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Bresadola's polypore collection at the Natural History Museum of Trento, Italy

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Abstract—From June 2004 to December 2005, 735 polypore specimens from the Bresadola's collection at the Natural History Museum of Trento (TR) were revised, representing 237 species including previously assumedly lost type specimens of *Favolus balansae* and *Polyporus hypomiltinus*. Parts of the types of *Polyporus flavidus* and *Polyporus bartholomaei* were recovered and the combination *Perenniporia bartholomaei* is proposed.

Key words—polypore types, *Trametes lilacea*, *Polyporus flaccidus*, *Poria longispora*

Introduction

Abbé Giacomo Bresadola was an Italian mycologist who worked in the end of the 19th and beginning of the 20th century in the province of Trento, near the Austrian border. Although leaving Italy just once for a short scientific trip in Albania and never leaving the Trento region again (Bauer 1979), he received mycological specimens from all over the world and kept a private herbarium with more than 30,000 exsiccates. Around 25,000 of these were sold to the Royal Natural Museum of Stockholm, now **Swedish Museum of Natural History** (S), in 1920 (Lazzari 1982, Bellù 1999), but some specimens can also be found in Beltsville (BPI), Berlin (B), Cambridge (FH), Kew (K), Leiden (L), New York (NY) and Paris (PC). Almost all types of the new polypores he described, now

mostly in S, were studied by Ryvarden (1988) who accepted 46 out of the 149 new species. In 1984, the Bresadolian herbarium kept at TR (Natural History Museum of Trento) was rediscovered (Bellù & Donini 1986) and, in 1995, Bernicchia (1997) started the revision of the *Aphyllophorales* exsiccates.

Results

The polypore collection at TR consists of 735 exsiccates, representing 237 species including presumed lost types of *Favolus balansae* (= *Polyporus tenuiculus*) and *P. hypomiltinus* (= *Amylosporus campbellii*). Isotypes of *Polyporus bartholomaei* (= *Perenniporia bartholomaei* comb. nov.) and *P. flavidus* were also recovered in TR. Comments on three unpublished species and on *Trametes lilacea* are also given.

The species are followed by the herbarium number and sampling location (between parentheses). The nomenclature was updated according to the CABI and CBS databases and the herbarium abbreviations follow Index Herbariorum (2005).

Favolus balansae Bres., Stud. Trent., ser. 2 7: 8 (1926)
(type B4527, B4471, Santa Ana, Misiones, Argentina)
= *Polyporus tenuiculus* (P. Beauv.) Fr.

Both collections are in good condition and have well preserved basidiospores, basidia and hyphae; B4527 includes a Latin description and "type" written on the label, which indicates it to be the lost type of *Favolus balansae* Bres. (see Ryvarden 1988). Although validly published, it is an illegitimate name being a homonym of *Favolus balansae* Speg., Revue mycol. (Toulouse) 11: 94 (1889) (= *Echinochaete brachypora* (Mont.) Ryvarden).

Polyporus bartholomaei Peck, Bull. Torrey bot. Club 23: 418 (1896)
(B1924, Stockton, Kansas, USA)
≡ ***Perenniporia bartholomaei*** (Peck) Gibertoni & Bernicchia, **comb. nov.**
(Basionym as cited above.)

On the label it is stated "part of the type", besides there is a short description of the material, and collection data. The holotype of *P. bartholomaei* (BPI 203625) was examined and shown to be identical to the holoype of *Polyporus semistipitatus* Lloyd (BPI 306519), also collected in Stockton and examined. *Polyporus bartholomaei* has priority over *Polyporus semistipitatus*.

Polyporus hypomiltinus Bres., Symb. Sinica 2: 45 (1937)
(B2097, Likiang-hsien [Lijiang], Yunnan, China)
= *Amylosporus campbellii* (Berk.) Ryvarden

This is selected as a lectotype of *Polyporus hypomiltinus* (designated here). The original collection apparently is lost: it is missing from the herbarium of

the University of Vienna (WU) [where it should have been filed as Handel-Mazzetti 12927 (Dr. Walter Till, pers. comm.)] and no specimen can be found W (Dr. Uwe Passauer, pers. comm.).

Trametes lilacea Bres., Bol. Acad. Nat. Ci. (Cordoba) 28: 388 (1926)
(B3950, isotype B4492, Argentina).

Accepted species. Basidiomes pileate, effused-reflexed; sterile surface glabrous, zonate, ochraceous darkening to vinaceous towards the margin, with lilac tint; pore surface pinkish; pores round to angular, 2-3 per mm; context ochraceous, darkening permanently in KOH, 1 mm thick; tube layer concolorous with the context and also darkening permanently in KOH. Hyphal system trimitic, generative hyphae clamped, 2.4-3.5 µm; skeletal hyphae 3.6-4.8 µm; binding hyphae 2.4-2.8 µm; basidia 25 x 7-8 µm; basidiospores cylindrical to fusiform, 7-11.2 x 3.3-4 µm. The label of B4492 has the following statement: "8, *Trametes lilacea* n. sp., sporae Ø; hyphae hym. ??? 1 ½ - 4µ; pilei 2-4 ½??? pallido, Argentina, Dr. Spegazzini", information partially repeated in B3950. The latter is apparently a part of B4492 since on its pilei it is written "8" as on the label of B4492.

Trametes lilacea was published with a Spanish description:

> *Hab.* Sobre palos de alambrados em los alrededores de Tucumán, octubre 1918; *Obs.* Especie que es muy próxima al *Trametes argyropotamicus* Speg., del cual difiere por el color violeta pálido de su sombrero, mientras el himenio ostenta una coloración blanco rosada; no esisten cerdas himeniales; las esporas son elítico-ovaladas (5-6,5 X 2,5-3 µ), lisas e incoloras.

The holotype is in LPS (30510) but it was not examined.

Besides the species mentioned above, three unpublished species were also found and are discussed below.

Polyporus flaccidus Bres. (B1948, B2076, Missouri, USA)
= *Phaeolus schweinitzii* (Fr.) Pat.

No mention of *P. flaccidus* Bres. was found in the literature. The label of B1948 has the following information: "*Polyporus flaccidus* Bres. n. sp.; ad truncos, Missouri, n.863", measurements, drawings of basidiospores and of the basidiome. On the label of B2076, part of these data is repeated. No further information was found about this species; *Polyporus flaccidus* Bres. is apparently an unpublished name. If validly published, it would be illegitimate as a later homonym of *Polyporus flaccidus* Pers.

Polyporus flavidus Peck (B1951, USA)
= unknown identity, poor material

On the label of this material it is written "part of the type" and the number 18732, a short description in Latin, a drawing of two basidiospores, and

collection data (Worcester, NY, leg. Peck). Another isotype is deposited at BPI (208676) and on the label it is stated that there is an additional collection in NYS, originally from the herbarium of James Weir, number 18732. *Polyporus flavidus* is an unpublished name and its true identity is unknown.

Poria longispora Burt (B4417, USA)

= *Phellinus* sp., poor and contaminated material.

The label states this to be a new species by Burt but the name is absent in the literature and the databases we have consulted. The collection includes a Latin description and drawings of the basidiospores. It was collected in Montgomery, Alabama, in 1916 and is a part of the Weir collection.

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We would like to thank Dr. Erast Parmasto and Dr. Mario Rajchenberg for critically reviewing the manuscript, Dr. Uwe Passauer, Dr. Vilma Rosato and Dr. Walter Till for helping us retracing the specimens, and Dr. Elaine Malosso for English improvements.

