
34	Color of pore surface	0 = yellow, 1 = brown, 2 = red, 3 = gray

Table 2. (cont.).

Character No.	CHARACTER	Character State
35	Pore surface in light	0 = not glancing, 1 = glancing
36	Shape of pore surface	0 = flat, 1 = round
37	Texture of pore surface	0 = glabrous, 1 = tomentose, 2 = sulcate
38	Pore shape	0 = angular, 1 = circular, 2 = irregular, 3 = regular, 4 = cappilate and / or toothed
39	Pores per mm	0 = up to 6, 1 = up to 9, 2 = up to 12
40	Tube layer	0 = indistinctly stratified, 1 = distinctly stratified
41	Color of tubes	0 = yellow, 1 = brown, 2 = red
42	Color of tube layer	0 = paler than context, 1 = concolorous, 2 = darker than context
43	Length of tubes	0 = short, 1 = long
44	Layer strata	0 = single, 1 = double or multiple
45	Black line between layers	0 = absent, 1 = present
46	Size of tubes	0 = up to 5 mm, 1 = up to 7 mm, 2 = up to 10 mm, 3 = up to 12 mm, 4 = more than 12 mm
47	Thickness of context	0 = thin, 1 = thick
48	Consistency of context	0 = fibrous, 1 = corky, 2 = woody hard
49	Luster of context	0 = silky or golden on broken surfaces, 1 = without a luster, 2 = fibrous luster
50	Texture of context	0 = azonate, 1 = zonate
51	Dark line between context	0 = absent, 1 = present
52	Tissue of context	0 = of one kind, 1 = of two kinds
53	Color of context	0 = yellow, 1 = brown, 2 = red, 3 = black
54	Size of context	0 = up to 5 mm, 1 = up to 10 mm, 2 = more than 10 mm
55	Generative hyphae	0 = thin-walled, 1 = thick-walled
56	Branching of generative hyphae	0 = branched, 1 = unbranched, 2 = rarely branched
57	Septa of generative hyphae	0 = unseptate, 1 = rarely septate, 2 = septate
58	Color of generative hyphae	0 = hyaline, 1 = yellow, 2 = brown, 3 = green
59	Size of generative hyphae	0 = up to 4 µm, 1 = up to 5 µm
60	Skeletal hyphae	0 = thin-walled, 1 = thick-walled
61	Branching of skeletal hyphae	0 = branched, 1 = unbranched, 2 = rarely branched
62	Septa of skeletal hyphae	0 = non-septate, 1 = rarely septate, 2 = septate
63	Color of skeletal hyphae	0 = yellow, 1 = brown
64	Size of skeletal hyphae	0 = below 6 µm, 1 = above 6 µm
65	Setae	0 = both absent, 1 = only hymenial setae, 2 = both present
66	Hymenial setae	0 = thick-walled, 1 = thin-walled, 2 = absent
67	Shape of hymenial setae	0 = straight, 1 = ventricose, 2 = uncinate, 3 = subulate, 4 = fusiform, 5 = conical, 6 = absent

Table 2 (*concluded*)

Character No.	CHARACTER	Character State
68	Septa of hymenial setae	0 = non-septate, 1 = septate, 2 = absent
69	Base of hymenial setae	0 = globular base, 1 = ventricose, 2 = inflated, 3 = bent base, 4 = bulbous base, 5 = absent
70	Tip of hymenial setae	0 = ventricose, 1 = straight, 2 = acute, 3 = absent
71	Color of hymenial setae in water	0 = yellow, 1 = brown, 2 = absent
72	Color of hymenial setae in KOH	0 = yellow, 1 = brown, 2 = absent
73	Tramal setae	0 = thick-walled, 1 = thin-walled, 2 = very elongated, 3 = absent
74	Septa of tramal setae	0 = non-septate, 1 = septate, 2 = absent
75	Apex of tramal setae	0 = acute, 1 = blunt, 2 = absent
76	Shape of tramal setae	0 = cylindrical, 1 = elongated, 2 = absent
77	Color of tramal setae in water	0 = yellow, 1 = brown, 2 = absent
78	Color of tramal setae in KOH	0 = yellow, 1 = brown, 2 = absent
79	Basidium shape	0 = globose, 1 = subglobose, 2 = clavate, 3 = pyriform, 4 = barrel shaped
80	Basidiospore morphology	0 = globose, 1 = subglobose, 2 = ovoid, 3 = ellipsoid
81	Basidiospore wall	0 = thin, 1 = thick, 2 = slightly thick
82	Basidiospore pigmentation	0 = hyaline, 1 = pigmented
83	Basidiospore color in water	0 = yellow, 1 = brown, 2 = hyaline
84	Basidiospore color in KOH	0 = pale golden brown, 1 = dull brown, 2 = olivaceous, 3 = brown

Acknowledgements

We would like to thank all the people that indirectly or directly contributed to this work, and, especially, Dr James Ginns and Dr Eric McKenzie for exhaustive reviews and invaluable criticism. This work is part of the PhD thesis of the first author and he would like to thank Dr Jitendra Vaidya as well as the head of the Department of Botany, University of Pune for providing necessary facilities.

Literature cited

Bagchee KD. 1961. The fungal diseases of Sal (*Shorea robusta* Gaertn. F. and Fils) IV. *Fomes caryophyllii* (Rac.) Bres. a destructive heart rot of Sal. Indian Forest Records (N.S.) 2: 25-58.

Bagchee KD, Bakshi BK. 1950. Some fungi as wound parasite on Indian trees. Indian Forester 76: 244-253.

Bakshi BK. 1958. New records of hymenomycetes in India. Indian Phytopathology. 11: 88.

Bakshi BK. 1971. The *Polyporaceae* (On Trees and Timber). ICAR, New Delhi 58-62, 246.

Bondarzew AS. 1953. The Polyporaceae of the European USSR and Caucasia. U.S.S.R Academy of Sciences Printing House, Moscow. [in Russian].

Corner EJH. 1991. Ad polyporaceas. VII. Beih. Nova Hedw. 101: 1-175.

Cunningham GH. 1965. *Polyporaceae* of New Zeland. New Zealand Department Scientific and Industrial Research Bulletin. 164: 1-304.

Dai YC. 1999. *Phellinus* sensu lato (*Aphyllophorales. Hymenochaetaceae*) in East Asia. Acta Bot. Fenn. 166: 1-115.

Dai YC, Xu MA. 1998. Studies on the medicinal polypore, *Phellinus baumii*, and its kin *P. linteus*. Mycotaxon 67: 191-200.

Domanski S, Orlos H, Skirgiello A. 1973. Fungi. *Polyporaceae* II (pileate), *Mucronoporaceae* II (pileate), *Ganodermataceae, Bonderzewiaceae, Boletopsidaceae, Fistulinaceae*. Foreign Scientific Publications, Poland.

Donk MA. 1974. Checklist of European polypores. Royal Netherlands Academy of Arts and Science Press, Netherlands.

Fiasson JL. 1982. Distribution of styrylpyrones in the basidiocarp of various *Hymenochaetaceae*. Bioch. Syst. Ecol. 10: 289-296.

Fiasson JL, Niemelä T. 1984. The *Hymenochaetales*: a revision of the European poroid taxa. Karstenia 24: 14-28.

Fidalgo O. 1968. *Phellinus* from Venezuela – I. Mem. New York Bot. Gard. 17: 109-147.

Fischer M. 1987. Biosystematische Untersuchungen an den Porlingsgattungen *Phellinus* Quél. und *Inonotus* Karst. Bibl. Mycol. 107: 1-133.

Fischer M. 1996a. Molecular and microscopical studies in the *Phellinus pini* group. Mycologia 88: 230-238.

Fischer M. 1996b. On the species complexes within *Phellinus*: *Fomitiporia* revised. Mycol. Res. 100: 1459-1467.

Ganesh PN, Leelavathy KM. 1986. New records of *Phellinus* from India. Curr. Sci. 55: 727-728.

Gilbertson RL. 1979. Wood rotting fungi of North America. Mycologia 72: 1-49.

Gilbertson RL, Ryvarden L. 1986. North American Polypores. Vol.1, Fungiflora, Norway.

Gilbertson RL, Ryvarden L. 1987. North American Polypores. Vol. 2, Fungiflora, Norway.

Goés-Neto A, Loguercio-Leite C, Guerrero RT. 2001. Morphological cladistic analysis of tropical *Hymenochaetales* (Basidomycota). Mycotaxon 79: 467-479.

Hansen L, Knudsen H. 1997. Nordic macromycetes. Vol. 3. Helsinki University Printing House, Finland.

Jahn H. 1981. Die resupinaten *Phellinus* – Arten in Mitteleuropa. Nachträge 1967-1981. Bibl. Mycol. 81: 109-151.

Jordan M, David C. 1995. Encyclopedia of Fungi of Britain and Europe. David and Charles Book, UK.

Jülich W. 1984. Basidiomycetes of South-East Asia. Persoonia 12: 107-117.

Kim S-Y, Jung HS. 2002. Cladistic analysis of the Polyporaceae using morphological characters. Mycotaxon 82: 295-314.

Kotlaba F, Pouzar Z. 1978. Revision of the original material of *Phellinus sulphurascens* Pil., *Xanthochrous glomeratus* ssp. *heinrichii* and *Polyporus rheades* Pers. (Hymenochaetaceae). Česká Mycologie 24: 146-152.

Larsen MJ, Cobb-Poulle LA. 1990. *Phellinus* (*Hymenochaetaceae*). A survey of the world taxa. Synopsis Fungorum 3: 1-206.

Lim YM, Lee JS, Jung HS. 2003. Type studies on *Phellinus baumii* and *Phellinus linteus*. Mycotaxon 85: 201-210.

Lloyd CG. 1915. Synopsis of the genus *Fomes*. Mycological Writings 4: 209-288.

Lowe JL. 1957. Polyporaceae of North America. The genus *Fomes*. State University College of Forestry at Syracuse University Technical Publication 80: 1-97.

Mizuno T. 2000. Development of an antitumour biological response modifier from *Phellinus linteus* (Berk. et Curt.) Teng (Aphyllophoromycetideae). Int. J. Med. Mushr. 2: 21-33.

Natarajan K, Kolandavelu K. 1985. Resupinate Aphyllophorales from South India – I. Kavaka 12: 71-76.

Niemelä T. 1972. On Fennoscandian Polypores. II. *Phellinus laevigatus* (Fr.) Bourd. & Galz. and *P. lundellii* Niemela, n. sp. Ann. Bot. Fenn. 9: 41-59.

Niemelä T. 1975. On Fennoscandian polypores 4. *Phellinus igniarius*, *P. nigricans* and *P. populicola*, n. sp. Ann. Bot. Fenn. 12: 93-122.

Nuss I. 1986. Zur Ökologie der Porlinge II. Bibl. Mycol. 105: 1-299.

Omar MB, Bolland L, Heather WA. 1979. A permanent mounting medium for fungi. Bull. Br. Mycol. Soc. 13: 31-32.

Overholts LO. 1929. Research methods in the taxonomy of Hymenomycetes. Proceedings of the International Conference of Plant Sciences 2: 1688-1712.

Overholts LO. 1953. The *Polyporaceae* of United States, Alaska and Canada. University of Michigan Press, U.S.A.

Owens CF. 1936. Studies on the wood rotting fungus *Fomes pini*. Variation in morphology and growth habit. Am. J. Bot. 23: 144-149.

Parmasto E. 1985. Species concept in *Hymenochaetaceae* (Fungi, *Hymenochaetales*). Proc. Ind. Acad. Sci. 94: 369-380.

Parmasto E. 1988. What is *Ochroporus ossatus* (*Hymenochaetaceae*)? Mycotaxon 32: 219-222.

Rabba AS. 1994. Studies in the genus *Phellinus* Quél. from Maharashtra. Ph.D. thesis. University of Pune, India.

Rabba AS, Vaidya JG, Nanda MK. 1994. The genus *Phellinus* from Bhimashankar forests. Biol. Ind. 5: 47-56.

Rajchenberg M. 1989. *Polyporaceae* (*Aphyllophorales*, Basidiomycetes) from southern South America: A mycogeographical view. Sydowia 41: 277-291.

Roy A. 1979. Taxonomy of *Fomes durissimus*. Mycologia 71: 1005-1009.

Ryvarden L. 1972. A critical checklist of the *Polyporaceae* in tropical East Africa. Norw. J. Bot. 19: 229-238.

Ryvarden L. 1978. *Polyporaceae* of North Europe. Fungiflora, Norway.

Ryvarden L. 1987. New and noteworthy polypores from tropical America. Mycotaxon 28: 525-541.

Ryvarden L. 1991. Genera of polypores, nomenclature and taxonomy. Synopsis Fungorum 5: 1-363.

Ryvarden L, Gilbertson RL. 1994. European polypores part 2. Synopsis Fungorum 7: 394-743.

Ryvarden L, Johansen I. 1980. A preliminary polypore flora of East Africa. Fungiflora, Norway.

Sharma JR. 1993. New records of polypores from India. Ind. J. For. 16: 186-187.

Singh B. 1966. Timber decay due to five species of *Fomes* as new record in India. Indian Forester 92: 653-655.

Smith JE, Rowan NJ, Sullivan R. 2002. Medicinal Mushrooms: their therapeutic properties and current medicinal usage with special emphasis on cancer treatments. Cancer Research, UK (URL http://sci.cancerresearchuk.org/labs/med_mush/med_mush.html).

Swofford DL. 1999. PAUP* 4.0: phylogenetic analysis using parsimony, version 4.0b10. Sinauer Associates Inc., U.S.A.

Thind KS, Chatrath MS. 1957. The *Polyporaceae* of the Mussoorie Hills II. Research Bulletin of the Punjab University 125: 431-442.

Thind KS, Dhanda RS. 1980. The *Polyporaceae* of India. X. Kavaka 8: 59-67.

Tiwari DP, Harsh NSK, Tiwari CK. 1989. Polypore flora of Jabalpur and its eastern Suburbs. Biomes 4: 69-79.

Vaidya JG. 1995. Biology of the Fungi. Satyajeet Prakashan, India.

Vaidya JG, Bhor GL. 1991. Medicinal important wood rotting fungi with special emphasis on phansomba. Deerghayu International 7: 16-19.

Vaidya JG, Lamrood PY. 2000. Traditional medicinal mushrooms and fungi of India. International Journal of Medicinal Mushrooms 2: 209-214.

Vaidya JG, Rabba AS. 1993. Fungi in folk medicine. Mycologist 7: 131-133.

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.

MYCOTAXON

Volume 95, pp. 133–136 *January–March 2006*

Paecilomyces verticillatus, a new species isolated from soil in China

ZHU LI, YANFENG HAN & ZONGQI LIANG*

zhuliluck@ 163.com swallow112886@yahoo.com.cn
**zqliang472@yahoo.com.cn*

Institute of Fungus Resources, Guizhou University
Guiyang 550025, China

Abstract—A new species, *Paecilomyces verticillatus*, isolated from soil samples of Guiyang City, Guizhou Province, China, is described and illustrated. It can be distinguished by white colonies when grown on Czapek agar, whorls of phialides arising from undifferentiated hyphae, and subglobose conidia.

Key words—fungi, hyphomycete, taxonomy, morphology

Introduction

Samson (1974) discussed the morphology differences between *Verticillium* Nees and *Paecilomyces* Bainier. The genus *Verticillium* is characterized by verticillate conidiophores, awl-shaped phialides and conidia in slimy heads. However, *Verticillium* sect. *Prostrata* contains some species with *Paecilomyces*-like, slightly swollen phialides and conidia in chains. Our new species, *Paecilomyces verticillatus*, resembles *Verticillium* species that produce phialides always in whorls on aerial hyphae or simple conidiophores. The fact that the phialides in our proposed new species typically have inflated bases with abruptly tapering necks places it in the genus *Paecilomyces*.

Materials and Methods

Collection and strains isolation

Strain GZDX-IFR49-01 was isolated from soil collected from Forest Park, Guiyang, Guizhou Province, China, May, 2003. Two grams of soil were added to a flask containing 20ml sterilized water and glass beads. The soil suspension was diluted to a concentration of 10^{-1}-10^{-3} after shaking for about 10min. A 1ml soil suspension (concentration 10^{-3}) was mixed with Martin medium in sterilized 9 cm diam Petri dish and incubated at 25°C for 5 days. Colonies showing a typical *Paecilomyces* conidiogenous structure were then purified by transplanting to Martin's slants.

*Corresponding author: Zongqi Liang

Identification of strains

The strains were transplanted onto Czapek agar, potato dextrose agar (PDA), and Sabouraud agar in accordance with procedures set forth in Brown and Smith (1957) and Samson (1974). After incubation at 25-26°C for 14 days, strains were identified based on colony characters, conidiogenous structures, and other biological features.

The type culture GZDX-IFR49-01 and the holotype GZDX49-01 of *P. verticillatus* (a dried plate culture on Czapek agar) were deposited in the Institute of Fungus Resources, Guizhou University, China.

Description of new species

Paecilomyces verticillatus Z.Q. Liang, Z. Li & Y.F. Han **sp. nov.** Figs. 1-6

On agaro Czapekii coloniae 35-55 mm diam in 14 diebus ad 25°C, albae, floccosa, margine irregularis, reserso albae. Hyphae hyaline, levia, 1.2-1.8 µm crassa. Conidiophora breva, 9.6-19.8 µm longa. Phialides 7.8-14.4 × 1.2-2.4 µm, verticillatis, conis vel bases cylindres. Conidia hyalina, levia, subglobasa vel ellipsoidea, catenulatae, 1.2-1.8 × 0.6-1.2 µm.

Typus: GZDX-IFR49-01 et cultara viva GZDX49-01, isolatus ab soli in sylvis, Guiyang, Provinice Guizhou, V, 2003, Y. F. Han & H. L. Chu; in Guizhou Univ., conservatur.

Colonies on Czapek agar growing rapidly, attaining a diameter of 35-55 mm within 14 days at 25°C; ridgy, white, floss, irregular in the margin; reverse white. Vegetative hyphae septate, hyaline, smooth-walled, 1.2-1.8 µm wide. Conidiophores hyaline, smooth-walled, 9.6-19.8 µm, directly bearing a whorl of 3 to 5 phialides or verticillate prophialides with a whorl of 3 phialides. Phialides 7.8-14.4 × 1.2-2.4 µm, awl-shaped or consisting of a cylindrical basal portion and a thin neck, less than 0.5 µm wide. Conidia one-celled, hyaline, smooth-walled, mostly subglobose to ellipsoidal, 1.2-1.8 × 0.6-1.2 µm; few fusiform, 1.8-3.0 × 1.8-2.4 µm, forming divergent, dry chains or aggregating spore group.

Distribution: Guizhou Province, China.

Discussion

Seven accepted species of *Paecilomyces* with subglobose conidia were identified using CABI Bioscience Database, CBS Database and recent papers (Table 1).

Table 1. Seven accepted species of *Paecilomyces* with subglobose conidia

P. militaris Z.Q. Liang	*P. stipitatus* Y.F. Han & Z.Q. Liang
P. niveus Stolk & Samson	*P. vinaceus* Y.F. Han & Z.Q. Liang
P. odonatae Zuo Y. Liu et al	*P. viridis* Segretain et al. ex Samson
P. rariramus Z.Q. Liang & B. Wang	

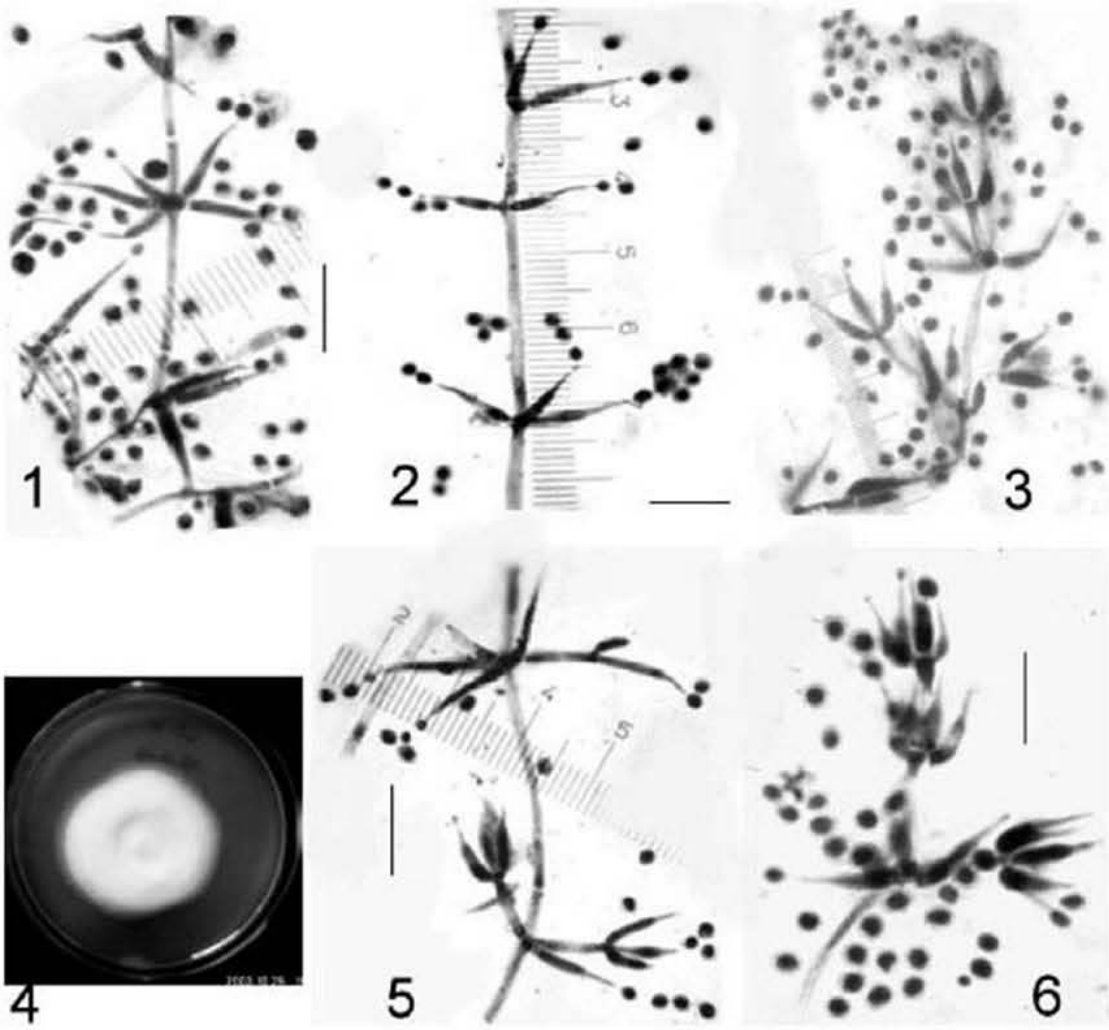


Fig. 1-6 Colony and conidiogenous structure of *Paecilomyces verticillatus*
1-3, 5-6. Conidiogenous structure. 4. Colony Bar = 10 μm.

The thermophilic nature of *P. niveus* (Samson 1974), the yellow-green colony reverse of *P. viridis* (Samson 1974), the vinaceous colony reverse of *P. vinaceus* (Han et al. 2005), the rarely branching conidiogenous structures of *P. rariramus* (Liang 2003), and the larger conidia (1.7-5.9 × 1.7-3.3 μm) and yellow colony reverse of *P. stipitatus* (Han et al. 2005) do not exist in *P. verticillatus*.

P. odonatae (Liu et al. 1996) and *P. militaris* (Liang 2001) are closely related to the new species. However, *P. odonatae* has both globose conidia in straight chains and cylindrical conidia in oblique chains. *P. militaris* also exhibits both straight and oblique chain conidial arrangements and produces larger conidia (2-3.2 × 1.5-2 μm) than those of *P. verticillatus*.

Paecilomyces verticillatus can be distinguished from all the other species in the genus by producing (1) phialides that often arise from undifferentiated hyphae in whorls, (2) white colonies on Czapek agar, and (3) subglobose conidia.

Acknowledgements

This project was supported by the National Natural Science Foundation of China (No. 30270011). We are grateful to Professors Zuoyi Liu and Jichuan Kang for their comments on the manuscript. At the same time, we sincerely appreciate editorial review and revisions.

References

Brown AHS, Smith G. 1957. The genus *Paecilomyces* Bainier and its perfect stage *Byssochlamys* Westling. Trans. Brit. Mycol. Sac. 40 (1): 17 - 89.

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

Liang ZQ, Wang B, Kang JC. 2003. Several rare entopathogenic fungi from western Sichuan Mountains. Fangal Diversity 12: 129 - 134.

Liang ZQ. 2001. A corroboration of the anamorph of *Cordyceps militaris* – *Paecilomyces militaris* Liang sp.nov.. Acta Edulis Fungi 8 (4): 28 - 32.

Liu ZY, Liang ZQ, Liu AY. 1996. A new species *Paecilomyces* isolated from *Cordyceps odonatae*. Mycosystema 9: 83 - 87.

Samson RA. 1974. *Paecilomyces* and some allied Hyphomycetes. Stud. Mycol. 6: 1 – 119.

MYCOTAXON

Volume 95, pp. 137–180 *January–March 2006*

A monograph of the genus *Cookeina* (Ascomycota, *Pezizales, Sarcoscyphaceae*)

TERESA ITURRIAGA & DONALD H. PFISTER

titurri@usb.ve
Departmento de Biología de Organismos, Universidad Simón Bolívar
Caracas, Venezuela

dpfister@oeb,harvard.edu
Department of Organismic and Evolutionary Biology, Harvard University
Cambridge, MA, USA

Abstract—Eight species of the wood inhabiting pantropical genus *Cookeina* are described and illustrated. The genus *Cookeina* is characterized by large, stipitate or sessile brightly colored apothecial ascoma, with or without hairs, and by distinctive, thick-walled asci that have eccentricly placed opercula. An overview of the morphology, development and life histories of the species are given along with discussion of their relationships. A new species, *C. colensoiopsis*, is described from Venezuela, *C. speciosa* is recognized as a species complex, and a lectotype is designated for *C. sinensis*.

Key words—Pezizomycetes, cup-fungi, taxonomy

Table of Contents

Introduction

In this monograph we present an account of the genus *Cookeina*, a member of the *Pezizales*, which is comprised of species with lowland tropical and subtropical distributions. Species in the genus inhabit recently fallen angiospermous woody substrates and are presumed to be saprotrophic. The apothecial ascomata are brightly colored, range in size up to about 3 cm in diameter and are often stipitate. Because they are large, brightly colored and sometimes occurr in profusion in a single small area, members of this genus are frequently collected. Even so, distributional records are incomplete and primarily account for the common species. Nonetheless, the knowledge of the biology of the species is minimal.

The genus has been placed in the *Sarcoscyphaceae* by all modern authors (Denison 1967, Eckblad 1968, Korf 1970, 1972, 1973, Le Gal 1953, Rifai 1968) and it has been well characterized based on macro- and microscopic features. Circumscription has been debated only in regard to the placement of *Peziza insititia*. This taxon has been placed in *Cookeina* or alternatively in the monotypic genus *Boedijnopeziza* (Ito & Imai 1937). Recently, Melendez-Howell et al. (2003) and Weinstein et al. (2002) include *Boedijnopeziza* in *Cookeina*. Within the *Sarcoscyphaceae Cookeina* has been allied most closely to *Microstoma*. Together *Cookeina* and *Microstoma* form a monophyletic group that has been recognized formally as the tribe *Boedijnopezizeae* (Cabrello 1988, Harrington et al. 1999, Korf 1970, 1972, 1973).

In this work we summarize current knowledge about the genus and provide identification keys, descriptions, and commentaries. We bring together in a single source the literature related to this genus. We are aware of certain gaps related to distributional records, particularly regarding Africa.

Historical background

Dating from the earliest days of biodiversity exploration in the Caribbean, the history of the genus *Cookeina* spans three hundred years. In 1705 an illustration of *Peziza speciosa* from the West Indies was published (Plumier 1705). The figure caption in Latin and French, a polynomial and the only description we have of Plumier's collections, reads *"Fungoides cyathiforme coccineum, oris pilosis/Foungoide en maniére de verre couleur d'écarlete, à bord velu."* With this brief commentary, the defining macroscopic characters of this fungus and of the genus *Cookeina*, to which it would ultimately be referred, were set down. These fungi are goblet-shaped, scarlet to carmine, with hairs at the mouth or margin of the apothecial ascomata. Although recorded by Fries (1822) under *Peziza speciosa* this early record went largely unnoticed until Dennis (1994) provided an intrepretation of Plumier's illustration that placed it in the genus *Cookeina*. Under the broad, inclusive genus *Peziza* other species sharing these characteristics were described in the years following Fries. As tropical areas of the world were explored during the middle years of the 19th century several species were added, which ultimately were treated in the genus *Cookeina*. The short descriptions from this period often lacked essential details of spore size and hair morphology resulting in the production of many synonymous names for the common species. In the late 19th century, as part of a trend toward erecting segregate genera for the larger members of the *Pezizales*, several authors

nearly simultaneously created genera to accommodate these distinctive species. Cooke (1879) placed *P. sulcipes*, *P. hindsii*, *P. tricholoma* and *P. insititia*, all referable to *Cookeina* today, in *Peziza* subgenus *Trichoscypha*. Saccardo (1889) raised Cooke's subgenus *Trichoscypha* to generic level but in doing so created a later homonym. *Trichoscypha* Hooker f. (Bentham & Hooker 1862) is a genus in the *Anacardiaceae*. Further confusion exists because Boudier (1885) used *Trichoscypha* as a generic name for inoperculate discomycetes mostly belonging to the genus *Lachnellula* (*Hyaloscyphaceae*). Saccardo (1889) included species with both operculate and inoperculate asci in *Trichoscypha*. When Kuntze (1891) erected the genus *Cookeina* his circumscription created a highly heterogeneous assemblage of taxa including members of both the *Pezizales* and *Helotiales* but encompassed those taxa previously treated in *Trichoscypha*. Finally, *Pilocratera* was described (Hennings (1891). It post-dates the creation of *Cookeina* but was in general use for a period. Seaver (1927) designated *P. tricholoma* as the type species of the genus *Cookeina*; all authors have followed this typification. *Cookeina*, *Trichoscypha* and *Pilocratera*, are all based on the same type species (Eckblad, 1968).

Seaver (1913, 1925, 1927, 1928, 1936, 1942) studied the American species and codified both the use of the name and the concept of the genus *Cookeina*. At the same time, Boedijn (1929, 1933) studied and described Asian materials. Boedijn's observations on spore germination and ascus construction contributed to the overall knowledge of the genus. With some hesitation Seaver (1925) added *C. tetraspora* to the genus. This species differs in construction of the excipulum and in spore morphology. Later, it was designated the type species of the genus *Nanoscypha* (Denison 1972). Le Gal (1953) regularized the taxonomy through study of type material and elucidated the ascus morphology, as discussed more fully below. Weinstein et al. (2002) discussed relationships of the species based on a molecular phylogenetic study. Several authors treated one or more species from specific geographical regions as follows: **Africa and Madagascar** (Alasoadudra 1972, Douanla-Meli & Langer 2005, Le Gal 1953, 1960, Moravec, 1997), Indonesia (Boedijn 1929,1933), the **Americas** (Calonge 1986, Chacón & Medel 1990, Denison 1963, 1967, Dennis 1970, Gamundí, 1957, 1959, 1971, Hanlin et al. 1991, Hanlin 1993, Romero & Gamundí 1986, Tobon 1991), the **West Indies** (Dennis 1954, Maldonado González 2000, Patouillard in Duss 1903, Pfister 1974, Seaver 1936, Vooren 2002, 2003), Asia and India (Durrieu et al. 1997, Liou & Chen 1977, Nagao 1997, Otani 1971, 1975, Pfister & Kausal 1984, Wang 1997, Wang 2001, Yang 1990) and **Australasia** (Rifai 1968).

Materials and methods

This study used herbarium specimens and living material, particularly from South America. Type specimens of all taxa were examined when available. A concerted effort was made to collect and document specimens during two summers in an Amazonian forest in the southern part of Venezuela. In that study color variation in *Cookeina speciosa* was a particular focus. Collections from that study were deposited in the following herbaria: FH, USB, VEN.

Dried specimens were prepared for microscopic examination by rehydrating a small portion of an apothecium in water for 1-2 hours. The sample was then oriented on the stage of a sliding freezing microtome, covered with 50% aqueous commercial mucilage

and frozen. Median sections 20 to 50 µm thick were made. Sections were removed from the blade with a small, wet brush and placed on a microscope slide, where they were either mounted directly for examination or left to air-dry on the slide. In either case sections were selected under the dissecting scope, transferred with an insect pin to a slide and mounted in water, Cotton Blue in lactic acid or Congo Red in ammonia. Where quality and condition allowed 10 to 30 measurements of each structure were recorded for each set of sections. Only asci that contained mature ascospores were measured. Ascus measurements do not include the thin hyphal base. Ascospore sizes are based on the measurement of discharged ascospores; colors are given for fresh, dry and re-hydrated material. Drawings were made using a measured free hand method.

Terminology for cell types and arrangements follows Korf (1952, 1973) and Pfister & Kimbrough (2001). Herbarium acronyms follow *Index Herbariorum* (www.nybg.org/bsci/ih/ih.html); author's names are abbreviated following *Authors of Fungal Names* (www.indexfungorum.org/AuthorsOfFungalNames.htm).

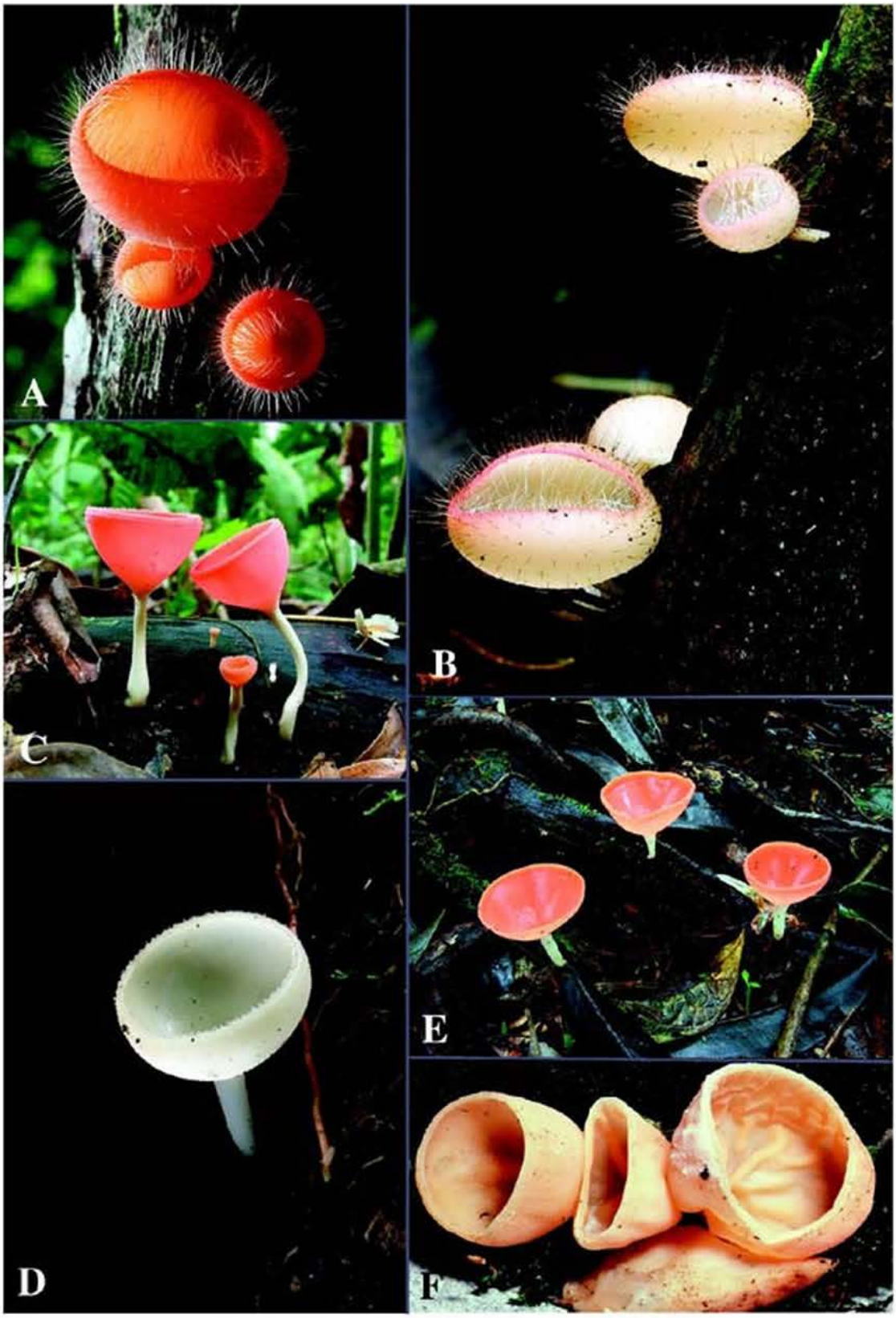
In the nomenclators the notation "!!" following citations indicates, that holotype, neotype, or isotype material was examined. The notation "!" indicates that syntype, paratype, or other authentic material was examined. A question mark before a species name indicates that type material was not examined but that the indicated placement is probable. Specimens examined are cited with the data as they appear on the packet label, supplemental data are enclosed in square brackets. Other abbreviations used are HT = holotype, IT = isotype, PT = paratype, and NT = neotype. Over the course of these studies many collections were consulted most are listed in the specimen cited section but citations have been shortened and a few collections that were consulted incidentally have not been listed.

Results and general discussion

Macroscopic features

Apothecia of *Cookeina* species are relatively large, ranging up to 3 cm in diam. They are characteristically pliable, resilient and not easily broken by handling. Carotenoids are present (Arpin 1969) which give the hymenia colors ranging from yellow and orange to scarlet and dark tones of mauve (see figure 1). In a few cases ascomata are white; in others maroon to brown. Apothecia of *C. colensoi* and *C. venezuelae* have short stipes or are nearly sessile. When present, stipes may range in length up to 8 cm. The outer surface of the ascomata, or the receptacle, may have distinct hairs distributed either over the entire surface, as in *C. tricholoma* and *C. sinensis*, or at the margins, as in *C. insititia* and *C. speciosa*. *Cookeina colensoi*, *C. indica* and *C. venezuelae* lack prominent hairs. Hairs are composed of fascicles of fused hyphae originating from the ectal or the medullary excipulum. Receptacle surfaces of all species are to some degree tomentose due to the projecting free hyphae that arise from the ectal excipulum.

Figure 1. Habitat photographs of species of *Cookeina*. A. *C. tricholoma* TL-11427 (C). B. *C. tricholoma* TL 11409 (C). C. *C. speciosa* TL 8405 (C). D. *C. speciosa* TL – 11393 (C). E. *C. speciosa* TL- 11475 (C). F. *C. venezuelae* Halling 5452 (NY). A-E courtesy of Jens Petersen (copyright Jens H. Petersen/MycoKey) specimens from Ecuador, and F. was used with the permission of Roy Halling, specimen from Venezuela.


A
B
C
D
E
F

Asci

Asci are large, up to 550 µm long and 40 µm broad and have thick walls. No part of the wall colors blue in iodine solutions; wall layers are differentially stained in Congo red in ammonia and the operculum stains more deeply in Congo red than surrounding regions of the wall. The long cylindrical asci are rounded proximally and distally. Asci have prominent, apically thickened opercula eccentrically located at the ascus apex. The asci open along a line of dehiscence to form the operculum. The thickened operculum is hinged at the lower region and it folds back at the time of rupture. Samuelson (1975) described the apical apparatus using TEM and Melendez-Howell et al. (2003) gave detailed information on ascus wall-layering using TEM. The asci are produced from narrow ascogenous hyphae which expand abruptly at the base of the asci. This gives the asci a rounded base. No croziers were observed. Because of the thinness of the hyphae at the ascus base, the hymenium often separates from the subhymenium when preparing mounts for microscopy. In all species asci mature synchronously. Within a single ascoma all ascospores are at exactly the same stage of development. The controls involved in this process are unknown. Asci that are constricted basally and that mature simultaneously are known in *Cookeina*, its sister genus *Microstoma* and in *Chorioactis* Kupfer ex Eckblad (Pfister & Kurogi 2004) which is placed in the *Sarcosomataceae*.

Le Gal (1953), Eckblad (1968) and Samuelson (1975) discussed the construction of the ascus in *Cookeina* species with a particular emphasis on their apical structure. The eccentric position and thickening of the operculum have been variously interpreted. The notation of such asci as "suboperculate" has been discussed by these authors.

Ascospores

Ascospores are pink or buff in deposit and range up to 52 µm long and 21 µm wide. They are ellipsoid, fusoid, or naviculate often appearing flattened on one side or curved, as in *C. insititia*. In light microscopy ascospores are smooth or have low longitudinal ridges or grooves and occasionally have transverse folds. The ridges may be unbroken from pole to pole or they may form disjunct rows that may anastomose. Berkeley (1875), who was the first to observe the markings, mentioned that one specimen of *C. tricholoma* had "longitudinal dots as a Diatom." SEM studies of the smooth-spored species show some divergence. Melendez-Howell et al. (2003) illustrated low ridges and reticulations on the surface of ascospores of *C. insititia* and Moravec (1997) depicted similar markings in *C. colensoi* but Weinstein et al. (2002) indicate that the spores are smooth.

In some species the ascospore walls are thickened at the poles, forming short apiculae. Apiculae are well developed in *C. speciosa* and *C. venezuelae*, whereas in *C. tricholoma* the walls are thickened but the spores are not conspicuously apiculate. In other species polar thickenings are variably present. Boedijn (1933) found that in these species germ tubes originated from the apiculae. He observed that *C. insititia* has a single wall layer; Pfister (1973) verified this and noted that the other species of *Cookeina*, including *C. colensoi* and *C. venezuelae*, all have double spore walls. Pfister (1973) stated that these walls separate readily in 10-15% KOH. Melendez-Howell et al. (2003) through TEM studies showed that the perispore layer of *C. insititia* is very thin and that the spores have one wall layer or "paroi proper" as compared to the multiple layers present in *C. tricholoma*. TEM studies of *C. speciosa* (as *C. sulcipes*) failed to show clear ascospore wall layers (Melendez-Howell et al. 2003).

Berthet (1964) reported, and Pfister (1978a) confirmed, that ascospores are multinucleate, a character of the family *Sarcoscyphaceae*. Ascospores always contain oil guttules. There may be a single guttule, several large guttules or numerous small droplets; guttulation is somewhat variable within a species. There is a tendency for the guttules to fuse and amalgamate in drying and rehydration and, although the presence or absence of guttules is an important character, their number and arrangement is not reliable, particularly in dried specimens.

Paraphyses

Paraphyses are 1-6 µm wide at the apex, hyphoid and are sometimes slightly thinner below the apex but are not prominently enlarged above. Their cells form lateral projections that frequently fuse with cells of adjacent paraphyses. The result is a tight, interwoven, three-dimensional network surrounding the asci, among which individual paraphyses are often difficult to discern. For this reason some authors have said that paraphyses are lacking. We have seen paraphyses in all material examined. The apices are free and in some collections extend above the hymenium. In *C. colensoiopsis* and *C. speciosa* the terminal cells form setae that project above the level of the hymenium. Berthet (1964) reports the cells of the paraphyses to be multinucleate.

Hairs and receptacle surface

In all taxa, the surface of the receptacle is minutely tomentose or granulose due to the presence of globose to angular cells on the outer surface. These cells give the receptacle a pruinose appearance. In addition, short projecting hyphae, only clearly seen under the microscope, produce a tomentum. The tomentum may show two morphologies: 1) individual monilioid processes that arise from the margin and the receptacle. These elements are composed of 2–5 short hyaline cells with thick and rugose walls; 2) fused triangular bundles of cells at the margin that are wide at the base and narrow towards the apex.

True hairs are easily seen with the unaided eye and may reach a length of 7 mm. They are composed of adherent hyphal filaments running parallel to one another. The hairs arise from the cells of the outer excipulum and are located in 3-5 rows at the margin of the disc except in *C. sinensis* and *C. tricholoma* where the hairs arise from the medullary excipulum and are more or less evenly distributed over the outside of the receptacle and the stalk (fig. 2).

Excipular construction

The patterns of excipular organization vary only in minor detail from species to species. The ectal excipulum is composed of two layers: an outer ectal excipulum up to 175 µm thick, of *textura globosa* to *textura angularis*, the cells of which are arranged in indistinct rows of 3 to 7 cells. These cells have thick walls, especially the cells toward the outer surface where they also become rounded. The inner ectal excipulum is a layer at the junction between the medullary and outer ectal excipulum. It is composed of *textura intricata* or *textura oblita*, of loosely interwoven, septate, branched, thin–walled hyphae. In some cases the hyphae are immersed in a distinct gelatinous matrix with hyphae oriented perpendicular to the surface of the receptacle. This gelatinous layer can be seen as a light refractive continuous band in median sections. A gel layer is present in *C. colensoi*, *C. colensoiopsis*, *C. insititia* and *C. venezuelae*. Despite its prominence gel has often been overlooked in these species. We occasionally saw gel in other species

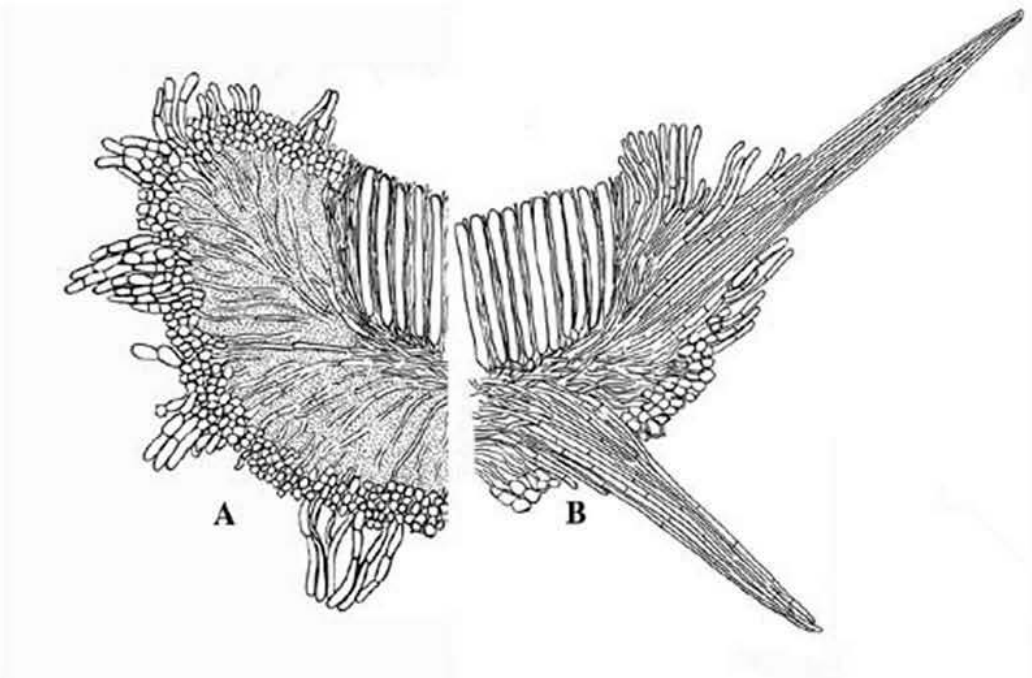


Figure 2. *Cookeina venezuelae* and *C. tricholoma*, cross sections of apothecia showing tissues and hairs. A. *C. venezuelae*, stipled regions indicate gelatinous tissues, hairs are superficial and arise from the ectal excipulum. B. *C. tricholoma*, no gelatinous tissues are present and hairs arise from the medullary excipulum.

but in those cases it occurred in isolated pockets within the excipulum rather than as a continuous, uniform layer and was variable within even a single collection.

The medullary excipulum, the innermost layer, which forms the core of the apothecium, is composed of *textura porrecta* to *textura intricata*. It is built up of narrow, septate, somewhat thick-walled hyphae that run parallel to the outer surface of the apothecium. The subhymenium, the layer beneath the hymenium, from which asci arise, is of dense *textura intricata*.

Development

Only *C. tricholoma* has been studied in any detail regarding apothecial development (Pfister 1978a). Based on a study of primordia collected in the field the hymenium is exposed in the youngest material observed. Pfister (1978a) suggested that all *Sarcoscyphaceae* develop in agymnohymenial fashion; this has yet to be challenged or confirmed across the entire family. Boedijn (1933) reported that in juvenile states the hymenium of *C. insititia* is covered by a "nearly continuous subconical sheath, which by expansion of the cup ruptures radially and gives rise to a ring of hairs." Wang (1997) made similar observations. We have made no attempt to comparatively study primordial states in this work.

Spore discharge

In all species asci mature simultaneously. Boedijn (1933) observed that ascospores were discharged mostly in an oblique direction due to the eccentricity of the ascus opening. Both Seaver (1928) and Boedjin (1933) commented on ascospore discharge in *Cookeina*, most probably in *C. speciosa*, based on their drawings of the ascospores.

Boedjin claimed that the ascus jet (ascospores and epiplasm) passed through the ascostome (ascus pore) all at once, while Seaver (1928) suggested there was a contraction between each individual spore ejection. In clarifying his earlier observation Seaver (1942) said that he had not stated there was a pause between each ascospore being ejected, as implied by Boedijn (1933), but that there was an expansion and contraction of the ascostome between each spore ejection.

Despite the uniform maturation of the asci, Boedijn (1933) noted that ascospores were discharged over a period of several days. Zoberi (1973) showed that as water evaporated from the apothecium, or when it was removed mechanically, ascospore discharge occurred. All spores were discharged within a 5-hour period.

One of our observations from the field relates to Zoberi's experimental work. In the stipitate taxa the cup may fill with water during rains. As these cups fill the added mass causes the tough and resilient stipes to bend and dump out the accumulated water. Because the stipes are resilient and flexibile the cup resumes its previous position and is undamaged. Thus, the cups can fill, be emptied and be hydrated for ascospore discharge.

Anamorphic state, growth and cultivation

Boedijn (1929, 1933) reported germination of ascospores of *Cookeina tricholoma* and *C. speciosa* as *C. sulcipes*. He noted three types of germination. One in which one or two germ tubes were formed but no conidia, a second in which spores produced numerous short germ tubes, each of which bore several conidia, and a third type in which several germ tubes formed, elongated but only rarely produced conidia. Modes of germination in *Cookeina* species were studied by Paden (1975), Hanlin et al. (1991), Hanlin (1993) and Melendez-Howell (1986) and were found to conform to the original observation of Boedijn. The anamorphic states are similar to those of *Sarcoscypha* (Alexopoulos & Butler 1949, Harrington 1990, Rosinski 1953), *Phillipsia* (Paden 1975, 1984) and *Nanoscypha* (Pfister 1973).

Berthet (1964) stated that cultures were light in color, white or cream, never grey or black. He indicated that septal aureoles, thickenings associated with septa, are very well developed in cultures. Sánchez et al. (1993) and Sánchez Vázquez et al. (1995), investigating in Mexico the edible *Cookeina speciosa*, determined the conditions under which ascomata develop and the cultural requirements necessary for fruiting. Sánchez Vázquez et al. (1995) suggests this species causes a white rot which is in agreement with our general observations on the condition of wood associated with fruiting.

Distribution

Two species, *C. speciosa* and *C. tricholoma*, are pantropical but *C. speciosa* represents a species complex and there is variation within the complex (Weinstein et al. 2002). Other species seem to be more limited in distribution. *Cookeina colensoi* is primarily a southern hemisphere taxon occurring in subtropical zones. A few collections are known above the equator in Asia and the Americas. *Cookeina indica, C. insititia*, and *C. sinensis* are restricted to Asia. The range for *C. indica* has been expanded in recent years from India to Southwestern China (Yang 1997). In the Americas, *C. venezuelae* is known from northern South America, Central America and from the West Indies. Gamundí (1983) presented a distribution map for Central and South American species. In this paper *C. colensoiopsis* is described from Mexico and Venezuela.

Phylogeny and relationships

The genus *Cookeina* has been placed in the family *Sarcoscyphaceae* in modern treatments (Cabrello 1988, Eckblad 1968, Harrington et al. 1999, Korf 1970, 1972, 1973, Le Gal 1969, Weinstein et al. 2002). The family is recognized fundamentally in the sense of Korf (1970, 1972, 1973) as one of two families considered to have thick ascus walls and thickened opercular areas. The *Sarcoscyphaceae* are generally brightly pigmented and the *Sarcosomataceae* are generally dark in color. In all molecular phylogenetic studies a monophyletic *Sarcoscyphaceae* is recovered. Within the group, *Cookeina* and *Microstoma* form a well-supported clade. This group corresponds to the tribe *Boedijnopezizeae* as delimited by Korf (1970).

Weinstein et al. (2002) studied the species of *Cookeina* using ITS sequence data. Morphologically the species are distinguished by the combination of several features including ascospore shape and surface relief, presence and orgin of apothecial hairs and presence or absence of gelatinous material within the cortical layer of the excipular tissue. The genus was shown to be monophyletic with several well-supported lineages that correspond to the morphological species concept traditionally used. Collections referred to as *C. speciosa* segregate within a clade. Hymenial color differences correlate with groups within that clade. In this work we consider *C. speciosa* to represent a species complex. Detailed populational studies will be necessary to understand fully relationships within this complex. The placement of *C. insititia* in the ITS study is ambiguous but falls within *Cookeina*. Thus, the genus *Boedijnopeziza*, with *C. insititia* as the type species, is not recognized.

Taxonomic treatment

Cookeina Kuntze, Rev. Gen. Pl. 2:849. 1891.

[= *Trichoscypha* (Cooke) Sacc., Syll. fung. 8: 160. 1889, non Hook. f, 1862.]

= *Pilocratera* Henn., Bot. Jahrb. Syst. 17: 9. 1891.

= *Boedijnopeziza* S. Ito & S. Imai, Trans. Sapporo Nat. Hist. Soc. 15: 58. 1937.

TYPE SPECIES: *Peziza tricholoma* Mont. (selected Seaver, 1927)

Apothecia medium to large, cupulate to funnel-shaped, sessile or stipitate. **Hymenium** white, pink, yellow, orange, salmon, rose, or chocolate. **Outer surface** of the apothecium concolorous or lighter than the hymenium, nearly glabrous to tomentose or with long, prominent fasciculate hairs on the margin. **Excipulum** of two distinct layers: an inner layer of *textura intricata* of rather narrow diameter and an outer layer of pyriform to globose cells which arise from hyphae originating in the medullary excipulum. The outer layer is constructed of two zones, the inner zone of which may contain gelatinous material. **Asci** cylindrical with a prominently thickened lateral operculum, J–, eight-spored, at the base abruptly connected to a narrow, long, hypha, all spores within a single apothecium at the same state of maturation. **Ascospores** hyaline, smooth or with longitudinal and rarely transverse markings, ellipsoid to fusoid, pinkish or buff in deposit, often bilaterally asymmetrical, guttulate. **Paraphyses** anastomosing to form a network around the asci, in some species developing apically to form setiform hairs.

SUBSTRATE: On decaying, generally recently dead, twigs, branches, and larger logs.

DISTRIBUTION: Species are found throughout the lowland tropics. *C. tricholoma* and *C. speciosa* are pantropical. Other species have restricted distributions.

Key to species of *Cookeina*

1. Outer surface of the ascomata with distinct hairs that are visible without a handlens, with a well developed stipe 1

1. Outer surface of the ascomata lacking obvious hairs, lacking a stipe or with a short stipe..... 5

2. Hairs arranged prominently at the margin of the apothecium, hairs pyramidal in form, apothecia narrow goblet form, gel layer present in the excipulum, ascospores narrow sub-fusoid to fusoid, asymmetrical and distinctly curved, with pointed ends ..... ***C. insititia***

2. Hairs either grouped at the margin or more or less evenly distributed over the outersurface of the apothecium, apothecia widely flaring, ascospores ellipsoid to broadly fusoid..... 3

3. Hairs forming distinct rows or ridges at the margin of the apothecia, hairs arising from the medullary layer, ascospores ellipsoid ..... ***C. speciosa*** complex

3. Hairs more or less evenly covering the outer surface of the apothecium, spores ellipsoid to broad fusoid..... 4

4. Ascospores smooth ..... ***C. sinensis***

4. Ascospores with longitudinal striations ..... ***C. tricholoma***

5. Excipulum lacking gelatinous material, ascospores elliptical to broadly fusoid with longitudinal striations, flattened at one side, appearing sub-papillate ... ***C. indica***

5. Excipulum with gelatinous material 6

6. Ascospores ornamented with both longitudinal and transverse folds, ellipsoid, apiculate at each end, bilaterally symmetrical or asymmetrical..... ***C. venezuelae***

6. Ascospores smooth (if considered short stipitate, *C. insititia* could key here) 7

7. Paraphyses without setose projections, ascospores ellipsoid to subfusoid, sometimes short apiculi or papillae present at poles ..... ***C. colensoi***

7. Paraphyses with setose projections, ascospores ellipsoid, smooth .... ***C. colensoiopsis***

Descriptions of species

Cookeina colensoi (Berk.) Seaver, Mycologia 5: 191. 1913. Fig. 3

≡ *Peziza colensoi* Berk. in Hooker, Fl. nov.-zel. 2: 200. 1855 !! ≡ *Sarcoscypha colensoi* (Berk.) Sacc., Syll. fung. 8: 157. 1889. ≡ *Cookeina colensoi* (Berk.) Seaver, Mycologia 5: 191. 1913. [misapplied = *Cookeina venezuelae* (Berk. & M.A. Curtis.) Le Gal] ≡ *Boedijnopeziza colensoi* (Berk.) Korf & Erb, Phytologia 21: 202. 1971.

= *Peziza aluticolor* Berk., J. Linn. Soc., Bot. 13: 176. 1872 [1873] !! ≡ *Geopyxis aluticolor* (Berk.) Sacc., Syll. fung. 8: 64. 1889. ≡ *Ciboria aluticolor* (Berk.) Rick, Ann. Mycol. 2: 408. 1904.

= *Geopyxis moelleriana* Henn., Hedwigia 41:30. 1902.

= *Geopyxis ciborioides* Starbäck, Ark. Bot. 20 (2): 1. 1904. ≡ *Geopyxis aluticolor* var. *ciborioides* (Starbäck) Rick, Brotéria Sér. Bot. 25: 81. 1931. ≡ *Cookeina colensoi* var. *ciborioides* (Starbäck) Gamundí, Bol. Soc. Argent. Bot. 6: 218. 1957.

= *Ciboria sessilis* Starbäck, Ark. Bot. Utgivet. Avk. Svenska 2 (5): 3. 1904 !
= *Ciboria argentinensis* Speg., Anales Mus. Nac. Hist. Nat. Buenos Aires III 19: 444. 1909 !!, !
[= *Peziza subtropica* Speg. in ed., fide Gamundi (1959)]

Apothecia scattered, short stipitate centrally, seldom subsessile, deeply cup-shaped, when dry, 2–15 mm tall and 2–17 mm diam. **Disc** brighter colored than receptacle, when fresh, orange to orange-yellow, when dry, ochre, ochraceous or orange–ochraceous. **Margin** frequently in-rolled when dry, with 0–4 low circular ridges more evident when dry, with tomentum bundles originating from the outer excipulum. **Receptacle** when fresh, paler than disc, up to 25 mm tall and 2–20 mm diam; when rehydrated, orange to golden–yellow to yellow to light–yellow to cream; when dry, 10–17 mm diam, cream, light yellow, yellow, orange, ochre, beige, or brown; sometimes drying in a venose, convoluted, ribbed pattern, more evident at the base of the receptacle where it shows a ribbed or venous pattern, continuing as striations on the stipe; furfuraceus. **Stipe** short to substipitate, when fresh or re-hydrated light yellow to cream-colored to whitish and 2–20 x 1–3 mm, when dry yellow to orange, concolorous with dry receptacle and 2–15 x 1–2 mm, sub-cylindrical somewhat wider at the base with a disc-shaped "holdfast" reaching 2 mm diam, with longitudinal ridges and furrows when dry on all of its length and sometimes extending towards the receptacle. **Tomentum** of two types: 1) individual monilioid processes that arise from the margin and also sparsely covering all the receptacle giving it a furfuraceous appearance, composed of 3–5 short hyaline cells, cells 8–12 µm diam with thick and rugose walls, walls 2–4 µm wide, hairs 44–100 x 10–14 µm; 2) fused triangular-shaped bundles of cells present at the margin, 40–100 µm long, 34–64 µm wide at the base, and 8–22 µm wide at the apex. **Outer excipulum** of *textura primatica* to *textura angularis*, becoming globose on the outside, forming a 3–5 celled-layer of 20–40 µm thick, cells 8–14 x 8–16 µm, walls of outer cells roughened with brownish material, outer layer is irregularly thickened giving it a pruinose appearance. **Medullary excipulum** divided into two layers: the layer adjacent to the ectal excipulum of *textura oblita*, of thin-walled hyphae immersed in a gel and oriented perpendicular to the receptacle surface, (20-) 40–80 µm wide, hyphae 1–5 µm diam. The layer more proximal to the sub-hymenium of *textura porrecta* 60–90 µm thick, sometimes with gel in patches, long-celled, arranged parallel to the receptacle surface, cells 3–6 µm wide. **Subhymenium** *textura intricata*, 20–40 µm wide, somewhat gelatinized. **Hymenium** 280–350 µm thick, with no setae present. **Asci** cylindrical, base round to slightly tapering, (252-) 340–416 x 16–24 µm, abruptly arising from thin basal hyphae 8–32 x 4–8 µm, 8-spored located in the top 1/2 of the ascus, **Ascospores** obliquely uniseriate, broad elliptic-fusoid narrowing at the poles, unequal with a flatter side, sometimes short apiculi or papillae present, (0-)2(-3) large oil guttules and often several smaller ones, hyaline, smooth, 24–40 x 9–16 µm. **Paraphyses** filiform, septate, braching, with frequent anastomosis forming a dense network, agglutinated, 1.6–4 µm wide in the middle, enlarging at the apex to 4 µm, equal to the asci or exceeding them by 2–4 µm.

SUBSTRATE: on twigs 6–10 mm diam, on decomposed wood.

DISTRIBUTION: Australia, New Zealand, India, Madagascar, Samoa, China, Argentina, Brasil, Colombia, Jamaica, Mexico .

ILLUSTRATIONS: Hooker (1855) as *Peziza colensoi,* f. 5a-c; Cooke (1879) as *P. colensoi* fig 108, as *P. aluticolor* f. 198; Cooke (1892) as *Geopyxis aluticolor,* fig. 144; Massee (1896)

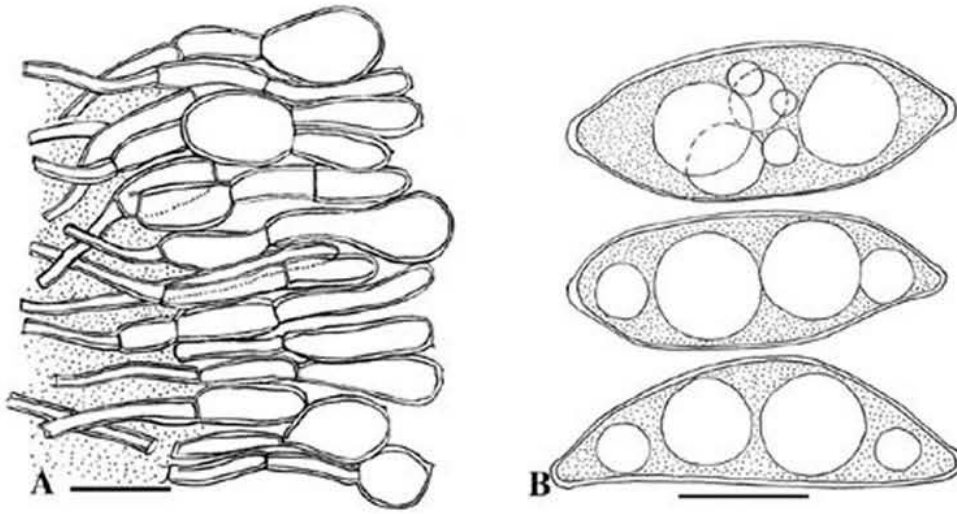


Figure 3. *Cookeina colensoi.* A. Cross section showing outer layer of the excipulum, bar = µm. B. Ascospores, bar = µm. New Zealand, Bay of Plenty, Kaimai Ranges, vic. Katikati, 15 Feb 1998, *S. P. Mortimer* (PDD 68535).

tab. 16, fig. 14-15; Starbäck (1904) as *Geopyxis ciborioides*, f. 1–3; Starbäck (1904) as *Ciboria sessilis*, figs 8, 9; Le Gal (1953) figs. 110–113;

Gamundí (1957) Lam. I; Rifai (1968) figs. 21, 22; Chacón & Medel (1990) figs. 17-20; Hood (1992) fig. 14 a; Weinstein et al. (2002) fig. 3E.

NOTES ON TYPE SPECIMENS AND NOMENCLATURE: The holotype specimen of *C. colensoi* from Berkeley's herbarium (K) has a drawing of a the characteristic spore on the packet. The specimen was placed in a type cover by R. W. G. Dennis (Brian Spooner, pers. com.) although it is note labeled as completely as the prologue suggests (see specimens cited below). Massee (1896) cites Colenso, no. 2810. His drawing and description accurately depict the structure of the outer excipulum and may be the first to describe and illustrate the anatomy of this species. After a study of the holotype of *Peziza aluticolor* we agree with Cooke (1879) and Saccardo (1889) that this material should be referred to *C. colensoi*. Seaver (1928) used the name *C. colensoi* for a different species, *C. venezuelae,* as pointed out by Le Gal (1953). The type specimen of *Geopyxis ciborioides* (Brazil, Rio Grande do Sul, col. Ijuhy, ad ramos mucescentes humi jacentes in silva primaea, 4/4 1893, 323 B) was not located in our search. Gamundí (1957) also was unable to locate the type specimen and followed Rick (1931) in treating this as *G. aluticolor* var. *ciborioides*. Gamundí (1957) stated that *Geopyxis aluticolor* var. *ciborioides* differs from *Cookeina colensoi* only by the absence of paraphyses. In our experience, all species of *Cookeina* have paraphyses; we question the observation that they are absent in this taxon. We studied the holotype and isotype specimens of *Ciboria argentinensis* as did Gamundí, but found that Gamundí's (1957) measurements of ascospores and asci differed from ours, 24–28.8 x 8.4–9.6 µm vs. 24–32 x 8.8–13.6 µm for ascospores and 317–335 x 14.5–18.8 µm and 340–380 x 16–24 µm for asci. She stated that asci and ascospores of *C. argentinensis* are smaller than those found in other collections of *C. colensoi*. It is the case that asci and ascospores of *C. argentinensis* fall at the lower range for this species but they are not as small as she indicated. Based on the description, Le Gal (1953) thought *G. elata* was a synonym of *C. colensoi*, not of *C. sulcipes* as Boedijn

(1933) indicated. On reading the description, we can understand Le Gal's interpretation, since the evident marginal hairs and furrows of *C. speciosa* are not mentioned, though two of the characters that Massee (1898) describes are not at all typical of *C. colensoi*: the length of the stipe (6–8 cm) and its growing on the ground. We were able to examine the type specimen (NY) of this species, and determined it to be *C. speciosa*. It presents the following characters, typical of *C. speciosa*: marginal ridges (three in this specimen) with evident hairs, no gel in the excipular tissues, fine striations on the ascospores, and hymenial setae. It is likely that Massee's mention of this fungus growing on soil is based on material fruiting on buried twigs. We were unable to locate any of the original material of *Geopyxis moelleriana* (St. Cathar. bei Blumenau und Velha auf Holz, April 1891, 24 November 1891. No. 54b, 252, 903. Col. Möller). The holotype of *Ciboria sessilis*, from Brazil, consists on a few apothecia, all with short stipes (up to 5 mm), with the exception of one which has a stipe 15 mm long. The specific epithet "*sessilis*" may not have been particularly appropriate.

General Notes: This species is easily recognized because of its lack of hairs, presence of a gelatinous excipular layer and ascospores that appear smooth under the light microscope. The ascospore surface was shown by Weinstein et al. (2002) to be smooth under SEM examination; this conforms to the standard interpretation of the species. Moravec (1997) described the spore ornamentation under light microscopy as wrinkled and under SEM showed low, interconnected ridges and channels. His material was from Madagascar and has not been reexamined by us. Le Gal (1953) indicated that ascospores were smooth in the materials she examined from Madagscar. Neither Moravec nor Le Gal mentioned the presence of a gelatinous layer. As fresh material from Madagascar becomes available it might be worthwhile to reexamine it critically and to consider the possiblity that the Madagascar specimens represent a distinct, undescribed species.

There are several variable features among collections. In some specimens, the cells of both types of tomentum were covered with an amorphous material or deposition. These deposits give the cells a rugose appearance. There is variation in spore and ascus size. For example, a collection from Sao Leopoldo, Brazil, from the Lloyd herbarium (BPI) has spores 13–14 x 5–6 µm; these are smaller than we recorded but the other characters match well *C. colensoi*. Le Gal (1953) reported asci up to 440 µm, triangular hairs up to 160 µm tall and 100 µm wide at the base. These are larger than we found for these structures. Rifai's (1968) measurements of hairs are larger as well, 150 µm long and 80 µm at the base. But he reports asci and paraphyses that are thinner: asci 14–18 µm, paraphyses 1–1.8 µm. Korf & Erb (Korf 1971) transfered *C. colensoi* to *Boedijnopeziza* and later Korf (1973) used the character of presence of a gelatinous layer to distinguish the genus *Boedijnopeziza*. Examination of their material showed it to be *C. venezuelae* rather than *C. colensoi*. The gel layer as a character for distinguishing the genus *Boedijnopeziza* has been the subject of considerable debate over the years. For a more detailed discussion of the confusion surrounding *Boedijnopeziza* and gelatinous material see the introduction.

Specimens examined. ARGENTINA. BUENOS AIRES: Punta Lara, ad ramenta arborum sempervirentium in silva marginali, locis umbrosis, 9 Jun 1949, *R. Singer 2129* (CUP); TUCUMÁN: ramas muertas putrescentes, Celtis sp., 16 April 1906, *C. Spegazzini 4107* (LPS, HT with Spegazzini's drawings of asci, ascospores and paraphyses,

IT (2 packets) of *Ciboria argentinensis*); Anta Muerta, Sierra de San Javier, on old fallen branches, 24 Apr 1949, *Singer & Digilio 2116* (CUP); Quebrada de Lules, ad ramos emortuos, 2 Apr 1949, *R. Singer 2114* (CUP); 35km del camino a Tafi del Valle, 26 Feb 1949, *R. Singer 2115* (CUP). AUSTRALIA. NEW SOUTH WALES: Clarence River, HT of *Peziza aluticolor* (K, NY-G. Massee Herb.); Bobong Creek, Wild Cattle Creek State Forest, near Cascade, on undetermined wood, 11 Feb 1984, R. Coveny 38/1984 (DAR 63642a); Dorrigo, Dorrigo National Park, on undetermined wood, 12 Feb 1984, R. Covey 56/1984 (DAR 63646a). BRASIL. MATO GROSSO: Sta. Anna de Chapada, in silva ad lignum. 23 Feb 1894, Madine 546 (B); HT of *Ciboria sessilis* Starbäck (S); *G. O. Malme*, 546B (S); NOVA PETROPOLIS: 1923, *Rick* (FH); SANTA CATARINA: Porto Novo, Sta. Catharina, 1928, *Rick 531* (FH) [as *Geopyxis aluticolor*]; Sao Leopoldo, in ramis frequentissima, 1903, *Rick 14* Austro-Americani (NY, FH, FH-Pat) [as *Ciboria aluticolor*]; Feb 1904 (FH) [as *Ciboria aluticolor*]; Sao Leopoldo, Rio Grande do Sul, 1925, *Rick* (FH) [as *Geopyxis aluticolor*]; Sao Leopoldo, *J. Dutra 33* (NY); S. Salvador, 4 Jan 1944, *Rick 20803* (NY) [as *Ciboria*], packet is empty. CHINA. GUIZHOU: on twigs, 4 Aug 1988, *Li Yu Zong, Yu-chen & Ying Jian-zhe 59537* ex HMAS (FH), Xishungbanna, Menlen, ex situ of endangerous plants area, 500 m. alt, on rotten wood. *M. Zang 11532*, 25 X 1988 (HKAS 20381). COLOMBIA. MAGDALENA: Sierra Nevada de Santa Marta, Cerro Quemado trail, 1500-2300m, 24 Aug 1935, *G. W. Martin 3714* (FH). INDIA. West Kameng, A. P., on wood in an angiospermous forest, 5 Sept 1981, *Rishi Kaushal 18556* (FH); as previous, *Rishi Kaushal 18557* (FH). MEXICO. TAMAULIPAS: Rancho del Cielo, on fallen limb, 29 Jul 1974, *A. J. Sharp 62500* [ex Herb. Univ. Tenn. 39652] (CUP 62500) (FH 39652). NEW ZEALAND. SOUTHERN NORTH ISLAND.: On dead sticks, near the River Manawatu, Colenso, holotype of *P. colensoi* (K), (NY-G. Massee Herb) [as *Peziza colensoi, Peziza aluticolor*]; AUCKLAND: Hunua Ranges, Cossey's Track, on wood, 9 May 1996, *1996 Fungal Foray* (PDD*66040*); BAY OF PLENTY: Kaimai Ranges, Timms Road, vic. Katikati, on decorticated wood, 15 Feb 1998, *S. P. Mortimer* (PDD *68535*); COROMANDEL: Kauaeranga Valley, vic. Thames, on decorticated wood, 1 Apr 1981, *G. J. Samuels & H. Thiers* (PDD *42052*); On decorticated wood, 1 Apr 1981, *G. J. Samuels, H. Thiers,* (PDD *42053*); Kopu-Tairua Road, Kaitarakihi Summit Track, 37 08'S, 175 41'E, on decorticated wood, 14 Mar 1998, *P. R. Johnston, R. E. Beever, S. L. Stephenson* (PDD *68628*); vic. Port Charles, track from Stoney Bay to Fletcher Bay, on wood, 25 Feb 1989, *P. R. Johnston* (PDD *55306*); NORTHLAND: Mangamuka Scenic Reserve, on wood, 8 May 1983, *G. J. Samuels, T. Matsushima, R. H. Petersen* (PDD *46278*); Omahuta S. F., Omahuta Kauri Sanctuary vic. Mangamuka Bridge, on wood, 10 May 1981, *G. J. Samuels, E. Horak* (PDD *42049*); WAIKATO: vic. Otorohanga, Native Forest Restoration Trust, Owen Lewis Reserve, 220m, on blackened, decorticated wood, 24 May 2000, *P. R. Johnston* (PDD *71534*); Waitomo, on bark and decort. wood, 26 Apr 1983, *G. J. Samuels, P. R. Johnston, R. H. Petersen* (NY, PDD *46838*). SAMOA. *C. G. Lloyd 5020* (FH-Pat) [as *Peziza (Geopyxis) aluticolor*]; Jan 1900, *C. G. Lloyd 5020* (NY); 1904-5, *C. G. Lloyd 5021* (NY), infertile.

Cookeina colensoiopsis Iturriaga & Pfister, **sp. nov.** Fig. 4

Haec species C. colensoi *similitudit ex strato gelatinoso, tomento et ascosporis laevibus adest, sed haec differt eo setas in hymenio habet. Holotypus: Cerro El Avila, on wood, Norte de Caracas, Agosto 2002,* Tamia Souto (FH)

Apothecia scattered, centrally stipitate, deeply cup-shaped, up to 20 mm tall when fresh, and 14–15 mm tall when dry. **Receptacle,** when fresh, 17 mm tall and 2–15 mm diam, when dry 6–8 mm tall and 15–20 mm diam; when fresh lighter colored

than the disc, when rehydrated, light yellow receptacle and margin; when dry, beige; drying in a venose–ribbed pattern at the base, which continues with striation in the stipe, furfuraceous uniformly because of white hair-like projections. **Stipe** cream-colored (fresh), sub-cylindrical, somewhat wider at the base, 3-13 x 1-3 mm (fresh) and up to 2 x 9 mm (dry), longitudinally ribbed when dry, furfuraceous with white hair-like projections. **Disc** darker colored than receptacle, bright yellow to orange (fresh), ochre (dried), orange (rehydrated). **Margin** concolorous to receptacle when fresh or dry, ribbed with three striations or ridges, presenting the two types of tomentum. **Tomentum** of two types, originating from the outer excipulum: 1) individual monilioid processes, minute, as hair-like projections, covering margin, receptacle and stipe, giving it a furfuraceous appearance, 30–92 x 10–24 µm, 2–10 cells tall, cells round or elongated with thick-rugose walls, cells 10–22 x 8–16 µm; 2) short and whitish triangular-shaped bundles consisting of 5–12 fused individual monilioid *gosto 2002, Tamia Souto (FH).* processes, only present on marginal ridges. **Outer ectal excipulum** of *textura globulosa* to *textura prismatica*, 4–5–celled layer 30–90 µm wide, cells 8.0–14 µm diam. **Medullary**

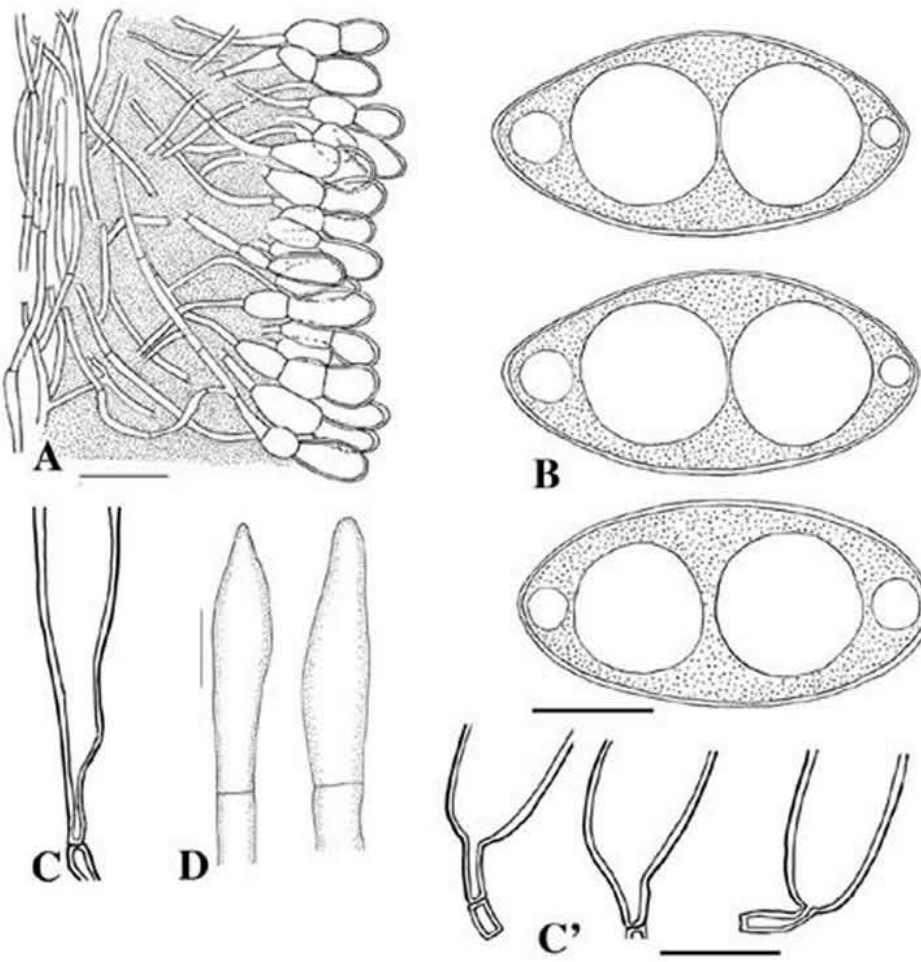


Figure 4. *Cookeina colensoiopsis.* A. Cross section showing outer layer of the excipulum, bar = 25 µm. B. Ascospores, bar = 10 µm. C, C'. Ascus bases, bar = 25 µm. D. Setose apices of paraphyses, bar = 25 µm. Caracas, Venezuela; on decaying wood, 1903, *A. F. Blakeslee* (FH).

excipulum divided into two layers: the layer proximate to the ectal excipulum of *textura oblita*, thin-walled hypha immersed in a gel and oriented outwards perpendicular to the receptacle's surface, layer 50–100 µm wide, hyphae 2–4 µm diam. The layer proximate to the sub-hymenium (or more distant to the ectal excipulum) of *textura porrecta*, long-celled, layer 60–100 (–600) µm wide, cells 4–6 µm wide. **Subhymenium** *textura intricata*, somewhat gelatinized, layer 4550 µm wide. **Hymenium** 380–450 µm thick. **Hymenial setae** present, intemixed with asci and paraphyses, brownish, 430–440 x 2 µm, with lanceolate terminal cell, exceeding hymenial elements by 10–20 µm. Asci long cylindrical with a round base, 340–420 x 10–20 µm, ending in an abrupt manner to connect with hyphal-like basal appendage, a few times tapering slightly at base, basal appendage 4–28 x 4 µm. **Ascospores** obliquely uniseriate broad elliptic, unequally sided, narrowing slightly at ends, with a short apiculum present at both ends, mostly 2 large central oil guttules with two smaller ones at ends, hyaline, smooth walled, with no wall markings, 30–34 x 12–14 µm. **Paraphyses** filiform, septate, branching, anastomosing to form a network, agglutinated, 2–4 µm wide in the middle, enlarging in a clavate shape at the apex to 4.0 µm.

SUBSTRATE: on decaying wood.

DISTRIBUTION: known from Venezuela, possibly only from El Ávila National Park.

GENERAL NOTES: Our attention was caught by an unusual specimen identified as *C. colensoi*. Denison (1967) studied this collection and wrote that "a single collection [of *C. colensoi*] is known from Venezuela, which suggests that it may yet be found in Central America." In order to determine if this specimen really belonged to *C. colensoi*, it was re-examined and found to differ in form of the paraphyses from *C. colensoi*. This specimen was collected by A. F. Blakeslee in 1903, in Caracas, Venezuela, on decaying wood (FH). Specimen annotations by Blakeslee indicated that "it is not *P. venezueliana* [sic]" and that ascospores are 40–45 x 14–16 µm (our measurements from the same specimen were 30-34 x 12-14 µm). The species was known only from that single collection from the Caracas region, and we do not know the exact locations Blakeslee visited. Since the Caracas area is reasonably well collected and in view of the urban expansion, we assumed that the species no longer existed. Those initial conclusions proved to be wrong. In August 2002 a *Cookeina* specimen collected from Parque Nacional El Avila massif, located at the northern side of the city of Caracas was brought to the senior author for determination. It proved to be this species that we have now described as *C. colensoiopsis*.

Measurements from the recent collection (Paratype: PT) are larger than those from Blakeslee (HT): outer ectal excipulum layer 40–50 µm wide (HT), 30-90 µm (PT); inner ectal excipulum gelatinized, 30-40 µm widte (HT) and 50-100 µm (PT); medullary excipulum non-gelatinized 60-100 µm wide (HT) and 470-600 µm (PT); asci up to 360 µm (HT) and to 420 µm (PT).

This species resembles *C. colensoi* in the presence of a gel layer, tomentum and smooth ascospores, but differs from it in having hymenial setae. Such setae were observed previously only in *C. speciosa*.

SPECIMENS EXAMINED. VENEZUELA. FEDERAL DISTRICT: Caracas, on decaying wood, 1903, *A. F. Blakeslee*, Det.: D. H. Linder. [as *Cookeina colensoi*] (FH). Holotype; Cerro El Avila, on wood, Norte de Caracas, Agosto 2002, Tamia Souto (FH).

Cookeina indica Pfister & R. Kaushal, Mycotaxon 20: 117. 1984 !!, ! Fig. 5

Apothecia scattered to gregarious, cupulate, disc-shaped when dry, centrally to slightly eccentrically stipitate, sub-stipitate, or sessile, with a narrow point of attachment, up to 35 mm high and up to 30 mm in diam, tough in consistency. **Receptacle** concolorous with the disc, yellow when fresh, when dry, orange to blackish, light ochre when re-hydrated, nearly smooth except at the margin. **Stipe**, when present, solid, terete, whitish, smooth, up to 22 mm long and up to 1.5 mm thick, short or often reduced to a narrow point of attachment of 1 x 1 mm. **Disc** deeply concave, yellow when fresh, smooth. **Margin** entire, minutely tomentose. **Tomentum** as hair-like processes arising from the cells of the outer excipulum, composed of up to 4 round cells, 40–80 × 10–14 µm. **Ectal excipulum** of *textura angularis* to *textura globulosa*, of 3-6 cell layers, 40–50 µm thick, cells 10–25 × 14.5–25 µm. **Medullary excipulum** divided into two layers: the layer proximate to the ectal excipulum of *textura porrecta*, long and parallel, without a gel. The layer proximate to the subhymenium of *textura intricata* to *textura porrecta*, up to 160 µm thick, of interwoven hyphae in a more or less parallel arrangement at the junction between the medullary and outer layers, 4–6 µm diam. **Subhymenium** of *textura intricata* of loosely interwoven septate and branched hyphae 2–2.7 µm diam. **Asci** long cylindrical, apices obtuse, at the base usually abruptly contracted or attenuated into a narrow basal hyphal extension, 300–370 × 14–20 µm, thick-walled, with 8 ascospores. **Ascospores** ellipsoid to broad elliptic-fusoid to fusiform in face view, in side view, flattened at one side narrowing towards the poles, in both views appearing sub-papillate; wall 1.0–1.5 µm, thicker at the poles; hyaline, ornamentation of fine longitudinal, parallel ridges approximately 1 per µm that sometimes anastomose; guttules arranged in four possible ways: 1) with 3 guttules, 2) 1–2 central guttules with smaller surrounding guttules, 3) two large central guttules, two of middle size accompanied by smaller ones toward the poles, or 4) numerous guttules; (18-) 26.5–40.0 (–47) × 10–15 (–17) µm, usually obliquely uniseriate. **Paraphyses** thread-like, delicate, septate, frequently anastomosing, sometimes constricted at septa, (–2.5) 3-4 (–4.5) µm in the middle, branching more often at the apex, and presenting varied types of apices, sometimes several types can be present in one apothecium: 1) swollen-clavate apices up to 5 µm. 2) mucronate apices with 5 µm at its widest diameter ending in a somewhat pointed apex of 1 µm diameter, or 3) irregular up to 4 µm wide; the mucronate type apices (2) projects slightly beyond the ascus tips.

SUBSTRATE: On angiospermous wood.

DISTRIBUTION: India, West Kameng (holotype and paratype locality), and China, Yunnan (Yang 1990).

ILLUSTRATIONS: Pfister & Kaushal (1984), fig 1; Weinstein et al. (2002), fig. 3B.

NOTES ON TYPE SPECIMENS AND NOMENCLATURE: Specimens examined are mostly those studied by Pfister & Kaushal (1984). No specimens of *Cookeina mundkurii* S. C. Kaushal have been available for study but we suspect it is *C. indica*.

GENERAL NOTES: *Cookeina indica* has narrow ellipsoid to fusoid, often inequilateral, ascospores that are narrower than those found in either *C. sulcipes* or *C. tricholoma*, the other species with longitudinally striate ascospores. The striations in *C. indica* form more or less continuous bands on the spores. This species is characterized further by having a smooth receptacle, with only minute marginal hair-like projections. There is no

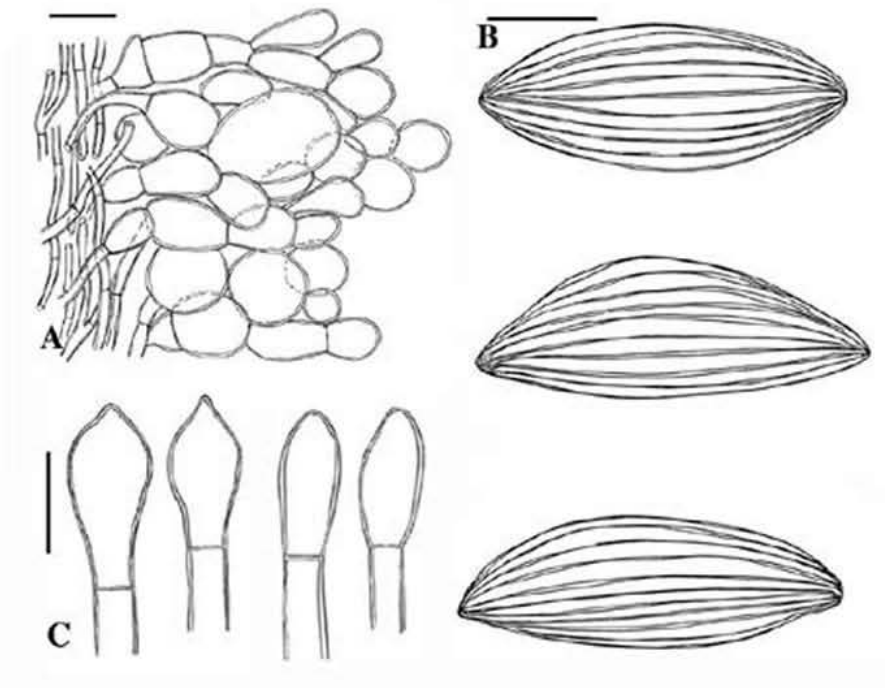


Figure 5. *Cookeina indica.* A. Cross section showing outer layer of the excipulum, bar = 25 µm. B. Ascospores, bar = 10 µm. C. Apices of paraphyses, bar = 10 µm. Yunnan, China; 5 Nov 1999, *119* (HMAS).

gelatinous material in the ascomata. A distinctive feature for this species is the variety of shapes of the apical cells of the paraphyses. Mucronate and irregular cell shapes such as these are only present in this species. The typical filiform, slightly clavate, paraphyses found in all species of the genus and are also present in *C. indica*. Yang (1990) suggested that Teng (1963) reported *C. indica* under the name *C. colensoi.*

SPECIMENS EXAMINED. CHINA. YUNNAN: On wood, 5 Nov 1999, *119* ex HMAS (FH); On wood, 5 Nov 1999, *119* (HMAS). INDIA. West Kameng, A. P. [Arunachal Pradesh], Tipi, on wood in an angiospermous forest, (alt. 300 m), 16 Sept 1981, *Rishi Kaushal 18611*, Holotype (FH); Photo of isotype specimen [as *Cookeina insititia*] at PAN (FH) (not examined at this time previously examined by Pfister & Kaushal (1984)); Dehra, on *Dalbergia* sp., 2 Sept 1952, *K. S. Thind 572400*, Paratype (BPI) [as *Cookeina colensoi*] slide made from Paratype specimen (FH).

Cookeina insititia (Berk. & M.A. Curtis) Kuntze, Revis. gen. pl. 2: 849. 1891. Fig. 6

≡ *Peziza insititia* Berk. & M.A. Curtis, Proc. Amer. Acad. Arts 4: 127. 1860 !, !! ≡ *Trichoscypha insititia* (Berk. & M.A. Curtis) Sacc., Syll. fung. 8: 161. 1889. ≡ *Pilocratera insititia* (Berk. & M.A. Curtis) Sacc. & Traverso, Syll. fung. 20: 412. 1911. ≡ *Boedijnopeziza insititia* (Berk. & M.A. Curtis) S. Ito & S. Imai, Trans. Sapporo. Nat. Hist. Soc. 15: 58. 1937. ≡ *Microstoma insititia* (Berk. & M.A. Curtis) Boedijn, Sydowia 5: 212. 1951.

=*Trichoscypha magnispora* Lloyd, Mycol. Writings 6: 1050. 1921 !

=*Boedijnopeziza sphaeroidospora* Y. Otani in Kobayasi et al., Bull. Natl. Sci. Mus. 14(3): 407. 1971 !

Apothecia scattered to gregarious, centrally stipitated, 9–25 mm tall when dry, mostly not exceeding 1 cm in length when fresh (fide Boedjin, 1933). Disc deeply concave, white to pale cream, when dry concolorous or lighter than dry receptacle. **Receptacle** deep-cup shaped, infundibiliform, urceolate to turbinate, seated on a well defined stipe, white to whitish, to pale cream colored, paler than the disc; when dry beige or yellow-ochre, 5–12 mm tall and 4–11 mm diam. **Margin** sometimes flesh-colored or concolorous with the receptacle, with white, erect, triangular-flattened hairs. **Stipe** terete whitish, when dry 3–16 mm long by 1–2 mm diam, when fresh up to 40 mm long fide Boedjin (1933), drying in a venose pattern due to contraction of the gel, covered by tomentum, sometimes with a disc-shaped point of attachment. **Hairs** of three types, all originated from outer ectal excipulum cells: 1) marginal twisted (when dry) hairs, light yellow, triangular and flattened, in 1–2 rows, up to 2 mm long and 0.5 mm at the base and gradually tapering towards the pointed apex; when young these hairs totally cover the hymenium in a nearly continuous sub-conical sheath, which later opens as the disc expands, splitting into 4–5 separate compound hairs positioned in an imbricate fashion then dividing at maturity in to many compound hairs, each formed by bundles of parallel, septate, unbranched, sub-hyaline hyphae; 2) hairs, straight, in the margin intermixed with the twisted hairs, and covering mainly the upper part of the receptacle, though some cover the receptacle, flat, half the size of the marginal ones, but similar in structure to them, composed of bundles of parallel, septate, unbranched, sub-hyaline hyphae 4–9 µm diam, turning wider and shorter, up to 14 µm wide, at the base of the bundle. 3) a tomentum composed of hyphal projections of th outer cells of the excipulum covering receptacle and stipe. **Ectal excipulum** composed of two layers: **Outer ectal excipulum** *texturaglobulosa* to *angularis*, layer of 30–50 µm thick, composed of two to four or sometimes more layers of globose, sub-globose or rarely polygonal cells 9–24 µm diam; the most external cells are globose, up to 28 µm diam, with thick and sometimes warted walls 2–3 µm wide. In some cases these cells aggregate to form masses of loosely connected cells, which appear as irregular small projections at surface view. **Inner ectal excipulum** of *textura oblita*, of loosely interwoven, delicate, septate, branched, thin-walled hyphae immersed in a distinct gelatinous matrix and oriented perpendicular to the receptacle's surface, layer (20–)40–80 µm thick,hyphae 1.0–5.0 µm diam. **Medullary excipulum** of *textura porrecta* to *intricata*, of parallel hyphae running parallel to the outer surface of the receptacle, 1.8–6.3 µm diam, septate, typically unbranched and becoming intricate near the margin. **Subhymenium** of *textura intricata*, composed of loosely interwoven septate and branched hyphae 2–2.7 µm diam. **Hymenium** about 390 µm thick. **Asci** cylindrical, tapering to a long thin obconical base, 400–453 x 12–16 µm, thick-walled, wall 1.5–2 µm wide, with 8 ascospores. **Ascospores** usually obliquely uniseriate, narrow sub-fusoidal to fusoidal, asymmetrical or distinctly curved, with pointed ends, hyaline, smooth-walled under light microscope, containing numerous guttules, 36–47(–52) × 8.0–16 µm. **Paraphyses** filiform, delicate, septate, branched and irregularly anastomosing, hyaline, 1–2.0 µm diam, sometimes with irregular swellings; their apices profusely divided forming a small number of short branches, 1.5 µm diam, forming a dense irregular network. SUBSTRATE: on wood, on decomposed wood.

DISTRIBUTION: China, Indonesia, Japan, Phillipines, Samoa.

ILLUSTRATIONS: Berkeley & Broome (1875) as *Peziza insititia*, tab. 5, fig 21; Boedjin (1933) figs. 2D–E, 3F, I; Lloyd (1921) as *Trichoscypha magnispora*, plate 179, fig. 1950;

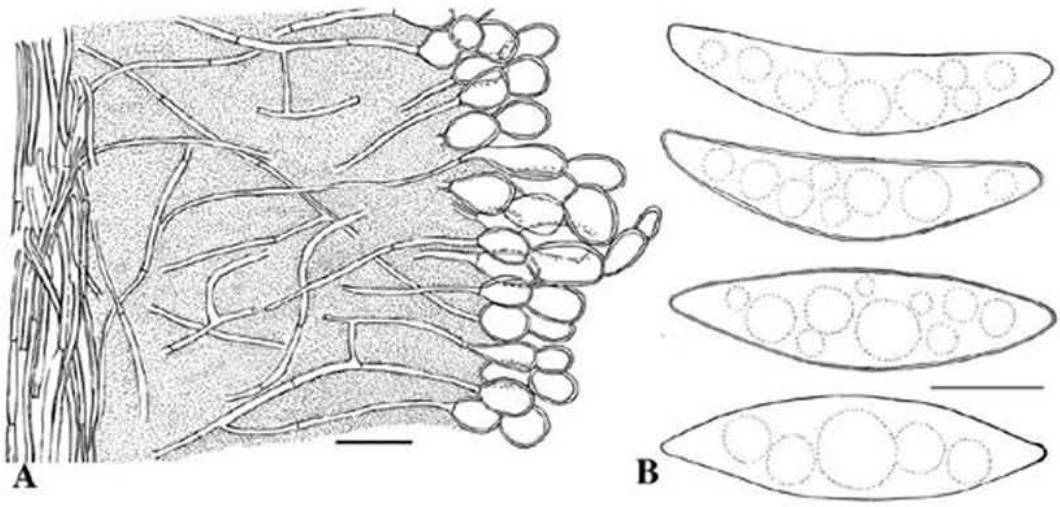


Figure 6. *Cookeina insititia*. A. Cross section showing outer layer of the excipulum, bar = 20 µm. B. Ascospores, bar = 10 µm. Yunnan, China; 17 Oct 1980, *Zang Mu* (CUP-CH 2527, HKAS 7240).

Massee (1896) as *P. insititia*, tab. 16, fig. 26–27; Melendez-Howell et al. (2003) figs. 8A–G, 9A–B, 10A–C and 11A–G; Otani (1971) figs. 17, 18; Rifai (1968) fig 23–25; Seaver (1928) fig 17i; Weinstein et al. (2002) fig. 3G.

Notes on type specimens and nomenclature: Both the holotype (K) and the isotype (FH-Curt.) of *Peziza insititia* were examined. Charles Wright collected the specimens on the U.S. North Pacific Exploring Expedition under Commanders Ringgold and Rodgers, but they have slightly different data on their labels. This is not unusual because of labeling for distribution. A primary set of specimens was given to Asa Gray who sent specimens to Curtis who in turn sent portions of them to Berkeley. Often only abbreviated information was provided to Berkeley. The holotype (K) bears the number 148 on the packet, which is the species number as originally listed for *P. insititia* by Berkeley & Curtis. Other data given are "on dead wood, Bonin Islands" but no further data on substrate or specific collecting date it states 1853-1856. The isotype (FH-Curt.) bears a more precise collecting date (Oct. 1854) and information on substrate (ad lign. inter folia dejecta), as well as the number 367 (C. Wright's collecting number). Wright and Small collected in the Bonin Islands between October 19 and November 1, 1954 (Pfister, 1978b). Berkeley & Curtis indicate as well that this species is allied to *P. tricholoma* Mont.

Ito & Imai (1937) erected *Boedijnopeziza* as a separate genus for *C. insititia* because of two features: the presence of a gel layer in the excipulum and smooth ascospores. The genus *Boedijnopeziza* is still a question of debate, being accepted by some investigators, such as Rifai (1968), Korf (1971, 1972, 1973) and Otani (1972) and not by others as Seaver (1928), Le Gal (1953), Denison (1967), Eckblad (1968), Pfister (1973), and Weinstein et al. (2000). Boedjin (1951) did not agree on the placement of *C. insititia* in the genus *Boedjinopeziza*, and considered it a member of the genus *Microstoma* stating that it had the characters of that genus: a gel layer, large fusoid spores, and anatomosing paraphyses. More recently a subgenus *Bedijnopeziza* was created in *Cookeina* for *C. insititia* (Melendez-Howell at al. 2003). This was based on SEM and TEM data related

to wall layering and formation of ascospores and asci. It should be pointed out that Melendez-Howell used original material collected by Wright in the Bonin Islands (PC) in 1854 for their study. This appears to be an isotype. *Cookeina* and *Microstoma* resolve as sister groups in several analyses (Harrington et al. 1999). Weinstein et al. (2002) used *Microstoma* as an outgroup in their study of *Cookeina*.

Boedijnopeziza sphaeroidospora (Otani 1971) was studied by DHP (unpublished) who concluded that the type specimen was an immature specimen of *Cookeina institia*, and hence the round ascospores were immature. Otani (1975) came to the same conclusion after studying a series of developing apothecia of *C. insititia* in the field.

General Notes: We have not seen fresh material of this species; data on fresh specimens has been incorporated from Boedjin (1933), Rifai (1968), and Durrieu et al. (1997). The spores are smooth when viewed with the light microscope but they show low convolute markings under SEM (Melendez-Howell et al. 2003). Bi et al. (1993) mention that some spores are faintly ribbed but we have not seen such markings. It had been thought that among all the other species in the genus, a unique characteristic of *C. insititia* was the presence of a single ascospore wall layer (Boedjin, 1933; Pfister 1973). Melendez-Howell et al. (2003) studied the wall composition of ascospores of *C. insititia, C. speciosa* (as *C. sulcipes*) and *C. tricholoma*. The "paroí propre," or proper wall together with the perispore, are the two layers seen in all the ascospores of the *Cookeina* species studied by them. They showed that the structure of the "paroi propre" in *C. insititia* is less complex than in the other two species. The difference between species is not in the number of wall layers (as was previously thought), but in the complexity of the "paroí propre." The three species all have proper wall and a perispore, which are similar in thickness in the three species. The proper wall is more complex with at least three different layers in *C. tricholoma* and *C. speciosa* than in *C. insititia* (Melendez-Howell et al., 2003). Melendez-Howell et al. (2003) found the ascus apex to differ from the other species of *Cookeina* and the absence of the d2 wall layer distinguishes *C. insititia* from the other species. We do not find compelling evidence for the segregation in a separate genus of *C. insititia* particularly in light of the phylogenetic study (Weinstein et al. 2002).

Specimens examined. CHINA. HAINAN: Chang-Kiang, 12 Nov 1934, *S. Q. Deng 6374* (CUP-CH 1386); Tan-hsien, 24 Oct 1943, *S. Q. Deng 5564* (CUP-CH 1363); as above, 30 Oct 1934, *S. Q. Deng 5790* (CUP-CA 620); Ting-an, on wood, 18 Nov 1934, *S. Q. Deng 6681* (CUP-CH 622); as above, 13 Nov 1934, *S. Q. Deng 6453* (CUP-CH 621). YUNNAN: Hsichung Panna Autonomous, Prefecture, of Tai Nationality Region, Monlin, Nature Reserve, on rotten wood, 17 Oct 1980, *Zang Mu* (CUP-CH 2527, HKAS 7240). INDIA: Photo of India specimen at PAN (FH). INDONESIA. JAVA: Somarang, *Di van Leeuven 82* (NY). JAPAN. BONIN ISLANDS: On dead wood, C. Wright 148, U. S. Pacific Exploring Expedition, [holotype of *Peziza insititia*] (K); ad lign. inter folia dejecta, Oct. 1854, U.S. Pac. Ex. Ex., C Wright (367) (FH, FH–Curt.), [isotype of *Peziza insititia*] (FH-Curt.); 6 Oct 1915, *A. Yasuda 332* [very fragmented] (NY); Titizimia Island, Renzyudani, 23 Nov 1936, *Y. Kobayasi 664* (CUP-JA 664). PHILIPPINES: Six collections without collection data in OSC, *W. C. Denison*; On dead wood, *Denison 3941* = OSC 24420; *Denison 3942* (OSC 67796, 24419); Laguna, Los Baños, on dead wood, 24 Oct 1921, *Colin G. Welles 11671* (NY); Luzon, Mt. Maguiling, on dead wood, 26 Oct 1920, *A. Abesanis 10460* (FH-Pat); Oct 1920, *O. A. Reinking 10252* (FH-Pat); 28 Sept 1920, *O. A. Reinking 28341* (BPI-Lloyd) [holotype of *Trichoscypha magnispora*]; 25 Oct

1920, *P. Malabassan 10447* (FH-Pat); Bois pourris de arbres, 19 Oct 1887, *Balansa 43* (FH-Pat); Palo, on fine damp sticks, Jan 1906, *A. D. E. Elmer 7205* (NY). SAMOA: 1904-5, *C. G. Lloyd 5019* (NY).

Cookeina sinensis Z. Wang, Mycotaxon 62: 293. 1997 !!

Apothecium solitary or scattered, cupulate, centrally stipitate, up to 25 mm high and 50 mm diam when dry. **Receptacle** concolorous or paler than the disc, cinnamon-buff when dry, covered more or less uniformly with conspicuous long hairs. **Stipe** short, when rehydrated 8 x 1–2 mm and brownish-orange to cinnamon-buff, concolorous with receptacle, sub-cylindrical, somewhat wider at the base, with longitudinal ridges and furrows when dry over its length and sometimes extend to the receptacle. **Disc** deeply concave, pinkish, pinkish orange, buff to salmon, ochraceous-orange when dry. **Margin** with somewhat inrolled. **Hairs** fasciculate, white to brownish, arising from the medullary excipulum, composed of bundles of parallel, septate, thick-walled hyphae, stiff, bristle-like, 3–7 mm long, individual hyphae 6–8 µm diam, walls 1.5–2.5 µm wide. **Tomentum** not seen. **Outer excipulum** of *textura globulosa*, layer (50–) 80–175 µm wide, cells arranged perpendicularly to the surface of the receptacle, 8–24 µm diam, cells thick-walled, particularly the most external ones, walls 1.5–2.5 µm thick, hyaline. In some cases these cells aggregate to form masses of loosely connected cells, which gives the receptacle a pruinose surface. **Inner ectal excipulum** a thin layer of loose *textura porrecta* to *intricata* of thin-walled hyphae, layer 64–80 µm wide, hyphae 4–11 µm diam, no gel present. **Medullary excipulum** of *textura intricata*, 230–300 µm thick, hyphae septate, 2.5–10 µm wide. **Subhymenium** of *textura intricata*, indistinguishable from the medullary excipulum, 20–40 µm wide. **Hymenium** 500–525 µm thick, easily separated from the excipular layer. Asci cylindrical, long, 280–387 x 16–20 µm, narrow-hyphoid at base, thick-walled, 2–3 µm thick, 8 ascospores. **Ascospores** broad sub-fusoid to lemon-shaped, pointed at both ends, pale yellow when mature, smooth-walled, 0- to biguttulate, 25–40 x 12–17 µm. **Paraphyses** moniliform, slender, septate, branched and anastomosing, 2.5–4 µm.

SUBSTRATE: On dead twigs and debris.

DISTRIBUTION: Only known from China.

ILLUSTRATIONS: Wang (1997) fig. 2.; Wang (2001) fig. 1; Weinstein et al. (2002) fig. 3F.

NOTES ON TYPE SPECIMENS AND NOMENCLATURE: The designated holotype from HMAS 70088 has no ascospores. The type specimen being infertile, **we designate here an epitype, HKAS 14679, a paratype collected in the same area.**

GENERAL NOTES: *Cookeina sinensis* is very similar to *C. tricholoma*, the difference being that the ascospores of *C. sinensis* are smooth, and those of *C. tricholoma* are striate. There are apparently few collections of this fungus and its range to date is limited to China, including Taiwan (Wang 2001). We were only able to obtain three collections on loan. Molecular data show it is part of a larger group that contains *C. tricholoma*, but it appears to be distinctive from *C. tricholoma* (Weinstein et al., 2002).

SPECIMENS EXAMINED. CHINA. YUNNAN: MENLEN: Xishuangbanna: On twig, 8 Jun 1986, *Li Yu 372* [70088] (HMAS) without ascospores, holotype of *Cookeina sinensis*; as above, *72003* (HMAS); Limestone Hill, 1200 m, on rotten wood, 15 Aug 1985, *Zang Mu 10398*, 14679 (HKAS) [epitype].

Cookeina speciosa (Fr. : Fr.) Dennis, Mycotaxon 51: 239. 1994. **Figs. 1 C-E, 7**

= *Peziza speciosa* Fr., Syst. Mycol. 2: 84. 1822 [Type is illustration by Plumier cited by Dennis (1994) as listed above.] !

= *Peziza sulcipes* Berk., London J. Bot. 1: 141. 1842. [Type specimen: Surinam Hostin. (K).] infertile, no spores] ! = *Trichoscypha sulcipes* (Berk.) Sacc., Syll. fung. 8: 161. 1889. = *Cookeina sulcipes* (Berk.) Kuntze, Revis. gen. pl. 2: 849. 1891. = *Pilocratera sulcipes* (Berk.) Sacc. & Traverso, Syll. fung. 20: 413. 1911.

= *Peziza hindsii* Berk., London J. Bot. 1: 456. 1842. [Type specimen: on dead wood, New Ireland, July] (K!) = *Lachnea hindsii* (Berk.) Pat., Bull. Soc. Mycol. France 4: 98. 1888. = *Trichoscypha hindsii* (Berk.) Sacc., Syll. fung. 8: 161. 1889. = *Cookeina hindsii* (Berk.) Kuntze, Revis. gen. pl. 2: 849. 1891. = *Pilocratera hindsii* (Berk.) Henn., Hedwigia 32: 225. 1893.

= *Peziza* (*Aleuria*) *javanica* Nees ex Lév., Ann. Sci. Nat. Bot. Ser 3 3: 39. 1845. [Type specimen: Java, ad palmas, herb. Blume] PC! = *Trichoscypha javanica* (Nees ex Lév.) Sacc., Syll. fung. 8: 162. 1889. = *Cookeina javanica* (Nees ex Lév.) Kuntze, Revis. gen. pl. 2: 849. 1891. = *Aleuria javanica* (Nees ex Lév.) Overeem & D. Overeem, Bull. Jard. Bot. Buitenzorg. III 4: 12. 1922.

= *Peziza* (*Lachnea*) *amoena* Lév., Ann. Sci. Nat. Bot. III 3: 39. 1845. [Type specimen: Guiana ad truncos] = *Trichoscypha amoena* (Lév.) Sacc., Syll. fung. 8: 161. 1889. = *Cookeina amoena* (Lév.) Kuntze, Revis. gen. Pl. 2: 849. 1891.

= *Peziza afzelii* Fr., Nova Acta Regiae Soc. Sci. Upsal. III 1: 121. 1851. [type specimen: ad terra in Guinea, not found at UPS.] = *Trichoscypha afzelii* (Fr.) Sacc., Syll. fung. 8: 161. 1889. = *Cookeina afzelii* (Fr.) Kuntze, Revis. gen. pl. 2: 849. 1891. = *Pilocratera afzelii* (Fr.) Sacc. & Traverso, Syll. fung. 20: 412. 1911.

= *Peziza (Geopyxis) hindsii* var. *beccariana* Ces., Atti Accad. Sci. Fis. 8 (4): 11. 1879. [Type specimen: lignicola, Ceylon] = *Trichoscypha hindsii* var. *beccariana* (Ces.) Sacc, Syll. fung. 8: 162. 1889.

= *Pilocratera engleriana* Henn., Bot. Jahrb. Syst. 14: 363. 1892. (tab. 6, fig. 9.) (!) [Lectotype: designated here because holotype lost, Kamerun, Zenker (B)] ! = *Trichoscypha engleriana* (Henn.) Sacc., Syll. fung. 11: 398. 1895.

= *Geopyxis elata* Massee, Bull. Misc. Inform. 138: 123. 1898! [Type specimen: On the ground, Kumusi River, W. Fitzgerald, New Guinea (K)!]

= *Pilocratera maxima* P. Syd., Ann. Mycol. 10: 82. 1912. [Type specimen: ad ligna vel ramos(?), Süd-Ost-Borneo. Hayoep, 18. 6. 1908, leg H. Winkler no. 2531]

= *Pilocratera novoguianensis* Ramsb. in Gibbs, Fl. Arfak Mts. p. 185. 1917. [Holotype: In ligno putrido. Manokoeari, sec. jungle, edge of "korang" forest, 200'. Jan 1914, Gibbs 6152] !

= *Cookeina sumatrana* Boedijn, Recueil Trav. Bot. Néerl. 26: 407. 1929. [Type specimen: auf vermoderten Baumstammen im Walde zu Soengai Pantojer (Deli) but a specimen is not particularly noted] = Have not examined type. Le Gal (1953) has it as a synonym of *Cookeina sulcipes*.

[= *Geopyxis striatospora* Maubl. & Roger, Bull. Soc. Mycol. France 52: 83. 1936 (teste Le Gal, 1953). Nom. inval. No Latin description or diagnosis given] [no specimen in PC] [Type specimen: leg. A. Mallamaire, Cote-d'Ivoire, 1934]

= *Cookeina sulcipes* var. *fusca* Alas., Nova Hedwigia 23: 771. 1972. [Type specimen: U.I.B/ L. 176 but this seems to refer to a series of collections from 1963 and 1964].

= *Cookeina globosa* Douanla-Meli, Mycotaxon 92: 225. 2005.

Apothecia solitary or clustered, centrally stipitate to rarely subsessile, deep cupulate to goblet shaped, leathery, becoming wrinkled with age, 10–50 mm broad, 12–80 mm tall.

Receptacle cup shaped or rarely funnel shaped, sometimes whitish, minutely scurfy except around the margin where there are usually up to 5 distinct concentric ridges from which compound hairs arise in mature specimens, in young specimens the ridges are absent and the hairs are arranged around the margin as a single row, variable in color, concolorous or much paler than the disc; when rehydrated light-brown, light-yellow, light yellowish-beige, yellow, yellowish-brown to ochraceous-yellow, ochraceous-orange to even white, and brown; when dry, beige to beige-orange, to light-brown, to dark brown, when dry 6–25 mm diam and 6–14 mm tall; when rehydrated 16–50 mm diam and 8–20 mm tall. **Stipe** terete or compressed, sometimes grooved, slender, hollow, slightly attenuate below and often forming a disc-like holdfast at the bottom, concolorous or even paler than the receptacle, 3–40(–75) x 1–6 mm. **Disc** deeply concave, appears smooth to the unaided eye, when fresh pink or salmon, or light-coral to coral to deep coral, orange, yellow, mauve or light-brown. **Margin** not inrolled at maturity, when dry inrolled, when fresh concolorous to receptacle, brown to light yellow when rehydrated, provided with several rows of long hairs. **Tomentum** of two types: 1) individual monilioid processes that are present on the margin and as well covering sparsely all the receptacle giving it a furfuraceous appearance, composed of 2–5 short hyaline cells, cells 20–30 µm diam with thick and rugose walls, walls 2–5µm thick. 2) fused triangular-shaped bundles of cells present at the margin, 40–100 µm long, 34–64 µm wide at the base, and 8–22 µm wide at the apex. **Hairs** located in 2-5 concentric ridges or rows around the margin, approximate distance between rows.µm wide, hyphae 2–3 µm wide, not staining with Congo Red. **Medullary excipulum** *textura porrecta* not 0.25–0.75(–1) mm; all hairs of approximate the same length, 0.25–1 mm long when dry, 0.75–1.25 mm long when rehydrated, each hair composed of fascicles of hyphae which are longitudinally fused, the exterior hyphae shorter than the others so the compound hair has a broad base up to 200 µm diam, diminishing in width up to a pointed apex, individual hyphae white to beige 4.5–9.0 µm diam. **Outer ectal exipulum** *textura globosa* to *angularis* or *prismatica*, layer (28–) 30–60 (–80) µm wide, composed by a few cell layers not staining with Congo Red, lying perpendicular to the surface of the receptacle, outer cells round to elongated, (15–)16–30 x (9–)12–24 µm, cells becoming rounder and thicker-walled towards the flanks, at the surface of the receptacle groups of thick-walled and sometimes warted, globose or pyriform cells are often irregularly aggregated causing the pruinose appearance of the receptacle; internal cells are smaller and prismatic. **Inner ectal excipulum** *textura intricata* to lax *intricata*, without a gel; this layer is gelatinized only in infertile young specimens, disappearing at maturity, layer (20–) 30–80 gelatinized, layer (30–) 40–300 µm wide, composed of long compressed parallel hyphae, 2–4 (–5) µm wide, not staining with Congo Red. **Subhymenium** 15–30 µm thick of *textura intricata* to *porrecta*, gelatinized in immature specimens, hyphae irregular, thread-like and loosely interwined with each other. **Hymenium** 200–390 µm tall, with interspread setae present. **Setae** sometimes dark, tortuose, thick-walled, exceeding the hymenium by 22–40 µm. **Asci** long cylindrical, (61.6–)250–430(–460) x 10–30(–40) µm, thick-walled, walls 2 µm thick; with 8 spores located in the top 2/3 on the ascus, round at the base and abruptly contracted into a basal hyphal appendix, appendix 6–24(–40) x 2–6(–10) µm. **Ascospores** uniseriate, ellipsoid to broad elliptic fusoid to subfusoid, somewhat asymmetrical, sometimes one end more pointed and the other rounder, with more or less projecting apiculi at the poles, subhyaline under the

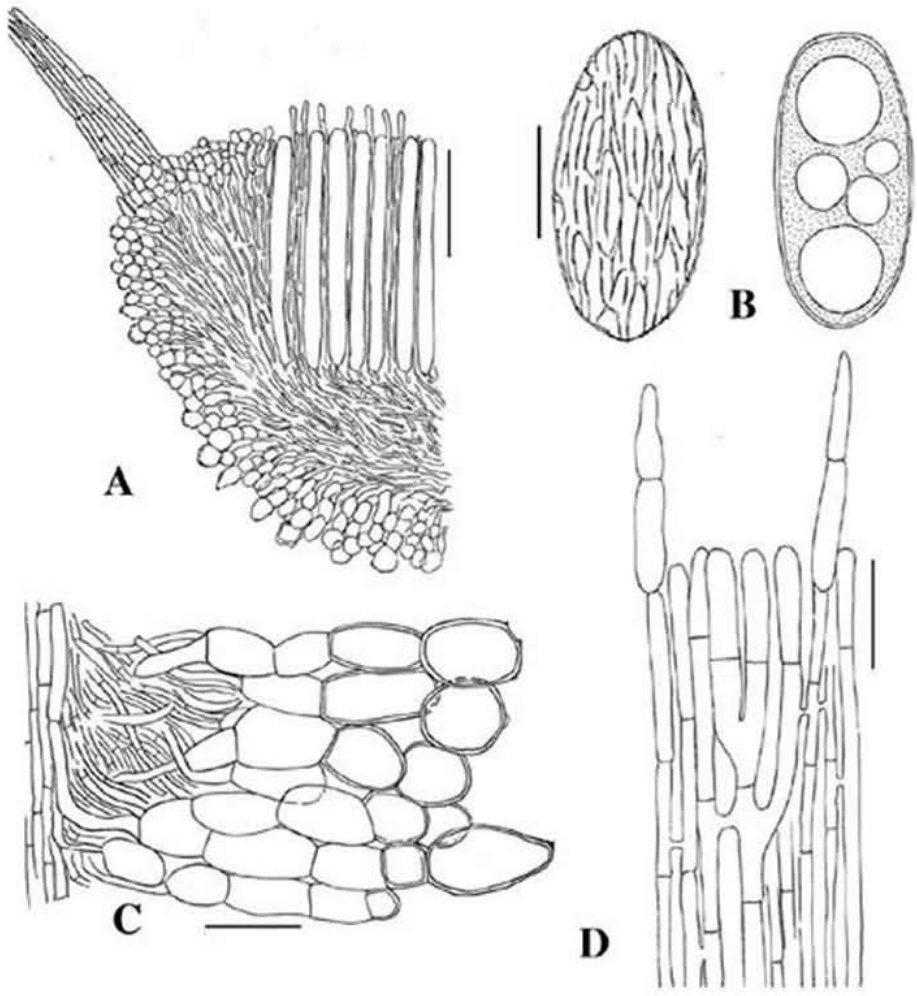


Figure 7. *Cookeina speciosa.* A. Cross section of an apothecium, bar = 120 µm. B. Ascospores, bar = 10 µm. C. Cross section showing outer layer of the excipulum, bar = 25 µm. D. Portion of hymenium with setose paraphyses, bar = 10 µm. Yutajé, Venezuela; *T. Iturriaga & K. Samuels*, 4A-D4; 4 Jul –7Jul 1997 (FH).

microscope, thick-walled, wall 1 µm thick, with 0–2(–multi) guttules, mostly with two large central guttules and numerous smaller oil drops, at maturity appearing striate from the presence of fine, rarely anastomosing paralled striate low ridges 1(–2) per µm, spores 20–36 x10–18(–20) µm. Paraphyses filiform, thread-like, delicate, simple or branching, anastomosing and forming a network of thin, septate, hyphae, sometimes with irregular peg-like and one-sided swellings at their middle, more profusely branched at their apex, ending in rounded clavate tips up to 3 µm diam, containing fine granules; same height as the asci, or exceeding them slightly, (1–)2–3 µm wide in the middle, 1–5(–7) µm wide at the apex.

SUBSTRATE: on wood, on fallen logs, twigs or branches.

DISTRIBUTION: Distributed throughout the tropics in both the new and the old world.

ILLUSTRATIONS: Plumier (1705) tab. 168, fig. C; Berkeley (1842) as *Peziza hindsii*, pl. 15; Berkeley (1852) as *P. hindsii*, tab. 15, fig. 4; Fries (1860) as *Peziza afzelii*, pl. 12, fig.

28; Cooke (1874) as *P. hindsii*, plate 27, fig 3; Cooke (1879) as *Peziza sulcipes* fig. 199, as *P. hindsii* fig. 200; Cooke (1892) as *Trichoschypha hindsii*, fig. 153; Hennings (1892) as *Pilocratera engleriana*, pl. VI, fig. 9 a, b; Seaver (1928, 1942) as *C. sulcipes*, pl. 18, fig.1; Le Gal (1953) as *C. sulcipes*, figs. 114–119; Rifai (1968) as *C. sulcipes*, figs 18–20; Nagao (1997) as *C. sulcipes*, fig. 1; Vooren & Lopez (2002) fig. 2; Melendez-Howell et al. (2003) as *C. sulcipes*, fig. 1, 3–5, 7.

NOTES : *Peziza speciosa* was based on Plumier's Tab. 168 Fig C, as pointed out by Dennis (1994). Prior to Dennis's observation this species was generally known under the name *C. sulcipes* and *C. hindsii*. The number of synonyms for this species is no doubt related to the diffuse mycological literature of the early to mid 19th century and also to the variability of this species in hymenial color. In an ITS sequence analysis all collections referred to *C. speciosa* fall within a monophyletic clade. Within that clade there is phylogenetic structure that indicates some genetic variation that correlates as well with color differences. It is perhaps best to consider this as a species complex until such time as more complete population studies are done. This and *Cookeina tricholoma* are the most common species of the genus in most parts of the tropics. The hairs in rows at the margin of the disc serve to distinguish this species from *C. tricholoma*.

For those who might wish to segregate color forms the following guide to the application of names might be followed: 1) *Pilocratera engleriana* is the oldest name for an orange–yellow species. It has not been combined in *Cookeina*. 2) *Peziza javanica* and *Peziza amoena* were both described in the same publication, one from Java and one from Guiana but both were described as yellow. 3) fawn or darker forms from Africa were referred to as *C. sulcipes* var. *fusca*. Our morphological studies did not find distinctions in size of asci, ascospores or apothecia to warrant recognition of these taxa.

GENERAL NOTES: In parts of Mexico *C. sulcipes* is used as a food as summarized by Villarreal & Pérez-Moreno (1989) and is listed among those fungi known and used by indigenous people in Mexico (Chacon 1988). It is used medicinally in Cameroon, Africa (Dijk et al. 2003).

SPECIMENS EXAMINED. AFRICA. CAMEROON: *Zenker* Nr. P41, from alcohol (B), Zenker, Aus der Alkoholsammlung, *P41* (B) [holotype of *Pilocratera engleriana*]; Mount Cameroon (IDENAU. lava floco) on leaf litter, coffee colour from transparencies inside packet, 1922, Alt (m): 2, *S. Dawson 45*, K (M): 57300. LIBERIA. CENTRAL PROVINCE: Gbanga, 20 Sept 1926, *D. H. Linder 726* (FH); 7 Sept 1926, *D. H. Linder 392* (FH); as above, 23 Sept 1926, *D. H. Linder 392* (FH); Kassa Ta, 29 Sept 1926, *D. H. Linder 392A* (FH); Mount Barclay, 20 Jul 1926, *D. H. Linder* (FH); Pehata, 8 Oct 1926, *D. H. Linder* (FH); UGANDA: Uganda Protectorate, decaying log. [400 Ft], Mt. Nayge, greyish ochre, abril 1916, *R. Dummer 2845* (K). BRAZIL. AMAZONAS: On rotten wood, June 1901, *2811* (FH). CHINA. YUNNAN: Monlin, Hsichuang Panna Autonomous Prefecture of Tai Nationality, on rotten wood, 17 Oct 1980, *Zang Mu 7240* (FH); Xishungbanna, Menlen, ex situ of endangered plants area, 500m alt, on rotten wood, 25 Oct 1988, *Zang Mu 11532*, 20381 (HKAS). COLOMBIA. MAGDALENA: San Sebastian, *Ruth Aldava 296* (FH). COSTA RICA. Cartago, Forest of Turrialba Instituto, 1700 ft, 17 Sept 1964, *W. C. Denison, et al. 2354, 2359, 2360, 2363, 2364* (=OSC 21542, 21547, 58562, 67758, 67760); as above, on stick, 19 Sept 1964, *Denison, et al. 2389* (= OSC 67770); as above,1700ft, 19 Sept 1964, *Denison, et al. 2394* (= OSC 67772); LIMÓN PROVINCE: Finca Castilla, 30m, 23, 25, 26, 29 Jul 1936, *C. W. Dodge & V. F. Goerger* 9314 (FH); Guapiles, Finca Diamante, on dead wood, 18 Sep 1964,. *Denison, et al. 2376*

(= OSC 67767); as above, 400ft, on dead wood, 18 Sept 1964, *W. C. Denison, et al. 2375, 2376, 2386* (= OSC 21516, 67766, 67768); as above, 700ft, dead stick, 18 Sept 1964, *Denison, et al. 2386* (= OSC 21548); Portete, 50ft, sticks, 26 Aug 1964, *Denison et al. 2111* (= OSC 67717); Westphalia, 10ft, 26 Aug 1964, *Denison et al. 2118* (= OSC 67719); PUNTARENAS: Coto, United Fruit Co., Finca 59, 75ft, on limb, 3 Oct 1964,. *Denison 2462* (= OSC 67784, 21531); as above, on rotting wood, 3 Oct 1964, *Denison 2453* (= OSC 67781, 21549); as above, 75ft, dead wood, 3 Oct 1964, *Denison 2452* (= OSC 67780); as above, 75ft, 3 Oct 1964, *Denison, et al. 2454* (= OSC 67782); Golfito, Ravine back of Balneario, rotting wood, 2 Oct 1964, *W. C. Denison 2448, 2449* (= OSC 21512, 21550, 67777, 67778); Above Golfito, 150ft, on rotten wood, 29 Aug 1964, *Denison et al. 2158* (= OSC 67720, 21530); Gorge back of Golfito, 150ft, dead wood, 30 Aug 1964, *Denison, et al. 2162* (= OSC67723, 21544); Hills above Golfito, 200ft, stick, 30 Aug 1964, *Denison, et al. 2179, 2181* (= OSC 67726, 67727); Guanacaste, Tilaran, 1700ft, rotten limb, 15 Sept 1964,. *Denison, et al. 2330* (= OSC 67753, 21517); as above, Rotting wood, 15 Sept 1964, *Denison et al. 2329* (= OSC 67752); Alajuela, hot springs near La Marina, 1400ft, branch on ground, 11 Sept 1964, *Denison et al..2262* (= OSC 67742); as above, 1500ft, rotting wood, 11 Sept 1964, *Denison et al. 2257, 2258* (= OSC 21518, 67739); Palmar Norte, 200ft, 30 Aug 1964, *Denison, et al. 2186* (= OSC 67729. 21532); Gorge just north of Palmar Norte, 175ft, 31 Aug 1964, *Denison, et al. 2195* (= OSC 67731, 21515); as above, 175ft, stick, 31 Aug 1964, *Denison, et al. 2197* (= OSC 67732); PanAm Highway north of Palmar Norte, 200ft, on stick in cacao plantation, 1 Oct 1964, *Denison 2444* (= OSC 67774); San Jose, University of Costa Rica, 3500ft, standing dead tree, 25 Aug 1964, *W. Westman, Denison 2109* (=OSC 67716, 21521). CUBA. 1856–7, *C. Wright* (FH); *C. Wright* (FH). DOMINICAN REPUBLIC. SEIBO: Canada Hondo, on dead sticks, Nov 1946, *R. A. & E. S. Howard* (FH); Higuey, on fallen logs in dense woods, Nov 1946, *R. A. & E. S. Howard* (FH). FRENCH GUIANA: Vicinity of Cayenne, taken from material in 418, 1921, *W. E. Broadway 418b* (FH). GUATEMALA. 'Alsacia' Mountains, 1200ft, in wet ravine, 17 Jul 1936, *Winslow Hatch 411* (FH). GUYANA. Plantation Vryheid, 2 Feb 1924, *D. H. Linder 843* (FH); Bartica, 9 Dec 1923, *D. H. Linder 464* (FH). JAMAICA. Portland, Blue Mountains, Stony River Base Camp, 1250ft, in woodland, on scree, on fallen branch, 13 Dec 1973, *B. D. Morley & C. Whitefoord 505* (FH); Jul 1902 (FH); Port Antonio, Road to Park Mount, 6 Feb 1906, *A. E. Wight 218* (FH); St. Margaret's Bay, 26 Feb 1906, *A. E. Wight* (FH). PANAMA. Barro Colorado Island (FH); On spring palm stem, 12 Dec 1928, *W. H. Weston 3298* (FH); Dec 1928 (FH); Canal Zone, trail below Madden Dam, 250ft, on branch, 7 Oct 1964, *Denison 2465, 2466* (=OSC 67787, 67788, 67792, 21541); Las Cruces Trail, 400ft, on rotting wood, 7 Oct 1964, *Denison 2471, 2474* (= OSC 67790, 67792). PAPUA NEW GUINEA: Kumusi River, 1859, *W. Fitzgerald 58274* (K); New Ireland, *R. B. N. 58275* (K). PHILIPPINES. ISABELA PROVINCE: Luzon Island, Planan, Sitio Dipaguiden, Branagay San Isidro, on decayed log in shade, 16 Apr 1991, *Benito C. Tan 361* (FH); Laguna, Los Baños, on dead wood, 24 Oct 1921, *C. G. Wells 11670* (NY); Island of Luzon, Los Baños (Mt. Maquiling), Province of Laguna, June-July 1917, *18329* (FH); On dead wood, 24 Oct 1921, *Colin G. Welles* (CUP 11683); University of the Philippines Campus, College of Agriculture, on dead wood, Dec 1958, *Lewis A. Schafer* (NY); Mud Spring, on wood, 24 Nov 1966, *Denison 3938* (= OSC 24423); as above, Dead branches, 27 Nov 1966, *Denison 4730* (= OSC 28876); as above, Wood, 24 Nov 1966, Rebeca de Guzman, *Denison 3943* (= OSC 24418); as above, On dead logs, 23 Aug 1966, *Denison 4706* (= OSC 27971); Quarry, in bark of dead wood, 13 Oct 1966, *Denison 3940* (= OSC 24421). SURINAM. Tafelberg, 390m, 11 Aug 1944, *Bassett Maguire* 24312 (FH). TRINIDAD. Arima, Verdant Vale, 1913, *R. Thaxter* (FH); Arima Valley, Jan 1975, *Sylvia Stein* (NY); 1879, *Rev. M. J. Berkeley 35303* (K); Maravel Valley,

on wet decaying wood at border of brook, 18 Aug 1923, *D. H. Linder 66* (FH); Port of Spain, 1912–13, *R. Thaxter 3698* (FH); 1913, *R. Thaxter 3699* (FH). VENEZUELA. AMAZONAS: Oeste del Caño Yutajé, 1km NE del Campamento Yutajé, Bosque de las Ceibas, pie de monte, 5°35'N, 66°10'O, tronco muerto, 21 Jun 1996, *Teresa Iturriaga y colaboradores 2721, 2722, 2723* (USB); NE del Campamento Yutajé, Bosque en el lado norte del río Yutajé, 5°36'51"N, 66°6'85"W, madera muerta, 15 Jun 1996, *Teresa Iturriaga y colaboradores 2596* (USB); Yutajé, Bosque primario donde está localizada la parcela 'FEX,' madera en descomposición, 17 Jun 1996, *Teresa Iturriaga y colaboradores 2610, 2612, 2613* (USB); Yutajé, 80 collections by *K. Samuels* as part of an ecological study, 4 Jul –7Jul 1997 (FH, USB); BOLIVAR: Sifontes, Tumeremo, Carretera Tumeremo – Bochinche, Campamento maderero de INTECMACA, orillas del Río Botaramo, sobre tronco, 17–19 Nov 1994, *T. Iturriaga, L. Bracamonte, L. Ryvarden, O. Holmquist 2167, 2170, 2180, 2185* (USB); MIRANDA: Parque Nacional Guatopo, 10°03'N, 66°26'W, 500–600m, on decorticated wood, 27–30 Nov 1990, *G. J. Samuels, B. Hein, S. M. Huhndorf* 7680 (FH); *G. J. Samuels, B. Hein, S. M. Huhndorf 7681* (FH).

Cookeina tricholoma (Mont.) Kuntze, Revis. Gen. Pl. 2: 849. 1891. **Figs. 1 A, B, 2**

≡ *Peziza* (*Lachnea*) *tricholoma* Mont., Ann. Sci. Nat. Bot. II 2: 77. 1834 !! ≡ *Lachnea tricholoma* (Mont.) Pat., Bull. Soc. Mycol. France 4: 98. 1888. ≡ *Trichoscypha tricholoma* (Mont.) Sacc., Syll. fung. 8: 160. 1889. ≡ *Pilocratera tricholoma* (Mont.) Henn., Bot. Jahrb. Syst. 17: 9. 1891.

= *Peziza tricholoma* [var.] ß *minor* Mont., Ann. Sci. Nat. Bot. II 2: 77. 1834.

= *Peziza hystrix* Berk. Ann. Mag. Nat. Hist. II 9: 201. 1852 !!

= *Pilocratera tricholoma* var. *celebica* Henn., Monsunia 1: 33. 1900.

= *Peziza medusina* Speg. Anales Mus. Nac. Hist. Nat. Buenos Aires III 1: 78. 1902 !! ≡ *Pilocratera medusina* (Speg.) Sacc. & D. Sacc., Syll. fung. 18: 32. 1906 !!

= *Peziza (Sarcoscypha) striispora* Ellis & Everh. Bull. Lab. Nat. Hist. Iowa State Univ. 4: 69. 1896. ≡ *Sarcoscypha striispora* (Ellis & Everh.) Sacc., Syll. fung. 14: 754. 1899.

Apothecia solitary or gregarious, deep cupulate, centrally stipitated to rarely subsessile, frequently elongated on one side being then suboblique, leathery, receptacle and stipe covered with long conspicuous hairs more abundant at margin specially in young apothecia, when dry 7–25 mm tall and (5–)10 x 35(–50) mm diam, when rehydrated 20–25 mm tall. **Receptacle** when fresh 10–40 mm diam and 5–15 mm deep, paler than the disc, orange to yellowish-orange, to reddish, to pinkish, to coral red; when drying 5–20 mm diam and light reddish-brown to beige, when rehydrated 10–35(–50) mm diam, orange to yellow-ochraceus to yellowish brown. **Stipe** central or slightly eccentric, slender, concolorous with receptacle, when fresh fleshy, white, orange-buff to salmon-orange to beige, when dry tough, 2–35(–50) x 1–4 mm, cylindrical or compressed, with hairs mainly present on the upper half, these being shorter than the ones in the receptacle. **Disc** smooth, variable in color, concolorous with receptacle or lighter, when fresh pale orange, to buff-orange to rose-orange, in old specimens nearly whitish, when rehydrated light yellow. **Margin** enrolled in dry specimens, covered with abundant long conspicuous hairs especially in young apothecia and by short hairs (tomentum). In young apothecia the hairs form an in-curved border that close the apothecium. **Hairs** whitish (especially in younger specimens) to brownish-yellow to brown, when dry cream-colored to beige,

fasciculate, darker at the base, covering all margin and receptacle, composed of septate parallel hyphae 2–4 µm wide, arising from the inner ectal excipulum and breaking though the outer ectal excipulum at a right angle. Marginal hairs up to 7 mm long and up to 250 µm diam, twice as wide as the receptacle hairs, abundant, 2 per mm. Receptacle hairs located on the upper 1/3 of the receptacle or covering it completely, 2–4 mm long and 64–90 µm diam in the middle of the fascicles, widening up to 90–130 µm diam at the base. Hairs originate from the medullary excipulum and penetrate the ectal excipulum extending obviously above the receptacle's surface. **Tomentum**, of two types: 1) individual monilioid processes that arise from the margin and also sparsely cover the receptacle, these cells produce the pruinose appearance of the receptacle, these catenulate processes composed of 3–5 short hyaline cells, cells 10–20 µm diam, outermost cells with thick and rugose brownish thick walls, hairs 40–80 x 7–10 µm. 2) fused triangular-shaped bundles of the catenulate (monilioid) cells present at the margin. **Outer ectal excipulum** of a few layers of cells of *textura globulosa* to *angularis*, 10–72(–100) µm wide, cells arranged perpendicularly to the surface of the receptacle, cells 7–25 x (5.5–) 7–18(–20) µm. Outer cells with thick walls which are roughened become loose and grouped, giving the receptacle a pruinose appearance. **Inner ectal excipulum** of loose *textura intricata* of thin-walled hyphae oriented perpendicular to the receptacle's surface, layer 30–60 µm wide, hyphae 2–4 µm wide, no gel present. This layer is almost non-existent in wholly mature specimens, but can be evident in young specimens, where some gelatinization of this layer may be present as well. **Medullary excipulum** *textura porrecta* without gel of 160–200 µm wide, parallel or seldom branching septate hyphae composed of long cells with some spaces occasionally between them, hyphae of 2–7.5 µm diam. **Subhymenium** loose *textura intricata*, layer 40–60 µm wide, hyphae up to 5–6 µm diam. **Hymenium** 260–440 µm thick. **Asci** cylindrical, with rounded blunt base, 255–390 x 10–30 µm, walls up to 2 µm wide, connecting to short, narrow basal hyphae, 6–14(–30) x (1–) 4–6 µm, with 8 ascospores. **Ascospores** uniseriate, elliptic-fusoid, apiculate at both ends though one end frequently is more pointed than the other, subhyaline, (0–) 2 large guttules and several smaller ones may be present as well; with an inner and outer wall, at maturity distinct markings present, consisting of fine parallel longitudinal, low, ridges which sometimes anastomose 1–2 per µm, wall 1 µm diam, 25–39 x 12–21 µm, normally restricted to the top 160–190 µm of the ascus. The ornamentation is only seen in mature spores. **Paraphyses** filiform, septate, hyaline, branched and frequent anastomosiing to form a dense network, especially very profusely near the apex where they form short erect branches and end in a compact layer, 1.5–4.5 µm in the middle, enlarging at the apex in a clavate shape to 2–6 µm, exceeding the asci.

SUBSTRATE: On wood, on fallen logs, twigs or branches.

DISTRIBUTION: Throughout the lowland tropics, both new and old world. The species has on occasion been collected in Florida.

ILLUSTRATIONS: Montagne (1834) as *Peziza tricholoma*, Plate 4, fig. 2; Cooke (1874) as *P. tricholoma*, pl. 27, fig. 4, as *P. hystrix* pl. 27, fig. 12; Cooke (1879) as *Peziza tricholoma* f. 202; Ferdinandsen & Winge (1910) fig. 4, page 218; Seaver (1913) fig. 1, 2; Seaver (1928, 1942) pl. 18, fig. 2; Boedijn (1933) as *C. tricholoma*, fig. 2b, 3h, 4a, 4e; Le Gal (1953) fig. 105–108; Dennis (1954) as *C. tricholoma*, fig. C; Gamundí (1959), fig. 1–8; Denison (1967) fig. 3, 5-6; Rifai (1968) fig. 15–17; Dennis (1970) fig. 7U; Otani (1971) plate 3 c, fig. 15, 16; Gamundí (1983) map 6, distribution map for neotropics; Weinstein

et al. (2002) fig. 3D; Vooren & Lopez (2002) fig. A; Melendez-Howell et al. (2003) fig 3c, 7e–g, 14.

NOTES ON TYPE SPECIMENS AND NOMENCLATURE: Montagne's description of *P. tricholoma* is based on material from Brazil from the herbarium of Gaudichaud collected in 1831/1832 around Rio de Janeiro and labeled no. 44. There are three collections at PC that fit this information. All match the original description and all are labeled number 44. After examining the three collections we have selected one as lectotype because of its good state of preservation and maturity.

Peziza tricholoma var. *minor* was described at the same time as *P. tricholoma* by Montagne (1834), he mentioned that this variety was different from *P. tricholoma* because it is almost glabrous with few setae "setis raris vel nullis" and that it is smaller. From Montagne's description, it is evident that ß minor was collected in or at the vicinity of Rio de Janeiro, Brazil. There is one collection in Montagne's herbarium that does not bear a collection number, collected by Gaudich, and it is from Rio de Janeiro. **We designate this collection as the lectotype of var. *minor*.**

Peziza hystrix was erected by Berkeley (1852) in the belief that *P. tricholoma* was a smaller species, that the external surface was costate, and that the hairs in P. *tricholoma* covered only the margin as shown in Montagne (1834) figure 2a (see list of illustrations below). Montagne did mention that there were some hairs on the external surface, but that these were mainly present, and in a higher number, at the margin. Cooke (1879) examined Montagne's specimen and found that the hairs covered the receptacle and stipe. Having seen both Montagne's and Berkeley's collections, Cooke concluding that *P. hystrix* was a synonym of *P. tricholoma*.

Peziza (Pilocratera) medusina was considered to have smooth ascospores (Spegazzini 1902). We examined the type specimen of *P. medusina* and have observed striations present on the ascospores. We conclude that this is a synonym of *C. tricholoma*, as Gamundí (1959) had already stated.

GENERAL NOTES: *Cookeina tricholoma* and *C. speciosa* are the commonest species of *Cookeina* encountered. In parts of Mexico *C. tricholoma* is used as a food as summarized by Villarreal & Pérez-Moreno (1989) and is listed among those fungi know and used by indigenous people in Mexico (Chacon 1988). It is used medicinally in Cameroon, Africa (Dijk et al. 2003). *C. tricholoma* can be easily distinguished by the more or less uniform covering of hairs on the outer surface of the apothecium. Boedjin (1933) indicated that ascospores are faintly rose in color, and that spore deposits of this species were pink. Spore prints are not routinely made of discomycetes and so we do not have comparative data on spore colors in other species. Alasoadura (1972) indicates that the hairs are covering the "mouth" of the apothecium at night and early morning, that is, when spore discharge is not appreciable, at other times the hairs point upwards leaving the "mouth" of the cup open. Boedijn (1933) indicates that the ascospore has a thick inner and a thinner outer wall; he observed that for a long time the outer spore wall remained smooth, but when fully ripe, the outer wall shows a delicate longitudinal striation, caused by low, sparingly anastomosing ridges. Melendez-Howell et al. (2003) have made a comprehensive study of wall layers in asci, paraphyses and ascospores, as well as SEM ascospore observations. They show that ascus walls in *C. tricholoma* are thick; that there is a gel layer that covers the ascus, thinning out towards the apex, that there are multiple randomly located germ pores on ascospores of *C. tricholoma*, and that the low

ridges that form the ascospore ornamentation have a slightly spinose surface (see list of photographs below). They state that ascospores may be covered by the perispore, which masks somewhat the ornamentation of the "paroi propre."

SPECIMENS EXAMINED. AFRICA. CAMEROON: Sakbayene, 1926, *Rev. Charles Schwab* (FH); June 1918, *28* (FH-Pat); Sur un bronc pourrissant d'un Eryshrina caralledenstrae, *1483* (FH-Pat); June 1918, *21* (FH-Pat); June 1918, *19* (FH-Pat). CONGO: Nov 1893-Mar 1894, *Dybowski* (FH-Pat); LIBERIA: Gbanga, 20 Sept 1926, *D. H. Linder 727* (FH); Sept 1926, *D. H. Linder 392* (FH). ARGENTINA. S/ramas muertas, Misiones, Puerto Pampa, 8-4-1901, Leg. E. Kermes [holotype of *Peziza medusina*] (Packet from LPS bears the number 28026) BRAZIL: Ad ligna, Rio de Janeiro, Brazil, Gaudich. no 44 (PC), [lectotype of *Peziza* (*Lachnea*) *tricholoma*, designated by Iturriaga & Pfister] (PC); Rio de Janeiro, 1831-33, *44*, [isolectotype of *Peziza* (*Lachnea*) *tricholoma*, designated by Iturriaga & Pfister] (PC); 1831-33, [isolectotype of *Peziza* (*Lachnea*) *tricholoma*, designated by Iturriaga & Pfister] (PC); ad ligno, Rio de Janeiro, Exdono Gaudichii, (as *Peziza tricholoma*) [lectotype of *Peziza tricholoma* var. ß *minor*, designated by Iturriaga & Pfister], Rio de Janeiro (PC), Crypt. Guyani 444, sur le petioles pourris de l'...carium vulgare, *890* (PC); Crypt. Guyani 444, *891* (PC); Guyani (PC); Amazonas, Mowary, Juruá, auf vermodertom Hok, Sept 1900, 2812 (FH); Porto Novo, Sta. Catharina, 1978 (FH); on rotting log, bank of brook in shady gully, 5 Jan 1906, *A. E. Wight 137* (FH); St. Catharina, mar 1888 (FH). CHICALAPA. Sur le bois pourri dans les grandes forêts, ils sous eouges ou violes et en forme de vase, Dec 1857, *Sallé 303* (FH-Pat); JAVA: Iter javanicum secundum, *H. Zollinger 2042* (FH-Pat); Ile Sansos Hebrides, Jul 1906, *Le Rat 12* (FH-Pat). CHINA. KWANGSI PROVINCE: Ta Chai Shan, 1933, *S. Y. Cheo 2391* (FH); YUNNAN: Hsichuang Panna, Monlin, Calcareous Mountain, on rotten twigs, 3 Sept 1974, *Zang Mu 1171* (FH); Mengla, on rotten wood, *Zhuliang Yang 23238* ex HMAS (FH); On wood, 1 Nov 1999, ex HMAS (FH). COSTA RICA. LIMON: Portete, 50ft, on stick, 26 Aug 1964, *Denison et al. 2112* (= OSC 67718); Guapiles, Finca Diamante, 700ft, stick, 18 Sept 1964, *Denison et al. 2387* (= OSC 67769); PUNTARENAS: Pan-American Highway South of Buenos Aires, 430ft, in a ravine with waterfall, 29 Aug 1964, *Denison et al. 2160* (= OSC 67722); San Jose, 15 km. South of San Isidro del Gen., 1600ft, stick, 29 Aug 1964, *Denison et al. 2159* (= OSC 67721); Guanacaste, El Silencio, 2500ft, on large limbs, 15 Sept 1964, *Denison et al. 2319* (= OSC 67751); San Vito, Oxan's, 4000ft, on sticks, 22 Oct 1964, *W. C. Denison 2536, 2537* (= OSC 67794, 67795); Cartago, Turrialba, forest at Instituto, 1700ft, on wood, 17 Sept 1964, *Denison et al. 2351* (= OSC 67754); as above, Dead wood, 17 Sept 1964, *Denison et al. 2352, 2357* (= OSC 67755, 67757); Guanacaste, north of Puntarenas, 100ft, wood, 13 Sept 1964, *Denison et al. 2285* (= OSC 67745); PanAm Highway, 100ft, on rotten wood, 13 Sept 1964, *Denison et al. 2284* (= OSC 67744); near Santa Cruz, 100ft, wood, 14 Sept 1964, *Denison et al. 2295* (= OSC 67747); as above, Sticks, 14 Sept 1964, *Denison et al. 2316* (= OSC 67750); Santa Cruz, 100ft, on rotten limbs, 14 Sept 1964, *Denison et al. 2315* (= OSC 67749); Caña, 150ft, 13 Sept 1964, *Denison et al. 2288* (= OSC 67746); Rio Pobrenos, 350ft, 13 Sept 1964, *Denison et al. 2306* (= OSC 67748); Alajuela, La Marina, Hot Springs, 1500ft, 11 Sept 1964, *Denison, Jiménez et al. 2256, 2261, 2264* (= OSC 67738, 67741, 67743); as above, On stick, 11 Sept 1964, *Denison, Jiménez et al. 2259* (= OSC 67740); as above, 1500ft, rotten wood, 10 Sept 1964, *Denison et al. 2252* (= OSC 67736); as above, On dead branch, 11 Sept 1964, *Denison et al. 2255* (= OSC 67737); Alajuela, Buena Vista, Finca Ensayña, 2800ft, 10 Sept 1964, *Denison et al. 2246* (= OSC 67734); as above, On rotten wood, 10 Sept 1964, *Denison, Jiménez, et al. 2247* (= OSC 67735); Gorge near Golfito, 150ft, on sticks, 30 Aug 1964, *Denison et al. 2163* (= OSC 67724); as above, 200ft, 30 Aug 1964,

Denison et al. 2183 (= OSC 67728); as above, 30 Aug 1964, *Denison et al. 2168* (= OSC 67725); Golfito, near Hotel Balneario, 50ft, on rotten wood, 2 Oct 1964, *Denison 2446* (= OSC 67775); Ravine back of Balneario, 50ft, dead wood, 2 Oct 1964, *Denison 2447* (= OSC 67776); Coto, United Fruit Co., Finca 59, 75ft, wood, 3 Oct 1964, *Denison 2451, 2455* (= OSC 67779, 67783); Palmar Norte, 175ft, 31 Aug 1964, *Denison et al. 2192* (= OSC 67730). CUBA. Trinidad Mountains, Sierra de San Juan, Mina Carlota, on log, 5 Jul 1941, *W. L. White* 722 (FH); Amazon Basin, 1000 ft, on old rotten log in forest, 19 Jan 1922, *O. E. White 2358* (FH); *C. Wright 664* (FH); C. *Wright 665* (FH); *C. Wright* (FH-Pat); *C. Wright 657* (FH); *C. Wright* (FH); SANTA CLARA: Soledad, La Veguita de San Antonio, 17-23 Aug 1935, *D. H. Linder* 72 (FH). DOMINICAN REPUBLIC. On dead wood, Salle, no. 35, St. Domingo [holotype of *Peziza hystrix*] (K); Seibo, on humus in deep woods, Nov 1946, *R. A. & E. S. Howard* (FH). FRENCH GUIANA. Vicinity of Cayenne, on ground beneath trees, 6 Jul 1921, *W. E. Broadway, 692* (FH). GUADELOUPE. Capesterre, 100-250 m, on twig in banana plantation, 10 Jan 1974, *D. H. Pfister, S. Carpenter, M. Sherwood 1190* (FH); Pointe-Noire, sur les peliles branches pourries, *61* (FH-Pat); Sur un morcean bois pourri d'un Cheobroma Cacao, *Duss 980* (FH-Pat); Sur un branc pourri de Megrisleca moscati, *Duss 998* (FH-Pat); Sur un éclas de bois pourrissant, 1902, *Duss 623* (FH-Pat). GUATEMALA. Alta Verapaz, on decaying fallen log, 27 Jul 1936, *Winslow Hatch 413* (FH); Los amates, 'Alsacia' Mountains, on decaying wood, 17 Jul 1936, *Winslow Hatch 412* (FH). GUINÉE FRANCAISE. Simbaïa, 20 Apr 1909, *Duport* (FH-Pat); St. Domingo, *58273* (K). GUYANA. Bartica, Dec 1923, *D. H. Linder* (FH). INDIA. KERALA: Wynad, Periya Reserve Forest, on fallen twigs on forest floor, 23 Aug 1984, *P. Manimohan* (FH). INDONESIA. JAVA: *Tjiboya 2042* (FH-Pat) [as *Peziza aurantia* var. *stipitata*]; Iter javanicum secundum, *H. Zollinger 2039* (FH-Pat). JAMAICA. 1909, *A. E. Wight* (FH). MEXICO. Circa le Alagirines, S.L.P. 11 Aug 1891, *7084* (FH-Pat). VERACRUZ. Sur des branches de bois mort á terre dans la forêt, Oct 1854, *Sallé 50* (FH-Pat). OUBANGUI. 1891, *Dybowski* (FH-Pat); Bois mort, 1891, *Dybowski* (FH-Pat). PANAMA. Canal Zone, on dead log, 8 Oct 1946, *N. L. H. Krauss 76* (FH); Canal Zone, Las Cruces Trail, 7 Oct 1964, *Denison 2475* (= OSC 67793); as above, Dead wood, 400ft, 7 Oct 1964, *Denison 2473* (= OSC 67791); Alahuela, Madden Dam, Azote Caballo Road, 90-100m, 27 Nov 1934, *C. W. Dodge 8952* (FH); Trail below Madden Dam, 250ft, stick, 7 Oct 1964, *Denison 2463*, 2464 (= OSC 67785, 67786); Madden Dam, 250ft, 7 Oct 1964, *W. C. Denison 2467* (= OSC67789); Sabanas near Chepo, 30m, 20 Jan 1935, *A. A. Hunter & P. H. Allen 8584* (FH); Barro Colorado Island, *Seephot 3385* (FH);. PHILIPPINES. RIZAI: Luzon, Aug 1913, *M. Ramos 21945* (FH); Luzon, Mt. Maguiling, on dead wood, 4 Oct 1920, *Medina 10291* (FH-Pat); 26 Oct 1920, *R. Reyes 10408* (FH-Pat); 25 Oct 1920, *P. Malabassan 10444* (FH-Pat); 23 Sept 1917, *S. Marquez 3393* (FH-Pat); Oct 1920, *O. A. Reinking 10269* (FH-Pat); 24 Oct 1920, *F. Bernardo 10446* (FH-Pat); 20 Oct 1920, *A. Abesamis 10417* (FH-Pat); 29 Aug 1917, *R. Reyes 3324* (FH-Pat); 30 Aug 1917, *S. Marquez 3393* (FH-Pat); 25 Oct 1920, *P. Malabassan 10459* (FH-Pat); 11 Oct 1920, *P. Lisou 10295* (FH-Pat); Mud Spring, along trail, 27 Aug 1966,. *Denison 4728* (= OSC 28874); Mt. Mekiling, Decaying bark of palms, 8 Oct 1966, B. D. Ona, *Denison 3946* (= OSC 67797). PUERTO RICO. Rio Sabana, 65°43'30"W 18°21'N, on partially buried twigs, 17 Jan 1996, *D. H. Pfister, F. A. Harrington, D. J. Lodge* (FH); On decaying wood, 17 Jan 1996, *D. H. Pfister & F. A. Harrington* (FH); On decaying wood, 17 Jan 1996, *D. H. Pfister & F. A. Harrington* (FH); Rio Pedras, 19 Dec 1911, *J. R. Johnston 173* (FH). TRINIDAD. Port of Spain, on partly submerged wood, 8 Aug 1923, *D. H. Linder 32* (FH); Port of Spain, 1912-1913, *R. Thaxter 3734* (FH); Port of Spain, Maraval, 1912, *R. Thaxter* (FH); St. Anne's Valley, on dead wood, 22 Aug 1923, *D. H. Linder 106* (FH); *R. Thaxter* (FH); 1913, *R. Thaxter 3802* (FH). USA. FLORIDA: Dade

County, Castellow County Park, on sticks, 10 Oct 1997, *J. Trappe 19953* (= OSC 60205). VENEZUELA. AMAZONAS: Yutajé, 5–7 Jul 1997, *K. Samuels,* 18 collections in USB; Oeste del Caño Yutajé, 1km NE del Campamento Yutajé, Bosque de las Ceibas, pie de monte, 5°35'N, 66°10'O, rama Muerta, 21 Jun 1996, *T. Iturriaga y colaboradores 2705* (USB); Madera en descomposición, 21 Jun 1996, *T. Iturriaga y colaboradores 2738* (USB); 21 Jun 1996, *T. Iturriaga y colaboradores 2738* (USB); 21 Jun 1996, *T. Iturriaga y colaboradores 2705* (USB); SOLANO: San Carlos trail, 100-130 m, on dead branches, 1959, *J. J. Wurdack & L. S. Adderley 43401* (FH); Tobagan de la Selva, Caño Coromoto, 75m, on a rotten trunk, 17 Oct 1988, *G. A. Romero 1772* (FH); Entre Maypures et San Fernando, sur branche pourrie, Aug 1887, *242* (FH-Pat); Entre Maypures et San Fernando, 27 Aug 1887, *Gaillard 243* (FH-Pat).

Cookeina venezuelae (Berk. & M.A. Curtis ex Cooke) Le Gal, Prodr. Flore Madagascar 4: 241. 1953. **Figs. 1 F, 2, 8**

≡ *Peziza venezuelae* Berk. & M.A. Curtis ex Cooke, Mycographia p. 120. 1875! ≡ *Phillipsia venezuelae* (Berk. & M. A. Curtis ex Cooke) Massee, J. Linn. Soc. 31: 473. 1896.

= *Discina pululahuana* Pat., Bull. Soc. Mycol. France 9: 145. 1893!

= *Discina epixyla* Pat. in Duss, Énumération méthodique des champignons recueillis à la Guadeloupe et à la Martinique p. 63. 1903!, !! (paratype)

Apothecia solitary to clustered, slightly to deeply cupulate, sessile to subsessile, when fresh up to 30 mm diam, when dry up to 20 mm diam. **Receptacle** concolorous or slightly lighter than the disc, frequently drying in a venose, convoluted-cerebriform ribbed pattern, more evident at the base of the receptacle where it shows a ribbed or venose pattern; apparently smooth but when closely examined minutely pubescent, and under the dissecting scope one observes that it is covered by a fine tomentum. **Stipe** present or lacking (sessile), when present central or slightly excentric, obconic, very short, 1–3 x 2 mm, concolorous to receptacle. Disc glabrous; when fresh, salmon to rose pinkish, when dry, cream colored to beige to light yellowish to ochraceous to light brown. **Margin** with 1–4 low circumferential ridges, which become more evident when dry, when rehydrated only uppermost ridge remains evident; under magnification appearing downy, and under the compound microscope there are evident short bundles, each bundle 30–120 µm long by 20–50 µm wide at the base, by 10–20 µm wide at the apex, each composed of several monilioid processes that cluster together; each monilioid process is formed by 4–5 round to ellipsoid cells in a filament, terminal cell of the filament round or tapering to a blunt point, cell walls thick and rugose due to encrustation or deposition, cells 60–70 x 10 µm. These bundles are more evident on the uppermost ridge of the margin. **Outer ectal** of the following: a) occasional groups of 5–12 thick-walled globose or elongate cells which extend to form pustules b) 2-celled short hairlike processes with globose, clavate or pyriform terminal cells c) monilioid filamentose hairlike processes composed of 3–5 round to ellipsoid cells; the two last ones (b & c) extend to form short hairs or "hairlike processes" as seen on the receptacle surface under a hand lens or dissecting scope 2) Inner ectal excipulum gelatinized, 66–88 µm thick, hyphae 1.5–4 µm in diameter, parallel to one another, but perpendicular to the outside of the apothecium and surrounded by refractive gelatinous material, which does not stain in cotton-blue lactophenol. **Medullary excipulum** 80–90 µm thick of *textura porrecta* with hyphae parallel to one another and also parallel to the outer surface of the apothecium, 3.0–

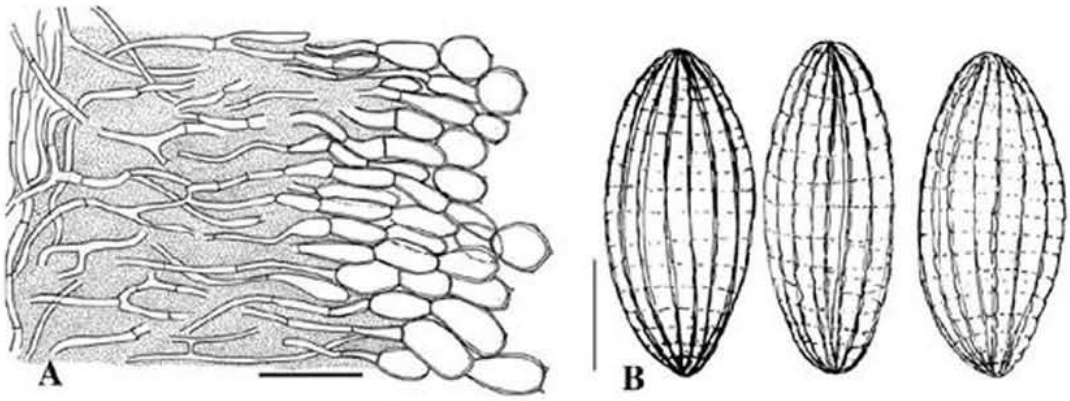


Figure 8. *Cookeina venezuelae*. A. Cross section showing outer layer of the excipulum, bar = 50 µm. B. Schematic representation of ascospores with longitudinal and transverse markings, bar = 10 µm. Haut Matouba, Guadeloupe, FWI; 9 Jan 1974, *D. H. Pfister, S. Carpenter, M. Sherwood 1161* (FH).

3.5 µm in diam. **Subhymenium** *textura intricata* to *porrecta*, not a well defined layer. **Asci** cylindrical, base round to slightly tapering, 275–550 x (10–) 20–30 µm, abruptly rising from thin basal hyphae (8–)12–32(–38) x 2–6 µm, 8 spores located at top 1/2 of the ascus. **Ascospores** elliptic fusoid, apiculate at each end, bilaterally symmetrical or asymmetrical, pale yellow, (24–)30–43 x (9.0–)14–18 µm, ornamentation consisting of few longitudinal ribs separated 3–4 µm from each other, and these connected by many fine transverse interconnecting ridges, (0–)2(–3) large central guttules surrounded by smaller ones towards both ends, uniseriate. **Paraphyses** filiform, septate, simple to branching, highly anastomosing, forming an interconnecting network, 2–5 µm diam in the middle, sometimes slightly enlarging at apex to 5 µm diam. **Excipulum** of *textura globulosa* to *angularis*, 3–5 cells thick, cells 6–20(–24) µm diam, radially arranged, outer layer of cells giving rise to one or several

SUBSTRATE: On decorticated wood, on wood and branches.

DISTRIBUTION: Known from Central America, northern South America (Venezuela is the type locality of *P. venezuelae*), Jamaica, Puerto Rico and Guadeloupe (type locality of *D. epixyla*).

ILLUSTRATIONS: Cooke (1875) pl. 69, fig 305; Cooke (1879) tab. 69, fig. 305. Cooke (1879) as *Peziza venezuelae* f.; Massee (1896) as *Phillipsia venezuelae*, tab. 16, fig. 4–5; Seaver (1928, 1942) as *Cookeina colensoi*, pl. 17, fig. 3; Le Gal (1953) fig. 109; Dennis (1954), fig. G; Gamundí (1957), Lam. II; Denison (1967) fig. 2, 4; Dennis (1970), fig. 7W; Pfister (1974), Fig. 1; fig. 9-11; Gamundí (1983) map 6, distribution in neotropics; Weinstein et al. (2002), fig. 3C.

NOTES ON TYPE SPECIMENS AND NOMENCLATURE: Some apothecia of the holotype of *Peziza venezuelae* (K) are sterile, but at least one of the apothecia is fertile, in good condition and many ascospores were seen by Le Gal (1953) and by us. Several parts of Fendler's original collection exist. One in the Sprague Herbarium (FH) is immature, a collection in the Ellis Herbarium (NY) is mature and these are assumed to be parts of the same gathering and are presumed isotypes.

Some commentary on the names listed among the synonyms may aid further investigators. The holotype material of *Discina pululahuana* is housed at FH but is

in poor condition; therefore it is recommended that the slide that accompanies this specimen be examined. We confirmed that tissues and striate ascospores are identical to those of *C. venezuelae* as was suggested by Pfister (1974). Two specimen numbers are mentioned in the original description of *D. epixyla*, 249 and 527 and both specimens are in FH. **We designate here specimen number 249 as the lectotype of *D. epixyla*,** since number 527 is immature. The designated lectotype has a drawing by Patouillard of three ascospores on the packet. Patoulliard (in Duss 1903) noted that this species was very close to *D. pululahuana*, mentioned above, the differences being that the latter had larger ascomata and ascospores, as well as a reddish color. This was confirmed in examination of material, our measurements of ascospores of *D. pululahuana* are 40 x 14 (though they are described as 35–42 x 12–16 µm) and *D. epixyla* is reported as being 33 x 13–15 µm. We consider these differences irrelevant. Dennis (1954) first suggested that *D. epixyla* might be a synonym. Pfister (1974) examined Patouillard's specimen and proved that Dennis was correct.

General Notes: Seaver (1913,1928) treated this species as *Cookeina colensoi*. Le Gal (1953) pointing out that the ascospores of *C. colensoi* are smooth whereas those in *C. venezuelae* are distinctively marked with longitudinal ribs as Seaver has described for West Indian collections. Korf (1971, 1973) placed *C. colensoi* in the genus *Boedijnopeziza*, a previously monotypic genus. Based on a study of the specimens Korf had at hand, Pfister (1974) determined that Korf, like Seaver had confused *C. colensoi* and *C. venezuelae*. This is understandable since both species are hairless and have stipes. Both also have gelatinous material in the inner ectal excipulum. The recognition of the genus *Boedijnopeziza* has not been accepted by Le Gal (1953), Denison (1967), Pfister (1974), Pfister & Kaushal (1984) and Weinstein et al. (2002). Le Gal states that the shape and size of ascospores in *C. venezuelae* and *C. colensoi* are similar, but there are differences between them with regard to the ornamentation and appiculations. The spores of *C. colensoi* are smooth and have apiculate ascospores; *C. venezuelae* has striate non-apiculate ascospores. Le Gal illustrates *C. venezuelae* ascospores as narrowing at the poles, but with no apiculum present, whereas her illustrations of *C. sulcipes*, and *C. colensoi* show apiculi formed by a [stated by her as a mucilaginous] perispore. In some cases the perispore layer is uniform as Le Gal states, but we disagree with her, since we have observed that in other cases the perispore layer thickens clearly at the poles forming apiculi (one at each end) which seem to be formed by wall material and not gel.

Specimens examined. COLOMBIA: Trail between Hacienda Cincinnati and Jamonical, 100-1250m, 12 Aug 1935, *G. W. Martin 3312* (NY). ECUADOR. Sur la terre [probably on buried wood or wood fragments], Cratère de Pululahua, Lagerheim, Equador, Feb 1892 (holotype of *Discina pululahuana*) (FH-Pat). GUADELOUPE: Sur loutes sartes de branches mortes, Bois de la Riviére Saint-Louis, Guadeloupe, Fèvrier 1901, Duss 249, [Lectotype of *Discina epixyla*] (FH-Pat); Camp Jacob, sur bois pourri jeune coffee arabica, Fèv 1902, *527* [paratype of *Discina epixyla*] (FH-Pat) [as *Peziza* peut-être *Discina epixyla*]; Haut Matouba, Victor Hughes Trail, 700-1071m, on twigs and fallen branches, 9 Jan 1974, *D. H. Pfister, S. Carpenter, M. Sherwood 1161* (FH); Grand Matouba, Victor Hughes Trail, 700m, on twigs, 8 Jan 1974, *D. H. Pfister, S. Carpenter, M. Sherwood 1107* (FH); Saint Claude, Camp Jacob, 500-550m, on twigs and larger pieces of wood, 7 Jan 1974, *D. H. Pfister, S. Carpenter, M. Sherwood 1033* (FH); Montagne de St. Louis, 1902, *P. Duss* (NY). JAMAICA. Chester Vale, 3000-4000ft, 21-24 Dec 1908, *W. A. Murrill & Edna L. Murrill 349* (NY); Chestervale, 3000ft, 7 Feb 1903,

L. M. Underwood 1160 (NY); Morce's Gap, 5000ft, 29-30 Dec 1908, 2 Jan 1909, *W. A. & Edna L. Murrill 669* (NY), infertile but with asci; Rose Hill, 3500ft, on dead wood, 20 Oct-24 Nov 1902, *F. S. Earle 51* (NY); On wood, along trail between Woodcutter's Gap and ruins of Major Wallin's House, vicinity of Newcastle, Portland, Parish, 9.I.1971, *R.P. Korf et al.* (CUP-MJ-139); On twigs, along Lady's Mile Trail to just south of Woodcutter's Gap, vicinity of Newcastle, border of St. Andrew and Portland Parishes, 9.I.1971, *R.P. Korf et al.* (CUP-MJ-146, CUP-MJ-176); along Ulster Road Trail, Newcastle, St. Andrew Parish, 9.I.1971, *R.P.Korf et al.* (CUP-MJ-197); On wood, *Cecropia peltata* and other substrates, Chesterville Youth Development Camp, above Newcastle, St. Andrew Parish, 8.I.1971, *R.P.Korf et al.* (CUP-MJ-1, OSC 30140); On wood, near Dick's Pond, west of Hardwar Gap, near Holywell Recreation Area, St. Andrew Parish, elev. 2800-3000', 11.I.1971, *R.P.Korf et al.* (CUP-MJ-326); On twigs, Cinchona Botanical Gardens, St. Andrew Parish, elev. 4750', 8.I.1971, *R.P.Korf et al.* (CUP-MJ-53); On twigs, Cinchona Botanical Gardens, St. Andrew Parish, elev. 4750', 8.I.1971, *R.P.Korf et al. (CUP-MJ-47).* PANAMA. CHIRIQUI: Llanos del Volcan, 1100-1200m, in forest, 13 Jul 1935, *G. W. Martin 2782* (FH). PUERTO RICO: Cordillera Central, Toro Negro, Mun. de Juan Diaz, Long. 66°32'8" Lat. 18°9'10", on big log, 24 Jun 1996, *S. A. Cantrell 3381* (FH). VENEZUELA. On the ground, unlocalized, year 1855, Leg. *A. Fendler 282*, Venezuela (holotype of *Peziza venezuelae*) (K); Venezuela, *Fendler 282*, (isotype of *Peziza venezuelae*) Curtis Herbarium (FH); *Fendler* [probably an isotype of *Peziza venezuelae,* but with no number,], in an immature specimen with asci but no ascospores (Sprague Herbarium-FH), ; *Fendler* (NY) [as *Peziza venezuelae, Cookeina colensoi*], [probably an isotype of *Peziza venezuelae,* but with no number,], Ellis (NY); AMAZONAS: Sobre ramita caida, 25 Oct 1997, *T. Iturriaga 6065* (FH); ARAGUA: Maracay, Camino de Interpretación de la Naturaleza 'Andy Fields', Parque Nacional Henry Pittier, Estación Biológica Rancho Grande, sobre corteza de madera, 24 Nov 1994, *T. Iturriaga, L. Bracamonte, L. Ryvarden, O. Holmquist 2257* (VEN); Maracay, Camino de Interpretación de la Naturaleza 'Andy Fields', Estación Biológica Rancho Grande, Parque Nacional Henry Pittier. DISTRITO FEDERAL: On unidentified mossy log, trail from Quebrada Mariperez, through Vivero El Cuno and El Papelon to ca. 1 km. below Hotel Humboldt, El Avila, Parq. Nac. El Avila, Dto. Fed., *K.P. Dumont (VE-6194), R.F. Cain & G.J. Samuels,* 27.VII.1972 (NY); On unidentified wood, along trail 1-2 km above las [Los] Venados, El Avila, Parq. Nac. El Avila, Dto. Fed., *K.P. Dumont (VE-5828), R.F. Cain, G.J. Samuels & B. Manara,* 24.VII.1972 (NY); On unidentified wood, vicinity refugio "No te Apures", south facing slope of La Silla, Parq. Nac. El Avila, Edo. Miranda [Dto. Fed.], *K.P. Dumont (VE-3810), G.J. Samuels & B. Manara,* 30.VI.1972 (NY); On unidentified wood, between refugio "No te Apures" and Quebrada Los Palos Grandes, south facing slope of La Silla, Parq. Nac. El Avila, Edo. Miranda [Dto. Fed.], *K.P. Dumont (VE-3743), G.J. Samuels & B. Manara,* 30.VI.1972 (NY). MIRANDA: Baruta, Sartenejas, sobre corteza rama caida, Oct 1997, *T. Iturriaga 6066* (immature), *6034* (FH); Baruta, Sartenejas, sobre corteza rama caida, Oct 1997, O. del Guidice *6033* (FH).