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Notes on taxa of the genus *Pholiota* described by C. Kalchbrenner

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Abstract—Taxa of the genus *Pholiota* described by C. Kalchbrenner – all of them described from the area of present day Slovakia – are revised and identified. *Agaricus decussatus* subsp. *illustris* is conspecific with *Pholiota lubrica*, and *Agaricus punctulatus* represents *Pholiota gummosa*. The specimen collected from the area of the type locality is designated as epitype for *Agaricus decussatus* subsp. *illustris*. The identity of *Agaricus filamentosus* subsp. *lampas* and *Agaricus filamentosus* subsp. *lepturus* cannot be revised exactly because no original herbarium material is available, but both taxa certainly represent either *Pholiota adiposa* or *P. limonella*. Kalchbrenner's illustrations are designated as lectotypes for all four taxa.

Key words—nomenclature, typification

Introduction

Carl Kalchbrenner (1807-1886) was one of the first mycologists studying fungi in the area of present day Slovakia. He settled in Spišské Vlachy (Szepes Olaszi in Hungarian, Wallendorf in German), northern Slovakia in 1832. He served there as an evangelical priest and studied fungi until his death (Lizoň 1992). In his monograph of the fungi of the region Spiš "A Szepesi gombák jegyzéke" (Kalchbrenner 1865, 1868) and in the iconography of the Hymenomycetes of Hungary (which also included Slovakia at that time), he described numerous new fungal taxa (Kalchbrenner 1873, 1874, 1875, 1877). A full list of Kalchbrenner's new taxa was published by Lizoň (1992, 1997) and some of them were commented on later by Lizoň & Jančovičová (2000).

The goal of our project is to revise Kalchbrenner's "forgotten" taxa with respect to current taxonomic concepts and to check the nomenclatural status of his names.

Kalchbrenner described four taxa that are members of the genus *Pholiota* in its current delimitation, as *Agaricus* (*Pholiota*) *filamentosus* subsp. *lepturus* (Kalchbrenner 1868), *Agaricus* (*Pholiota*) *filamentosus* subsp. *lampas* (Kalchbrenner 1868), *Agaricus* (*Flammula*) *decussatus* subsp. *illustris* (Kalchbrenner 1874) and *Agaricus* (*Pholiota*) *punctulatus* (Kalchbrenner 1874). Although part of his herbarium is preserved in BP and BRA, original or type specimens of the above listed taxa are missing (Lizoň 1997) and no lectotypes or neotypes have been designated until now. Two of these taxa have already been revised by Holec (2001).

Material and methods

Macroscopic characters of the proposed epitype were observed in fresh material. Colours of basidiocarps were compared with Kornerup & Wanscher (1978) and are noted in parentheses by appropriate code. Micromorphological characters were observed in dried material using a light microscope with oil immersion lens. Fragments of lamellae, stipe and pileipellis were examined in 5% KOH, Melzer's reagent, and a solution of Congo Red in ammonia (1 ml of 25% ammonia dissolved in filtrated solution of 1.5 g of Congo Red and 50 ml of distilled water). Values of micromorphological characters are calculated as average ± standard deviation of 30 measurements. Values in parentheses are extremes. Abbreviations of herbaria are cited in accordance with Index Herbariorum (Holmgren et al. 1990). The location of collecting sites is presented by geographical coordinates and quadrant (Q) of the Central European grid mapping system (UTM).

Results

Agaricus decussatus* subsp. *illustris Kalchbr., Icon. Select. Hymenom. Hung. fasc. 2: 26, 1874

Identity — *Pholiota lubrica* (Pers.: Fr.) Singer (= *Agaricus decussatus* Fr. subsp. *decussatus*).

Original collecting site — "In silvis montanis Scepusii, ad truncos Pinuum et in vicinia eorum, sed etiam procul ab iis, locis udis, graminosis, ad terra, haud frequens. Octob." [Northern Slovakia, region of Spiš]

Lectotype — Kalchbrenner, Icon. Select. Hymenom. Hung. fasc. 2: pl. 15, fig. 1, 1874; **designated here.**

Epitype — Slovakia, Galmuská planina (Slovenské rudohorie Mts.), National Nature Reserve Červené skaly near the village of Poráč, alt. 432 m, geografic position 20°46'08"E, 48°52'47"N, Q 7190b, gregarious and in clusters on decaying wood of conifers and on

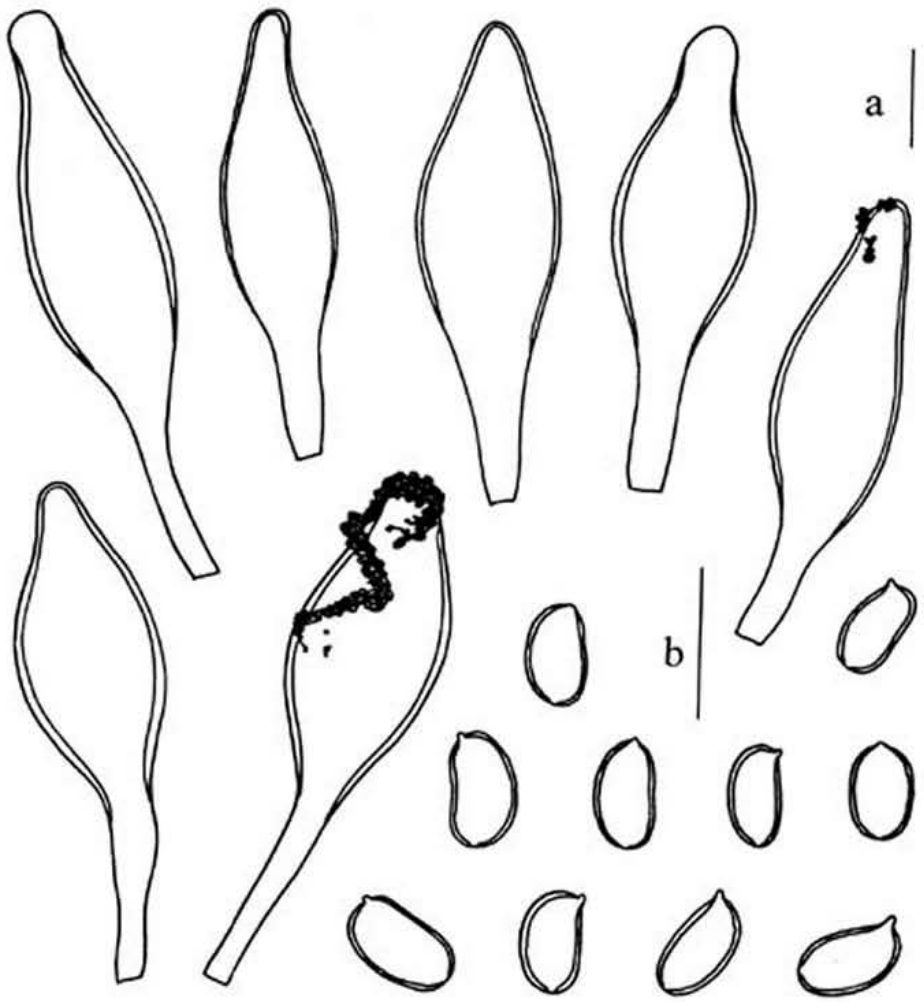

Fig. 1. *Agaricus decussatus* subsp. *illustris* – epitype: a. cystidia, b. spores (bars = 10 µm).

litter, under *Picea abies* and *Corylus avellana* in stream flood area, 26 Sept.2004, S. Adamčík & al. (SAV 1225); **designated here.**

Description of the epitype (Fig. 1) — Pileus 32-70 mm diam., first hemispherical, later obtusely conical, expanding to plano-convex to almost plane when mature, later sometimes with indistinct obtuse broad umbo, with inflexed margin, not hygrophanous, not translucently striate, surface strongly glutinous, smooth, innate radially fibrillose (fibrils darker than background) towards centre, cream to light yellow at margin, (4A3-4A4), towards the centre orange yellow (4B5) and more orange, centre light brown to cocoa brown (6D7, 6E6), sometimes almost to margin dark red brown (young basidiocarps), with white fibrillose-floccose scales of veil on margin when young. Stipe 50-90 × 4-13 mm, clavate to subbulbose, with white rhizoids on the base, solid when young, in young stage

connected with margin of pileus by white cortina leaving later indistinct ring zone, above ring zone almost smooth, below it with white and later brownish fibrillose scales, base more brown to dark red-brown. Lamellae 3-6 mm wide, moderately distant, L = 40-50, l = 3-7, adnexed or decurrent with tooth, greyish ochre (young fruitbodies), edge irregular, concolorous, later paler. Context pale ochraceous in pileus, dark red-brown in base of stipe, with indistinct smell reminding *Pholiota squarrosa,* taste slightly bitter. Spore print dark brown.

Spores (5.6-)6-6.7(-7.5) × (3.1-)3.2-3.6(-4) µm, av. 6.3 × 3.4 µm, Q = (1.5-) 1.7-2(-2.3), av. Q = 1.9, ellipsoid or ovoid, distinctly phaseoliform from side view, thick-walled, germ pore small, wall brownish ochre to brownish yellow. Cheilocystidia and pleurocystidia of the same size and shape, both abundant, (42-)45.5-54.5(-59) × (11.5)12.5-15(-16.5) µm, av. 50 × 13.5 µm, mostly lageniform, rarely fusiform or clavate, usually with long narrow stipe-like base and conical or cylindrical apical neck that is sometimes subcapitate; cell walls usually thickened in inflated part, hyaline or filled with yellow pigment, sometimes with yellow incrustation on terminal part. Pileus cuticle an ixocutis, stipe cuticle a cutis; clamp connections present in all tissues.

Notes — According to ICBN (Greuter et al. 2000), epitypes can be designated to support types that are ambiguous and cannot be critically identified for purposes of the precise application of the name of a taxon. Although the lectotype (illustration by Kalchbrenner) is very good, it cannot serve for study of microcharacters, which are very important in fungi. Consequently, the epitype (herbarium specimen) is designated here to make a "full picture" of the taxon in question.

The epitype specimen was found on wood lying on soil under *Picea abies* and *Corylus avellana.* It was collected in the flood area of the Poráčsky potok Stream and that is why the substrate could include also wood of other nearby growing trees, such as *Abies alba, Pinus sylvestris* and *Fagus sylvatica.* Holec (2001) listed *Abies, Acer, Betula, Fagus sylvatica, Picea abies* and *Quercus* as substrates for *Pholiota lubrica..*

Kalchbrenner reported *Agaricus decussatus* subsp. *illustris* from the stumps of *Pinus* and their vicinity so the substrate might include also remains of wood of other trees. Even if his description of the habitat is vague, characters shown in the illustration and noted in the original diagnosis match with those of *Pholiota lubrica*: distinctly fibrillose-scaly surface of the stipe, innate radial darker fibrils on pileipellis, paler yellow colour of pileus margin contrasting to darker orange brown centre, disappearing fibrillose-floccose veil on margin of pileus.

Most of Kalchbrenner's herbarium specimens were lost or destroyed during 19th century and only a small part of his herbarium has survived in BP and BRA (Lizoň 1992, 1994). The only available original material for the selection of the type is Kalchbrenner's illustration (ICBN Art. 9.1 Note 1). His notes on

ecology and collection site helped also for designation of that illustration as lectotype (ICBN Art. 9.2). Our collection designated as epitype was collected in a similar habitat to that described by Kalchbrenner (moist place, soil and decaying wood of conifers) and the collecting site is located also in the region of Spiš. All macromorphological characters of the epitype agree with the original description of the fungus.

Kalchbrenner's description of *Agaricus decussatus* subsp. *illustris* is based on robust fruitbodies with bright coloured pileus. He noted that the fungus has similar characters with *Agaricus decussatus* Fr. (finely radially innate darker fibrils) and therefore he treated it as a subspecies of the later. The taxon was proposed without specificied rank as "*Agaricus Flammula decussatus* Fr. * *illustris* Kalchbr." but at the end of the protologue Kalchbrenner specified that it is a subspecies of *Agaricus decussatus*.

Some authors (Moser 1978, 1983, Breitenbach & Kränzlin 1995) have distinguished *Pholiota decussata* and *Pholiota lubrica* by the saturation of color (besides of spore size and ecology). The monograph of the genus *Pholiota* (Holec 2001) considers *Pholiota decussata* a taxon falling within the variability of *Pholiota lubrica*, which is a rather variable species. Our team agrees with this solution and, consequently, considers *Agaricus decussatus* subsp. *illustris* identical and thus synonymous with *Pholiota lubrica*.

Agaricus punctulatus Kalchbr., Icon. Select. Hymenom. Hung. fasc. 2: 25, 1874.

Identity — *Pholiota gummosa* (Lasch: Fr.) Singer

Original collecting site — "In solo humoso, graminoso, ad margines Pinetorum Olasziensium prope rivulum vallis Kundratka; unico saltem loco, sed ibi jam per plures annos repertus. Nunquam in truncis nascentem vidi, semper vero ramentis sub terra putrescentibus adhaeret. Sept. Oct." [Slovakia, valley Kondrátka near the town of Spišské Vlachy].

Lectotype — Kalchbrenner, Icon. Select. Hymenom. Hung. fasc. 2: pl. 14, fig. 2, 1874; **designated here.**

Notes — Holec (2001) was of the opinion that Kalchbrenner's description and illustration of *Agaricus punctulatus* represents *Pholiota gummosa*. He stressed that the illustration by Kalchbrenner is a perfect drawing of *P. gummosa* with a slight olive tinge (a typical character), although this tinge is not mentioned in the protologue. We agree with this conclusion here.

Agaricus filamentosus **subsp. *lampas*** Kalchbr., *Math. Természettud. Közlem.* 5[1867]: 232, pl. 1, fig. 4, 1868.

Identity — *Pholiota adiposa* (Batsch: Fr.) P. Kumm. or
Pholiota limonella (Peck) Sacc.

Original collecting site — "Szepes, Igen árnyas fenyvesek sajátja" [Northern Slovakia, region of Spiš, in very shadowy conifer woods].

Lectotype — Kalchbrenner, Math. Természettud. Közlem. 5[1867]: pl. 1, fig. 4, 1868: **designated here.**

Notes — The main diagnostic characters of *Agaricus filamentosus* subsp. *lampas* are the following: Pileus 3.7-5 cm, plano-convex, at first with involute margin, viscid, with indistinct and rare scales that are glutinous, or they are disappearing and the surface is naked, colour of background golden yellow-fulvous. Lamellae watery-argillaceous, then cinnamon-brown. Stipe 5-7.5 × 0.6-0.8 cm, cylindrical with slightly thickened lower part and acute rooting base, at first solid, then hollow, elastic, fibrillose, yellow, with upright, cortinate-floccose, striate annulus which breaks easily, above the annulus paler, naked or yellow punctulate, below the annulus with adpressed floccose scales or subsquarrose. Context white-yellowish. Odour indistinct, by no means pleasant. Kalchbrenner (1968) wrote that the fungus resembles *Agaricus adiposus* but differs by thinner stature in all parts and almost non-viscid stipe.

According to the original description and illustration (lectotype), the taxon clearly belongs to *Pholiota* sect. *Adiposae* Konrad & Maubl. ex Holec, which is characterized by medium-sized to large fruitbodies with scaly and viscid to glutinous pilei (Holec 2001). However, it is impossible to identify *A. filamentosus* subsp. *lampas* without study of micromorphological characters, especially size of spores and shape of cheilocystidia. The fungus was collected in shadowy coniferous forest. The habitat does not agree with that of *Pholiota cerifera* (P. Karst.) P. Karst. that is almost exclusively found on wood of *Salix*. From other species of section *Adiposae*, the description and illustration fit either to *Pholiota adiposa* (sensu Fries 1821, Jacobsson 1987, Holec 2001; non *P. adiposa* sensu Ricken, Konrad & Maublanc, J.E. Lange, Kühner & Romagnesi, Moser, etc. = *P. jahnii*) or to *Pholiota limonella*. Both *P. adiposa* and *P. limonella* grow on wood of conifers and are known from Slovakia (Holec 2001). However, both species are almost identical macroscopically and are delimited only by a slight difference in spore size (Jacobsson 1987, Holec 2001). Consequently, the exact identity of *A. filamentosus* subsp. *lampas* remains unclear but the fungus certainly represents either *Pholiota adiposa* or *P. limonella*.