Misapplied Names, Synonyms, and Doubful or Excluded Species

GENERAL NOTE: There are many *Trichoscypha* species that are not accounted for in this synonymy list. Most are combined in the genus *Trichoscyphella*, a genus of the *Hyaloscyphaceae*.

abnormis – *Pilocratera abnormis* Peck, N. Y. St. Educ. Dept. Bull 495: 37. 1911.
This is on *Betula* in New York and is an inoperculate discomycete.

afzelii – *Peziza afzelii* Fr. = *Cookeina speciosa*

aluticolor – *Peziza aluticolor* Berk. = *Cookiena colensoi*

amoena – *Peziza amoena* Lév. = *Cookeina speciosa*

antillarum – *Peziza venezuelae* var. *antillarum* Pat. in Duss, Énum. Champ. Guadeloupe, p. 64. 1903. [sur le sol dans une cafèyere FH) !
This is *Phillipsia domingensis* (Berk.) Berk.

beccariana – *Peiza hindsii* var. *beccariana* Ces. = *Cookeina speciosa*

argentinensis – *Ciboria argentinensis* Speg. = *Cookeina colensoi*

calyciformis – *Trichoscypha calyciformis* (Willd.) Grélet, Rev. Mycol. (Paris) (NS) 16: 87. 1951.
This is an inoperculate discomycete.

calycina – *Trichoscypha calycina* (Schumach.) Vuill., Bull. Soc. Mycol. Fr. 1: 117. 1885.
This is an inoperculate discomycete.

celebica – *Pilocratera tricholoma* var. *celebica* Henn. = *Cookeina tricholoma*

ciborioides – *Geopyxis ciborioides* Starbäck = *Cookeina colensoi*

colensoi – *Cookeina colensoi* (Berk.) Seaver sensu Seaver = *Cookeina venezuelae*

crocina – *Peziza hindsii* var. *crocina* (Mont. & Fr.) Cesati, Atti Reale Accad. Sci. Fis. 8: 11. 1878 [1879].
This small species, originally described from France as *Peziza crocina* is mostly likely referable to a group of inoperculate discomycetes.

discifera – *Cookeina discifera* (Haszl.) Kuntze, Rev. gen. Pl. 849.1891 = *Craterium disciferum* Hazsl., Verh. K.K. zool.- Bot. Ges. Wien 37: 167. 1887) = *Trichoscypha discifera* (Hazsl.) Sacc., Syll. fung. 8:163. 1889 = *Pilocratera discifera* (Hazsl.) Sacc. & Traverso, Syll. fung. 20: 412. 1911.
This is a species of *Helvella* judging by the illustration and since the material is from Hungary, an unlikely location for a species of *Cookeina* to occur, it is excluded.

elata – *Geoyxis elata* Massee = *Cookeina speciosa*

engleriana – *Pilcratera engleriana* Henn. = *Cookeina speciosa*

epixyla – *Discina epixyla* Pat. = *Cookeina venezuelae*

fusca – *Cookeina sulcipes* var. *fusca* Alas. = *Cookeina speciosa*

fusispora – *Sarcoscypha fusispora* Sawada, Special Publication, College of Agriculture, National Taiwan University 11: 49. 1959.
Published without a Latin description or diagnosis this is a nomen nudum that refers to *Cookeina insititia*.

globosa – *Cookeina globosa* Douanla-Meli = *Cookeina speciosa*
This taxon was described and illustrated with a fringe of marginal hairs as in *C. speciosa* but as having globose to subglobose ascospores. Our attempt to obtain the specimen has been unsuccessful. Judging by the illustrations and descriptions it seems clear that this species is based on immature specimens of *C. speciosa*. The spores are small 12-15 x

10-12 µm and thin-walled. Since asci mature simultaneously it is often possible, with a single collection as is the case here, to misjudge maturation. Without the specimen our recourse has been to treat this as a synonym of *C. speciosa*.

hindsii – *Peziza hindsii* Berk. = *Cookeina speciosa*

hystrix – *Peziza hystrix* Berk. = *Cookeina tricholoma*

insititia – *Peziza insititia* ≡ *Cookeina insititia*

javanica – *Peziza javanica* Nees ex Lév. = *Cookeina speciosa*

magnispora – *Trichoscypha magnispora* Lloyd = *Cookeina insititia*

maxima – *Pilocratera maxima* P. Syd. = *Cookeina speciosa*

minor – *Peziza tricholoma* var. *minor* Mont. = *Cookeina tricholoma*

medusina – *Peziza medusina* Speg. = *Cookeina tricholoma*

moelleriana – *Geopyxis moelleriana* Henn. = *Cookeina colensoi*

mundkurii – *Cookeina mundkurii* S. C. Kaushal, J. Indian Bot. Soc. 65: 405. 1986.

Specimens of this species have not been available to us for study. Based on the description it is likely that this represents a collection of *C. indica*. It agrees with that species in lacking obvious hairs, in the long ellipsoidal ascospores with longitudinal striations that do not anastomose. The name *C. indica* (Pfister & Kaushal 1984) has priority and *C. mundkurii* is considered a synonym.

notarisiana – *Peziza notarisiana* Bagnis, Atti Reale Accad. Lincei 8: 15. 1876– 1877. *Trichoscypha notarisiana* (Bagnis) Sacc., Syll. fung. 8: 162. 1889. ≡ *Cookeina notarisiana* (Bagnis) Kuntze, Revis. gen. pl. 849. 1891. ≡ *Pilocratera notarisiana* (Bagnis) Sacc. & Traverso, Syll. fung. 20: 413. 1910.

This is an inoperculate discomycete.

novoguianensis – *Pilocratera novo-guianensis* Ramsb. = *Cookeina speciosa*

pululahuana – *Discina pululahuana* Pat. = *Cookeina venezuelae*

sessilis – *Ciboria sessilis* Starbäck = *Cookeina colensoi*

sphaeroidospora – *Boedijnopeziza sphaeroidospora* Y. Otani = *Cookeina insititia*

striatospora – *Geopyxis striatospora* Maubl. & Roger

This is a nomen nudum; the description refers to *Cookeina speciosa*.

striispora – *Peziza striispora* Ellis & Everh. = *Cookeina tricholoma*

subfloccosa – *Plectania subfloccosa* Hazsl. Magyar. Discomyc., tab. 5 fig. 29 ≡ *Pilocratera subfloccosa* (Hazsl.) Sacc. & Traverso, Syll. fung. 20: 413. 1911.

sulcipes – *Peziza sulcipes* Berk. = *Cookeina speciosa*

sumatrana – *Cookeina sumatrana* Boedijn = *Cookeina speciosa*

tetraspora – *Cookeina tetraspora* Seaver, Mycologia 17: 45. 1925 ≡ *Phillipsia tetraspora* (Seaver) Le Gal, Prodr. Flore Mycol. Madagascar, 262. 1953. ≡ *Sarcoscypha tetraspora* (Seaver) Denison, Rev. Biol. Trop. 11: 107. 1963. ≡ *Nanoscypha tetraspora* (Seaver) Denison, Mycologia 64:619. 1972.

This species is the type species of *Nanoscypha* Denison (1972).

tricholoma – *Peziza tricholoma* Mont. ≡ *Cookeina tricholoma*

viridirubescens – *Trichoscypha viridirubescens* (Bagnis) Sacc., Syll. fung. 8: 162. 1889. ≡ *Peziza viridirubescens* Bagnis, Atti Reale Accad. Lincei 8: 15. 1876-1877. ≡ *Cookeina viridirubescens* (Bagnis) Kuntze, Revis. gen. pl. 2: 849. 1891. ≡ *Pilocratera viridirubescens* (Bagnis) Sacc. & Traverso, Syll. fung. 20: 413. 1911.

This is an inoperculate discomycete.

Acknowledgments

This work was supported by NSF grants DEB-9521944 and DEB-0315940 to Donald Pfister and by a grant from the David Rockefeller Center for Latin American Studies of Harvard University which supported Teresa Iturriaga during an extended study leave at Harvard. We wish to thank Richard N. Weinstein, for work done on the project during a post-doctoral fellowship, and Karen Hansen, with whom we were able to discuss various aspects of the project. Richard Korf and Amy Rossman reviewed a draft and Jack D. Rogers and Sharon Cantrell served as formal reviewers. Shaun Pennycook provided us with valuable nomenclatural and technical advice. We thank Jens Petersen, Thomas Læssøe, and Roy Halling for photographs. We owe a debt to the curators of the following herbaria who allowed access to specimens: B, BPI, CUP, K, NY, PC, OSC, PDD, S, USB, VEN. The authors acknowledge the inspiration of Richard P. Korf, their professor at Cornell, to whom they dedicate this paper.

Literature cited

Alexopoulos CJ, Butler EE. 1949. Conidia-like structures in *Plectania coccinea*. Mycologia 41: 180-182.

Alasoadudra SO. 1972. Studies in the higher fungi of Nigeria. IV. Some operculate discomycetes. Nova Hedwigia 23: 767-780.

Arpin N. 1969. Les caroténoïdes d'Discomycètes: Essai chimiotaxinomique. Bull. Mens. Soc. Linn. Lyon, Suppl. 38: 1-169

Bentham G, Hooker JD. 1862. Genera plantarum ad exemplaria imprimis in herbariis kewensibus servata definita. Vol. 1(1). A. Black. London. Pp 1-434.

Berkeley MJ. 1852. Enumeration of some fungi from St. Domingo. Ann. Mag. Nat. Hist. series II. 9: 192-203.

Berkeley MJ, Broome CE. 1875. Enumeration of the fungi of Ceylon. J. Linn. Soc. 14: 29-140.

Berthet P. 1964. Essai Biotaxinomique sur les Discomycètes. Joanny Lorge. Lyon.

Bi Z-s, Zheng G-y, Li T-h. 1993. The Macrofungus Flora of China's Guangdong Province 734 p. Hong Kong, Chinese University Press.

Boedijn KB. 1929. Beitrag zur Kenntnis der Pilzflora von Sumatra. Recueil. Trav. Bot. Néerl. 26: 396-439.

Boedijn KB. 1933. The genera *Phillipsia* and *Cookeina* in Netherlands India. Bull. Jard. Bot. Buitenzorg. 13: 57-76

Boedijn KB. 1951. Some mycological notes. Sydowia 5: 211-229.

Boudier JLE. 1885. Nouvelle classification naturelle des discomycètes charnus connus généralement sous le nom de pezizes. Bull Soc Mycol France 1: 91-120.

Cabello MN. 1988. Estudio sistematico del suborden *Sarcoscyphineae* (*Pezizales*, Ascomycotina) empleando tecnicas numericas. Bol. Soc. Argent. Bot. 25: 395-413.

Calonge FD. 1986. Ilustraciones de hongos y liquenes de la expedicion botanica a Nueva Granada, depositadas en le real Jardin Botanico de Madrid. Caldasia 15: 47-51.

Chacón, S. 1988. Conocimiento etnoecologico de los hongos en Plan de Palmar, Municipio de Papantla, Veracruz, Mexico. Mic. Neotrop. Aplic. 1: 45-54.

Chacón, S, Medel R. 1990. Ascomycetes little known in Mexico V. Description of some *Pezizales*. Revista Mex. Micol. 6: 199-206.

Cooke MC. 1874. Carpology of *Peziza*. Grevillea 3: 30-31, pl. 27-30.

Cooke MC. 1875. Carpology of *Peziza*. Grevillea 3:186, pl. 43-44.

Cooke MC. 1879. Mycographia, seu Icones fungorum. I. Discomycetes. Part I. Williams & Norgate, London.

Cooke MC. 1892. Handbook of Australian Fungi. William & Norgate. London. 456 pp.

Denison WC. 1963. A preliminary study of the operculate cup-fungi of Costa Rica. Rev. Biol. Trop. 11: 99-129.

Denison WC. 1967. Central American *Pezizales*. II. The genus *Cookeina*. Mycologia 59: 306-317.

Denison WC. 1972. Central American *Pezizales*. IV. The genera *Sarcoscypha*, *Pithya*, and *Nanoscypha*. Mycologia 64: 609-623.

Dennis RWG. 1954. Operculate Discomycetes from Trinidad and Jamaica. Kew Bull. 9: 417-421.

Dennis RWG. 1970. Fungus flora of Venezuela and adjacent countries. Kew Bull. Additional Ser. 3. 531 pp.

Dennis RWG. 1994. Plumier's Discomycetes. Mycotaxon 51: 237-239.

Dijk H van, Onguene NA, Kuyper TW. 2003. Knowledge and utilization of edible mushrooms by local populations of the rain forest of south Cameroon. Ambio 32: 19-23.

Douanla-Meli, C. Langer E. 2005. Notes on discomycetes (*Helotiales, Pezizales)*: New species and new records from Cameroon. Mycotaxon 92: 223-237.

Durrieu G, He Q, Chaumeton J-P, Chauveau C. 1997. *Cookeina insititia*, a new Discomycetes from China. Acta Bot. Yunnanica. 19: 128-120.

Duss A. 1903. Énumération méthodique des champignons recueillis a la Guadeloupe et a la Martinique. Fungi by N. T. Patouillard. Lons-le-Saunier

Eckblad F-E. 1968. The genera of operculate discomycetes. A re-evaluation of their taxonomy, phylogeny and nomenclature. Nytt Mag. Bot. 15: 1-191.

Ferdinandsen C, Winge Ø. 1910. Fungi from prof. Warmings expedition to Venezuela and the West-Indies. Dansk Tidsskr. 30: 208-222.

Fries EM. 1822. Systema Mycologicum sistens fungorum ordines, genera et species huc usque cognitas. 2 part 1. Griefswald.

Fries EM. 1860. Reliquiae Afzelianae, sistentes icons fungorum quos in Guinea collegit et in aere incises excudi curavit Adamus Afzelius. Upsaliae. Edquist & Soc.

Gamundí IJ. 1957. El genero *Cookeina* en la República Argentina. Bol. Soc. Argent. Bot. 6: 212-222.

Gamundí IJ. 1959. Addenda a las especies Argeninas de *Cookeina* Kuntze. Bol. Soc. Argent. Bot. 7: 201-204.

Gamundí IJ. 1971 Algunos discomycetes de Chile. Bol. Soc. Argent. Bot. 13: 260-289.

Gamundí IJ. 1983. *Pezizales* de America Tropical. Pp. 151-171 in Anais [Congresso Nacional de Botânica] 34 congresso, v.1.

Hanlin RT. 1993. *Cookeina sulcipes* - an addendum. Mycotaxon. 46: 403-405.

Hanlin RT, Chien C-Y, Tortolero O. 1991. Icones Ascomycetum Venezuelae: *Cookeina sulcipes*. Trans. Mycol. Soc. R. O. C. 6: 45-53

Harrington FA. 1990. *Sarcoscypha* in North America (*Pezizales, Sarcoscyphaceae*). Mycotaxon. 38: 417-458.

Harrington FA, Pfister DH, Potter D, Donoghue MJ. 1999. Phylogenetic studies within the Pezizales. I. 18S rDNA sequence data and classification. Mycologia 91: 41-50.

Hennings P. 1892 [1891]. Fungi africani. Bot. Jaarb. Syst. 14: 337-373.

Hood IA. 1992. An Illustrated Guide to Fungi on Wood in New Zealand. Auckland University Press. Aukland.

Hooker JD 1855. The botany of the Antarctic voyage...II. Flora novae-zelandiae. London. Authoriy of the Lord Commissioners of the Admiralty.

Ito S, Imai S. 1937. Fungi of the Bonin Islands II. Trans. Sapporo Nat. Hist. Soc. 15: 52-59.

Kaushal SC. 1986. A new species of *Cookeina* (*Pezizales*) from India. J. Indian Bot. Soc. 65: 404-407.

Korf RP. 1951. A monograph of the *Arachnopezizeae*. Lloydia 14: 129-180.

Korf RP. 1970. Nomenclatural notes. VII. Family and tribe names in the *Sarcoscyphineae* (Discomycetes) and a new taxonomic disposition of the genera. Taxon 19: 782 - 786.

Korf RP. 1971. Some new Discomycete names. Phytologia 21: 201-207.

Korf RP. 1972. A synoptic key to the genera of the *Pezizales*. Mycologia 64: 937-994.

Korf RP. 1973. Discomycetes and *Tuberales*. In: Ainsworth GC, Sparrow FK, Sussman AS, eds. The fungi: an advanced treatise. Vol 4A. New York: Academic Press. p 249 - 319.

Kuntze O. 1891. Revisio Generum Plantarum 2: 375-1011.

Le Gal M. 1953. Le Discomycètes de Madagascar. Prodr Flore Mycol Madagascar 4: 1-465.

Le Gal M. 1960. Flore iconographique des champignons du Congo dédiée a sa majesté Lépold III. Illustrée en couleurs par Mme. M. Goossens-Fontana. 9: 167-183.

Le Gal M. 1969. Position taxinomique du genre *Phaedropezia* Le Gal et révision de la famille des *Humariaceae*. Bull. Soc. Mycol. France. 85: 5-19.

Lloyd CG. 1921. *Trichoscypha magnispora* from Otto A. Reinking, Philippines.Mycological Writings 6: 1050.

Maldonado González S. 2000. El género *Cookeina* Kuntze (Ascomycota) en Cuba. Revista, Jard. Bot. Nac. Univ Habana. 21: 305-307.

Massee G. 1896. Redescription of Berkeley's types of fungi. J. Linn. Soc. Bot. 31: 462-525.

Massee G. 1898. Fungi exotici, I. Kew Bull. 1898: 113-136.

Melendez-Howell LM. 1986. Les champignons dans la degradation de la forêt primaire de l'Arataye. Mem. Mus. Nat. Hist. Nat. (Paris), A 132: 257-261.

Melendez-Howell LM, Mascarell G, Bellemere A. 2003. Etudes ultrastructurales dans le genre *Cookeina* (Ascomycetes, *Peizales, Sarcoscyphaceae*). Mycotaxon 87: 53-80.

Montagne C. 1834. Nouvelles espèces de cryptogames. Ann. Sci. Nat. Bot. ser. 2 2:77.

Moravec, J. 1997. Discomycetes of Madagascar – I. *Phillipsia ranomafanensis* sp. nov. and ascospore sculpture of *Cookeina colensoi* proved by SEM (Discomycetes, *Pezizales, Sarcoscyphaceae*). Czech Mycol. 50: 21 – 33.

Nagao H. 1997. Materials for the fungus flora of Japan (51). Mycoscience 38: 351-353.

Otani Y. 1971. Mycological reports from New Guinea and the Solomon Islands. 3. Enumeration of the *Sarcoscyphaceae* and *Scutellinia* (*Humariaceae*). Bull. Nat. Sci. Mus., Tokyo 14: 401-422.

Otani Y. 1975. Discomycetes collected in Papua New Guinea pp. 5-41 in Reports on the cryptogams in Papua New Guinea, The party 1973-'74, of The botanical expedition to Papua New Guinea. The National Science Museum, Tokyo.

Paden JW. 1975. Ascospore germination, growth in culture, and imperfect spore formation in *Cookeina sulcipes* and *Phillipsia crispata*. Canad. J. Bot. 53: 56-61.

Paden JW. 1984. A new genus of Hyphomycetes with teleomorphs in the *Sarcoscyphaceae* (*Pezizales, Sarcoscyphineae*). Canad. J. Bot. 62: 211-218.

Pfister DH. 1973. Notes on Caribbean Discomycetes. III. Ascospore germination and growth in culture of *Nanoscypha tetraspora* (*Pezizales, Sarcoscyphineae*). Mycologia 65: 952-956.

Pfister DH. 1974. Notes on Caribbean Discomycetes. IV. *Cookeina venezuelae, C. colensoi* and the genus *Boedijnopeziza*. Phytologia 27: 55-62.

Pfister DH. 1978a. Apothecial development in *Cookeina tricholoma* with comments on some related species. Mycologia 70: 1253-1257.

Pfister DH. 1978b. Cryptogams of the United States North Pacific Exploring Expedition, 1853-1856. Farlow Reference Library and Herbarium. Cambridge, Ma

Pfister DH, Kaushal R. 1984. *Cookeina indica*, a new species from India with a key to the species of *Cookeina*. Mycotaxon 20: 117-121.

Pfister DH, Kimbrough JW. 2001. Discomycetes pp. 257-281 in The Mycota, eds. McLaughlin, McLaughlin & Lemke. Springer-Verlag, Berlin, Heidelberg.

Pfister DH, Kurogi S. 2004. A note on some morphological features of *Chorioactis geaster* (*Pezizales*, Ascomycota). Mycotaxon 89: 277-281.

Plumier C. 1705. Traité des fougères de l'Amerique. Paris. 146 pp, 170 pl.

Rick J. 1931. Monographia Pezizinearum Riograndensium. Broteria Ser. Bot. 25: 77 - 98. 1931.

Rifai MA. 1968. The Australasian *Pezizales* in the herbarium of the Royal Botanic Gardens Kew. Verh. Kon. Ned. Akad. Wetensch., Afd. Naturk. Tweede Sect. 57: 1-295.

Romero AI, Gamundí IJ. 1986. Algunos Discomycetes xilofilos del area subtropical de la Argentina. Darwiniana 27: 43-63

Rosinski MA. 1953. Two types of spore germination in *Sarcoscypha coccinea* (Scop. ex Fr.) Lambotte. Mycologia 45: 302-306.

Saccardo PA. 1889. Sylloge fungorum. Discomycetum et Phymatosphaeriacearum. Vol. 8. 1143 p.

Samuelson DA 1975. The apical apparatus of the suboperculate ascus. Canadian Journal of Botany 53: 2660-2679.

Sánchez AD, Chacón S, Sánchez JE. 1993. Producción natural de *Cookeina sulcipes* (Ascomycotina, *Pezizales*) en la región de Tapachula, Chiapas (México). Rev. Mex. Mic. 9: 47-56.

Sánchez Vázquez JE, Huerta Palacios G, Calvo Bado LA. 1995. Progress in the cultivation of the edible mushroom *Cookeina sulcipes*. Pp. 857 – 862 in Science and Cultivation of Edible Fungi, vol. 2, T. J. Elliott ed. Balkema, Rotterdam.

Spegazzini C. 1902. Mycetes Argentinensis. Anal. Mus. Nac. Buenos Aires, ser. 3 1902: 49 – 89.

Seaver FJ. 1913. Some tropical cup-fungi. Mycologia 5: 185-193.

Seaver FJ. 1925. Studies in Tropical Ascomycetes – III. Porto Rican cup-fungi. Mycologia 17: 45-50.

Seaver FJ. 1927. A tentative scheme for the treatment of the genera of *Pezizaceae*. Mycologia 19: 86-89.

Seaver FJ. 1928. The North American cup-fungi (Operculates). Published by the author. New York

Seaver FJ. 1936. The genera *Phillipsia* and *Cookeina*. Mycologia 28: 90-92.

Seaver FJ. 1942. The North American cup-fungi (Operculates). Supplemented. Published by the author. New York.

Starbäck K. 1904. Ascomyceten der ersten Regnellschen Expedition, III. Ark. Bot. 2: 1-22.

Teng SC. 1963. Fungi of China. Beijing pp. 277-279.

Tobon LE. 1991. Ascomicetos de Colombia: Discomicetos del departamento de Antioquia. Caldasia 16: 327-336.

Villarreal L, Perez-Moreno J. 1989. Los hongos comestibles silvestres de Mexico, un enfoque integral. Micol. Neotrop. Apl. 2: 77-114.

Vooren N van. 2003. Deux discomycètes intéressants récoltés à La Martinique, note complémentaire. Bull. Mens. Soc. Linn. Lyon 72: 156-157.

Vooren N van, Lopez F. 2002. Deux discomycètes intéressants récoltés à La Martinique. Bull. Mens. Soc. Linn. Lyon 71: 152-156.

Wang Z. 1997. Taxonomy of *Cookeina* in China. Mycotaxon 62: 289-298.

Wang YZ. 2001. Discomycetes of the *Sarcoscyphaceae* in Taiwan. Mycotaxon 79: 329-336.

Weinstein RN, Pfister DH, Iturriaga T. 2002. A phylogenetic study of the genus *Cookeina*. Mycologia 94: 673-682.

Yang Z-L. 1990. Several noteworthy higher fungi from southern Yunnan, China. Mycotaxon 38: 407-416.

Zoberi MH. 1973. Influence of water on spore release in *Cookeina sulcipes*. Mycologia 65: 155-160.

MYCOTAXON

Volume 95, pp. 181–184 *January–March 2006*

A new nematode-trapping hyphomycete of *Arthrobotrys*

WEIFENG HU, YAN LI, MINGHE MO & KEQIN ZHANG*

**kqzhang111@yahoo.com.cn*
Laboratory for Conservation and Utilization of Bioresources
Yunnan University, Kunming 650091, P.R. China

Abstract—*Arthrobotrys multisecundaria*, isolated from Yunnan, China, was illustrated and described as a new nematode-trapping fungus, which captures nematodes by means of adhesive three-dimensional networks. It is characterized mostly by one-septate primary, elliptical conidia, which produce unicellular secondary conidia from both distal and basal ends. The new species differs obviously from other related species by producing up to four secondary catenulate conidia.

Keywords—*Dactylella, Monacrosporium,* predacious fungi, taxonomy

Introduction

Nematophagous fungi have been the subject of research for several decades in the fundamental studies of microbiological ecology, distribution and systematics, and potential biological control agents of nematode pests of plants and animals (Liu & Zhang 2003). These fungi usually can be categorized into four types: endoparasitic, nematode-trapping, egg- and female-parasitizing, and toxin-producing fungi (Barron & Thorn 1987). Among the four types, nematode-trapping fungi (NTF) can produce various trapping-devices to capture nematodes and other small animals (Duddington 1951, Scholler et al. 1999, Ahrén et al. 2004). Traditionally, these predacious hyphomycetes were assigned to three genera (*Arthrobotrys, Dactylella, Monacrosporium*) according to the morphology of conidia (Cooke & Dickinson 1965). Trapping structures were used to rationalize the classification of the nematode-trapping fungi with the molecular data (Liou & Tzean 1997, Pfister 1997, Ahrén et al. 1998). Based on the analyses of partial 18S rDNA, ITS and 5.8S rDNA, Scholler et al. (1999) classified NTF into four genera: *Arthrobotrys, Dactylellina, Drechslerella* and *Gamsylella*. Li et al. (2005) redefined the systematic classification of nematode-trapping fungi based on phylogenies inferred from molecular analyses of 28S rDNA, 5.8S rDNA and β-tubulin genes, which indicated NTF should be divided into three genera: *Arthrobotrys, Dactylellina* and *Drechslerella*.

Materials and methods

Soil samples from Tengchong, Yunnan Province were sprinkled on corn meal agar (CMA) plates inoculated with free-living nematodes, *Panagrellus redivivus*. After approximately one month, a fungus forming adhesive three-dimensional networks was isolated, and identified as a new taxon after a detailed morphological study.

Based on the classification of NTF by Li et al. (2005), we assigned this new taxon to *Arthrobotrys* and here propose the name *Arthrobotrys multisecundaria*. Morphological distinctions between the new species and similar species are discussed.

Taxonomic Description

Arthrobotrys multisecundaria W.F. Hu & K.Q. Zhang **sp. nov.** (Figs. 1-14)

Coloniae in agaro CMA albidae, post 5 dies 25°C 2.5 cm diam. Mycelium sparsum, hyphis septatis, ramosis, 4–7.5 µm latae. Conidiophora erecta, hyalina, simplicia, 200–365 µm longa, 2.5 µm lata ad apicem. Conidia hyalina, ellipsoideas, 32.5-55×15-22.5µm, 1 septata vel non-septata. Conidia secundaria non-septata. Reticula tenacia quae vermiculos nematodeos capiunt evolventibus.

Etymology: The species name refers to the formation of conidia in a catenulate array.

Holotype: YMF1.01821A, Tengchong, Yunnan Province, China, 2005, Weifeng Hu. The holotype and its culture (YMF1.01821) are deposited in the Laboratory for Conservation and Utilization of Bioresources, Yunnan University.

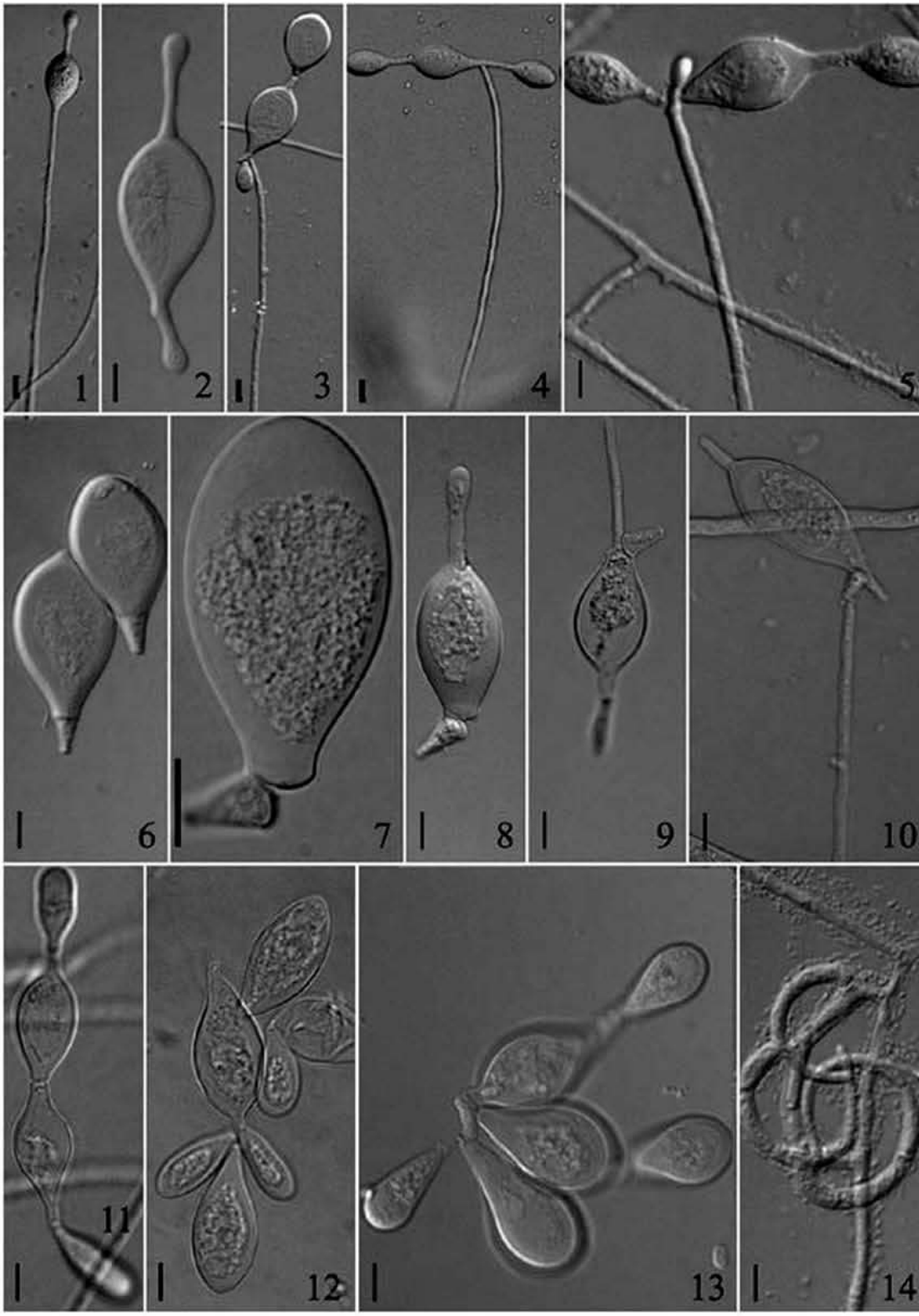
Colonies on CMA whitish, slowly-growing and extending a diameter of 2.5 cm at 25° within 5 days. Mycelium hyaline, scanty, vegetative hyphae, septate, branched, 4-7.5 µm wide. Conidiophores (Fig. 1, 3, 4-5) erect, hyaline, septate, unbranched, 200-365 µm long, 5 µm wide at the base, gradually tapering upward to a width of 2.5 µm at the apex, bearing one or two conidia. Conidia (Figs. 6-7) hyaline, ellipsoidal, 32.5-55 × 15-22.5 µm, 1-septate (75%) or non-septate (25%). Secondary conidia (Figs. 3-5, 11-13) can be produced from both distal and basal ends of primary conidia, non-septate, 32.5-55 × 15-22.5 µm. The predacious organ exhibits adhesive three-dimensional networks.

The single spore culture produced conidia after six days incubation on PDA at 25 °C. Each conidiophore produced one to two conidia (Figs. 4, 5, 9, 10, 13) that proliferated to form secondary conidia from both the distal and basal ends of primary conidia (Figs. 1, 2, 8).

This process sometimes was repeated two to three times so that three to four conidia could be produced on each conidiophore in catenulate arrangement (Fig. 3, 4, 11). Sometimes up to three conidia were produced from the distal end of a conidium (Fig. 12).

An interesting process was observed during our study: primary conidia were observed to dehisce at the septa to form germ tubes from the end of the distal cell (Figs. 7-8) while the basal cell remain attached to the distal cell (Fig. 10).

Comments-This species resembles *Monacrosporium indicum* (Chowdhry & Bahl) Xing Z. Liu & K.Q. Zhang (1994) and *M. janus* S.D. Li & Xing Z. Liu (Li et al. 2003) in conidial shape and number of septa but differs in conidial size and method of conidial germination. Additionally, in *M. indicum*, conidia are elliptic, obovoid or top-shaped, 22-30×14-20µm, and mostly 2-septate with distinct hila. In *M. janus*, conidia are broadly turbinate to napiform, 15-26 × 17.5-37.5 µm, 1-2-septate (mostly 1 septa). *A. multisecundaria* is distinguished by the catenulate conidial arrangement and germination that occurs from both basal and distal ends of conidia, characters that were not observed in *M. indicum*, *M. janus*, or other related nematode-trapping fungi.



Figs. 1-14. *Arthrobotrys multisecundaria.* Figs. 1, 3-5, 10. Conidia on conidiophores. Figs. 2, 6-9, 11-13. Primary conidia with secondary conidia. Fig. 14. Adhesive three-dimensional networks. Bars = 10 μm

Acknowledgments

We wish to thank Dr Xingzhong Liu and Dr Shidong Li for their suggested revisions of the manuscript. This work was supported by the project from the Department of Science and Technology of Yunnan Province, P. R. China (2005NG05).

Literature Cited

Ahrén D, Faedo M, Rajashekar B, Tunlid A. 2004. Low genetic diversity among isolates of the nematode-trapping fungus *Duddingtonia flagrans*: evidence for recent worldwide dispersion from a single common ancestor. Mycol. Res. 108: 1205-1214.

Ahrén D, Ursing BM, Tunlid A. 1998. Phylogeny of nematode trapping fungi based on 18r DNA sequences. FEMS Microbiology Letters 158: 179-184.

Barron GL, Thorn RG. 1987. Destruction of nematodes by species of *Pleurotus*. Can. J. Bot. 65: 774-778.

Cooke RC, Dickinson CH. 1965. Nematode-trapping species of *Dactylella* and *Monacrosporium*. Trans. Br. Mycol. Soc. 48: 621-629.

Duddington CL. 1951. The ecology of predacious fungi. I. Preliminary survey. Trans. Br. Mycol. Soc. 34: 322-331.

Li SD, Miao ZQ, Zhang YH, Liu XZ. 2003. *Monacrosporium janus* sp. nov. a new nematode-trapping hyphomycete parasitizing sclerotia and hyphae of *Sclerotinia sclerotiorum*. Mycol. Res. 107: 888-894.

Li Y, Hyde KD, Jeewon R, Cai L, Vijaykrishna D, Zhang KQ. 2005. Phylogenetics and evolution of nematode-trapping fungi estimated from nuclear & protein coding genes. Mycologia (in press)

Liou GY, Tzean SS. 1997. Phylogeny of the genus *Arthrobotrys* and allied nematode-trapping fungi based on rDNA sequences. Mycologia 89: 876-884.

Liu XF, Zhang KQ. 2003. *Dactylella shizishanna* sp. nov. from Shizi Mountain. China.Fungal Diversity 14: 103-107.

Liu XZ, Zhang KQ. 1994. Nematode-trapping species of *Monacrosporium* with special reference to two new species. Mycol. Res. 98: 862-868.

Pfister DH. 1997. Castor, Pollux and life histories of fungi. Mycologia 89: 1-23.

Scholler M, Hagedorn G, Rubner A. 1999. A reevaluation of predatory orbiliaceous fungi. II. A new generic concept. Sydowia 51: 89-113.

MYCOTAXON

Volume 95, pp. 185–188 *January–March 2006*

Hyphodontia tubuliformis, a new species from Taiwan

SHENG-HUA WU

shwu@mail.nmns.edu.tw
Department of Botany, National Museum of Natural Science
Taichung, Taiwan 40419, Republic of China

Abstract—*Hyphodontia tubuliformis*, collected from *Pinus* sp. in subtropical northern Taiwan, is described as new to science. This new species is characterized by having tubular cystidia and cylindrical basidiospores. A description and line drawing are provided for this new taxon.

Key words—*Aphyllophorales*, Basidiomycota, taxonomy, wood-decaying fungi

Introduction

The genus *Hyphodontia* J. Erikss. is a corticioid member of the Homobasidiomycetes, with about one hundred species (including *Alutaceodontia* Hjortstam & Ryvarden and *Kneiffiella* P. Karst.) known worldwide (Parmasto et al., 2004). *Hyphodontia* spp. are wood-decaying saprobes, causing a white rot in wood. Molecular evidence (Larsson et al., 2004; Binder et al., 2005) shows that *Hyphodontia* belongs to the hymenochaetoid clade of Homobasidiomycetes. Previous surveys of *Hyphodontia* spp. include those of Lin & Chen (1990), Wu (1990), Langer (1995), Wu (2000) and Wu (2001). This study adds a new species of *Hyphodontia* collected from subtropical northern Taiwan.

Materials and Methods

Free-hand thin sections of the basidiocarp were prepared for microscopic studies. For observations and measurements of microscopic characters, 5% KOH was used as a mounting medium to ensure rehydration. Melzer's reagent (IKI) was employed to detect amyloidity and dextrinoidity. Cotton blue (CB) was used as a mounting medium to determine cyanophily.

Taxonomy

Hyphodontia tubuliformis Sheng H. Wu, sp. nov. (Fig. 1)

Basidiocarpus effusus, submembranaceo-pelliculus, 80-200 µm crassus; superficies hymenialis grandinioideo-odontoidea. Systema hypharum monomiticum; hyphae fibulatae. Cystidia tubuliformia. Basidia suburniformia, 7-13 x 3.3-4 µm, 4 sterigmatibus. Basidiosporae cylindricae, laeves, tenuitunicatae, 4.7-5.5 x 1.8-2.2 µm, IKI-, CB-.

Etymology. From *tubuliformis* (= tubule-like), referring to the shape of cystidia in this species.

Basidiocarp resupinate, effuse, submembranaceous-pellicular, fairly soft, 70-200 μm thick in section (aculei excluded). Hymenial surface cream, grandinioid-odontioid, not cracking; margin thinning out, arachnoid, concolorous. Aculei separate or fused, > 10 per mm, conical or subulate, up to ca. 120 μm long and 60 μm wide.Hyphal system monomitic; hyphae nodose-septate. Subiculum with fairly loose texture; hyphae moderately ramified, colorless, ± vertically oriented, distinct and fairly straight, 2.5-4.5 μm diam., hyphal walls from slightly thickened to 1.2 μm thick. Hymenium somewhat thickening, with dense texture; hyphae colorless, much narrower than those of subiculum, thin-walled. Cystidia numerous, more concentrated in aculei, scattered elsewhere, usually projecting, arising from subiculum, tubular, sometimes slightly constricted near apices, colorless, 40-200 x 5-8 μm, thick-walled (0.5-2.5 μm thick) except for the thin-walled apex. Basidia suburniform, 7-13 x 3.3-4 μm, 4-sterigmate. Basidiospores cylindrical, adaxially slightly concave, smooth, thin-walled, 4.7-5.5 x 1.8-2.2 μm, IKI-, CB-.

Distribution: Taiwan.

Holotype. Taiwan. Taipei: Kunliao, alt. 100 m, on branch of *Pinus* sp., *leg. Y.F. Lin*, 25 Jul 1991, *Lin 591* (TNM F18973).

Remarks. This new species is similar to *Hyphodontia microspora* J. Erikss. & Hjortstam, but has longer basidiospores. The spore measurements for *H. microspora* were respectively given as 2.5-3.5 x 1.5-1.8 μm (Eriksson & Ryvarden 1976), 3.8-4.5 x 1.8-2.2 μm (Wu 1990), 3.7-4.3 x 1.8-2.1 μm (holotype, Wu 1990) and 2.5-4.5 x 1.5-2.5 μm (Langer 1994). The feature of tubular and thick-walled cystidia in *H. tubuliformis* corresponds with the concept of the *H. barba-jovis* group in *Hyphodontia* (Eriksson & Ryvarden 1976), also equivalent to the generic concept of *Kneiffiella* proposed by Hjortstam & Ryvarden (2002). The author accepts a broader view of the generic delimitation of *Hyphodontia*, treating the new taxon in this genus.

Acknowledgements

This study was supported by the National Science Council of ROC (No. NSC 94-2621-B-178-002). Mr. Y.F. Lin provided the specimen for this study. The author thanks Dr. Nils Hallenberg and Dr. Peter Roberts for reviewing this paper.

Literature Cited

Binder M, Hibbett DS, Larsson K-H, 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.

Eriksson J, Ryvarden L. 1976. The *Corticiaceae* of North Europe 4. *Hyphodermella-Mycoacia*. pp. 547-886. Fungiflora, Oslo.

Hjortstam K, Ryvarden L. 2002. Studies in tropical coticioid fungi (Basidiomycota, Aphyllophorales) *Alutaceodontia, Botryodontia, Hyphodontia* s.s. and *Kneiffiella*. Synop. Fung. 15: 7-17.

Langer E. 1994. Die Gattung *Hyphodontia* John Eriksson. Biblioth. Mycol. 154: 1-298.

Larsson K-H, Larsson E, and Kõljalg U. 2004. High phylogenetic diversity among corticioid homobasidiomycetes. Mycol. Res. 108: 983-1002.

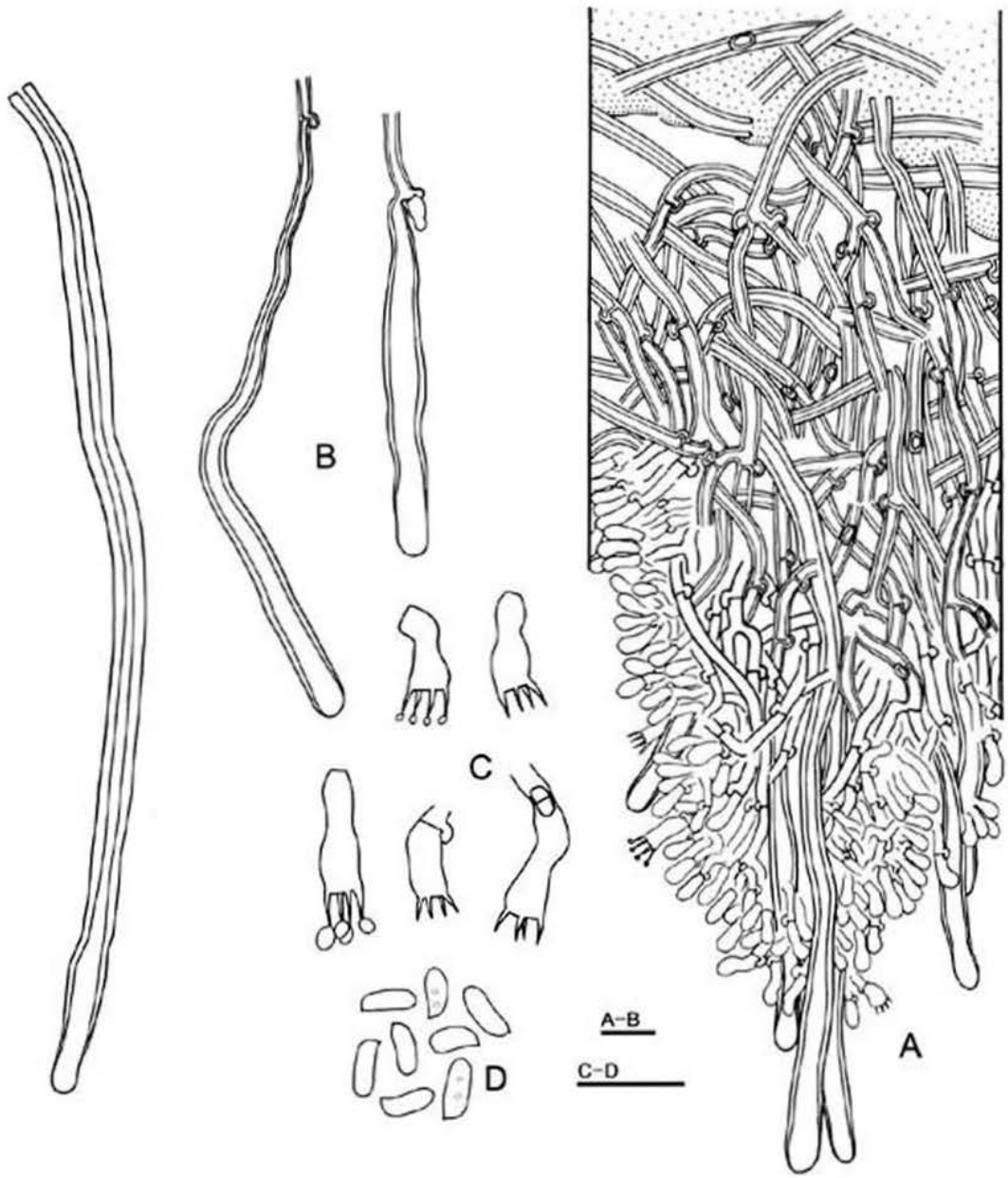


Fig. 1. *Hyphodontia tubuliformis* (holotype). A. Basidiocarp section. B. Cystidia. C. Basidia. D. Basidiospores. Scale bars = 10 µm.

Lin SH, Chen ZC. 1990. The *Corticiaceae* and the resupinate *Hydnaceae* of Taiwan. Taiwania 35: 69-111.

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

Wu SH. 1990. The *Corticiaceae* (Basidiomycetes) subfamilies *Phlebioideae*, *Phanerochaetoideae* and *Hyphodermoideae* in Taiwan. Acta Bot. Fennica 142: 1-123.

Wu SH. 2000. Studies on *Schizopora flavipora* s.l., with special emphasis on specimens from Taiwan. Mycotaxon 76: 51-66.

Wu SH. 2001. Three new species of *Hyphodontia* with poroid hymenial surface. Mycologia 93: 1019-1025.

MYCOTAXON

Volume 95, pp. 189–194 *January–March 2006*

Calculating minimum sample sizes for taxonomic measurements: examples using Gäumann's *Peronospora* spore data

ANDREW J. HAMILTON[1,2] & JAMES H. CUNNINGTON[1]

Andrew.Hamilton@deakin.edu.au *James.Cunnington@dpi.vic.gov.au*

[1]*Primary Industries Research Victoria—Knoxfield*
Private Bag 15, Ferntree Gully Delivery Centre, Victoria 3156, Australia.

[2]*School of Life & Environmental Science, Deakin University*
P.O. Box 423, Warrnambool, Victoria 3280, Australia.

Abstract—Methods are presented for calculating minimum sample sizes necessary to obtain precise estimates of fungal spore dimensions. Using previously published spore-length data sets for *Peronospora* species, we demonstrate that 41–71 spores need to be measured to estimate the mean length with a reasonable level of statistical precision and resolution. This is further progressed with examples for calculating the minimum number of spore lengths to measure when matching an undetermined specimen to a known species. Although applied only to spore-length data, all described methods can be applied to any morphometric data that satisfy certain statistical assumptions.

Key word—spore size, spore diameter

Introduction

The question of selecting appropriate sample sizes for taxonomic measurements in mycology is often discussed amongst individuals but rarely raised in the scientific literature. One exception to this has concerned how many spore lengths and widths to measure when undertaking taxonomic studies within the *Peronosporales*, and *Peronospora* in particular (Gustavvson 1959). This arises from Gäumann's (1923) monograph of the genus *Peronospora,* in which he measured approximately 500 spores from each species, believing that 500 measurements were required to produce sufficient data for differentiating similar species.

Using examples from Gäumann's *Peronospora* data, we present methods to address the following two questions:

1. What is the minimum number of spores that need to be measured to determine the mean spore length of a species?
2. What is the minimum number of spores that need to be measured to match an undetermined specimen with a described species?

Methods and Results

Three phylogenetically distinct groups of *Peronospora* species were chosen to infer results that could be applied to *Peronospora* species in general. Gäumann's (1923) data for the species groups on *Vicia* (p. 192), *Stellaria* (p. 48), and *Potentilla* (p. 292) were chosen based on a recent phylogenetic study (Voglmayr 2003) which revealed these to be quite unrelated groups of species. Gäumann used reference numbers to identify the species in his analyses, and the same numbers are used here. The species to which they refer to are: 1 through 4 on *Potentilla* are *P. potentillae anserinae* Gäum., *P. potentillae reptantis* Gäum., *P. potentillae sterilis* Gäum. and *P. potentillae* de Bary; 1 and 2 on *Stellaria* are *P. parva* Gäum. and *P. media* Gäum.; and 1 through 5 on *Vicia* are *P. viciae* (Berk.) Gäum., *P. sepium* Gäum., *P. mayorii* Gäum., *P. viciae sativae* (Thüm.) Syd., and *P. narbonensis* Gäum.. Gäumann's data were manually transcribed from his distribution graphs using a ruler. It is interesting to note that he measured in 1.6 μm units, which is presumably a function of the magnification and the resolution of the graticule he had available. The spore-length ranges (and standard deviations), in μm, were as follows: 8.0–22.4 (2.31), 11.2–25.6 (2.23), 16.0–28.8 (2.15) and 19.2–35.2 (2.50) for species 1 through 4 on *Potentilla*; 9.6–24.0 (2.51) and 19.2–35.2 (3.01) for species 1 and 2 on *Stellaria*; and 9.6–27.2 (2.74), 11.2–30.4 (2.57), 16.0–33.6 (2.51), 19.2–36.8 (2.50) and 22.4–41.6 (2.89) for species 1 through 5 on *Vicia*.

The methods and calculations below were applied to all species in these groups. The methods described here are sensitive to two key assumptions: (i) that the distribution of the measured variable can be closely approximated by the normal distribution, and (ii) that the estimate of the standard deviation, s, of that normal distribution is close to the true standard deviation, σ (Sokal & Rohlf 1969, Zar 1984). Nonetheless, Gäumann's data sets were normal, and morphometric data would generally be expected to be normally distributed.

1. Minimum sample size for estimating the mean spore lengths of *Peronospora* species

The minimum sample size, n, necessary to gain an estimate ($\bar{x}_L$) of the true mean spore-length (μ_L) can be calculated as follows (Harris et al. 1948):

$$n = \frac{s^2 t^2_{\alpha(2),(n-1)} F_{\beta(1),(n-1,\nu)}}{d^2} \qquad \text{equation 1.}$$

where s^2 is the sample variance (assumed to be a good estimate of the true population variance, σ^2), $t_{\alpha(2),(n-1)}$ is the two-tailed critical value for Student's t distribution (with $n-1$ degrees of freedom, df), $F_{\beta(1),(n-1,\nu)}$ is the one-tailed critical value for the F distribution (with $n-1$ and ν the numerator and denominator df respectively), and d is the half-width of the nominal confidence interval (CI) (i.e. ± distance from $\bar{x}_L$). The confidence level for the confidence interval equals $1-\alpha$ and the assurance that the confidence interval will be no larger than specified is $1-\beta$ ($1-\beta$ = statistical power). An existing data-set is needed to calculate s^2.

A problem arises when trying to solve equation 1, as to obtain $t_{\alpha(2),(n-1)}$ and $F_{\beta(1),(n-1,v)}$ we need to know n, which by definition is unknown. This paradox can be resolved by iteration: solving equation 1 for different values of n until the guess value approximates the value calculated from the equation. The method is perhaps more clearly appreciated in the example below.

Using measurements for Gäumann's 'species 1' on *Vicia* (n = 424), we calculated s^2 to be 7.513 (see any standard statistical text to calculate s^2). Suppose we want to be 90% certain that the 95% confidence interval (CI_{95}) is no wider than 1.6 μm (the resolution of Gäumann's measurements), then d = 0.8 μm, $1-\beta = 0.90$, $\beta = 0.10$, $1-\alpha = 0.95$, and $\alpha = 0.05$.

We now need to solve for the minimum sample size by iteration. We can start by guessing that n_{min} = 50 spores. Thus, $n-1$ = 49 and v = 423, which gives $t_{0.05(2),423} = 2.010$, and $F_{\beta(1),(n-1,v)} \approx 1.32$. Substituting into equation 1:

$$n = \frac{7.513 \times 2.010^2 \times 1.32}{0.8^2} = 62.58$$

Our guess was less than this estimate so we need to try a higher guess, say 61.

Thus, $n-1 = 60$ and $v = 423$, which give $t_{0.05(2),423} = 2.000$, and $F_{\beta(1),(n-1,v)} \approx 1.27$. Substituting into equation 1:

$$n = \frac{7.513 \times 2.000^2 \times 1.27}{0.8^2} = 59.65$$

Therefore, to obtain $\bar{x}_L$ with a 90% probability that the 95% confidence interval will be no wider than 1.6 μm (i.e. $\pm$ 0.8 μm), we need to measure more than 59 spores (i.e. 60). Note that there is no point continuing the iteration procedure until the guess and estimate are exactly equal, since fractions of spores will not be counted. Iteration should stop once the smallest integer that is greater than the estimate is reached, keeping in mind that the relationship between the guess and the estimate is dynamic.

We used this procedure to determine the minimum sample size needed to estimate mean spore-length for all the *Peronospora* species considered here. A 1.6 μm CI_{95} was used for all species. The selection of the size of the desired CI_{95} is somewhat subjective. When describing a species for taxonomic purposes a relatively narrow CI_{95} is required, as the estimate $\bar{x}_L$ will be used as a standard by other researchers. We believe that 1.6 μm is sufficiently small to meet this need, and it is also the resolution of Gäumann's measurements.

For the three species groups used in this study, 41 to 71 spores would need to be measured to be 90% certain that the CI_{95} for $\bar{x}_L$ was no wider than 1.6 μm (Table 1). The *Potentilla* species group generally demanded the smaller sample sizes, 41–51, compared to 52–67 for the *Vicia* group, and 52–71 for the *Stellaria* group.

Table 1. The minimum number of spores that need to be measured to be 90% certain that the CI_{95} about $\bar{x}_L$ is no wider than 1.6 μm.

species group (by host plant)	Gäumann's species' reference number				
	1	2	3	4	5
Potentilla	45	42	41	51	
Stellaria	52	71			
Vicia	60	59	52	59	67

Therefore, inferring from these three phylogenetically distinct groups of species, a conclusion may be drawn that to get an accurate estimate of mean spore length in *Peronospora* species, between about 40 and 70 spores need to be measured.

2. Minimum sample size for estimating the mean spore length to match an unknown specimen with a known species

In the example above we wished to obtain a very precise estimate of μ_L so that this could be used as a reference value. For routine diagnostic examination of specimens, however, such precision is not necessary. Consequently, a wider CI_{95} can be accepted. Once again, the appropriate width of the CI_{95} is somewhat subjective, but will largely depend on the differences between the mean spore-lengths of the species within the group.

This is best illustrated with the two species on *Stellaria* which have mean spore-lengths that differ by 11.07 μm. Thus, in practice, you would only need to measure enough spores to be within 5 μm of the true mean to indicate to which of these two species an undetermined specimen on *Stellaria* would belong, presuming of course that the unknown was one of these two. This value, however, shrinks to 1.7 μm for the species on *Potentilla*, as the minimum difference between any two means is 3.47 μm. Considering these values, we decided to calculate the minimum number of spores that would need to be measured to determine $\bar{x}_L$ with a CI_{95} of 2 μm and 3 μm for *Potentilla*, and 2 μm, 3 μm, 4 μm, and 5 μm for *Stellaria*. The minimum difference between any two species within the *Vicia* group was 0.75 μm, but most species were much farther apart, with the next smallest difference being 2.78 μm. Thus, we calculated minimum sample sizes to obtain CI_{95}s of 0.70 μm, 2 μm, and 3 μm.

The widening of the CI_{95}s for diagnostic measurements substantially reduced the minimum sample-sizes required for all groups (Tables 2–4). Very large numbers of spores would need to be measured if species 2 and 3 on *Vicia* were to be distinguished with any confidence, as indicated by the values for the 0.7 μm CI_{95} in Table 4. In contrast, only 10 spores needed to be measured to differentiate the two species on *Stellaria*.

Table 2. For species found on *Stellaria*, the minimum number of spores that need to be measured to be 90% certain that the CI_{95} about $\bar{x}_L$ is no wider than specified.

nominal CI_{95} (μm)	Gäumann's species' reference number	
	1	2
2	36	48
3	19	25
4	12	16
5	10	11

Table 3. For species found on *Potentilla*, the minimum number of spores that need to be measured to be 90% certain that the CI_{95} about $\bar{x}_L$ is no wider than specified.

nominal CI_{95} (μm)	Gäumann's species' reference number			
	1	2	3	4
2	31	29	27	36
3	16	16	15	19

Table 4. For species found on *Vicia*, the minimum number of spores that need to be measured to be 90% certain that the CI_{95} about $\bar{x}_L$ is no wider than specified.

nominal CI_{95} (μm)	Gäumann's species' reference number				
	1	2	3	4	5
0.7	281	272	235	270	312
2	41	40	36	39	45
3	21	21	19	21	23

Discussion

Gäumann measured around 500 spores for each of the various *Peronospora* species he described, and for some species he measured around 1,000 spores. This is indeed an admirable effort, but in many cases it would not be practicable to measure so many spores. The general question that arises is how many spores need to be measured in morphometric studies? Other studies of downy mildews have involved measuring 100 (Gustavvson 1959), 200 (Smith 1970), or 500 (Ling & Tai 1945) spores. None of these studies described how they determined the number of spores to be measured. Likewise, Hawksworth (1974) recommended making 50–250 spore measurements for general fungal taxonomic studies, but gave no indication as to how he arrived at this range. Furthermore, claims relating to the 'reliability' of particular methods have not been rigorously justified and do not address type I and II error rates (Gustavsson 1959). Presumably, the sample-sizes used in these studies were based on the intuitive notion that more spores would need to be measured when there is large variability in length among spores. While this concept is indeed correct, the subjective manner in which it has been applied almost certainly explains the broad range of minimum sample-sizes propounded. In this paper, more formal and objective approaches that used s^2 as the measure of variability were presented. Also, the question of how many spores to measure was considered more carefully than has been done in the past, with distinctions being made between taxonomic/descriptive and diagnostic requirements.

Regardless of the specific question being addressed, the findings of our work tend to support the general assertion made by others (Gustavsson 1959), namely, that there is no need to measure 500 or 1,000 spores: much smaller sample sizes will suffice. Fewer spores needed to be measured for diagnostic purposes because, compared to the taxonomic agendum, a relatively relaxed level of precision can be accepted. In situations where two or more species have very similar means, as was the case for the *Vicia* group, large numbers of spores need to be measured to distinguish between species.

The techniques described in this paper can be readily applied to other groups of fungi and other morphometric characteristics, such as width or the ratio of width to length, providing such data satisfy the relevant statistical assumptions (i.e. normality and an accurate estimation of s). Also, note that the methods described here assume that s^2 is an adequate estimate of σ^2. This assumption adds further random variation into the estimated sample sizes, so the results should be interpreted conservatively. Where the source data set is large, as was the case for each species here, then s^2 is likely to be a sound estimate of σ^2. But for small data sets, where s^2 may be a poor estimate of σ^2, particular care should be taken in using and interpreting the methods. Caution is also warranted when considering these methods for species where spore morphology is unstable and dependent on environmental factors (Guarro et al. 1997, Arenal et al. 2004).

Acknowledgments

The authors thank Roger Shivas and Wayne Robinson for their expert review and useful suggestions, which improved the quality and clarity of the manuscript. Helpful observations by Shaun Pennycook and Chris Triggs are also appreciated.

Literature cited

Arenal F, Platas G, Peláez, F. 2004. Variability of spore length in some species of the genus *Preussia (Sporormiella)*. Mycotaxon 89: 137-151.

Gäumann, E. 1923. Beiträge zu einer monograhpie der Gattung *Peronospora* Corda. Beitr. Krypt.-fl. Schweiz 4. Zürich.

Guarro J, Abdullah SK, Gené J, Al-Saadoon, AH. 1997. A new species of *Preussia* from submerged plant debris. Mycol. Res. 101: 305-308.

Gustavsson A. 1959. Studies on Nordic peronosporas: II. General account. Opera Botanica 3: 5-61.

Harris M, Horvitz DG, Mood AM. 1948. On the determination of sample sizes in designing experiments. J. Amer. Statist. Assoc. 43: 391-402.

Hawksworth DL. 1974. Mycologists' Handbook. An introduction to the principles of taxonomy and nomenclature in the fungi and lichens. Surrey, Commonwealth Mycological Institute.

Ling L, Tai MC. 1945. On the specialisation of *Bremia lactucae* on Compositae. Trans. Brit. Mycol. Soc. 28: 16-25.

Smith A. 1970. Biometric studies on conidia of *Peronospora tabacina*. Trans. Brit. Mycol. Soc. 55: 59-66.

Sokal RR, Rohlf FJ. 1969. Biometry: the principles and practice of statistics in biological research. San Francisco, WH Freeman and Company.

Voglmayr H. 2003. Phylogenetic relationships of *Peronospora* and related genera based on nuclear ribosomal ITS sequences. Mycol. Res. 107: 1132-1142.

Zar JH. 1984. Biostatistical analysis (2nd edition). Englewood Cliffs, New Jersey, Prentice-Hall.

MYCOTAXON

Volume 95, pp. 195–200 *January–March 2006*

Tricholoma borgsjoeënse, a new species from a boreal coniferous forest in Fennoscandia

S. Jacobsson[1], S. Muskos[2] & E. Larsson[1]

stig.jacobsson@botany.gu.se
[1]*Dept. of Plant- and Environmental Sciences, Göteborg University*
Box 461, SE 405 30 Göteborg, Sweden
[2]*Klövervägen 13, SE 864 33 Matfors, Sweden*

Abstract—*Tricholoma borgsjoeënse*, a species new to science, is described and illustrated. Its systematic position was investigated by use of ITS and LSU nuclear rDNA sequence data. The phylogenetic analysis indicates that the new species belongs in section *Terrea* and is closely related to the American species *Tricholoma atroviolaceum*.

Key Words—Basidiomycotina, *Agaricales*, *Tricholomataceae*, taxonomy, phylogeny

Introduction

Tricholoma is a large genus with at least 50 species known in Fennoscandia. All of them are ectomycorrhizal with various forest trees, and several well-known species occur in the boreal coniferous forests. However, in some sections of the genus, morphological differences are small and not always evident. One such section is *Terrea* Konrad & Maubl., which comprises a large number of rather similar taxa. This section is characterized by a dry, brownish or greyish, more or less scaly or tomentose pileus surface.

Since 1988 we have observed a rather striking species of this complex in the province of Medelpad, central Sweden that was not possible to identify. It is characterized by a very dark, tomentose-fibrillose pileus, and grows in old, mossy forests with Norway spruce (*Picea abies*). It soon became obvious that it represented an undescribed species, in spite of its rather striking characters.

As the species is connected to old virgin forests, an environment strongly threatened by modern forestry, it is important to have a name for it. The new species is here described as *Tricholoma borgsjoeënse*.

Materials and methods

The complete internal transcribed spacer region (ITS1, 5.8S, ITS2) and approximately 900 base pairs of LSU nuclear rDNA were sequenced for the designated type of the new species *T. borgsjoeënse* SM05/024, *T. borgsjoeënse* SJ030827, *T. orirubens* Quél., RGC04-053, *T. virgatum* (Fr.) P.Kumm., SJ010927 and *T. apium* Jul.Schäff., EL37-99. The sequenced collections are deposited at Göteborg University Herbarium (GB).

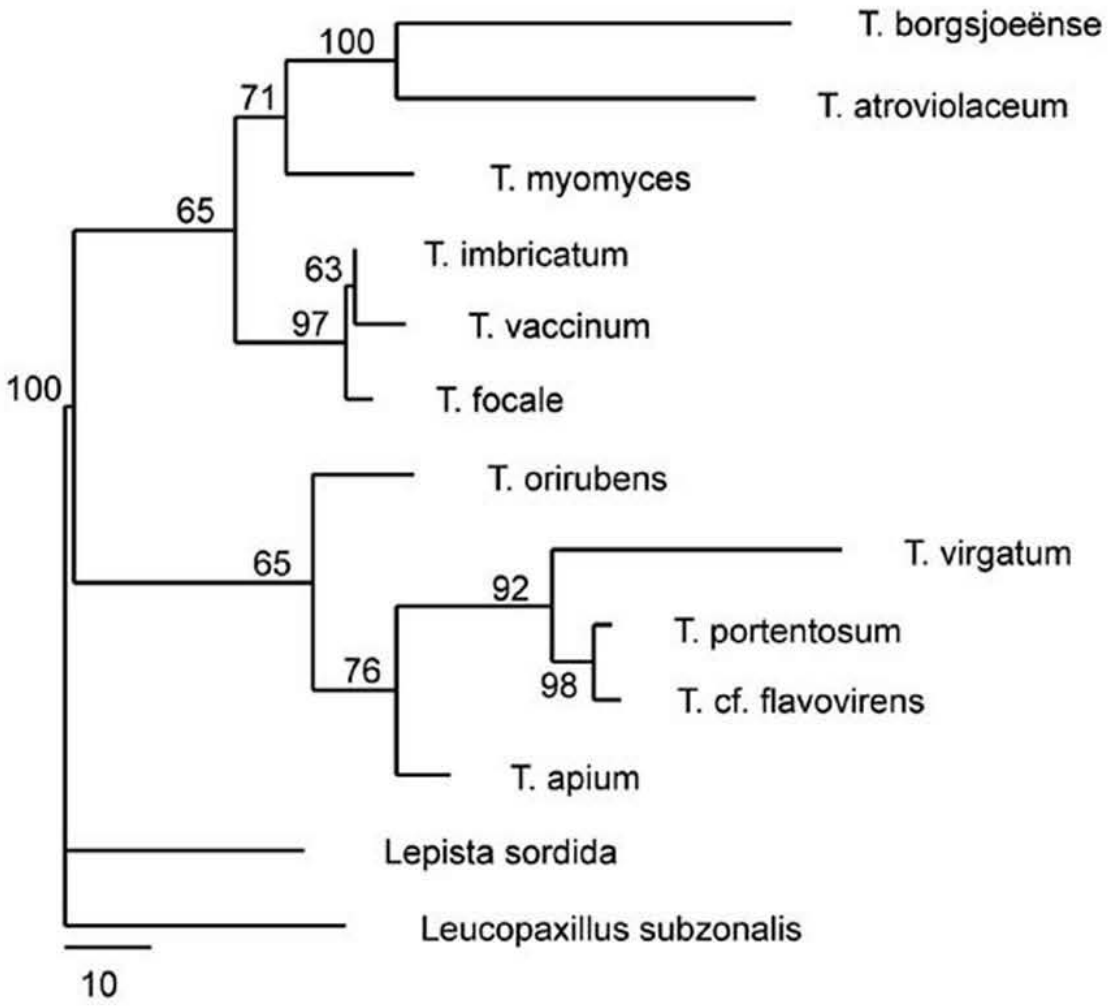


Fig. 1. The single most parsimonious tree from the phylogenetic analysis, showing the position of *T. borgsjoeënse*. Bootstrap values above 50% are indicated on branches.

Sequences were obtained from fresh material or from herbarium specimens following protocols described in Larsson & Jacobsson 2004. Sequences have been deposited in GenBank (accession numbers DQ415731, DQ389733-DQ389736). Additional sequences were taken from GenBank selected through blast search using the ITS2 region of *T. borgsjoeënse* as target (U7657, AY750166, AF319428, AF18660, U86443, U76458, U76460, U76464, U86672). *Leucopaxillus subzonalis* (Peck) H.E.Bigelow and *Lepista sordida* (Schumach.) Singer were used as the out group.

Sequences were aligned using the data editor in PAUP* (Swofford 2003). Gaps for insertion-deletion events were introduced to aid in the alignment. Heuristic searches for most parsimonious trees were performed using PAUP *. All transformations were considered unordered and equally weighted. Variable regions with ambiguous alignment were excluded, and gaps were treated as missing data. Heuristic searches with 1000 random-addition sequence replicates, TBR branch swapping, were performed. Relative robustness of clades was assessed by the bootstrap method using 1000 heuristic search replicates with 100 random taxon addition sequence replicates and TBR swapping.

Molecular results

The alignment of the 13 specimens was 2198 characters long. After exclusion of ambiguous areas 1623 characters remained for the analysis, of which 1428 were constant, 95 were variable but parsimony uninformative, and 100 were parsimony informative. The maximum parsimony analysis yielded one most parsimonious tree (length=217, CI= 0.7970, RI= 0.6893). Figure 1 shows the single most parsimonious tree presented as a phylogram and bootstrap frequencies are shown on branches. In the tree *T. borgsjoeënse* and *T. atroviolaceum* A.H.Sm. cluster with 100% bootstrap support, indicating a close relationship. The two species further cluster with *T. myomyces* (Pers.) J.E.Lange with a moderate support of 71%.

Taxonomy

Tricholoma borgsjoeënse Jacobsson & Muskos **sp. nov.** FIGURE 2

Pileus 35-88 mm latus, initio convexus, late planoconvexus vel subumbonatus, siccus, tomentosus vel minute squamulosus, atrobrunneus - cinereobrunneus, margine pallidior. Lamellae emarginatae, leviter latae, cineraceae. Stipes 55-105 mm longus, 10-17 mm crassus, saepe flexus, fibrillus, radicans, basi flavida vel albido. Caro pallide cinerea, in pileo atrocinerea, odore farinoso, sapore leviter amaro. Sporae ellipsoideae, 7.5-9 x 5-6 µm, leviae. Cystidia nulla. Hyphae defibulatae. Crescit in silvis abietis inter muscos.

Holotypus: Sweden, Medelpad Muskos 05-024: in herbarium GB concervatus est.

Additional material studied: Sweden, Medelpad, Borgsjö, Julåsen 2005-08-26, leg. Siw Muskos & Jan-Olof Tedebrand; Muskos 05-024 (Holotype, GB), 2003-08-27 (SJ03/012); Mpd, Attmar, Sörlindsjö, 2003-.09-12 (Muskos 03-009, GB); Mpd, Tuna, Kalberget, 1999-08-23 (Muskos 99-009).

Etymology: After the parish of Borgsjö in the province of Medelpad, where several specimens of the species, including the holotype, have been collected.

Pileus 35-88 mm broad when mature, at first obtusely conical with slightly incurved margin, becoming planoconvex, generally without but sometimes with a blunt umbo, dark greyish brown to blackish brown, with age or in dry condition somewhat paler, especially towards the margin, surface dry, completely covered with a dark, blackish tomentum or somewhat fibrillose scaly. **Lamellae** moderately crowded to somewhat subdistant, 40-60 reaching the stipe, strongly emarginate, rather ventricose, up to 12 mm broad, greyish, the edge often becoming blackish spotted when injured. **Stipe** 55-105 mm long and 10-17 mm wide, almost cylindrical or thickest in the middle part, towards the base often curved and more or less rooting, greyish fibrillose but gradually paler towards base and the base pale yellowish, especially when grown in deep moss. No trace of a cortina seen. **Context** in cap thin towards the margin and dark grey marbled, in the stipe dark grey in the upper part but gradually paler towards the base. Odour more or less farinaceous, at least when freshly cut, taste mild or weakly bitter. **Spores** (7-)7.5–9 x 5-6 µm, Q = 1.4-1.8 (20 spores measured), broadly ellipsoid to ovoid with a distinct hilar appendage, smooth, neither amyloid nor dextrinoid. **Basidia** slenderly clavate, 36–48 x 8-10 µm, 4-spored, without clamp connections.

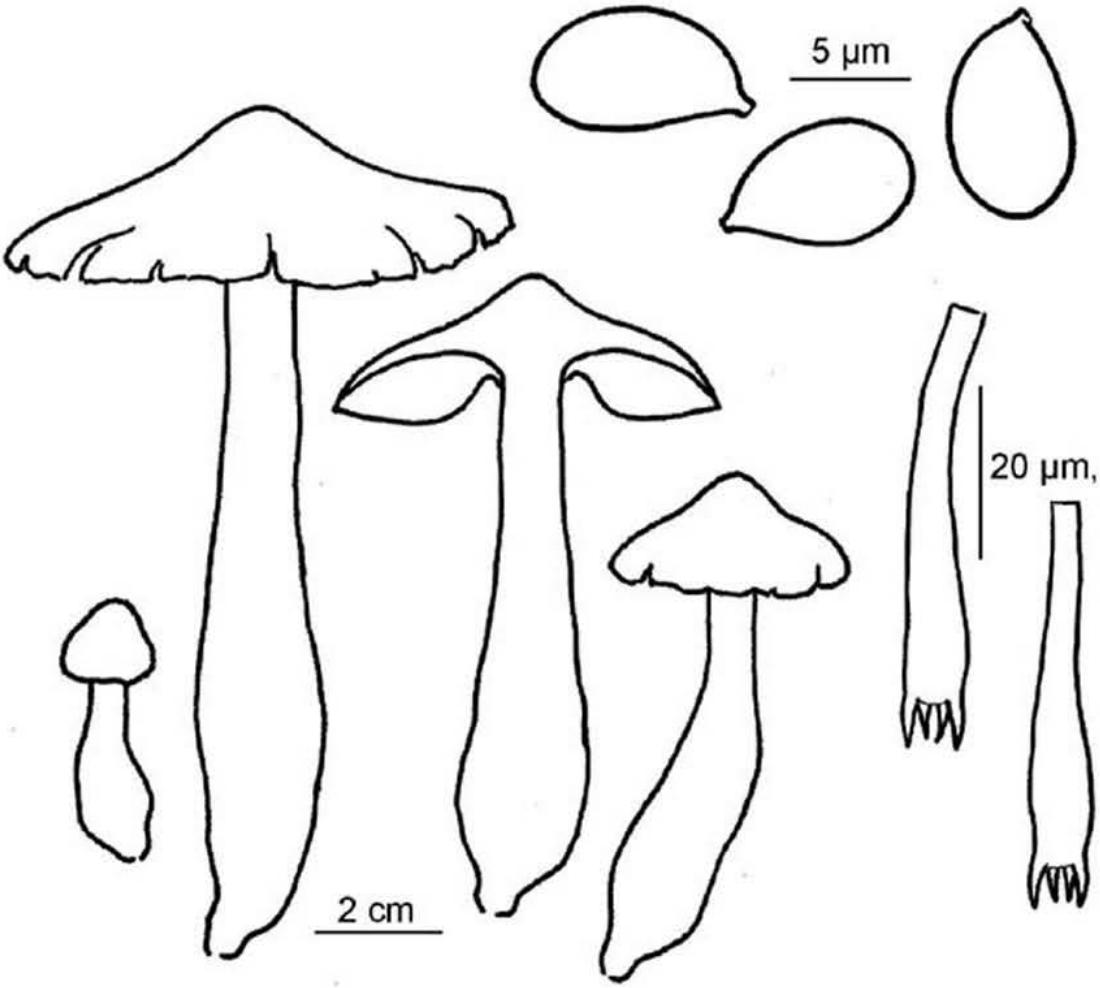


Fig. 2. Spores, basidia and basidiocarps of *Tricholoma borgsjoeënse*.

Lamellae edge fertile, only a few clavate basidioles seen. **Pileipellis** a cutis made up of bundles of strongly septate hyphae, elements 15-30 x 8-20 µm, thick-walled and very dark colored by membranal and sometimes slightly incrusting pigments. Below is a subpellis formed by more inflated and weaker pigmented hyphae, sometimes appearing subcellular. Context of hyphae hyaline and of various thickness. Clamp connections absent in all tissues.

Ecology and distribution—*Tricholoma borgsjoeënse* grows in small groups or rows in boreal coniferous forests of a virgin character, on rather moist and mossy ground with nutrient-rich soil. In all localities Norway spruce (*Picea abies*) was the only or dominant tree, suggesting *T. borgsjoeënse* to form ectomycorrhiza associated with spruce. In this region there is no indication that it could be connected with *Pinus* or any other tree species. Hitherto the species is noted from at least 6 localities in the province of Medelpad, central Sweden.

In the type locality at Julåsen it grows in a rather moist depression not far from a small brook. Within a few meters some other rare agarics have been found as *Hygrophorus purpurascens* (Alb. & Schwein.) Fr. *Cortinarius serarius* Fr., *Limacella glioderma* (Fr.)

Maire. Typical and common species in the same habitat are e.g. *H. erubescens* (Fr.) Fr., *Lactarius scrobiculatus* (Scop.:Fr.) Fr. and *L. badiosanguineus* Kühn. & Romagn. Various ferns and herbs like *Lactuca alpina* are also present. In other localities the habitat is also described as herb-rich spruce forest or in one case more ordinary blue-berry forest. Fruiting time is August - September.

It is surprising that such a striking species has not been described before. To our knowledge it has not yet been found in other parts of Sweden than in the rather small province of Medelpad but it is likely to have a wider distribution. The explanation may be that it is restricted to boreal forests of virgin character. Large areas of boreal forests in the northern half of Sweden are rarely visited by mycologists and much research remains to be done. It is also worth mention that the fruit bodies may often be difficult to discover as a consequence of the dull colors and the growth deep in mosses. The species is found in various parts of Finland according to I. Kytövuori (personal communication), which suggests that it has a wider distribution.

Discussion

Both the macro- and micro-morphological characters of *T. borgsjoeënse* unambiguously indicate that it belongs to section *Terrea*, a section characterized by a dry, woolly-tomentose to squamulose pileus and absence of clamp-connections on the hyphae. Bon (1984) made a subsection *Terreina* containing 13 species in Europe and Riva (1988) included 12 species in the subsection. In Noordeloos & Christensen (1999) only 7 of these taxa were included. Typical members of the subsection *Terreina* are *T. terreum* and its relatives and the complex around *T. orirubens*, a group still poorly investigated and in which the interpretation of some names is disputed.

T. borgsjoeënse clearly differs from the other known taxa belonging to section *Terrea* by several characters: darker colours on pileus and stipe, tomentose rather than a squamulose pileus surface, a fibrous, not squamulose stipe, larger spores and longer basidia. The nature of the pileipellis and pigmentation seems to be rather uniform within the section. Species belonging to the *T. orirubens* group have a strong tendency to redden in parts of the basidiom with age, a character never observed in *T. borgsjoeënse*.

Bresadola (1927, pl. 79) described and depicted a species that shares some characters with *T. borgsjoeënse*, viz. *T. gausapatum* (Fr.)Quél. It possesses large spores (7-9 x 4-4.5 µm), and also the tomentose pileus, somewhat rooting stipe and the occurrence in coniferous forest are characters similar to *T. borgsjoeënse*. Thus *T. gausapatum* ss Bres. may be related to or possibly identical with *T. borgsjoeënse*, but his interpretation deviates in several respects from the original description by Fries (1821). Besides, Fries described *T. gausapatum* as a species growing under deciduous trees in the southernmost part of Sweden.

In the phylogenetic tree *T. borgsjoeënse* cluster with *T. atroviolaceum*, a species described from coniferous forests in western United States (Oregon and California) by Smith (1944). The description shows that *T. atroviolaceum* shares several morphological characters with *T. borgsjoeënse*, e.g. a fibrous pileus surface, large spores and absence of cheilocystidia. However, there are also differences such as the distinct violaceus shade and a subbulbous stipe of *T. atroviolaceum*. No doubt the two species are closely related, but yet distinct from each other.

T. borgsjoeënse and *T. atroviolaceum* form a clade with *T. myomyces*. In contrast, *T. orirubens* and allied species fall in a different clade, in spite of similar morphological characters. However, our dataset includes too few species to be able to infer subgenetic classifications.

Old growth virgin spruce forests are strongly threatened by forestry and most areas with such forest have been clear-cut during the last decades. *T. borgsjoeënse* grows together with species that are on the Red List of Swedish species (Gärdenfors 2005), i.e. *Hygrophorus purpurascens*, *H. inocybiformis* A.H.Sm. and several species belonging to *Cortinarius* subg. *Phlegmacium*. These species indicate areas of highly valuable undisturbed forest that host many threatened species.

Acknowledgements

We gratefully acknowledge Gro Gulden, Natural History Museum, Oslo, Norway and Henning Knudsen, Botanical Museum, Copenhagen, Denmark for critically reviewing and valuable suggestions to improve the manuscript. Financial support was received from the Swedish species initiative project (ArtDatabanken, SLU).

Literature cited

Bon M. 1984. Tricholomes de France et Eur. occ. 67-278. – Lechevalier, Paris.

Bresadola G. 1927. Iconographia micologica 1, Milan.

Fries E. 1821. Systema Mycologicum. 1. Stockholm.

Gärdenfors U. 2005. The 2005 Redlist of Swedish species. ArtDatabanken, SLU, Sweden.

Larsson E., Jacobsson S. 2004. Controversy over *Hygrophorus cossus* settled using ITS sequence data from 200 year-old type material. Mycological Research 108:781-786.

Noordeloos, M.E., Christensen, M. 1999. *Tricholoma* (Fr.:Fr.) Staude. In Bas, C., Kuyper, Th., Noordeloos, M.E., Vellinga, E. (eds), Flora Agaricina Neerlandica 4:107-152.

Riva, A. 1988. *Tricholoma* (Fr.) Staude. Fungi Europaei 3. Saronno.

Smith A.H. 1944. New North American Agarics. Mycologia 36:242-262.

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

MYCOTAXON

Volume 95, pp. 201–204 *January–March 2006*

A new variety of *Meliola thalliformis* from Brazil

DARTANHÃ J. SOARES,
DOUGLAS F. PARREIRA & ROBERT W. BARRETO

dartjs@yahoo.com.br
Departamento de Fitopatologia, Universidade Federal de Viçosa
Viçosa, Minas Gerais, 36570-00, Brazil

Abstract—*Meliola thalliformis* var. *major* var. nov., associated with leaf spots on *Bathysa australis* (*Rubiaceae*), is described and illustrated.

Key words—tropical fungi, *Meliolales*, *Meliolaceae*, black mildew

Introduction

During fungal collections undertaken in a stretch of Atlantic tropical rainforest of the nature reserve Parque Estadual da Serra do Brigadeiro in the state of Minas Gerais (Brazil), leaves of the tree *Bathysa australis* (St. Hil.) Benth. & Hook. f. (*Rubiaceae*) were found colonized by a black mildew. Besides the usual black superficial colonies of the fungus, distinct leaf spots were also seen in close association with such colonies.

Bathysa australis is an endemic plant of the Brazilian Atlantic tropical rainforest and it is distributed throughout the South and Southeastern states of Brazil (Germano Filho, 1999). The latter author considered that this species as not threatened with extinction in a broad sense but in the state of Rio Grande do Sul it is considered to be endangered.

A literature survey yielded no fungal records on this host (Viégas, 1961; Minter & Silva, 1995; Mendes et al. 1998; Farr et al. 2005). The occurrence of this fungus represents therefore, the first fungal record on this host which is presented below.

Material and Methods

Freshly collected samples were examined under a stereomicroscope. Hand free sections and adhesive tape slides containing the fungal structures were mounted using lactophenol. Observations, measurements and line drawings were prepared by using an Olympus BX 50 light microscope fitted with a drawing tube. Representative specimens of the fungi were deposited in the herbarium at the Universidade Federal de Viçosa (Herbarium VIC).

Taxonomic Description

Meliola thalliformis var. ***major*** D.J. Soares & R.W. Barreto, **var. nov.**

MycoBank MB500734 (FIGS 1-2)

Differt a var. thalliformis *cellulae myceliales longioris et ascosporis magnioris*

Etymology: named in reference to its larger ascospore size.

Holotype: on *Bathysa australis*, Brazil, state of Minas Gerais, Araponga, Parque Estadual da Serra do Brigadeiro, December 2003, D.J. Soares (VIC-29381).

Colonies on living leaves, predominantly hypophyllous, mostly on the leaf-veins, crustose, to velvety, very densely thalliform, black, seemingly strongly parasitic, directly associated with amphigenous pale brown circular to elliptical leaf spots, 5–40 mm in diam. Hyphae slightly undulate, branching alternate or opposite at acute to wide angle, closely reticulate and thalloid, cells 23–45 x 5.5–11 µm. Appressoria alternate to unilateral, brown to dark brown, straight to slightly curved, 23.5–49 µm long, stalk cells cylindrical, 6.5–23 x 6–9 µm, head cells subglobose to ovate, sometimes angulose, 13–20.5 x 10–16 µm. Phialides separate, on loosely radiating hyphae growing on a upper level above the mycelial plate, opposite or alternate, brown, ampuliform, 14–25 x 7–9.5 µm. Mycelial setae very numerous, both scattered to and grouped around perithecia, mostly widely curved, hooked, rarely substraight, up to 454 x 6–9.5 µm long, dark brown, smooth, tip simple, obtuse, entire, or rounded. Perithecia black, scattered, globose, with crenate to crenulate surfaces, up to 260 µm in diam. Ascospores brown, oblong, obtuse, 4-septate, slightly constricted at septa, 47–61.5 x 12–19.5 µm, smooth.

Comments — 58 specific and 23 infraspecific *Meliola* epithets were included in Hansford's (1961) monograph having members of the family *Rubiaceae* as hosts. None on these fungal taxa had a member of the genus *Bathysa* as a known host. The general morphological characteristics of the fungus described above together with its (uncommon for this group of fungi) evident pathogenic habit agreed well with those described for the species *Meliola thalliformis* Deigthon and *M. thalliformis* var. *naucleae* Deighton. Some biometric differences were nevertheless noted and considered here as sufficient to justify its recognition as a new variety in the species, namely its longer hyphal cells and its larger ascospores. *Meliola canthii* Hansf., another closely-related species having Beeli formulae 3111.5222, is easily distinguishable by the mixed appressoria and phialides and sometimes 2–4-lobate appressoria. Another aspect worthy of consideration is its disjunct distribution as compared with other occurrences of *M. thalliformis* – all recorded only from Africa (Table 1, p. 204).

Acknowledgments

The authors wish to thank the Departamento de Biologia Vegetal of the Universidade Federal de Viçosa for providing support on plant identification, particularly to Michelia Soares, Amilcar Saporetti and Wilson Marcelo. The authors also wish to thank Dr. Bin Song, Dr. Hosagoudar and Dr. Harry Evans for reviewing the manuscript.