Agaricus filamentosus* subsp. *lepturus Kalchbr., *Math. Természettud. Közlem.* 5[1867]: 232, pl. 1, fig. 3, 1868.

Identity — *Pholiota adiposa* (Batsch: Fr.) P. Kumm. or
Pholiota limonella (Peck) Sacc.

Original collecting site — "Szepes, Fenyőtuskókon, verőfényes helyiségeken" [Northern Slovakia, region of Spiš, on pine stumps in sunny places]

Lectotype — Kalchbrenner, Math. Természettud. Közlem. 5[1867]: pl. 1, fig. 3 1868: **designated here.**

Notes — The main diagnostic characters of *Agaricus filamentosus* subsp. *lepturus* are the following: Pileus 2.5-7.5 cm, thick-fleshed, convex, yellow-brown- to

orange-brown, distinctly viscid, surface broken into scales which are denser at the centre and subimbricate to fibrillose towards the margin, adpressed, later flattened and scattered. Lamellae at first pale, then waterish cinnamon-brown. Stipe 2.5-5 × 0.4-0.6 cm, in basal part up to 0.6-0.8 cm, truncate at the base but with a thin radicant protuberance, whitish-yellowish, fibrillose-striate, towards the base broken into scales, dark yellow-brown at maturity, with floccose and disappearing annulus. Context yellowish. Odour indistinct, pleasant. Taste not distinctive. Kalchbrenner (1868) wrote that its scaly pileus resembles *Agaricus heteroclitus* but that fungus has the odour of *Armoracia*, thick and white stipe and is a different species.

The discussion on *Agaricus filamentosus* subsp. *lepturus* could be almost the same as in the case of the previous taxon (see above). Considering general habit of its basidiocarps, especially its scaly and viscid pileus, the taxon belongs to *Pholiota* sect. *Adiposae*. The illustration (lectotype), especially the subimbricate scales on the pileus surface, strongly resembles *Pholiota cerifera*, but the substrate (pine stumps) is atypical for it. Consequently, *Agaricus filamentosus* subsp. *lepturus* represents either *Pholiota adiposa* (sensu Fries 1821, Jacobsson 1987, Holec 2001; non *P. adiposa* sensu Ricken, Konrad & Maublanc, J.E. Lange, Kühner & Romagnesi, Moser, etc. = *P. jahnii*) or *Pholiota limonella* (for detailed discussion see the previous taxon). Kalchbrenner mentioned that the description and illustration represent a fruitbody collected from exposed places. At such places, basidiocarps of *Pholiota* have usually darker colours and more distinct and darker scales than those collected in shadowy places and moist conditions when the scales are covered by slime. The character of scales in dry conditions is in agreement with the appearance of *A. filamentosus* subsp. *lepturus* on plate 1, fig. 3. Finally, it is impossible to decide without study of spore size if *Agaricus filamentosus* subsp. *lepturus* represents either *Pholiota adiposa* or *P. limonella* (see also the discussion above).

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Studies on the genus *Paecilomyces* in China IV. Two new species of *Paecilomyces* with monophialides

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Abstract—Two new monophialidic species of *Paecilomyces*, *P. furcatus* and *P. cinereus*, were isolated and discovered from soils of Shandong and Hebei Provinces, respectively, in China. Characters common to the two new species are as follows: [1] Optimum growth temperatures are 40°C. [2] Conidiophores are absent or very simple. [3] Phialides arise solitarily from the aerial hyphae. Phylogenetic analysis of the rDNA ITS region suggest that both new species *P. furcatus* and *P. cinereus* form a separate sub-clade within a clade also containing *P. inflatus*, *P. biformis* and *P. crassosporus*.

Key Words—fungi, hyphomycetes, morphology, taxonomy

Introduction

In 1967, a section of monophialidic species in the genus *Paecilomyces* was put forward by Onions & Barron. This section included those species whose main axes of conidiophores were absent and phialides arose solitarily from vegetative hyphae or 2-3 phialides on short and simple conidiophores. It is an unfortunate that, however, they neglected the basal character of the genus *Paecilomyces* and put some species with awl-shaped phialides into this section (Onions & Barron 1967). Subsequently, Gams (1971) removed most species of the section into the genus *Acremonium* and only one species, *P. inflatus* (Burnside) J.W. Carmich. remained in genus *Paecilomyces*. This species has phialides with globose to ellipsoidal inflated bases and simple conidiophores.

So far, there are six typical monophialidic species, *P. inflatus* (Samson 1974), *P. ampullaris* Matush. (Matushima 1971:42), *P. ampulliphorus* Matush.

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(Matushima 1975:104), *P. iriomoteanus* Matush. (Matushima 1975:105), *P. major* (Liang et al.) Z.Q Liang, H.L. Chu & Y.F. Han (Chu et al. 2004, Liang et al. 2006b), and *P. biformis* Z.Q. Liang, H.L. Chu & Y.F. Han (Chu et al. 2004, Liang et al. 2006a) in the genus *Paecilomyces*. In this paper we report and illustrate two additional new species with monophialides.

Materials and methods

Sample collection and strain isolation

Strains GZDXIFR-H104-1 and GZDXIFR-H57-1 were isolated from soil samples from Yantai, Shandong Province and Tangshan, Hebei Province. Two grams of soil were added to a flask containing 20ml sterilized water and glass beads. Each soil suspension was shaken for about 10min and then diluted to concentrations of 10^{-1}-10^{-2}.One ml suspension (10^{-2}) was mixed with Martin medium in a sterilized 9cm diam. Petri dish and incubated at 40°C for 4 days.

Strain identification

The studied strains were transplanted on Czapek agar, potato dextrose agar (PDA) and Sabouraud agar. After incubation at 40°C for 7 days, these strains were identified based on colony character, conidiogenous structures and biology according to Brown & Smith (1957) and Samson (1974).

Reagent and DNA extraction

Taq enzyme and dNTP are bought from Shanghai Sangon, Agarose Gel DNA Purification kit ver 2.0 was bought from TRKARA Company.

Two strains from soils of Shandong and Hebei Provinces used for the molecular identification were incubated on Czapek agar and potato dextrose agar. Subsequently, the fresh sporulating cultures were used for DNA extraction according to Tigano-Milani et al. (1995), and then DNA was stored at -20°C.

PCR amplification and determination of ITS rDNA sequencing

Polymerase chain reaction (PCR) amplification was performed according to the manufacturer's instructions. 50μL reaction system: 10 × reaction buffer 5 μL, dNTP 1μL, primer ITS4 1μL, ITS5 1μL, Pfu buffer 0.5 μl, 2μL of template DNA and ddH_2O 39.5 μL. The amplification program : a first step of 94°C for 5 min; then 35 cycles consisted of 94°C for 40 s, 49°C for 40 s, and 72°C for 1 min; and a final step of 72°C for 10 min. To amplify ITS1-5.8S-ITS2 rDNA sequence, the following primers were used: ITS5 (5'-GGTGAGAGATTTCTGTGC-3') and ITS4 (5'-TCCTCCGCTTAT TGATATGC-3'). PCR products were purified using Agarose Gel DNA Purification kit ver 2.0 according to its procedure (TRKARA Company), 1μL purification product were determined in ρ=1%

Table 1. Strains used in the molecular study

Species	Strain	GenBank No.
Aphanoascus cinnabarinus		AY753349
Byssochlamys fulva		AY753341
Byssochlamys nivea		AY753339
Chaetomium globosum		AY429054
Chaetomium nigricolor		AJ458185
Cordyceps takaomontana		AY624198
Corynascus verrucosus		AJ224203
Isaria japonica		AY624200
Paecilomyces aerugineus		AY753346
P. amoeneroseus		AY624168
P. biformis	GZDXIFR-H28, China	DQ191963
P. cateniannulatus		AY624172
P. cateniobliquus		AY624173
P. cicadae		AY624175
P. cinereus	GZDXIFR-H57-1, China	DQ243694
P. coleopterorum		AY624177
P. crassosporus	GZDXIFR-H57-2, China	DQ243696
P. farinosus		AY624181
P. fumosoroseus		AY624183
P. furcatus	GZDXIFR-H104-1,China	DQ243695
P. inflatus		AB099943
P. tenuipes		AY624195
P. variotii		AY753337
Talaromyces leycettanus		AY753342
Thielavia hyrcaniae		AJ271581
T. rapa-nuensis		AJ271580
T. terricola var.*minor*		AJ271582

Agarose by electrophoresis and sequenced with the above primers by Beijing Sunbiotech Co. Ltd. The rDNA ITS1-5.8s-ITS2 regions of two strains were submitted to GenBank (DQ243694, DQ243695).

Sequence alignment and phylogenetic analysis

Table 1 listed stains used in the molecular study. These ITS1-5.8S-ITS2 region nucleotides sequences of representative species of *Paecilomyces* and other genera were obtained from Genbank database. The sequences of two new species were aligned using the ClustalX1.83 computer programme for multiple sequence alignment and manually corrected. Then the phylogenetic tree was constructed by neighbor-joining method of MEGA version 3.1 (Kumar, Tamura, Nei 2004). Confidence values for individual branches were determined by bootstrap analysis (1000 replications).

Results

Descriptions

Paecilomyces furcatus Z.Q. Liang, H.L. Chu & Y.F. Han **sp. nov.** **Figs. 1-3**

In agaro Czapekii, coloniae 25 mm diam in 7 diebus ad 40°C, planae humiles. Hyphis septatis, hyaline, lzecibus, 1.2-3.5 µm crassis. Conidiophora simplicia. Phialides singulares, 4.0 - 20.1 × 1.8 - 4.5 µm, e basi inflata ellipsoidea vel fusiformia, in collum distinctum apice inspissato angustatae. Conidia ellipsoidea , 4.0 - 7.9 × 1.9 - 3.9 µm

Colony on Czapek agar, attaining a diameter of 25 mm within 7 days at 40°C, round, flat, short floccose, light fulvous, yellowish zones in middle, regular in the margin. Reverse grey. Vegetative hyphae hyaline, smooth-walled, 1.2-3.5µm wide. Conidiophores simple. Phialides single, directly borne on the vegetative hyphae, sometimes clustering in small groups on the very short conidiophores. Phialides (3.7-)4.0–20.1(-23.3) × 1.8-4.5 µm, with an ellipsoidal or fusiform swollen basal portion, tapering into a distinct neck, usually proliferating in two furcations. Conidia smooth-walled, long-ellipsoidal or ovoid, (3.6-)4.0-7.9 × 1.9-3.9(-4.3) µm.

Distribution: Shandong Province, China.

Materials examined: The holotype, GZDXIFR-H104-1, was isolated by H. L. Chu from soil of Yantai, Shandong Province, China, in September, 2003.

The holotype of *P. furcatus* GZDXIFR-H104-1 and a dried plate culture of GZDXIFR-H104-1-1 on Czapek agar are deposited in the Institute of Fungus Resources, Guizhou University, China.

The species *P. furcatus* is characterized by the obvious proliferation and furcated phialides. Although *Acremonium furcatum* W. Gams is similar to *P. furcatus* in possessing furcated phialides (Gams 1971), the phialides of *A. furcatum* are more typically awl-shaped and lack inflated bases.

Monophilic species which have typical characters of *Paecilomyces* and ellipsoidal spores include *P. ampullaris*. Its phialides also proliferate but the new species *P. furcatus* differs from *P. ampullaris* by having obviously furcated phialides (Figs. 1-3) and larger conidia.

Paecilomyces cinereus Z.Q. Liang, H.L. Chu & Y.F. Han **sp. nov.** **Figs. 4-6**

In agaro Czapekii, coloniae 60mm diam in 7 diebus ad 40°C planae humiles. Hyphis septatis, hyaline, lzecibus, 1.4 - 3.6 µm crassis. Phialides singulares, 4.0-20.8(-24.6)× 2.2-6.0µm, e basi inflata ellipsoidea, in collum distinctum apice inspissato angustatae, 3.0-10.1(-11.2)µm. Conidia ellipsoidea , 3.1-9.6(-13)× 1.4-4.8(-5.4)µm

Colony on Czapek agar, attaining a diameter of 60 mm within 7 days at 40°C, round, flat, short floccose, light grey zone in center; reverse dark. Vegetative hyphae hyaline, smooth-walled, 1.4-3.6 µm wide. Conidiophores simply, phialides single, directly borne on the vegetative hyphae, sometimes clustering

Fig. 1. Conidiogenous structures of two new species
1-3 *P. furcatus* Z. Q. Liang et al.
4-6 *P. cinereus* Z. Q. Liang et al.
Bars1-6 = 10 μm

in small groups on very short conidiophores. Phialides 4.0-20.8(-24.6)× 2.2-6.0μm, with a swollen, ellipsoidal or cylindrical basal portion, tapering into a distinct neck, 3.0-10.1(-11.2)μm long. Conidia smooth-walled, long-ellipsoidal, 3.1-9.6(-13)× 1.4-4.8(-5.4)μm, in divergent long chains.

Distribution: Hebei Province, China.

Materials examined: The holotype, GZDXIFR-H57-1 was isolated by H. L. Chu from soil of Tangshan, Hebei Procince, China, 2003.8.

The holotype of *P. cinereus* GZDXIFR-H57-1 and a dried plate culture of GZDXIFR-H57-1-1 on Czapek agar are deposited in the Institute of Fungus Resources, Guizhou University.

At present, among six monophialidic species reported hitherto (Matushima 1971:42, 1975, Samson 1974, Chu et al. 2004, Liang et al. 2006a), the fungus *P. cinereus* can be distinguished from the other species by grey colony, black reverse and longer (13 μm) conidia (Table 2). The above characters are closely similar to *P. biformis*, however, the latter species can be distinguished from *P. cinereus* by its dimorphic conidiogenous structure and rough conidiophore.

Table 2. A comparison of morphological characteristic of *P. cinereus* with allied species

Species	Colonies	Phialides	Conidia (μm)
P. cinereus	Grey, reverse dark	Ellipsoidal or cylindrical	Long-ellipsoidal 3-13×1.4-5.4
P. furcatus	Grey-brown, reverse grey	Ellipsoidal, furcate	Long-ellipsoidal 3.6-7.9× 1.9-4.3
P. biformis	Grey-brown, reverse dark	various	Ellipsoidal fusiform 4.5-13×3.5-7

Molecular Identification

Based on the phylogenetic relationships analysis derived from partial large subunit (LSU) and partial small subunit (SSU) rRNA gene sequences of *Paecilomyces* spp., *Verticillium* spp. and *Beauveria* spp., Obornik et al. (2001) proposed that the genus *Paecilomyces* was polyphyletic. Subsequently, phylogenetic relationships of the genus *Paecilomyces* were more studied by Luangsa-ard et al. (2004, 2005). Their results showed that the monophialidic species, *P. inflatus* had a more closed affinity with *Sordariales*, but it could not be linked with other mesophilic species with hypocrealean affinities.