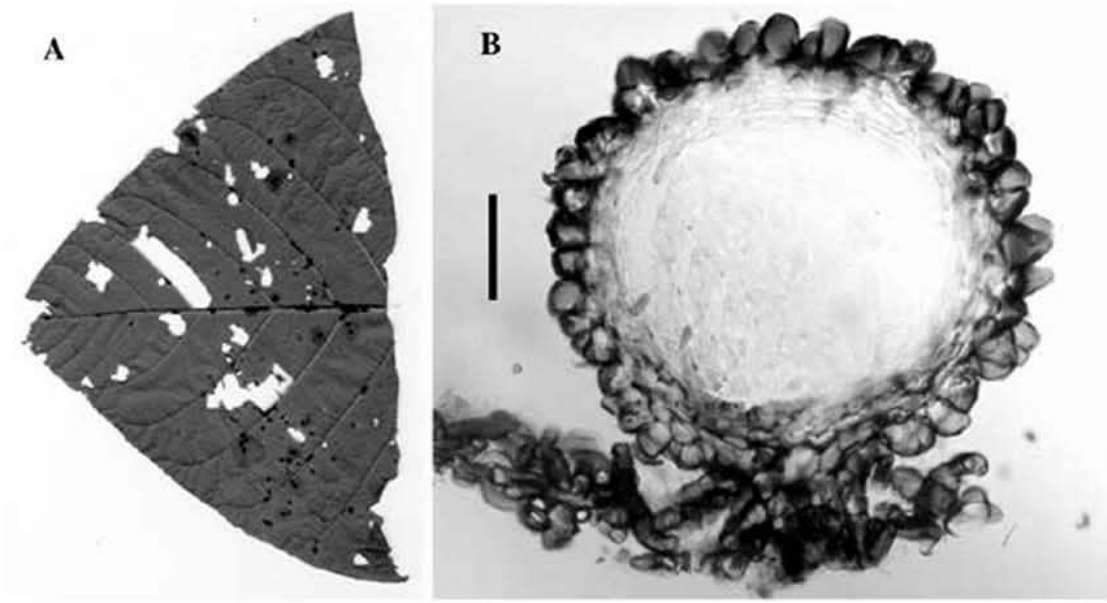


Fig 1. Leaf fragment showing the colonies of *Meliola thalliformis* var. *major* associated with the spots on *Bathysa australis* (A) and transversal section of the perithecium showing the crenulate surface (B). Scale Bar = 30 µm

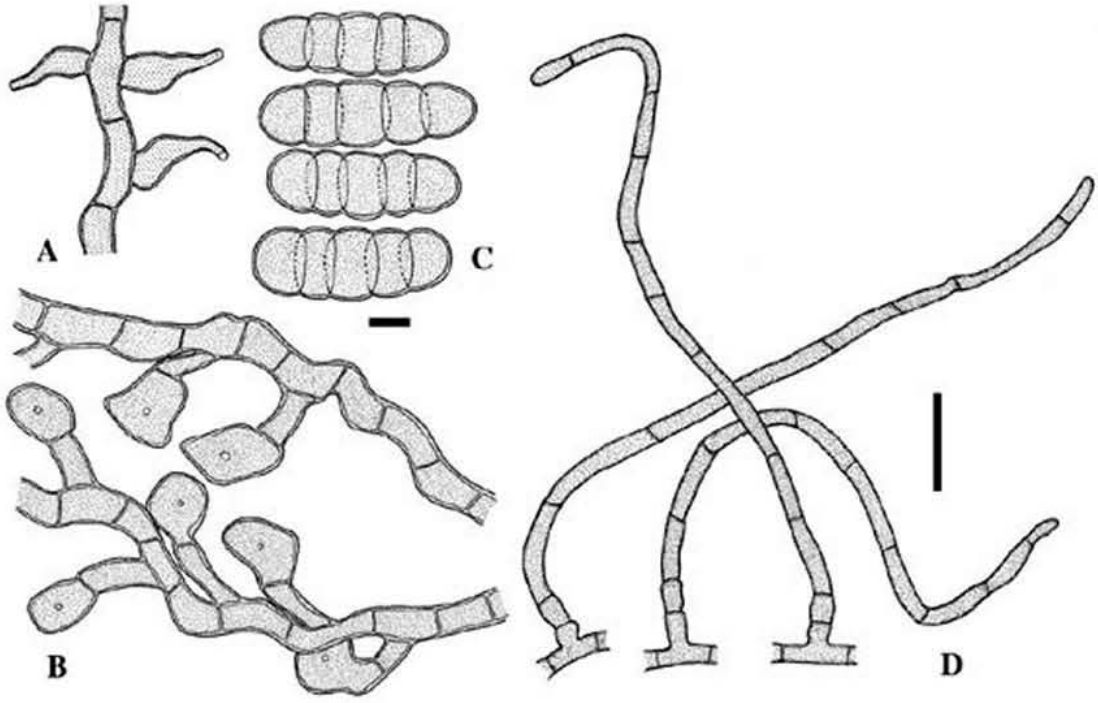


Fig 2. Line drawing of *Meliola thalliformis* var. *major* on *Bathysa australis*. Phialides (A), appressoria (B), ascospores (C) and widely curved and hooked mycelial setae (D). A-C, Scale Bar = 10 µm; D, Scale Bar = 50 µm

Table 1. Morphological features of *Meliola thalliformis* and its varieties.

Features		*M. thalliformis**	*M. thalliformis* var. *naucleae**	*M. thalliformis* var. *major***
Beeli formula		3121.4232	3111.4232	$3121.623^{2}/_{3}$
Hypha cell		10–20 x 6–9 µm	11–20 x 8–10 µm	23–45 x 5.5–11 µm
Mycelial setae		up to 350 x 8–9 µm	up to 320 x 8–9.5 µm	up to 454 x 6–9.5 µm
Appressoria	stalk cell	3–14 µm long	7–12 µm long	6.5–23 x 6–9 µm
	apical cell	11–20 x 10–14 µm	15–22 x 11–16 µm	13–20.5 x 10–16 µm
Phialide		12–20 x 6–8 µm	16–20 x 7–9 µm	14–25 x 7–9.5 µm
Ascoma		up to 230 µm diam	up to 220 µm diam	up to 260 µm diam
Ascospores		38–48 x 14–16 x 12–14 µm	38–48 x 13–15 x 12–13 µm	47–61.5 x 12–19.5 µm
Host		*Mitragyna stipulosa* (DC.) Kuntze	*Nauclea diderrichii* (De Wild.) Merr.	*Bathysa australis*
Geographic range		Sierra Leone	Sierra Leone	Brazil

* Hansford 1961; ** this publication.

Literature Cited

Farr DF, Rossman AY, Palm ME, & McCray EB. 2005. Fungal Databases, Systematic Botany & Mycology Laboratory, ARS, USDA. Retrieved October 12, 2004, from http://nt.ars-grin.gov/fungaldatabases/.

Germano Filho P. 1999. Estudos taxonômicos do gênero *Bathysa* C. Prels. (*Rubiaceae, Rondeletieae*), no Brasil. Rodriguésia 50 (76/77): 49-75.

Hansford CG. 1961. The *Meliolineae* – A monograph. Sydowia Beihefte 2: 1-806.

Mendes MAS, Silva, VL, Dianese JC, Ferreira MASV, Santos CEN, Neto EG, Urben AF, Castro C. 1998. Fungos em plantas no Brasil. Brasília-DF, Embrapa.

Silva M, Minter DW. 1995. Fungi from Brazil recorded by Batista and co-workers. Mycological Papers 169: 585 p.

Viégas AP. 1961. Índice de Fungos da América do Sul. Instituto Agronomico, Campinas-SP, Siqueira.

MYCOTAXON

Volume 95, pp. 205–215 *January–March 2006*

Russula in Himalaya 2: Four new taxa

KANAD DAS[1*], S.L. MILLER[2]
& J.R. SHARMA[3]

**daskanad@yahoo.co.in*
[1]Mycology and Plant Pathology Group, Agharkar Research Institute
G.G. Agarkar Road, Pune 411004, India

[2]Botany Department, University of Wyoming
Laramie, Wyoming 82071 USA

[3]Botanical Survey of India, 192, Kaulagarh Road
Dehradun 248195, India

Abstract—*Russula mayawatiana, R. dhakuriana, R. appendiculata* and *R. puellaris* var. *atrii* are proposed here as new taxa. Phylogenetic positions within the genus *Russula* are supported by macroscopic and microscopic characters as well as rDNA sequences in the ITS gene region.

Key words—*Russulaceae*, taxonomy, ribosomal DNA, phylogeny, India

Introduction

Critical taxonomic studies based on the morphological and anatomical characters of the genus *Russula* from Himalaya have been carried out by different authors (Watling & Gregory 1980, Saini et al. 1982, Atri & Saini 1989, Atri et al. 1991, Atri et al. 1992, Atri et al. 1993, Saini et al. 1993, Atri et al. 1994, Shajahan & Samajpati 1995, Atri et al. 1997, Rawla 2001, Das & Sharma 2003, Das 2005, Das et al. 2006) for the last twenty five years. The flora of the large genus *Russula* from the world over is creating confusion among taxonomists about the proper taxonomic circumscription of species and their placement in the infrageneric classification schemes. Moreover, the morphological and anatomical characters are sometimes not sufficient to comparatively analyse the taxa or establish them as undescribed (new). To eliminate this confusion, efforts have been initiated by a few workers (Miller et al. 2001, Miller & Buyck 2002) to use DNA sequencing to support comparative taxonomic approaches. During a number of macrofungal surveys in Western and North-western Himalaya, the authors gathered a large number of specimens which after thorough morphological and microscopic studies revealed numerous undescribed taxa. Further, DNA sequencing of five taxa also confirmed their status as new to science. Four of them, viz., *R. mayawatiana*, *R. dhakuriana*, *R. appendiculata* and *R. puellaris* var. *atrii* are described and illustrated below, whereas, the fifth one i.e. *R. mukteshwarica* has been submitted (Das et al. 2006) for publication. The molecular tree supporting circumscription of these taxa as new is also provided (Fig. 5, p. 214).

Materials and Methods

Morphological characters were recorded from fresh specimens in the field. Anatomical characterization was done with dry samples by mounting free hand sections of basidiomes in 5% KOH, Melzer's reagent, Congo red, Lactophenol-cotton blue and carbol fuchsin. Colour terms follow Kelly & Judd (1955). Microscopic line drawings were made with the aid of a camera lucida at original magnification of 1500x for basidiospores and 1000x for other microstructures. Density of lamellae (L/cm) was measured at the margin of the pileus excluding lamellulae. Colour codeing used for spore prints is after Romagnesi (1967). Basidiospore length excludes the length of ornamentation. Basidium length excludes the length of sterigmata. Quotient (Q = L/W) was calculated considering the mean value of length and width of 25 basidiospores. Herbarium names used follow Holmgren et al. (1990). Materials and methods for rDNA sequencing were similar to those used in Miller & Henkel (2004).

Description of the species

Russula mayawatiana K. Das, S.L. Mill. & J.R. Sharma **sp. nov.** Fig. 1.

Etymology: From Mayawati, referring to the type locality.

Pileus 40–65 mm diam., planoconvexus ad infundibuliformis, crustosus in centro, rufus ad rutilus. Lamellae subdecurrentes, densae, luteae. Stipes 40–50 x 7–12 mm, cylindricus ad subclavatus, luteoalbus. Sporae in cumulo luteae, 7.7–11.5 x 6.2– 9 µm, globosae vel ellipsoidae, amyloideae, verrucosae. Pleurocystidia 68–125 x 9–15 µm, fusiformia. Cheilocystidia 46–70 x 6–9 µm, fusiformia. Pileocystidia cylindrica.

Holotypus: INDIA, Uttaranchal, Champawat, Mayawati, September 2002, leg. K. Das & J.R. Sharma, KD4542 (HOLOTYPUS, BSD; ISOTYPUS, TUR-A).

Pileus 40–65 mm diam., convex, then planoconvex to infundibuliform with a depression at maturity; pileipellis viscid when moist, often crustose (cracked) at the center, peeling only at margin, deep yellowish pink to medium or deep red or yellowish red, medium to dark or orange yellow at center; margin slightly sulcate. **Lamellae** adnexed to subdecurrent, close (7–8 per cm), forked, pale to orange yellow. **Stipe** 40–50 x 7–12 mm, central, cylindric to subclavate, yellowish white. $FeSO_4$ (+). **Taste** acrid. **Spore print** pale yellow.

Basidiospores 7.7–11.5 x 6.2–9 µm, globose, subglobose, broadly ellipsoid to ellipsoid (Q = 1.05–1.4); ornamentation amyloid, composed of numerous conic warts, up to 1.75 µm high, rarely connected by fine ridges. **Basidia** 40–50 x 7–9 µm, subclavate to clavate, 4-spored; sterigma up to 6 µm long. **Pleurocystidia** 65–125 x 7.7–15 µm, emergent up to 40 µm, abundant, fusiform or with acute, acuminate to narrowly moniliform apex; contents dense. Lamellae edge sterile with few cystidia. **Cheilocystidia** 46–70 x 6–9 µm, fusiform; contents dense. Subhymenium layer up to 20 µm thick, cellular. **Pileipellis** up to 100 µm thick, composed of erect to suberect hyphae and abundant pileocystidia; pileocystidia up to 12 µm, broad, fusiform to cylindrical or acuminate-rostrate, 3–6 septate. **Stipitipellis** composed of mostly repent hyphae and abundant cystidia. **Caulocystidia** up to 8 µm broad, clavate, subclavate or fusoid; contents dense.

Ecology—*Russula mayawatiana* grows in close association with species of *Quercus* and *Rhododendron* in moist mixed temperate forests.

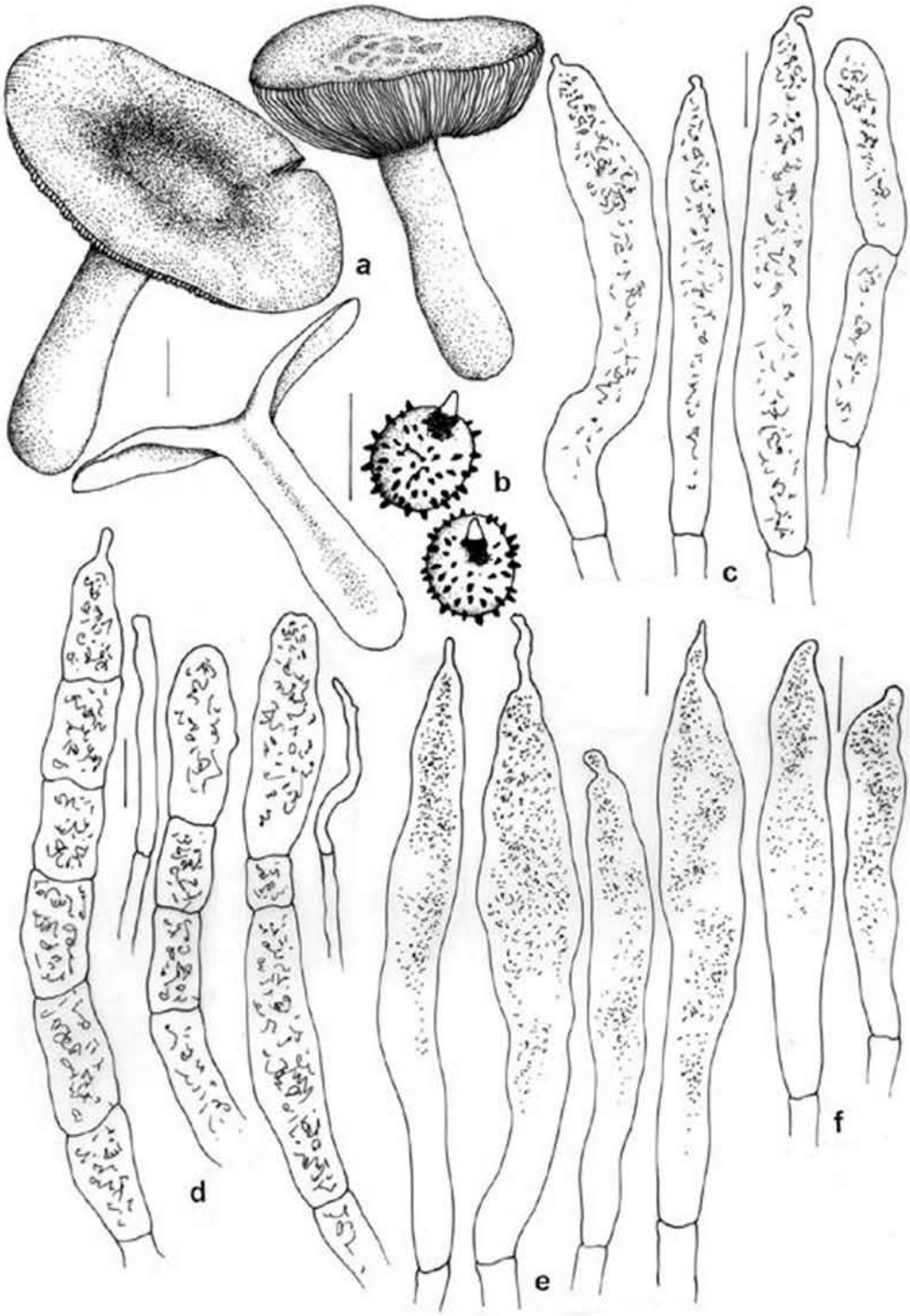


Fig. 1. *Russula mayawatiana* (from **Holotype**): a. Basidiomes b. Basidiospores c. Caulocystidia d. Elements from pileipellis e. Pleurocystidia f. Cheilocystidia. Bars: a = 10 mm; b–f = 10 µm.

OTHER SPECIMENS EXAMINED—**INDIA, Utaaranchal** NAINITAL, Gagar, August 2002, leg. K. Das, KD2149, KD2158 (BSD).

Notes: Bright reddish coloration of pileus, pale yellow spore print and multiseptate (3-6 septate) pileocystidia firmly place *R. mayawatiana* in the subgenus *Russula* emend.

Sarnari. It is differentiated easily by its reddish pileus with yellowish center, distinctly acrid taste, large basidiospores. The present taxon is close to *R. maculata* Quélet & Roze. However, the presence of rusty spotted pileus and stipe surface, non-sulcate pileus margin, non-septate pileocystidia in *R. maculata* separate it from *R. mayawatiana*. Molecular analysis (fig. 5) clearly shows the closeness between these two taxa. Moreover, Rayner (1970) reported spore size ranging from 8–10 x 7–9 µm with wart size up to 1.25–1.5 µm in *R. maculata* as compared to the spore size (7.7–11.5 x 6.2–8.3 µm with warts measuring up to 1.75 µm) recorded for *R. mayawatiana*.

Russula dhakuriana K. Das, J.R. Sharma & S.L. Mill. **sp. nov.** **Fig. 2.**

Etymology: From Dhakuri, referring to the type locality.

Pileus 80–120 mm diam., planoconvexus, leviter depressus in centro, rufus. Lamellae annexae ad subdecurrentes, densae, luteae. Stipes 50–125 x 20–28 mm, subclavatus ad clavatus, roseus. Sporae 6.5–10.2 x 6 –7.7 µm, globosae vel late ellipsoidae, amyloideae, verrucosae. Pleurocystidia 60–115 x 7–12 µm, cylindrica. Cheilocystidia 60–75 x 9–13 µm,clavata ad fusiformia. Pileocystidia absentia

Holotypus: *INDIA, Uttaranchal, Bageshwar, Dhakuri, September 2003, leg. K. Das & J.R. Sharma, KD7029 (HOLOTYPUS, BSD; ISOTYPUS, GUH).*

Pileus 80–120 mm diam., convex, planoconvex with depressed center to uplifted at maturity; pileipellis dry, somewhat pruinose but never velvety or scurfy, soft to medium to deep red, often with brilliant orange yellow areas; margin often tuberculately sulcate, split. **Lamellae** adnexed to subdecurrent close to rather crowded (*ca* 8 per cm), often forked from the stipe, brilliant to light orange yellow; lamellulae absent. **Stipe** 50–125 x 20–28 mm, central, subclavate to clavate, yellowish with deep pink to medium red areas, white with tinge of deep pink, $FeSO_4$ (+); context pale yellow. Dried material (lamellae) never red with sulfovanillin. Odour indistinct. Taste mild. **Spore print** not obtained.

Basidiospores 6.5–10.2 x 6–7.7 µm, globose to broadly ellipsoid (Q = 1.03–1.26); ornamentation amyloid, composed of isolated conic to spiny warts (up to 1.75 µm). **Basidia** 40–60 x 9–14 µm, subclavate, 4-spored; sterigmata up to 7.5 µm long. **Pleurocystidia** 60–115 x 7–12 µm, emergent up to 45 µm, abundant, cylindrical to subfusoid, thick walled; wall up to 1.5 µm thick; contents dense. Lamellae edge fertile with basidia and cystidia. **Cheilocystidia** 60–75 x 9–13 µm, clavate to fusoid, thick walled; wall up to 1.75 µm thick. **Subpellis** cellular. **Pileipellis** composed of erect to suberect hyphae; hyphae up to 5 µm broad, often with incrustations. **Pileocystidia** absent. Pilear trama with abundant sphaerocytes. **Stipitipellis** composed of suberect to repent hyphae and cystidia.

Ecology—*Russula dhakuriana* grows in close association with species of *Rhododendron* in moist mixed temperate forests.

OTHER SPECIMENS EXAMINED—INDIA, Utaaranchal BAGESHWAR, Dhakuri, September 2003, leg. K. Das & J.R. Sharma, KD7092, KD7093 (BSD).

Notes: Morphologically, the bright coloration of pileipellis and microscopically, the presence of incrusted hyphae and absence of pileocystidia in the pileipellis, undoubtedly place these specimens under the subgenus *Incrustatula*. The characters recorded for these

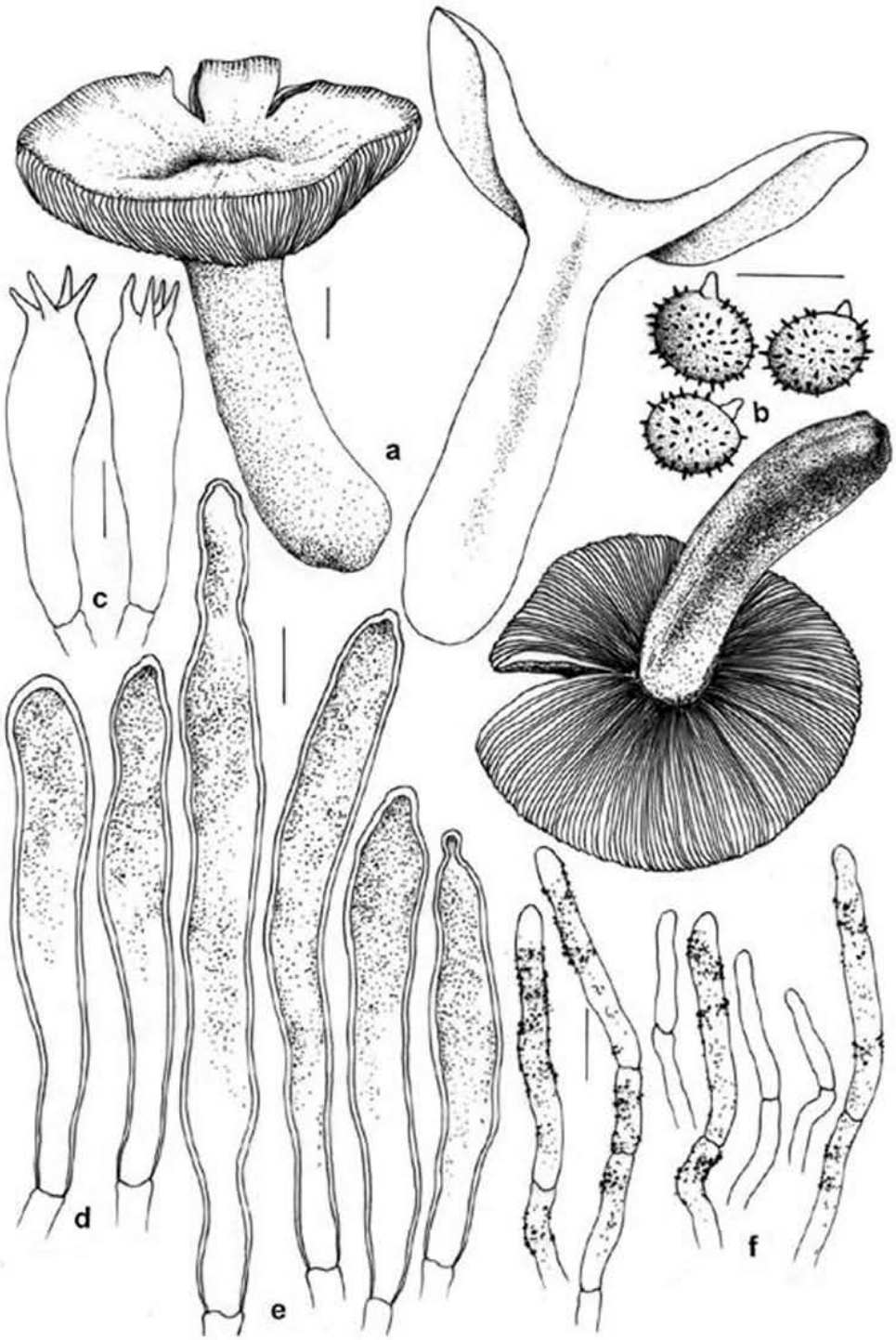


Fig. 2. *Russula dhakuriana* (from **Holotype**): a. Basidiomes b. Basidiospores c. Basidia d. Cheilocystidia e. Pleurocystidia f. Elements from pileipellis. Bars: a = 10 mm; b–f = 10 µm.

specimens are quite close to those of *Russula rosea* Quél., as has also been confirmed by the molecular analysis (Fig. 5). However, the smaller spores and cellular nature of the subpellis are features enough to separate *R. rosea* from *R. dhakuriana*. Further, unlike the present species, the dried lamellae of *R. rosea* stain carmine red in sulfovanillin.

Russula appendiculata K. Das, S.L. Mill. & J.R. Sharma **sp. nov.** **Fig. 3.**

Etymology: After the characteristic appendiculate pleurocystidia.

Pileus 60–90 mm diam., planoconvexus ad infundibuliformis, brunneolus. Lamellae late annexae, luteae. Stipes 37–70 x 13–18 mm, cylindricus ad subclavatus, luteoalbus. Sporae (6) 7–8.8 x 5.4–7.8 µm, globosae vel late ellipsoidae, amyloideae, verrucosae. Pleurocystidia 60–100 x 7.5–12 µm, fusiformia, appendiculata. Cheilocystidia 50–70 x 8–11 µm, cylindrical ad clavata. Pileocystidia cylindrical ad clavata.

Holotypus: INDIA, Uttaranchal, Champawat, Mayawati,September 2002, leg. K. Das & J.R. Sharma, KD4541 (HOLOTYPUS, BSD; ISOTYPUS, TUR-A).

Pileus 60–90 mm diam., convex, planoconvex to umbelliform with depressed center; pileipellis gelatinous when young, dry at maturity, cracked to areolate towards margin, brownish pink, light gray brown or gray yellowish brown with cream to pale yellow at the center, gray yellow, medium yellow, dark yellow or dark grayish yellow at maturity, never darkening with KOH; margin plane, nonstriate. **Lamellae** broadly adnexed, close (7–8 per cm), forked near the stipe or from the middle, pale yellow; lamellulae in two rows. **Stipe** 37–70 x 13–18 mm, central, cylindric to subclavate, yellowish white, $FeSO_4$ (+); context stuffed, white unchanging. **Taste** mild. **Odor** fruity. **Spore print** not obtained.

Basidiospores (6) 7–8.8 x 5.4–7.8 µm, globose to broadly ellipsoid [Q = 0.95–1.2 (1.30)]; ornamentation amyloid, 0.2–0.4 µm high, composed of irregular isolated warts, few connected by isolated lines, never forming a reticulum. **Basidia** 38–50 x 8–12 µm, clavate, 4-spored. **Pleurocystidia** 60–100 x 7.5–12 µm, cylindric, fusoid or ventricose with rounded, mucronate, appendiculate or narrowly lageniform (tailed) apex, emergent up to 40 µm. **Cheilocystidia** 50–70 x 8–11 µm, cylindrical to clavate. **Pileipellis** composed of suberect septate branched hyphae and cylindrical to clavate pileocystidia with rounded to mucronate apices.

Ecology—Rare, grows in ectomycorrhizal association with species of *Pinus* in mixed temperate forests.

OTHER SPECIMENS EXAMINED—**INDIA, Utaaranchal,** NAINITAL, Gagar, August 2002, leg. K. Das, KD2176 (BSD).

Notes: Based on the color of the pileus and nature of the pileipellis, the present taxon appears to belong to the subgenus *Heterophyllidia* (Sect. *Rigidae* sensu Singer, 1986) along with *R. virescens* (Schaeff.) Fr. However, the latter has a distinct pseudoparenchymatous subpellis, absence of appendiculate (tailed) pleurocystidia and larger spore ornamentation which clearly separate *R. virescens* from *R. appendiculata*. The absence of any color change of pileipellis with KOH points towards inclusion of *R. appendiculata* under the subgenus *Ingratula* Romagn. emend Sarnari alongwith *R. farinipes* Romell as also supported strongly by molecular analysis (Fig. 5). However, *R. farinipes* differs by having a distinctly nonareolate pileus, larger spore ornamentation and above all lacks the lageniform to tailed pleurocystidia of *R. appendiculata* .

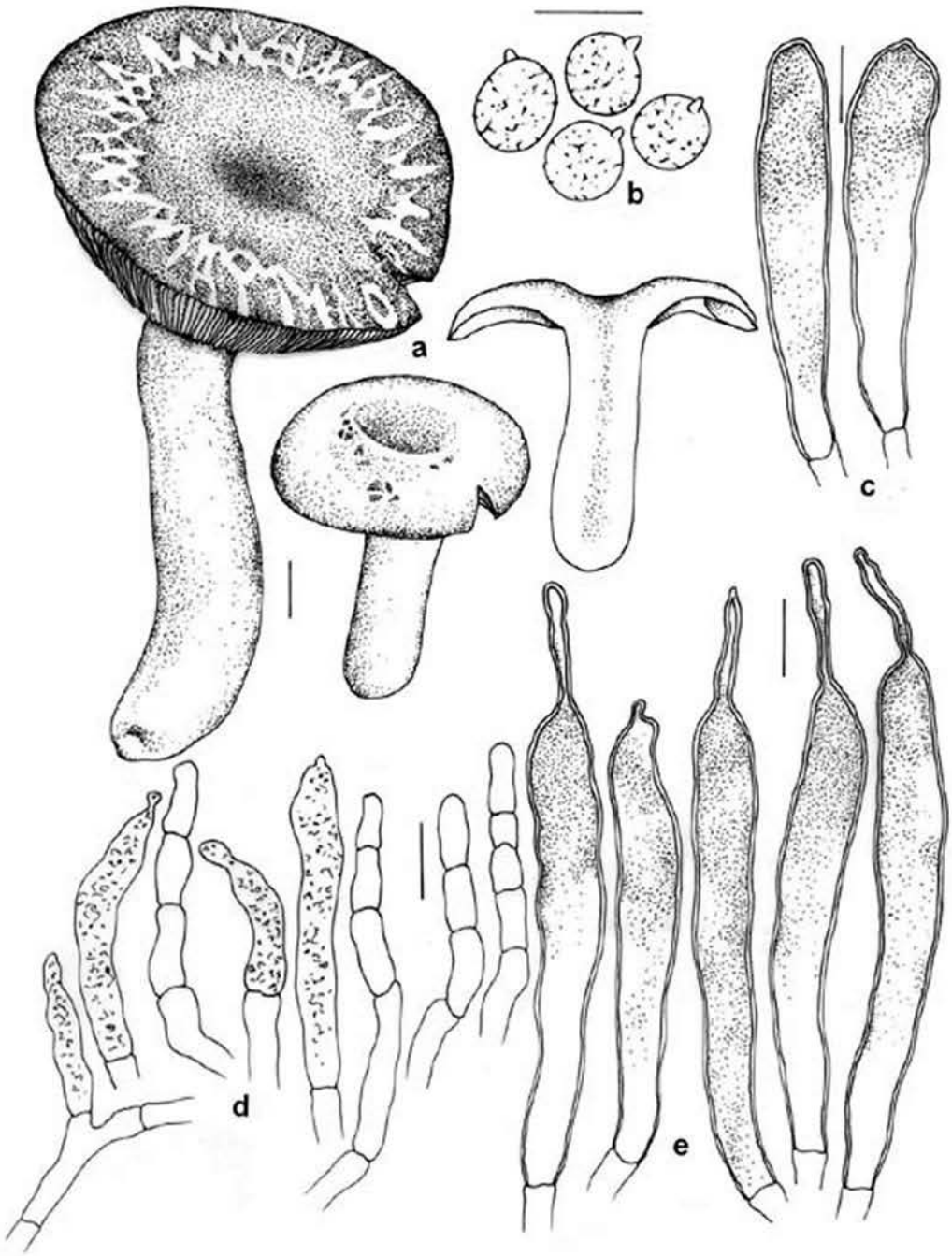


Fig. 3. *Russula appendiculata* (from **Holotype**): a. Basidiomes b. Basidiospores c. Cheilocystidia d. Elements from pileipellis e. Pleurocystidia. Bars: a = 10 mm; b–e = 10 µm.

Russula puellaris var. ***atrii*** K. Das, S.L. Mill. & J.R. Sharma **var. nov.** **Fig. 4.**

Etymology: In recognition of N.S. Atri for his contribution to the *Russulaceae*.

Pileus 20–35 mm diam., planoconvexus, leviter depressus in centro, atropurpureus Lamellae annexae, luteae. Stipes 23–63 x 5–13 mm, cylindricus ad clavatus, luteoalbus. Sporae in cumulo luteolae, 7.4–9.6 x 6–7.7 µm, subglobosae vel ellipsoidae, amyloideae, verrucosae et corrugatae. Pleurocystidia 50–74 x 9–12 µm, fusiformia. Pileocystidia subclavata ad clavata.

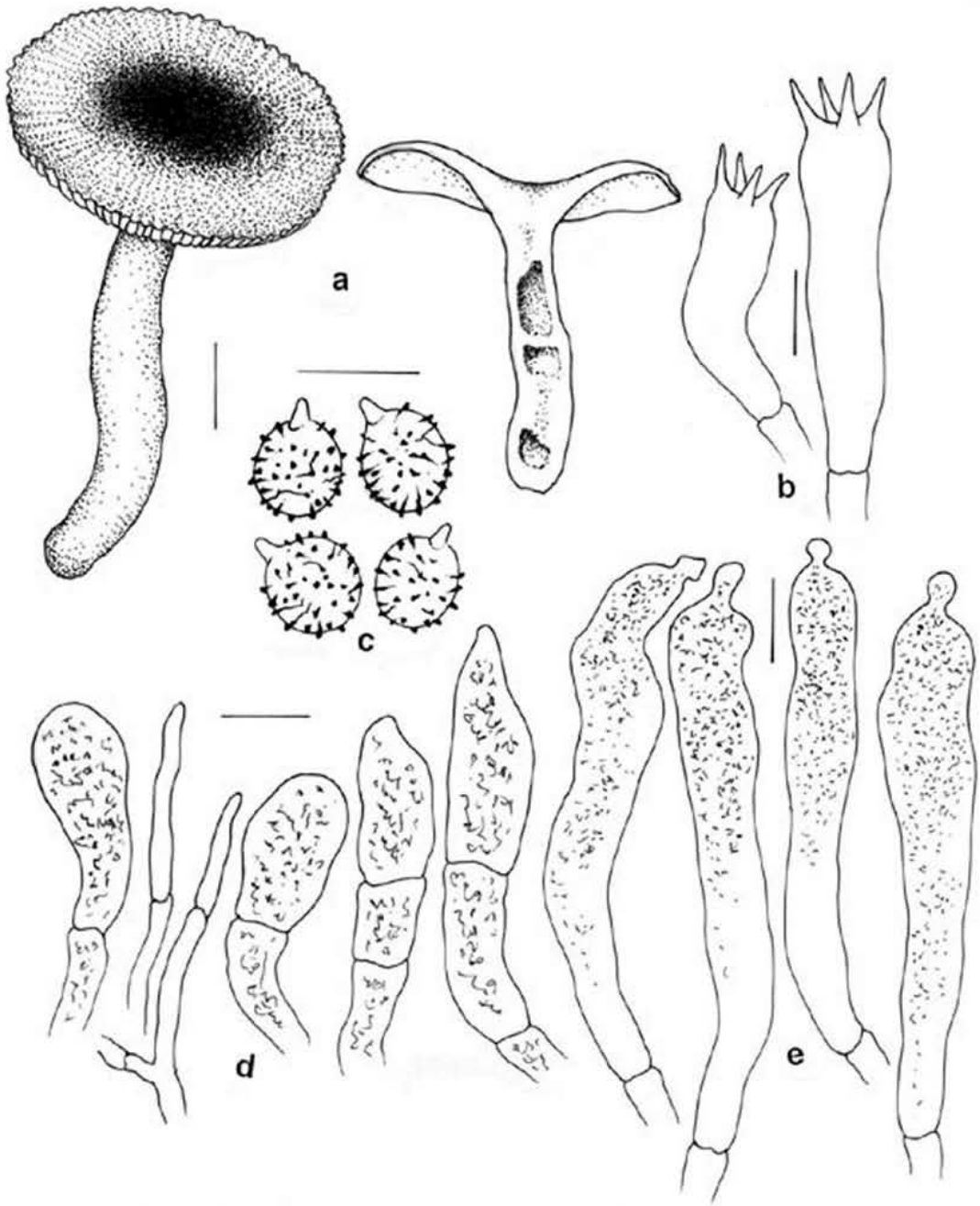


Fig. 4. *Russula puellaris* var. *atrii* (from Holotype): a. Basidiomes b. Basidia c. Basidiospores d. Elements from pileipellis e. Pleurocystidia. Bars: a = 10 mm; b–e = 10 µm.

Holotypus: INDIA, Uttaranchal, Bageshwar, Dhakuri, September 2003, leg. K. Das & J.R. Sharma, KD7022 (HOLOTYPUS, BSD).

Pileus 20–35 mm diam., convex, planoconvex with slightly depressed center at maturity; pileipellis viscid when moist, soft to dark reddish purple with blackish purple center, light grayish or grayish to dark purplish red, slowly yellowish orange at maturity or after bruishing, peeling up to ½ of the radius; margin plane, tuberculately striated. **Lamellae** adnexed to subdecurrent, crowded (10–12 per cm), entire, forked from the stipe,

yellowish white, yellowish orange at maturity or after bruising. **Stipe** 23–63 x 5–13 mm, central, cylindrical to clavate, yellowish white, distinctly yellowish orange after bruising or at maturity $FeSO_4$(+); context white, yellowing after bruising. **Taste** mild. **Spore print** yellowish to buff.

Basidiospores 7.4–9.6 x 6–7.7 µm, subglobose to ellipsoid (Q = 1.08–1.43); ornamentation amyloid, up to 1.4 µm high, composed of conic to spinose warts and ridges, aligned or joined with few connectives to form broken reticulum. **Basidia** 26–45 x 7–11.5 µm, clavate, 4-spored; sterigma up to 6 µm. **Pleurocystidia** 50–74 x 9–12 µm, emergent up to 12 µm, abundant, fusiform to cylindrical with capitate, or appendiculate apices; contents dense. Lamellae edge fertile with basidia and few cystidia. **Cheilocystidia** same as pleurocystidia. Subhymenium layer up to 28 µm thick, cellular. **Pileipellis** composed of upper erect to suberect hyphae up to 5 µm broad and pileocystidia up to 10 µm, broad, subclavate to clavate, 1–2 septate, contents dense; below a layer of parallel compact hyphae.

Ecology—Common, grows in ectomycorrhizal association with species of *Quercus* and *Rhododendron* in temperate deciduous to mixed forests.

SPECIMENS EXAMINED – INDIA, UTTARANCHAL: **Bageshwar**, Dhakuri, September 2003, leg. K. Das & J.R. Sharma, KD7022 (**HOLOTYPE**, BSD); *ibid.*, **Pithoragarh**, Dafia Dhura, October 2001, leg. K. Das & J.R. Sharma, KD4063.

Notes: *Russula puellaris* var. *atrii* is differentiated in the field by the reddish purple pileus with tuberculately striate margin and basidiomes which turn gradually yellow to yellowish orange. The bright coloration of the pileus, septate pileocystidia and nature of hymenial cystidia place the present taxon in the subgenus *Russula*. The morphological and microscopic characters of specimens from Kumaon Himalaya match almost completely those of *R. puellaris* Fr. except slight variation in the spore ornamentation. Romagnesi (1967) reported the spore size ranging from 6.5 – 8.5 (9.5) x 5.5 – 7 µm with wart height extending up to 1.25 µm for *R. puellaris* Fr. var. *puellaris*. Spores are smaller in *R. puellaris* var. *minutalis* (Britzelm.) Singer, 6.5 – 7 (8) x 5 – 6.2 (6.5) µm with warts up to 1.25 µm. The present taxon however, differs from both the above mentioned varieties in having slightly larger spores. The proximity with *R. puellaris* in the parsimonious tree justify the undescribed taxon *R. puellaris* var. *atrii* (Fig. 5).

Acknowledgements

We are thankful to Dr. M. Sanjappa, Director and Dr. D.K. Singh, Joint Director, Botanical Survey of India, Kolkata and Dr. V.S. Rao, Director, Agharkar Research Institute, Pune for providing facilities during the present study, to Dr. N.S. Atri, Punjabi University, Patiala (India) and Dr. Teresa Lebel, Royal Botanical Gardens, Melbourne (Australia) for critically reviewing the manuscript and checking the Latin diagnosis. Editorial assistance by Dr. L.L. Norvell, PNW Mycology Service, Portland (USA) is also duly acknowledged. This research is partially supported by funding to S.L. Miller from the National Science Foundation (DEB – 0315607), USDA (2003 – 01542) and EPSCoR (04 – 47681). We gratefully acknowledge Terry McLean from the Nucleic Acid Exploration Facility at the University of Wyoming for sequencing these specimens.

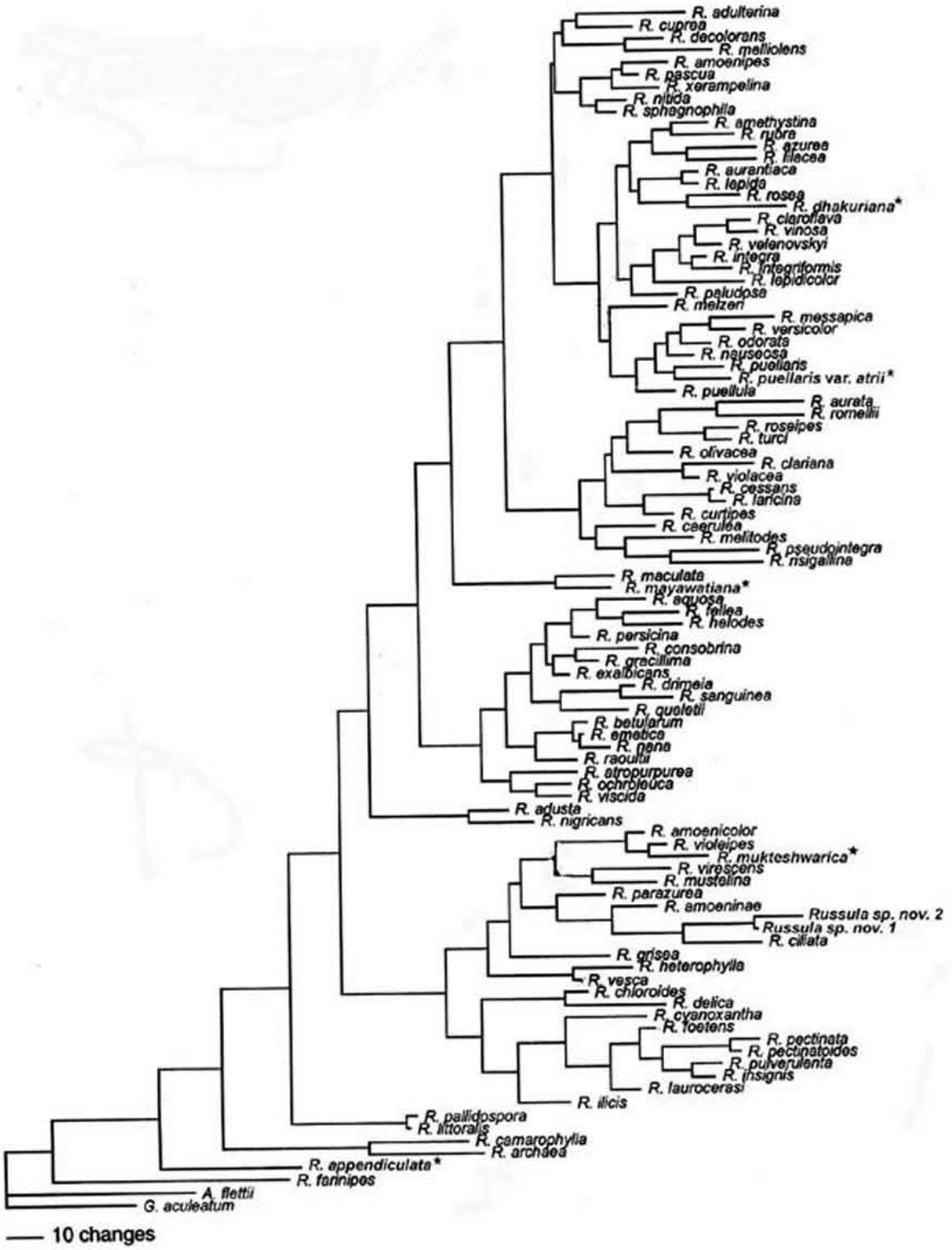


Fig. 5. Best of 16 most parsimonious trees (1 ln likelihood – 12607, 60827) of 2183 steps inferred from equally weighted parsimony analysis of ITS1, 5.8S and ITS2 rDNA sequences depicted as a phylogram. The CI was 0.285, the RI was 0.530 and the RC was 0.151.

Literature Cited

Atri NS, Saini SS. 1989. Family *Russulaceae* Roze – a review, in M.L. Trivedi, B.S. Gill, S.S. Saini (eds.) 115–128. Plant science research in India, present status and future challenges. New Delhi, India.

Atri NS, Saini SS, Mann DK. 1991. Genus *Russula* Pers. in Dalhousie, in N.C. Aery & B.L. Choudhary (eds.) 92–99. Botanical researches in India. Udaipur, India.

Atri NS, Saini SS, Saini MK. 1993. Some Russulaceous fungi from Dalhousie (H.P.) – The genus Russula Pers. Geobios New Reports 12: 137–140.

Atri NS, Saini MK, Saini SS. 1994. Indian *Russulaceae* Roze – A checklist, in T.A. Sharma, S.S. Saini, M.L. Trivedi & M. Sharma (eds.) 81– 93. Current researches in Plant Science. Dehradun, India.

Atri NS, Saini SS, Saini MK. 1997. Studies on genus *Russula* Pers. from north western Himalayas. Mush. Res. 6 (1): 1–6.

Atri NS, Saini SS, Saini MK, Gupta AK. 1992. Two new records of genus *Russula* from India. Geobios New Reports 11: 101–103.

Das K. 2005. Taxo-Ecological studies on the family *Russulaceae* of Kumaon Himalaya. Text, 179 pp, 31 pl., 75 fig., D. Phil. thesis.

Das K, Sharma JR. 2003. New records of *Russula* from Kumaon Himalaya. Indian Journal of Forestry 26 (3): 320–326.

Das K, Miller SL, Sharma JR, Sharma P, Bhatt RP. (2005) 2006. *Russula* in Himalaya 1: A new species of subgenus *Amoenula*. Mycotaxon 94: 85–88.

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index Herbariorum. Part 1: Herbaria of the world, 86th ed. Brox: New York Botanical Garden.

Kelly KL, Judd DB. 1955. The ISCC-NBS Method of Designating Colors and a Dictionary of Colour Names. ISCC-NBS Color-Name Charts Illustrated with Centroid Colors. National Bureau of Standards Circular 553. U.S. Government Printing Office, Washington, DC.

Miller SL, Buyck B. 2002. Molecular phylogeny of the genus *Russula* in Europe with a comparison of modern infrageneric classifications. Mycol. Res. 106 (3): 259–276.

Miller SL, Henkel TW. 2004. Biology and molecular ecology of subiculate *Lactarius* species from Guyana, in C.L. Cripps (ed.). Fungi in forest ecosystems – systematics, diversity and ecology. New York Botanic Garden, vol. 89, pp 297 – 313.

Miller SL, McClean TM, Walker JF, Buyck B. 2001. A molecular phylogeny of the *Russulales* including agaricoid, gasteroid and pleurotoid taxa. Mycologia 93: 344–354.

Rawla GS. 2001. Himalayan species of *Russula* Pers. Ex S.F. Gray, in P.C. Pande & S.S. Samant (eds.) 1 – 48. Plant Diversity of the Himalaya. India.

Romagnesi H. 1967. Les Russules d'Europe et d'Afrique du nord. Bordas, Paris.

Saini SS, Atri NS, Singer R. 1982. North Indian *Agaricales*–II. Sydowia Annales Mycologici Ser II 35: 238–241.

Saini SS, Atri NS, Anjula, Saini MK. 1993. Studies on the Russulaceous fungi from Narkanda (H.P.) – The genus *Russula* Pers. J. Indian Bot. Soc. (suppl.) p 36.

Shajahan M, Samajpati N. 1995. Ectomycorrhizal fungi of *Shorea robusta* G.f. from West Bengal. Ind. J. Mycol. Res. 33: 105–117.

Singer R. 1986. The *Agaricales* in modern taxonomy. 4th ed. Vaduz J. Cramer. Germany.

Watling R, Gregory NM. 1980. Larger fungi from Kashmir. Nova Hedwigia 26 (3): 320–326.

MYCOTAXON

Volume 95, pp. 217–228 *January–March 2006*

The distinction between *Menegazzia cincinnata* and *M. valdiviensis* (*Parmeliaceae*)

Mónica T. Adler

adler@bg.fcen.uba.ar
Departamento de Biodiversidad y Biología Experimental
Facultad de Ciencias Exactas y Naturales
Universidad de Buenos Aires (Ciudad Universitaria)
1428 Buenos Aires, Argentina

Susana Calvelo

scalvelo@crub.uncoma.edu.ar
Centro Regional Universitario Bariloche
Universidad Nacional del Comahue
8400 Bariloche RN, Argentina

John A. Elix

John.Elix@anu.edu.au
Department of Chemistry, Faculty of Science
Australian National University, Canberra, ACT 0200, Australia

Abstract—The aim of the present investigation is to assess the status of *Menegazzia cincinnata* and *Menegazzia valdiviensis*, two closely related species from southern South America. The main characters used previously to segregate the two species are discussed and evaluated. The main conclusions are that the presence/absence of thamnolic acid in the thallus medulla correlates well with differences in ascospore length, which, therefore, can be used in combination to propose a new delimitation of both species. In addition, differences in geographic distribution are showed to be consistent with this distinction. A complete chemical profile is detailed for each species, thus redefining, correcting and complementing previously published data. Gyrophoric acid is reported for the first time for the complex and is, with lecanoric acid, consistently present in both species. Other secondary metabolites are reported for the first time for the species.

Key words— Patagonian lichenized Ascomycota, South American lichens.

Introduction

Prior to 1937, *Parmelia cincinnata* was the only known fertile species in subgenus *Menegazzia* Vain. to have a greenish yellow thallus and lacking vegetative diaspores. In 1937 Räsänen described a second species with these features, *Parmelia* (*Menegazzia*)

valdiviensis, which reportedly differed from the former by its 2–spored asci, in contrast to the mostly 8–spored asci of *M. cincinnata*. The distinction was subsequently maintained by Santesson (1942), who placed *M. cincinnata* in subgenus *Octospora* R. Sant. and *M. valdiviensis* in subgenus *Dispora* R. Sant. However, he used a second key character to distinguish the two species; namely that the apothecial margin of *M. cincinnata* was thick crenulate whereas *M. valdiviensis* had an entire, thin apothecial margin. At that time, cortical and medullary chemistry were not used as taxonomic characters. Calvelo & Adler (1994) and Bernasconi et al. (2002) subsequently utilized the same features to distinguish the two species, because, at that time, the type material of *M. valdiviensis* was unavailable. However, they did note a further possible distinguishing character, the presence of medullary thamnolic acid in *M. valdiviensis* that was absent in *M. cincinnata*. When the type material of *M. valdiviensis* was examined, it became evident that the asci were not 2–spored but 8–spored, or rarely 6–spored as recently published (Bjerke 2005). Consequently, the reported distinguishing characters were reduced to "thalline exciples of young apothecia crenulate and slightly corrugate, lobes distinctly yellow or yellow–green, asci well–developed" for *M. valdiviensis* and "thalline exciples of young apothecia thin, smooth and not crenulate; lobes greenish or yellow–green; asci often underdeveloped" for *M. valdiviensis* (Bjerke 2005). Given these characters, the distinction of the two species is very difficult and they are therefore considered to comprise a complex of two very closely related species.

The present investigation of *M. cincinnata* and *M. valdiviensis* is part of a more extensive study of *Menegazzia* A. Massal. from southern South America (Adler & Calvelo 1996; Calvelo & Adler 1994; Bernasconi et al. 2002). This paper discusses the taxonomic characters used to segregate *M. cincinnata* from *M. valdiviensis*, reports further characters previously overlooked, and proposes a new delimitation of, and redescribes, both species.

Materials and Methods

Collection sites: Samples of *Menegazzia* collected from the western areas of Chubut, Neuquén, Río Negro and Tierra del Fuego provinces between 39° S and 55° S (Argentina), from Chile near the border with Argentina between 36° S and 55° S, and from the southern Chilean Pacific islands were studied. Phytogeographically, the area is quite homogeneous; it belongs to the Antarctic Region, Sub–Antarctic Province (Cabrera 1994). Autochthonous species of *Nothofagus* occur as the principal forest cover, from 700 m to 1,800 m above sea level in the north, and from sea level to 600 m in the south. However, there are important mean annual precipitation differences, varying from 3,000 mm in the north to 545 mm in the southernmost part of the study area (Conti 1998, Tuhkanen 1992).

Specimens examined: The studied material had the main following characteristics: thallus with a grayish yellow, yellowish green to yellowish olive–green upper surface, absence of vegetative propagules, frequently with apothecia, and presence of gyrophoric and lecanoric acids as constant medullary substances. The study is based on *Menegazzia* specimens collected by Adler and Calvelo and on herbarium material. The specimens cited below were selected from a much larger number of collections studied and housed in the following herbaria: BAFC, BCRU, H, S, TUR. Part of the authors' personal

collections are kept in the Calvelo private herbarium (and cited as #). An "isolectotype" of *Parmelia cincinnata* (S), previously labeled by Galloway "Cotypus ex herb. Acharius", was examined. A photograph of this specimen, collected by Archibald Menzies in February 1787, at New Year's Harbour, Staten Island, is available online (http://linnaeus.nrm.se/botany/kbo/ach/ps/L1196.html.en). This specimen had been previously cited as the type material (Santesson 1942). An isotype of *Parmelia valdivienis*, collected by Hollermayer (number 1146 H, ex herb. Räsänen) at Cordillera Pelada, La Reina (Chile) was also studied. So far it has not been possible to clarify whether this specimen is a duplicate of that cited in the protologue (number 6883 of herbarium Gunkel and presumably kept at VALD). We consider that the envelope at H labeled as TYPE (Hollermayer 1146) is the holotype and that a second specimen, lacking the type annotation, is an isotype. The latter was examined during the present study and its identity as an isotype was confirmed by Dr. Orvo Vitikainen (pers. comm.). The names of the herbaria are abbreviated according to Holmgren & Holmgren (2001) and the names of the authors according to Brummitt & Powell (1992).

Laboratory analysis: Thallus and apothecial morphology was examined with a Zeiss Stemi SR dissecting microscope. Observations with the light microscope were performed on hand made thin sections, after immersing the material in 10 % KOH for 1 minute, washed with distilled water, and stained with lactophenol cotton blue. The largest mature ascospores in each slide were chosen and measured to obtain the final size range. For length and width the medial dimensions and standard deviation were calculated. Ascospores measurements were then expressed as minimum value measured – medial minus standard deviation – medial plus standard deviation – maximum value.

Chemical Analysis: The identification of lichen substances present in each of the specimens examined was performed by routine thin-layer chromatography (Culberson & Ammann 1979) and by comparison with authentic samples. The methodology used for high performance liquid chromatography has been described previously (Elix et al. 2003).

Results and Discussion

Species characters in the *Menegazzia cincinnata–M. valdiviensis* complex

During our study of the *Menegazzia* collections, it became obvious that some characters commonly used to segregate *M. cincinnata* from *M. valdiviensis* were ambiguous because intermediate forms were observed (e.g. the apothecial margin) and that the color of the upper surface of freshly collected material was extremely variable. As the frequency of intermediate forms often made it impossible to identify a significant proportion of collections, we were compelled to review the taxonomic value of the characters used previously. These characters are discussed and their use evaluated for consistently separating the two species.

Thallus morphology

Lobe width. The lobe widths reported for *M. cincinnata* were 1.5–2 mm (Santesson (1942), 1.5 mm (Calvelo & Adler 1994), 1.2–2.0 mm (Bjerke 2005) whereas for *M.*

valdiviensis they were 1.5–3.0 (Santesson 1942, Bjerke 2005) and 1–2 mm (Calvelo & Adler 1994). Results from the present study indicate that the range of lobe width throughout the complex is 0.5–2 (–3) mm. Differences observed in lobe width do not correlate with the main differential characters observed in this study, and are therefore not used to segregate the two species.

Branching pattern of the lobes. Previously this has been described as being irregular for *M. cincinnata* (Santesson 1942, Calvelo & Adler 1994, Bjerke 2005), whereas for *M. valdiviensis* it was characterized as being "irregularly dichotomously ramified" (Santesson 1942), dichotomous at the periphery and subdichotomous to irregular at the centre of the thallus (Calvelo & Adler 1994) and irregular (Bjerke 2005). Our present observations show that most of the specimens had subdichotomously branched lobes, more rarely dichotomously branched, and very rarely irregular branched lobes. As a consequence this feature cannot be used to distinguish the two species.

Perforations. For *M. cincinnata* the perforations have been described as rather numerous, small, usually less than 0.5 mm diam. (Santesson 1942), dispersed (sparse) 0.2–0.6 (–1.0) mm diam. (Calvelo & Adler 1994), scarce to numerous (Bernasconi et al. 2002), sparse to numerous 0.2–0.7 (–1.0) mm (Bjerke 2005) whereas for *M. valdiviensis* they were described as sparse and up to 0.7 mm diam. (Santesson 1942), sparse and up to 0.5 mm diam. (Calvelo & Adler 1994) and sparse to numerous, small 0.05–0.7 mm diam. (Bjerke 2005). Our present observations showed that the perforations exhibit similar variation all over the whole complex. The smaller perforations, located at the periphery of the thallus, are 0.05–0.8 mm diam., whereas the larger ones, situated at the thallus centre, are 1–2 (–3) mm diam. Perforations are sparse, moderate or numerous depending on the specimen and are not correlated with other characters. Consequently this feature cannot be used to distinguish the two species.

Color of the upper surface. The upper surface of *M. cincinnata* has been described as pale yellow or yellowish gray, sometimes greenish (Santesson 1942, Calvelo & Adler 1994) to greenish gray (Calvelo & Adler 1994), yellowish gray (Bernasconi *et al.* 2002) or pale yellow or yellowish gray, often with a greenish tinge (Bjerke 2005) whereas the upper surface of *M. valdiviensis* was described as pale grayish yellow or greenish straw-colored (Santesson, 1942), yellowish green (Calvelo & Adler 1994, Bernasconi et al. 2002), greenish gray or pale yellow green (Bjerke 2005). Only Bjerke (2005) segregated the two species using the color of the lobes as a differential character in his key: *M. cincinnata* characterized by "lobes distinctly yellow or yellow-green (paler in shade forms)" and *M. valdiviensis* by "lobes greenish or yellow-green". Our survey of numerous collections has shown this to be an ambiguous character, since numerous intermediate colors can be observed in the field, some even having an olive tinge and other specimens from the north seem to be more yellowish. Further difficulties arise because the color varies between fresh to dry specimens, making it impossible to compare herbarium material, and type specimens in particular. Moreover, the chemical analysis of specimens with different colored upper surface showed no correlating differences in cortical substances or in their concentrations. The variations are probably due to environmental factors yet to be established. For these reasons we consider that the color of the upper surface cannot be used to segregate the two species.

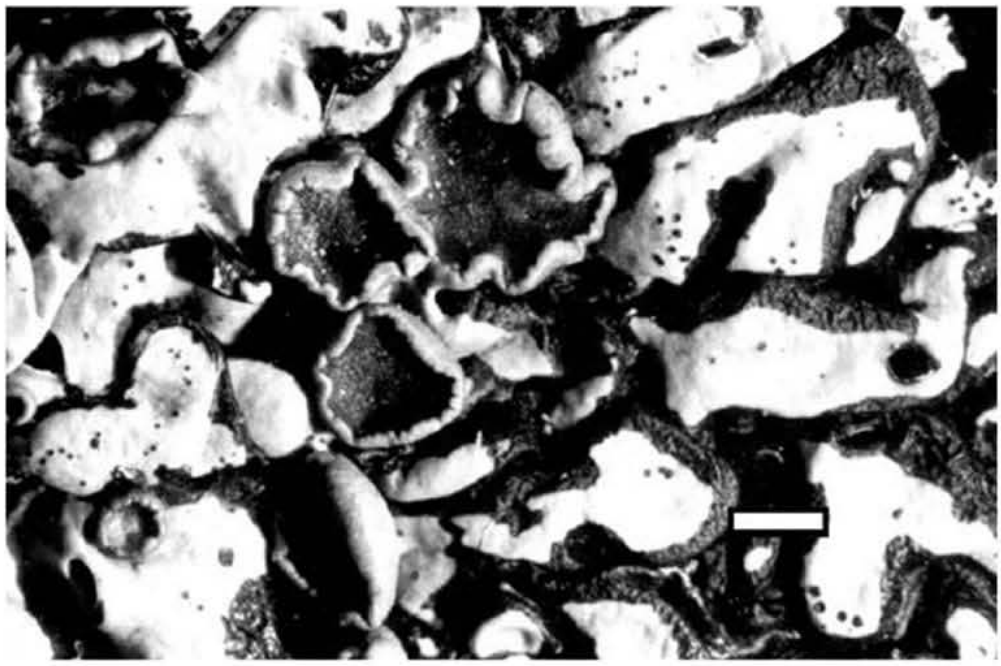


Fig. 1. Part of the isotype of *Parmelia* (*Menegazzia*) *valdiviensis* studied (Hollermayer 1146), showing apothecia with slight to very crenulate (almost incised) apothecial margins.
Scale = 1 mm.

Apothecial morphology and anatomy

Morphology of the Apothecial Margin. The presence of a crenulated apothecial margin was previously considered to be characteristic of *M. cincinnata* (Santesson 1942, Calvelo & Adler 1994, Bernasconi et al. 2002, Bjerke 2005), whereas a thin, entire (smooth) apothecial margin was considered typical of *M. valdiviensis* (Santesson 1942). Even very recently when it was recognized that "the thickness and crenulation of the thalline exciple of *M. cincinnata* is more variable than previously expected" the species were still differentiated as follows: "thalline exciples of young apothecia crenulate and slightly corrugate: *M. cincinnata*" and "thalline exciples of young apothecia thin, smooth and not crenulated: *M. valdiviensis*" (Bjerke 2005). During the present survey, we frequently observed that only one type of apothecial margin (crenulate or entire) commonly develop in a particular specimen, but it was possible to find specimens with both types of apothecia developing side by side, or other thalli with apothecia with slightly crenulate margins among other apothecia with markedly crenulate margin, as is the case for the type of *M. valdiviensis* (Hollermayer 1146, Fig. 1).

A study of numerous collections led us to conclude that this too is an ambiguous character that does not clearly segregate the species. Nevertheless, there is some correlation between the type of apothecial margin and the main differential characters established in the present study, and this will be discussed below (under Relevant taxonomic characters).

Ascospores. The type material of *M. valdiviensis* was recently reported to have mostly 8–spored asci (Bjerke 2005) so it does not belong to subgenus *Dispora* as was previously reported. We have now confirmed that all specimens in the complex generally have asci

with 8, sometimes with 6, or rarely with 4 ascospores, and very frequently have mature apothecia with mature asci. Bjerke (2005) reported that *M. valdiviensis* was characterized by the "frequency of underdeveloped asci" but we do not consider this to be a reliable distinguishing character. According to our observations the mature ascospores in all the specimens of the complex are hyaline, ellipsoidal and with smooth to granular inner contents. Very mature (probably over mature) ascospores retained (not released) in the asci are commonly brown to tan. The epispore is commonly rather thick (2–6 µm) in mature ascospores, but is sometimes thinner (1–1.5 µm). The granulation of the inner content, the color of the ascospores and the thickness of the epispore vary in a similar way over all the specimens of the complex, and therefore cannot be used as differential characters.

However, the measurement of a very large number of ascospores revealed the presence of two discontinuous groups of specimens:

Group A, with small ascospores, mostly less than 30 µm in length and in the range [(16-)20–29(-30) × (11-)12.5–20(-22) µm]; similar to that given for *M. cincinnata* by other authors, Santesson (1942) [20–30(-35) × 12–20(-23) µm], Bjerke (2005) [19–28 × 12–18 µm].

Group B, with large ascospores, very frequently exceeding 30 µm in length, and in the range [(20-)26.5–35(-39) × (12-)15–23.5(-26) µm]; similar to that given for *M. valdiviensis* by Santesson (1942): 21–34 × 11–19 µm, but not by Bjerke (2005): 19.0–29.5 ×11.0–18.0 µm.

The possibility of segregating the collections in the complex by ascospores sizes into two groups, and the coincidence of these groups with the two main chemical groups, indicated that ascospores size is a good discriminator, which will be discussed below.

Conidiomata and conidia

In this complex, conidiomata (pycnidia) are frequently present on the thalli immersed in the upper surface. They are globose, 100–200 µm diam. and with a reddish to brown ostiole. Pycnidia characteristics have not been used previously to distinguish *M. cincinnata* and *M. valdiviensis*. We also observed that the conidia are similar throughout the complex, being bacilliform frequently with acute ends to very weakly fusiform, (4-)6–7(-8) µm long. These observations are consistent with previous reports (Santesson 1942, Calvelo & Adler 1994, Bernasconi et al. 2002) and can not be used to segregate the species.

Secondary Chemistry

Thallus chemistry. Previous studies reported that usnic and lecanoric acids were the characteristic substances present in *M. cincinnata* (Calvelo & Adler 1994; Bernasconi et al. 2002; Bjerke 2005). Two additional unidentified compounds were also reported: unid. 1 (absent to minor), with UV spectrum similar to lecanoric acid, and unid 2 (trace to minor), also probably similar to lecanoric acid; thamnolic acid was reported as an accessory substance in some specimens (Bjerke 2005). Usnic, lecanoric and thamnolic acids have been reported as being characteristic for *M. valdiviensis* (Calvelo & Adler 1994, Bernasconi et al. 2002), but Bjerke (2005) reported the presence of usnic and lecanoric acids as constant (characteristic) compounds, together with three other secondary metabolites: thamnolic acid (absent to major), and the unidentified compounds unid. 1

(absent to trace) and unid. 2 (minor to major), the same two compounds reported for *M. cincinnata*.

Our thallus TLC analyses (confirmed by HPLC) of the specimens in the complex led to the identification of the following metabolites: usnic, lecanoric and thamnolic acids (all reported previously), gyrophoric acid, 5–*O*–methylhiascic acid, decarboxythamnolic acid, atranorin, hiascic acid, strepsilin, di–*O*–methylstrepsilin, alectosarmentosin, norascomatic acid and secalonic acid A. More particularly, we established that the medullary depsides gyrophoric and lecanoric acids were present in all specimens (albeit in variable amounts). The third depside, 5–*O*–methylhiascic acid, was detected in the large majority of specimens studied. Our second find concerned the occurrence of thamnolic acid. Approximately half of the collections studied lacked thamnolic acid whereas the remainder contained minor to major amounts of this compound. The specimens could be segregated into two groups: Group A (chemistry): thamnolic acid absent (including the type of *M. cincinnata*) and Group B (chemistry): thamnolic acid present (including the type of *M. valdiviensis*).

Alectosarmentosin and norascomatic acid were detected in some specimens of Group A whereas secalonic acid A was only detected in some specimens of Group B which had yellow patches in the medulla. Traces of atranorin, hiascic acid, strepsilin and di–*O*–methylstrepsilin were detected in some of the specimens in both groups A and B.

In summary, the related depsides gyrophoric, lecanoric, 5–*O*–methylhiascic and hiascic acids are common to all specimens in this complex, so the most important species diagnostic compounds are the β-orcinol *meta*-depsides, thamnolic and decarboxythamnolic acids.

Usnic acid was present in minor to submajor amounts in c. 70% of the specimens of *M. cincinnata*, and c. 50% of the specimens of *M. valdiviensis* as delimited here. In the remaining specimens of both species, usnic acid was present in trace amounts or it was not detected (by TLC). Given this variation, the concentration of cortical usnic acid cannot be used as a differential character in this species complex.

Apothecial chemistry. We observed that the apothecial medullary layer under the hymenium was white except for very old herbarium collections, which frequently have a yellow to orange medulla. Recently the yellow–orange color of the apothecial medulla in this complex was attributed to the presence of anthraquinones (Bjerke 2005). In our investigations the HPLC analysis of apothecia detached from recently collected specimens could not detect anthraquinones and showed that apothecial chemistry was identical to that of the corresponding thallus, apart from the concentration of usnic acid (which was lower in the apothecia).

Ecology and Substratum

The majority of the specimens examined in the present study were collected in *Nothofagus* forests between sea level and c. 1300 m. The specimens were usually corticolous growing on the branches and/or trunks of various species of *Nothofagus* (*N. alpina*, *N. antarctica*, *N. betuloides*, *N. dombeyi*, *N. obliqua*, *N. pumilio*) as well as on *Fitzroya cupressoides*, *Drimys winteri*, and *Lomatia hirsuta*; rarely were they collected on rocks. Neither *M. cincinnata* nor *M. valdiviensis* were substrate specific.

Distribution

In previous studies *M. cincinnata* was reported from Patagonia, Tierra del Fuego and southern Chilean Pacific islands (Santesson 1942), southern South America, particularly for the continental areas of Argentina (Calvelo & Adler 1994), Patagonia and Isla de los Estados, Argentina and Chile (Bernasconi et al. 2002) and southernmost South America from approximately 46° 00' S (Laguna San Rafael) to the southernmost part of Tierra del Fuego (Bjerke 2005). *Menegazzia valdiviensis* was previously reported from the Valdivian region of Chile, Patagonia (area of Nahuel Huapi lake) and from one Pacific Chilean island locality (Santesson 1942, Calvelo & Adler 1994), and Tierra del Fuego (Calvelo & Adler 1994), Patagonia (Argentina and Chile, Bernasconi et al. 2002), southern South America along the Cordillera de los Andes, 37° 40´S (Parque Nacional Nahuelbuta in Chile) to southernmost South America (probably to 52° S, Bjerke 2005).

In the present study we found that the specimens studied corresponding to chemical Group A, thamnolic acid absent, occurred mostly in the Andean and sub Andean localities of Chile and Argentina, 88% at latitudes above 42° S and only 12% in southern Andean localities below 50° S. In contrast, 91% of the examined specimens of chemical Group B, thamnolic acid present, were from southermost localities below 50° S, and only 9% from northern Andean areas of Chile and Argentina.

Relevant taxonomic characters and conclusions

The major result of this study was the discovery that there was a correlation between the presence or absence of thamnolic acid in the thallus medulla and ascospores length. We believe that these two characters should be used to segregate *M. cincinnata* from *M. valdiviensis*. Those specimens with small ascospores (mostly less than 30 µm long) that lack thamnolic acid are considered to represent *M. cincinnata*, whereas those with large ascospores (mostly longer than 30 µm) and with thamnolic acid represent *M. valdiviensis*. Only ca. 10 % of the specimens studied could not be segregated in this manner because they contained thamnolic acid but had small ascospores. This could possibly be explained by the fact that the ascospores were immature, or even that these individuals represent hybrids of the two species.

We also found that *M. cincinnata* and *M. valdiviensis* as segregated here have disjunct distribution in southern South America with the former exhibiting a more northerly distribution (north of 42° S) and the latter with a preference for more southerly areas (below 50° S).

In the case of *M. cincinnata* as defined above, we observed that 80% of specimens had an entire apothecial margin, 8% had a crenulated apothecial margin, and 12% had apothecia with both types of margin. In *M. valdiviensis*, on the other hand, 65% of specimens had apothecia with a crenulated margin, 20% had apothecia with an entire margin and 15% had apothecia with both types of margin. We conclude that the characteristics of the apothecial margin and the color of the thallus can not be used to distinguish the two species because they are too variable. Even so, we did observe that *M. valdiviensis* was more likely to have apothecia with a crenulated margin and *M. cincinnata* more likely to have apothecia with an entire margin, the opposite of what had been accepted previously.

The species

Menegazzia cincinnata (Ach.) Bitter

In Hedwigia 40: 172 (1901).

Parmelia cincinnata Ach., Meth. Lich. 252 (1803). Type: ARGENTINA, Tierra del Fuego Province, Staten Island (Isla de los Estados), New Year´s Harbour, II.1787, A. Menzies, s.n. (E-lectotype fide Galloway 1995, p. 103, S-isolectotype! labeled by Galloway "cotypus").

Lichen cincinnatus Sm. ex Ach., Meth. Lich.: 252 (1803) nom. illeg. Art. 52.1.

Lichen bullatus Menzies ex Ach., Lich. Univ.: 495 (1810) nom. illeg. Art. 52.1.

Parmelia cincinnata Lam., Encycl. Method. Bot., Suppl. 3: 406 (1813) nom. illeg. Art. 52.1.

Thallus foliose, mostly corticolous, up to c. 10 cm diam., tightly attached to the substratum. Lobes narrow, 0.5–2 (–3) mm wide, straight or irregularly zigzagging, parallel and contiguous at the margins, subdichotomously or dichotomously branched or rarely with irregular branching, not parallel at the centre. Upper surface without soredia or isidia, grayish yellow to greenish yellow, sometimes with olive tinge. Perforations circular to elliptical, 0.05–2 (–3) mm diam., sparse or moderate, rarely numerous, always on the median line of the lobes. Medulla white in the upper part of the cavity, black in the lower part. Lower surface black, scrobiculate.

Apothecia common, adnate to shortly stipitate, disc imperforate, 1–4 (–10) mm diam., pale to chestnut brown to dark brown; margin mostly entire, not crenulated, or sometimes slightly crenulated, rarely markedly crenate, sometimes with both types of margin in the same thallus. Asci elongated to subglobose, 100–120 × 50–60 µm when mature, usually with 8, sometimes with 6 or rarely with 4 ascospores. Ascospores hyaline, ellipsoid, smooth to slightly granular (vacuolated) within when mature, with a brown epispore when overmature, (16–) 20–29 (–30) × (11–) 12.5–20 (–22) µm, epispore (1–) 2–3 (–6) µm thick.

Conidiomata (pycnidia) common, immersed, globose, up to 200 µm diam. Conidia bacilliform to weakly fusiform commonly with acute ends, (4.5–) 6–7.5 (–8) × 1–1.5 µm.

Chemistry: Upper surface K–; containing usnic acid (submajor to trace), ±atranorin (trace). Medulla K– or K+ pale yellow, sometimes orange in the algal layer, C– or C+ pink or red, sometimes red in the algal layer, KC– or KC+ pink, orange or red; containing gyrophoric acid (major to minor), lecanoric acid (minor to trace), ±5-*O*-methylhiascic acid (minor to trace), hiascic acid (minor to trace), alectosarmentosin (minor to trace), strepsilin (minor to trace), ±3-*O*-methylstrepsilin (trace), ±di-*O*-methylstrepsilin (trace), ±norascomatic acid (trace).

REPRESENTATIVE SPECIMENS EXAMINED— **Argentina.** Prov. de Chubut. Lago Futalaufquen, E side, on *Nothofagus. antarctica*, 20 I 1938, A. Kalela 238a (H). Prov. del Neuquén. Lago Aluminé, Angostura, c. 1400 m, *Araucaria araucana–N. pumilio* forest, 24 XII 1937, A. Kalela 156d (H); 3 km SE of Angostura, 1120 m in heath, on *N. antarctica*, 24 XII 1937, A. Kalela 165c (H). Paso Tromen, near Río Malleo, on *N. alpina*, 15 II 1994, Messuti s.n. (Herb. Calvelo # 951). Lago Quillén, S side, on *N. obliqua*, 28 XII 1937, A. Kalela 179c (H). Lago Nahuel Huapi, San Leo, alt. 1100 m, on twigs of *Nothofagus*, 1896, P. Dusén 165 (S). Provincia Río Negro. Bariloche, Arroyo Casa de Piedra, on *N. dombeyi*, alt. 800 m, 28 V 1995, Calvelo (# 990), 5 I 1995 Calvelo (# 992); E

side, alt. 850 m, on *N. dombeyi*, 7 II 1986, Calvelo (# 57); W side, 16 V 1988, Calvelo (# 749). Cerro López, 1060 m, on *N. pumilio*, 4 IV1987, Calvelo (# 48), 1300 m, 25 V 1999, Calvelo (# 1614). Lago Gallardo, 5 III 1999, Calvelo (# 1618). Llao Llao, pathway Soria Moria to Lago Escondido, on *N. dombeyi*, 7 X 1993, Calvelo (# 913). Cerro Bella Vista, W slope, alt. 1350 m, on *N. pumilio*, 27 I 1990, Calvelo (Herb. C.-422). Cerro Catedral, 1300 m, on *N. pumilio*, 24 III 1987, Calvelo (# 752, BCRU-000754). Cerro Chalhuaco, 31 X 1999, Bernasconi s. n. (# 1617). Cerro Tronador, pathway to Castaño Overa, 1150 m, on *N. pumilio*, 8 IV 1993, Calvelo (# 844), 1300 m, Calvelo (# 845). Puerto Blest, 14 VII 1897, Dusén 162a (S), Puerto Blest, pathway to Laguna Ortiz Basualdo, on *Fitzroya cupressoides*, 1300 m, 12 III 1994, Calvelo (# 954). Villa Tacul, coast of lago Nahuel Huapi, on *Lomatia hirsuta*, 7 X 1993, Calvelo (# 918). Provincia de Tierra del Fuego. Isla de los Estados, Bahía Flinders, W part of bay, 54° 49' S, 64° 36' W, 120 m, on *Nothofagus*, 7 XI 1972, Imshaug 53457 (BCRU-01597). Isla Grande, Aguas Claras, Calvelo & Adler XI 1997 (BAFC-39218). **Chile.** Región de los Lagos, Prov. de Llanquihue. Parque Nacional V. Pérez Rosales, mallín, III 1970, Redón 02157 (TUR-12299).

Menegazzia valdiviensis (Räsänen) R. Sant.

In Ark. Bot. 30A(11):26 (1942).

Parmelia valdiviensis Räsänen, Revista Univ. (Santiago) 22: 197 (1937). Type: CHILE, Provincia de Valdivia, Cordillera Pelada, la Reina, cortícola, 900 m., 30.XI.1934, A. Hollermayer 1146, ex herb. Räsänen (H-holotype, H-isotype!).

Thallus foliose, corticolous or rarely saxicolous, tightly attached, up to c. 10 cm diam., orbicular. Lobes narrow, 0.5–2 (–3) mm wide, straight or irregularly zigzagging, mainly parallel and contiguous, infrequently separated, subdichotomously to dichotomously branched, not parallel at the centre of the thallus. Upper surface lacking isidia or soredia, greenish yellow to grayish yellow, occasionally with olive tinge. Perforations circular to elliptical, 0.1–2 (–3) mm diam., sparse to moderate, rarely numerous, occurring on the median line of the lobes. Medulla white, rarely with yellow patches in the upper part of thallus cavity, black in the lower part. Lower surface black, scrobiculate.

Apothecia adnate to shortly stipitate, disc imperforate, chestnut brown to tan, 1–4 (–5) mm diam., margin usually crenulated, infrequently entire, sometimes apothecia with both types of margin same thallus. Asci elongated to subglobose when mature, 100–150 × 50–70 µm, mostly with 8, sometimes with 6, or rarely with 4 ascospores. Ascospores hyaline, ellipsoid, smooth inside to somewhat granular when mature, with a brown to tan epispore when over mature. Ascospores (20–) 26.5–35 (–39) × (12–) 15–23.5 (–26) µm, epispore (1–) 2–3 (–6) µm thick.

Conidiomata (pycnidia) frequent, globose, immersed, 85–120 µm diam.; conidia bacilliform to weakly fusiform, (5–) 6.5–7.5 (–8) × 1–1.5 µm, commonly with acute ends.

Chemistry: Upper cortex K–; containing usnic acid (submajor to trace), ±atranorin (trace). Medulla K+ yellow, C– or C+ pale pink, KC+ yellow turning reddish orange; containing gyrophoric acid (major to minor), lecanoric acid (minor to trace), ±5-*O*-methylhiascic acid (minor to trace), thamnolic acid (major to minor), decarboxythamnolic acid (minor to trace), hiascic acid (trace), ±secalonic acid A (minor), ±strepsilin (trace), ±di-*O*-methylstrepsilin (trace), ±alectosarmentosin (trace).

REPRESENTATIVE SPECIMENS EXAMINED— **Argentina.** Provincia de Neuquén. Lago Traful, on slope, on *N. pumilio*, 19 XI 1937, A. Kalela 59:b (H). Provincia Río

Negro. Bariloche, Lago Nahuel Huapi, 5 XI 1896, P. Dusén 168 (S). Prov. de Tierra del Fuego. Isla Grande, Cerro Cabras, on *N. pumilio*, 460 m, 28 XII 1986, S. Stenroos 2161 (H), Valle Carbajal, Sierra de Sorondo, *Nothofagus* forest, 54° 43' S, 68° 07' W, 300 m, 28 XI 1971, Imshaug 55564 (BCRU-01683); N slope, on *N. pumilio*, 200 m, 6 II 1940, Santesson 750 (UPS), Cerro Chennen, SE slope, alt. 200–250 m, 54° 21' S, 67° 52' W, *N. pumilio* and *N. antartica* forest, 8 I 1989, Ahti (48163) & Stenroos (H), Río Larsiparsalik, on *N. betuloides* forest, XI 1997, Calvelo & Adler s. n. (BAFC-39172, 39173, 39174, 39175), Laguna Victoria, 70 m, on *N. pumilio*, Calvelo & Adler s. n. (BAFC-39168, 39169, 39170, 39171, 39176). Isla de los Estados, Port Cook, 18 XI 1902, C. Skottsberg s. n., ex Herb. Erik P. Vrang (H), Puerto Parry, *Nothofagus-Drimys*, 54° 47' S, 64° 22' W, near sea level, 10 XI 1971, Imshaug 53906 (BCRU-01598). **Chile.** Región de Magallanes, Prov. de Magallanes, Estrecho de Magallanes, NE side of Pto. Gallant, 53° 41' S, 72° 00' W, 6 X 1969, Imshaug 45104 (BCRU-01675. Isla Clarence. Southern peninsula, 40 m, 16 I 1987, S. Stenroos 2583 (H); 110 m, on *N. betuloides*, 17 I 1987, S. Stenroos 2922b (H). Isla Desolación, Puerto Angosto, 12 IV 1896, P. Dusén s.n. (S); 16 IV 1896, P. Dusén s.n.(S); 12 IV 1896, P. Dusén 226 ex herb. Malme (S). Isla Furia, E part, alt. 100 m, on *Drimys winteri*, 20 I 1987, S. Stenroos 2639 (H); on *N. betuloides*, 40 m, 20 I 1987, Stenroos 2633 (H); 100 m, on *N. betuloides*, 20 I 1987, S. Stenroos 2635 (H). Isla Newton, 30 V 1896, P. Dusén 48 (S). Prov. Última Esperanza, Fjordo de Agostini, 54°26´S, 70°26´W, 22 II 1929, H. Roivainen s. n. (H). Fjordo Almirante Martínez, 52°52'S, 73°28´W, on *N. betuloides*, 21 II 1929, H. Roivainen s.n. (H).

Acknowledgements

We are grateful to the curators of the following herbaria for the loan of material which in some cases included type specimens: BAFC, BCRU, H, S, TUR and to Dr Orvo Vitikainen for the critical information on collections. We thank Dr. Alan Fryday and Dra. Sionara Eliasaro for the revision of the manuscript. The study was supported by Secretaría de Investigación, Universidad Nacional del Comahue (Project B04 122) and CONICET (Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina), Programa de la Flora Criptogámica de Tierra del Fuego and Grant PIP 2268. MTA is Member of the Research Career of CONICET (Argentina).

Literature Cited

Adler MT, Calvelo S. 1996. Two new species of the genus *Menegazzia* (*Parmeliaceae* sensu lato, lichenized Ascomycotina) from Southern South America. Mycotaxon 59: 367–372.

Brummitt R, Powell C. 1992. Authors of Plant Names. Royal Botanical Garden, Kew.

Bernasconi E, Calvelo S, Adler MT. 2002. *Menegazzia* (*Parmeliaceae*: Ascomycota) and an associated lichenicolous fungus, *Abrothallus parmeliarum*, from Patagonia, Argentina. Aust. Syst. Bot. 15: 527–534.

Bjerke JW. 2005. Synopsis of the lichen genus *Menegazzia* (*Parmeliaceae*, Ascomycota) in South America. Mycotaxon 91: 423–454.

Cabrera AL. 1994. Regiones Fitogeográficas Argentinas. Enciclopedia Argentina de Agricultura y Jardinería: Tomo 2, Fasc. 1. 1ra. reimpresión, Acme. Buenos Aires.

Calvelo S, Adler MT. 1994. *Menegazzia* (Ascomycota, Liquenizado) en la Argentina. Bol. Soc. Argent. Bot. 30: 119–125.

Conti HA. 1998. Características climáticas de la Patagonia en Flora Patagónica. Parte 1, Colección Científica del INTA, Buenos Aires, Correa, Director.

Culberson CF, Ammann K. 1979. Standardmethode zur Dünnschichtchromatographie von Flechtensubstanzen. Herzogia 5: 1–24.

Elix JA, Giralt M, Wardlaw JH. 2003. New chloro-depsides from the lichen *Dimelaena radiata*. Biblioth. Lichenol. 86: 1–7.

Galloway DJ. 1995. The extra-European lichen collections of Archibald Menzies MD, FLS (1754-1842). Edinb. J. Bot. 52: 95–139.

Holmgren P, Holmgren N. 2001. Index Herbariorum. Part 1. The Herbaria of the World, ed. 8. Regnum Vegetabile 120. New York Botanical Garden, NY.

Räsänen V. 1937. Líquenes Chilenos coleccionados por el R. P. Atanasio Hollermayer en 1927–36. Rev. Univ. (Santiago). 22: 195–211.

Santesson R. 1942. The South American *Menegazziae*. Ark. Bot. 30A (11):1–35.

Tuhkanen S. 1992. The climate of Tierra del Fuego from a vegetation geographical point of view and its ecoclimatic counterparts elsewhere. Acta Bot. Fennica 145: 1–64.

MYCOTAXON

Volume 95, pp. 229–240 *January–March 2006*

NATS truffle and truffle-like fungi 13: *Tuber quercicola* and *T. whetstonense*, new species from Oregon, and *T. candidum* redescribed

JONATHAN L. FRANK[1], DARLENE SOUTHWORTH[1] & JAMES M. TRAPPE[2]

frankjon@sou.edu

[1]*Department of Biology, Southern Oregon University 1250 Siskiyou Blvd. Ashland, OR 97520-5071, USA*

[2]*Department of Forest Science, Oregon State University Corvallis, OR 97331-5752, USA*

Abstract—Two new truffle species, *Tuber quercicola* and *T. whetstonense* (*Tuberaceae, Pezizales*), are described from southern Oregon, USA. *Tuber candidum* is redescribed. These hypogeous species are ectomycorrhizal with *Quercus garryana*. Descriptions of *T. whetstonense* and *T. candidum* include ectomycorrhizal morphotypes.

Key words—hypogeous fungi, mycorrhizas, DNA

Introduction

Recent research on biodiversity of ectomycorrhizal fungi in oak woodlands included a survey of hypogeous sporocarps at Whetstone Savanna Preserve in southern Oregon (Valentine et al. 2004, Frank et al. 2004, Frank 2005). The site is a remnant woodland of *Quercus garryana* Dougl. ex Hook. interspersed with *Ceanothus cuneatus* (Hook.) Nutt. shrublands. Eighteen species of hypogeous fungi were collected for this survey (Frank 2005), of which three were in the genus *Tuber: T. candidum, T. quercicola* sp. nov. and *T. whetstonense* sp. nov.

Molecular methods were used to compare field collections to hypogeous fungi in GenBank and to match sporocarps to ectomycorrhizas (Gardes & Bruns 1993, Valentine et al. 2004, Frank et al. 2004). Our molecular analysis supports the proposition that spiny-spored and reticulate-spored *Tuber* species form distinct clades (Zobel 1854, Frank 2005).

Tuber candidum, the most frequently collected hypogeous species at the study site, was also among the more common ectomycorrhizal morphotypes collected, second only in frequency to the ubiquitous *Cenococcum geophilum* Fr. (Valentine et al. 2004, Frank 2005). Spores from all three *Tuber* species were present in the fecal pellets of three small mammals, *Microtus californicus, Peromyscus maniculatus*, and *Reithrodontomys megalotis*, trapped at the research site (Frank 2005).

Materials and Methods

Whetstone Savanna Preserve (42°25'N, 122°54'W), owned by The Nature Conservancy, is on an alluvial plain near the Rogue River in southern Oregon. Precipitation is 40-50 cm of rainfall per year. Hypogeous sporocarps were collected by raking the ground with a short-tined garden cultivator beneath and around *Quercus garryana* (Oregon white oak, Garry oak) weekly from April through June, 2003 through 2005, and less frequently in other months. Leaf litter and soil were examined for sequestrate fruiting bodies. Specimens were described the same day (Weber et al. 1997). Sporocarps were photographed in the field with a Canon EOS digital SLR camera and in the lab under a Leica MZ75 dissecting microscope with a SPOT RT Color camera (Diagnostic Instruments, Inc.) and under a Leica DMLB compound microscope with a SPOT QE insight camera. Microscopic characters were described from razor-blade sections of fresh specimens mounted in 5% aqueous KOH. Sections were stained with Melzer's reagent (Castellano et al. 1989), rinsed and mounted with polyvinyl lactic acid glycerol (Brundrett et al. 1996) to make permanent slides for archiving with dried specimens. Collections were deposited in the herbaria of Southern Oregon University (SOC) and Oregon State University (OSC).

Mycorrhizas were obtained from soil cores taken under mature trees and seedlings (Valentine et al. 2004). Roots were rinsed over sieves, examined and mycorrhizal morphotypes photographed under the dissecting microscope. Ectomycorrhizal outer mantles were peeled with a sharp needle, mounted in water, and photographed under the compound microscope. Description of cell morphology of sporocarps and mycorrhizas follows terminology in Goodman et al. (1996).

DNA was extracted from sporocarps and mycorrhizas with CTAB and amplified in polymerase chain reactions (PCR) with fungal specific primers ITS1F and ITS4 (White et al. 1990, Gardes & Bruns 1993). Molecular data were obtained by sequencing of the internal transcribed spacer (ITS) region, including ITS1, the 5.8S ribosomal DNA gene and ITS2. PCR products were cleaned in Montage PCR Centrifugal Filter Devices (Millipore Corporation). Clean PCR products were prepared for sequencing with BigDye Terminator Ready Reaction Mix and sequenced by an ABI 310 Genetic Analyzer (Applied Biosystems). Sequences were edited with Chromas 1.45 (McCarthy 1998) and compared to other fungal sequences in GenBank, the NCBI electronic database (*www.ncbi.nlm.nih.gov*), with BLAST and to each other with ClustalX (Altschul et al. 1990, Thompson et al. 1997). Sequences were submitted to GenBank; accession numbers are given with the collection numbers under each species description. Phylogenetic alignments were generated and edited in ClustalX. Phylogenetic trees using maximum parsimony and bootstrap values from 1000 replicates with full heuristic searches were generated in PAUP* 4.0b 10 (Swofford 2002). All characters were equally weighted and unordered. Gapped positions were treated as missing data (gap = missing).

Taxonomic Descriptions

Tuber candidum Harkn., Proc. Cal. Acad. Sci. Ser. 3 Bot. 1: 274, 1899.

Figures 1, 2, 4, 5

= *Tuber olivaceum* Harkn., Proc. Cal. Acad. Sci. Ser. 3 Bot. 1: 275, 1899.
= *Terfeziopsis lignaria* Harkn., Proc. Cal. Acad. Sci. Ser. 3 Bot. 1: 279, 1899.

Ascomata globose to irregularly subglobose stereothecia, 1-4 cm x 1-5 cm. **Peridium** smooth, light yellowish brown to reddish brown. **Gleba** firm, hard when dried, light tan to dark reddish brown, intricately marbled with thin white sterile veins continuous with the inner peridium. **Odor** mild to slightly earthy; **taste** bland.

Peridium 100-300 µm thick with two layers: **outer layer** 30-100 µm thick, light brown, of irregularly compact to elongated cells 4-10 x 2-5 µm; **inner layer** 70-200 µm thick, hyaline, of interwoven hyphae with irregularly elongated cells 5-15 x 2-3 µm. **Glebal trama** hyaline, of irregularly isodiametric to elongated cells 4-15 x 2-5 µm, sometimes with interhyphal spaces. **Asci** globose to subglobose, 60-85 x 45-70 µm with a double wall and a stem 15-50 µm long with a forked base, 1-5 spored, hyaline, arranged randomly throughout the glebal fertile tissues.

Spores light brown, subglobose to ellipsoid, 19-42 x 14-34 µm excluding ornamentation and depending on number of spores per ascus: in 1-spored asci 36-42 x 26-34 µm, 2-spored 28-36 x 22-30 µm, 3-spored 23-31 x 18-25 µm, and 4-5-spored 19-30 x 14-25 µm; **ornamentation** of curved spines 2-5 µm long at maturity; **spore walls** 1-2 µm thick.

Habit, habitat and season hypogeous; associated with *Quercus garryana* in southern Oregon, 400 m elevation, Mediterranean climate with dry summers and less than 50 cm annual precipitation; also associated with *Quercus* spp. from Washington and Idaho south to southern California. Sporocarps fruit below leaf litter in top 2-7 cm of mineral soil, March to August in our study area but year round over the entire range.

Ectomycorrhizal morphotype tan to brown with lighter tips, cystidia lacking; **outer mantle** of interlocking irregular synenchyma to net synenchyma; **inner mantle** non-interlocking irregular synenchyma to regular synenchyma.

Collections examined: HOLOTYPE — UNITED STATES. CALIFORNIA: **Placer Co.** AUBURN, Harkness 195, May (BPI, isotype OSC). OTHER COLLECTIONS — UNITED STATES. CALIFORNIA: **Alameda Co.** OAKLAND, Mountain View Cemetery, N. Gardner 133, 4 May 1903 (OSC 55902), **Butte Co.** MERRIMAC, T. Norman, 29 Nov 1933, Trappe 2567 (OSC 80591). **Los Angeles Co.** SAN GABRIEL MTNS., Evey Canyon, 4.5 mi N of Claremont, R. Benjamin, 13 Oct 1955, Trappe 17610 (OSC 80596). **Mariposa Co.** Hwy 120 at Greeley Hill Road, M.A. Castellano, 27 Mar 1985, Trappe 8440 (OSC 46928). **Monterey Co.** Hastings Natural History Reserve, Melin River, J.M. Linsdale, 53, 23 May 1945, (OSC 80617). **Placer Co.** Auburn, H. W. Harkness 197, May (Holotype of *Tuber olivaceum* BPI, Isotype OSC); H. W. Harkness 206, June (Type of *Terfeziopsis lignaria* BPI, Isotype OSC). **Sacramento Co.** SACRAMENTO, N. L. Gardner, undated, Gilkey 1149 (OSC 80615). **San Mateo Co.** PORTOLA VALLEY, S. Rutherford, 4 May 1975, Trappe 4089 (OSC 80592). IDAHO: **Ada Co.** BOISE, C. Baker, 1976, Trappe 4908 (OSC). OREGON: **Benton Co.** 4.5 mi. W of Alpine, M. Hinds, 5 July 2004, Trappe 29542 (OSC). **Douglas Co.** ELKTON, Phipps Nursery, G. Menser, 9 Apr 1986, Trappe 8879 (OSC). **Jackson Co.**

MEDFORD, Whetstone Savanna Preserve (42°25'N, 122°54'W). J. L. Frank, 30 Apr 2004, 727 (SOC, OSC 111407, GenBank AY830856); 27 May 2003, 500, 501, 502; 13 June 2003, 512; 8 July 2003, 516; 8 August 2003, 520; 17 March 2004, 608; 25 March 2004, 618, 619, 627; 6 April 2004, 657, 661, 663, 673; 15 April 2004, 675, 677, 678, 679, 681, 683; 23 April 2004, 693, 694, 695; 26 April 2004, 698; 27 April 2004, 703, 705, 708, 711, 715, 719, 721; 30 April 2004, 735; 25 May 2004, 739, 740, 743; 31 May 2004, 746, 748, 750, 752, 754 (OSC 111408), 755; 1 June 2004, 757, 758 (OSC 111409), 759 (OSC 111410); 3 June 2004, 768; 5 June 2004, 778; 6 June 2004, 783 (OSC 111411) (SOC). ASHLAND, Emigrant Lake (42°08'N, 122°36'W). J. L. Frank, 2 April 2004, 645, 5 April 2004, 652 (SOC). **Linn Co.** near LEBANON, L. Taylor, 3 Dec 1959, Gilkey 948 (OSC 80599). **Marion Co.** TURNER, Marion Hill, Otis Bynum, 20 June 1980, Trappe 5831 (OSC). **Polk Co.** 5 mi. W. of MONMOUTH, J. Trappe 1604, 10 Sep 1968 (OSC 80590). **Yamhill Co.** CHEHALEM MTN., S.M. Zeller, Gilkey 1144 (OSC 80613).

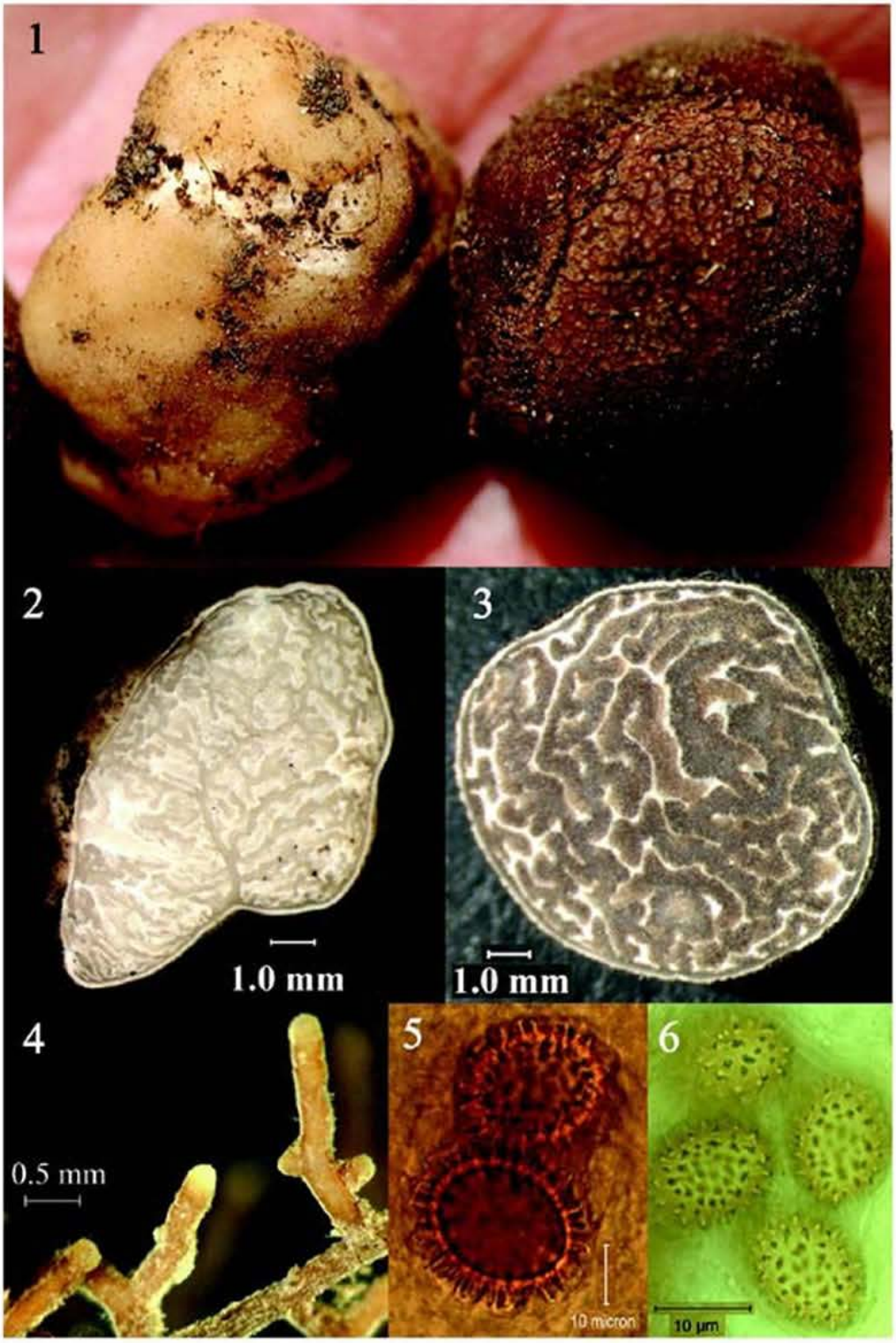
COMMENTS – *Tuber candidum* was given two other names by Harkness (1899): *Tuber olivaceum*, a glebal color variant that is a slightly immature stage of *T. candidum*, and *Terfeziopsis lignaria*, a very immature stage of *T. candidum* with a white gleba. The anatomy of all three is identical except for developmental differences. *T. candidum* is similar enough to the European *T. nitidum* Vittad. that the former was regarded as synonymous with the latter by Lange (1956), Ceruti (1961) and Trappe (1968). Although *T. candidum* and *T. quercicola* (below) are morphologically close to *T. nitidum* and *T. rufum* respectively, DNA sequences indicate that the North American species are distinct from the European species (Figure 7). Additionally, unlike the *T. rufum* group, including forma *nitidum*, forma *ferrugineum*, and variety *rufum*, the North American species *T. candidum* and *T. quercicola* are morphologically and molecularly distinct (Montecchi & Sarasini 2000, Ceruti et al. 2003). *T. candidum* and *T. quercicola* are distinctive among the *Tuber* species analyzed here; both have an 85-90 base pair insert in ITS1. Whereas sequences of *T. rufum* (AF106892) and *T. ferrugineum* (AF132506) are nearly identical, sequences *T. candidum* and *T. quercicola* differ by over 10% in ITS1 and ITS2. Accordingly, despite the lack of a sequence for *T. nitidum*, it seems appropriate to retain the name *T. candidum* for the North American genotype.

The mycorrhizal status of *Tuber candidum* was confirmed by DNA sequences. ITS sequence data from SOC727 (OSC 111407; GenBank AY830856) matched a mycorrhiza (SAP0901; GenBank AY969005) collected from *Quercus garryana* roots at Whetstone Savanna Preserve; the two sequences are greater than 97% similar.

Tuber quercicola J.L. Frank, Southworth & Trappe **sp. nov.** **Figures 1, 3, 6**

Ascomata globosa vel subglobosa, stereothecia, 1-3 cm lata. Peridium 250-500 µm crassum, verruculosum vel squamosumque rimosum, obscure rubrum vel rubiginosum, stratis duobus: exteriore 20-100 µm crasso, hyphis arcte intertextis; interiore 130-400 µm crasso, hyphis laxe vel arcte intertextis. Gleba firma, brunneola vel atroporphyrea, venis angustis albis sterilibus intricate marmorata. Asci irregulariter globosi vel subglobosi, 62-80 x 40-55 µm, parietibus duplicibus, stipite 10-35 µm longa, sporis 1-5. Sporae brunneolae, ellipsoideae, 20-45 x 15-35 µm, spinis 2-5 µm longis ornatae. Typus J. L. Frank 738 (SOC).

Etymology: Latin, *querci-* (oak) and *-cola* (dweller), "dweller with oaks."



Figures 1–6. Comparison between *Tuber candidum* and *T. quercicola* sp. nov. **Figure 1.** External surfaces: *Tuber candidum* (left) vs. *T. quercicola* (right). **Figures 2–3.** Cross-sections. **Figure 2.** *T. candidum* (SOC602). **Figure 3.** *T. quercicola* (SOC747). **Figure 4.** *T. candidum* mycorrhiza (MAT0901). **Figures 5–6.** Ascospores. **Figure 5.** *T. candidum* (SOC512). **Figure 6.** *T. quercicola* (SOC702).

Ascomata globose to subglobose stereothecia, 1-3 cm broad. **Peridium** minutely verrucose to scaly and cracked, dark red to brownish red. **Gleba** firm, hard when dried, light tan to dark reddish brown, intricately marbled with thin white sterile veins continuous with inner peridium. **Odor** mild to slightly earthy or often of fresh green beans. **Taste** bland.

Peridium 250-500 µm with two layers: **outer layer** 20-100 µm thick, rusty brown, of loosely to tightly interwoven hyphae 3-6 µm broad; **inner layer** 130-400 µm thick, of hyaline, loosely to tightly interwoven hyphae 2-4 µm broad. **Glebal trama** of hyaline, tightly interwoven hyphae 3-5 µm broad. Asci irregularly globose to subglobose, 62-80 x 40-55 µm, with a double wall and a stem 10-35 µm long and with a forked base, 1-5 spored, hyaline, arranged randomly throughout the glebal fertile tissue.

Spores light brown, broadly to narrowly ellipsoid, 20-45 x 15-35 µm excluding ornamentation and depending on number of spores per ascus: in 1-spored asci 36-45 x 26-35 µm, 2-spored 30-36 x 24-30 µm, 3-spored 22-32 x 20-26 µm, and 4-5-spored 20-28 x 15-20 µm; **ornamentation** of curved spines 2-5 µm long at maturity; **spore walls** 1-2 µm thick.

Habit, Habitat and Season: hypogeous; associated with *Quercus garryana* in southern Oregon, 400 m elevation, Mediterranean climate with dry summers and less than 50 cm annual precipitation; also occurring elsewhere in western Oregon to northern California. Sporocarps fruit below leaf litter in top 2-7 cm of mineral soil, March to August.

Collections examined: HOLOTYPE— UNITED STATES. OREGON: Jackson Co. MEDFORD, Whetstone Savanna Preserve (42°25'N, 122°54'W), J. L. Frank, 25 May 2004, 738 (SOC, isotype OSC 111405, GenBank AY918956). **PARATYPES: UNITED STATES. CALIFORNIA: El Dorado Co.** Above Hwy 49 S of American River Crossing, Trappe 3907, 18 May 1974 (OSC). **Fresno Co.** SIERRA NATIONAL FOREST, Ross Creek drainage, Turtle Cr., K. Pendleton, L. Baker, B. Oakley, 25 June 1997, Trappe 22599 (OSC). **Sonoma Co.** Kelley Road, S. of Asti, R. Stone, 5 Nov 1976, Trappe 4912 (OSC). **OREGON: Benton Co.** OAK CREEK, C. Wheeler, 18 Apr 1978, Trappe 5195 (OSC). **Douglas Co.** NORTH UMPQUA RIVER, Oak Flat, L. & I. Spaulding 5 May 1984, Trappe 7881 (OSC). **Jackson Co.** MEDFORD, Whetstone Savanna Preserve (42°25'N, 122°54'W) north of Medford, J. L. Frank 6 April 2004, 662 (SOC, OSC 111403); 15 April 2004, 682; 27 April 2004, 702 (SOC); 30 April 2004, 733 (SOC, OSC 111404); 31 May 2004, 747 (SOC, OSC 111406). **Linn Co.** PETERSON'S BUTTE, D. Wheeler, 21 June 1987, Trappe 9572 (OSC). **Marion Co.** TURNER, Marion Hill Road, O. Bynum, 28 June 1980, Trappe 5854 (OSC). **Polk Co.** RICKREALL CREEK, W. Bushnell, 20 June 1987, Trappe 9559 (OSC). **Yamhill Co.** CHAMPOEG STATE PARK, A. Beyerle, 17 June 2000, Trappe 27170 (OSC 80215).

COMMENTS – *Tuber quercicola* is closely related to *T. candidum* and to the European spiny-spored species, *T. rufum* Pico and *T. ferrugineum* Vittad. *T. quercicola* with a rough, scaly, red peridium, and *T. candidum* with a smooth, tan peridium can fruit together under the same tree. The ITS region of *T. quercicola* is distinct from that of *T. candidum* with less than 90% of base pairs in common in the ITS1 and ITS2 regions. Molecular data position *T. quercicola* with *T. candidum* in a different clade from *T. rufum* and *T. ferrugineum* (Figure 7).

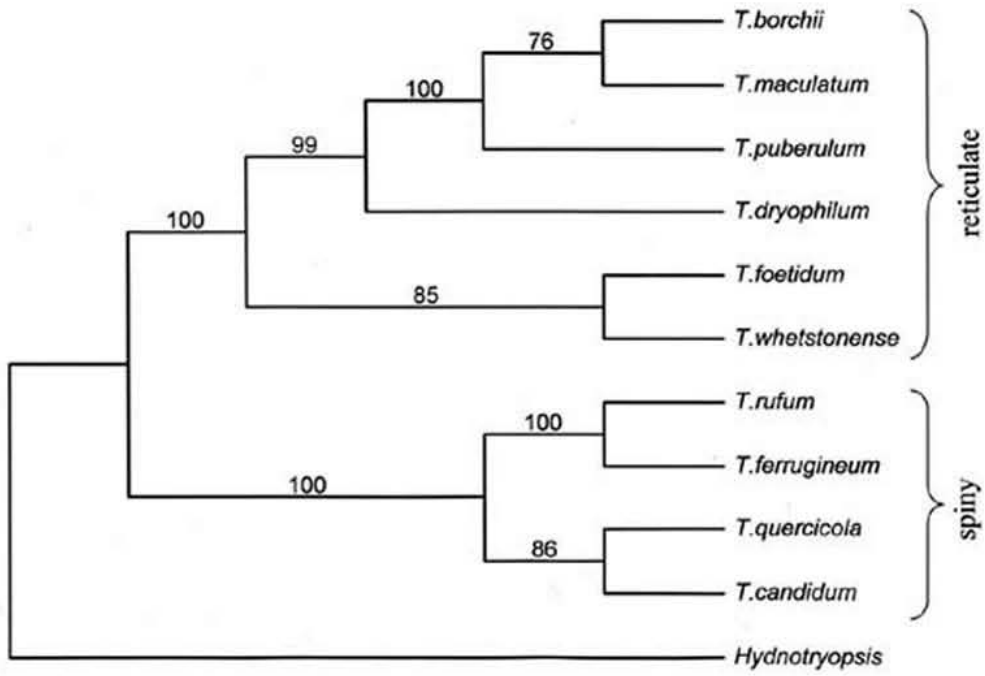


Figure 7. Phylogenetic tree of ten species in the genus *Tuber* constructed using maximum parsimony with bootstrap frequencies (values greater than 50%), comparing ITS sequences from three southern Oregon species (*T. candidum*, *T. quercicola* and *T. whetstonense*) to sequences of European species in GenBank, *T. borchii* (AF132505), *T. maculatum* (AF003909), *T. puberulum* (AJ557534), *T. dryophilum* (AF003917), *T. foetidum* (AJ557544), *T. rufum* (AF106892), *T. ferrugineum* (AF132506). Outgoup, *Hydnotryopsis setchellii* (AY927852).

Tuber whetstonense J.L. Frank, Southworth & Trappe **sp. nov.** **Figures 8-13**

Ascomata stereothecia hypogaea, globosa vel subglobosa, 5-15 mm lata, cartilaginea vel firma. Peridium minute furfuraceum, saepe rimosum, brunneolum vel obscure castaneum; suprapellis irregularis, cellulis versiformibus usque ad 4-8 (-10) µm latis; pellis 30-60 µm crassa, cellulis irregularibus vel isodiametris, 3-7 (-12) µm latis; subpellis 70-180 µm crassa, hyphis intertextis 2-4 (-6) µm latis. Gleba fuscum, venis albis marmorata. hyphis hyalinis intertextis 2-4 (-6) µm latis. Asci globosi, ellipsoides vel ovoides, 50-80 x 40-60 µm, sporis 1-5, maturitate parietes 1-2 µm crassis. Sporae aureobrunneae, ellipsoideae, in ascis unisporis 42-55 x 34-44 µm sine ornamentato, in ascis bisporis 30-40 x 26-38 µm, in ascis trisporis 24-34 x 20-30 µm, in ascis quadri- vel quinquesporis 15-26 x 14-22 µm; ornamentum reticulatum alveolatum 2-4 µm altum, alveolis 9-12 secus longitudinem sporarum. Holotypus J. L. Frank 756 (SOC).

Etymology: in reference to the type locality, Whetstone Savanna Preserve.

Ascomata globose to subglobose stereothecia 5-15 mm broad, rubbery to firm. **Peridium** minutely scurfy and pubescent with cracks and depressions, often cracked along the ascocarp perimeter, light brown to dark reddish brown. **Gleba** solid, with broad, dark grayish brown fertile tissue marbled with narrow white veins. **Odor** mildly peppery. **Taste** not recorded.

Peridium 180-240 µm thick: **suprapellis** at maturity an irregular surface of versiform cells 4-8 (-10) µm broad and with golden brown walls 1-2 µm thick; **pellis** 30-60 µm thick, a pseudoparenchyma of irregular to isodiametric cells 3-7 (-12) µm broad with golden brown walls 1-2 µm thick near the suprapellis grading to hyaline near the subpellis; **subpellis** intergrading from the pellis, 70-180 µm thick, of hyaline, thin-walled, interwoven hyphae 2-4 (-6) µm broad, in places arranged parallel to the ascomatal surface. **Glebal trama** of hyaline, thin-walled, interwoven hyphae 2-4 (-6) µm broad, the sterile veins of similar hyphae, mostly parallel to subparallel. **Asci** globose to ellipsoid or ovoid 50-80 x 40-60 µm, 1-5 spored, hyaline, lacking a stem or sometimes with a stem up to 20 x 10 µm, walls 1-2 µm thick at maturity, embedded randomly through the tramal tissue.

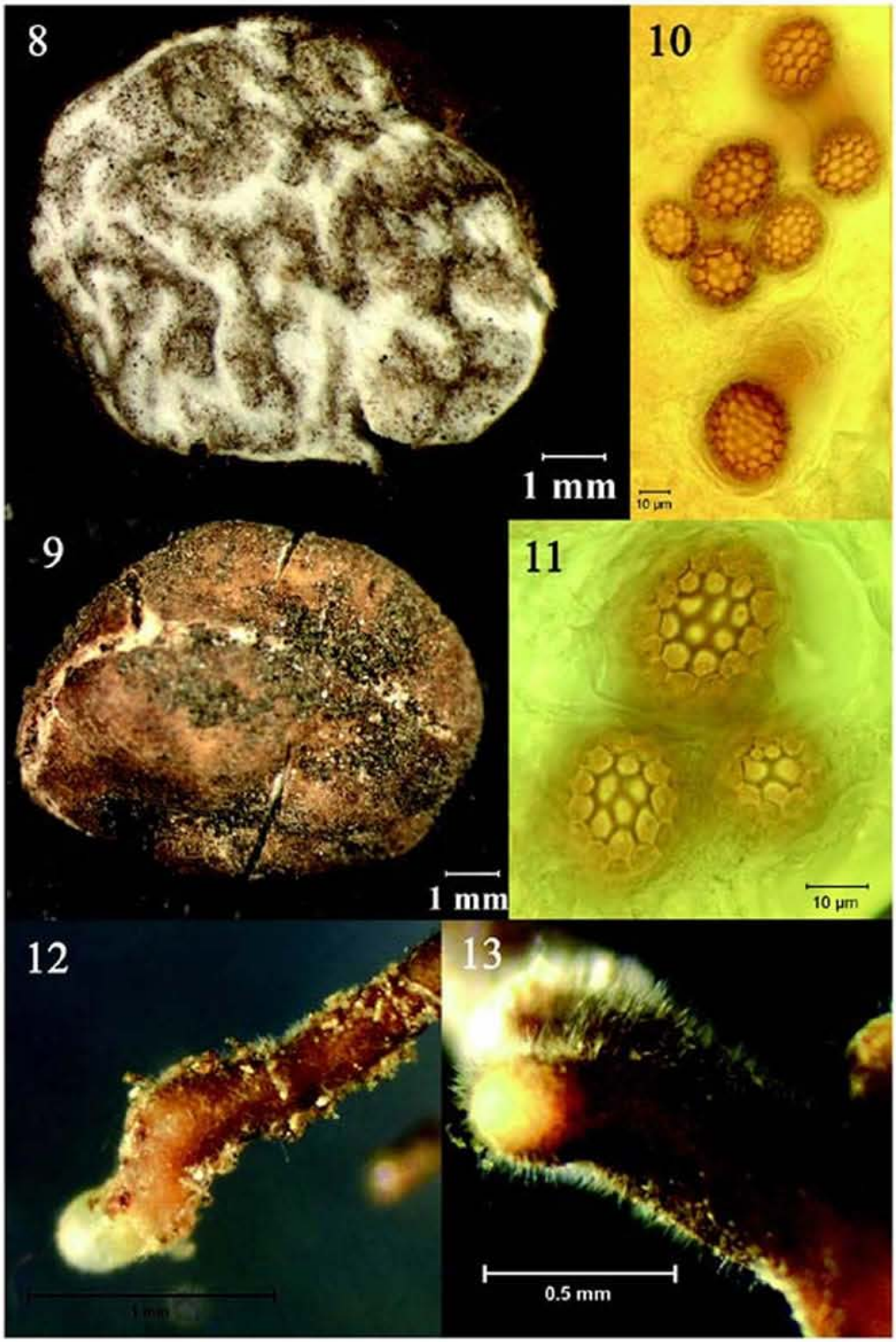
Spores golden brown, subglobose to ellipsoid, 15-55 x 14-44 µm excluding ornamentation and depending on number of spores per asci: in 1-spored asci 42-55 x 34-44 µm, 2-spored 30-40 x 26-38 µm, 3-spored 24-34 x 20-30 µm, and 4-5-spored 15-26 x 14-22 µm; **ornamentation** an alveolate reticulum 2-4 µm tall with 9-12 meshes along the spore length; spore walls 3-5 µm thick.

Ectomycorrhizal morphotype tan to brown with lighter tips, the surface with septate cystidia 50-60 µm long. **Outer mantle** an interlocking irregular synenchyma to net synenchyma. **Inner mantle** a non-interlocking irregular synenchyma to regular synenchyma.

> **Collections examined: HOLOTYPE — UNITED STATES. OREGON:** Jackson Co., MEDFORD, Whetstone Savanna Preserve (42°25'N, 122°54'W) 1 June, 2004. J. L. Frank 756 (SOC, isotype, OSC 111412, GenBank AY830855). **PARATYPES: UNITED STATES. OREGON:** Jackson Co., MEDFORD Whetstone Savanna Preserve (42°25'N, 122°54'W). J. L. Frank, 3 June 2004, 762 (SOC, OSC 111413), D. Southworth, 17 May 2000, 40; 13 April 2001, 148 (SOC).

COMMENTS – The distinctive morphological characters of *T. whetstonense* are its fine-meshed spore reticulum (9-12 meshes along the spore length) in combination with a brown, pseudoparenchymatic peridiopellis, relatively thick-walled asci, and association with *Quercus garryana* in xeric habitats. It resembles *Tuber anniae* Colgan & Trappe, but the latter species has smaller, globose to subglobose spores, a glabrous, yellow to dark olive brown peridium, and a peridiopellis with scattered cells inflated up to 20 µm broad. Moreover, *T. anniae* inhabits mesic conifer forests in contrast to *T. whetstonense*, an inhabitant of xeric oak communities. *Tuber pacificum* Trappe et al. also has spores with a fine-meshed reticulum and thick-walled asci, but its peridium has a suprapellis of appressed to tangled hyphae, and it occurs in mesic conifer forests. A number of other small and not very distinctive *Tuber* collections at OSC are similar to the species noted above but differ in various respects. Evidently, these small species comprise a complex as morphologically vexing as that found for similar species in Europe (Halász et al. 2005).

Of the *Tuber* species in Oregon oak woodlands, *T. whetstonense* is morphologically and molecularly distinct from the more common, spiny-spored species *T. candidum* and *T. quercicola*. The length of its ITS region is shorter than 600 bp, whereas those of *T. candidum* and *T. quercicola* are longer than 700 bp. Molecular analysis with ITS data



Figures 8–13. *Tuber whetstonense* sp. nov. **Figure 8.** Cross-section (SOC756). **Figure 9.** External surface. **Figures 10–11.** Ascospores stained with Melzer's reagent. (SOC756). **Figure 12.** Mycorrhiza (MAT0502) showing light tip. **Figure 13.** Mycorrhiza (MAT0502) showing cystidia.

separates the spiny-spored species from the reticulate-spored species, indicating two major clades within the genus *Tuber* (Figure 7). *T. whetstonense* fruited rarely: in five years, 4 sporocarps were collected, compared with over 200 for *T. candidum* and 32 for *T. quercicola*.

The mycorrhizal status of *Tuber whetstonense* was confirmed by DNA sequences. ITS sequence data from the holotype (J. L. Frank 756 [SOC]; OSC 111412; GenBank AY830855) matched a mycorrhiza (MAT0502; GenBank AY969006) collected from *Quercus garryana* roots at Whetstone Savanna Preserve; the two sequences are greater than 98% similar.

Ecology

Hypogeous fungi are common in Mediterranean climates, having evolved under selection pressures for survival in warm, dry climates (Montecchi & Sarasini 2000, Trappe & Claridge 2005). Subterranean fruiting strategies to conserve moisture require alternatives to the aerial spore dispersal mechanism common to epigeous mushrooms. Animals, attracted by volatile aromatics produced by the hypogeous fruiting bodies at maturity, dig them up, consume them, and disperse the spores in their feces (Claridge & Trappe 2005).

Analysis of fecal pellets of three small mammals, *Microtus californicus*, *Peromyscus maniculatus*, and *Reithrodontomys megalotis*, revealed that the distinctive, large, spiny spores of *T. candidum* were among the more frequently observed fungal spores in fecal pellets. Spores from *T. quercicola* and *T. whetstonense* were also present in pellets (Frank et al. 2004; Frank 2005).

Acknowledgements

Seth Barry and Lori Valentine provided mycorrhizal data from Whetstone Savanna Preserve. David Oline and Kathleen Page, Southerrn Oregon University, and Peter Kennedy, University of California, Berkeley, assisted with molecular analysis. Matthew E. Smith, University of California, Davis, assisted with molecular analysis and shared data from collections at the Sierra Nevada Research site. Karen Hansen, Harvard University Herbaria, made useful suggestions about the manuscript, in particular regarding molecular methods and phylogenetic analysis. Greg Bonito, Duke University, discovered in his sequences of North American *Tuber* species that a collection identified as *Tuber anniae* had a sequence identical to that of *T. whetstonense*. We rechecked the specimen and found it to be, in fact, *T. whetstonense*. He also made helpful suggestions about the manuscript.

We thank The Nature Conservancy for access to the study site. This material is based upon work supported by the National Science Foundation under Grants No. 9981337, DEB-0516229 and DBI-0115892, and by NATS, the North American Truffling Society (to JLF). Dr. Trappe's participation in the research was supported in part by the USDA Forest Service Pacific Northwest Research Station, Forestry Sciences Laboratory, Corvallis, Oregon.

Literature Cited

Altschul SF, Gish W, Miller W, Myers EW, Lipman DJ. 1990. Basic local alignment search tool. J Mol Biol 215: 403-410.

Brundrett M, Bougher N, Dell B, Grove T, Malajczuk N. 1996. Working with mycorrhizas in forestry and agriculture. ACIAR Monograph 32. Pirie Printers. Canberra, Australia.

Castellano MA, Trappe JM, Maser Z, Maser C. 1989. Key to spores of the genera of hypogeous fungi of north temperate forests with special reference to animal mycophagy. Mad River Press, Eureka, California.

Ceruti A. 1961. Revisione di alcune specie di *Elafomicetale* e di *Tuberali* dell'America del Nord. Allionia 7: 1-25.

Ceruti A, Fontana A, Nosenzo C. 2003. Le specie europee del genere *Tuber*–Una revisione storica. Museo Regionale di Scienze Naturali, Torino.

Claridge AW, Trappe JM. 2005. Sporocarp mycophagy: nutritional, behavioral, evolutionary and physiological aspects. In J Dighton, JF White & P Oudemans (eds), The Fungal Community—Its Organization and Role in the Ecosystem, Taylor & Francis, Boca Raton, Florida. pp. 599-611.

Frank J, Petersen C, Berninghausen H, Southworth D. 2004. Oaks, hypogeous fungi and mammal mycophagy: complex mutualism. Abstract, 89th Annual Meeting of the Ecology Society of America. Portland, Oregon.

Frank JL. 2005. Complex mutualism in an Oregon white oak woodland: hypogeous fungi, mycorrhizas and small mammal mycophagy. Masters Thesis, Southern Oregon University, Ashland, Oregon.

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.

Goodman DM, Durall DM, Trofymow JA, Berch SM. 1996. A manual of concise descriptions of North American ectomycorrhizae. Mycologue Publications Sydney, Australia.

Halász KZ, Bratek D, Szeg S, Rudnóy I, Rácz D, Lásztity, Trappe JM. 2005. Tests of species concepts of the small, white, European group of *Tuber* species based on morphology and rDNA sequences with special reference to *Tuber rapaeodorum*. Mycological Progress 4: 291-298.

Harkness HW. 1899. California hypogeous fungi. Proc. Calif. Acad. Sci. Ser. 3 Bot. 1: 241-292.

Lange M. 1956. Danish hypogeous macromycetes. Dansk Bot Ark 16: 1-84.

McCarthy C. 1998. Chromas 1.45. School of Health Science, Griffith University, Southport, Queensland, Australia.

Montecchi A, Sarasini M. 2000. Funghi ipogei d'Europa. Fondazione Centro Studi Micologie dell'A. M.B., Vicenza, Italy.

Swofford, DL. 2001. PAUP*: Phylogenetic analysis using parsimony and other methods, 4.0 10 ed. Sinauer Associates, Sunderland, Massachusetts.

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 Res 24: 4876-4882.

Trappe JM. 1968. Relazioni fra le specie di tartufi europee e nord-americane. Ati Congresso Internazionale sul Tartufo, Spoleto. pp. 134-137.

Trappe JM, Claridge AW. 2005. Hypogeous fungi: evolution of reproductive and dispersal strategies through interactions with animals and mycorrhizal plants. In J Dighton, JF White & P Oudemans (eds), The Fungal Community—Its Organization and Role in the Ecosystem. Taylor & Francis, Boca Raton, Florida. pp. 613-623.

Valentine LL, Fiedler TL, Hart AN, Peterson CA, Berninghausen HK, Southworth D. 2004. Diversity of ectomycorrhizas associated with *Quercus garryana* in southern Oregon. Can J Bot 82: 123-135.

Weber NS, Trappe JM, Denison WC. 1997. Studies on western American *Pezizales*. Collecting and describing ascomata—macroscopic features. Mycotaxon 61: 153-176.

White TJ, Bruns T, Lee S, Taylor J. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: MA Innis, DH Gelfand, JJ Sninsky, TJ White (eds). PCR Protocols: a guide to methods and applications, pp. 315-322. Academic Press, New York.

Zobel JG. 1854. Augusti Car. Jos. Corda, Iconum Fungorum Hucusque Cogitorum Tomus VI. (Ultimus). Libraria Friderici Ehrlich, Prague.

MYCOTAXON

Volume 95, pp. 241–245 *January–March 2006*

Two new species of *Parmotrema* (*Parmeliaceae*, Lichenized Ascomycota) from Brazil

CRISTINE G. DONHA & SIONARA ELIASARO

sionara@ufpr.br
Depto. Botânica, Biológicas, Universidade Federal do Paraná
Cx. P. 19031, 81531-970, Curitiba, PR – Brazil

Abstract—*Parmotrema sorediosulphuratum* and *Parmotrema superaguiense* are described as new. Both species were collected in Guaraqueçaba Environmental Protection Area, located in the northern coast of the Paraná State, southern Brazil. The former species was found in areas of the atlantic rain forest at 40 m altitude and the latter one was found only in the Parque Nacional do Superagüi in restinga, a characteristic type of vegetation occurring on nutrient-poor sandy soils along the Brazilian coastline. The species are morphologically and chemically characterized and illustrated. Comments with related species are also presented.

Key words—eumitrin, lichens, pigments

Introduction

Parmotrema A. Massal. is one of the most prominent group of foliose lichens in Brazil, and is mainly characterized by the large thallus with broad lobes, broad naked marginal zone on the lower surface, simple to rarely branched rhizines and sublageniform to filiform conidia (Elix 1993). The medulla in the majority of the species is totally white or sometimes with an orange to orange-red coloration mainly near the lower cortex, due to the presence of anthraquinones and related substances that react K+ purple. However, there are 34 species with a totally or partially yellow or yellow-orange pigmented medulla that contain pigments such as pulvinic acid and its derivatives and the ergochromes that do not react with K (Hale 1965, 1974, 1977, 1986, Kurokawa 1974, 1984, Krog & Swinscow 1981, 1983, Louwhoff & Elix 1999, 2002, Nash III & Elix 2002). These species of *Parmotrema* with a yellow medulla form a heterogeneous group that belongs to several different phylogenetic lines (Hale 1974).

During an extensive study of the taxonomy and distribution of the family *Parmeliaceae* in Paraná State, two new species of *Parmotrema* with yellow pigments in the medulla were discovered. These species are described as new based upon their morphological and chemical characteristics.

Materials and Methods

The two new species were described from specimens collected in Guaraqueçaba Environmental Protection Area (24°45'–25°30'S and 48°00'–48°45'W), located on the

northern coast of the Paraná State, southern Brazil. This region represents the best-preserved area of continuous Atlantic forest left in Brazil. The different types of habitats in the area include mangroves, restinga (a characteristic type of vegetation occurring on nutrient-poor sandy soils along the Brazilian coastline), lowland forest, submontane, montane, and upper montane forests. The climate of the region is humid subtropical (IPARDES 1990).

Collections of the new species were deposited in UPCB. Specimens of related species borrowed from S were examined for comparison. The specimens were examined with a dissecting microscope for morphological characterization. Apothecia and pycnidia were cut by hand with a razor blade and observed under a light microscope to examine the anatomical characters. Lichen substances were identified by thin layer chromatography according to the methods standardized for lichen products (Culberson & Ammann 1979, Elix & Ernst-Russell 1993) and comparison with authentic samples.

Taxonomic Description

Parmotrema sorediosulphuratum Eliasaro & Donha **sp. nov.** **Fig. 1**

Thallus membranaceus ad subcoriaceum, adnatus, usque 14 cm lati. Lobi subirregulares ad sublineares, marginibus crenatis ad fortitutos sublaciniatus, moderatis ad densos ciliatis; cilia maxime simplicia. Superficies supra viridis cineracea, immaculata. Soralia marginalia et submarginalia. Medulla flava sulphurea. Superficies infra nigra cum marginibus brunneis atris ad claros; rhizinae simplices ad furcatas. Apothecia et pycnidia ignota. Atranorinam, acidum vulpinicum et pigmenta flava ignota continens.

Type: BRAZIL. PARANÁ: Antonina. CHÁCARA DONHA (25°14'31"S 48°44'49"W) – 29.IX.2004, *C G Donha 1808* (**HOLOTYPE-UPCB**).

Thallus corticolous, membranaceous to subcoriaceous, adnate, up to 14 cm wide. Lobes subirregular to somewhat sublinear, plane or ascending, 4-10 mm wide, with rotund apices, margins crenate to sublaciniate, moderate to densely ciliate; cilia black, mainly simple or bifurcate, rarely trifurcate, 1.0-3.5 mm long. Upper surface grey green, emaculate, smooth, becoming rugose and irregularly cracked towards the center. Soralia marginal and submarginal, soredia granular to subgranular. Medulla bright sulphur-yellow. Lower surface black with a dark to pale brown margins, smooth to rugose, moderately rhizinate with a narrow bare marginal zone, 1.0-4.5 mm wide; rhizines black, in scattered groups, simple to furcate, 0.5-1.0 (-2.0) mm long. Apothecia and pycnidia not seen.

Chemistry: cortex: K+ yellow (atranorin); medulla: K-, C-, KC-, UV- (vulpinic acid, two undetermined yellow pigments).

Ecology, Range and Distribution – *Parmotrema sorediosulphuratum* is known only from the type locality, where it grows on tree trunks in areas of atlantic rainforest at 40 m altitude.

REPRESENTATIVE SPECIMENS EXAMINED – **BRAZIL. PARANÁ: Antonina.** CHÁCARA DONHA (25°14'31"S 48°44'49"W) – 03.VII.2003, *C G Donha 972* (UPCB). Specimen examined for comparison: **BRAZIL. MATO GROSSO: Jangada.** FAZENDA SANTA ELINA – VII.2000, *G Ceccantini s.n.* (*Parmotrema cornutum* (Lynge) Hale-UPCB).

Comments – *Parmotrema sorediosulphuratum* is characterized by the ciliate lobes, the marginal and submarginal soralia and by the intensely sulphur yellow medulla due to the production of vulpinic acid. The occurrence of vulpinic acid in *Parmotrema* species is rare and known only in two another species, *P. cornutum* (Lynge) Hale and *P. sulphuratum* (Nees & Flot) Hale. *Parmotrema sorediosulphuratum* differs from both by the production of soredia and may be considered the sorediate counterpart of *P. cornutum*.

Parmotrema superaguiense Donha & Eliasaro **sp. nov.** **Fig. 2**

Thallus membranaceus, laxe adnatus, usque 16 cm lati. Lobi irregulares 10-20 mm lati, marginibus moderatis ciliatis; cilia maxime simplicia. Lacinulae frequentes, maxime in centrum thalli, simplices ad irregulares ramosas. Superficies supra viridis cineracea, immaculata. Isidia et soredia absentes. Medulla flava. Superficies infra nigra cum marginem brunneum clarum ad brunneum flavum; rhizinae simplices. Apothecia in laminatiam, pedicellata ad subpedicellata, discus imperforatus, margo thallinus eciliatus fortuitus laciniatus, spori 20,0-27,5 (-32,5) x 10,0-15,0 µm. Pycnidia frequentia, conidia sublageniformia 6-8 x 1 µm. Atranorinam, acidum graxum et duo pigmenta flava continens.

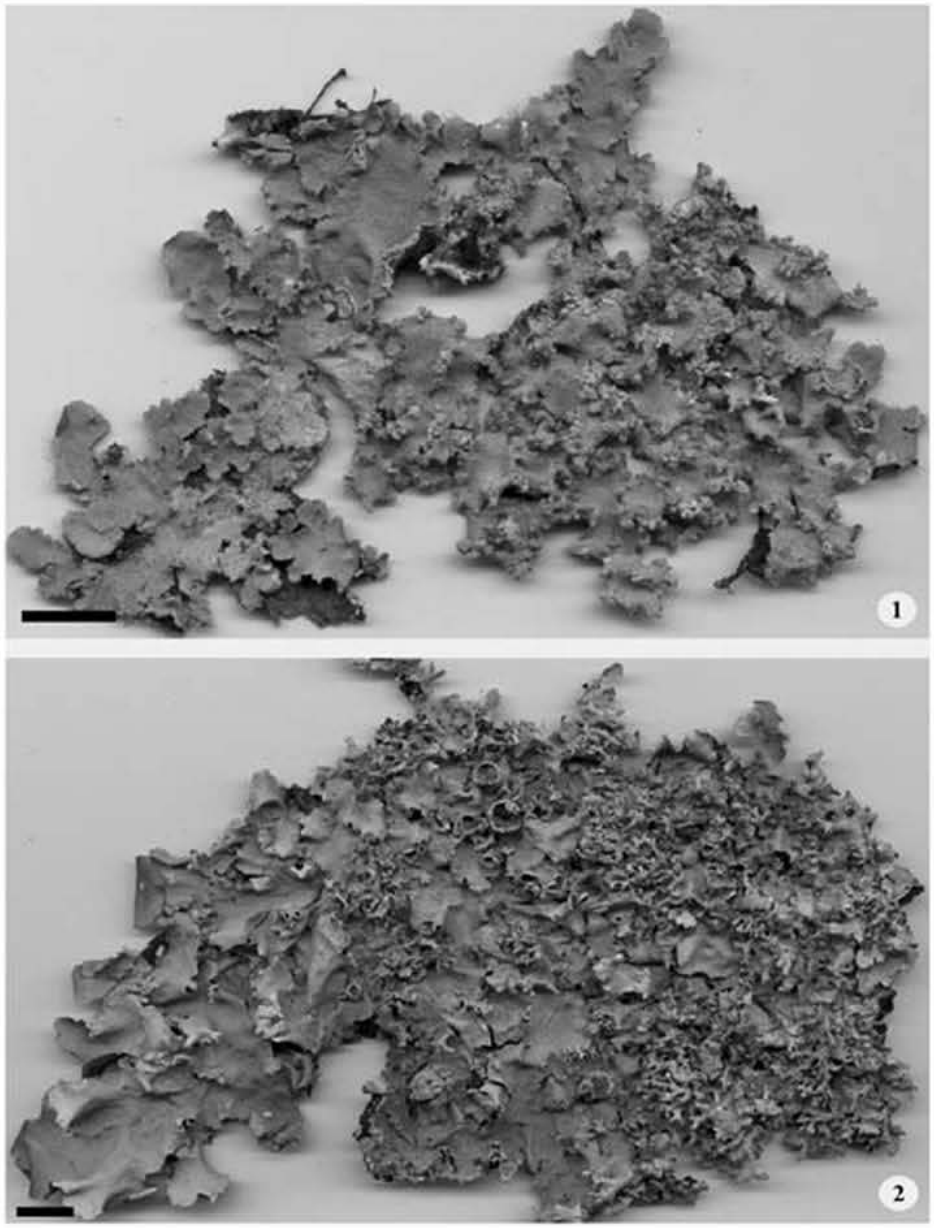
Type: BRAZIL. Paraná: Guaraqueçaba. Parque Nacional do superagüi, Ilha das Peças (25°28'20"S 48°17'58"W) – 24.IV.2004, *S Eliasaro 2755* (**HOLOTYPE-UPCB**).

Thallus corticolous, membranaceous to subcoriaceous, loosely adnate, 12-16 cm broad. Lobes irregular, plane to ascending, 10-20 mm wide, with rotund apices, margins entire to laciniate toward the center of the thallus, laciniae 0.5-1.5 mm wide, moderately ciliate; cilia black, mainly simple, rarely furcate, robust, 0.5-2.0 mm long, mainly in lobes axils. Upper surface greenish gray, entire, smooth to rugose on older lobes. Isidia and soredia lacking. Medulla deep yellow. Lower surface black with a yellowish brown margin, smooth to rugose, sparsely rhizinate with a broad, bare marginal zone, up to 10 mm wide; rhizines black, in scattered groups, simple, up to 1 mm long. Apothecia common, laminal, stiptate to substiptate, disc imperforate, 2-10 mm in diameter, thalline margin eciliate, entire to rarely laciniate, laciniae often pycnidiate; amphithecium maculate, sometimes rugose veined; spores 20.0-27.5 (-32.5) x 10.0-15.0 µm. Pycnidia common, submarginal on lobes and lacinulae; conidia sublageniform, 6-8 x 1 µm.

Chemistry: cortex K+ yellow (atranorin); medulla K-, C-, KC-, UV- (fatty acid, eumitrin B and eumitrin A group of pigments).

Ecology, Range and Distribution – *Parmotrema superaguiense* is so far only known from the Parque Nacional de Superagüi, in restinga.

REPRESENTATIVE SPECIMENS EXAMINED – **BRAZIL. Paraná: Guaraqueçaba.** Parque Nacional do superagüi, Ilha das Peças (25°28'20"S 48°17'58"W) –24.IV.2004, *S Eliasaro 2748* (UPCB); Ilha de Superagüi (25°27'S 48°14'W) – 8.IV.2003, *S Eliasaro & C G Donha 2589* (UPCB); 10.IV.2003, *S Eliasaro & C G Donha 2706* (UPCB); 15.VIII.2004, *C G Donha 1832* (UPCB). Specimens examined for comparison: **BRAZIL. Mato Grosso: Coxipó, near Cuiabá** – *Malme 2198B* (holotype-S, *Parmelia lyngeana* Zahlbr.: based on *Parmelia merrillii* Lynge, 1914, *non Parmelia merrillii* Vain., 1909); **Santa Anna da Chapada** – *Malme 2477* (holotype-S, *Parmelia cornuta var. crocea* Lynge).



Figures 1-2. New species of *Parmotrema*: 1. *Parmotrema sorediosulphuratum* (holotype in UPCB). 2. *Parmotrema superaguiense* (holotype in UPCB). Bars = 10 mm.

Comments – *Parmotrema superaguiense* is characterized by the yellow medulla, the ciliate lobe margins, the presence of laciniae and the imperforate apothecial disc. It is superficially similar to *P. lyngeanum* (Zahlbr.) Hale, which has narrow lobes (5-10 mm wide) and the holotype produces protocetraric acid and skyrin. Other ciliate *Parmotrema* species that lack vegetative propagules and have a distinctly yellow to orange yellow medulla differ from *P. superaguiense* in chemical properties and other characters: *P. lopezii* Hale has a yellowish green thallus with usnic acid and atranorin in the upper cortex and protocetraric acid and secalonic acid A in medulla. *P. cristatum* (Nyl.) Hale contains protocetraric acid in medulla. *P. appendiculatum* (Fée) Hale produces barbatic acid in the medulla and, according to Krog & Swinscow (1983), a pigment restricted to the vicinity of the apothecia and the thalline exciple.

Acknowledgements

The authors wish to thank the curator of S herbarium for the loan of specimens, Prof. Nasser K. Hammad for checking the Latin descriptions; Dr. John A Elix and Dr. Susana Calvelo for the critical revision of the manuscript and "Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis" (IBAMA) for collection permission n° 118/2002 and 133/2003. Cristine G. Donha is grateful to "Coordenação de Aperfeiçoamento de Pessoal de Nível Superior" (CAPES) for a master fellowship.

Literature Cited

Culberson CF, Ammann K. 1979. Standarmethode zur Dünnschicht-chromatographie von Flechtensubstanzen. Herzogia 5: 1-24.

Elix JA. 1993. Progress in the generic delimitation of *Parmelia sensu lato* lichens (Ascomycotina: Parmeliaceae) and a synoptic key to the *Parmeliaceae*. Bryologist 96: 359-383.

Elix JA, Ernst-Russell KD. 1993. A catalogue of standardized thin layer chromatographic data and biosynthetic relationships for lichen substances. Australian National University, Canberra.

Hale ME. 1965. A monograph of the *Parmelia* subgenus *Amphigymnia*. Contributions from the United States National Herbarium 36: 193-358.

Hale ME. 1974. Notes on species of *Parmotrema* (Lichenes: Parmeliaceae) containing yellow pigments. Mycotaxon 1: 105-116.

Hale ME. 1977. New species in the lichen genus *Parmotrema* Mass. Mycotaxon 5: 432-448.

Hale ME. 1986. New species in the lichen family *Parmeliaceae* (Ascomycotina). Mycotaxon 25: 85-93.

[IPARDES] Instituto Paranaense de Desenvolvimento Econômico e Social. 1990. Macrozoneamento da Área de Proteção Ambiental de Guaraqueçaba. Curitiba.

Krog H, Swinscow TDV. 1981. *Parmelia* subgenus *Amphigymnia* (Lichenes) in East Africa. Bulletin of British Museum of Natural History (Bot.) 9: 143-231.

Krog H, Swinscow TDV. 1983. A new species and new combinations in *Parmotrema* (*Parmeliacae*). Lichenologist 15: 127-130.

Kurokawa S. 1974. Four new species of *Parmelia* from Brazil. Bulletin of the National Science Museum (Tokyo) 17: 297-300.

Kurokawa S. 1984. Joint occurrence of diffractaic and barbatic acids in *Parmelia*, subgenus *Amphigymnia* (Lichenes). Journal of Japanese Botany 59: 193-198.

Louwhoff SHJJ, Elix JA. 1999. *Parmotrema* and allied lichen genera in Papua New Guinea. Bibliotheca Lichenologica 73.

Louwhoff SHJJ, Elix JA. 2002. The *Parmeliaceae* (lichenized Ascomycota) of New Caledonia. Lichenologist 34: 373-394.

Nash III TH, Elix JA. 2002. *Parmotrema*. In: Lichen Flora of the Greater Sonoran Desert Region (TH Nash III, BD Ryan, C Gries, F Bungartz, eds.). ASU Lichen Herbarium, Tempe, v.1, p.318-329.

MYCOTAXON

Volume 95, pp. 247–254 *January–March 2006*

Russula siamensis: a new species of annulate *Russula* from Thailand

S. YOMYART[1], J. PIAPUKIEW[2], R. WATLING[3], A. J. S. WHALLEY[4] & P. SIHANONTH[5]✧

✧*sprakits@chula.ac.th*

[1]*Program of Biotechnology, Faculty of Science, Chulalongkorn University Bangkok 10330, Thailand*

[2]*Department of Botany, Faculty of Science, Chulalongkorn University Bangkok 10330, Thailand*

[3]*Caledonian Mycological Enterprises, Crelah 26 Blinkbonny Ave, Edinburgh EH4 3HU. Scotland, U.K.*

[4]*School of Biomolecular Science, Liverpool John Moores University Byrom Street, Liverpool, L3 3AF, U.K.*

[5]*Department of Microbiology, Faculty of Science, Chulalongkorn University Bangkok 10330, Thailand*

Abstract—*Russula siamensis*, associated with *Dipterocarpus alatus*, is described as new. An annulate *Russula* is unique in the Thai mycota.

Key words—*Pellicullariae, Ingratae, Pectinatae*

Introduction

Annulate species of *Russula* Pers. are totally unfamiliar to European field mycologists except for a privileged few who can collect in the tropics, yet Europe was the continent that spawned the basic classification of the genus. Studies there attempted to organize, in what was thought to be a natural way, those species found in the temperate areas of the world; for a recent account see Romagnesi (1967). As exploration was made more distant from Europe collections were made which stretched this classification to breaking point. No more so when Heim (1938ab) described material from Madagascar when it soon became clear that all was not well with the previously held, rather simplified, views. Heim described a range of species of *Russula* which possessed rings and which he clustered around his names '*Russula annulata, R. heliochroma & R. parasitica*'. Even then he adopted a rather cautious approach in dealing with these fungi, although Heim was often prepared to accept rather unorthodox and controversial views (Heim 1948, 1971). Species with an annulus were even a novelty to him and he created the new Sect. *Pellicullariae* to house the species he studied emphasising the thin-flesh, pectinate pileus-margin and an annulus, which could be very fugitive indeed.

The next stage in the development of this saga was the description from South America of *Russula brasiliensis* Singer, a fungus later found by to be the same as *Clitocybe puiggarii* Speg. and subsequently the epithet was transferred to *Russula* by Singer, similarities in structure lying with other *Pellicullariae*; see Singer (1986). There is little doubt that Mme. Goossens-Fontana when resident in the then Belgian Congo had been familiar with annulate russules and had illustrated them, the description of *R. xylophila* Beeli and its allies resulting from these observations (Beeli 1928, 1936). It was not until one of us (RW) visited the Cameroon, West Africa, and Buyck published on the East African and Congo *Russula* mycota (Buyck 1993, 1994) that the number of annulate *Russula* species became awe-inspiring. Thirteen annulate species have now been formally described from Africa and several more are known from field notes. Subsequently *Russula puiggarii* was collected in the Caribbean by Pegler (1983), along with a second new species, *R. hygrophytica* Pegler (Pegler & Singer 1980). Buyck & Ovrebo (2002) in their study of Russula species from Panama considered *R. puiggarii* and *R. hygrophytica* to be conspecific but Pegler (pers. comm.) maintains that they are distinct taxa. A whole raft of S. American taxa all attributed to Sect. *Pellicullariae*, some with rings and others closely related lacking such a structures, are now known.

In the *Pellicullariae* Singer (1986) recognized eight subsections, viz. *Epitheliosae* Singer, *Guayarenses* Singer, *Radicantes* R. Heim, *Heliochrominae* R. Heim, *Discopodinae* R. Heim, *Diversicolores* Singer, *Pluviales* Singer and *Batistae* Singer. Subsections *Heliochrominae* and *Discopodinae* and possibly *Pluviales* contain representatives from both Africa and from South America, whilst the others are based on S. American elements—except subsect. *Guayarenses*, which includes a single species from Australasia, viz. *R. eburneoareolata* Hongo. Thus this last taxon was the only Asiatic species then known in the group. Since Singer's summary, Buyck & Horak (1999) have described *R. cingulata* from Papua New Guinea, and although it would have been placed within Heim's concept of Sect. *Pellicullariae*, these authors placed their new taxon in Sect. *Fistulosae* subsect. *Meleagrinae* in keeping with the re-evaluation of pellicularioid *Russula* spp. The species are distributed, as Buyck has eloquently demonstrated, not just in one section, viz. *Pellicullariae*, but in several sections of *Russula* indicating that the annulate/thin-fleshed morphotype had evolved several times, probably in response to environmental factors (Buyck 1988ab).

The present article reports for the first time on an annulate *Russula* from Thailand indicating that the annulate feature is a more widely distributed phenomenon than first thought, exposing still further the inadequacies of our present approach to understanding the genus *Russula* based on European taxa alone. The finding of such a fungus was in the opinion of one of us inevitable, as elements had already been found amongst the Malaysian *Russula* mycota that demonstrated copious veil production attached to the pileus-surface in much the same way as the recently described *R. messapica* Sarnari from Italy.

Materials and Methods

During collecting trips to plantations of *Dipterocarpus alatus* Roxb. (*Dipterocarpaceae*) in eastern Thailand, several interesting mycorrhizal fungi have been collected. One of these was a species of *Russula* characterised by a distinctly annulate stipe. Its basic

appearance was one of a thin-capped pileus with pectinate-striate margin, slender stature and isolated spines on the basidiospores. These fundamental characters agree in all ways with the Neotropical members of the Sect. *Pellicula riae*, but further analysis was necessary for placement in the scheme proposed by Buyck et al. (1986). The present species grows on bare sandy loam soil with *D. alatus* which prefers moist soils, and with ground cover of Malaysian grass.

DNA analysis

Genomic DNA was prepared from the fresh stipe tissue and extracted with cetyltrimethylammonium bromide (CTAB) as described in Zhou et al. (1999). PCR amplification of the internal transcribed spacer (ITS) was performed in a total volume of 50 µl which comprised approx. 100 ng genomic DNA, 1× PCR Master Mix (Fermentas, California, USA), and the primer ITS1f (Gardes & Bruns 1993) and ITS4 (White et al. 1990). The amplification was performed in a thermocycler (TGradient; Biometra, Germany) with 94 °C for 5 min , followed by 38 cycles of 94 C for 1 min, 51 C for 1 min and 72 C for 1 min, with a final extension of 72 C for 5 min. PCR product was purified using the NucleoSpin® (Macherey-Nagel Inc., Easton, USA) and sequenced externally by Macrogen (Seoul, Korea) using the same primers as for amplification. The ITS sequence of *R. siamensis* was submitted to GenBank with accession number AB206535.

Taxonomic Description

Russula siamensis Yomyart, Piapukiew, Watling, Whalley & Sihan. **sp. nov.**

Figs. 1-2

Pileus 28 mm, convexus dein depresso-explanatus, centro glabro sed conspicue sulcato marginum versus griseo brunneus vel pallide fuscus, subviscidus. Stipes 18 x 7mm, cylindricus, lamellis concoloris, siccus, fragile, annulo distincto membranaceo mobili concolore instructis vel pileis-concolores. Lamellae adnatae - adnexae, subdensae, primo albidae dein pallide. Caro albida, tenua. Sapore leviter acri; Odore leviter frugose. Sporae albidae in cumulo 8 -9 x 6 -7 µm subglobosae vel ovoideae verruculosis cylindricis isolatis amyloideis suprahilaris inamyloidea. Basidia 4-sporigera. Cystidia cylindrica vel fusoideo-mucronata numerosa. Holotypus: Thailand, Khao Hin Sorn, Chacherngsoa prov. 22 viii 2004, sub Dipterocarpus alatus. Wat.No. 28784 in E.

Pileus 28mm, convex then plano-convex but slightly and shallowly depressed at centre, not involute, pectinate-striate at margin, strongly striate to 2/3rds, brownish biege to pale ochraceous grey, darker along the radial ridges and then even hazel colour, slightly viscid when fresh, radially fibrillose-wrinkled but not disrupting to form flakes or squamules. Fig 2A; **stipe** 18 x 7mm, whitish, flushed with colour of pileus in smudges below annulus, cylindric, equal, with obtuse abrupt rounded base slightly depressed at point of attachment to the substratum, darkening at very base; **annulus** about 1mm thick with a lower zone concolorous with pileus and an upper white zone, membranous, loosening, discrete; **lamellae** adnate to adnexed, concolorous with stipe, cream-colour, relatively widely spaced, very few intermediates but some major lamellae venose at their base. Fig 2B; **context** very thin; **taste** slightly acrid; **odour** slightly fruity.

Basidiospores heterotropic orthotropic, white to very pale cream-colour in mass (A - B), 8 - 9 x 6 - 7 µm excl. ornamentation, subglobose to broadly ellipsoid with a

slight suprahilar applanation, but lacking distinct plage, hyaline, with strongly amyloid ornamentation consisting of isolated or almost isolated conical warts 0.5-1µm high, neither catenulate nor reticulate, hilar appendage distinct < 2µm long with a basal slightly amyloid cuff. Figs. 1F & 2D; b/w photos; **cheilocystidia** crowded forming an almost completely homogeneous margin, 29 - 48 x (5.6-) 6.7 - 11 µm, hyaline, elongate-clavate, some drawn out into broad lanceolate apex or clavate with minute apical papilla, changing to either yellowish sepia in SV or where more deeply seated dark purple-brown. Figs. 1B, C & 2C; **macrocystidia** widespread, hyaline with or without granular contents in ammoniacal solutions, similar to cheilocystidia but more distinct, more elongate-clavate and appendages at apex more elaborate, often drawn out into

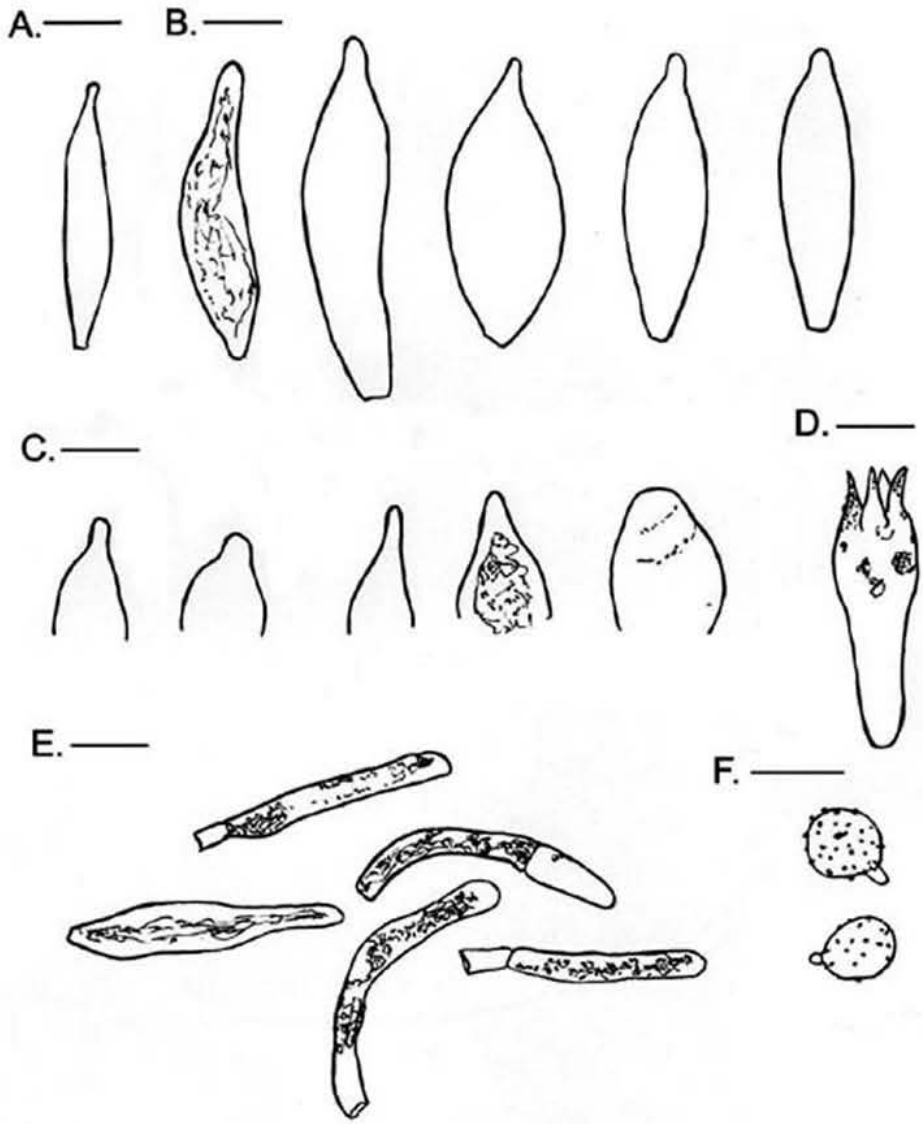


Fig. 1. *R. siamensis* holotype. A. Macrocystidium. B. Cheilocystidia. C. Range of apices of cheilocystidia. D. Basidium. E. Terminal elements of pileipellis. F. Basidiospores.

Bars: A-E = 10 µm; F = 5 µm.

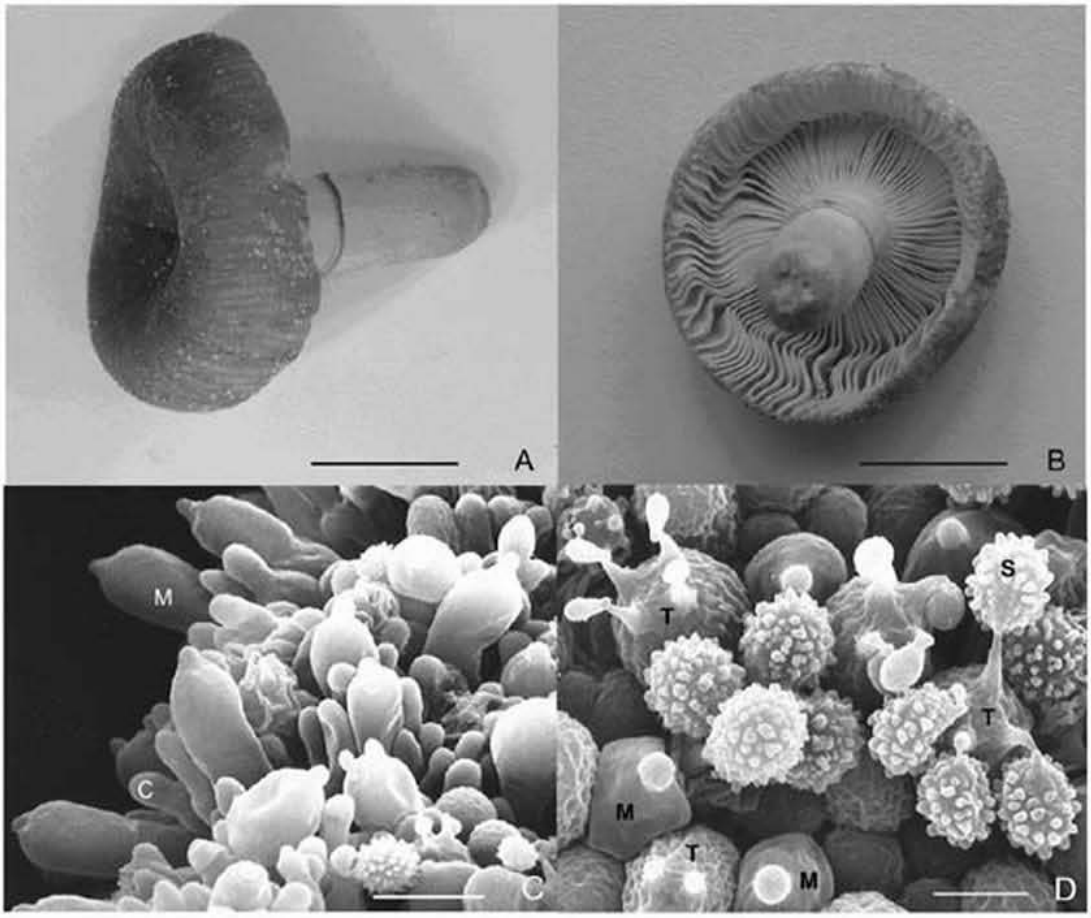


Fig. 2. *R. siamensis* holotype. A.&B. Fresh basidiome. C. Scanning electron micrograph of cheilocystidia (C), macrocystidia (M) of *R. siamensis*. D. High magnification of macrocystidia (M), basidiospore (S) and tetrasterigmatic basidia (T) with various stages of basidiospore formation of *R. siamensis*. Note: smooth surface of papillate macrocystidia compared to wrinkled surface of basidia. Bars: A = 10 mm; B&C = 10 µm; D = 5 µm.

elongate papilla, dark purple-brown in SV with granular contents. Figs. 1A, 2C&D; **basidia** 4-spored, narrowly clavate, in upper part with parallel sides, hyaline, with granular contents especially in SV, 30 - 38 x 6.5 - 8.5 (- 10) µm; sterigmata distinct 2- 4 µm long. Figs. 1D & 2D; **pileipellis** ixodermic with upper gelatinized zone 15 µm thick, suprapellis composed of radially arranged hyphae 4.5 - 6.5 µm broad with shiny walls and aggregated in places to give yellowish brown skeins intermixed with broader elements 13µm plus broad and with some rounded sphaerocytes 20 - 35 µm broad exposed between the skeins; yellowish brown, granular contents in SV in many hyphae but apparently randomly distributed over the pileus except where concentrated in the skeins of hyphae; no prominent dermatocystidia seen, replaced by poorly differentiated obtuse or torpedo-shaped terminal elements 17 - 20 (- 60) x 6.5 -11 µm or mixture of broader elements, generally with granular yellowish sepia contents in SV. Fig. 1E; **stipitipellis** with poorly developed, filamentous, terminal elements, dark purple-brown in SV, seated on hyaline, more-or-less parallel or intertwined, filamentous hyphae 2.5 -3.5 µm broad; similar in structure to parts of the pileipellis but less organized; **clamp connections** absent.

Habitat Thailand, Chacherngsoa Province, Panomsarakam District, Khao Hin Sorn Royal Development Study Area, 22 viii 2004, under *Dipterocarpus alatus*, in plantation, legit Sunadda Yomyart et al., *Wat.* No. 28784 in E; duplicate in Department of Microbiology, Faculty of Science, Chulalongkorn University, Bangkok, Thailand.

Note SV = Sulphovanillin reagent.

Discussion

In overall features the present species closely approaches *Russula cingulata* Buyck & E. Horak, described from Papua New Guinea, but in minutiae there are important differences, especially in that the pileus does not disrupt into flakes or into scales as *R. cingulata*; the basidiospores are also larger and less strongly ornamented. In colour *R. siamensis* resembles members of the North Temperate *Russula amoenolens* Romagn. / *R. sororia* (Fr.) Romell - complex, although the margin of the pileus is pectinate-striate from a much earlier stage probably because of the thinness of the flesh. In the pectinate feature it agrees with *R. pectinatoides* Peck in addition to the slightly russet flush which develops with age at the stipe-base. Buyck & Horak (1999) placed their fungus in Sect. *Fistulosae* subsect. *Meleagrinae* but they indicated that it certainly comes close to Sect. *Ingratae* subsect. *Pectinatineae* erected by Bon (1986). Interestingly *R. amoenolens* is the type of the subsection. It is suggested that *R. siamensis* should be placed therein and this is supported by the ITS sequencing data. Miller & Buyck (2002) examined ribosomal DNA sequences for 87 species of *Russula* from Europe but these did not include an annulate species. Therefore at present available DNA sequences for the ITS region of members of Russulaceae is limited, and only indicative as the family is probably of the order of 400 species and complex in nature. At the moment our novel species sits uneasily until further annulate species are sequenced. The species was introduced as *R. insignis* Quél., then later in the same year it was recombined as a variety of *R. pectinata* – *R. pectinata* var. *insignis* (Quél.) Quél. (Quélet 1888) and considered by Romagnesi (1967) to be the same as *R. livescens* (Batsch) Quél. but differs in that there is evidence of a pale yellow marginal veil. This would be in keeping with a placement near to *R. siamensis* with its rather more fully developed velar tissue.

In parallel to the Thai fungus, *Russula cingulata* is found with a member of the *Dipterocarpaceae* but the host of *R. siamensis* occurs only in the evergreen forests of Myanmar (Burma) and Thailand, and the Andaman Islands. *Dipterocarpus alatus* is not found in Peninsula Malaysia, except doubtful records at 152 m. in Penang and near Ipoh in Perak. (Symington 1941). It would, however, be expected to occur further north but not south into the collecting areas visited by Horak in Papua New Guinea since there appears to be some host specificity shown by the two S.E. Asian annulate *Russula* spp.

Acknowledgements

This work was financial supported by the Thailand Research Fund through the Royal Golden Jubilee Ph.D. program to S. Yomyart and P. Sihanonth under the research project no. 2.B.CU/47/N.1. Thanks to Dr. Warawut Chulalaksananukul for use of his laboratory facilities. We are grateful to Professor Steven Miller and Professor David Pegler for reviewing the manuscript.

Literature Cited

Beeli M. 1928. Contribution à lëtude de la Flore mycologique du Congo, champignons récoltés par Mme. Goossens et determinés par M. Beeli. V. Fungi Goossensiani. Bulletin de la Société Royale de Botanique de Belgique 2nd series 60: 153-169.

Beeli M. 1936. Contribution à lëtude de la Flore mycologique du Congo, champignons récoltés par Mme. Goossens et determinés par M. Beeli. XI Fungi Goossensiani. Bulletin du Jardin Botanique National de Belgique 14: 83-91.

Bon M. 1986. Novitates. Documentes Mycologigues 17 (No 65): 51-56.

Buyck B. 1988a. Étude microscopique de specimens types de Russules tropicales de la sous section *Diversicolores*. Mycotaxon 33: 57-70.

Buyck B. 1988b. ditto. sous section *Pluviales*. Mycotaxon 33: 71-80.

Buyck B. 1993. *Russula* I (*Russulaceae*). Flore Illustrée des Champignons d'Afrique Centrale, (Fasc.15): 337-447.

Buyck B. 1994. *Russula* II. (*Russulaceae*). Flore Illustée des Champignons d'Afrique Centrale (Fasc. 16): 411-541.

Buyck B, Horak E. 1999. New species of *Russula* (Basidiomycotina) associated with *Anisoptera* (*Dipterocarpaceae*) in Papua New Guinea. Australian Systematic Botany 12: 727-742.

Buyck B, Ovrebo CL. 2002. New and interesting *Russula* species from Panama. Mycologia 94: 888-901.

Buyck B, Thoen D, Watling R. 1986. Ectomycorrhizal fungi in Africa, in IJ Alexander et al. (eds.), Essays on the ecology of the Guinea-Congo Rainforest. Royal Society of Edinburgh Proceedings, Series B. 104: 313-334.

Gardes M, Bruns TD. 1993. ITS primers with enhanced specificity for basidiomycetes: application to the identification of mycorrhizae and rusts. Molecular Ecology 2: 113-118.

Heim R. 1938a. Diagnoses latines d'espèces et varietés nouvelles de Lactario-russulés du domaine oriental Madagascar. Candollea 7: 374 -394.

Heim R. 1938b. Les Lactario-russulés du domiane oriental de Madagascar, essai sur la classification et la phylogenie des *Asterosporales*. Prodrome à une flore mycologique de Madagascar et dépendences 1: 196 p. 4 pl.

Heim R. 1948. Phylogeny and classification of macro-fungi. Transactions of the British Mycological Society 30: 161-178.

Heim R. 1971. The interrelationships between the *Agaricales* and *Gasteromycetes*. 505-534, in RH Petersen (ed.), Evolution in the Higher Basidiomycetes. Knoxville, University of Tennessee Press.

Miller SL, Buyck B. 2002. Molecular phylogeny of the genus *Russula* in Europe with a comparison of modern infrageneric classifications. Mycological Research 106: 259-276.

Pegler *DN*. 1983. Agaric Flora of the Lesser Antilles. Kew Bulletin. Additional Series IX: 617-621 pl. 21A-B, figs 126 a-h.

Pegler DN, Singer R. 1980. New Taxa of *Russula* from the Lesser Antilles. Mycotaxon 12: 92-96.

Quélet L. 1888. Flore Mycologique de la France: 346.

Romagnesi H. 1967. Les Russules d'Europe et d'Afrique du Nord. 998pp. Bordas, France.

Singer R. 1986. The *Agaricales* in modern taxonomy. Königstein, Koeltz Scientific Books.

Symington CF. 1941. Forest Manual of Dipterocarps. Malayan Forest Manual 16, 244 pp.

White T, 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. San Diego, Academic Press.

Zhou Z, Miwa M, Hogetsu T. 1999. Analysis of genetic structure of a *Suillus grevillei* population in a *Larix kaempferi* stand by polymorphism of inter-simple sequence repeat (ISSR). New Phytologist 144: 55- 63.

MYCOTAXON

Volume 95, pp. 255–260 *January–March 2006*

Embellisia oxytropis, a new species isolated from *Oxytropis kansuensis* in China[1]

QI WANG[2]

qwang2003@hotmail.com
Institute of Mycology, Jilin Agricultural University
Changchun 130118, P. R. China

HIDEYUKI NAGAO

Genebank, National Institute of Agrobiological Sciences
Tsukuba 305-8602, Japan

YU-LING LI & HONG-SHENG WANG

Institute of Grassland, Qinghai Academy of Animal Science & Veterinary Medicine
Xining 810003, P. R. China

MAKOTO KAKISHIMA

Graduate School of Life and Environmental Sciences, University of Tsukuba
Ibaraki 305-8572, Japan

Abstract—*Embellisia oxytropis*, isolated from *Oxytropis kansuensis* in China, is described and illustrated as a new species. This species is characterized by cylindrical conidia with 3-4 transverse septa and 1-celled abundant chlamydospores.

Key words—cultures, isolation, conidiophores, conidia, spores

Introduction

Since the genus *Embellisia* was established and segregated from *Helminthosporium* by Simmons (1971) based on the morphological characteristics of conidiophores, conidia and conidial septa, 21 species have been described or transferred from other genera (de Hoog & Muller 1973; Muntañola-Cvetković & Ristanović 1976; Simmons 1983, 1990, 2004; David et al 2000).

[1]Supported by National Natural Science Foundation of China (No. 30270008) and Japan Society for the Promotion of Science (JSPS). Contribution no. 203, Laboratory of Plant Parasitic Mycology, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan.

[2]Corresponding author

Oxytropis kansuensis Bunge (*Leguminosae*) is widely distributed in grassland of Tibet plateau in China. This species is reported as a locoweed, which is poisonous to animals and causes diseases of livestock (Chang et al. 1981). An endophytic fungus was isolated from its healthy flowers, stems and leaves. Based on the morphological examination we consider this fungus a member of *Embellisia*. Comparative morphology with 21 species shows that this fungus is morphologically different from them. Therefore, we describe this fungus as a new species.

Materials and Methods

Plant sample: The healthy locoweed, *Oxytropis kansuensis*, was collected at Mt. Daming, Qinghai, China, July 20, 2004 and kept in a refrigerator at 4C° for fungal isolation.

Isolation: The fungus was isolated with the method modified from Koga (1993) and Braun et al. (2003). Plant samples were first immersed in 50% ethanol for 20s to eliminate bubbles prior to surface sterilization and were sterilized as indicated in Table 1. The sterilized samples were dried on the sterilized filter papers, then cut into small pieces and incubated on PDA medium at 18C° in darkness. After isolation, the fungus was cultured on PDA, CMA, V-8 and EDMA media.

Table 1. Methods of surface sterilization

Solution	Treatment times
70% ethanol	30 seconds
1% NaClO	3 minutes (leaf or flower)
	5 minutes (stem)
Sterilized water	1 minute rinse, 2 times

Examination: The characteristics of the fungal colonies were observed with a stereomicroscope. Hyphae and conidia obtained from cultures were mounted in lacto-phenol solution on glass slides and examined with a light microscope (LM). For scanning electron microscopy (SEM), they were fixed by vapors from 10% glutaraldehyde solution and coated with platinum, and then observed with a Keyence VE-7800 SEM operating at 2kv or 5kv.

Observation of the fungus in plant tissues: The small pieces of plant samples were boiled in the alcoholic lacto-phenol solution (1 part lacto-phenol to 2 parts 95% ethanol) for 5-10min and stained in analine-blue solution for 30sec. Lacto-phenol contains 10g phenol, 10ml glycerine, 10ml lactic acid and 10ml distilled water. After staining they were immersed in the same solution to destain its pigment for a short time. The hyphae in plant tissues were observed with LM by the method of Koga (1993). For SEM observation, small pieces cut from dried plant samples or plant samples whose epidermis was removed were prepared. They were directly coated by platinum with a JEOL JFC-1600 Auto Fine Coater and observed with a Keyence VE-7800 SEM operating at 2kv or 5kv.

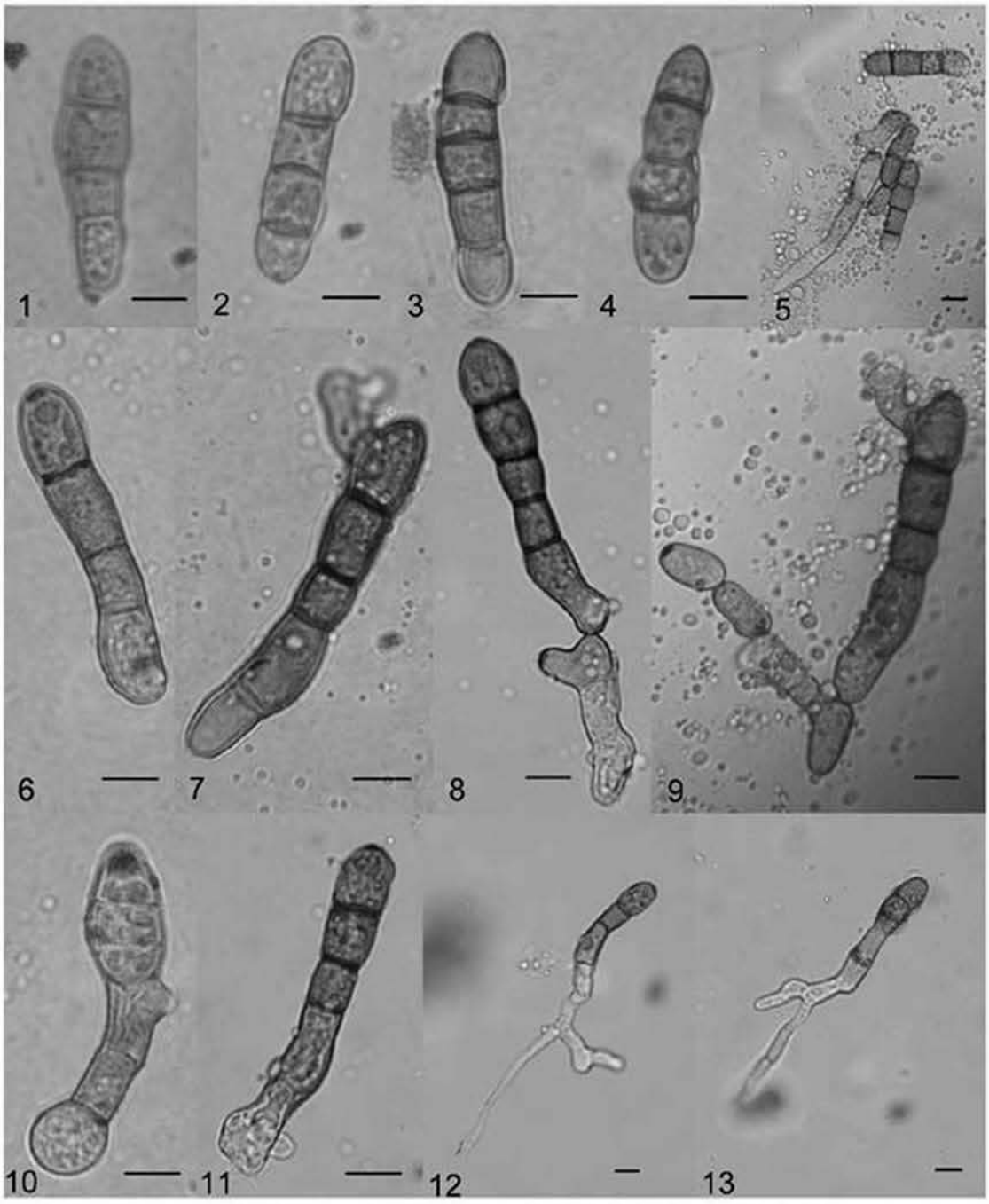


Fig.1. Conidia and conidiophores of *Embellisia oxytropis* isolated from *Oxytropis kansuensis* and cultured on PDA. 1, 2, 3, 4, 6, 7, 10, 11, 12, 13. Conidia. 5, 8, 9. Conidia and conidiophores.