A result of Blast in GenBank based on the ITS1-5.8S-ITS2 region showed that several monophialidic *Paecilomyces* species including the fungus *P. inflatus* had higher identities with some ascomycetes and were classified in the order *Sordariales* (clade III) (Fig.2). The reconstruction of the phylogenetic tree inferred from the analysis of the ITS1-5.8S-ITS2 region showed that both new species GZDXIFR-H57-1 and GZDXIFR-H104-1 are clustered together with the sister groups in the same clade III, which groups consist of both monophialidic species *P. biformis* H28-1 and *P. crassosporus* H57-2 as well as other ascomycetes. But two new species formed an unispecific sub-clade in the clade III (Fig.2). Morphologically, the anamorphs of some ascomycetes in clade III are also different from the two new species by dark hyphae and terminal aleuriospores (Kiffer & Morelet, 1997).

P. inflatus is similar to the two new species in morphology, but it can be separated by the fusiform conidia. The molecular evidence showed that the fungus *P. inflatus* formed a separate branch in clade III (Fig.2), further supporting its distinctness.

Some entomogenous and thermotolerant species of the genus *Paecilomyces* were aggregated in clade II and clade I (Fig.2). They had affinities for *Hypocreales* (*Clavicipitaceae* and *Hypocreaceae*) and *Eurotiales* (*Trichocomaceae*).

Fig.2. Phylogenetic tree based on the neighbour-joining method of representative of *Paecilomyces* spp. inferred from the ITS1–5.8S–ITS2 rDNA region. Bootstrap values calculated from 1000 replicates indicated at the branches.

The fungus *Acremonium furcatum* is similar to the new species *P. furcatus* in possessing furcated phialides. The phylogenetic analysis (Fig.2) demonstrates phylogenetic separation of *A. furcatum* from *P. furcatus* and *P. cinereus*.

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Three new species of *Corynespora* from Indonesia

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Abstract–*Corynespora hamata, C. acalyphae* and *C. gracilis* are described and illustrated as new species, based on collections made in Indonesia.

Key words–hyphomycetes, Java

Introduction

The concept of the genus *Corynespora* Güssow was well-established once Wei (1950) elucidated the conidiogenesis of the type species, *C. cassiicola* (Berk & M.A.Curtis) C.T. Wei. Additional species have been described by many authors including Ellis (1957, 1960, 1961a,b, 1963a,b, 1971, 1976), Dyko and Sutton (1979), Morgan (1988), Siboe et al. (1999), Zhang and Ji (2005), Zhang and Shi (2005), and Zhang and Xu (2005). Conidial characters (size, shape, septations and to some extend colourations) have been used to distinguish species within the genus (Ellis 1957, 1976; Siboe et al. 1999).

In making general collections of hyphomycetes from Indonesia, three undescribed species of *Corynespora* have been found. They are described and illustrated as new species.

Taxonomic Descriptions

Corynespora hamata Wulandari, sp. nov. Fig. 1

Coloniae limitatae, effusae, brunneae. Mycelium superficiales vel immersum, ex hyphis ramosis, septatis, pallide brunneis, laevibus, 2–3.5 µm crassis. Conidiophora pallide brunneae vel brunneae, singula, erecta, flexuosa, cylindrata, laevibus, septata, per usque ad 3–7 proliferationes successivas elongascentia, 264–462 µm longa, 8.8–11 µm crassa. Conidia singula, primo in apice conidiophori et dein proliferationes cujusque successivae oriunda, obclavata, recta, apicem hamata, laevia, pallide olivacea, 14–19 distoseptata, 158–198 µm longa, 9–11 µm crassa, basi truncata 6–8 µm lata.

Holotypus: Habitat in ramulis emortois, Curug Nangka, Bogor, Java, 30 Marcius 2006, Nilam F. Wulandari 37 **(BO 22525).**

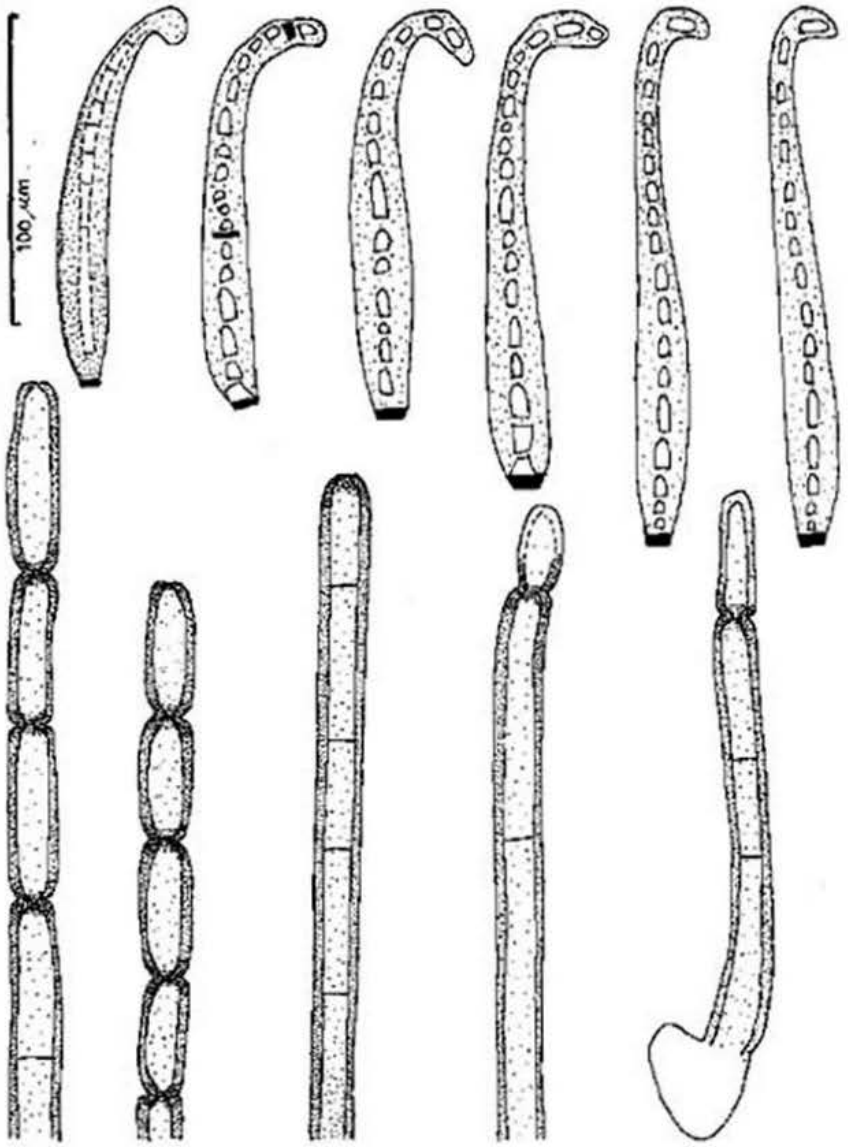

Figure 1. Conidia and conidiophores of *Corynespora hamata*

Colonies restricted, effused, brown. *Mycelium* superficial or immersed, composed of branched, septate, pale brown, smooth-walled hyphae, 2–3.5 µm wide. *Conidiophores* single, pale brown to brown, erect, flexuous, cylindrical, smooth-walled, septate, elongating by 3–7 successive cylindrical proliferations, 264–462 µm long, 9–11 µm wide. *Conidia* formed singly through a pore at the apex of the conidiophore, which then proliferates through the apical pore and forms another conidium at the apex of the proliferation, straight, obclavate, hamatate at the apex, pale olivaceous brown, smooth, 14–19 distoseptate, interspersed with 3–8 eusepta, 158–198 µm long, 9–11 µm wide, 6–8 µm at the truncate base.

Corynespora hamata is unique among species of *Corynespora* because of its crooked, pale coloured conidia. The conidiophores are exceptionally long.