Bars=10μm

Taxonomic description

Embellisia oxytropis Q. Wang, Nagao & Kakish. sp. nov. Fig.1

Hyphae in PDA effusae pallide brunneae, crassiparietales, septatae, ca. 6~8μm diam. Chlamydosporae abundae, catenulatae, intercalares vel terminales, 1-cellulares, crassiparietales, atrobrunnea. Conidiophora simplicia vel ramosa, pallide brunnea, plerumque geniculata in locis conidiogenis. Conidia longe ellipsoidea vel cylindracea, recta, transverse (2~)3~4-septata, atrobrunnea, 8~10×50~60μm, levia vel minute verruculosa.

Holotype: dried culture specimen on PDA, isolated from the leaf of *Oxytropis kansuensis* Bunge, Mt. Daming, Qinghai, China, 20 July 2004, Q. Wang, HMJAU 10012, deposited in the Mycological Herbarium of the Jilin Agricultural University, Changchun, China (HMJAU).

Other specimens examined: dried culture specimens on PDA, isolated from *O. kansuensis*, Mt. Daming, Qinghai, China, July 20, 2004, Q. Wang, HMJAU 10027, 10030, 10032.

Hyphae septate, thick-walled, pale brown, mostly 6~8μm in diam. Chlamydospores abundant as chains, intercalary or terminal, one celled, thick-walled, dark brown. Conidiophores simple or branched, pale brown, mostly becoming several geniculate at conidiogenic loci, secondary sporulation occurring by means of a secondary conidiophore at apex of primary conidia. Conidia long ellipsoid or cylindroid, sometimes straight or slightly inequilateral, mostly with (2~)3~4 transverse septa, dark brown, ca. 8~10×50~60μm. Conidial surfaces smooth or minutely verruculose.

Results and Discussion

Embellisia oxytropis was frequently isolated from healthy plant samples which were kept in a refrigerator at 4C° after collection. The fungus usually appeared from the sides of cross sections 3 days after incubation on PDA. The average ratio of isolation frequency was 20% from leaves, 70% from stems and 85% from flowers, respectively. Therefore, it was suspected that the fungus colonized in all organs of *Oxytropis kansuensis* as an endophyte because no disease symptom was observed in the plant.

Hyphae of the fungus were also frequently observed in the tissues of leaves, stems and flowers with LM and SEM (Fig. 2). They were branched, 2~4μm in diameter and were found under the epidermis or between the plant cells. These hyphae showed the similar characteristics with those observed in cultures on agar media. The hyphae are abundant in flowers and stems but less frequent in leaves. This observation supports the results of fungal isolations. Therefore, we suspected that the flowers were more suitable substrate for the growth of this fungus though it caused no obvious damage to them.

The growth speed on agar media is very slow, about 0.2~0.4mm per day on PDA at 18C°. When the colonies were transferred at 25C° from 18C°, the horizontal growth stopped and the colonies became dark green and formed domes. Colonies on PDA, CMA, V-8 and EDMA showed somewhat different cultural characteristics in color and shape (Fig. 3). On V-8 and PDA, abundant aerial hyphae were observed around the margin of colonies and center of the colonies became dome shaped with dark green to black mycelia. The white flat colonies grew relatively fast on CMA whereas the dark colonies grew more slowly on EDMA.

Embellisia oxytropis is characterized by cylindrical conidia with 3~4 transverse septa and 1-celled abundant chlamydospores. Among 21 described *Embellisia* species, *E. oxytropis* is morphologically similar to *E. abundans* E.G. Simmons, *E. hyacinthi* de Hoog & P.J. Mull. bis, *E. allii* (Campan.) E.G. Simmons, *E. telluster* E.G. Simmons, *E. chlamydospora* (Hoes et al.) E.G. Simmons in shape and/or size of conidia (Simmons 1983, 1990). However, this species is different from them in number of conidial septa and/or direction of septa and also distinguished from *E. hyacinthi* and *E. telluster* by the presence of chlamydospores.

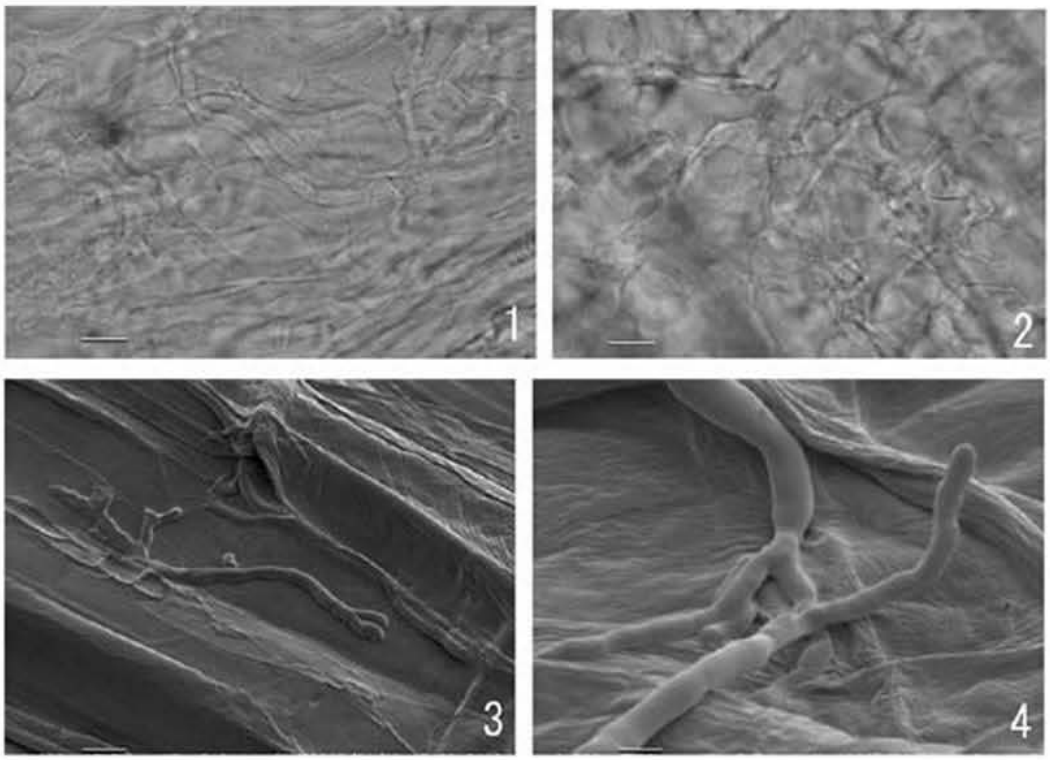


Fig. 2. Hyphae of *Embellisia oxytropis* in plant tissues of *Oxytropis kansuensis* 1. Hyphae observed in the flower by LM. 2. Hyphae observed in the leaf by LM. 3, 4. Hyphae obsetved in the stem by SEM. 1, 2, 3: Bars=10μm, 4: Bar=4μm

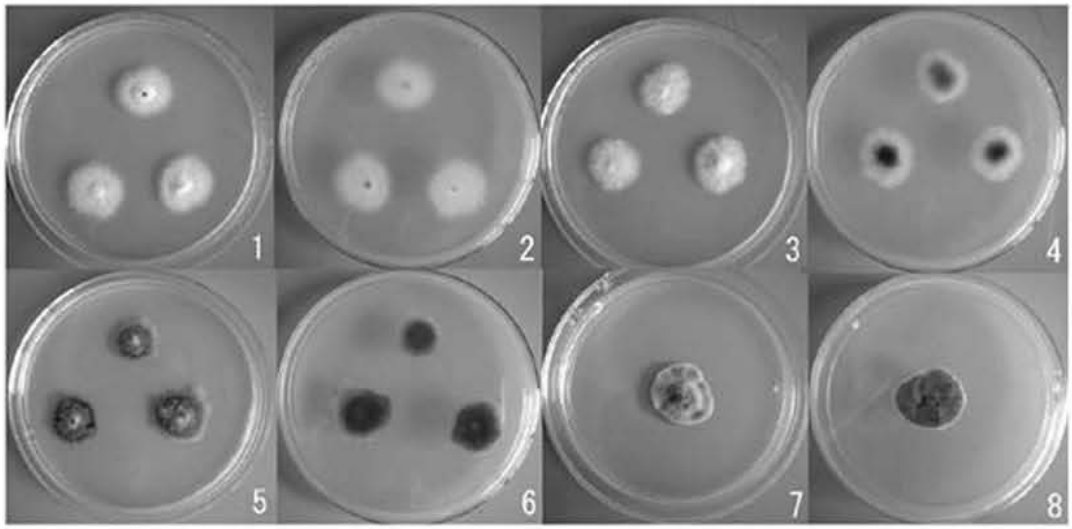


Fig. 3. Colony characteristics of *Embellisia oxytropis* on agar media. 1, 2. On CMA. 3, 4. On V-8. 5, 6. On EDMA. 7, 8. On PDA.

Acknowledgements

Our deep thanks to Dr. K. Okuno and Dr. T. Sato, Genebank of National Institute of Agrobiological Sciences (NIAS), Japan, and Dr. T. Tsukiboshi, National Institute of Floricultural Sciences (NIFS), National Agriculture and Bio-oriented Research Organization, NARO, Japan, for their kind suggestions of our experiments. We are also grateful to Dr. K. Katumoto for his critical reading of the manuscript and revision of the Latin diagnosis, to Dr. Y. L. Guo, Institute of Microbiology, Chinese Academy of Sciences, China, for her critical review of the manuscript.

Literature Cited

Braun K, Romero J, Liddell C, Creamer R. 2003. Production of swainsonine by fungal endophytes of locoweed. Mycol. Res. 107: 980-988.

Chang S, Gao Q, Hou D, Chen J, Zhu X. 1981. Poisoning by *Oxytropis kansuensis*. Acta Veterinaria et Zootechnica Sinica. 12: 145-150 (in Chinese).

David JC, Coles K, Fisher J, Moss ST. 2000. A new species of *Embellisia* from soil with high levels of heavy metals. Mycoscience 41: 533-537.

de Hoog GS, Muller PJ. 1973. A new species of *Embellisia*, associated with skin disease of hyacinths. Neth. J. Pl. Path. 79: 85-93.

Koga H, Christensen MJ, Bennett RT. 1993. Incompatibility of some grass–*Acremonium* endophyte associations. Mycol. Res. 97: 1237-1244.

Muntañola-Cvetković M, Ristanović B. 1976. A new species of *Embellisia* isolated from sea water. Mycologia 68: 47-51.

Simmons EG. 1971. *Helminthosporium allii* as type of a new genus. Mycologia 63: 380-386.

Simmons EG. 1983. An aggregation of *Embellisia* species. Mycotaxon 17: 216-241.

Simmons EG. 1990. *Embellisia* and related teleomorphs. Mycotaxon 38: 251-265.

Simmons EG. 2004. Novel dematiaceous hyphomycetes. Studies in Mycology 50: 109–118.

MYCOTAXON

Volume 95, pp. 261–270 *January–March 2006*

Some hyphomycetes from Brazil. Two new species of *Brachydesmiella*, two new combinations for *Repetophragma*, and new records

RAFAEL F. CASTAÑEDA RUIZ

rfcastaneda@inifat.co.cu
Instituto de Investigaciones Fundamentales en Agricultura Tropical "Alejandro de Humboldt", Calle 1 Esq. 2, Santiago de Las Vegas C. Habana, Cuba. C.P. 17200.

LUÍS FERNANDO PASCHOLATI GUSMÃO

lgusmao@uefs.br
Universidade Estadual de Feira de Santana-UEFS
Departamento de Ciências Biológicas
Caixa Postal 252, 44.031–460, Feira de Santana, BA, Brazil

GABRIELA HEREDIA ABARCA

heredia@ecologia.edu.mx
Instituto de Ecología, A.P. 63, Km,
2.5 Antigua carretera a Coatepec, Xalapa, Veracruz, México

MASATOSHI SAIKAWA

saikawa@u-gakugei.ac.jp
Department of Biology, Tokyo Gakugei University
Nukuikita-machi, Koganei-shi 184–8501, Tokyo, Japan

Abstract—*Brachydesmiella brasiliensis* anam. sp. nov., found on decaying pods of unidentified *Leguminosae* and *Brachydesmiella obclavata* anam. sp. nov., collected on the rotten leaf of an unidentified plant, both from the semi-arid region of Bahia State, Brazil, are described and illustrated. The former is distinguished by navicular to broad fusiform, 3–euseptate, densely verrucose, brown conidia; the latter by obclavate, rostrate, 1–euseptate, pale brown, smooth-walled conidia. A key to *Brachydesmiella* species is provided. *Repetophragma fasciatum* comb. nov. and *Repetophragma filiferum* comb. nov. are proposed. Some other microfungi are reported from the semi-arid region of Brazil.

Key words—anamorph, leaf litter, rotten pod, systematics

Introduction

Over 35 hyphomycetes were collected during mycological surveys of conidial fungi from the semi-arid region in Bahia State, Brazil. Among the collections were two conspicuous fungi clearly related to the genus *Brachydesmiella* G. Arnaud ex S. Hughes (1961) that appear to be new to science. *Brachydesmiella* is characterized by differentiated, mononematous, brown to pale brown conidiophores and tretic, multilocal, sympodial, indeterminate, terminal and intercalary conidiogenous cells. The conidial secession is schizolytic. Six species of *Brachydesmiella* have been validly published in the literature, *B. biseptata* G. Arnaud ex S. Hughes, in Hughes (1961) (the type species); *B. caudata* V. Rao & de Hoog, in Rao & de Hoog (1986); *B. anthostomelloidea* Goh & K. D. Hyde, in Goh & Hyde (1996), *B. orientalis* (V. Rao & de Hoog) Goh, in Sivichai et al. (1998), *B. verrucosa* Goh et al., in Sivichai et al. (1998) and *B. eugecapiellana* R.F. Castañeda et al., in Castañeda Ruiz et al. (2003).

Materials and Methods

Leaf litter samples were placed in separate paper bags and taken to the laboratory. Samples were incubated in Petri dish moist chambers at 25 °C in plastic containers (50 L capacity) with 200 ml of sterile water plus 2 ml of glycerol and examined at regular intervals for the presence of microfungi. Aeration was supplied with a fan (Daytron) for 5 to 10 minutes at 45 minutes intervals. Mounts were prepared in polyvinyl alcohol-glycerol (8.0 g in 100 ml of water, plus 5 ml of glycerol) and measurements made at 1000 x magnification. The conidial fungi were isolated from single conidia picked out under a stereomicroscope after four days incubation from the substrate. They were grown on corn meal agar mixed 1:1 with carrot extract, incubated at 25 °C under alternating cycles of 12 hours of daylight and darkness.

Taxonomy Description

Brachydesmiella brasiliensis R.F. Castañeda, Gusmão & Heredia anam. **sp. nov.**
Fig. (1–5)

Ad fungos conidiales, hyphomycetes pertinens. Coloniae in substrato naturali caespitosae, effusae, brunneae. Conidiophora conspicua, mononematosa, erecta, sinuata vel leviter geniculatae, 1– ad 6–septata, 20–110 µm alta, 6–7 µm crassa ad basim, brunnea, levia, simplicia, non ramosa vel interdum ramosa; rami 12–39 µm longi. Cellulae conidiogenae multilocales, treticae, 10–25 × 5–6 µm. Loci conidiogeni pori, 1 µm diam, plerumque obcuri circa poros. Conidia solitaria, navicularia usque ad ample fusiformia, aequilateralia, leviter constricta ad centro, utrimque obtusa vel rotundata cicatricata ad basim, 3–septata, perverrucosa, brunnea, 30–36 × 6–7 µm; 1.5 µm crassa ad basim. Teleomorphosis ignota.

Etymology: Latin, *brasiliensis*, in reference to Brazil.

Matrix: BRAZIL. BAHIA STATE: Senhor do Bonfim, *in capsula putrida leguminosa non determinata*, legit L.F.P. Gusmão, 17.VII.2005. **Holotypus:** HUEFS97984. **Isotypus:** INIFAT C05/7.

Conidial fungi, Hyphomycetes. **Colonies** on the natural substratum caespitose, effuse, brown. Mycelium superficial and immersed. Hyphae septate, branched, brown, smooth-

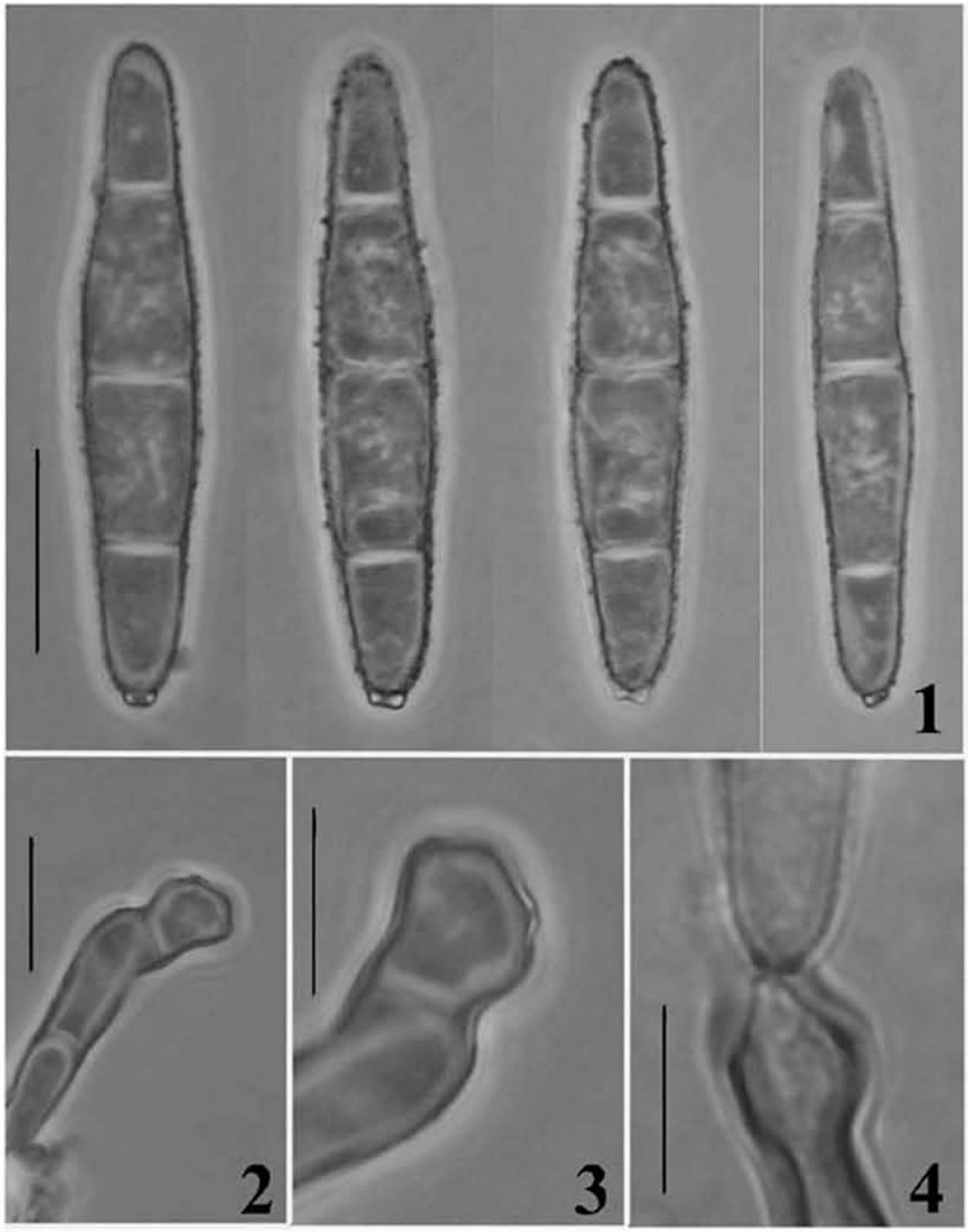


Fig. 1–4. *Brachydesmiella brasiliensis*. 1. Conidia; 2. Geniculate conidiophore; 3–4. Detail of conidiogenous cells. (Bars = 10μm)

walled, 2.0–3.5 μm diam. **Conidiophores** differentiated, mononematous, erect, sinuate to slightly geniculate, somewhat nodose, 1– to 6–septate, 20–110 μm tall, 6–7 μm wide at the base, brown, smooth, mostly simple, sometimes slightly branched; branches 12–39 μm long. **Conidiogenous cells** multilocal, tretic, terminal and intercalary, sympodially proliferating, indeterminate, 10–25 × 5–6 μm, integrated, smooth-walled, brown. **Conidiogenous loci** pores 1 μm diam, with distinct melanized to blackish areas

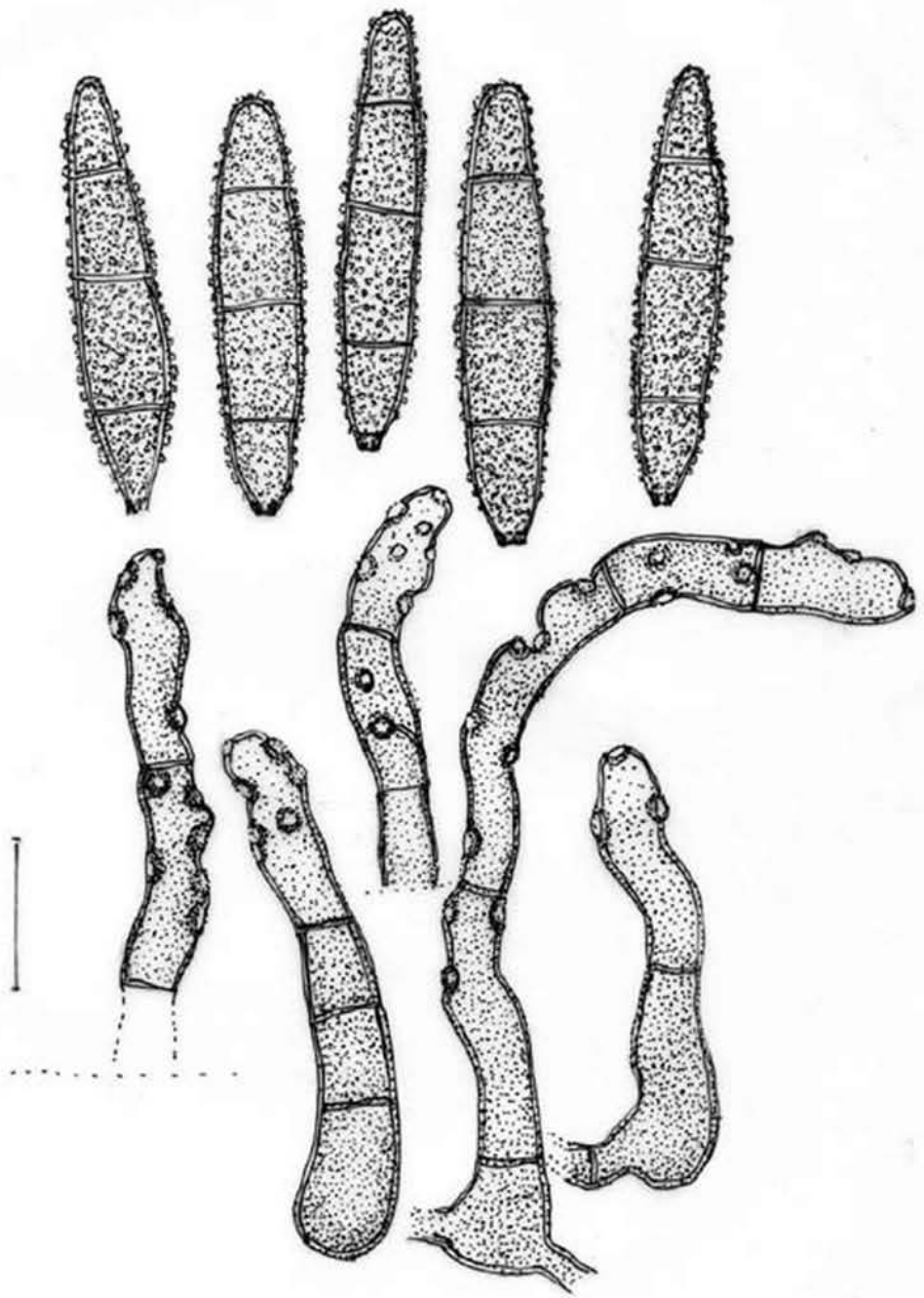


Fig. 5. *Brachydesmiella brasiliensis*. Drawings of conidiophores, conidiogenous cells and conidia. (Bar = 10µm)

around the pores. **Conidial secession** schizolytic. **Conidia** solitary, navicular to broadly fusiform, equilateral, slightly constricted at the middle, obtuse or rounded at the ends, cicatrized at the base with a scar 1.5 µm wide, 3–septate, coarsely verrucose, brown, acropleurogenous, dry, 30–36 × 6–7 µm. Teleomorph: unknown.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on decaying pods of unidentified *Leguminosae*, L.F.P. Gusmão, 17.VII.2005. **Holotypus:** HUEFS97984. **Isotypus:** INIFAT C05/7.

Note: *Brachydesmiella brasiliensis* resembles *B. verrucosa* and *B. caudata* in conidial ornamentation and number of septa, but *B. verrucosa* has ampulliform, 56–92 × 12–17 µm, unequally pigmented conidia with pale olivaceous brown central cell that is darker than the apical and basal cells. Also, the apical rostrate cell of *B. verrucosa* is 4–6 µm wide. *Brachydesmiella caudata* is characterized by smooth, ellipsoidal to truncate-limoniform, 52.5–72.0 × 13–33 µm conidia with dark reddish brown central cells.

Brachydesmiella obclavata R.F. Castañeda, Gusmão & Saikawa anam. **sp. nov.**

Figs. (6–10)

Ad fungos conidiales, hyphomycetes pertinens. Coloniae in substrato naturali pilosae usque ad caepitosa, effusae, hypophyllae, brunneae vel luteo-brunneae. Conidiophora conspicua, mononematosa, erecta, sinuata vel geniculata, plerumque nodosa vel inflata ad apicem, 2– ad 5–septata, 40–75 µm alta, 4–5 µm crassa ad basim, brunnea vel dilute brunnea, levia, plerumque simplicia, raro ramosa;; rami 10–22 µm longi. Cellulae conidiogenae multilocales, treticae, 11–20 × 3.0–3.5 µm. Loci conidiogeni pori, 0.5–1 µm diam, plerumque obcuri circumvallati circa pori. Conidia solitaria, obclavata, obscura cicatricata ad basim, 1–septata, raro 2– septata, levia, dilute, brunnea, 18–23 (–26) × 3 µm; 1.5–2 µm crassa ad basim. Teleomorphosis ignota.

Etymology: Latin, *obclavata*, refers to the clavate conidial shape.

Matrix: BRAZIL. BAHIA STATE: Senhor do Bonfim, *in foliis dejectis putridis non determinatae*, legit L.F. P Gusmão, 17.VII.2005. **Holotypus:** HUEFS97983. **Isotypus:** INIFAT C05/14.

Conidial fungi, hyphomycetes. **Colonies** on the natural substratum pilose to caespitose, effuse, hypophyllous, brown to yellow-brown. Mycelium mostly immersed. Hyphae septate, branched, brown to pale brown, smooth-walled, 1.5–2 µm diam. **Conidiophores** differentiated, mononematous, erect, sinuate to slightly geniculate, mostly nodose or inflated towards the apex, 2– to 5–septate, 40–75 µm tall, 4–5 µm wide at the base, brown or pale brown, smooth, mostly simple, sometimes slightly branched; branches 10–22 µm long. **Conidiogenous cells** multilocal, tretic, terminal and intercalary, sympodially proliferating, indeterminate, 11–20 × 3.0–3.5 µm, integrated, smooth-walled, brown. **Conidiogenous loci** pores 0.5–1.0 µm diam, mostly melanized near the pore. **Conidial secession** schizolytic. **Conidia** solitary, obclavate, cicatrized at the base with a scar 1,5 µm wide, 1–septate, rarely 2–septate, smooth-walled, pale brown, acropleurogenous, dry, 18–23 (–26) × 3 µm; 1.5–2 µm at the base. Teleomorph: unknown.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on dead leaves of unidentified plant, L.F.P. Gusmão, 17.VII.2005. **Holotypus:** HUEFS97983. **Isotypus:** INIFAT C05/14.

Note: *Brachydesmiella obclavata* is somewhat similar to *B. eugecapiellana* in conidial pigmentation, but *B. eugecapiellana* has navicular to narrow fusiform, rostrate, 2–3–septate, 32–40 × 4.0–6.5 µm, verruculose conidia.

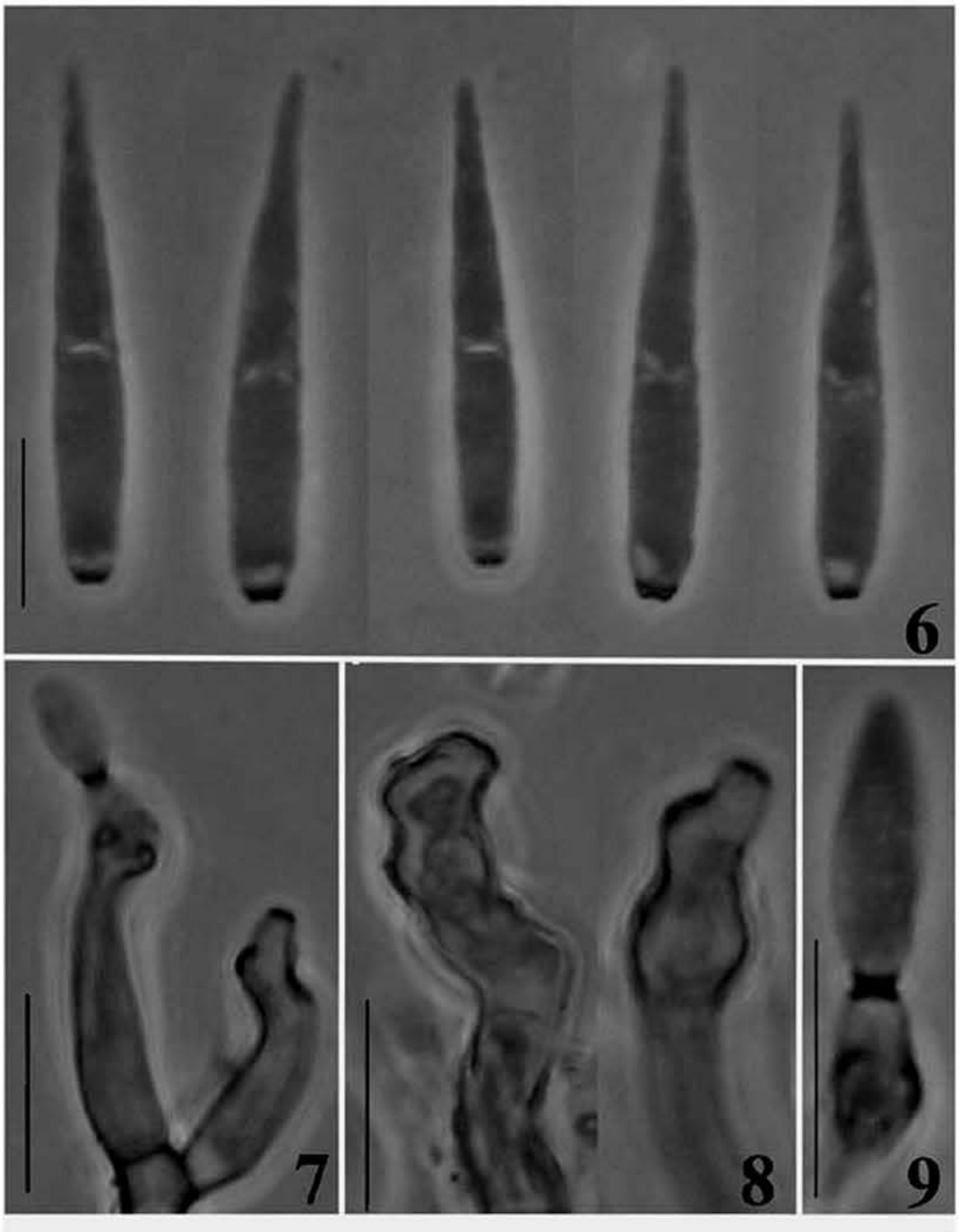


Fig. 6–9. *Brachydesmiella obclavata*. 6. Conidia; 7. Conidiophores; 8. Detail of the conidiogenous cells; 9. Detail of young conidium (Bars = 10μm)

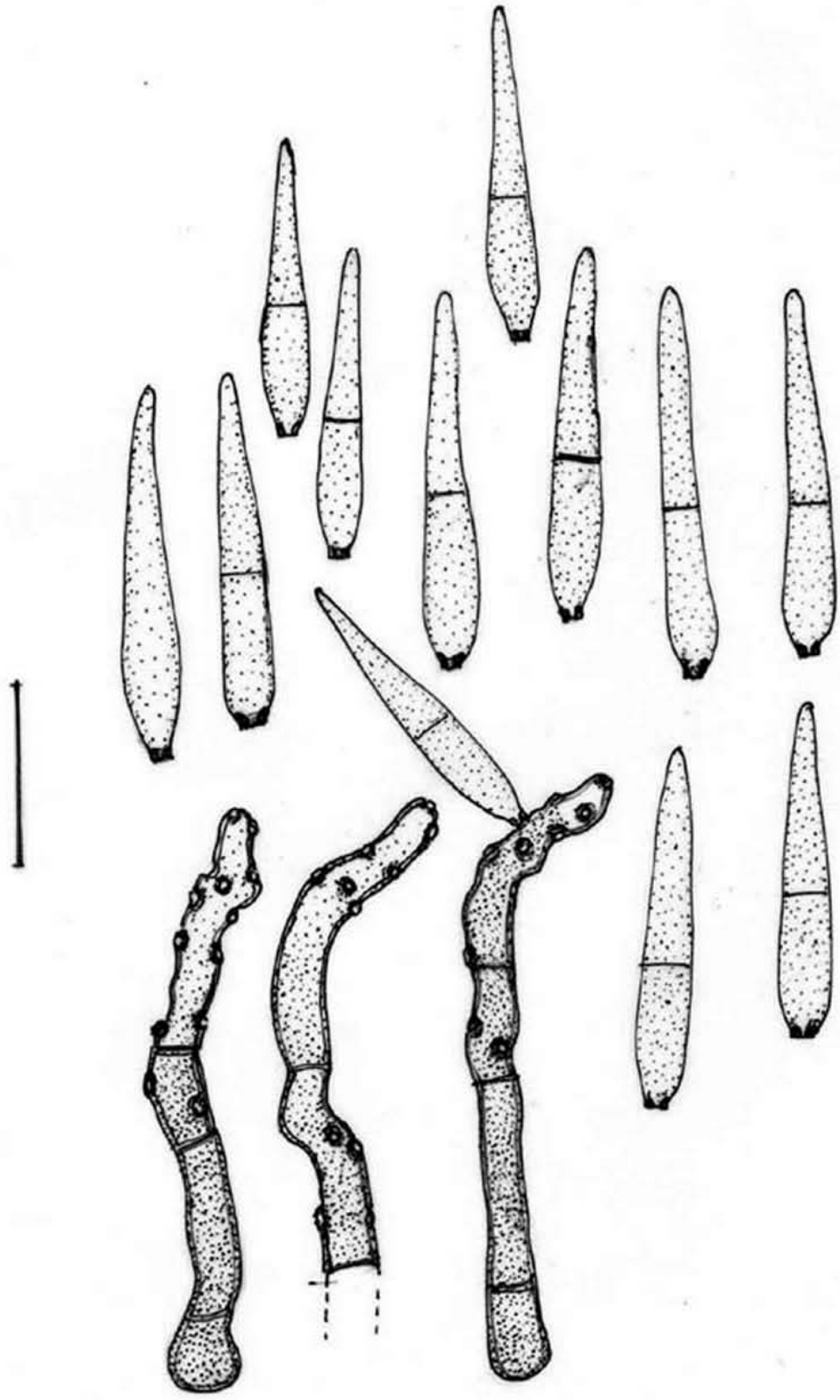


Fig. 10. *Brachydesmiella obclavata*. Drawings of conidiophores, conidiogenous cells and conidia. (Bar = 10μm)

Key to *Brachydesmiella* species

1. Conidia 1–septate 2

1a. Conidia usually with more than 1 septum 3

2. Conidia obclavate, pale brown, 18–23 (–26) × 3 µm; 1.5–2 µm at the base ..... ***B. obclavata***

2a. Conidia limoniform to ampulliform, apical cell cylindrical, pale brown to subhyaline and apical cell darkly olivaceous brown, 35–47 × 14–18 µm ..... ***B. anthostomelloidea***

2b. Conidia pyriform, basal cell broad trapezoid, subhyaline and apical cell blackish brown, 30.0–37.5 × 17.5–22.5 µm ..... ***B. orientalis***

3. Conidia 2–septate 4

3a. Conidia sometimes or always with more than 2 septa 5

4. Conidia limoniform, 37.5–51.0 × 17.5–20.0 µm, unequally pigmented, the apical cell subhyaline, more or less conical, the central cell basal black and obtuse, the basal cell trapezoid, subhyaline ..... ***B. biseptata***

4a. Conidia limoniform-caudate, 52.5–72.5 × 13–33 µm, unequally pigmented, the apical cell subhyaline, cylindrical, the central cell dark reddish brown, elliptical and subhyaline, the basal cell obconical-truncate ..... ***B. caudata***

4b. Conidia ampulliform-caudate, 56–92 × 12–17 µm, unequally pigmented, the apical cell cylindrical subhyaline, the central ellipsoid pale olivaceous brown and hyaline to subhyaline, the basal cell obconical-truncate ..... ***B. verrucosa***

5. Conidia 2– to 3–septate, navicular to narrow fusiform, rostrate, 32–40 × 4.0–6.5 µm, pale brown ..... ***B. eugecapiellana***

5a. Conidia 3–septate, navicular to broadly fusiform, equilateral, slightly constricted at the middle, obtuse or rounded at the ends, 30–36 × 6–7 µm, brown ..... ***B. brasiliensis***

Other microfungi recorded from semi-arid regions in Brazil

Acumispora phragmospora Matsush., Matsushima Mycological Memoirs 1: 3. 1980.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on rotten stem of *Bambusa* sp., L.F.P. Gusmão, 15.VII.2005 (HUEFS42877; INIFAT C05/10–1).

Diploöspora zinniae Matsush., Matsushima Mycological Memoirs 2: 8. 1981.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on rotten stem of *Bambusa* sp., L.F.P. Gusmão, 15.VII.2005 (HUEFS42884; INIFAT C05/13)

Phialosporostilbe setosa Bhat & W.B. Kendr., Mycotaxon 49: 57. 1993.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on rotten stem of *Bambusa* sp., L.F.P. Gusmão, 15.VII.2005 (HUEFS56578; INIFAT C05/9).

Physalidiella matsushimae (R.F. Castañeda & W.B. Kendr.) M. Morelet, Annales de la Société des Sciences Naturelles et d'Archéologie de Toulon et du Var 47: 91. 1995.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on rotten pod of unidentified *Leguminosae*, L.F.P. Gusmão, 15.VII.2005 (HUEFS56579; INIFAT C05/6).

Repetophragma fasciatum (R.F.Castañeda) R.F. Castañeda, Gusmão & Saikawa **comb. nov.**

Basionym: *Chaetendophragmia fasciata* R. F. Castañeda, in Deuteromycotina de Cuba. Hyphomycetes III. Instituto de Investigaciones Fundamentales Agricultura Tropical, "Alejandro de Humboldt", Cuba p.5. 1985.

=*Endophragmiella fasciata* (R. F. Castañeda) R. F. Castañeda, in Fungi Cubenses III (La Habana, Cuba): 20. 1988.

Specimen examined: BRAZIL. BAHIA STATE: Palmeiras, Capão valley, on decaying leaves of *Cupania paniculata* Cambess. (Sapindaceae), L.F.P. Gusmão, 24.VI. 2000, (HUEFS56675).

Repetophragma filiferum (Piroz.) R. F. Castañeda, Gusmão & Heredia **comb. nov.**

Basionym: *Sporidesmium filiferum* Piroz., in Mycol. Pap. 129: 55. 1972.

Specimen examined: BRAZIL. BAHIA STATE: Palmeiras, Capão valley, on decaying leaves of *Cupania paniculata* Cambess. (Sapindaceae), L.F.P. Gusmão, 24.VI.2000, (HUEFS42798); **BRAZIL. BAHIA STATE:** Senhor do Bonfim, on rotten leaf of unidentified plant, L.F.P. Gusmão, 15.VII.2005, (INIFAT C05/2,).

Note: After re-examination of several samples of both fungi, the schizolytic conidial secession after the production of euseptate conidia by several enteroblastic percurrent proliferations was confirmed; these characters were described for *Repetophragma* Subram. (1992); those fungi were recently recorded in Brazil by Grandi & Silva (2005).

Stylaspergillus laxus B. Sutton, Alcorn & P.J. Fisher, Trans. Br. Mycol. Soc. 79: 340. 1982.

Specimen examined: BRAZIL. BAHIA STATE: Senhor do Bonfim, on rotten pod of unidentified *Leguminosae*, L.F.P. Gusmão, 15.VII.2005, (HUEFS56583; INIFAT C05/6-4).

Acknowledgements

We are grateful to Dr. L. M. Carris (Washington State University), Dr. D. W. Minter (International Mycological Institute) for kindly reviewing the manuscript. We are grateful to the Cuban Ministry of Agriculture for providing facilities during this study. We (RFCR, LFPG and GH) are indebted to the CYTED for support this during this study. The second author extends the grateful to the "PPBIO - semi-arid" and the Brazilian Ministry of Technology & Science (MCT).

Literature Cited

Castañeda Ruiz RF, Kendrick B. 1990. Conidial Fungi from Cuba II. University of Waterloo Biology Series 33: 1-61.

Castañeda Ruiz RF, Iturriaga T, Minter DW, Saikawa M, Vidal G, Velázquez-Noa S. 2003. Microfungi from Venezuela. A new species of *Brachydesmiella*, a new combination, and new records. Mycotaxon 85: 211–229.

Ellis MB. 1971. Dematiaceous Hyphomycetes. Commonwealth Mycological. Institute, Kew.

Goh TK, Hyde KD 1996. *Brachydesmiella anthostomelloidea*, a new species of dematiaceous Hyphomycete from Australia. Mycological Research 100: 1364–1366.

Grandi RAP, Silva TV. 2005. Fungos anamorfos descompositores do folhedo de *Celsalpinia echinata* Lam. In Anais, V Congreso Latinoamericano de Micologia, p. 272, Brasilia, Brazil,

Hughes SJ. 1961. Microfungi. VII. *Brachydesmiella* Arnaud. Canadian Journal of Botany 39: 1095–1097.

Rao V, de Hoog GS. 1986. New or critical hyphomycetes from India. Studies in Mycology. 28: 1–84.

Sivichai S, Goh TK, Hyde KD, Hywel-Jones NL. 1998. The genus *Brachydesmiella* from submerged wood in the tropics, including a new species and new combination. Mycoscience 39: 239–247.

Subramanian CV. (1992). A reassessment of *Sporidesmium* (Hyphomycetes) and some related taxa. Proceedings of the Indian National Science Academy B58: 179–190.

MYCOTAXON

Volume 95, pp. 271–275 *January–March 2006*

Russula in Himalaya 3: A new species of subgenus *Ingratula*

KANAD DAS[1*], J.R. SHARMA[2] & N.S. ATRI[3]

**daskanad@yahoo.co.in*

[1]Mycology and Plant Pathology Group, Agharkar Research Institute
G.G. Agarkar Road, Pune 411004, India

[2]Botanical Survey of India, 192, Kaulagarh Road
Dehradun 248195, India

[3]Botany Department, Punjabi University
Patiala 147002, India

Abstract—*Russula natarajanii*, a new species of subgenus *Ingratula* from Kumaon Himalaya characterized by a whitish pileus, is described and illustrated in detail.

Key words—macrofungi, *Russulaceae*, taxonomy, India

Introduction

Although generally considered one of the largest ectomycorrhizal genera, *Russula* is represented by only approximately 100 taxa on the Indian subcontinent. Of those, only twenty—*Russula delica* Fr., *R. densifolia* Secr. ex Gillet, *R. foetens* Pers., *R. gracillima* Jul. Schäff., *R. heterophylla* (Fr.) Fr., *R. minutula* var. *robusta* Saini et al., *R. nitida* (Pers.) Fr., *R. versicolor* Jul. Schäff., *R. flavida* Frost, *R. compacta* Frost, *R. rhodomelanea* Sarnari, *R. raoultii* Quél., *R. anatina* Romagn., *R. praetervisa* Sarnari, *R. decolorans* (Fr.) Fr., *R. mukteshwarica* K. Das et al., *R. mayawatiana* K. Das et al., *R. puellaris* var. *atrii* K. Das et al., *R. dhakuriana* K. Das et al. and *R. appendiculata* K. Das et al.—have been described in detail from Kumaon Himalaya (Saini et al. 1982, Atri & Saini 1986, Atri et al. 1994, Rawla 2001, Das & Sharma 2001, Das et al. 2002, Das & Sharma 2003, Das & Sharma 2004, Das et al. 2006a, b). Earlier explorations (Atri et al. 1994, Rawla 2001) have been restricted to the other Himalayan regions of Himachal, Kashmir, and Garhwal. Our recent intensive surveys of the different altitudinal zones within Kumaon Himalaya resulted in collections of some additional taxa not previously cited. Comparison with the literature of previously described taxa revealed an undescribed new species, which we formally describe here as *Russula natarajanii*.

Materials and Methods

The present communication is based on specimens collected periodically during recent years from the Pithoragarh and Bageshwar districts of Kumaon Himalaya.

Macromorphological characters were noted from fresh specimens. Colour changes resulting from the addition of $FeSO_4$ on fresh material were also noted. Micromorphological examinations were made of free-hand sections of dried material mounted in 5% KOH, Melzer's reagent, Congo red, Lactophenol-cotton blue, and Carbol Fuchsin. Colour terms follow Kelly & Judd (1955). Microscopic line drawings were made with the aid of a camera lucida at original magnification of 1500x for basidiospores and 1000x for other microstructures. Density of lamellae (L/cm) was measured at the margin of the pileus. Basidiospore measurements exclude the height of ornamentation. Basidium length excludes the length of sterigmata. Quotient (Q = L/W) was calculated considering the mean value of length and width of 25 basidiospores. Herbarium names follow Holmgren et al. (1990).

Description of the species

Russula natarajanii K. Das, J.R. Sharma & Atri **sp. nov.** **Fig. 1**

Etymology: To honour K. Natarajan for his contributions to Indian mycota.

Pileus 60–105 mm latus., planoconvexus, ad umbelicatus, sulcatus, albidus. Lamellae adnexae,,satis distantes, albocremeae. Stipes 40–70 x 16–22 mm, cylindricus, ad subclavatus, albidus. Sporae in cumulo luteoalbae, 6.5–8 x 5.8–7.1 µm, subglobosae ad late ellipticae, amyloideae, subreticulatae. Pleurocystidia 60–90 x 6–10.5 µm, fusiformia. Cheilocystidia nulla. Pileocystidia ad 6 µm lata.

Holotypus: INDIA, Uttaranchal, Pithoragarh, Dafia Dhura, October 4, 2001, leg. K. Das & J.R. Sharma, KD4097 (HOLOTYPUS, BSD).

Pileus 60–105 mm diam., convex, planoconvex, planoconcave to umbilicate at maturity; pileipellis dry, viscid when moist, white to yellowish white with yellowish gray in the center, sometimes light to medium brown spots at the periphery, unchanging; margin tuberculate-sulcate, decurved, gradually plane at maturity. **Lamellae** adnexed, subdistant to close (ca 6–7 per cm), forked near stipe, brittle, yellowish white to cream; lamellulae absent; edges even. **Stipe** 40–70 x 16–22 mm, dry, central, cylindric to subclavate, concolorous with pileus; context solid to stuffed, white to yellowish white, unchanging. **Taste** mild. **Odor** not distinctive. **Macrochemical** (stipe): $FeSO_4$ positive (salmon). **Spore print** yellowish white.

Basidiospores 6.5–8.8 x 5.8–7.1 µm, subglobose to broadly ellipsoid, Q = 1.08–1.25 (1.34); ornamentation amyloid, up to 0.4 µm high, composed mostly of minute warts and ridges and forming incomplete reticulum. **Basidia** 28–35 x 7.5–9 µm, subclavate to clavate, 4-spored; sterigmata up to 6 µm long. **Pleurocystidia** 60–90 x 6–10.5 µm, emergent up to 30 µm, fusiform with mucronate to capitate apex, content dense. Lamellae edge fertile. **Cheilocystidia** not found. **Subhymenium** layer up to 27 µm thick, cellular. **Pileipellis** composed of suberect hyphae and pileocystidia; pileocystidia up to 5 µm broad. **Stipitipellis** composed of parallel hyphae (up to 3 µm broad). **Stipe trama** composed of numerous sphaerocytes.

Ecology—*Russula natarajanii* grows in close association with *Quercus* species in moist, temperate (2300–2700 m), deciduous/mixed forests in the Kumaon Himalaya.

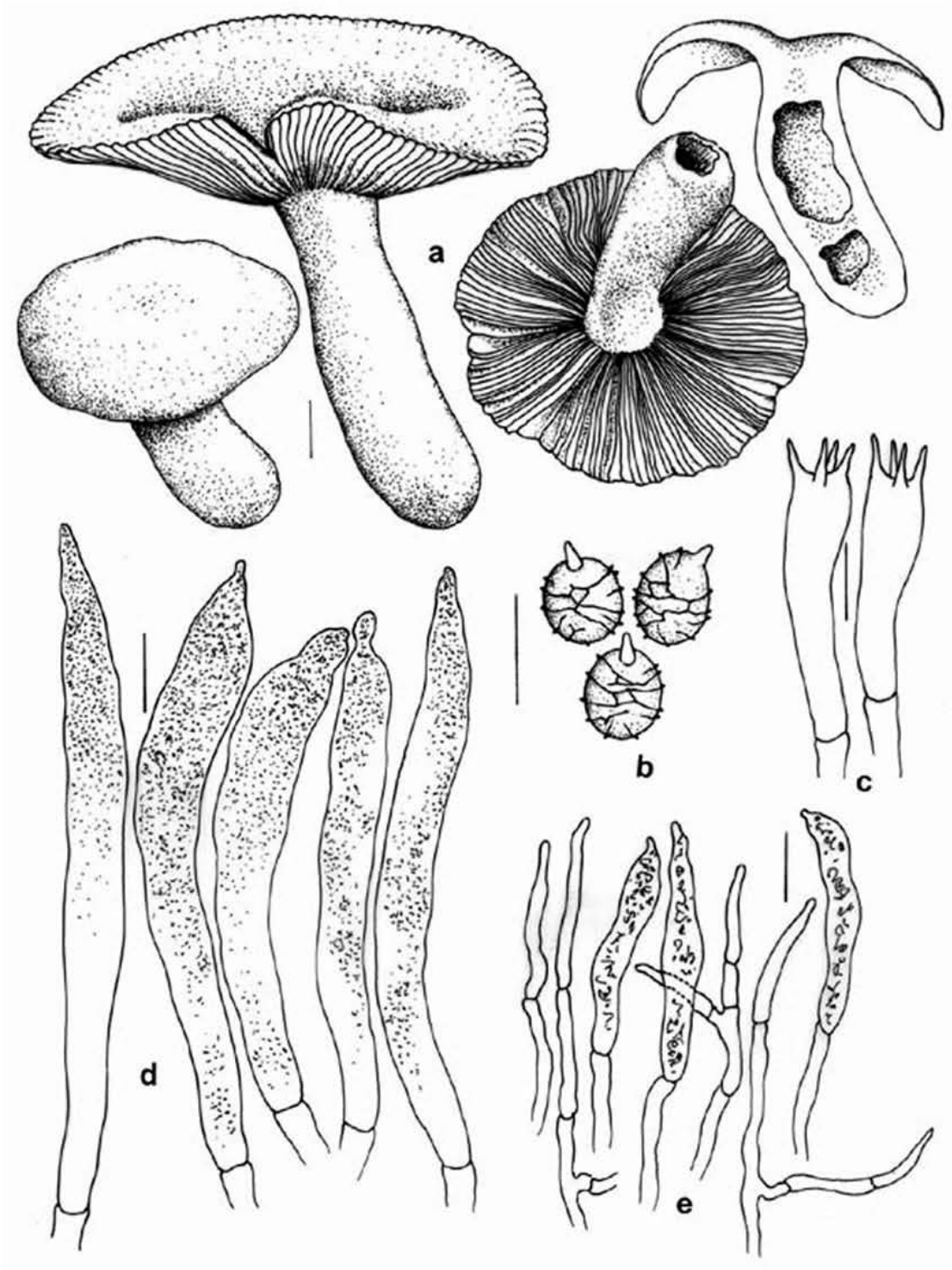


Fig. 1. *Russula natarajanii* (from Holotype): a. Basidiomes b. Basidiospores c. Basidia d. Pleurocystidia e. Pileipellis. Bars: a = 10 mm; b-e = 10 µm.

OTHER SPECIMENS EXAMINED—INDIA, Utaaranchal BAGESHWAR, Dhakuri, September 2003, leg. K. Das & J.R. Sharma, KD7008 (GUH); *ibid.*, KD7070 (BSD).

Comments—*Russula natarajanii* is distinguished in the field by having the unique combination of a whitish pileus color that is unchanging with bruising or age, a tuberculate pileus margin, and minutely warted basidiospores with ridges. The viscid pileipellis, sulcate pileus margin, adnexed lamellae, low ornamented basidiospores and the presence of pileocystidia support placing *R. natarajanii* in the subgenus *Ingratula* as emended by Sarnari (1998).

In the field, *R. natarajanii* appears quite close to *R. brevipes* Peck var. *brevipes* and *R. delica*. However, typically shorter stipes, numerous lamellulae, absence of tuberculate-sulcate pileus margin (cf. Shaffer 1964, Sarnari 1998), acrid taste, and higher spore ornamentation separate both *R. brevipes* var. *brevipes* and *R. delica* from the newly named species. Moreover, the typically decurrent lamellar attachment also helps to separate *R. brevipes* var. *brevipes* from *R. natarajanii*.

Acknowledgements

We wish to express our gratitude to (Director) Dr. M. Sanjappa and (Joint Director) Dr. D.K. Singh of the Botanical Survey of India, Kolkata and Dr. V.S. Rao, Director, Agharkar Research Institute, Pune for providing facilities. We also thank Jukka Vauras (Åbo Akademi University, Turku, Finland) and Dr. Lorelei L. Norvell (PNW Mycology Service, Portland OR, USA) for critically reviewing the manuscript.

Literature Cited

Atri NS, Saini SS. 1986. Further contribution on the studies of North West Himalayan *Russulaceae*. Geobios New Reports 5: 100–105.

Atri NS, Saini MK, Saini SS. 1994. Indian *Russulaceae* Roze – a check list, in T.A. Sharma, S.S. Saini, M.L. Trivedi & M. Sharma (eds.). 81 – 93. Current Researches in Plant Sciences, Dehradun.

Das K, Sharma JR. 2001. *Russula rhodomelanea* Sarnari – a new record for India. Mushroom Research 10 (2): 109–111.

Das K, Sharma JR. 2003. New records of *Russula* from Kumaon Himalaya. Indian Journal of Forestry 26 (3): 320–326.

Das K, Sharma JR. 2004. *Russula compacta* Frost & Peck – A new record from India. J. Mycol. Pl. Pathol., 34 (1): 149–150.

Das K, Sharma JR, Bhatt RP. 2002. *Russula flavida* Frost – an addition to the Indian ectomycorrhizic fungi. Mushroom Research 11 (1): 9–10.

Das K, Miller SL, Sharma JR. 2006b. *Russula* in Kumaon Himalaya 2: Four new taxa. Mycotaxon 95: 205–215.

Das K, Miller SL, Sharma JR, Sharma P, Bhatt RP. (2005) 2006a. *Russula* in Kumaon Himalaya 1: A new species of subgenus *Amoenula*. Mycotaxon 94: 85–88.

Holmgren PK, Holmgren NH, Barnett LC. 1990. Index Herbariorum. Part 1: Herbaria of the world, 86th ed. Brox: New York Botanical Garden.

Kelly KL, Judd DB. 1955. The ISCC-NBS Method of Designating Colors and a Dictionary of Colour Names. ISCC-NBS Color-Name Charts Illustrated with Centroid Colors. National Bureau of Standards Circular 553. U.S. Government Printing Office, Washington, DC.

Rawla GS. 2001. Himalayan species of *Russula* Pers. Ex S.F. Gray, in P.C. Pande & S.S. Samant (eds.). 1–48. Plant Diversity of the Himalaya. India.

Saini SS, Atri NS, Singer R. 1982. North Indian *Agaricales* – II. Sydowia, Annales Mycologici, Ser. II 35: 238–241.

Sarnari M. 1998. Monografia illustrata del genere *Russula* in Europa. Tomo Primo. Italia. 799 pp.

Shaffer RL. 1962. The subsection *Compactae* of *Russula*. Brittonia 14: 254–284.

MYCOTAXON

Volume 95, pp. 277–280 *January–March 2006*

Wallemia—a genus newly recorded from China

GUANGYU SUN[1], MIAO ZHANG[1], RONG ZHANG[1], HUINING MA[1]
& MARK L. GLEASON[2]

sgy@nwsuaf.edu.cn
[1]*College of Plant Protection, Northwest A & F University*
Yangling, Shaanxi, 712100, China

[2]*Department of Plant Pathology, Iowa State University*
Ames, Iowa 50011, U.S.A

Abstract—*Wallemia sebi* (Basidiomycota) is reported from China for the first time. The fungus was found on the epicuticular wax of apple fruit sampled from an orchard in Shaanxi Province, China. Its conidiophores are unbranched or sympodial, erect, and phialidic; conidiogenous cells at the apex of conidiophores constrict and disarticulate distally into four arthrospore-like conidia; conidia are one-celled, initially short cylindrical, and finally spherical; the fungus can grow on potato dextrose agar (PDA) and malt extract agar (MEA) media without additional solutes. A description based on the Chinese material and illustrations are provided.

Key words—Wallemiomycetes, taxonomy, sooty blotch

Introduction

Wallemia sebi (Fr.) Arx is a cosmopolitan xerophilic and osmophilic fungus that has been reported from several continents, usually on sweet food (jams, fruits, sugar, cakes), salted food (salted meats, fish, peanuts), dried materials (causing spoilage on dried hay, bread, and dried fruits) (Samson et al. 2002), and seeds (sunflower, rye, wheat), as well as in indoor environments (Takahashi 1997). Terracina (1974) found that the septum of *W. sebi* was similar to those formed by many basidiomycetes and some ascomycetes. Moore (1986, 1996) further ascertained that the hyphae of *W. sebi* contained dolipore septa. Nevertheless *W. sebi* was ascribed to ascomycetes in Kirk et al. (2001). However, Zalar et al. (2005) proposed a new basidiomycetous class, Wallemiomycetes, based on unique dolipore morphology, xerotolerance, and sequence data of ITS rDNA (the rDNA internal transcribed spacer regions), and included three species (*Wallemia sebi*, *W. ichthyophaga* and *W. muriae*) in the now-basidiomycete genus *Wallemia*. In this paper we provide the first description of morphological and colonial characteristics of *W. sebi* collected in China.

Materials and Methods

Apple fruits were collected from Qianyang County in Shaanxi Province. To obtain a pure culture thalli were sampled directly from the apple fruit surface (Sun et al. 2003).

The isolate was cultured on potato dextrose agar (PDA) at 24° in darkness.

The characteristics of the isolate were described and photographed growing on dishes of PDA and malt extract agar (MEA); fungal structures were mounted in lactophenol for microscopic examination. The colony diameter of the isolate was determined on three media (YGA, YGA2, and M40Y) 15 days after inoculation at 24°.

Media: PDA (200 g potato; 20 g dextrose; 15 g agar; 1000 ml distilled water); MEA (20 g Bacto™ malt extract; 15 g agar; 1000 ml distilled water); YGA (10 g yeast extract, 50 g glucose, 4 g K_2HPO_4, 15 g agar, and 1000 ml distilled water); YGA2 (YGA amended with 100 g glucose); M40Y (powdered malt extract 20 g, yeast extract 5 g, sucrose 400 g, agar 15 g, and 1000 ml distilled water).

Taxonomic Description

Wallemia sebi (Fr.) Arx, Gen. Fungi Sporul. Cult.: 166. 1970.
= *Sporendonema sebi* Fr., Syst. Mycol. 3: 435. 1832.

On surface of apple fruit mycelia are dark brown, forming sooty blotch colonies with thick tree-like branched margins. Colonies on plate usually slow growing, variable in shape. On M40Y, forming mounded cones, walnut or gray brown in color, fragments easily dislodged from colonies and forming satellite colonies on the dish, darker color at the colony margins, sometimes secreting light to dark yellowish mucous drops golden to black in color, 16 mm colony diameter after 15 days. Colonies on YGA clumped, walnut or gray brown, compact, slightly mounded in center, spreading deeply into medium, surface usually dry but sometimes secreting tiny, light-colored drops that are initially golden and slowly become brown or black, sometimes white aerial mycelia, 10 mm diameter after 15 days. On YGA2, 13 mm diameter after 15 days, colonies similar to those on YGA, but including easily dislodged fragments leading to scattered satellite colonies.

On PDA, colonies ridged, 6 mm in diameter after 15 days, hyphae hyaline, smooth, thin-walled, septate, mycelia loosely arranged, branched, and 1.5-3.0 µm wide. Conidiophores erect, short, subhyaline, compactly arranged, unbranched, phialidic, smooth-walled, densely arranged. Conidiogenous cells at the apex of conidiophores, cylindrical, not smooth-walled, basauxically extending, constricting basipetally and disarticulating into four arthrospore-like conidia. Conidia one-celled, initially short cylindrical, slightly brown or nearly hyaline, soon becoming spherical, not smooth, thick-walled, brown or pale brown, 1.5-3.0 (-4.0) µm diameter. Conidia forming long or short, straight or bending chains. On MEA, colonies are similar to those on PDA.

HABITAT: In salty environments, on seeds (sunflower, wheat, rye, and soybean), soil, air, sugary foods, hay, fruits, textiles, man, animal and the surface of apple fruit.

Discussion

Three species, *Wallemia sebi*, *W. ichthyophaga*, and *W. muriae*, were accepted by Zalar et al. (2005) in the genus *Wallemia*. They can be distinguished by morphology (conidial size, having or not having sarcina-like structures) and especially growth on media. Both *W. ichthyophaga* and *W. muriae* grow on MEA only when amended with additional solutes. In our experiment, the isolate from the apple fruit surface grew well on media

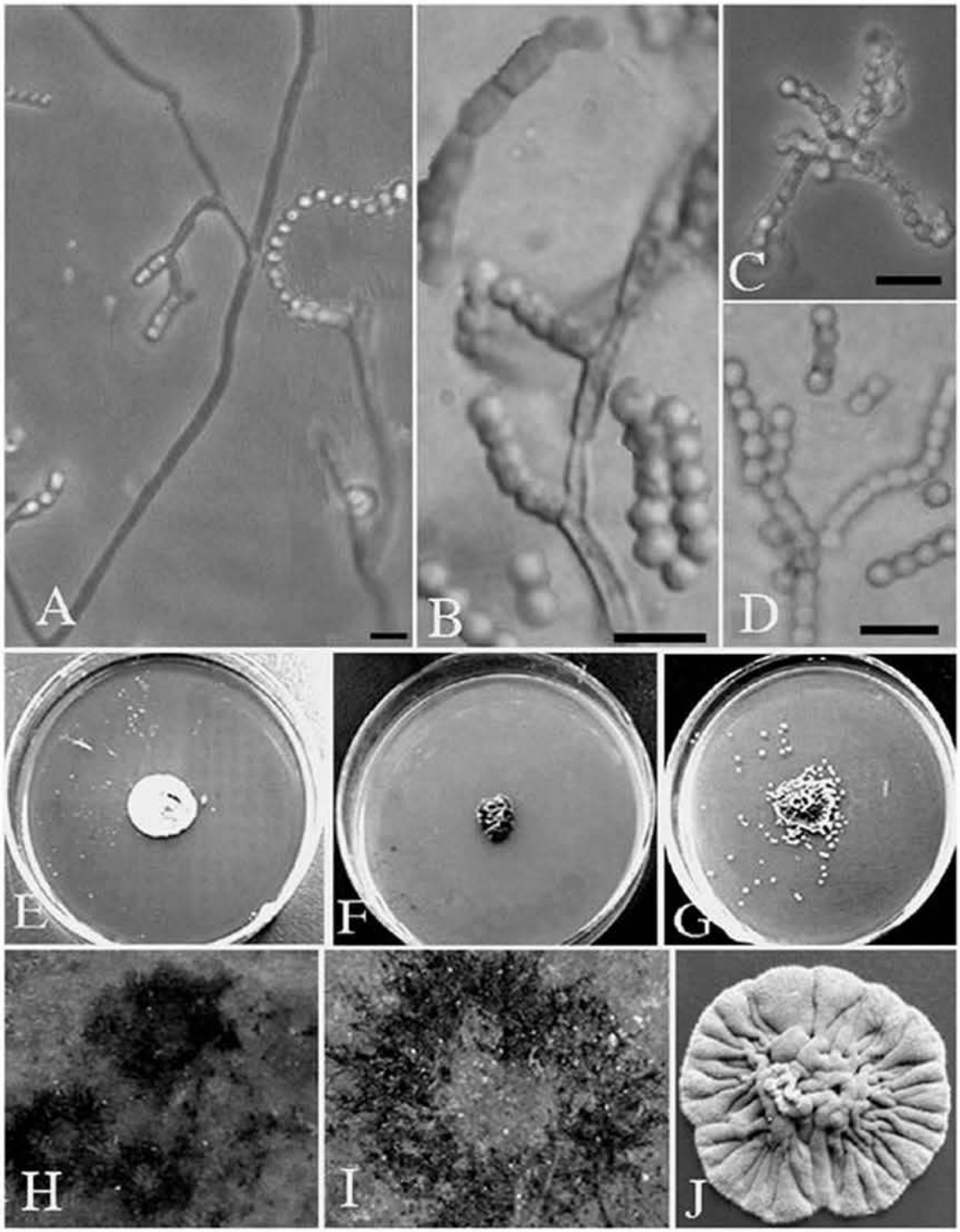


Fig. 1 *Wallemia sebi*

A: Hyphae, conidiophores and chains of conidia; B: Spherical conidia and initially cylindrical conidial chains, and sympodially elongating conidiophores; C: Conidial chains arising from a conidium; D: Conidia in chains; Bars = 10 µm. E: Colonies on M40Y; F: Colony on YGA; G: Colonies on YGA2, satellite colonies scattering in the plate; H: Colony on the surface of apple peel; I: Mycelia of the colony on the apple surface under stereo microscope; J: Colony on PDA.

such as MEA and PDA, its conidial size was similar to that of *W. sebi*, and sarcina-like structures (typical of *W. ichthyophaga*) were absent. Based on these characters we identified the isolate as *W. sebi*.

Wallemia sebi has been reported commonly as growing on food and from the indoor environments. This is the first report of its occurrence as a saprophyte on living plants.

Acknowledgements

This work was supported by International Science Foundation (D/S3538-1). The authors wish to thank Dr. Turner Sutton (Department of Plant Pathology, North Carolina State University, Raleigh, NC 29695) and Dr. Pedro Crous (Centraalbureau voor Schimmelcultures, Fungal Biodiversity Centre, PO Box 85167, 3508 AD Utrecht, The Netherlands) for reviewing the manuscript.

Literature Cited

Kirk PM, Cannon PF, David JC, Stalpers JA. (eds). 2001. Dictionary of the fungi, 9th ed. Wallingford, CAB International.

Moore RT. 1986. A note on *Wallemia sebi*. Antonie van Leeuwenhoek 52: 183-187.

Moore RT. 1996. The dolipore/parenthesome septum in modern taxonomy. 13–35. In: B Sney et al. (eds.), *Rhizoctonia* Species: Taxonomy, Molecular Biology, Ecology, Pathology and Disease Control. Dordrecht, Kluwer Acad. Publ.

Samson RA, Hoekstra ES, Frisvad JC, Filtenborg O. 2002. Introduction to Food and Airborne Fungi, 6th ed. Centraalbureau voor Schimmelcultures, Utrecht, the Netherlands.

Sun GY, Zhang R, Zhang Z, Zhang M. 2003. Isolation of sooty blotch and flyspeck fungi from apple surface by picking up the thalli. Acta Phytopath. Sin. 33 (5): 479-480 [in Chinese].

Takahashi T. 1997. Airborne fungal colony-forming units in outdoor and indoor environments in Yokohama, Japan. Mycopathologia 139 (1): 23-33.

Terracina FC. 1974. Fine structure of the septum in *Wallemia sebi*. Can. J. Bot. 52: 2587-2590.

Zalar P, de Hoog GS, Schroers HJ, Frank JM, Gunde-Cimerman N. 2005. Taxonomy and phylogeny of the xerophilic genus *Wallemia* (Wallemiomycetes and *Wallemiales*, cl. et ord. nov.). Antonie van Leeuwenhoek 87 (4): 311-128.

MYCOTAXON

Volume 95, pp. 281–284 *January–March 2006*

Phialophora sessilis, a lithobiont fungus

GIUSEPPE CARETTA[1], SOLVEIG TOSI*[1], EDUARDO PIONTELLI[2] & G.S. DE HOOG [3]

solveig.tosi@unipv.it

[1]*Sezione di Micologia, Dipartimento di Ecologia del Territorio e degli Ambienti Terrestri Università di Pavia via S. Epifanio 14, 27100 Pavia, Italy*

[2]*Catedra de Micologia, Facultad de Medicina, Universitad de Valparaiso Casilla 92, Valparaiso, Chile*

[3]*Centraalbureau voor Schimmelcultures P.O. Box 85167, NL-3508 AD Utrecht, The Netherlands*

Abstract—*Phialophora sessilis* was repeatedly isolated from marble powder in a cemetery site in Pavia (Italy). Morphological characteristics of this strain are reported. Its probable role as a lithobiont with a high adaptability to different organic sources is discussed.

Key words—rock-inhabiting fungi, adelophialide

Introduction

During a survey on rock-inhabiting fungi from marble powder in the cemetery site of Sommo, a suburb of Pavia (Italy), numerous fungal taxa were isolated. Among the species recognized by molecular identification was *Phialophora sessilis* de Hoog (de Hoog et al. 1999). In this paper the first record of this species in the Mediterranean is reported and the isolation of the fungus from nutrient-poor substrates such as marble powder is discussed.

Phialophora sessilis was firstly reported by de Hoog et al. (1999) from *Picea abies* resin in Baarn (Netherlands) and described in a comparative study of 34 strains belonging to the *Phialophora verrucosa* complex. Additional strains of *P. sessilis* originated from forest soil in Sweden, from the lichen *Peltigera polydactyla* and from a biological filter for styrene-containing fumes (de Hoog et al. 1999; for further data refer to www.cbs.knaw.nl/databases/). Important phenetic characteristics of *P. sessilis* are the dark, slow-growing colonies, conspicuous collarettes which are darker than the rest of the phialide and are laterally inserted on undifferentiated hyphae, and conidia inflating to germinating cells prior to germination and then frequently bearing phialidic collarettes. A key to *Phialophora* species occurring as opportunists on humans and bearing morphological similarity to *P. sessilis* was provided by de Hoog et al. (2000).

Phialophora sessilis, despite its apparent phylogenetic position in the Ascomycetes order *Chaetothyriales* containing numerous opportunists on humans (de Hoog et al. 1999), has never been found causing infections in warm- or cold-blooded animals, and it seems to lack any ecological preference. Wrona & Grabowski (2004 a, b) considered *P. sessilis* to be one of the causal agents of apple sooty blotch disease, growing their strain only on the apple skin, utilizing fructose and glucose as primary source of carbon (Wrona & Grabowski 2004 a). However, the possibility is not excluded that a well-known *Phialophora*-like apple-colonizer, *Cadophora malorum* (Kidd & Beaumont) W. Gams (McColloch 1944; Gams 2000) was concerned. We were unable to verify this, as no voucher strain was sent upon request.

The present finding of consistent growth on marble may shed some light on the ecology of *P. sessilis*.

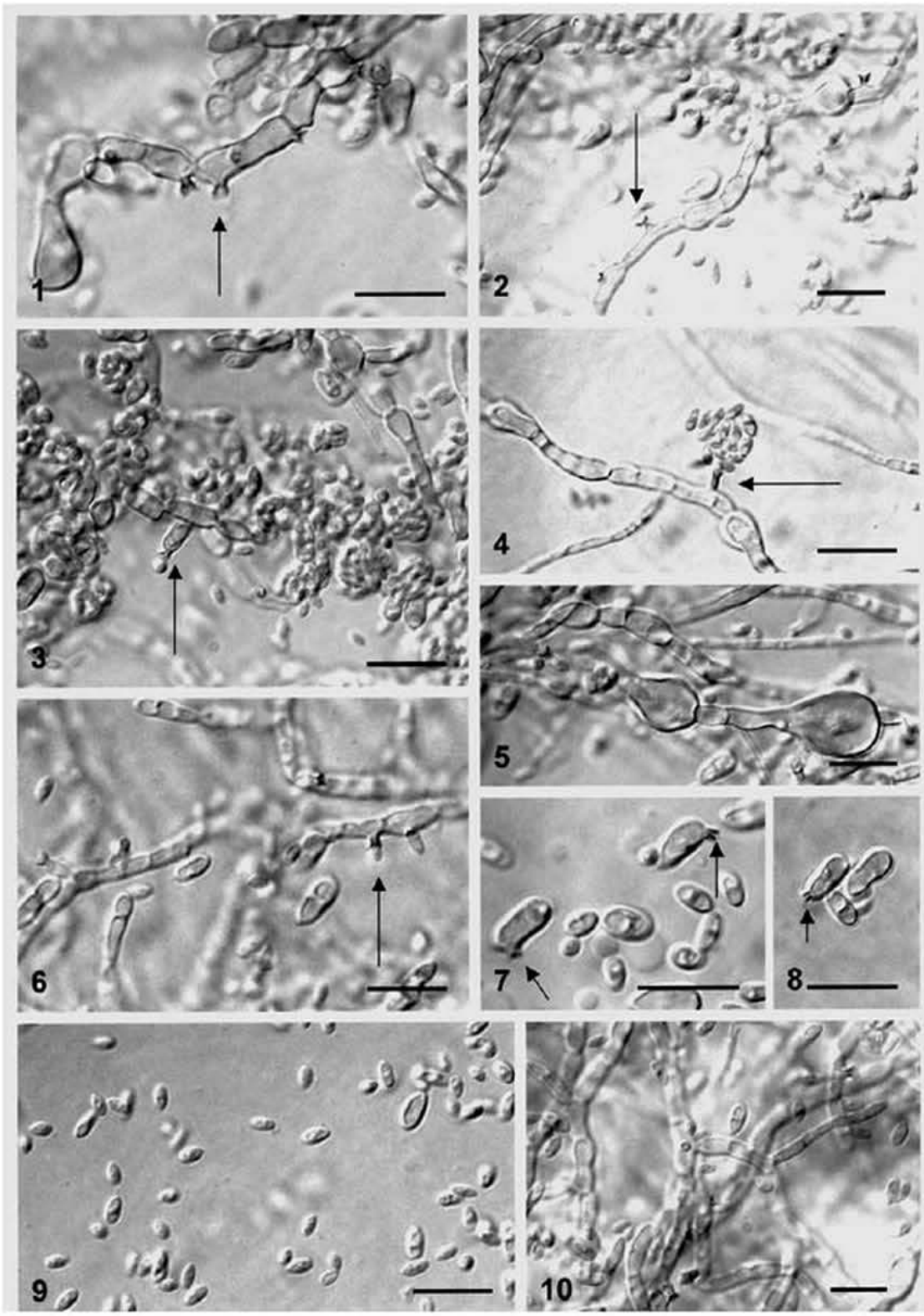
Material and Methods

Powder of marble, originating from an indoor cemetery marble stone near Pavia (Italy), was collected in a sterile plastic box in November 2003. The powder was spread on Petri dishes containing potato dextrose agar (PDA Sigma-Aldrich, Steinheim, Germany), dichloran rose bengal agar (DRBA, Sigma-Aldrich), oat meal agar (OA, Sigma-Aldrich) and potato carrot agar (PCA).

Media were prepared separately with and without cycloheximide, tested at a concentration of 0.1% (w/v). Numerous fungal taxa were isolated and among these *P. sessilis* was, consistenly appearing on all plates and media. Cultural characteristics and morphology were studied on malt extract agar 2% (MEA 2%, ME of Sigma-Aldrich), DRBA, OA, PCA, water agar (WA, bacteriological agar of Sigma-Aldrich) in which cycloheximide, sterile marble powder and sterile $CaCO_3$ were added separately and compared with controls. The plates (in triplicate) were incubated at 20°, 25°, 30°C and observed after 30 days. Tolerance of 5%, 10% NaCl (w/v) was detected in 5% glucose liquid medium at 20°C, following method of Kurtzman & Fell (1998). Radial growth of colonies was measured after 30 days on PDA at 8°, 15°, 20°, 25°C. Morphological observations were made on PDA after 7 weeks of incubation by means of Zeiss microscope (Axioskop2 Plus) connected with a Ks-100 imaging System Release 3.0. Each mean value reported in this paper was calculated from a set of 50 measures.

Results and discussion

Molecular ID using the rDNA Internal Transcribed Spacer (ITS) region resulted in 100% sequence identity with the ex-type strain of *Phialophora sessilis*, CBS 243.85. The morphological characteristics of our specimens of *P. sessilis* isolated from marble powder agree with those described by de Hoog et al. (1999) and can be summarized as follows (Figs 1-10): colonies olivaceous black, attaining up to 20 mm in diam in 30 days on PDA at 20°C and 7 mm in diam at 8°C, granular, cerebriform. Optimum of growth temperature: 20°C. No growth at 30°C. Hyphae torulose near the germinating cell, evenly wide higher up the filament, smooth-walled, 2.25–3.68 µm; sometimes inflated hyphal cells 4.0–9.7 µm wide; most phialides intercalary, with conspicuous, dark collarettes inserted laterally on the supporting cells (adelophialides), 1.4–2.3 × 1.6–2.2 µm. Non-sessile phialides rare, 3.6–9.4 × 2.0–2.8 µm with similar collarettes. Conidia subhaline,



Figs 1-2. Sessile collarettes (arrow). Figs 3-4. Conidia in slimy balls and some conidiogenous cells (arrow). Fig. 5. inflated hyphal cells. Fig. 6. Phialides bearing conidia (arrow). Figs 7-8. Conidia with open collarettes (arrow). Fig. 9. Small conidia. Fig. 10. Aspect of mature mycelium.

Bar in all figures 10 µm.

smooth, biguttulate, obovoidal to ellipsoidal, of two types: (1) 2.3–4.1 × 1.5–2.2 µm, and (2) 4.7–7.0 × 2.4–3.5 µm. Conidia in slimy heads 6.2–8.8 × 7.1–8.2 µm. Chlamydospores absent.

Little variation was observed in *P. sessilis* growing on the different cultural media used. PDA was the most suitable substrate for growth. Differences in tolerance of NaCl and in the growth temperature were recorded. The strain isolated from marble can grow well with 5% NaCl and weakly with 10% NaCl. It grows at relatively low temperature reaching 7 mm in diam at 8°C in one month and does not grow at 30°C.

Interest in *P. sessilis* is driven particularly by the apparent capacity of this fungal species to colonize and survive in lithic material such as marble, by the variety of sources of isolation not easy degradable (resin, styrene, lichen) and by the low competitive ability with mesotrophic microorganisms. Colonization of marble, where it probably lives on degraded bacteria or components of air pollution (Sterflinger & Prillinger 2002) then would fit such ecology. Prenafeta-Boldú et al. (2006) suggested that the assimilation of toxic hydrocarbons might be an essential factor in the ecology of black yeast-like members of the *Chaetothyriales*. The detection and identification of this possible lithobiont is important for the future studies on the deteriogenic processes of stone monuments where chemioorganotrophic bacteria, fungi, and phototrophic organisms, are present in microbial consortium. The finding of *P. sessilis*, consistently isolated at the sampling site in Pavia (northern Italy), extends southward the distribution area and habitat of this rare species, isolated to central and northern Europe.

Acknowledgments

We are grateful to Prof. S. Onofri (Dipartimento di Scienze Ambientali, Università della Tuscia, Viterbo, Italy) and Prof. C. Urzì (Dipartimento di Scienze Microbiologiche, Genetiche e Molecolari, Università di Messina, Italy) for presubmittal review of the manuscript.

References

de Hoog GS, Weenink XO, Gerrits van den Ende AHG. 1999. Taxonomy of the *Phialophora verrucosa* complex with the description of two new species. Stud. Mycol. 43: 107-122.

de Hoog GS, Mayser P, Haase G, Horré R, Horrevorts AM. 2000. A new species, *Phialophora europaea*, causing superficial infection in humans. Mycoses 43: 409-416.

Gams W. 2000. *Phialophora* and some similar morphologically little-differentiated anamorphs of divergent ascomycetes. Stud. Mycol. 45: 187-199.

Kurtzman CP, Fell JW. 1998. The Yeasts: a taxonomic study. Elsevier, Amsterdam, The Netherlands.

McColloch LP. 1944. A study of the apple rot fungus *Phialophora malorum*. Mycologia 36: 576-590.

Prenafeta-Boldú FX., Summerbell RC, de Hoog GS. 2006 Fungi growing on aromatic hydrocarbons: biotechnology's unexpected encounter with biohazard. FEMS Microbiol. Rev. (in press).

Sterflinger K, Prillinger H. 2001. Molecular taxonomy and biodiversity of rock fungal communities in an urban environment (Vienna, Austria). Antonie van Leeuwenhoek 80: 275–286.

Wrona B, Grabowski M. 2004 a. Influence of fructose and glucose occurring on fruit surface on the growth of fungi that cause sooty blotch of apple. J. Plant Protection Res. 44 (4): 287-291.

Wrona B, Grabowski M. 2004 b. Etiology of apple sooty blotch in Poland. J. Plant Protection Res. 44 (4): 294-297.

MYCOTAXON

Volume 95, pp. 285–293 *January–March 2006*

Revision of *Termitomyces* species originally described from China

B.-H. TANG[1,2] T.-Z. WEI[1] & Y.-J. YAO[1*]

yaoyj@sun.im.ac.cn
[1]*Key Laboratory of Systematic Mycology and Lichenology*
Institute of Microbiology, Chinese Academy of Sciences
Beijing 100080, China

[2]*Graduate School of Chinese Academy of Sciences*
Beijing 100080, China

Abstract—Revision of the four *Termitomyces* species originally described from China was carried out to clarify their taxonomic status. Among them, *T. bulborhizus* was reported recently with well supported specimens and is confirmed as a distinct and reliable species, whilst the other three, viz. *T. albiceps*, *T. cylindricus* and *T. macrocarpus*, were described in the 1980s and are determined here to be synonymous with other species of the genus. *Termitomyces albiceps* and *T. macrocarpus* are synonyms of *T. eurhizus*, and *T. cylindricus* of *T. aurantiacus*. Full descriptions of available specimens cited in the original publication of *T. albiceps* and *T. cylindricus* are also provided for reference.

Key words—*Tricholomataceae*, termite symbionts, nomenclature, taxonomy

Introduction

Four species of *Termitomyces* R. Heim, an agaric genus associated with termites, have been described from China. They are *T. albiceps*, *T. bulborhizus* T. Z. Wei et al., *T. cylindricus* and *T. macrocarpus*. Among them, *T. bulborhizus* was described recently with descriptions in both English and Latin, well supported by a number of specimens preserved in internationally accessible herbaria (Wei et al. 2004), whilst the other three were published in the 1980s in Chinese with Latin diagnoses and with specimens mostly not easily accessible (He 1985, Zhang & Ruan 1986). Both *T. albiceps* and *T. cylindricus* were described from collections made in Guizhou (He 1985) and were included in Wu (1990) and Ying & Zang (1994). *Termitomyces albiceps* was further included in Zhang (1991) and *T. cylindricus* in Huang (1998). The latter was also reported from Fujian (Guo 1995) and other localities of Guizhou (Hu et al. 2000). However, none of the later publications noted any additional material of the taxa reported. Based on

* Author for correspondence

the Latin diagnosis of He (1985), Pegler & Vanhaecke (1994) suspected *T. albiceps* was conspecific with *T. eurhizus* or with *T. globulus* R. Heim & Gooss.-Font., and treated *T. cylindricus* as a distinct species. However, according to the full description in Chinese (He 1985), *T. albiceps* is quite different from *T. globulus* in having a broad and blunt perforatorium and blackish brown pseudorhiza in contrast with a scarcely developed (or absent) perforatorium and tawny to rusty brown pseudorhiza in the latter (see Pegler & Vanhaecke 1994). *Termitomyces cylindricus* is medium-sized with pileus 6.5–12.0 cm diam. and with white pseudorhiza, although it was considered similar to *T. globulus* (pileus 8–20 cm diam., tawny to rusty brown pseudorhiza, see Pegler & Vanhaecke 1994) by He (1985). *Termitomyces macrocarpus* was introduced based on two collections from Yunnan (Zhang & Ruan 1986) and was included by Ying & Zang (1994), Zang et al. (1996) and Shao & Xiang (1997). Again, no further collections were noted in these later publications.