Corynespora acalyphae Wulandari, sp. nov Fig. 2

Coloniae effusae, velutinae, fuscae. Mycelium superficiales vel immersum ex hyphis ramosis, septatis, pallide brunneis, laevibus, 2–3.5 µm crassis. Conidiophora pallide brunneae vel brunneae, singula, erecta, flexuosa, cylindrata, laevibus, septata, per usque ad 3–7 proliferationes successivas cylindricas elongascentia, 183–330 µm longa, 11–13 µm crassa. Conidia singula, primo in apice conidiophori et dein proliferationes cujusque successivae oriunda, recta vel curvata, obclavata, apicem attenuata, laevia, pallide brunneae vel brunneae, 8–16 distoseptata, 85–120 µm longa, 9–11 µm crassa, basi truncata 6–8 µm lata.

Holotypus: Habitat in ramulis emortois Acalyphae hamiltonianae, Kotabatu, Bogor, Java, 24 April 2006, Nilam F. Wulandari 232 (BO 22529).

Colonies effused, velvety, blackish brown. *Mycelium* superficial or immersed, composed of branched, septate, pale brown, smooth-walled hyphae, 2–3.5 µm wide. *Conidiophores* single or sometimes in groups, pale brown to brown, erect, flexuous, cylindrical, smooth-walled, septate, elongating by 3–7 successive cylindrical proliferations, 183–330 µm long, 11–13 µm wide. *Conidia* formed singly through a pore at the apex of the conidiophore, which then proliferates through the apical pore and forms another conidium at the apex of the proliferation, straight or curved, obclavate, tapering to the apex, pale brown to brown, smooth, 8–16 distoseptate, interspersed with 3–8 eusepta, 85–120 µm long, 9–11 µm wide, 6–8 µm at the truncate base.

Additional specimens examined: on dead wood of *Acalypha hamiltonianna*, Kotabatu, Bogor, Java, 10 January 2006, Mien A. Rifai. s.n. **(BO 22528)** and 12 February 2006, Mien A. Rifai s.n. **(BO 22527)**, 24 April 2006.

The conidia of *Corynespora acalyphae* are very similar in shape to those of *C. calicioidea* (Berk & Broome) M.B. Ellis. However, *C. calicioidea* has larger conidia that measure 50–170 µm long x 10–15 µm wide and synnematous conidiophore (Siboe et al. 1999).