In a survey of *Termitomyces* species in China, all the reported taxa of the genus have been examined based on specimen and literature study. Some specimens of *T. albiceps* and *T. cylindricus* cited by He (1985) were traced in the Herbarium Mycologicum, Academia Sinica (HMAS) and the Herbarium of Cryptogams, Kunming Institute of Botany, Academia Sinica (HKAS). They were examined and redescribed in detail and compared with collections of *T. eurhizus* and *T. aurantiacus* from China and abroad to determine their identity. The authors have contacted Mr. Z.-F. Zhang (co-author of Zhang & Ruan 1986), and according to him, the specimens of *T. macrocarpus* are no longer traceable and apparently lost (Zhang, pers. comm. 2003–2004) and study on its taxonomic status has been based on the original description and the follow-up reports. *Termitomyces bulborhizus* is confirmed as a distinct and reliable species in the genus and is not repeated here.

Materials and Methods

Dried specimens from Guizhou in the herbaria listed above were examined both macroscopically and microscopically. The dried herbarium specimens were photographed and the following description is based on the examination of the material. For microscopic studies, free-hand sections of dried basidiocarps, including lamellae, cutis and pileal context, were prepared using a razor-blade and mounted in a 5 % KOH solution. Size ranges of basidiospores, basidia, hyphae of lamella and trama, pileal and stipe context were measured using an ocular micrometer. At least 30 basidiospores and 20 basidia of each mature specimen were measured.

Taxonomy

Termitomyces albiceps S. C. He in Acta Mycol. Sinica 4: 106 (1985). Fig. 1

Synonym of *T. eurhizus* (Berk.) R. Heim in Arch. Mus. Hist. Nat. Paris, Sér. 6, 18: 140 (1942).

Pileus up to 9.5 cm. diam., applanate with a round perforatorium; surface brown at centre, yellowish brown elsewhere and paling toward margin, radially striate; margin straight, radially splitting. *Lamellae* free, up to 6.0 mm wide, greyish white; crowded, with

lamellulae. *Stipe* 9.0 cm long, 1.5 cm thick, central, cylindrical and thickening slightly at ground level; surface greyish to brownish, smooth; solid and fibrous, of longitudinally parallel hyphae, thin-walled and hyaline, 2.5–25 µm diam. *Pseudorhiza* up to 20 cm long, tapering, with a pale yellowish disk connected with termite comb; surface dark brown in upper part and black below, longitudinally striate; solid, fibrous, consisting of thin-walled and hyaline hyphae, 2.5–33 µm diam. *Partial veil* not found. *Context* fleshy, white, of inflated, thin-walled and hyaline hyphae, 2.0–7.5 µm diam., inflating up to 35 µm. *Basidiospores* 5.5–9.0 × 4.0–5.5 µm, ovoid to ellipsoid, thin-walled and subhyaline. *Basidia* 16.0–26 × 6.0–9.0 µm, clavate, tetrasporic, thin-walled and subhyaline. *Lamella-edge* heterogeneous. *Cheilocystidia* 14.0–33 × 10.0–17.0 µm, clavate to pyriform, thin-walled and hyaline. *Pleurocystidia* not found. *Hymenophoral trama* regular, up to 50 µm wide, of thin-walled and hyaline hyphae, 4.0–20 µm diam. *Subhymenial layer* 5.0–10.0 µm wide, of branched, thin-walled and hyaline hyphae, 2.0–6.0 µm diam. *Pileipellis* a repent epicutis of narrow, radially parallel hyphae, 3.0–5.0 µm diam.

> *Specimens examined* - CHINA: **Guizhou:** Xingyi, Baiwayao, alt. 1530 m, solitary on nest of *Odontotermes formosanus* (Shiraki) in coniferous forest, 22 Aug. 1983, S.-C. He 1056, HMAS 47850 (paratype); same details, 26 Aug. 1983, S.-C. He 469, HKAS 14660 (paratype).

Most of the 10 specimens cited by He (1985) in the original description of *T. albiceps*, including the type, are now apparently lost. The above description is based on the two dried collections from Guizhou cited here, which are paratypes of *T. albiceps*. The following specimens of *T. eurhizus* were also examined for comparison to confirm the above determination.

> CHINA: **Yunnan:** Xishuangbanna, Mengla, Menglun, Xishuangbanna Tropical Botanical Garden, on termite nest of *Odontotermes* sp., 1 Aug. 2004, M. Li & B.-H. Tang, T0453, HMAS96507. **Sichuan:** Dechang, Badong Town, Songbai Village, 14 Aug. 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao, W03-36, HMAS 79897; Hongqi Village, 14 Aug. 2003, H. Deng, Y.-J. Yao, S.-Z. Fu and L. Jiao, W03-37, HMAS 84715; Pujiang, purchased in local market, 18 Aug. 2002, B. Wang 200235, HMAS 76913. **INDIA: Kerala:** Malappuram Dist., Calicut University Campus, near school ground, solitary on ground, 30 Jul 1986, V. Vrinda, V 236, F1095161; Malappuram Dist., Botanical Garden, Calicut University Campus, ca. 40-50 m., roadside, front of garden, on ground, 13 Jun 1984, K.M. Leelavathy, F 177, F 1091313. **South Africa: Pretoria:** attached to termite nest underground, I. Bredenkamp, 14 March 1966, PREM 43147.

According to the original description of He (1985), the pileus of *T. albiceps* is up to 18 cm diam., and the surface of its pseudorhiza is blackish brown, similar to that of *T. eurhizus*. Comparison of the above two collections, cited for *T. albiceps* by He (1985), with *T. eurhizus* collections from China and abroad revealed that the pseudorhiza of *T. albiceps* specimens was black, which is a distinct character of the *T. eurhizus* specimens examined. Furthermore, the other characters of the two specimens, such as large basidiocarp, brownish pileus, round perforatorium and size of basidiospores, are almost identical with those of *T. eurhizus* (see Pegler & Vanhaecke 1994). He (1985) mentioned *T. albiceps* had some irregular tubercles on the pileus margin and its stipe surface was covered by some fluffy squamules. However, neither of the two characters was detected on the dried material, and no tubercles could be seen in the illustration of the type in

the protologue. Moreover, the present authors consider these two characters are not constant for species identification. The tubercles on the pileus margin may be accidental variation, which can also be found in some *T. eurhizus* collections, e.g. HMAS 96507. The squamules on the stipe, which are occasionally found in some fresh material of *T. eurhizus*, e.g. HMAS 79897, HMAS 84715 and HMAS 96507, are probably ephemeral remains of a partial veil that are easily lost in specimen preservation. According to He (1985), no pleurocystidia were found in *T. albiceps*. This was confirmed in the present study of the two specimens examined. The number of pleurocystidia can vary from numerous to scattered or rare, e.g. *T. clypeatus* R. Heim and *T. entolomoides* R. Heim (Pegler & Vanhaecke 1994, Wei et al. 2003), or absent, e.g. *T. radicatus* Natarajan (Natarajan 1977) in some species of the genus. This phenomenon was also present in some *T. eurhizus* collections, e.g. pleurocystidia were reported rare in AMH 4479 (Sathe & Deshpande 1981) and AMH 4546 (Sathe & Daniel 1981, Tang et al. 2006), and were absent in some specimens examined in this study, e.g. HMAS 76913 and F 1095161. Therefore, the pleurocystidia are also not a constant character for species identification. Consequently, there is no reliable morphological character to distinguish *T. albiceps* from *T. eurhizus* and they are evidently conspecific.

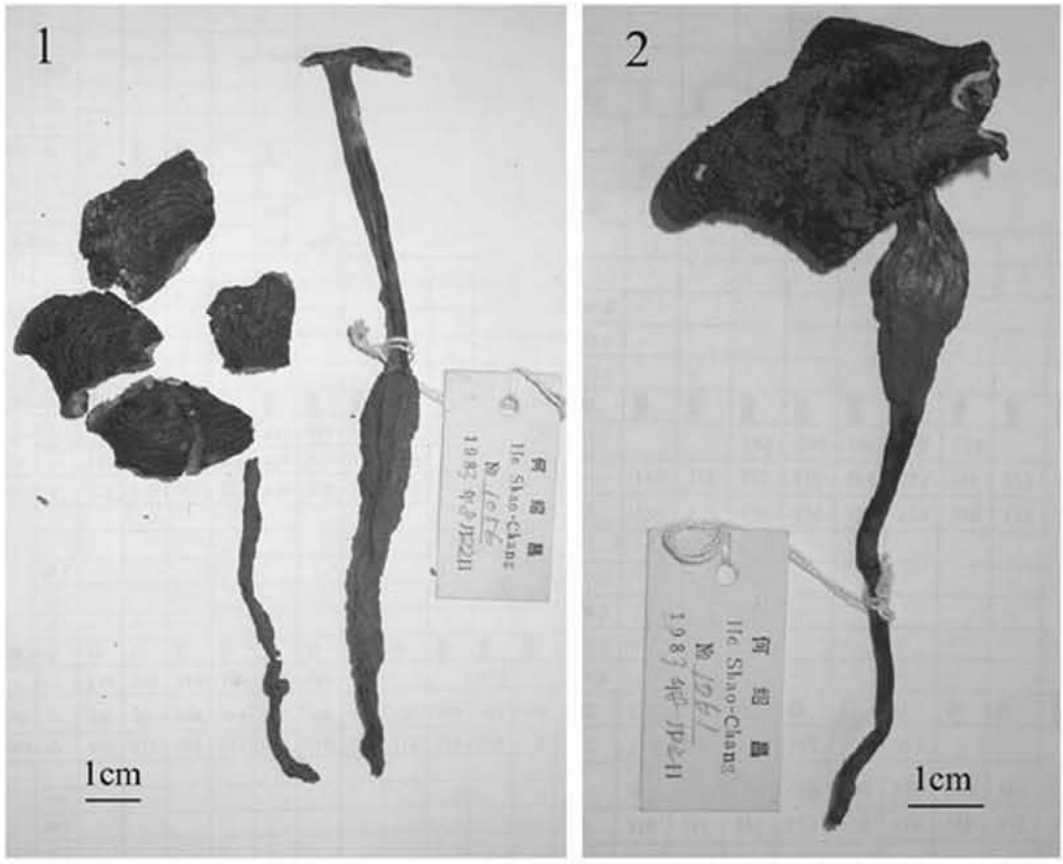
Collections of *Termitomyces albiceps* were found on nests of *Odontotermes formosanus*, *O. quinquedentatus* and *O. periformosanus* (He 1985). In our field work in the southwest of China, *T. eurhizus* was often found associated with *Odontotermes* species.

Termitomyces cylindricus S.C. He in Acta Mycol. Sinica 4: 104 (1985). Fig. 2

Synonym of *T. aurantiacus* (R. Heim) R. Heim in Termites et Champignons (Paris): 56 (1977).

Pileus up to 9.3 cm diam., conical-applanate, with a small and bluntly pointed perforatoium; surface brown to blackish and darker at the centre, glabrous; margin straight, radially striate and splitting. *Lamellae* free, 3.0–4.0 mm wide; greyish white; crowded, with lamellulae. *Stipe* 6.0–7.0 × 1.5–2.3 cm, central, cylindrical and slightly thickened at ground level; surface greyish white to brownish, smooth and glabrous; solid, of longitudinally parallel, thin-walled hyphae, 2.0–25 µm diam. *Pseudorhiza* up to 17.0 cm, 1.1 cm wide and tapering downward from ground level, terminating with a pale, cylindrical base; surface brownish, longitudinally striate; solid, of longitudinally parallel, thin-walled hyphae, 2.0–25 µm diam. *Partial veil* not found. *Context* fleshy, white, of inflated, thin-walled and hyaline hyphae, normally 2.5–8.0 µm diam. inflating to 35 µm diam. *Basidiospores* 5.0–7.5 × 3.5–4.5 µm, ovoid to ellipsoid, thin-walled and subhyaline. *Basidia* 17.0–22 × 6.0–7.5 µm, clavate, tetrasporic, thin-walled and subhyaline. *Lamellae edge* heterogeneous. *Cheilocystidia* 25–43 × 12.0–23 µm, clavate to pyriform, thin-walled and hyaline. *Pleurocystidia* not found. *Hymenophoral trama* regular, 40–50 µm wide, of thin-walled and hyaline hyphae, 4.0–18.0 µm diam. *Subhymenial layer* narrow, of branched hyphae, 2.0–5.0 µm diam. *Pileipellis* an epicutis of narrow, radial hyphae, containing yellowish granules, 2.5–5.0 µm diam.

Specimens examined - CHINA: **Guizhou:** Xingyi, Baiwayao Town, alt. 1530 m, symbiotic with *Macrotermes orthognathus* Ping et Xu, 22 Aug. 1983, S.-C. He 1062, HKAS 14695 (paratype); alt. 1330 m, 22 Aug. 1983, S.-C. He 1061, HMAS 47851 (paratype).



Figs 1–2. Photographs of *Termitomyces* spp. from China. Fig. 1. Habit of *Termitomyces albiceps* (HMAS 47850). Fig. 2. Habit of *Termitomyces cylindricus* (HMAS 47851).

The above description is solely based on these two dried collections from Guizhou, which were cited in the protologue of *T. cylindricus* (He 1985). The following specimens of *T. aurantiacus* were also examined for comparison.

> CHINA: **Yunnan:** Mengla, Menglun, Xishuangbanna Tropical Botanic Garden, on termite nest, G.-R. Hu & T.-Z. Wei, 8 Aug. 2003, w03-19, HMAS 84720; the same locality, on termite nest of *Macrotermes* sp, M. Li & B.-H. Tang, 2. Aug. 2004, T0456, HMAS 99569; the same locality, on mounds of *Macrotermes* sp., Li & B.-H. Tang, 8 Aug. 2004, T0493, HMAS 99570; Jingdong, Phoenix Mountain, alt. 1260 m, 25 Aug. 1991, Z.-L. Yang 1642, HKAS 23955. THAILAND: **River Kwai:** Kanchanaburi, Kang Chaw, Boonthungs Farm, 20 Sept. 1980, B. J. Bels, K(M) 94661.

The type and most of the 11 specimens cited for *T. cylindricus* by He (1985) cannot now be traced. The two collections cited in the protologue and examined here resemble *T. aurantiacus* in having medium-sized basidiocarps with a pointed perforatorium and pale pseudorhiza. Microscopically, the two *T. cylindricus* specimens are identical with those of *T. aurantiacus*. According to He (1985), *T. cylindricus* can be distinguished from other species of the genus by its cylindrical pseudorhiza base. However, several collections of *T. aurantiacus* from Xishuangbanna, Yunnan, (e.g. HMAS 99569, HMAS 99570 and HMAS 84720), also have a cylindrical base at the end of the pseudorhiza. The present authors found no small squamules mentioned by He (1985) on the stipe surface

of the two collections. The structure is probably formed by ephemeral remains of partial veil and can often be seen in fresh material of *T. aurantiacus*.

Termitomyces aurantiacus is distinct in its constantly bright reddish ochraceous to orange pileus and its firm texture (Pegler & Vanhaecke 1994). The pileus of *T. cylindricus* was described as 'brunneolus vel cinerascens' in Latin and 'pale brown to ash-grey' (literary translation) in Chinese by He (1985), and is brown to blackish in the two dried herbarium specimens examined by the present authors, but the illustration of the type material in the protologue (Plate I-2) shows no clear difference in pileus color from *T. aurantiacus* as seen in the field, although the plate seems not to be produced perfectly in color.

He (1985) described the lower part of the pseudorhiza of *T. cylindricus* as 'pale yellowish green', different from the white pseudorhiza of *T. aurantiacus* (Pegler & Vanhaecke 1994). Unfortunately, this character cannot be detected in the dried specimens. In some *T. aurantiacus* collections from Yunnan, the lower part of the pseudorhiza was slightly yellowish when fresh, but no green pseudorhiza have been seen in any species of *Termitomyces*.

Based on the discussion above and the morphological characters observed from the two specimens of *T. cylindricus*, it is concluded here that *T. cylindricus* is synonymous with *T. aurantiacus*.

Termitomyces aurantiacus is widely distributed in both Africa (Heim 1977, Mossebo et al. 2002, Aanen et al. 2002, Frøslev et al. 2003) and Asia (Pegler & Vanhaecke 1994, Aanen et al. 2002, Frøslev et al. 2003, Wei & Yao 2003). According to He (1985), *T. cylindricus* grows on nests of *Macrotermes barneyi* and *M. orthognathus*. In our field work in Xishuangbanna, Yunnan, *T. aurantiacus* was also found to be symbiotic with *Macrotermes* species. In Africa, *T. aurantiacus* was reported to be associated with the termite *Pseudacanthotermes militaris* (Batra & Batra 1979, Pegler & Vanhaecke 1994).

Termitomyces macrocarpus Z.F. Zhang & X.Y. Ruan in Acta Mycol. Sinica 5: 10 (1986). nom. invalid (Arts 37.1 and 37.2, ICBN).

Synonym of *T. **eurhizus*** (Berk.) R. Heim in Arch. Mus. Hist. Nat. Paris, Sér. 6, 18: 140 (1942).

In the protologue of *T. macrocarpus*, the specimens examined were listed as 'YUNNAN: Ad *Odontotermim formosanum* Shiraki et *O. yunnanensem* Tsai, alt. 1200–1900 m, Zhang Zheng-fu 1979–1981 (Typus Y B002, Y B003)'. Similar phrases were used in the description of the material in Chinese, but adding two locations as '禄劝、蒙自' (Luquan, Mengzi). Apparently, the description of the material is a mixture, with different locations, hosts and dates, and the designation of the type, either one specimen 'Y B002' or both specimens 'Y B002' and 'Y B003', is unclear. Although Ying & Zang (1994) was later able to specify 'YB002' from Luquan and 'YB003' from Mengzi and declared the type was deposited in the Herbarium of Yunnan Agricultural University (YB), the two numbered specimens are no longer traceable and the status of the type material cannot be further clarified. Because Zhang & Ruan (1986) did not unambiguously designate the holotype, the name '*Termitomyces macrocarpus* Z. F. Zhang & X. Y. Ruan' is invalid according to Arts 37.1 and 37.2 of ICBN (Greuter et al. 2000).

According to the description by Zhang & Ruan (1986), the basidiocarp of *T. macrocarpus* was large and robust, with pileus up to 38 cm diam., and the stipe base dark, often fuliginous-brown. In the illustration in the protologue, the badiocarps show typical characters of *T. eurhizus* in terms of the shape of pileus and stipe, and the pseudorhiza surface which is apparently darker than that of the stipe and possibly blackish. Because the pseudorhiza was not mentioned in their description, the dark stipe base described for *T. macrocarpus* by Zhang & Ruan (1986) is possibly referable to the pseudorhiza. *Termitomyces eurhizus* is recognized by its large fleshy, gray brown pileus with an obtusely rounded or broadly umbonate perforatorium, and the long, cartilaginous pseudorhiza encrusted with black-brown cuticle (Pegler 1977, Pegler & Vanhaecke 1994). The pileus of *T. eurhizus* can also extend to 36 cm in diam. (Pegler 1977), and the color of its pileus surface varies from almost white to dark brown. The morphological characters described by Zhang & Ruan (1986) and Ying & Zang (1994) for *T. macrocarpus* are identical with those of *T. eurhizus*. Therefore, *T. macrocarpus* is an additional synonym of *T. eurhizus*, although it was not validly published.

Discussion

Termitomyces is a paleotropical genus of macrofungi cultivated by termites belonging to the subfamily *Macrotermitinae* (*Isoptera*) (Heim 1942, 1977, Batra & Batra 1979, Bels & Pataragetvit 1982, Pegler & Vanhaecke 1994). In total, 68 taxa have been published in *Termitomyces*, with 81 names including combinations and autonyms. In recent decades, many new taxa were described from Asia, especially China (He 1985, Zhang & Ruan 1986, Wei et al. 2004) and India (Dhancholia et al. 1991, Natarajan 1975, 1977, 1979, Sathe & Daniel 1981, Sathe & Deshpande 1981). However, quite a few taxa described from this region have been found to be synonyms of early published names, i.e. taxa originally reported from India, *T. longiradicatus* Sathe & J. T. Daniel, *T. poonensis* Sathe & S. D. Deshp. and *T. quilonensis* Sathe & J. T. Daniel (Tang et al. 2006) and *T. indicus* Natarajan (Pegler & Vanhaecke 1994). Many more taxa of *Termitomyces* have been documented from Africa (Heim 1942, 1977, Otieno 1966, 1969, Pegler 1977, Van der Westhuizen & Eicker 1990, Mossebo et al. 2002) and the taxonomic status of some of them is also suspicious, i.e. *T. narobiensis* Otieno has been regarded as a synonym of *T. microcarpus* (Berk. & Broome) R. Heim, *T. biyii* Otieno and *T. rabuorii* Otieno considered a representative of an exannulate form of *T. letestui* (Pat.) R. Heim and of *T. mammiformis* R. Heim respectively, and *T. magoyensis* Otieno close to *T. schimperi* (Pat.) R. Heim (see Pegler 1977), and *T. umkowaanii* (Cooke & Massee) D. A. Reid very close to *T. eurhizus* (Pegler & Vanhaecke 1994). Mossebo et al. (2002) proposed eight new taxa based on material from Cameroon, but most of them resemble existing taxa. Careful revision of these taxa is required to confirm their taxonomic status.

Acknowledgements

The authors are grateful to Drs Peter Roberts and Zhu-Liang Yang for serving as pre-submission reviewers and for their valuable comments and suggestions, and to Prof. Fu-Sheng Huang for assistance in identification of the termite. This project is supported by a general grant (30470008) and the National Science Fund for Distinguished Young Scholars (30025002) from the National

Natural Science Foundation of China, the Key Research Direction of Innovation Programme (KSCX2-SW-101C) and the scheme of Introduction of Overseas Outstanding Talents, operated by the Chinese Academy of Sciences, and the National Hi-Tech Research and Development Plan (2004AA227100) from the Ministry of Science and Technology.

Literature Cited

Aanen DK, Eggleton P, Rouland-Lefèvre C, Frøslev TG, Rosendah S, Boomsma JJ. 2002. The evolution of fungus-growing termites and their mutualistic fungal symbionts. Proceedings of the National Academy of Sciences of the United States of America 99: 14887–14892.

Batra LR, Batra SWT. 1979. Termite-fungus mutualism. In Batra, L R, 1979. Insect-Fungus Symbiosis. Nutrition, Mutualism and Commensalis. New York: Allanheld, Osmun & Co. 117–163.

Bels PJ, Pataragetvit S. 1984. Edible Mushrooms in Thailand, Cultivated by Termites. in Zhang, S. T. & T. H. Quimio. 1984. Tropical Mushrooms, Biological Nature and Cultivation Methods (2nd. edn). Hong Kong, the Chinese University Press. 445–461.

Dhancholia S, Bhatt JC, Pant SK. 1991. Studies on some Himalayan agarics. Acta Botanica Indica 19: 104–109.

Frøslev TG, Aanen DK, Læssøe T, Rosendahl S. 2003. Phylogenetic relationships of *Termitomyces* and related taxa. Mycological Research 107: 1277–1286.

Greuter W, Mcneill J, Barrie FR, Burdet H-M, Demoulin V, Filgueiras TS, Nicolson DH, Silva PC, Skog JE, Trehane P, Turland NJ, Hawksworth DL. 2000. International Code of Botanical Nomenclature (St Louis Code). Koeltz Scientific Books, Königstein, Germany.

Guo D-Z. 1995. *Termitomyces* species on Nantai Island, Fuzhou. Edible Fungi 17: 5. (in Chinese).

He S-C. 1985. Taxonomic studies of *Termitomyces* from Guizhou Province of China. Acta Mycologica Sinica 4: 103–108.

Heim R. 1942. Nouvelles Études sur Les Agarics Termitophiles d'Afrique Tropicale. Archives du Muséum National d'Histoire Naturelle, Séries. 6, 18: 1–60, pls 9–12.

Heim R. 1977. *Termites et Champignons*. Société Nouvelle Des Éditions Boubée, Paris. 1–206

Hu Q-X, Cang R, Xiang H. 2000. Investigation of wild *Termitomyces* in Shuicheng County, Guizhou. Edible Fungi 22: 7. (in Chinese).

Huang N-L. 1998. Cloured Illustrations of Macrofungi (Mushroom) of China. Beijing: Chinese Agricultural Press. (in Chinese).

Kirk PM, Cannon PF, David JC, Stalpers JA. 2001. Dictionary of the Fungi. 9th edn. CAB International, Wallingford, UK.

Mossebo DC, Amougou A, Atangana RE. 2002. Contribution a l'étude du genre *Termitomyces* (*Basidiomycètes*) au Cameroon: écologie et systematique. Bulletin de la Société Mycologique de France 118: 195–249.

Natarajan K. 1975. South Indian *Agaricales* I. *Termitomyces*. Kavaka 3: 63–66.

Natarajan K. 1977. A new species of *Termitomyces* from India. Current Science 46: 679–680.

Natarajan K.1979. South Indian *Agaricales* V: *Termitomyces heimii*. Mycologia 71: 853–855.

Otieno NC. 1966 [as 1964]. Contributions to a knowledge of termite fungi in East Africa: the genus *Termitomyces* Heim. Proceedings of East African Academy 2: 108–120.

Otieno NC. 1969 [as 1968]. Further contributions to a knowledge of termite fungi in East Africa: the genus *Termitomyces* Heim. Sydowia 22: 160–165.

Pegler DN. 1977. A Preliminary Agaric Flora of East Africa. Kew Bulletin. Additional Series 6: 277–295.

Pegler DN, Vanhaecke M. 1994. *Termitomyces* of Southeast Asia. Kew Bulletin 49: 717–736.

Rouland-Lefevre C, Diouf MN, Brauman A, Neyra M. 2002. Phylogenetic relationships in *Termitomyces* of ITS: a first approach to elucidate the evolutionary history of the symbiosis between fungus-growing termites and their fungi. Molecular Phylogenetics & Evolution 22: 423–429.

Sathe AV, Daniel J. 1981 [as 1980]. Maharashtra Association for the Cultivation of Science (MACS), Monograph No. 1: *Agaricales* (Mushrooms) of south west India (Pune): 75–108.

Sathe AV, Deshpande S. 1981 [as 1980]. Maharashtra Association for the Cultivation of Science (MACS), Monograph No. 1; *Agaricales* (Mushrooms) of South West India (Pune): 9–42.

Shao L-P, Xiang C-T. 1997. Mushrooms in the forest of China. Harbin: Northeast Forestry University Press. (in Chinese).

Tang B-H, Wei T-Z, Yao Y-J. 2006 [as 2005]. Type revision of three *Termitomyces* species from India. Mycotaxon. 94: 93–102.

Van der Westhuizen GCA, Eicker A. 1990. Species of *Termitomyces* occurring in South Africa. Mycological Research 94: 923–937.

Wei T-Z, Yao Y-J. 2003. Literature review of *Termitomyces* species in China. Fungal Science 18: 39–54. (in Chinese).

Wei T-Z, Yao Y-J, Li T-H. 2003. First record of *Termitomyces entolomoides* in China. Mycotaxon 88: 433–438.

Wei T-Z, Yao Y-J, Wang B, Pegler DN. 2004. *Termitomyces bulborhizus* sp. nov. from China, with a key to allied species. Mycological Research 108: 1458–1462.

Wu X-L. 1990. Macrofungi in Guizhou Province. Guiyang: Guizhou People's Republic Press. (in Chinese).

Ying J-Z, Zang M. (eds.) 1994. Economic Macrofungi from Southwestern China. Beijing: Science Press. (in Chinese).

Zang M, Li B, Xi JX. 1996. Fungi of the Hengduan Mountains. Beijing: Science Press. (in Chinese).

Zhang X-Y. 1991. Illustration of Edible Fungi and Poisonous fungi in Guizhou. Guiyang: Guizhou Technological Publisher. (in Chinese).

Zhang Z-F, Ruan X-Y. 1986. A new species of *Termitomyces-Termitomyces macrocarpus* Zhang et Ruan sp. nov. Acta Mycologica Sinica 5: 10–13. (in Chinese).

MYCOTAXON

Volume 95, pp. 295–300 *January–March 2006*

Two new species of *Marasmius* (Basidiomycota, *Marasmiaceae*) from Brazil

CARLA PUCCINELLI & MARINA CAPELARI

puccinellic@yahoo.com.br
Instituto de Botânica, Seção de Micologia e Liquenologia
Caixa Postal 4005, 01061-970 São Paulo, SP, Brazil

Abstract—Two new species of *Marasmius*, *M. pseudosetosus* and *M. dimorphus*, collected in Atlantic Forest at São Paulo city, SP, Brazil are described, illustrated and discussed. Both species belong to *Marasmius* sect. *Sicci* subsect. *Siccini* series *Leonini*.

Key words—*Agaricales*, taxonomy, biodiversity

Introduction

In the course of making collections of *Marasmius* for the revision of this genus in the Parque Estadual das Fontes do Ipiranga (PEFI), São Paulo, SP, Brazil, two new species have been collected and are here described. Both species are classified in *Marasmius* sect. *Sicci* Singer, subsect. *Siccini* Singer, series *Leonini* Singer (Singer 1976). This group of *Marasmius* is characterized by the hymeniform pileal surface composed by smooth or *Siccus*-type broom cells without setae, absence of pleurocistidia and stipe glabrous without dermatocystidioid hairs or setae.

Until now, eight species of this group have been reported for PEFI by Grandi et al. (1984) and Pegler (1997): *M. berteroi* (Lév.) Murrill, *M. haediniformis* Singer, *M. leoninus* Berk., *M. phaeus* Berk. & M.A. Curtis, *M. pusio* Berk. & M.A. Curtis, *M. rhabarbarinus* Berk., *M. ruber* Singer and *M. subrotula* Murrill.

The microscopic analyses have been made from dried material rehydrated in 70% ethanol followed by 5% KOH and Melzer's reagent. The Qm represents the mean length/width quotient of the total spores measured. All the specimens are deposited in SP.

Taxonomic descriptions

Marasmius pseudosetosus C. Puccin. & Capelari **sp. nov.** Figure 1

Pileus 5–20 mm latus, campanulatus dein convexus, cum papilla centralis, margine levis, glaber, reticulatus, hygrophanus, pallide aurantiacus. Lamellae liberae sed confertae stipes, pseudocollarium in juvenis, albidae vel cremeae, acie concolorae, confertus, cum lamellulae. Stipes 30–42 × 1 mm, cylindricus, rubro-brunneus vel vinaceus, apice concolor lamellae, fistulosus, mycelium basium flavus. Basidiosporae 7.5–11.25 × 3.0–5.0 µm, ellipsoidae-fusoidae, leves, hyalinae, inamyloideae, tenuitunicatae. Pleurocystidia

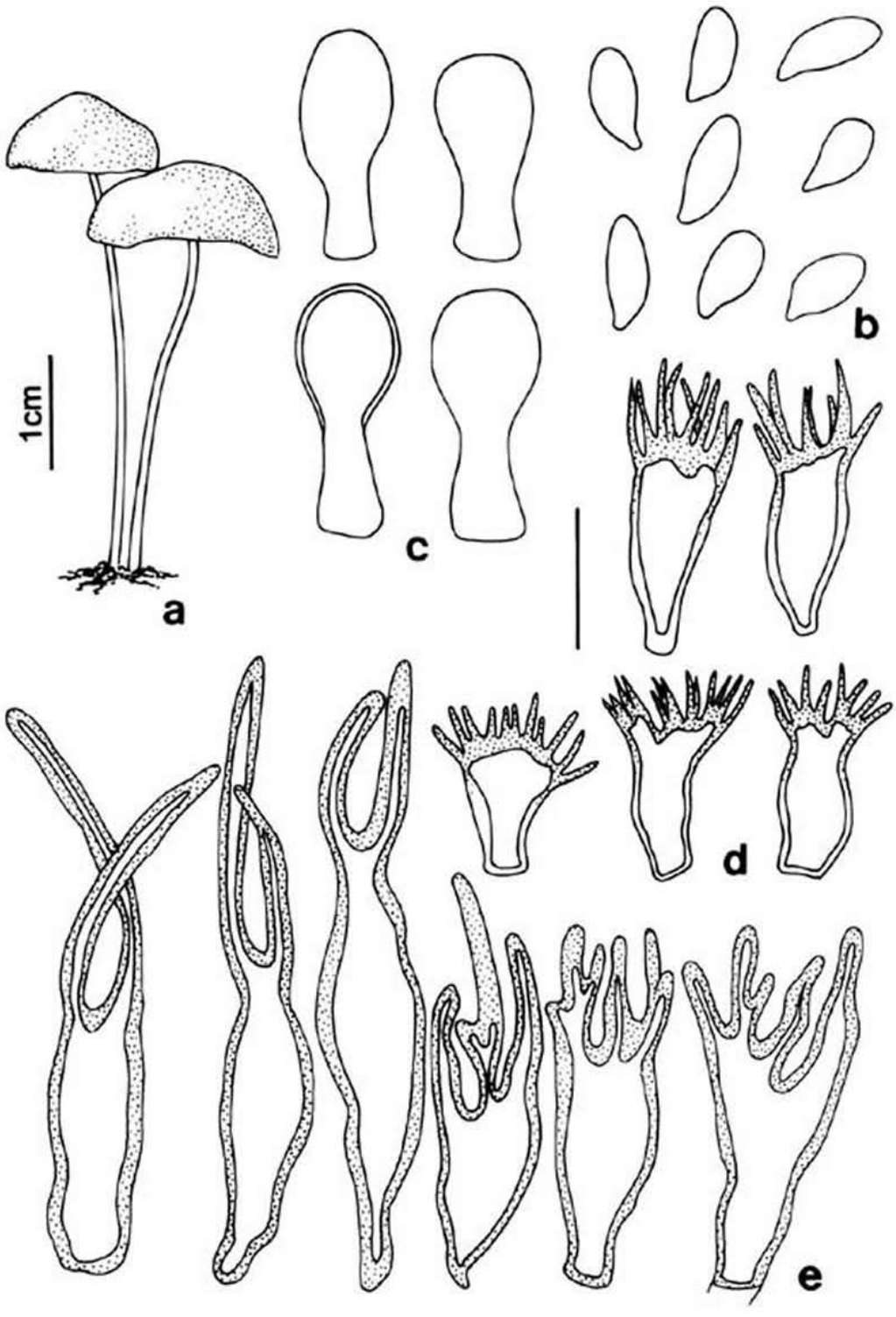


Figure 1. *Marasmius pseudosetosus* (holotype): a. basidioma, b. basidiospore, c. cheilocystidia, d. pileipellis cells, e. transitional cells. Scale bar = 10 µm.

nulla. Cheilocystidia similes cellulis hymenidermatis Marasmii sicci et clavatus pyriformis, 17.5-21.25× 7.5-8.75 µm hyalinus tenui vel crassitunicatis. Trama lamellarum regulare, ex hyphis dextrinoideis, 2.5-5 µm, tenuitunicatis, septatis, fibulae presentes. Pileipellis hymeniformis et cellulis similibus cellulis hymenidermatis Marasmii sicci et cellulis similibus setae. Cellulae setulosae 13.75-20 × 3.75-7.5 µm, clavate, hyalinae vel pallide luteo-brunneae, crassitunicatae, setulae ad apicem 6.25-8.75 µm; cellulae simili setae 31.25-55 × 5-8.75 µm, crassitunicatae, brunneae. Caulocystidia nulla. Dispersus ad folia sicca.

Holotypus: BRAZIL, SP, São Paulo. Parque Estadual das Fontes do Ipiranga, (23°39'S 46°37'W), 30 March 2005, Puccinelli 126 (holotypus in herbarium SP asservatur).

Pileus 5-20 mm diam., convex to campanulate, applanate when mature with a small central papilla, disc reticulate, margin smooth, glabrous, hygrophanous, pale orange and darker center. **Lamellae** free, but very close to the stipe, pseudocollarium present in the young specimens, with lamellulae, close, dirty white to cream, with concolorous edge. **Stipe** 30-42 x 1 mm, cylindrical, glabrous, central, hollow, reddish brown to vinaceous, becoming paler at apex where it is concolorous with the lamellae, yellowish cream, with a well-developed basal mycelium. **Context** thin, dextrinoid. **Basidiospores** 7.5-11.25 × 3.0-5.0 µm (Qm = 2.50, n = 40 basidiospores), ellipsoid-fusoid, smooth, hyaline, inamyloid, thin-walled. **Basidia** not observed. **Pleurocystidia** absent. **Cheilocystidia** of two types: a) similar to the broom cells from pileal surface, hyaline and very rarely found; b) predominantly clavate-pyriforme, 17.5-21.25 × 7.5-8.75 µm, smooth, hyaline, thin to thick-walled. **Pileipellis** hymeniform, composed of *Siccus*-type broom cells and transitional cells between broom cells and structures that resemble setae. *Siccus*-type broom cells with main body 13.75-20 × 3.75-7.5 µm, clavate, hyaline to brown or gold, thick-walled; apical setulae 6.25-8.75 µm; transitional cells 31.25-55 × 5-8.75 µm, scattered, brownish, thick-walled, some with similar shape to the broom cells. **Lamellar trama** regular, dextrinoid, with hyaline, thin-walled, septated hyphae, with clamp-connections, 2.5-5 µm diam. **Stipe** with cortical hyphae 3.75-7.5 µm diam, parallel, brownish yellow, dextrinoid, thick-walled; medullary hyphae 2.5-3.75 µm diam, hyaline, weakly dextrinoid, thin-walled. **Caulocystidia** absent. **Basidioma** scattered on dry leaves in the litter.

Material examined: BRAZIL, SP, São Paulo. Parque Estadual das Fontes do Ipiranga, (23°39'S 46°37'W), 30 March 2005, Puccinelli 125 (SP); Puccinelli 126 (holotype, SP); 01 April 2005, Puccinelli 131 (SP); 132 (SP).

Comments: This species is characterized by the hygrophanous, light orange, reticulated pileus, the close lamellae with lamellullae and stipe colour. Microscopically by the small and ellipsoid-fusoid basidiospores, absence of pleurocystidia, by the presence of dimorphic cheilocystidia (those similar with the broom cells are very difficult to find) and scattered transitional cells between setiform structures mixed with the broom cells in the pileipellis, (easily visible when the material is squashed). These structures are easily recognized by the larger size, the thickness of the wall and the deep colour. Among the species of *Marasmius* sect. *Sicci* with true setae in the pileipellis (series *Spinulosi* (Clémençon) Desjardin), *M. pseudosetosus* differs by the absence of setae in the pileipellis, by the pileus and stipe colour and by the dimorphic cheilocystidia. Macroscopically a close relative is *M. leoninus*, but they could be separated by the pileus colour and the peculiar pilleipellis structure of *M. pseudosetosus*.

Marasmius dimorphus C. Puccin. & Capelari **sp. nov.** **Figure 2**

Pileus 12–20 mm latus campanulatus dein convexus, margine crenata, glaber, sulcatus, spadiceus novus, brunneo–vinosus siccatus. Lamellae liberae, distantes, cremae, 17–18 lamella exclusus lamellulae. Stipes 4.8–5.6 mm, filiformibus, cavis, glabris, atrocastaneus, mycelium basium cremium. Basidiosporae 12.5–16.25 × 3.75–5 µm, clavate fusoideae, leves, hyalinae, inamyloideae, tenuitunicate. Pleurocystidia nulla. Cheilocystidia elementisque epicuticularibus setuligeris typi sicci sed minutus et hyalinus, crassitunicatae, 11.25–16.25 × 2.5–5 µm. Trama lamellarum regulare, hyphis hyalinis, dextrinoideis, 1.25–3.75 µm, tenuitunicatis, septatis, fibulae presentes. Pileipellis hymeniformis et cellulis similibus cellulis hymenidermatis Marasmii sicci, dimorphae. Minora cellulae setulosae 7.5–17.5 × 3.75–5 µm clavatae, crassitunicatae luteobrunneae et magna cellulae atrobrunnea, crassitunicatae, 32.5–45 × 5–6.25 µm. Caulocystidia nulla. Dispersus ad folia sicca.

Holotypus: BRAZIL, SP, São Paulo. Parque Estadual das Fontes do Ipiranga, (23°39'S 46°37'W), 19 January 2005, Puccinelli 62 (holotypus in herbarium SP asservatur).

Pileus 12-20 mm diam, campanulate to convex, margin crenate, surface glabrous but velutinous under a lens, sulcate, membranaceous, beige to light brown or pinkish brown, with darker center when fresh, turning vinaceous brown when dry. **Lamellae** free, distant (17-18), lamellulae absent, cream. **Stipe** 48-56 mm in length, central, glabrous, filiform, hollow, chestnut brown, with cream basal mycelium. **Context** thin, dirty white, dextrinoid. **Basidiospores** 12.5-16.25 × 3.75-5 µm (Qm = 3.8, n = 25 basidiospores), clavate-fusiform, smooth, hyaline, inamyloid, thin-walled. **Basidia** not observed. **Pleurocystidia** absent. **Cheilocystidia** like the broom cells of the pileipellis, but smaller and with pale color, slightly thick-walled, 11.25-16.25 × 2.5-5 µm. **Lamellar trama** regular; hyphae 1.25-3.75 µm diam., hyaline, dextrinoid, thin-walled, septated, with clamp-connections. **Pileipellis** hymeniform, composed of dimorphic *Siccus*-type broom-cells, normal broom-cells with main body 7.5-17.5 × 3.75-5.0 µm, clavate, light brown to light gold, thick-walled and larger broom-cells 32.5-45 × 5-6.25 µm, with few to many branches, deep brown, thick-walled. **Stipe** with cortical hyphae 6.25-8.75 µm diam, parallel, hyaline to brownish yellow, dextrinoid, thick-walled. **Caulocystidia** absent. **Basidioma** solitary on small sticks in litter.

Material examined: BRAZIL, SP, São Paulo, Parque Estadual das Fontes do Ipiranga, (23°39'S 46°37'W), 19 January 2005, Puccinelli 62 (holotype SP), 07 April 2005, Puccinelli 142 (SP).

Comments: *Marasmius dimorphus* is characterized by the pileus colour, which ranges from beige to light brown, with darker center when fresh, some are pinkish brown and after drying they become vinaceous brown, with distant cream gills. The microscopical features of the broom cells of this species are very distinct, being dimorphic and differing in shape and size. The larger broom cells differ from the normal ones by the color, the thickness of the wall, the absence of a visible delimitation between the basal body and the setulae and by the few branches of the apical portion. They are also larger and more abundant near the centre and smaller and less present near the margin. These characteristics distinguish this interesting species from all other described species of *Marasmius*.

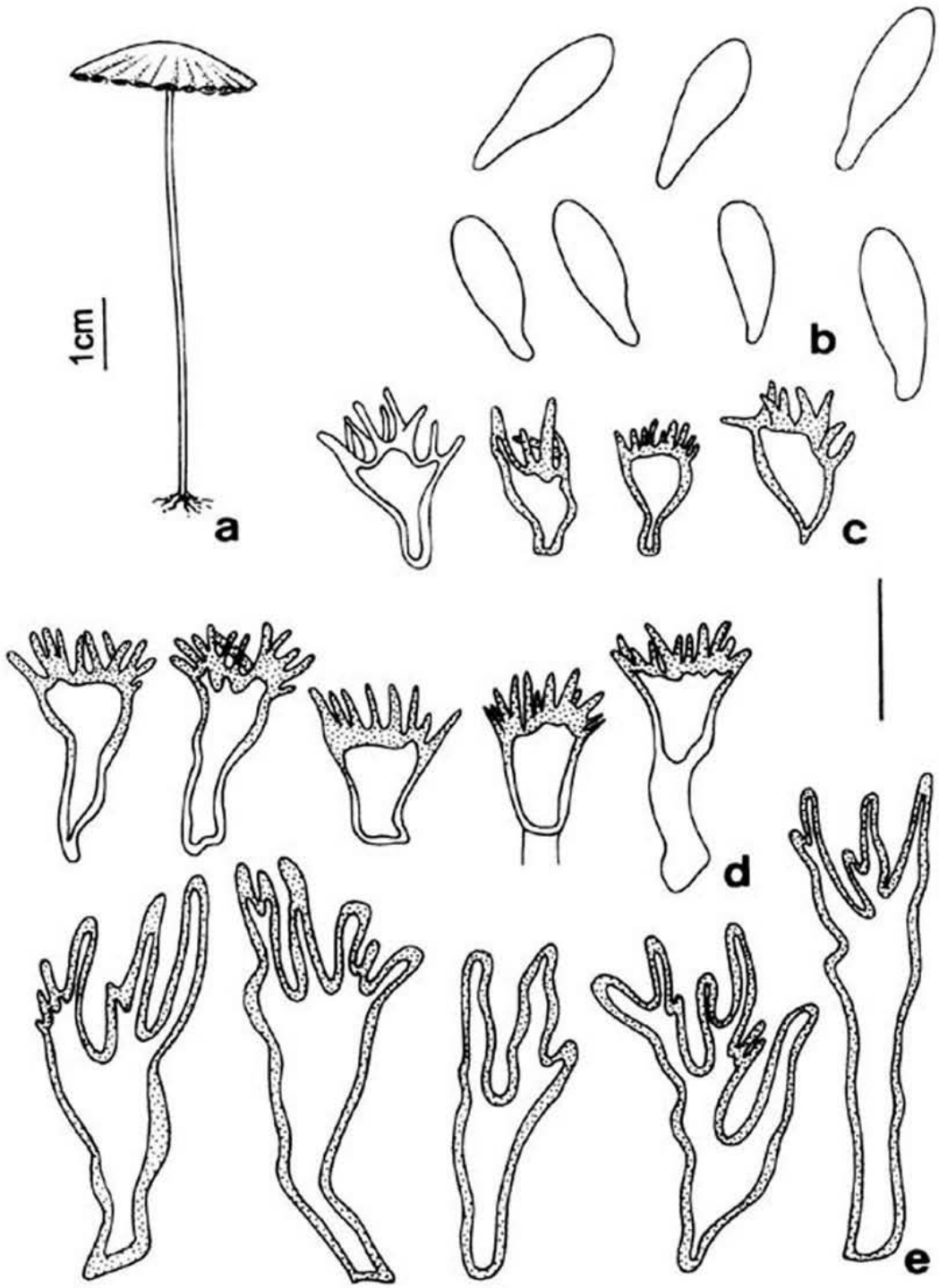


Figure 2. *Marasmius dimorphus* (holotype): a. basidioma, b. basidiospore, c cheilocystidia, d. normal pileipellis cell, e. larger pileipellis cell. Scale bar = 10 µm.

Acknowledgments

A special thanks to Maria Cecília Tomasi for inking the illustrations, Dr. Jefferson Prado, Instituto de Botânica, for revision of the Latin diagnosis. We also thank Dr. Vladimir Antonín, Moravian Museum, Dept. of Botany, and Dr. Dennis E. Desjardin, San Francisco State University, for their careful review of the manuscript. This study was supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, grant 04/04319-2).

Literature cited

Desjardin DE, Horak E. 1997. *Marasmius* and *Gloiocephala* in the South Pacific Region: Papua New Guinea, New Caledonia and New Zealand taxa. Part 1: Papua New Guinea and New Caledonia taxa. Part 2: New Zealand taxa. In Petrini O, Petrini LE, Horak E. (eds.), Taxonomic monographs of Agaricales II. Bibliotheca Mycologica 168: 1-152.

Grandi RAP, Guzmán G, Bononi VL. 1984. Adições às Agaricales do Parque Estadual das Fontes do Ipiranga, São Paulo, SP, Brasil. Rickia 11: 27-33.

Pegler DN. 1997. The agarics of São Paulo, Brazil. Royal Botanic Gardens, Kew, 68 p.

Singer R. 1976. *Marasmiae* (Basidiomycetes, *Tricholomataceae*). Flora Neotropica. Monograph 17: 1-347.

MYCOTAXON

Volume 95, pp. 301–304 *January–March 2006*

Geastrum hirsutum: a new earthstar fungus with a hairy exoperidium

I. G. Baseia[1] & F. D. Calonge[2]

baseia@cb.ufrn.br
[1]Universidade Federal do Rio Grande do Norte, CB
Depto. Botânica, Ecologia e Zoologia, 59072-970, Natal, RN, Brazil

calonge@ma-rjb.csic.es
[2]Real Jardín Botánico, CSIC
Plaza de Murillo 2, 28014 Madrid, Spain

Abstract– *Geastrum hirsutum* was found growing on decaying wood on an abandoned termites nest in Atlantic rainforest. This rare species is easily recognized by its small and caespitose basidiome with a very hirsute exoperidium.

Key words– Gasteromycetes, *Phallales*, taxonomy, neotropics, Brazil.

Introduction

Historically, the *Geastrum* has been placed in the *Lycoperdales*. Recently, however, molecular data have prompted a great modification in the systematics of the gasteromycetes that has led to the transfer of this genus to the *Phallales* (Hibbett et al. 1997). Despite several previous publications (Rick 1961, Bononi et al. 1984, Kimbrough et al. 1995, Baseia & Milanez 2002, Baseia et al. 2003, Sobestiansky 2005), *Geastrum* is still not well known Brazil.

During the last decade, the extent of fungal diversity was widely discussed (Hawksworth 1993; Hyde 1997). Today we know that—in terms of species numbers—Kingdom Fungi is probably surpassed only by the insects (Hyde & Hawksworth 1997). It is estimated that there are at least 1.5 million fungal species in the world (Hawksworth 2001) but, up to now, only 72,000 species (or 5% of the projected total) have been described. In this context, our goal is to contribute to what is known about fungal diversity in Brazil and the world in general, with emphasis on the taxonomy and ecology of the gasteroid fungi.

Materials and methods

Fieldtrips have been carried out during May and June 2003, to the Parque Dois Irmãos (07°55′ S and 34°52′ W) and Reserva Ecológica do Gurjaú (08°14′ S and 35°03′ W). Both are remnants of the Atlantic rainforest located in the State of Pernambuco. Sporocarps

were examined and photographed in the field. Macro and microscopic characters were determined according to Sunhede (1989). Colours were coded according to Kornerup & Wanscher (1978), with the indication "KW", bracketed in the text, and simultaneously described. They were dried up slowly and placed in containers with naphthalene.

Results

Geastrum hirsutum Baseia & Calonge, sp. nov. **Figs. 1-2**

Basidiomata juvene epigaeum, depresse globosum vel ovoideum, 4-8 mm latum, 5-10 mm altum, caespitosum, in subiculo pallide luteo. Exoperidium non hygroscopicum apertum 15-20 mm latum, fissum in 5-7 radios acutos, recurvos; stratum myceliale hirsutum, brunneoluteum; stratum medium pallide luteum, tenue; stratum internum brunneoluteum, tenue, persistens. Endoperidium sessile globosum cinereobrunneum laeve, 4-6 mm diam., cum; peristomio determinato, fibrilloso, cinereo. Gleba cinerea; columella indistincta; sporae globosae, 2.5-3 µm latae, brunneae, verrucis uniformibus subtilibus brevibus ornata. Hyphae capillitii longae, 1-1.5 µm latum, brunneae, verruculosae, non ramificatae.

Holotypus: *Brasil, Pernambuco, Recife, Reserva Ecológica do Gurjaú, ad lignum putridum, 12-VI-2003, leg. I. G. Baseia, UFRN-fungos 245.* **Paratypus:** *Dois Irmãos, 21/VI/2003, leg. I. G. Baseia URM 78711. MA-Fungi 67886.*

Basidiomata epigaeus when young, subglobose to obovate (Fig. 1), 4-8 mm broad, 5-10 mm high, caespitose, growing on a subiculum pale yellow (KW 4A3). Exoperidium, when open, 15-20 mm broad, split into 5-7 acute, recurving rays; nonhygroscopic (Fig. 1); mycelial layer densely hairy (Fig. 1), yellowish-brown (KW 5D8 to 5E7); hairs 1.5-3 mm long, made of hyphal aggregates with pointed ending, the hyphae are 2-5 µm diam., aseptate, clampless, with or without lumen, pale yellowish; medium layer pale yellowish (KW 4A3) to yellowish white (KW 4A2), thin; inner layer yellowish brown (KW 5E5), thin, persistent. Endoperidium smooth, brownish grey (KW 5D2), sessile, globose, 4-6 mm diam.; peristome definite, fibrillose, grey (KW 5B1). Gleba grey (KW 5F1), columella indistinct; spores globose, 2.5-3 µm broad, brown, with irregular short warts (Fig. 2a). Capillitium hyphae long, 1-1.5 µm broad, brown, covered with small wart-like outgrowths (Fig. 2b), not branching.

Discussion

Within *Geastrum* there are several species with some kind of hairy elements. Thus, *G. albonigrum* also has a hairy exoperidium (Calonge & Mata 2004), but it grows on soil, lacks any kind of a subiculum, and both basidiomata and spores are larger. On the other hand, *G. hieronymi* (Ponce de León 1968), *G. fimbriatum* var. *pseudohieronymi* (Calonge et al. 2005) and *G. setiferum* (Baseia & Milanez 2002) have a hairy or setose endoperidium, but they lack of any type of ornamentation on the exoperidium. Finally, *Phialastrum barbatum* (Sunhede 1989) shows a columella with a radiating sterile hyphal covering that resembles a beard.

An assembly of peculiar characteristics can easily identify this species: a mature developed subiculum and an exoperidium with a very hairy mycelial layer. Furthermore, it has very small spores 2.5-3 µm diam. The habitat is likewise unusual: decaying wood on an abandoned termites nest.

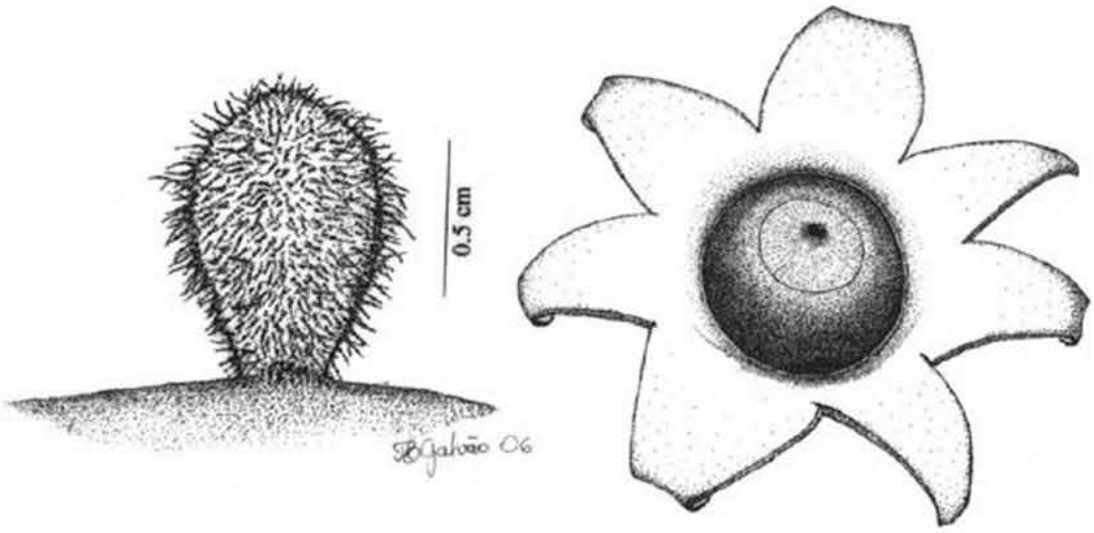


Fig. 1 *Geastrum hirsutum* (holotypus) a: Immature and mature basidiomata.

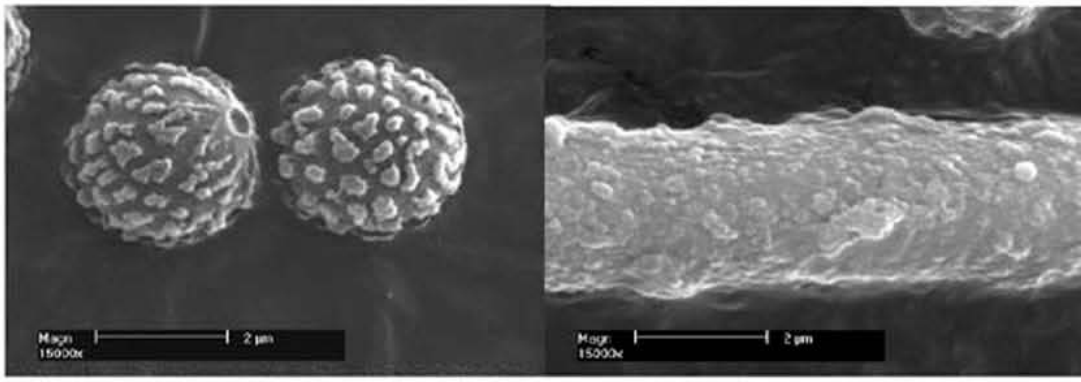


Fig. 2: *Geastrum hirsutum* (holotypus) a: Basidiospores under SEM, b: Capillitium surface.

Geastrum hirsutum is close to another tropical species, *G. schweinitzii* (= *G. mirabile*), in that both share several features in common: small, caespitose basidiomes growing on a well-developed subiculum that produce small spores and have a lignicolous habitat. In contrast, the exoperidium of *G. schweinitzii* has a smooth mycelial layer. All these features are enough to propose *G. hirsutum* as a new species.

Acknowledgments

We express our gratitude to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the partial financial support, and to Tereza Cristina de Oliveira Galvão for the illustrations. We also thank Professors H. Kreisel and G. Moreno for critical revision of the manuscript.

References

Baseia IG, Milanez AI. 2002. *Geastrum setiferum* (Gasteromycetes): a new species with a setose endoperidium. Mycotaxon 84: 135-139.

Baseia IG, Cavalcanti MA, Milanez AI. 2003. Additions to our knowledge of the genus *Geastrum (Phallales: Geastraceae)* in Brazil. Mycotaxon 85: 409-416.

Bononi VL, Guzmán G, Capelari M. 1984. Basidiomycetos do Parque Estadual da Ilha do Cardoso, V: Gasteromycetos. Rickia 11: 91-97.

Calonge FD, Mata M. 2004. A new species of *Geastrum* from Costa Rica and Mexico. Bol. Soc. Micol. Madrid 28: 331-335.

Calonge FD, Mata M, Carranza J. 2005. Contribución al catálogo de los Gasteromycetes (Basidiomycotina, Fungi) de Costa Rica. Anales Jardín Botánico Madrid 62 (1): 23-45.

Hawksworth DL. 1993. The tropical fungal biota: census, pertinence, prophylaxis and prognosis. In: Aspects of Tropical Mycology (eds. Issac S, Frankland JC, Watling R, Whalley AJS), Cambridge University Press, Cambridge: 265-293.

Hawksworth DL. 2001. The magnitude of fungal diversity: the 1.5 million species estimate revised. Mycological Research 105 (12): 1422-1432.

Hibbett DS, Pine EM, Langer E, Langer G, Donoghue MJ. 1997. Evolution of gilled mushrooms and puffballs inferred from ribosomal DNA sequences. Proceeding of the National Academy of Science USA 94: 12002-12006.

Hyde, KD. 1997. Can we rapidly measure fungal diversity? Mycologist 11(4): 176-178.

Hyde KD, Hawksworth DL. 1997. Measuring and monitoring the biodiversity of microfungi. In: Biodiversity of tropical microfungi (ed. Hyde, K. D.). Hong Kong University Press, Hong Kong: 141-156.

Kimbrough JW, Alves MH, Maia, LC. 1995. Basidiomycetes saprófitos presentes em troncos vivos e em folhedos de sombreiro (*Clitoria fairchiana* (Benth.) Howard). Biológica Brasílica 6 (1/2): 51-56.

Kornerup A, Wanscher JH. 1978. Methuen handbook of colours. Third edition. Eyre Methuen. London. 252 pp.

Miller OK, Miller HH. 1988. Gasteromycetes: Morphology and Developmental Features. Mad River, Eureka, CA, 157 pp.

Ponce de León P. 1968. A revision of the family *Geastraceae*. Fieldiana: Botany 31: 302-349.

Rick J. 1961. Basidiomycetes Eubasidii in Rio Grande do Sul. Iheringia, Ser. Bot. 9: 451-490.

Sobestiansky G. 2005. Contribution to a Macromycete Survey of the States of Rio Grande do Sul and Santa Catarina in Brazil. Brazilian Archives of Biology and Technology 48(3): 437-457.

Sunhede S. 1989. *Geastraceae* (Basidiomycotina). Morphology, ecology and systematics with special emphasis on the North European species. (*Synopsis Fungorum 1*). Fungiflora, Oslo, 535 pp.

MYCOTAXON

Volume 95, pp. 305–308 *January–March 2006*

Tricholoma lavendulophyllum, a new species from Yunnan, China

FU-QIANG YU[1,2], YUN WANG[3] & PEI-GUI LIU*

fqyu@mail.kib.ac.cn
[1]*Kunming Institute of Botany, Chinese Academy of Sciences*
Kunming 650204, China

[2]*Graduate School of Chinese Academy of Sciences*
Beijing 100039, China

[3]*Shenyang Institute of Applied Ecology, Chinese Academy of Sciences*
Shenyang 110016, China

Abstract—A new species of *Tricholoma* from the *matsutake* group, *Tricholoma lavendulophyllum*, is described and illustrated from Yunnan, China. It is characterized by its lavender lamellae and sweetish-aromatic smell resembling *T. matsutake*. The relationship of the new species to other closely related species is discussed.

Keywords—Matsutake, mushroom, taxonomy

Introduction

Tricholoma matsutake (S. Ito & S. Imai) Singer, commonly known as "Matsutake" or pine mushroom, is one of the most precious edible mushrooms in the world. There are a few closely related species, such as *T. bakamatsutake* Hongo, *T. caligatum* (Viv.) Ricken and *T. magnivelare* (Peck) Redhead, that are generally included in "Matsutake" (Wang et al., 1997). Although some taxonomical work has been done on this group (Zeller, 1934; Hotson, 1940; Hongo, 1960, 1974; Smith, 1979; Kytövuori, 1989), it is still insufficiently known, especially from China (Zang, 1990; Cao et al., 2003). In the fall of 2005, two collections of matsutake similar to *T. bakamatsutake* were obtained from Kunming wild edible mushroom markets. Careful examination of these two collections resulted in the description of a new species, *T. lavendulophyllum*.

Materials and Methods

Macroscopic characters were taken from fresh specimens. Descriptions of microscopic characters were observed under a Nikon E400 microscope with light and phase-contrast optics. Sections were made with a razor blade under the stereomicroscope, mounted

* Author for correspondence

in 5% KOH, and Melzer's solution, and then illustrated under the light microscope, with the aid of a drawing tube. Specimens examined were deposited in the Cryptogamic Herbarium of Kunming Institute of Botany, Academia Sinica (HKAS).

Taxonomy

Tricholoma lavendulophyllum F.Q. Yu, **sp. nov.** **Fig. 1–4**

Pileus 45-70 mm latus, subumbonatus vel convexus, margine involuto dein recto; castaneo in centro, subcremeo ad marginem, fibrilloso. Lamellae lavandulus, adnatae vel subliberae. Stipes 80-95 × 12-15 mm, annulato, aequali vel basi incrassato, supra annulum albo, infra annulum pileo concolore, fibrilloso castaneo squamosoque. Carne alba, odor fragrans sicut in T. bakamatsutake. *Basidia clavata, 40-50 × 7.5-15 μm; basidiosporae (5.5) 6-7.5 × (4.5) 5-5.5 (6) μm, late ellipsoideae.*

Etymology—The specific epithet refers to the lavender-coloured lamellae

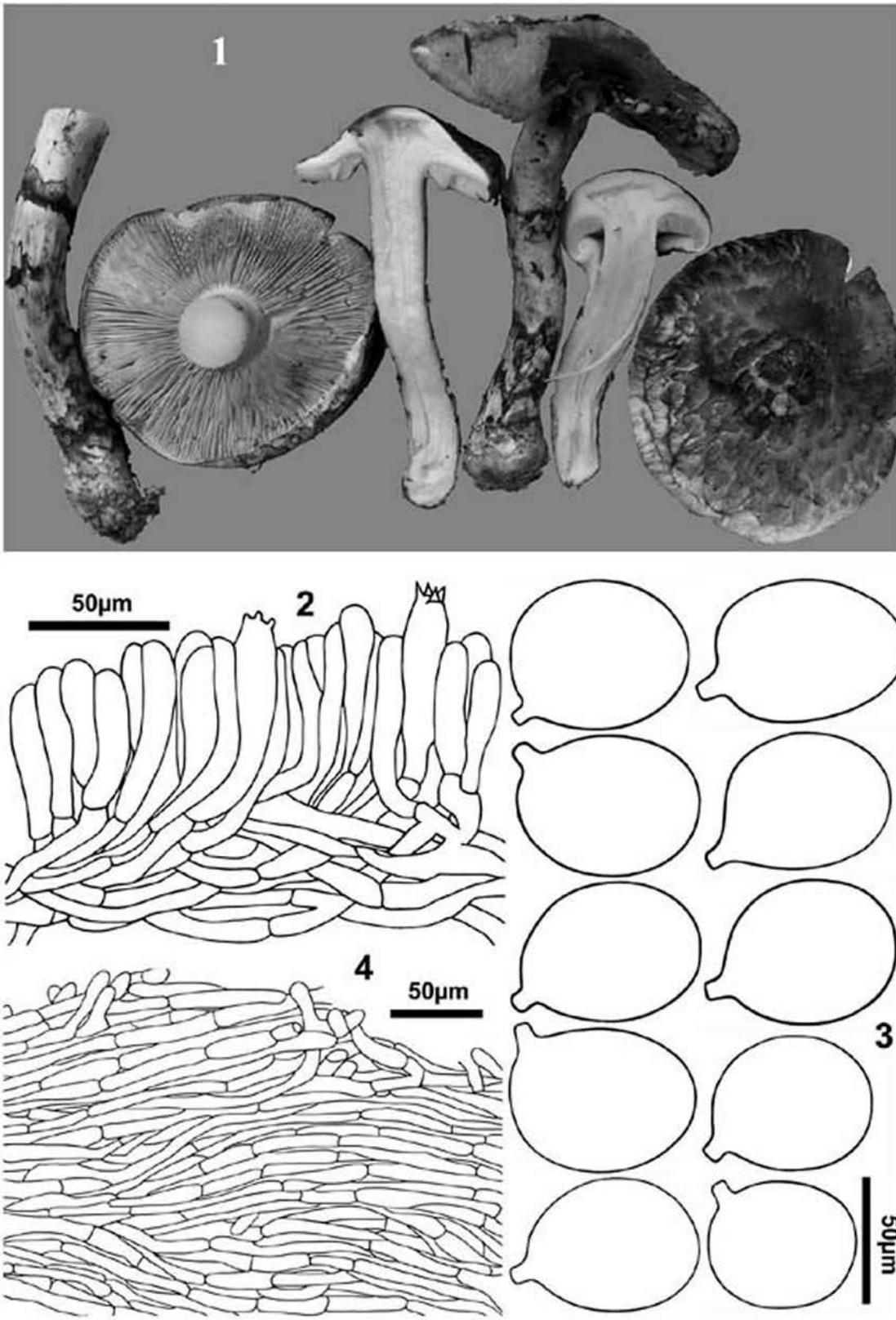
Pileus 45-70 mm broad, hemispherical to convex when young, becoming subumbonate to plano-convex when mature; surface slightly viscid when wet, chestnut brown to fuscous in the center, with appressed dark brown zoned scales, often becoming broken up into rather indistinct pieces; margin brown to whitish brown, inrolled when young. Context thick in the center, thin toward the margin, compact, white, taste sweetish. Aroma resembling *T. matsutake*, but stronger and with a slight smell of honey. Lamellae adnate, sinuate or arcuate, then separating from stem, pale to creamy lavender, with some lamellulae. Stipe 80-95 × 12-15 mm, equal or enlarged at the base, with an persistent but inconspicuous annulus on the upper part, 1.5-2.2 cm downward from the lamellae; concolorous with the pileus below the ring, with dark brown, appressed scales, whitish above the ring. Context white, solid, compact.

Pileipellis a layer of interwoven and thin-walled hyphae, 5-13 μm in diam., light yellowish brown, terminal elements subclavate to clavate, 7.5-9 × 22.5-67.5 μm. Lamellar trama subparallel, hyphae mostly 3-12 μm in diam., thin–walled, hyaline. Basidia 40-50 × 7.5-15 μm, clavate, hyaline, 4-spored, rarely 2- and 1-spored, sterigmata 2-5 μm long. Cystidia absent, but some clavate free hyphal ends present at the gill edge. Basidiospores (5.5-) 6-7.5 × (4.5-) 5-5.5 (-6) μm, Q= (1.18-) 1.25-1.33, broadly ellipsoid, thin-walled, hyaline, smooth, inamyloid. Stipitipellis with longitudinally arranged, appressed, parallel hyphae, 4-12 μm in diam., thin-walled, whitish brown to yellowish brown, terminal elements scattered, cylindrical, 6.8-9 × 30-54 μm, periclinally arranged.

Ecology: unknown.

Specimens examined—CHINA. YUNNAN PROVINCE: Kunming City, Aziying, wild edible mushroom market, 05 Aug. 2005, F. Q. Yu 1310B, HKAS49796; Kunming City, Wujing Road, wild edible mushroom market, 23 Jul. 2005, F. Q. Yu 1273, HKAS49804 (Holotype).

Notes—*T. lavendulophyllum* strongly resembles *T. bakamatsutake* in its appearance and aroma. It is sold as *T. bakamatsutake* at wild edible mushroom markets in Yunnan, China, but *T. lavendulophyllum* can be distinguished by its creamy lavender lamellae, and the absence of ventricose or flask-shaped cheilocystidia (Hongo, 1974). *T. fulvocastaneum* Hongo is another similar species to *T. lavendulophyllum* but differs in



Figs 1-4: *Tricholoma lavendulophyllum*, HKAS49804 (Holotype).
1. Basidiocarps; 2. Hymenium; 3. Basidiospores; 4. Section through pileipellis.

lacking of matsutake aroma, having whitish lamellae and a tapered base (Hongo, 1960). This species also resembles *T. caligatum* but the latter has whitish lamellae, relatively narrow spores, and a sweetish-bitterish to bitter taste (Kytövuori, 1989).

Acknowledgements

The authors wish to thank Dr. H. Knudsen of Copenhagen University, Dr. C. L. Ovrebo of University of Central Oklahoma, and Mr. E. Nagasawa of Tottori Mycological Institute for serving as pre-submission reviewers and for their valuable comments and suggestions. This project is partially supported by National Geographic Society of America (C56-04), Natural Science Foundation of Yunnan Province (2004C0050M), and National Natural Science Foundation of China (30470011).

Literature Cited

Cao ZM, Yao YJ, Pegler, DN. 2003. *Tricholoma zangii*, a new name for *T. quercicola* M. Zang (Basidiomycetes: *Tricholomataceae*). Mycotaxon 80: 159-164.

Hongo T. 1960. Notes on Japanese larger fungi (15). Journ. Jap. Bot. 35(3): 83-89.

Hongo T. 1974. Notes on Japanese larger fungi (21). Journ. Jap. Bot. 49(10): 294-304.

Hotson HH. 1940. The genus *Armillaria* in Western Washington. Mycologia 6: 776-790.

Kytövuori I. 1989. The *Tricholoma caligatum* group in Europe and North America. Karstenia 28: 65-77.

Smith AH. 1979. The Stirps *caligata* of *Armillaria* in North America. Sydowia Beih. 7: 368-377.

Wang Y, Hall IR, Evans LA. 1997. Ectomycorrhizal fungi with edible fruiting bodies I. *Tricholoma matsutake* and related fungi. Economic Botany 51: 311-327.

Zang M. 1990. A taxonomic and geographic study on the Songrong (matsutake) group and its allied species. Acta Mycologica Sinica 9(2): 113-127.

Zeller SM, Togashi K. 1934. The American and Japanese matsutake. Mycologia 26: 544-558.

MYCOTAXON

Volume 95, pp. 309–313 *January–March 2006*

Changes and additions to the North American lichen mycota – V

KERRY KNUDSEN

kk999@msn.com
Herbarium, Botany & Plant Sciences Department
University of California, Riverside
Riverside, CA, 92521-0124, USA

JAMES C. LENDEMER

lendemer@acnatsci.org
Lichen Herbarium, Department of Botany
The Academy of Natural Sciences of Philadelphia
1900 Benjamin Franklin Pky., Philadelphia, PA, 19103, USA

Abstract – *Lecanora utahensis is* placed in synonymy with *Lecanora peltasticoides*. A new combination is made: *Placopyrenium stanfordii*. *Dermatocarpon zahlbruckneri* (syn. *Catapyrenium zahlbruckneri*; *Placopyrenium zahlbruckneri*) is placed in synonymy with *P. stanfordii*. *Usnea cristatula* and *Cercidospora xanthoriae* reported new to North America.

1. *Cercidospora xanthoriae* (Wedd.) R. Sant., The Lichens and Lichenicolous Fungi of Sweden and Norway. p. 57. 1993.

Cercidiospora xanthoriae is known from Fennoscandia (Santesson 1993), Macaronesia (Hafellner 2002) and Europe (Sérusiaux et al. 1999). It is reported as new to North America, parasitic on *Xanthomendoza fallax* (Hepp ex Arnold) Søchting et al., in California. Javier Etayo verified the determination by the first author. The species usually has four strongly heteropolar spores per ascus.

USA. CALIFORNIA. SAN DIEGO CO.: Warner Hot Springs, Warner Hot Spring Ranch, 33°17'07" N, 116°37'31"W, elev. 1001 m., on *Xanthomendoza fallax* growing on *Quercus agrifolia*, *Knudsen* et al. *3900* (UCR, hb. Etayo).

2. *Lecanora peltasticoides* Hasse, The Bryologist, 17: 63. 1914. TYPE: USA, California, Riverside County, Palm Springs, on granite, 1901, *H.E. Hasse 861* (FH! holotype).

Syn. nov. *Lecanora utahensis* H. Magn., Acta Horti Gothob., 19(2): 39. 1952. TYPE: USA. Utah, Wayne County, Ekker's Ranch, on dry exposed sandstone, 6000 ft., *S. Flowers 359* (UPS, holotype; MIN! isotype).

Hasse (1914) published *Lecanora peltasticoides* based on a single collection made in 1901 in Palm Springs, California. The specific name refers to the similarity of the species

to *Acarospora peltastica* Zahlbr., a synonym of *Acarospora strigata* (Nyl.) Jatta, which is common in the Palm Springs area.

Magnusson saw the holotype of *L. peltasticoides* in 1926 and annotated it as a *Lecanora*. By the fifties, he had long since forgotten the Hasse taxon and while studying the Utah lichen collections of the bryologist S. Flowers he re-described the species as *Lecanora utahensis* (Magnusson 1952). The holotype, according to Śliwa (Ryan et al 2004), is a poor fungus-infected specimen. But Śliwa expressed the opinion that southwestern collections represented the same species as Magnusson's holotype. The isotype of *L. utahensis* at MIN was given to Clifford Wetmore by Flowers and is a much better specimen than the holotype. Śliwa also reviewed the isotype and verified it as *L. utahensis*. The first author's examination of the isotype reveals it is conspecific with the holotype of *L. peltasticoides*.

During the work on the *Lecanora* treatment for the Sonoran flora project the holotype of *L. peltasticoides* was not seen by Śliwa. While on loan to ASU it was placed with the specimens for the *Acarospora* treatment based on William Weber's erroneous annotation of the specimen as "*Acarospora smaragdula* mod. *strigata oligospora*". Correcting the placement of the species in *Acarospora*, Knudsen (2003) recognized *L. peltasticoides* as a distinct species in need of further taxonomic study. The name thus appears in the most recent edition of the North American Checklist (Esslinger 2005).

Reexamination of the holotype of *L. peltasticoides* by the first author for Bjorn Owe-Larsson, to exclude the possibility that it represented a species of *Aspicilia*, revealed that it matched a collection of *L. utahensis* (*Knudsen 3448*, UCR!) from the San Bernardino Mountains of southern California. Subsequent examination of the isotype of *L. utahensis* revealed it to represent *L. peltasticoides*. Thus *L. utahensis* is here placed in synonymy with *L. peltasticoides*.

The thallus of *L. peltasticoides* is formed of chalky white areoles with immersed or sessile apothecia that are a red-brown. The ascospores are simple and hyaline, 13.3-16.3 x 5.9-7.4µm. For a full description by Śliwa see Ryan et al. (2004). The species has been collected on sandstone, granite, soil, and limestone, and occurs throughout western North America (Ryan et al. 2004), though it is infrequently collected. Growing in areas where *A. strigata* is common, *L. peltasticoides* is probably under-collected because of its superficial resemblance to the *Acarospora*.

3. *Placopyrenium stanfordii* (Herre) K. Knudsen, comb. nov.

Verrucaria stanfordii Herre, Proceedings of the Washington Academy of Sciences, 12: 42-43. 1910. TYPE: USA, California, on rocks in the foothills of Stanford University, one and a half miles back of Mayfield, 150 ft., *A.C.T.W. Herre 146* (F!, lectotype **designated here**).

Syn. nov. *Dermatocarpon zahlbruckneri* Hasse, Bryologist, 16:2. 1913. TYPE: USA, Los Angeles, on trap rock in Topanga Canyon, Santa Monica Range (FH, holotype)

Catapyrenium zahlbruckneri (Hasse) J.W. Thomson, Bryologist 90: 38. 1987.

Placopyrenium zahlbruckneri (Hasse) Breuss in Nash et al., Lichen Flora of the Greater Sonoran Region, 1: 396-397. 2002.

Herre (1910) published *Verrucaria stanfordii* based on a specimen collected in the Santa Cruz Mountains in Santa Cruz County in central California. After its description

by Herre, *V. stanfordii* was forgotten. Hasse (1913) published the same species under the name *Dermatocarpon zahlbruckneri* three years later, perhaps unaware of Herre's specimens or their possible relevance with regard to his own lichen.

Later revisions of genera of Verrucariaceae placed in *Dermatocarpon* adopted Hasse's name for the taxon instead of Herre's name. In his revision of *Catapyrenium*, Thomson (1987) tranferred *D. zahlbruckneri* to *Catapyrenium*, based on the study of the holotype in the Farlow Herbarium (FH). When Breuss (2002) revised *Placopyrenium* in the Sonoran Desert region he transferred *C. zahlbruckneri* to *Placopyrenium*.

Recently, the first author (KK) reviewed the type of *V. stanfordii* and discovered it to be conspecific with *P. zahlbruckneri*. Agreeing with Breuss' circumscription of *Placopyrenium* from the related genera *Verrucaria* and *Catapyrenium*, but respecting the priority of Herre's original description, the new combination *Placopyrenium stanfordii* is made here. *Dermatocarpon zahlbruckneri* and its synonyms (*Catapyrenium zahlbruckneri* and *Placopyrenium zahlbruckneri*) are placed in synonymy with *P. stanfordii*.

For a description of *Verrucaria stanfordii* see Breuss (2002) under the name *Placyopyrenium zahlbruckneri*. The species is common in small populations mixed with other crustose lichens in southwestern North America. The specimen selected here as the lectotype was marked as a "co-type" but we have not been able to locate another specimen (and only one collection was cited in the protologue). Since the above annotation calls into question the status of the specimen as the holotype we have chosen to designate it as a lectotype to avoid ambiguity in the application of the name.

It should be noted that the epithet was originally published as "stanfordi". The epithet should be spelled "stanfordii". This orthographic error is corrected in the above new combination.

In his study of the lichen flora of Reno, Nevada, Herre (1911) reported *V. stanfordii*. Two specimens determined as *V. stanfordii* by Herre from Nevada were examined by the first author. The first collected at 5000 feet in Reno on March 5, 1910 (F!) and the second, collected in Marmol, Nevada, on April 30, 1910 (F!), are not *Placopyrenium stanfordii* but belong to the similar-looking *Verrucaria inficiens* group. The collections are characterized by subglose ascospores 10-13 x 7-9µm, evidence of being parasitic on two different lichen species (one a brown *Acarospora*), and as well as a broadly attached thallus (smaller than *P. stanfordii*). These collections correspond well with a new species of *Verrucaria* to be described by Breuss (in prep.) from the San Bernardino Mountains in southern California. Every specimen determined as *Verrucarria stanfordii* by Herre should thus not automatically be assigned to *Placopyrenium stanfordii*.

4. ***Usnea cristatula*** Motyka, Lich. Gen. *Usnea* Stud. Monogr. Pars Syst. 2(2): 643. 1938.
TYPE: Mexico, Michaocan, Morelia, Cerro Azul, elev. 3300 m, *A. Brouard* (LBL, holotype).

While revising A.W. Evans' collections of short apotheciate *Usnea* specimens for a revision the *Usnea strigosa* group (Lendemer & Ohmura in prep.) the second author encountered specimens of a taxon unrelated to *U. strigosa* (Ach.) Eaton. Though superficially similar to *U. strigosa*, the thalli contained diffractaic acid (TLC!) and a pink medullary pigment like that of *U. ceratina* Ach. The specimens had been erroneously identified by Herre and Motyka (one each) as *U. strigosa*. Since both collections were from Texas, USA it seemed

likely that the material represented a South/Central American taxon that reached the northern edge of its distribution in Texas. Examination of the available names led to the conclusion that the material represents *U. cristatula*, a species originally described from Michoacan, Mexico. The species is here reported for the first time from North America. The presence of diffractaic acid in the medulla as well as the medullary pigment easily separates this species from any other apotheciate taxon in North America and we hope that this report stimulates a search for modern collections from the region.

USA. TEXAS. [without county]: without locality, *Lindheimer s.n.* (NY); Guadalupe River region, i.1931, *sine legit 76* (YU!). ATASCOSA CO.: low *Celtis*-live oak woods along Atascosa Creek, 7 miles north of Jourdanton along Texas 346, 12.vii.1963, *Pursell 5912* (NY). BEXAR CO.: mesquite woods, 18 miles east of San Antonio, 17.v.1940, *Hubricht B-1890* (F!, YU!).

Acknowledgments

We thank the following for helpful discussions, criticism and searching for specimens in other herbaria: Othmar Breuss, Robert Lücking, Clifford Wetmore, and Richard C. Harris. We also thank the curators of the following herbaria for loaning material cited herein: F, FH, MIN, and YU. We thank Javier Etayo for his verification of *Cercidospora xanthoriae*, Scott Eliason and Chris L. Wagner of the U.S. Forest Service for facilitating work in the San Bernardino Mountains, and Char Glacy and Nancy Nenow.

Literature Cited

Breuss, O. 2002. *Placopyrenium*. In: Nash III TH, Ryan BD, Gries C, and Bungartz F (eds.): Lichen Flora of the Greater Sonoran Desert Region. I. Lichens Unlimited, Arizona State University, Tempe, Arizona, pp. 393-397.

Breuss, O. In prep. *Verrucaria*. In: Lichen Flora of the Greater Sonoran Desert Region, vol. 3.

Esslinger, TL. 2005. A cumulative checklist for the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. North Dakota State University: http://www.ndsu.nodak.edu/instruct/esslinge/chcklst/chcklst7.htm. Fargo, North Dakota.

Halfellner, J. 2002. Bemerkenswerte Funde von Flechten und lichenicolen Pilzen auf makaronesischen Inseln VI. Über einige Neufunde. Fritschiana, 36: 11-17.

Hasse, HE. 1913. Additions to the lichen flora of southern California. VIII. Bryologist, 16: 1-2.

Hasse, HE. 1914. Additions to the lichen flora of southern California. No. 9. Bryologist, 17: 61-63.

Herre, AWCT. 1910. The lichen flora of the Santa Cruz Peninsula, California. Proceedings of the Washington Academy of Sciences, 12: 27-269.

Herre, AWCT. 1911. The desert lichens of Reno, Nevada. Botanical Gazette, 51: 286-297.

Knudsen, K. 2003. Type specimens: investigations and observations. Bulletin of the California Lichen Society, 10(2): 36-38.

Magnusson, AH. 1952. New crustaceous lichen species from North America. Acta Horti Gotoburgensis, 19(1): 31-49.

Ryan, BD., Lumbsch HT., Messuti MI., Printzen C., Śliwa L., and Nash III TH. 2004. *Lecanora*. In: Nash III TH, Ryan BD, Diederich P, Gries C, and Bungartz F (eds.): Lichen Flora of the Greater Sonoran Desert Region, Vol. 2. Lichens Unlimited, Arizona State University, Tempe, Arizona, pp. 176-286.

Santesson, R 1993. The Lichens and Lichenicolous Fungi of Sweden and Norway. SBT-förlaget, Lund. 240 pp.

Sérusiaux, E., Diederich, P., Brand, AM., and van den Boom, P. 1999. New or interesting lichens and lichenicolous fungi from Belgium and Luxembourg. VIII [Lichens et champignons nouveaux ou intéressants pour la flore de la Belgique et du G.-D. de Luxembourg. VIII]. Lejeunia, 162: 1-95.

Thomson, JW. 1987. The lichen genera *Catapyrenium* and *Placidiopsis* in North America. Bryologist, 90: 27-39.

MYCOTAXON

Volume 95, pp. 315–318 *January–March 2006*

Four new lichens from Turkey

KENAN YAZICI*

kcagri_1997@yahoo.com
Karadeniz Technical University, Giresun Science and Art Faculty
Biology Department, Giresun, Turkey

ALI ASLAN

aliaslan@atauni.edu.tr
Biology Department, Kazım Karabekir Education Faculty
Atatürk University, Erzurum, Turkey

Abstract—Four species of lichenized fungi, *Acrocordia cavata*, *Cladonia awasthiana*, *Parmelinopsis afrorevoluta* and *Usnea silesiaca*, are reported new to the lichen flora of Turkey. For each, a short description is presented.

Key words—Ascomycetes, biodiversity, Giresun, Gümüşhane, Trabzon, Zonguldak

Interest in the lichen flora of Turkey has greatly increased in recent years (Aslan 2000, Aslan et al. 2002a,b, John 1995, 1996a,b, John & Breuss 2004, John et al. 2000, Yazıcı & Aslan 2002, 2003, 2005, Yazıcı et al. 2004, 2005). This present paper is a further contribution to these works.

The present report is based on collections in the three different provinces of Giresun, Gümüşhane and Trabzon between 12 October 1999 and 10 August 2005. A stereo microscope, a light-microscope and the usual spot tests were used in the identification of the samples, together with the following references: Ahti & Upreti (2004), Clerc (1991, 1997), Halonen et al. (1988), Louwhoff & Elix (2002) Purvis at al. (1992). *Acrocordia cavata* has been stored in the herbarium of Kazım Karabekir Faculty of Education, Biology Department of Atatürk University, Erzurum and the others in the herbarium of Biology Department, Giresun Science and Art Faculty, Karadeniz Technical University.

Results

Acrocordia cavata (Ach.) R.C. Harris

Thallus crustose, immersed, grey–white, cortex absent. Photobiont *Trentepohlia*. Perithecia 0.2–0.7 mm diam., half–immersed, brown–black, involucrellum hemispherical, colourless–pale brownish exciple. Ostiole mostly eccentric and rarely papillate. Hamathecium of persistent, slender, sparingly branched or anastomosing,

long-celled paraphysoids; no periphyses. Ascus 8–spored, cylindrical, fissitunicate; apical dome consiting of a broad ocular chamber surmounted by a hemispherical, meniscus-like structure, Ascospores uniseriate, colourless, elipsoid, the ends usually rounded, 1-septate, the median septum thick, 10–16 (–16.5) x 5.5–9.5 µm. Pycnidia absent.

This species normally grows on *Ilex* and *Corylus*. North America and Europe (Belgium, Germany, Sweden, Estonia, Norway, England, Netherlands, Luxemburg, France, Scotland, Slovenia, Spain).

Giresun: Keşap–Karabulduk, Çamlıca village, on *Corylus avellana*, at 1100 m, 40° 50' 50" N, 38° 32' 30" E, 12 October 1999, Aslan 1270.

Cladonia awasthiana Ahti & Upreti

Primary thallus evanescent, consisting of very small (0.4–2.1 x 0.4 mm), crenate squamules bearing granules, sometimes squamules patches present from basal up to cups but mostly only basal portion of potedia. Podetia 35–45 mm tall, 2–2.5 mm across, 0.2–0.5 mm thick, grey to brownish, sometimes dichotomously branched, often proliferate from margins, axils mostly closed; surface ± corticated at the very base but otherwise ecorticate, consisting of granular soredia and microsquamules; soredia from basal up to cups. Podetial wall 220–270 µm, medulla 70–90 µm, surface of central canal minutely papillulate. Hymenial discs brown. Conidiomata mostly not common, terminal, clearly constricted at the base. K–, P+ red, UV+ white; fumarprotocetraric acid (major), homosekikaic acid (major), confumarprotocetraric and protocetraric acids (minor).

This species normally grows on bare, humous soil in the middle and upper Himalayan forested slopes, both in the Western and Eastern Himalayan Regions in India, at the elevations of 950–2800 m. Recorded before from the Indian states Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim, Iran and Uttaranchal (Ahti and Upreti 2004).

Zonguldak: Çayköy, mainroad, on the mosses, 75 m, 41°22" N, 32°00" E, 10 August 2005, Yazici 1269.

Parmelinopsis afrorevoluta (Krog & Swinscow) Elix & Hale

Thallus grey, grey–white, some parts olive-green, loosely adnate, 4–12 cm wide. Lobes mostly abundant, subimbricate, sublinear, irregularly branched, to 3 mm wide; margins more or less entire or dentate, rarely irregularly incised, sometimes ± revolute, like slightly burned and wavy appearance, ciliate; cilia simple or partly forked, c. 1–1.2 mm long; cilia tips subrotund to subtruncate; granular soralia submarginal or in some parts laminally and pustular. Lower surface dark black and lobe margins mostly brown or rarely dark black, smooth to rugulose and with abundant rhizines; rhizines simple or bifurcate, to 2–2.5 mm long. Apothecia and pycnidia not seen. Medulla K–, P–, C+ rose, KC+ red; cortex C+ yellow; containing atranorin (minor), chloroatranorin (minor), gyrophoric acid (major), lecanoric acid (minor), 4, 5-Omethylhiascic acid (minor),5-O-methylhiascic acid (minor).

Grows in the warm-temperate and tropical regions of both hemispheres. Its distribution extends to Papua New Guinea, where it is uncommon, corticolous, occurring

in disturbed and undisturbed montane forest at 1600-3600 m altitude. Known Australia, Ethiopia, Tanzania, Eastern North America and Sweden. (Elix 1994).

Trabzon: Düzköy; Beypınar high plateau, on siliceous rock, at 700 m, 40° 48' N, 39° 20' E, 15 August 2004, Yazici 1273.

Usnea silesiaca Motyka

Thallus mostly pendulous (one of the specimens is subpendulous and partly shrubby), to 10 cm long (length of three samples are 6, 8 and 10 cm respectively), light-green or slightly yellow-green; cortex consisting of many annular cracks especially towards the base; base dark black, but black-brown base onwards to 2–3 cm.; cortex thick (10–20% of radius), K + red, C–, P–; medulla white, or sometimes slightly brown, compact, thin (9–15% radius), K+ red, P+ yellow, C–. Pseudocyphellae and soralia on cortex, soralia abundant, raised, confluent (but rare or absent on some branches, sometimes especially towards near the tips), mostly tuberculate, partly excavate and mostly larger than ½ of the branch diameter, K–, C–, P–. Isidia seen when young. Papillae generally indistinct. Branches are mostly isotomic and dichotomic, but anisotomic mostly near the tips. Thallus containing salazinic acid and accessory protocetraric and constictic acids.

Normally grows on conifers and deciduous trees, shrubs and hardwoods in open, humid forests at lower elevations. Common in humid coastal areas of North America (along the Pacific Northwest coast from Alaska and British Columbia south to California) and Europe (including Macaronesia, Austria, England, France, Netherlands Norway, Poland, Romania and Scotland) (Clerc 1991, 1997; Halonen et al. 1998)

Gumushane: Kürtün; Çıkrıkdüzü high plateau, "Örümcek forests" on *Picea orientalis*, 1900m., 40° 35' 30" N, 39° 03'30" E, 02 June.2001, Yazici 1271.

Acknowledgements

We are grateful to Dr. André Aptroot and Dr. Javier Etayo for linguistic revision and helpful comments on an earlier draft of this paper and would like to thank Dr. André Aptroot for the identification and verification of *Acrocordia cavata*, Professor Teuvo Ahti for *Cladonia awasthiana*, Professor Jack A. Elix for *Parmelinopsis afrorevoluta* and Dr. Philippe Clerc for *Usnea silesiaca*.

References

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

Aslan A, Yazıcı K, Karagöz Y. 2002a: Lichen Flora of the Murgul District (Artvin, Turkey) Israel J. Plant Sci. 50: 77–81.

Aslan A, Aptroot A, Yazıcı K. 2002b: New lichens from Turkey. Mycotaxon 84: 277–280.

Ahti T, Upreti DK. 2004: Two new species of *Cladonia* (*Lecanorales*) from the Himalayas. Biblioth. Lichenol. 88: 9–13.

Clerc P. 1991: *Usnea maderiensis* Mot. (ascomycète lichénisé): une espece meconnue de l'Europe et de l' Amérique du Nord. Candollea 46: 427–438.

Clerc P. 1997: Notes on the genus *Usnea* Dill. ex Adanson. Lichenologist 29: 209–215.

Elix JA. 1994: *Hypotrachyna*. Flora of Australia 55: 49–59.

Halonen P, Clerc P, Goward T, Brodo IM, Wulf K. 1988 : Synopsis of the Genus *Usnea* (Lichenized Ascomycetes) in British Columbia, Canada. The Bryologist 101(1): 36–40.

John V. 1995: Flechten der Turkei IV. Ergänzungen zum die Türkei betreffende lichenologische Schrifttum. Neunkirchen.

John V. 1996a. Preliminary catalogue of lichenized and lichenicolous fungi of Mediterranean Turkey. Bocconea 6: 173–216.

John V. 1996b. UTM-grid-mapping and distribution patterns of lichens in Turkey.- In Öztürk, M.A., Seçmen, Ö & Görk, G (eds.). Plant life in southwest and central Asia. Proceedings of 4th Plant life of Southwest Asia Symposium. 21–28 may 1995. İzmir: Ege Univ. Press. Bornova İzmir: 440–453.

John V, Seaward M.R.D, Beatty J.W. 2000. A neglected lichen collection from Turkey. Berkamsted School expedition 1971. Turk. J. Bot. 24: 239–248.

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

Louwhoff SHJJ, Elix JA. 2002: *Hypotrachyna* (*Parmeliaceae*) and allied genera in Papua New Guinea. Bibliotth. Lichenol. 81: 1–150.

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.

Yazıcı K, Aslan A. 2002: New records for the lichen flora of Turkey. Turk. J. Bot. 26: 117–118.

Yazıcı K, Aslan A. 2003: Lichens from the Regions of Gümüşhane, Erzincan and Bayburt (Turkey). Cryptogamie, Mycol. 24: 287–300.

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

Yazıcı K, Aslan A, Aptroot A. 2004: Four new lichen species from Turkey. Mycotaxon 90: 177–180.

Yazıcı K, Aslan A, Aptroot A. 2005: New lichen records from Turkey. Mycotaxon 92: 341–344.

MYCOTAXON

Volume 95, pp. 319–322 *January–March 2006*

Two new species in the genus *Morchella* (*Pezizales, Morchellaceae*) from China

SHU-HONG LI[1], YONG-CHANG ZHAO*[2], HONG-MEI CHAI[3] & MING-HUI ZHONG[4]

[1]*lmorelsh@yahoo.com.cn* [2]*yczhao@public.km.yn.cn** [3]*chm722@km169.net* [4]*yaasmushroom@yahoo.com.cn*

Yunnan Key Lab of Agricultural Biotechnology Kunming 650223, P. R. China

Abstract—Two new species of *Morchella, M. meiliensis* and *M. deqinensis*, collected from Yunnan, China are described and illustrated. The relationship of these two new species to other closely related species is discussed.

Key words— morel, ascocarp, taxonomy

Introduction

One thousand and thirty specimens of *Morchella* were collected from southwestern China and examined in the recent years. A total of ten species were identified, including two new species collected from Deqin County, Yunnan Province. Descriptions and illustrations of the two species, *M. meiliensis* and *M. deqinensis*, and comparisons with other morel species are provided below.

Taxonomy

Morchella deqinensis Shu H. Li, Y.C. Zhao, H.M. Chai & M.H. Zhong, **sp. nov.**

Fig. 1 a-f

Ascomata 5.2-9.5 cm alata, intus excavata. Capitulae 2.3–4.3 × 1.8–3.2 cm, ovoideae vel subconicae. Stipes conicus, cavus, 2.6-5.8 × 0.8-3.0 cm. Asci cylindricei, paraphysati, 8-spori, 9.91–10.49 × 105–148.65 µm. Sporidia elliposideo vel ovoideae, 6.4–8.1 × 9.2–9.6 µm.

Etymology: the specific epithet refers to the location of the holotype collected.

Ascomata 5.2–9.5 cm tall, hollow, with pileus completely attached to the stipe; pileus 2.3–4.3 × 1.8–3.2 cm, egg-shaped, sometimes broadly conical; ribs sparse and vertically

*Corresponding author

arranged, dark greenish-brown; pits irregular quadrilateral, 2–3 times longer in length than in width, creamy or pale creamy, with many tiny crystals on the surface under stereomicroscope; context thin, firm, creamy or pale creamy; odor and taste not distinctive. **Stipe** 2.6–5.8 × 0.8–3.0 cm, hollow, conical, tapering, about 1/3–1/2 of the top, whitish when young, becoming dark rust when mature or dried, with white granules at the top and grooves at the base.

Hymenium 6–10 μm thick, hyaline, parenchyma, the bottom flattened; asci 9.91–10.49 × 105–148.65 μm, hyaline, cylindrical, circular on apex, 8-spored, single-space arranged, coming forth a circular orifice (8.5–9.0 μm in diameter) and a hemisphere cap on the apex and freeing ascospores from the orifice at maturity; ascospores 6.4–8.1 × 9.2–9.6 μm, hyaline, smooth, ellipsoid to ovoid, without oil droplets, thin-walled, spore print creamy; paraphyses 3.59–4.50 × 43.38–43.42 μm, hyaline, club-shaped, with a septum on the base.

Holotype: CHINA, Yunnan, Deqin County, Xiaruo, alt.2800-3200 m, on the ground under coniferous or mixed forests, 20 April, 2005, Shu.H. Li (YKLAB, Yunnan Key Lab of Agricultural Biotechnology, Yunnan, China) YKLAB1002.

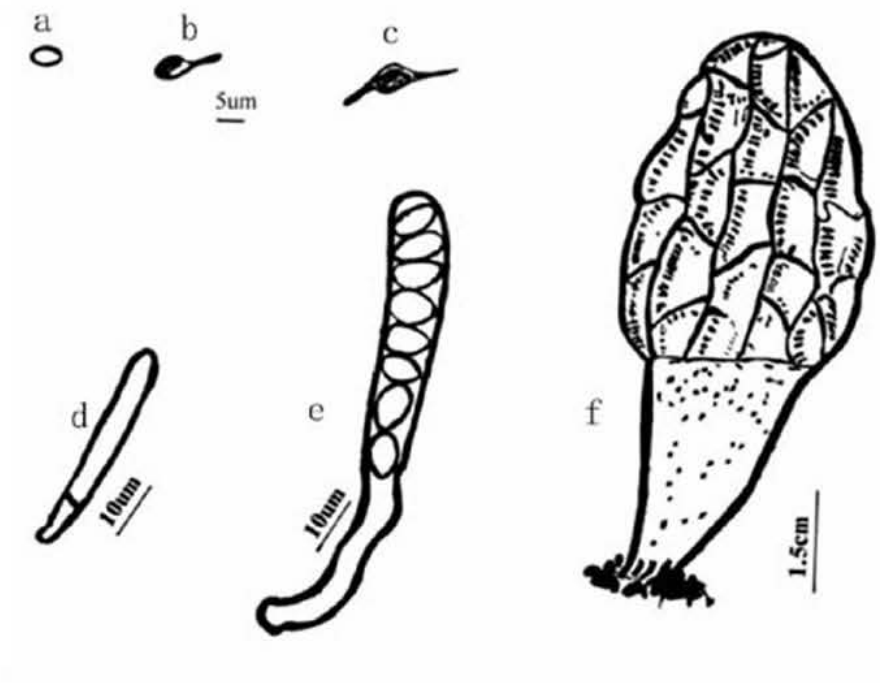


Fig.1—*Morchella deqinensis* (YKLAB1002). **a.** Ascospore. **b–c.** Germinating ascospores. **d.** Paraphysis. **e.** Ascus with ascospores. **f.** Fruiting body.

Morchella meiliensis Y.C. Zhao, Shu H. Li, H.M. Chai & M.H. Zhong, **sp. nov.**

Fig. 2 a-e

Ascomata 6.0–8.5 cm alata, intus excavata. Capitulae 3.5–4.8 × 1.2–2.0 cm, conicae. Stipes cylindricus, cavus, 2.3–3.5 × 0.8–2.0 cm. Asci cylindrcei, paraphysati, 8-spori, 5.18–5.87 × 91.16–94.44 μm. Sporidia elliposideo-oblonga, 4.67–5.10 × 5.20–5.66 μm.

Etymology: the specific epithet refers to the location of the holotype collected.

Ascomata 6.0–8.5 cm tall, hollow, completely attached to the stipe; pileus 3.5–4.8 × 1.2–2.0 cm, conical; ribs sparse and vertically arranged, dark brow to black; the hymenium of between the ridges merulioid; pits irregular-quadrilateral or rectangle, creamy to yellowish; context thin, firm when drying; odor and taste not distinctive. **Stipe** 2.3–3.5 × 0.8–2.0cm, whitish when fresh becoming waxy yellow when dry, cylindrical, with white granules at the top and grooves at the base.

Hymenium 8–15 μm, hyaline or pale, parenchyma, the bottom slightly wavy; asci 5.18–5.87 × 91.16–94.44 μm, hyaline, cylindrical, circular on the apex, 8-spored, single-space arranged; ascospores 4.67–5.10 × 5.20–5.66 μm, hyaline, smooth, ellipsoid, with oil droplets, thin-walled, swollen and darkening when germinating; spore print creamy; paraphyses 4.19–5.20 × 40.09–65.01 μm, dark, club-shaped.

Holotype: CHINA, Yunnan, Deqin County, Meili Snow Mountain, alt.2800-3500m, on the ground under broadleaf forests or mixed forests, 13 May, 2005, Y.C. Zhao (YKLAB, Yunnan Key Lab of Agricultural Biotechnology, Yunnan, China) YKLAB1080.

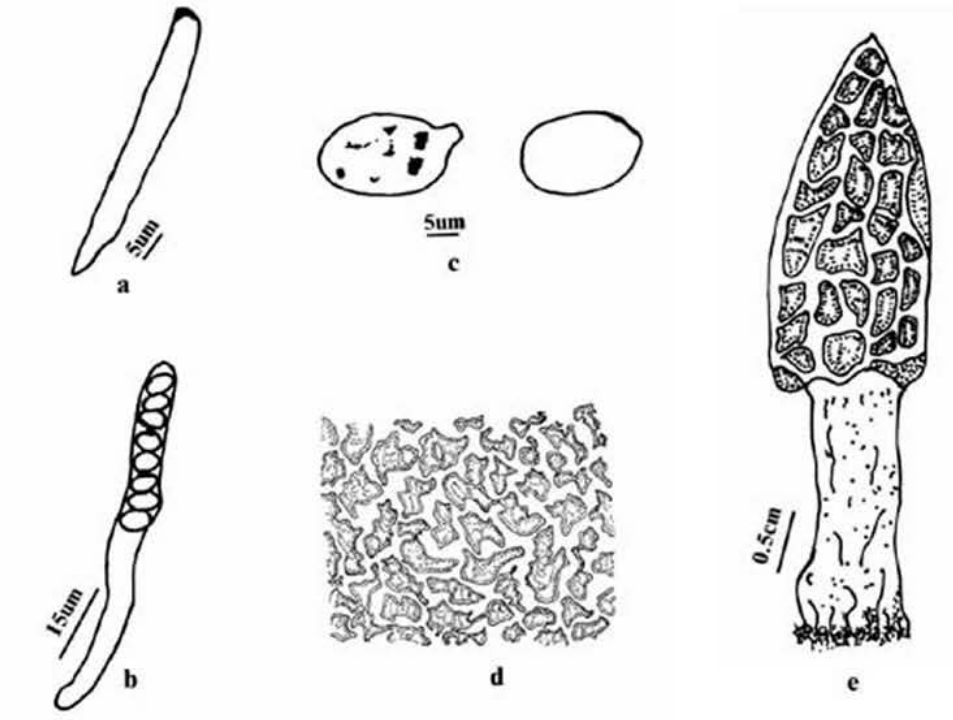


Fig.2—*Morchella meiliensis* (YKLAB1080). **a.** Paraphyses. **b.** Ascus. **c.** Germinating ascospores. **d.** Pores (under stereo-microscope). **e.** Fruiting body.

Discussion

M. deqinensis resembles *M. umbrina* Boud. (Huang 1998, Mao 2000) but differs in its tapering stipe with white granules and grooves at the base. Also *M. umbrina* has smaller pits and a deeper color than *M. deqinensis*.

M. meiliensis is closely related to *M. angusticeps* Peck (Bi 1994, Zang 1996, Mao 2000, Kuo 2005) and *M. conica* Pers. (Zang 1996, Huang 1998, Mao 2000). The merulioid hymenium, lighter colored ribs, and club-shaped paraphyses distinguish *M. meiliensis* from the other two species.

Acknowledgements

We would like to thank Profs. Yun Wang (Crop & Food Research, New Zealand) and Xin-Chang Luo (Department of Plant Protection, Huazhong Agricultural University) for paper review and good advice in English writing. This study was supported in part by Opening Grant of Shanghai Key Lab of Agricultural Genetics and Breeding (Shagb2005-02).

Literature Cited

Bi ZS, Zheng GY, Li TH. 1994. Macrofungi in Guangdong. Guangdong Science & Technology Press, Guangzhou.

Chen JY, Liu PG. 2005. A new species of *Morchella* (*Pezizales*, Ascomycota) from southwestern China. Mycotaxon 93: 89-93.

Huang NL. 1998. Colored Illustrations of Macrofungi of China. China Agricultural Press, Beijing.

Kuo M. 2005. The black morels. Retrieved from the MushroomExpert.Com web site: http://www.mushroomexpert.com/morchella_angusticeps.html

Kuo M. 2005. The *Morchellaceae*: True morels and verpas. Retrieved from the Mushroom Expert. Com Web site: http://www. mushroomexpert.com/morchellaceae.html

Mao XL. 2000. The Macrofungi in China. Henan Science and Technology, Zhengzhou.

Zang M. 1996. Fungi of the Hengduan Mountains. Science Press, Beijing.

MYCOTAXON

Volume 95, pp. 323–330 *January–March 2006*

Notes on some species of the lichen genus *Lecidea* from India

D.K. UPRETI[1]*, S. NAYAKA[1]
& M.P. ANDREEV[2]

*upretidk@rediffmail.com
[1]*Lichenology Laboratory, National Botanical Research Institute, Rana Pratap Marg Lucknow – 226 001, India*

[2]*Komarov Botanical Institute of the Russian Academy of Sciences 2, Prof. Popov St., 197376, St. Petersburg, Russia*

Abstract—A detailed morphotaxonomic account of seven species of *Lecidea* from India is provided. *Lecidea confluens*, *L. plana*, and *L. tessellata* are new records for the Indian lichen mycota.

Key words—*Lecideaceae*, lichen flora

Introduction

The lichen genus *Lecidea* is characterized by crustose, heteromerous, continuous, areolate or verruculose or squamulose thallus lacking rhizines and decorticated or with a thin cortex and sometimes sorediate, with photobionts being members of the Trebouxiophyceae. Apothecia are orbicular or angular, contorted, immersed, sessile or very shortly stalked, proper margin colourless, coloured or blackened, or closely woven hyphae; excipulum colourless or reddish or grayish; hypothecium colourless or coloured or ± black; paraphyses simple or branched with swollen, with free or conglutinate, capitate apices, free or conglutinate, *Lecidea*-type asci clavate, 8-spored; ascospores simple colourless, oblong-oval, ellipsoid, with thin wall, pycnidia immersed, with short conidia.

Awasthi (2000) listed 42 species of *Lecidea* s. lat. from Indian subcontinent, out of which about 20 species are known from the Karakorum and Khumbu Himal area of Nepal, five from Ceylon (Sri Lanka), and 17 species from India. Most of the taxa earlier listed under *Lecidea* from India are at present transferred to different lichen genera. The material of *Lecidea advena* Nyl. ex Hue, *L. albicans* Nyl., *L. caliginosa* Stirt., *L. fuscorubida* Nyl., *L. secernens* H. Magn., which were not traceable in the Indian herbaria, therefore are not included in the present study. *Lecidea nagalandica* G.P. Sinha & Kr.P. Singh, which Sinha & Singh (1987) described as a new foliicolous lichen from India, probably does not belong to *Lecidea* due to the presence of brown-black exciple.

The *Lecidea* species in India are widespread in higher altitudes (2000-4700 m) of the Himalayan region. The states of Uttaranchal and Himachal Pradesh in the western Himalayas include five each of taxa reported in the present study while only three species are found in Jammu and Kashmir.

Awasthi (1991) did not treat *Lecidea* species in his key to microlichens from the Indian subcontinent. The present communication provides a detailed morphotaxonomic account of seven species of *Lecidea* occurring in India according to the modern concept.

Materials and methods

Specimens were studied from the personal lichen collections of Dr. D.D. Awasthi (AWAS), Botany Department, Lucknow University Herbarium (LWU), and National Botanical Research Institute (LWG) preserved at LWG and representing all the phytogeographical regions of India. The specimens were examined morphologically, anatomically and chemically. For chemical spot reaction the usual reagents 5% potassium hydroxide (K), paraphenylenediamine (PD) and calcium hypochlorite (C) were applied.

Thallus and apothecial sections were cut using a microtome (Fuji-Japan) at 12-15 µm thickness and stained with lactophenol cotton blue. The chemical constituents were identified in solvent A (180 ml toluene : 60 ml 1-4-dioxane : 8 ml acetic acid) using the thin layer chromatography (TLC) technique by Culberson (1972) and Walker & James (1980).

Key to the *Lecidea* species from India

1a. Thallus brown to dark brown or yellow brown (medulla I+ violet) ..... ***L. atrobrunnea***

1b. Thallus whitish, greyish to pale yellowish brown or grey brown 2

2a. Medulla I+ deep violet (thallus thick, grey, hypothecium brown to dark brown) ..... ***L. confluens***

2b. Medulla I– 3

3a. Thallus K+ yellow (PD–, hypothecium pale to dark brown) ..... ***L. lapicida***

3b. Thallus K– 4

4a. Hypothecium colourless, epihymenium deep green ..... ***L. plana***

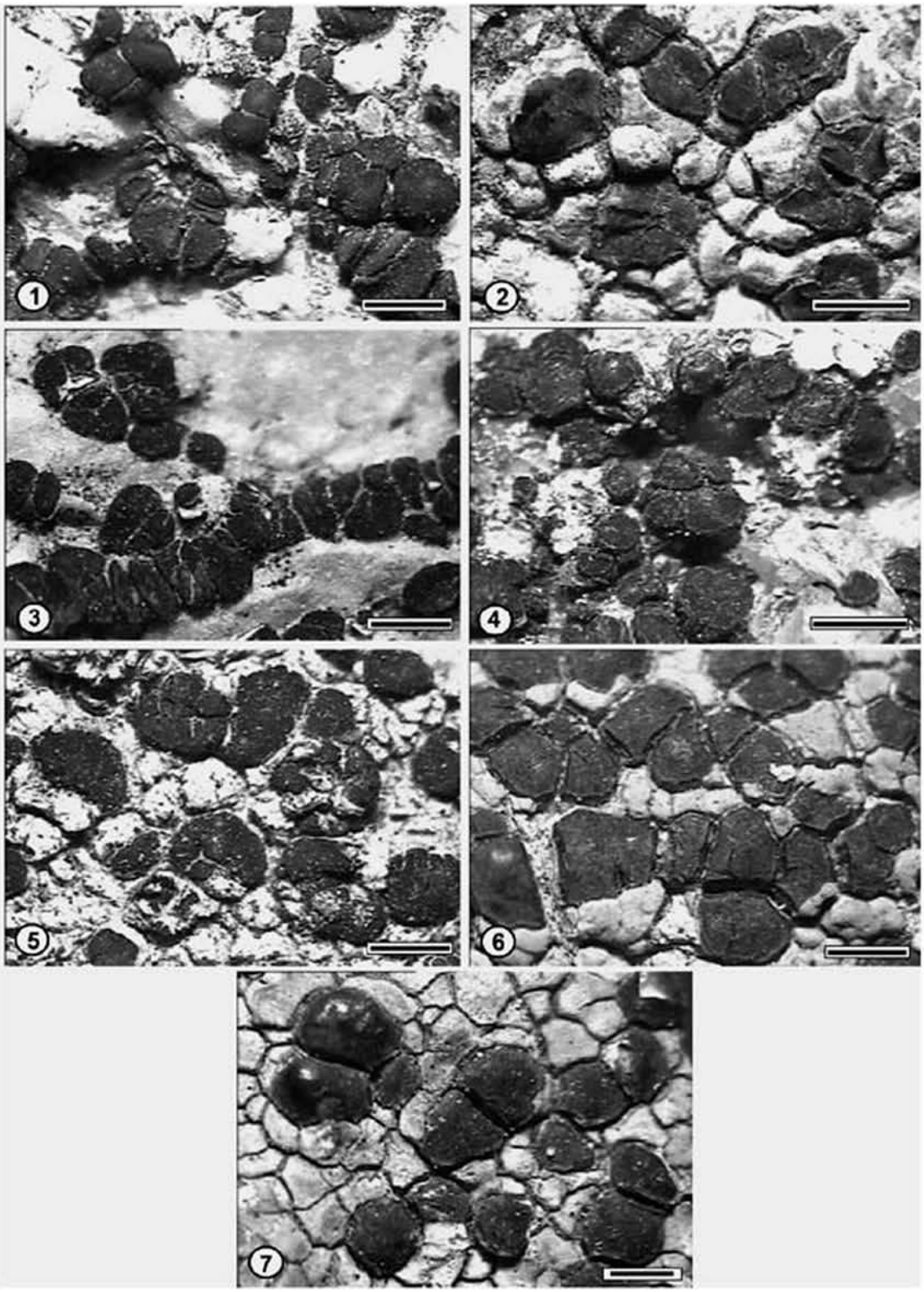
4b. Hypothecium brown to dark brown 5

5a. Apothecia immersed, thallus chalky white to grey, hypothecium pale brown ..... ***L. tessellata***

5b. Apothecia not immersed 6

6a. Excipulum usually broad, developed below the apothecium ..... ***L. auriculata***

6b. Excipulum not developed below the apothecium ..... ***L. paratropoides***



Figures–1-7. Habit

1. *Lecidea atrobrunnea*; **2.** *L. auriculata*;
3. *L. confluens*; **4.** *L. lapicida*;
5. *L. paratropoides*; **6.** *L. plana*;
7. *L. tessellata*.

Taxonomic descriptions

Lecidea atrobrunnea (Lam. & DC.) Schaer. Lich. Helv. Spic., sect. 3: 134 (1818). **Fig. 1**
– *Rhizocarpon atrobrunneum* Ramond ex Lam. & DC., Fl. Franç. ed. 3, 2: 367 (1805).

Thallus reddish brown with epinecral layer, squamulose-areolate, areolae rounded, plane, with whitish margin; hypothallus distinct, black; apothecia subimmersed to adnate, slightly constricted at base, upto 1.5 mm diam.; disc plane or somewhat convex in mature ones, epruinose, margin prominent, sometimes flexuose; excipulum 40–60 µm thick, blackish green externally, colourless internally; epithecium deep green to blackish green; hymenium 40–60 µm high, colourless, I+ blue; subhymenium 60–70 µm high, colourless, I+ blue; hypothecium brown, 80-100 µm high, I+ blue; paraphyses simple or sometimes branched, thickened at apices. Asci clavate, 40–50 x 10–13 µm; ascospores 8–10 x 4–6 µm; with obtuse ends.

Thallus K–, KC–, C–, PD–; a pale yellow spot at Rf class 5 in TLC.

SPECIMENS EXAMINED–HIMACHAL PRADESH: Kangra district, Bir Tea Estate area, Billing Hills, 2000-2500 m, on exposed rocks, Upreti 213602/A (LWG); Lahul Spiti district, Baralacha La Pass, 4700 m, on exposed rocks, Upreti and Chatterjee 03-001776 (LWG); Shimla district, Narkanada, Hatu Peak, 3360 m, on rocks, Nayaka and Srivastava 02-67181 (LWG).

Lecidea atrobrunnea is distinguished by a deep brown thallus with an epinecral layer and a well developed hypothecial medulla, small ascospores, and I+ blue medulla.

The species is widely distributed in alpine regions of all the continents. Hertel (1977) reported the occurrence of this species from Reti Runi area in Spiti valley. In India the species is known to occur in alpine regions of Himalayas in Himachal Pradesh between altitudes of 2000–4700 m in Lahul Spiti, Kangra and Shimla districts.

Lecidea auriculata Th. Fr. Nova Acta Reg. Soc. Sci. Upsal., Ser. 3, 3: 213 (1860). **Fig. 2**

Thallus endolithic, or cracked-areolate, medulla I+ blue; hypothallus indistinct; apothecia black, sessile, constricted at base, 1.0–2.0 mm in diameter; disc plane, epruinose or sometimes slightly pruinose; margin distinct, sometimes flexuose; excipulum developed below the apothecium, 100–150 µm thick, dark brown externally, internal part light brown, hyphae intricate-radiating, 3–5 µm, thin walled; epithecium blue-green; hymenium colourless, 30–40 µm high; subhymenium 40–50 µm high, light brown; hypothecium light brown; subhypothecial medulla prominent and raised up, I+ blue; paraphyses simple, thickened at the apices. Asci clavate, 25–40 x 7–9 µm; ascospores ellipsoid with obtuse ends, 6–11 x 2.5–4 µm.

Thallus K–, KC–, C–, PD–; no lichen substances detected with TLC.

SPECIMENS EXAMINED–JAMMU AND KASHMIR: Leh district, Ganglas area, 4000 m, on exposed rocks, Upreti and Chatterjee 03-001814/A (LWG). HIMACHAL PRADESH: Lahul Spiti district, Pasio, 3800 m, on exposed rocks, Upreti and Chatterjee 03-001742/A (LWG); Zinzibar, 4200 m, on exposed rocks, Upreti and Chattrjee 03-001756/A (LWG); Baralacha Pass, 4700 m, on exposed rocks, Upreti and Chatterjee 03-001772, 03-001774 (LWG).

The species is characterized by a well-developed excipulum below the apothecium, blue green epithecium, violet brown subhymenium, very narrow ascospores and the presence of confluentic acid.

According to Hertel (1977) this taxon has a bipolar distribution and is widespread and common in Arctic-alpine belt of the more humid high mountain rages in Europe, Asia and North America. In India the species is known to occur in alpine regions of Jammu and Kashmir and Himachal Pradesh between altitudes of 3800–4700 m. Awasthi (1963) first reported this species from Kangra district in Himachal Pradesh.

Lecidea confluens (Weber) Ach. Methodus Lich. 14 (1803). Fig. 3

– *Lichen confluens* Weber, Spicil. Fl. Goett. 180, tab II (1778).

Thallus cracked areolate, bluish grey to grey, medulla, I+ blue; prothallus black; apothecia adnate 0.5–1.2 mm diam., immersed to ± sessile, arising between the areoles, black; disc plane to slightly concave, epruinose; margin thick, prominent; epithecium green to olive green; hymenium colourless 70–100 µm high; hypothecium dark red brown to dark brown, 90–100 µm high; excipulum blackish at outer edge, ± colourless within. Asci clavate, 50–60 x 10–16 µm; ascospores ellipsoid, 10–12 x 4–6 µm.

Thallus medulla K–, KC–, C–, PD–; confluentic acid in TLC.

SPECIMENS EXAMINED–JAMMU AND KASHMIR, Glumarg, at Khilanmarg, 2760 m, on boulders, Dange 77-535 (LWU-LWG). UTTARANCHAL: Chamoli district, Badrinath, south of temple near Brahmini village, 3100–3200 m, on boulders, Dange 76-740 (LWU-LWG), north of temple, way to Mana Village 3100–3250 m, on boulders, Dange 76-892 (LWU-LWG).

The species is know to occur on siliceous rocks in northern Eurasia and North America and is a new record for Indian lichen flora.

This species is similar to *L. lapicida* and *L. tessellata*. *L. confluens* prefers to grow in more humid habitats, has wider areoles, dark red brown to dark brown hypothecium, K+ yellow excipulum and smaller ascospores than *L. lapicida*. From *L. tessellata* it differs in having an almost colourless hypothecium.

Lecidea lapicida (Ach.) Ach. Method. Lich. 37, (1803). Fig. 4

– *Lichen lapicida* Ach., Lich. Suec. Prodrom. 61, (1798).

Thallus cracked areolate, whitish grey, changed brownish in herbarium, medulla I+ blue; prothallus black; apothecia appressed to adnate, 0.5–1.5 mm diam., immersed to ± sessile, arising between the areoles, black; margin thick prominent; disc plane or slightly concave; epruinose with dark green at outer edge; epihymenium greenish black, K+ blue green; hymenium colourless, 90–120 µm high; hypothecium pale to dark brown, 80–100 µm high; excipulum blue-green externally, pale brown internally, K+ yellow; Asci clavate, 40–60 x 10–16 µm; ascospores ellipsoid, 19–11 x 4–6 µm.

Thallus medulla K+ yellow, C–, KC–, PD+ yellow; stictic and constictic acid in TLC.

SPECIMENS EXAMINED–UTTARANCHAL: Dehra Dun district, Mussoorie hills, way to Lal Tibba, 2250 m, on rocks, Joshi 75-340 (LWU-LWG). HIMACHAL PRADESH: Lahul Spiti district, 10 km before Sarchu, 4000 m, on rocks, Upreti 03-001783 (LWG).

The species is widespread in northern and southern hemispheres on siliceous rocks. Earlier, Hertel (1977) reported this species from Chandra Valley in Kangra district of Himachal Pradesh.

In having whiter thallus and K+ yellow reaction it is similar to *L. lactea* Flörke ex Schaer., which can be differentiated by the presence of norstictic acid and having more neatly arranged angular areoles.

Lecidea paratropoides Müll. Arg. Flora 57: 348 (1874). Fig. 5

Thallus indistinct (not developed); prothallus not seen; apothecia rounded to angular, crowded, 0.5–1.0 mm in diam.; margin thick, entire, black; disc plane to slightly convex, black, epruinose; epihymenium olive green to dark green 12–17 µm; hymenium colourless, 40–65 µm high; hypothecium brown to dark brown 40–50 µm high; excipulum colourless. Asci 26–30 x 10–15 µm; ascospores ellipsoid, 7–9 x 3.5–5 µm.

Thallus K–, KC–, C–, PD–: no lichen substances detected with TLC.

SPECIMEN EXAMINED–UTTARANCHAL: Chamoli district, Kedarnath hill side, on east and north of the temple, 3600–3700 m on boulders, Dange 76-293 (LWU-LWG); Almora (now Bageshwar) district, Pindari Glacier, on ridge of moraine, 3940 m, Awasthi 7716 (LWG – AWAS).

The species is widely distributed in the alpine regions of southern Europe and Central Asia. In India it has a restricted distribution in the western Himalayas and first reported by Hertel (1977) from Pindari glacier in Uttaranchal.

L. promiscens Nyl., which is close to this species, can be differentiated by having larger (9–12 x 3–5 µm) ascospores and blackish-brown hypothecium.

Lecidea plana (J. Lahm) Nyl. Flora 55: 552 (1872). Fig. 6

– *Lecidella plana* J. Lahm in Körber, Parerga Lich. 211 (1861).

Thallus absent or thin, white, granular to cracked, areolate, areoles flat, white to grey; prothallus indistinct; apothecia adnate 0.4–1.2 mm diam., black; margin thin, entire or more or less sinuous; disc flat to somewhat convex; epihymenium deep green, intensifying in K; hymenium colourless, 40–50 µm high; hypothecium colourless, 50–80 µm high; exciple colourless. Asci clavate, 30–40 x 8–14 µm; ascospores 8–14 x 3–6 µm, ellipsoid.

Thallus and medulla K–, C–, KC–, PD–; planaic acid in TLC.

SPECIMENS EXAMINED–HIMACHAL PRADESH: Lahul Spiti district, Sissu, 3100 m, on rocks, Upreti and Chatterjee 03-001706 (LWG). JAMMU AND KASHMIR: Leh district, Khardungla Pass, 4700 m, on rocks, Upreti and Chatterjee 03-001806/B (LWG). UTTARANCHAL: Chamoli district, Badrinath, East of Temple, way to Devdarshani, 3150 m, on boulders, Dange 76-814 (LWU-LWG).

The species is distributed in Europe, North America, Japan, Australia and is a new record for Indian lichen flora. It preferably grows on coarse to grained siliceous rocks in alpine habitats.

L. plana is closely related to *L. lithophila* (Ach.) Ach., in anatomy and morphology.

L. plana can be distinguished by having smaller ascospores, greenish epithecium, lower hymenium and adnate, purely black apothecia.

Lecidea tessellata Flörke Deutsche Lichenen, no. 64 (1819). Fig. 7

Thallus cracked areolate, chalky white to grey, areolate, plane, medulla I+ blue; apothecia subimmersed, appressed to adnate, black, 0.5–1.8 (–2.0) mm diam.; disc smooth, plane, rounded in young apothecia, convex, variously irregular in mature ones, with sometimes thin, white pruinose; epihymenium brownish-green to blackish green; hymenium colourless, 40–60 µm high; hypothecium pale brown, 30–40 µm high; excipulum blackish-green externally, colourless internally. Asci clavate, 30–50 x 8–14 µm, ascospores ellipsoid, 7–9 x 5–6 µm.

Thallus and medulla K–, C–, PD–; confluentic acid in TLC.

SPECIMENS EXAMINED–UTTARANCHAL: Chamoli district, Badrinath east of Temple, way to Devdarshani, 3150 m, on boulders, Dange 76-794 (LWU-LWG). HIMACHAL PRADESH: Lahul Spiti district, Keylong, 2040 m, on exposed rocks, Upreti (LWG).

This species is widely distributed in Afghanistan, Russian Asia, China, Nepal, Europe and North America. It is a new record for Indian lichen flora and known only from the alpine Western Himalayas at an altitude of 3450 m.

In the presence of white thallus, it is similar to *L. lapicida* and *L. confluescens* Nyl. *L. lapicida* can be distinguished by having K+ yellow reaction (stictic and constictic acid) while *L. confluescens* has much bigger (12–14 x 5–7 µm) ascospores and I– reaction in the medulla.

Acknowledgements

We are grateful to Dr. R. Tuli, Director, NBRI for providing necessary laboratory facilities, to Drs. Gerhard Rambold, Christian Printzen and Teuvo Ahti for their valuable comments on the manuscript.

Literature Cited

Awasthi DD. 1963. Some noteworthy additions to the lichen flora of India and Nepal. Univ. Colorado Studies. Ser. Biol. 10: 28-36.

Awasthi DD. 1991. A key to the microlichens of India, Nepal and Sri Lanka. Biblioth. Lichenol. 40: 1-337.

Awasthi DD. 2000. Lichenology in Indian Subcontinent. Bishen Singh Mahendra Pal Singh, Dehra Dun, India

Culberson CF. 1972. Improved conditions and new data for the identification of lichen products by a standard thin layer chromatographic method. J. Chromat. 97: 107-108.

Hertel H. 1977. Gesteinsbewohnende Arten der Sammelgattung *Lecidea* (Lichenes) aus Zentral, Ost-, und Südasien. Khumbu Himal 6(3): 145-378.

Magnusson AH. 1940. Lichens from Central Asia I. In Repts. Sci. Exped. NW Prov. China (the Sino-Swedish Expedition). (Ed. Hedin, S.). 13, XI. Botany, 1: 1-168. Aktiebolaget Thule\ Stockholm. Pp. 1-168.

Poelt J. 1961. Flechten aus dem N.W. Karakorum in Rahmen der Deutschen Karakorum-Expedition 1959, von F. Lobbichler und Dr. Schneider gesammelt. Mitteil. Bot. Staatssamml. München 4: 83-94

Schneider G. 1980 ('1979'). Die Flechtengattung *Psora* sensu Zahlbruckner. Biblioth. Lichenol. 13: 1-129.

Sinha GP, Singh KP. 1987. Foliicolous lichens from Nagaland, India. Geophytology 17(2): 174-185.

Timdal E. 1984. The delimitation of *Psora* (*Lecideaceae*) and related genera, with notes on some species. Nordic J. Bot. 4: 525-540.

Walker FJ, James PW. 1980. A revised guide to microchemical technique for the identification of lichen products. Bull. Brit. Lich. Soc. 46: 13-29.

MYCOTAXON

Volume 95, pp. 331–334 *January–March 2006*

Contributions to the macrofungi of Bolu and Düzce Provinces, Turkey

DURSUN YAĞIZ[1], AHMET AFYON[1],
MUHSIN KONUK[2] & STEPHAN HELFER[3]

dyagiz@selcuk.edu.tr aafyon@selcuk.edu.tr
mkonuk@aku.edu.tr s.helfer@rbge.org.uk

[1]*Selcuk University, Education Faculty*
42099, Meram, Konya-TURKEY

[2]*Afyon Kocatepe University, Faculty of Art and Science*
Afyonkarahisar-TURKEY

[3]*Royal Botanic Garden Edinburgh*
20A Inverleith Row, Edinburgh EH3 5LR, U.K.

Abstract—This study was based on specimens of macrofungi collected from Bolu and Düzce provinces between 1998 and 2004. According to the field and laboratory results, 277 taxa belonging to 44 families (7 families of *Ascomycetes* and 37 of *Basidiomycetes*) have been identified.

The full checklist is available at http://rbg-web2.rbge.org.uk/mycotaxon/56.pdf

Key words—macromycota, flora, Western Black Sea Region

Introduction

This research was carried out in Bolu and Düzce provinces of Turkey which are situated in the Western Black Sea Region (Figure 1). These provinces are placed in squares A3-A4 according to the floristic square system (Davis 1965-1985). In the study area mainly the second type of oceanic rain fall regime occurs (Akman 1990). But in some parts (e.g., in the west and southwest), it also displays continental climatic features.

One checklist for macrofungi of Turkey was produced by Sesli & Denchev (2005). According to this, there was only one previous study in the area (Sümer 1982). This account of wood decaying macrofungi and and a few other reports on other macrofungi are included here. The study area is covered mainly by natural forest due to the prevailing climatic and edaphic conditions and limited timber extraction. The canopy vegetation of the study area is composed of mainly coniferous and broadleaved trees. The research area therefore is an ideal habitat for mycological studies. This paper presents the most up-to-date and extensive list of macrofungi of Bolu and Düzce provinces.

Materials and Methods

Specimens were collected from the research area (Fig. 1) during field trips between 1998 and 2004. The morphological and ecological characters of the specimens were recorded *in situ* and their microscopic features determined in the laboratory. The diagnoses of the taxa were carried out with the help of Marchand (1971-1986), Phillips (1981), Moser (1983), Michael et al. (1983-1988), Breitenbach & Kränzlin (1984-1991) and Dähncke (1993). Taxa and their authors were given according to an amended CABI Bioscience electronic version (http://www.indexfungorum.org/Names/Names.asp). The specimens are kept at Selcuk University, Education Faculty Herbarium (KNYA).

Results

In our study, 277 species were recovered belonging to 44 families. The distribution of the species and their families are: *Dermataceae* 1, *Discinaceae* 1, *Helvellaceae* 4, *Rhizinaceae* 1, *Morchellaceae* 7, *Pezizaceae* 2, *Pyronemataceae* 1, *Agaricaceae* 14, *Albatrellaceae* 1, *Auriscalpiaceae* 1, *Bankeraceae* 3, *Bolbitiaceae* 11, *Boletaceae* 9, *Cantharellaceae* 1, *Clavariaceae* 1, *Clavulinaceae* 1, *Coprinaceae* 5, *Cortinariaceae* 15, *Dacrymycetaceae* 2, *Entolomataceae* 5, *Fomitopsidaceae* 1, *Ganodermataceae* 2, *Geastraceae* 4, *Gomphaceae* 2, *Gomphidiaceae* 2, *Hydnaceae* 1, *Hydnangiaceae* 1, *Hygophoropsidaceae* 1, *Hymenochaetaceae* 3, *Lycoperdaceae* 8, *Marasmiaceae* 16, *Paxillaceae* 1, *Phallaceae* 2, *Pleurotaceae* 1, *Pluteaceae* 11, *Polyporaceae* 10, *Ramariaceae* 4, *Rhizopogonaceae* 2, *Russulaceae* 38, *Stereaceae* 1, *Strophariaceae* 10, *Suillaceae* 4, *Tremellaceae* 2, and *Tricholomataceae* 64. Their collection dates, localities, habitats, collectors' names and herbarium numbers are given in the web version of the paper: http://rbg-web2.rbge.org.uk/mycotaxon/56.pdf .

Discussion

277 species of macrofungi were collected from the study area (Bolu and Düzce provinces, located in the western Black Sea Region of Turkey). 17 of them belonged to Ascomycotina and 260 to Basidiomycotina. Sümer (1982) reported 102 wood decaying macrofungi from the study area. There are no other reports related to our study area known to the authors. Öder (1986) reported 17 poisonous macrofungi and 14 edible taxa from the East Black Sea Region (Öder 1988). Some reports from neighbouring regions of the study area were: Afyon et al. (2000) 62 taxa from Bartın; Afyon & Konuk (2002) 77 taxa from Zonguldak; Afyon et al. (2004) 170 taxa from Sinop; Yagız et al. (2005) 121 taxa from Karabük, and Afyon et al. (2005) 80 wood decaying macrofungi from Western Black sea region. When comparing taxa given from the neighbouring areas, the present study gives a very high number of recorded taxa. Bolu seems to be the richest area for its macrofungi species when compared to the other parts of Turkey. A diversity of habitats may be the cause for this abundance of taxa. The five most species-rich families and their species numbers are *Tricholomataceae* 64, *Russulaceae* 38, *Marasmiaceae* 16, *Cortinariaceae* 15 and *Agaricaceae* 14. These 5 families include 147 species and their ratio is 53% when compared to total numbers of the taxa diagnosed.

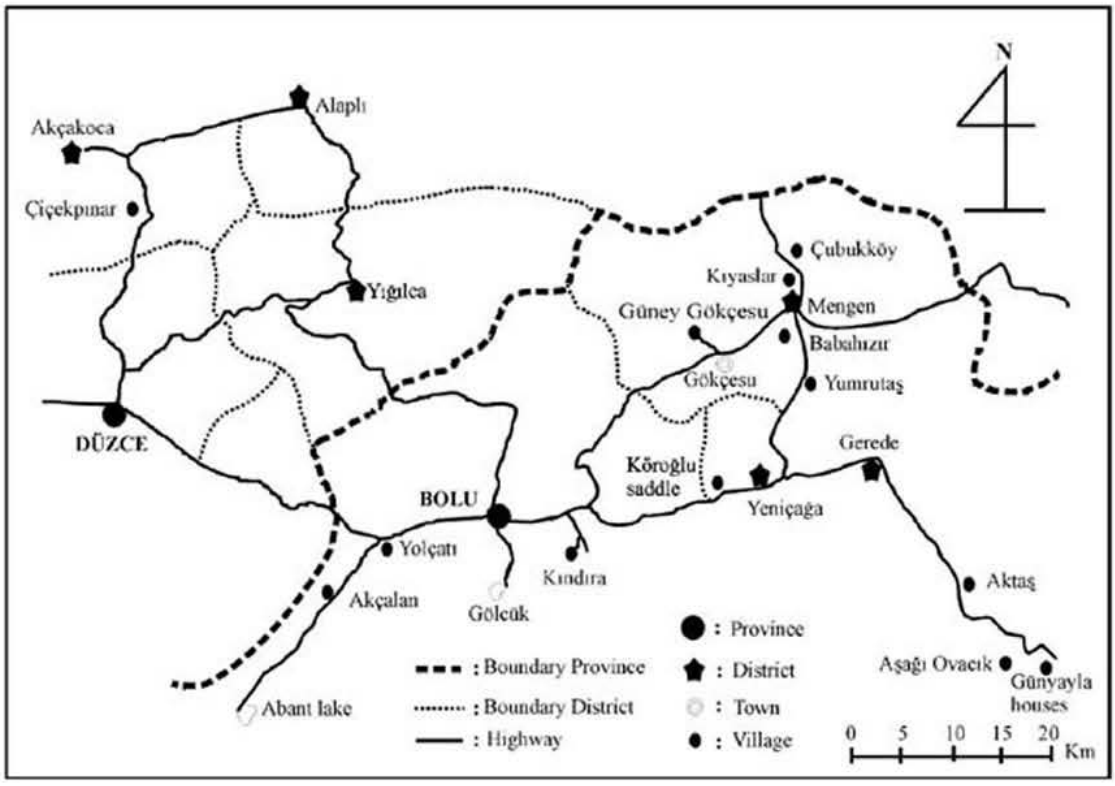


Figure 1: Map of the study area.

Acknowledgements

We would like to thank TÜBİTAK (The Scientific and Technical Research Council of Turkey) (TBAG-1659) and Selçuk University Scientific Research Project Commission (BAP: E.F/065) for supporting this study financially. Thanks are also due to Profs M. Isiloglu and R. Watling for reviewing the paper and for helpful comments.

Literature Cited

Afyon A, Konuk M, Yağız D. 2000. Bartın Yöresi Makrofungusları Üzerine Bir Araştırma. S. Ü. Eğitim Fak Fen Bilimleri Derg 8/2: 77-86.

Afyon A, Konuk M, Yağız D. 2004. Macrofungi of Sinop Province. Turk J Bot 28:351-360.

Afyon A, Konuk M, Yağız D, Helfer S, 2005. A study of wood decaying macrofungi of the western Black Sea Region, Turkey. Mycotaxon 93: 319-322.

Akman Y. 1990. İklim ve Biyoiklim. Ankara: Palme Yayın Dağıtım.

Breitenbach J, Kränzlin F. 1984-1991. Fungi of Switzerland.Vol.1-3. Lucerne: Verlag Mycologia.

Davis PH (ed.). 1965-1985. Flora of Turkey and East Aegean Islands. Vol. 1-9, Edinburgh Univ. Press.

Dähncke RM. 1993. 1200 Pilze. Aarau: AT Verlag.

Kirk PM, et al. 2004. Authors of fungal names. CABI Bioscience, Wallingford. Elecronic version: http://www.speciesfungorum.org/AuthorsOfFungalNames.htm

Marchand A. 1971-1986. Champignons du Nord et du Midi. Tome. 1-9. Perpignan: Soc. Mycol. Des Pyrénées Méditerr.

Michael E, Hennig B, Kreisel H. 1983-1988. Handbuch für Pilzfreunde. Bd. 1-5. Stuttgart: Gustav Fischer Verlag.

Moser M. 1983. In: Gams H (ed.). Kleine Kryptogamenflora. Stuttgart: Gustav Fischer Verlag.

Öder N. 1986. Karadeniz Bölgesinde (Sinop-Artvin İlleri Arası) Yetişen Önemli Bazı Zehirli Mantarlar Üzerinde Taksonomik Araştırmalar. S. Ü. Fen-Edebiyat Fak Fen Derg 5: 87-104.

Öder N. 1988. Karadeniz Bölgesinde (Sinop-Artvin İlleri Arası) Yetişen Halkın Tanıdığı Bazı Önemli Yenen Mantarlar Üzerinde Taksonomik Araştırmalar. S. Ü. Fen-Edebiyat Fak Fen Derg 8: 215-257.

Phillips R. 1981. Mushrooms and other Fungi of Great Britain and Europa. London: Pan Books Ltd.

Sesli E, Denchev CM. 2005. Checklists of the myxomycetes and macromycetes in Turkey. Mycologia Balcanica 2: 119-160.

Sümer S. (1982). Batı Karadeniz Bölgesi Özellikle Bolu Çevresinde Bulunan Odun Tahripçisi Mantarlar. İst. Üniv. Yayınları, No:2907/312.

Yağız D, Afyon A, Konuk M. 2005. The Macrofungi of Karabük Province. Turk J Bot., 29:345-353.

MYCOTAXON

Volume 95, pp. 335–340 *January–March 2006*

First isolation of *Aphanomyces frigidophilus* (*Saprolegniales*) in Europe

Isabel Ballesteros, María P. Martín & Javier Diéguez-Uribeondo

dieguez@ma-rjb.csic.es
Departamento de Micología, Real Jardín Botánico C.S.I.C.
Plaza Murillo 2, Madrid 28014, Spain

Abstract—*Aphanomyces frigidophilus* was isolated and described for the first time in Europe. The isolate was characterized by studying its ability to undergo repeated zoospore emergence, to parasitize crayfish, and to produce chitinase constitutively, and by sequencing the internal transcribed spacer of nuclear ribosomal DNA (ITS1+5.8S+ITS2). The physiological properties studied differed from those of the "crayfish plague" parasite, *A. astaci*, but they were similar to those of saprobiotic *Aphanomyces* species. The ITS nrDNA sequence obtained from this isolate corresponded to *A. frigidophilus*.

Key words—*Aphanomyces astaci*, crayfish, conservation, rDNA, taxonomy

Introduction

The genus *Aphanomyces* de Bary belongs to the order *Saprolegniales* (Oomycetes) and comprises ca 30 species. Many of the species of this group have a saprobiotic mode of life, living on decayed animals and plant remains. A few species are detrimental parasites and responsible for economically important diseases affecting agriculture and aquaculture crops, as well as wildlife populations of freshwater animals (Papavizas & Ayers 1974, Söderhäll & Cerenius 1999). *Aphanomyces frigidophilus* Kitanch. & Hatai is a recently described species, which so far has only been found in salmonids eggs in Japan (Kitancharoen & Hatai 1997, 1998). Specimens resembling *A. frigidophilus* have been described in fish eggs in Poland (Czeczuga et al. 2004a, b, 2005). However, no isolations have been done to confirm the presence of this species in Europe or to study the molecular relatedness of European strains to the Japanese reference isolate of *A. frigidophilus*.

The taxonomy of *Aphanomyces* is largely based on the morphological characters of their sexual structures. However, the main taxonomic problems when describing species of this genus are: (i) that no reference isolates or cultures exist for several of the described species, and (ii) that many isolates, especially those of animal parasitic species are sterile;

consequently, species identification is largely based on their ability to parasitize their host, and a number of physiological properties.

The recent application of molecular tools to the genus *Aphanomyces* has helped identifying sterile isolates either in culture or clinical samples (Oidtmann et al. 2002, 2004; Phadee et al. 2004, Royo et al. 2004, Vandersea et al. 2006) and even defining new species (Royo et al. 2004). In this article, we have studied the internal transcribed spacer of nuclear ribosomal DNA sequences (ITS nrDNA) to identify a sterile isolate obtained from a mass mortality of indigenous crayfish, *Austropotamobius pallipes* (Lereboullet 1858) that occurred in the Central Iberian Peninsula region. Because the isolate exhibited different physiological properties from the crayfish plague fungus, *A. astaci* Schikora, it was decided to explore this isolate more carefully and obtain ITS sequence data, the results of which are described in this contribution.

Materials and Methods

Dead crayfish, *Austropotamobius pallipes*, were collected in the river Tajuña, Guadalajara (Spain). The isolation procedure was done from pieces of sub-abdominal cuticle taken from the crayfish as described by Cerenius et al. (1988). The isolate was maintained on PG1-agar (Unestam 1965) and stored under the strain name SAP233 in the culture collection of the Real Jardín Botanico de Madrid. Morphological characters of asexual structures and measurements were made microscopically on material mounted in water. Light micrographs were captured using a QImaging Micropublisher digital camera (QImaging, Burnaby, BC, Canada) mounted on an Olympus BX51 compound microscope as described in Diéguez-Uribeondo et al. (2003).

Physiological properties: repeated zoospore emergence characteristic of parasitic *Aphanomyces species*, and constitutive production of chitinase, characteristic of *A. astaci*, were studied according to methods described by Cerenius & Söderhäll (1985), and Andersson & Cerenius (2002), respectively. Production of sexual structures was studied by growing the isolate in corn meal agar, hemp seed or snake skin. In corn meal agar the isolate was paired with representative strains of the four genotypes of *A. astaci* (Huang et al. 1994, Diéguez-Uribeondo et al. 1995). The cultures were maintained and regularly checked for the production of sexual structures during a one month period.

The ability to infect crayfish was tested by following the method described in Cerenius et al. (1988). After finishing the experiment pieces of sub-abdominal cuticle were examined under the microscope for the presence of hyphae.

For DNA extraction, mycelium was grown as drop cultures (Cerenius & Söderhäll 1985), and from them, genomic DNA was extracted using an E.Z.N.A.-Fungi DNA miniprep kit (Omega Biotek, Doraville, USA). DNA fragments containing internal transcribed spacers ITS1 and ITS2 including 5.8S, were amplified with primer pair ITS5/ITS4 (White et al. 1990) primers as described in Martín et al. (2004). Nucleotide BLASTN searches with option Standard nucleotide BLAST of BLASTN 2.6 were used to compare the sequence obtained against the sequences in the National Center of Biotechnology Information (NCBI) nucleotide databases. The new consensus sequence has been deposited in the EMLB database with the accession Number 281399.

Results

The isolate obtained exhibited thin hyphae with rounded hyphal tips, and with a hyphal diameter that ranged from 5 to 7 µm (Fig. 1a). The isolate produced sporangia with a single row of primary spores. The primary spores were eventually released and encysted at the hyphal tip forming spore-balls characteristic for the genus *Aphanomyces* (Fig. 1b). No oogonia or antheridia were seen in either individual cultures or in co-culture with the other isolates or with representive strains of four genetic groups of *A. astaci*. Thus the strains appeared to be sterile and lack sexual reproduction.

The encysted zoospores did not undergo repeated zoospore emergence and instead germinated. No chitinase activity was detected in the culture filtrates of the new isolate, while reference *A. astaci* strains produced high level of extracellular chitinase (Fig. 1 c, d, e). Crayfish challenged with zoospores of the *Aphanomyces* sp. isolate did not die under the experimental conditions. However, addition of zoospores of the reference isolates of *A. astaci* always caused 100% mortality of crayfish.

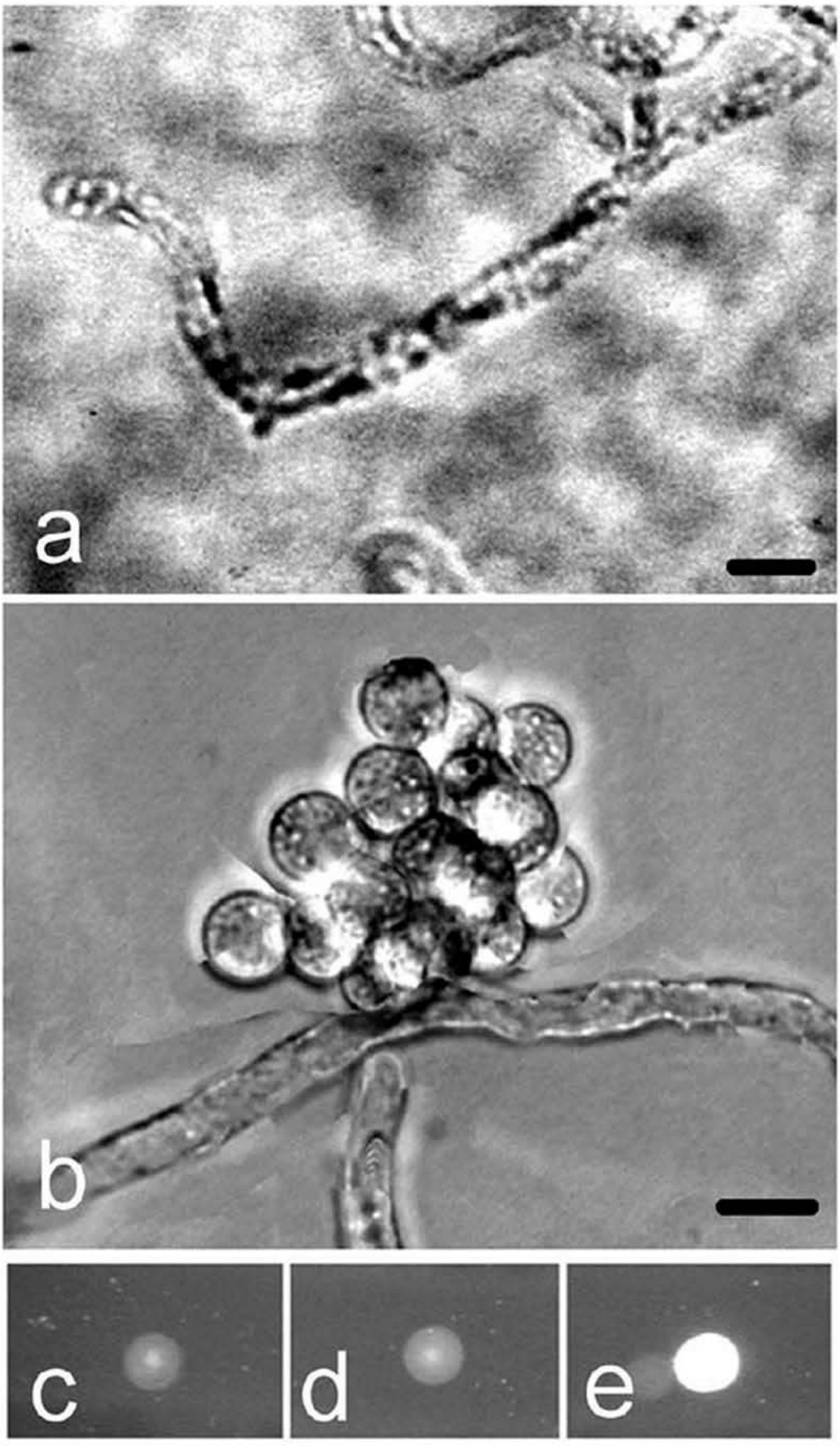
The blast search of the sequence of the isolate showed 99% similarity (the sequence differed in one base for ITS1 and four bases in ITS2 out of the 673 bases compared) to Genbank sequence AY647192 corresponding to strain NJM9500 of *A. frigidophilus* directly submitted by Phadee et al. (2004), and 95% (the sequence differed in 22 bases for ITS1 and 10 bases in ITS2 out of the 614 bases compared to Genbank sequences of *A. astaci*.

Discussion

Previous studies have shown that analyses of the ITS nrDNA represents a useful tool for differentiating individual saprolegniaceous species (Molina et al. 1995, Leclerc 2000, Oidtmann et al. 2004, Phadee et al. 2004). Due to the lack of sexual structures of the studied isolate, we carried out Genbank sequence comparisons of the two ITS nrDNA for species identification. The results indicated the sequence of our isolate corresponded to the species, *Aphanomyces frigidophilus*. Thus, this study represents the first isolation of *A. frigidophilus* in Europe and the first description of this species growing in a different substrate from salmonid eggs.

Interestingly, this isolate was growing in crayfish cuticle and associated to a mass mortality of indigenous European species of freshwater crayfish. These episodes are generally caused by the "crayfish plague" parasite *Aphanomyces astaci*. This parasite is considered among the 100 worst invasive species (Global Invasive Species Database 2005) and is responsible for the dramatic decline of the indigenous European freshwater crayfish species, which are currently endangered in Europe and at risk of extinction in the Iberian Peninsula (Diéguez-Uribeondo et al. 1997a, b, Söderhäll & Cerenius 1999). Current attempts to develop and improve techniques for rapid and accurate identification of this economically important parasitic species need to take into account the existence of closely related species, such as *A. frigidophilus*, in Europe.

Regarding the possible parasitic abilities of *A. frigidophilus*, our results indicate that its physiological properties are characteristic of a saprobiotic and/or opportunistic pathogen. Thus, the isolate exhibited a low percentage of secondary cysts undergoing repeated zoospore emergence, and, therefore, it lacks a character that appears to be


a
b
c
d
e

related to parasitism in *Aphanomyces* species (Cerenius & Söderhäll, 1985). The failure to kill crayfish challenged with zoospores and to produce chitinase constitutively, are also characters of the specialized crayfish parasite, *A. astaci* (Cerenius et al. 1988; Söderhäll & Cerenius 1999, Andersson & Cerenius 2004).

Aphanomyces frigidophilus and *A. astaci* seem to be closely related species which may occur in the same host with different abilities to colonize it. Further studies on phylogenetic relationships among *Aphanomyces* species need to be carried out in order to more accurately establish species limits. Finally, the results of this work emphasized the need to carry out isolations for a correct identification and characterization of saprolegniaceous species.

Acknowledgements

We thank Dr. Fernando Alonso (Centro de Investigaciones Agrarias de Albadalejito, Cuenca, Junta Castilla-La Mancha, Spain) for providing us with crayfish, and Dr. Stuart Gelder (Department of Science, University of Maine at Presque Isle, Maine, USA) for revising the English text. This study was supported by the Project Flora Micológica Ibérica (REN2002-04068-C02-01GLO), which also supported Dr. Isabel Ballesteros with a postdoctoral fellowship. We also acknowledge referees Dr. Lage Cerenius (Department of Comparative Physiology, University of Uppsala, Sweden) and Dr. Gordon Beakes (Department of University of Newcastle) for revising this article.

Literature Cited

Andersson MG, Cerenius L. 2002. Analysis of chitinase expression in the crayfish plague fungus *Aphanomyces astaci*. Diseases of Aquatic Organisms 51: 139-147.

Cerenius L, Söderhäll K, 1985. Repeated zoospore emergence as a possible adaptation to parasitism in *Aphanomyces*. Experimental Mycology 9: 259-263.

Cerenius L, Söderhäll K, Persson M, Ajaxon R. 1988. The crayfish plague fungus, *Aphanomyces astaci* – diagnosis, isolation, and pathobiology. Freshwater Crayfish 7: 131-144.

Czeczuga B, Kiziewicz B, Muszynska E. 2004a. Presence of zoospore fungus species on the eggs of whitefish from Lake Goldopiwo, Mazury Region. Medycyna Weterynaryjna 60: 379-383.

Czeczuga B, Kiziewicz B, Godlewska A. 2004b. Zoosporic fungi growing on eggs of *Coregonus lavaretus holsatus* Thienemann, 1916 from Lake Wdzydze in Kaszuby. Polish Journal of Environmental Studies 13: 355-359 2.

Czeczuga B, Bartel R, Kiziewicz B, Godlewska A, Muszynska E. 2005. Zoosporic fungi growing on the eggs of sea trout (*Salmo trutta* m. *trutta* L.) in river water of varied trophicity. Polish Journal of Environmental Studies 14: 295-303.

Diéguez-Uribeondo J, Huang TS, Cerenius L, Söderhäll K. 1995. Physiological adaptation of an *Aphanomyces astaci* strain isolated from the freshwater crayfish *Procambarus clarkii*. Mycological Research 99: 574-578.

Diéguez-Uribeondo J, Rueda-Díez A, Castién E, Bascones JC. 1997a. A plan of restoration for the native freshwater crayfish species, *Austropotamobius pallipes*, in Navarra. Bulletin Francais de la Peche et de la Pisciculture 347: 625-637.

Fig. 1 *Aphanomyces frigidophilus*. **a)** Hypha with a rounded tip growing within the cuticle of the freshwater crayfish *Austropotamobius pallipes*. **b)** "Spore balls" characteristic of the genus *Aphanomyces* (Bars 10 μm). **c–e)** Chitinase assay for production of chitinase constitutively during growth: **c)** negative control, without fungus; **d)** *A. frigidophilus* (negative); **e)** *A. astaci* (positive).

Diéguez-Uribeondo J, Temiño C, Múzquiz JL. 1997b. The crayfish plague fungus, *Aphanomyces astaci* in Spain. Bulletin Francais de la Peche et de la Pisciculture 347: 753-763.

Diéguez-Uribeondo J, Förster H, Adaskaveg JE. 2003. Digital image analysis of internal light spots of appressoria of *Colletotrichum acutatum*. Phytopathology 93: 923-930.

Global Invasive Species Database. 2005. Information Infrastructure (NBII) and Invasive Species Specialist Group (ISSG). *Aphanomyces astaci*. Available at: <http://www.issg.org/database/species/ecology.asp?si=107&fr=1&sts=sss>

Huang TS, Cerenius L, Söderhäll K. 1994. Analysis of the genetic diversity in crayfish plague fungus, *Aphanomyces astaci*, by random amplification of polymorphic DNA assay. Aquaculture 26:1-10.

Kitancharoen N, Hatai K. 1997. *Aphanomyces frigidophilus* sp. nov. from eggs of Japanese char, *Salvelinus leucomaenis*. Mycoscience 38: 135-140.

Kitancharoen N, Hatai K. 1998. Some biochemical characteristics of fungi isolated from salmonid eggs. Mycoscience 39: 249-255.

Leclerc MC., Guillot J, Deville M. 2000. Taxonomic and phylogenetic analysis of Saprolegniaceae (Oomycetes) inferred from LSU rDNA and ITS sequence comparisons. Antonie van Leeuwenhoek 77: 369-377.

Martín MP, Raidl S, Telleria MT. 2004. Molecular analysis confirm the relationship between *Stephanospora caroticolor* and *Lidtneria trachyspora*. Mycotaxon 90: 133-140.

Molina FI., Jong SC., MA, G. 1995. Molecular characterization and identification of *Saprolegnia* by restriction analysis of genes coding for ribosomal RNA. Antonie van Leeuwenhoek 68: 65-74.

Oidtmann B, Bausewein S, Hölzle L, Hoffmann R, Wittenbrink M. 2002. Identification of the crayfish plague fungus *Aphanomyces astaci* by polymerase chain reaction and restriction enzyme analysis. Veterinary Microbiology 85: 183–194.

Oidtmann B, Schaefer N, Cerenius L, Söderhäll K, Hoffmann RW. 2004. Detection of genomic DNA of the crayfish plague fungus *Aphanomyces astaci* (Oomycete) in clinical samples by PCR. Veterinary Microbiology 100: 269-282.

Papavizas GC, Ayers A. 1974. *Aphanomyces* species and their root diseases in pea and sugar beet. U.S. Department of Agriculture Technical Bulletin no 1485.

Phadee P, Kurata O, Hatai K, Irono I, Aoki T. 2004. Detection and identification of the fish-pathogenic *Aphanomyces piscicida* using polymerase chain reaction (PCR) with species-specific primers. Journal of Aquatic Animal Helath 16: 220-230.

Royo F, Andersson MG, Bangyeekhun E, Muzquiz JL, Söderhäll K, Cerenius L. 2004. Physiological and genetic characterisation of some new *Aphanomyces* strains isolated from freshwater crayfish. Veterinary Microbiology 104: 103-112.

Söderhäll K, Cerenius L. 1999. The crayfish plague fungus: history and recent advances. Freshwater Crayfish 12: 11-35.

Vandersea MW, Litaker RW, Yonnish B, Sosa E, Landsberg JH, Pullinger C, Moon-Butzin P., Green J., Morris JA, Kator H, Noga EJ, Tester PA. 2006. Molecular assays for detecting *Aphanomyces invadans* in ulcerative mycotic fish lesions Applied and Environmental Microbiology 72: 1551-1557.

Unestam T. 1965. Studies on the crayfish plague fungus, *Aphanomyces astaci* I. Some factors affecting growth in vitro. Physiologia Plantarum 18: 483-505.

White TJ, Bruns T, 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. Innis MA, Gelfand DH, Sninsky JJ, White TJ.), pp. 315-322. Academic Press Inc., San Diego, CA.

Nomenclatural novelties proposed in Mycotaxon 95

Arthrobotrys multisecundaria W.F. Hu & K.Q. Zhang, p. 182
Brachydesmiella brasiliensis R.F. Castañeda, Gusmão & Heredia, p. 262
Brachydesmiella obclavata R.F. Castañeda, Gusmão & Saikawa, p. 265
Calostoma zanchianum Baseia & Calonge, p. 114
Coccomyces taiwanensis C. L. Hou, R. Kirschner & Chee J. Chen, p. 73
Cookeina colensoiopsis Iturriaga & Pfister, p. 151
Doassansiopsis tomasii Vánky, p. 46
Embellisia oxytropis Q. Wang, Nagao & Kakish., p. 25
Geastrum hirsutum Baseia & Calonge, p. 302
Heterodoassansia hygrophilae (Thirum.) Vánky, p. 56
Hyphodontia tubuliformis Sheng H. Wu, p. 185
Kalmusia amphiloga O.E. Erikss. p. 67
Lycoperdon ovalicaudatum D. Bisht, J.R. Sharma & Kreisel, p. 92
Marasmius dimorphus C. Puccin. & Capelari, p. 298
Marasmius pseudosetosus C. Puccin. & Capelari, p. 295
Meliola thalliformis var. *major* D.J. Soares & R.W. Barreto, p. 202
Microbotryum afromontanum Vánky, p. 50
Morchella deqinensis Shu H. Li, Y.C. Zhao, H.M. Chai & M.H. Zhong, p. 319
Morchella meiliensis Y.C. Zhao, Shu H. Li, H.M. Chai & M.H. Zhong, p. 321
Paecilomyces verticillatus Z.Q. Liang. Z. Li & Y.F. Han et al, p. 134
Parmotrema sorediosulphuratum Eliasaro & Donha, p. 242
Parmotrema superaguiense Donha & Elisaro, p. 243
Pilocintractia adrianae Vánky, p. 54
Repetophragma fasciata (R.F. Castañeda) Castañeda, Gusmão & Saikawa, p. 269
Repetophragma filifera (Piroz.) R.F. Castañeda, Gusmão & Heredia, p. 269
Russula appendiculata K. Das, S.L. Mill. & J.R. Sharma, p. 210
Russula dhakuriana K. Das, J.R. Sharma & S.L. Mill., p. 208
Russula mayawatiana K. Das, S.L. Mill. & J.R. Sharma, p. 206
Russula natarajanii K. Das, J.R. Sharma & Atri, p. 272
Russula puellaris var. *atrii* K. Das, S.L. Mill. & J.R. Sharma, p. 211
Russula siamensis Yomyart, Piapukiew, Watling, Whalley & Sihan., p. 249
Sporisorium andropogonis-chinensis Vánky, p. 5
Sporisorium andropogonis-eucomi Vánky, p. 5
Sporisorium andropogonis-gabonensis Vánky, p. 7
Sporisorium andropogonis-pumili Vánky, p. 7
Sporisorium andropteri (Zambett.) Vánky, p. 59
Sporisorium clintonianum Vánky, p. 30
Sporisorium distachyum Vánky, p. 12
Sporisorium ingoldii Vánky, p. 50

Author Index—Volume 95

Reviewers, Volume Ninety-four

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers appearing in this volume.

Teuvo Ahti
Vladimír Antonín
André Aptroot
Narinder S. Atri
Gordon W. Beakes
Reinhard Berndt
Gregory Bonita
Irwin Brodo
Francisco D. Calonge
Susana Calvelo
Sharon A. Cantrell
Lori Carris
Lage Cerenius
Pedro Crous
Dennis E. Desjardin
Sionara Eliasaro
John A. Elix
Javier Etayo
Harry C. Evans
Alan M. Fryday
James H. Ginns
Gro Gulden
Ying-Lan Guo
Nils Hallenberg
Karen Hansen
Lennart Holm
V.G. Hosagoudar
Mustafa Isıloğlu
Peter Johnston
Jichuan Kang
Ken Katumoto
Henning Knudsen
Hanns Kreisel
Teresa Lebel
ShiDong Li
XingZhong Liu
Zuoyi Liu
Nils Lundqvist
Xin-Chang Luo
E.H.C. McKenzie
Steven Miller
David W. Minter
Gabriel Moreno
Eiji Nagasawa
Lorelei L. Norvell
Silvano Onofri
Breuss Othmar
Clark Ovrebo
Ian Pasco
David Pegler
Shaun Pennycook
Michael Priest
Christian Printzen
Gerhard Rambold
Peter Roberts
Wayne Robinson
Jack D. Rogers
Roger Shivas
Bin Song
Turner Sutton
Chris Triggs
Clara Urzi
Jukka Vauras
Roy Watling
Zhu L. Yang
Wen-ying Zhuang

ERRATA

Volume 92

p. 181, line 2	for: *abnormis*	read: *abnorme*
p. 214, line 15	for: *M.*	read: *Metarhizzium*
p. 243, Intro.line 10	for: *macrosporus*	read: *macrospora*
p. 244, line 9	for: *yungiensis*	read: *yungensis*
p. 264, line 5	for: [illegible overprint]	read: var. *robustum* MUCL
p. 302, 6th line from bot	for: *brogniartii*	read: *brongniartii*
p. 303, line 17	for: *A. ferrugineus*	read: *Ascobolus ferrugineus*
p. 304 & 305, legends	for: *gamundii*	read: *gamundiae*
p. 359, line 11	for: *chlamyfosporum*	read: *chlamydospora*
p. 384, 7th linn from bot	for: *Acroditys*	read: *Acrodictys*
p. 410, line 8	for: *Psecocercospora*	read: *Pseudocercospora*
p. 443, Abstr. line 8	for: *hydrocotyles, P.*	read: *hydrocotyles, P. spinulosa, P.*
—, *ibid.*	for: *achyrantis*	read: *achyranthis*
p. 448, line 8	for: *achyrantis*	read: *achyranthis*
p. 452, 5th line of tree	for: *spinulosus*	read: *spinulosa*
p. 456, line 19	for: *achyrantis*	read: *achyranthis*
p. 497, line 8	*for:* p. 385	*read:* p. 384
—, lines 9 & 10	*for:* p. 251	*read:* p. 252
—, lline 19	*for:* p, 224	*read:* p. 225
—, lline 33	*for:* p. 93	*read:* p. 92
p. 498, line 4 from bot	*for:* p. 410	*read:* p. 401

Volume 93

p. 379, line 4,	for: *aurelio@castillo@uah.es*	read: *aurelio.castillo@uah.es*

Volume 94

Front cover, last entry	*for:* Vamsaprija indica	read: *Vamsaprija indica*
p. ii, in Editorial Board	*for:* Sean Ross Pennycook	*read:* Shaun Ross Pennycook
p. iii, 7th line from bottom	*for:* Vamsaprija indica	read: *Vamsaprija indica*
p. 15, abstract, line 5	for: *C luteolus*	read: *C. luteolus*
p. 393, 5th from bottom	for: *Thyrostoma*	read: *Thyrostroma*
p. 400, Volume 93,	for: *aurelio.castillo.uah.es*	read: *aurelio.castillo@uah.es*

From the *Editor-in-Chief*

Color returns to Mycotaxon

Volume 95 brings with it a welcome surprise: color. Over two decades have passed since color has graced the pages of two previous Mycotaxon volumes, primarily due to the high printing cost. Fortunately, Iturriaga & Pfister and Frank, Southworth & Trappe were able to find sufficient funds to print their plates in full color in the current volume.

The results are stunning. You will find the photographs of *Cookeina* on page 141 and of *Tuber* on pages 233 & 237. Mycotaxon thanks the authors for allowing us to demonstrate mycology's more beautiful nature.

Publication schedule for 2006

Due to a combination of unanticipated problems, Mycotaxon is running behind schedule. Volume 95 was delayed by a series of computer and health set-backs, and Volume 96 is thinner than planned, primarily due to the number of manuscripts still in revision. We fully intend to bring you four volumes in 2006 and hope that we receive enough manuscripts to bring you the full number of pages promised in Volume 94. The good news is that the Editors are now completely caught up with their backlogs so that manuscript turn-around time is much quicker than usual. Volumes 96–98 will be sent as they fill, and the journal should be back on its normal quarterly schedule by year's end.

To our Authors

Authors are asked to download instructions and forms from our Instructions to Authors webpage on <www.mycotaxon.com> before preparing a paper for submission to our journal. An abbreviated set of instructions was also published in Mycotaxon 94: 401–411 (2005/2006). All files are also available as Email attachments from the *Editor-in-Chief* <editor@mycotaxon.com> on request.

Mycotaxon submission and publication preparation involves four steps:

Step 1—peer review: Authors send their formatted text document, illustration files, and Reviewer Guidelines + checklist to two experts for peer review. Peer reviewers must (a) return edited manuscripts and detailed comments to the authors and (b) Email completed checklist forms and brief comments to the *Editor-in-Chief* before authors submit their manuscripts for nomenclatural review.

Step 2—nomenclatural & French language review: After revising their manuscript following peer review recommendations, authors Email a revised master clone (containing footnotes, tables and captions but ***no*** illustrations) to the *Nomenclature Editor* at <PennycookS@LandcareResearch.co.nz>. The Email message must include the word 'Mycotaxon' on the subject line and list names **and** Email addresses of all peer reviewers. Manuscripts written in French should also be submitted to the *French Language Editor* <hennebertg@mbla.ucl.ac.be> at this time. Each Editor will return annotated files with a list of needed corrections to the authors and *Editor-in-Chief*.

Step 3—final submission: Authors Email/post the following to the *Editor-in-Chief*: a completed MYCOTAXON submission form; one manuscript PDF/MSWord file or printed copy showing all text, legends, tables, footnotes & graphics in place; a body text clone (and table/legend text clones when tables, footnotes, and legends are present), and artwork files. All materials ***must*** be correct so that the manuscript can be prepared for immediate publication if necessary. The *Editor-in-Chief* usually acknowledges receipt within two weeks, but acknowledgments of new submissions may slow near press deadlines or when the editorial office is closed for research.

Step 4—press preparation: The *Editor-in-Chief* combines all files together to produce a press-quality PDF. Entries for the Nomenclatural novelties and Author index pages are sent with the PDF to all coauthors for approval after conversion. Editorial errors are always corrected free of charge. Authors who request correction of errors present in original author-prepared files, however, must pay at least $10 per correction (minimum charge of $40) to cover editorial time and the production/delivery of an invoice. Payment arrangements of all fees should be made by writing the *Business Manager* <info@mycotaxon.com>

To our Readers

MYCOTAXON frequently updates its webpages and regularly posts abstracts, table of contents, 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

MYCOTAXON is published quarterly during the periods of January–March, April–June, July–September, and October-December by MYCOTAXON, LTD., 316 Richard Pl., Ithaca, NY 14850–0264. USPS Publication # 16-121, ISSN # 0093-4666. Periodical postage paid at Ithaca, NY, and at additional mailing offices. Subscription rates for 2006: In U.S. and possessions, one year, $330; reduced rate for personal subscribers, one year, $150. Foreign subscriptions, add $40 for IMEX air mail.

POSTMASTER!
Send address changes to MYCOTAXON, LTD.
P.O. Box 264, Ithaca, NY 14851-0264 USA

EDITORS OF MYCOTAXON

Lorelei L. Norvell, EDITOR-IN-CHIEF
Pacific Northwest Mycology Service
6720 NW Skyline Boulevard
Portland, OR 97229, U.S.A

Shaun R. Pennycook, NOMENCLATURE EDITOR
PennycookS@LandcareResearch.co.nz
Manaaki Whenua Landcare Research
Auckland, New Zealand

David L. Hawksworth
BOOK REVIEW EDITOR
MycoNova, Calle Aguila 12
Colonia La Maliciosa, Mataelpino
ES-28411 Madrid, Spain

Karen D. Gettelman
INDEX EDITOR
510 Lake Blvd., Apt. 166
Davis, CA 95616
U.S.A.

Grégoire L. Hennebert
FRENCH LANGUAGE EDITOR
32 Rue de l'Élevage
B-1340 Ottignies - LLN
Belgium

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 may be in English or in French. Summaries in those or any additional languages desired by the authors are given for longer articles. Printing is on high quality, acid-free book paper. Authors prepare their own *text-ready* files after having received critical comments from pre-submission reviewers and nomenclatural review by the Nomenclature Editor. *Instructions to Authors* (Mycotaxon **94:** 401–411, 2005) and *Guidelines for Reviewers* are updated and can be downloaded from our website at <www.mycotaxon.com>.

SUBSCRIPTION INFORMATION

All subscriptions are on an annual basis, with four quarterly volumes each year. Personal subscriptions are available at a substantially reduced rate for those who agree not to deposit their copies in a library other than their personal one within 3 years of receipt. Address **all** orders to the MYCOTAXON ORDER DEPARTMENT, P.O. Box 264, Ithaca, NY 14851-0264 USA, or your agent. Prices and availability of back volumes are posted on-line at <www.mycotaxon.com> or can be provided on request by Email from <info@mycotaxon.com>. Mycotaxon may be obtained on a journal-exchange basis. Proposals for such exchanges from journals, institutions, or individuals with difficulty in obtaining foreign currency should be addressed to the Order Department.

The annual subscription rates for 2006 (four volumes annually) are

	USA	Foreign (IMEX air assist)
REGULAR (multi-user)	$330	$370
PERSONAL (individual)	$150	$190

All back volumes [except volumes 22, 24, 34(2), 35, 41, 54, and 64, currently out of print] are available at $35 each by surface mail, $55 each by air mail. Volumes 1, 38, 39, 43 and 46 were reprinted in 2001; the original printing of volume 1, part 1 is provided, with parts 2 and 3 reprinted.

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 MICROFILM, PHOTOCOPY, & ELECTRONIC VERSIONS

MYCOTAXON is also partially available in *microfilm* from National Archive Publishing Company <www.napubco.com>. *Tear sheets* or *photocopies* of individual articles may be obtained from ISI Document Solution <www.isidoc.com>. Many back volumes are available as free downloads through Cyberliber <www.cybertruffle.org.uk/cyberliber/index.htm> under 'Catalogues & Journals.'

CONTACTING MYCOTAXON'S EDITOR-IN-CHIEF BY E-MAIL OR FAX

To reach the Editor-in-Chief regarding manuscripts, E-mail to <editor@mycotaxon.com> or Fax to Lorelei L. Norvell at +503.297.3296.

CONTACTING MYCOTAXON'S ORDER DEPARTMENT BY E-MAIL OR FAX

To reach the Order Department for information or placing orders, you may E-mail to <info@mycotaxon.com> or you may Fax to Orders, Mycotaxon, Ltd., May–October at +607.273.4357, and November–April at +727.321.1460.