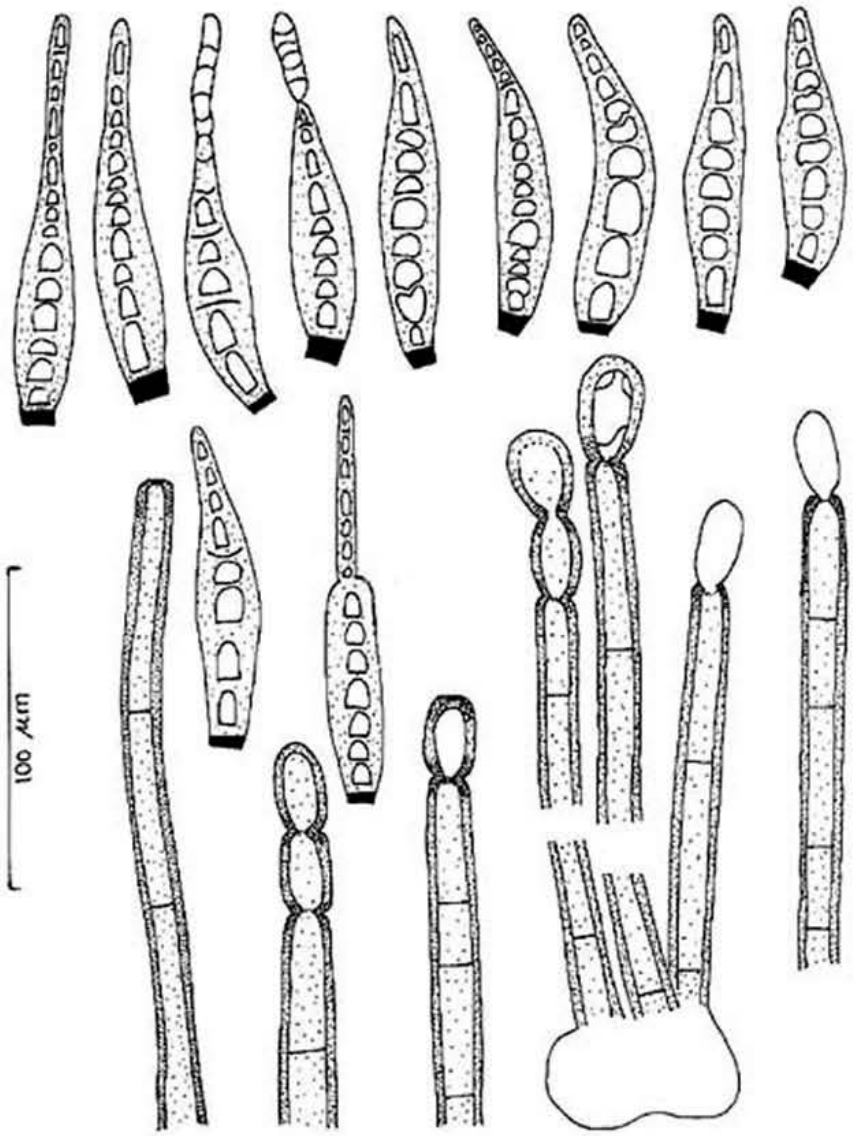

Figure 2. Conidia and conidiophores of *Corynespora acalyphae*

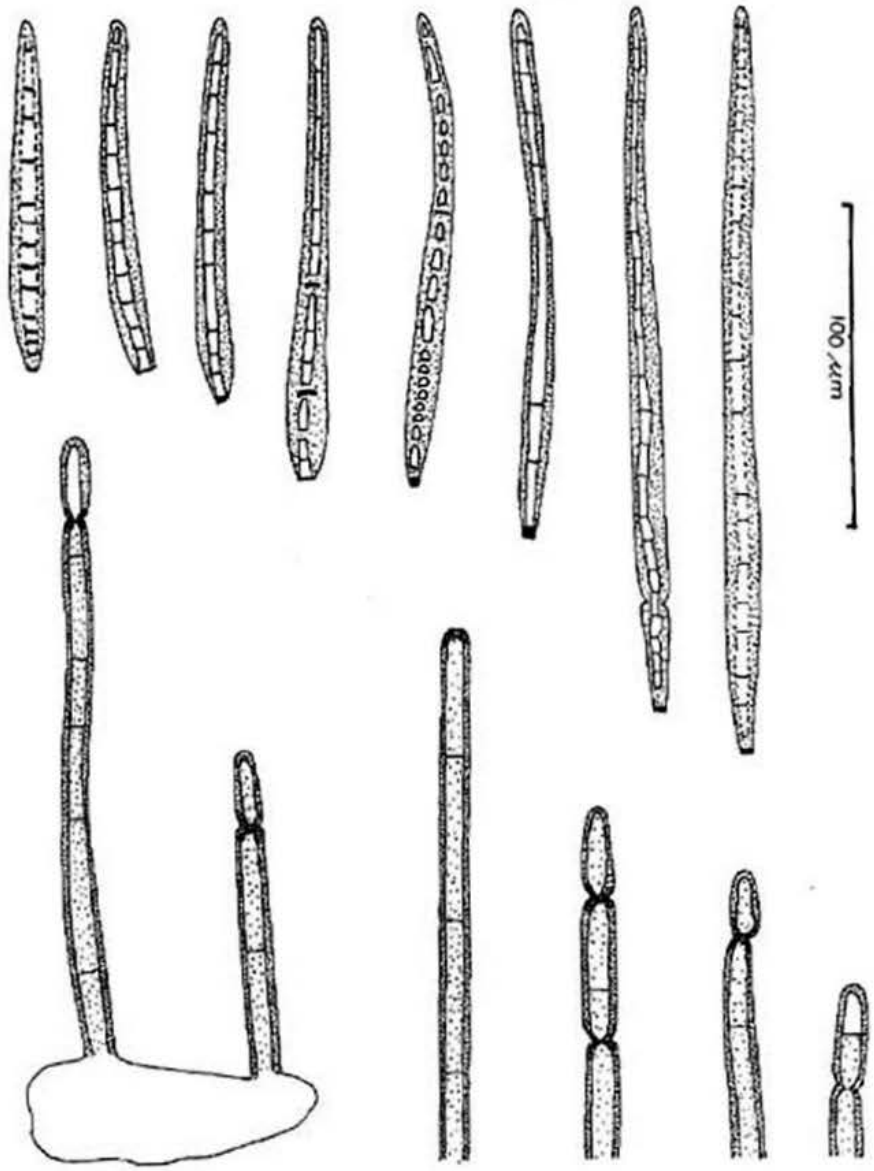

Figure 3. Conidia and conidiophores of *Corynespora gracili*

Corynespora gracilis Wulandari, sp. nov. **Fig. 3**

Coloniae effusae, fuscae. Mycelium superficiales vel immersum ex hyphis ramosis, septatis, pallide brunneis, laevibus, 2–3.5 µm crassis. Conidiophora pallide brunneae vel brunneae, singula, erecta, flexuosa, cylindrata, laevibus, septata, per usque ad 1–2 proliferationses successivas cylindricas elongacentia, 121–198 µm longa, 4–6 µm crassa.

Conidia singula, primo in apice conidiophori et dein proliferationses cujusque successivae oriunda, recta, gracile, apicem attenuata, pallide olivacea, laevia, 10–22 distoseptata, 92–138 µm longa, 5–7 µm crassa, basi truncata 4.5 µm lata.

Holotypus: Habitat in ramulis emortois Piperis betle, Merapi Mountain National Park, Kaliurang, Yogyakarta, Java, 21 April 2006, Nilam F. Wulandari 231 (BO 22526).

Colonies effused, blackish brown. *Mycelium* superficial or immersed, composed of branched, septa, pale brown, smooth-walled hyphae, 2–3.5 µm wide. *Conidiophores* single or in groups, pale brown to brown, erect, flexuous, cylindrical, smooth-walled, septate, elongating by 1–2 successive cylindrical proliferations, 121–198 µm long, 4–6 µm wide. *Conidia* formed singly through a pore at the apex of the conidiophore, which then proliferates through the apical pore and forms another conidium at the apex of the proliferation, straight, slender, tapering to the apex, olivaceous, smooth, 10–22 distoseptate, interspersed with 1–2 eusepta, 92–138 µm long, 5–7 µm wide, 4.5 µm at the truncate base.

The slender spored *Corynespora gracilis* is similar in shape to *C. smithii* (Berk & Broome) M.B.Ellis, but the latter species has much stouter conidia measuring 70–140 µm long x 12–19 µm wide.

Acknowledgements

The author is very grateful to Drs. Eric H. C. McKenzie and Mien A. Rifai for their constructive amendments to the draft manuscript of this paper.

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MYCOTAXON

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A new gymnopoid species from western Spain

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Abstract—A recent collection of an undescribed gymnopoid fungus from typical Mediterranean evergreen forests of western Spain is studied and described. The new species is characterized mainly by its convex and fan shaped white pileus, pruinose stipe and globose basidiospores.

Key Words—*Agaricales, Gymnopus, Marasmiellus,* Mediterranean area, taxonomy

Introduction

The Mediterranean region comprises habitats and ecosystems composed by different types of sclerophyllous evergreen forests. The rich flora of these formations represents a privileged area for biodiversity and taxonomical studies and some new gymnopoid species have been described (Robich et al.,1994, Moreno et al. 1997, Villarreal et al. 2002, Esteve-Raventós & Ortega 2003). The new species was sampled in a relictic tertiary formation *Viburno-Prunetum lusitanicae* Ladero, characterized by the presence of several evergreen and lauroid plant species such as *Erica arborea* L., *Viburnum tinus* L., *Arbutus unedo* L., *Prunus lusitanica* L. and *Phillyrea angustifolia* L. This formation is a vestige from tertiary lauroid forest, actually restricted to the macaronesian areas (Canary Island, Azores and Madeira), and several small microhabitats in the south and west of the Iberian Peninsula.

Materials and Methods

Sections and fragments of dried material were dehydrated in water and placed in 2% KOH, Congo red and Melzer's reagent to conduct amyloid tests.

Drawings were made with the aid of a camera lucida device. Basidiospore measurements in descriptions are given as (minimum value-)(mean-2SD)-mean-(mean+2SD)(-maximum value), as well as the Q value and the total number of measurements (n), according to the recommendations of Heinemann & Rammeloo (1985).

Taxonomy

Gymnopus sphaerosporus M. Villarreal, Arenal & G. Moreno. **sp. nov.** FIGURE 1

Basidiomata dispersa, parva. Pileus usque ad 12 mm latus, initio hemisphaericus postea convexus denum plano-convexus, haud hygrophanus, translucido-striatus, plicatus, minute granuloso-pruinosus, albus. Caro tenuis. Odore saporeque indistinctis. Lamellae c. 10 stipitem attingentes, distantes, adnatae, concolores. Stipes usque ad 8 mm longus, 0.8-1.5 mm latus, excentricus vel subexcentricus, aequalis, cylindraceus, minute pruinosus, pileo concolor, basi fibrillis albis substrato affixus. Basidiosporae 7-7.95-9 x 6.5-7.54-8.5 µm, globosae vel subglobosae. Basidia 34-41 x 7-9 µm, clavata, tetrasporigera, sterigmatibus usque ad 5 µm longis praedita. Cheilocystidia 32-55 (-70) x 5-10 µm, cylindrica vel subcylindrico-flexuosa apice rotundato interdum parum capitato. Pleurocystidia nulla. Pileipellis pseudotrichodermatis, hyphis 3-8 µm latis, haud pigmentatis, pileocystidia numerosa cheilocystidiis similia. Caulocystidia 19-55 x 4-8 µm, diversiformia, descendencia ad basim. Reactio chemicalis basidiocarporum nulla pars amyloidea vel dextrinoidea. Fibulae praesentes in totus partibus carposomatum.

TYPUS: Spain, Ávila, Arenas de San Pedro, 24-XI-2004, *leg.* F. Arenal et M. Villarreal, ad corticem *Arbuti unedo*. (AH 31888 *holotypus*)

Etymology: from Latin "*sphaerae*" = due to its globose basidiospores.

Pileus 3-12 mm, at first hemispherical to convex, finally convex-flabelliform, not hygrophanous, more or less strongly plicate or wrinkled, translucent-striate, minutely pubescent, white to dirty white, pale yellowish when dry, with concolorous, even to crenulate margin. Contex thin, whitish. Smell and taste absent. Lamellae c. 10, l = 0-2, distant, triangular, adnate becoming adnate-subdecurrent, with concave white edge, pruinose under lens. Stipe up to 8 x 0.8-1.5 mm, eccentric to nearly lateral, rarely central, sometimes absent, whitish, entirely pruinose, seated on a small radiating disc of silky mycelium.

Basidiospores 7-*7.95*-9 x 6.5-*7.54*-8.5 µm, Q = 1-*1.05*-1.15 (n=21), globose to subglobose, smooth, hyaline with abundant lipid guttules, unchanging in Melzer's reagent. Basidia 34-41 x 7-9 µm, clavate, tetrasporic, with sterigmata up to 5 µm long. Cheilocystidia 32-55 (-70) x 5-10 µm, cylindrical, straight to flexuose and multi-strangulate, sometimes apically mucronate, thin-walled, hyaline. Lamella edge heterogeneous. Pleurocystidia absent. Hymenophoral trama inamyloid and non-dextrinoid. Pileipellis a pseudotrichoderm, made up of hyphae 3-8 µm in diam, bearing terminal or integrated cylindrical to subclavate elements similar to cheilocystidia, sometimes septate. Subpellis made up of inflated elements, up to 25 µm broad. Stipitipellis a tangled trichoderm

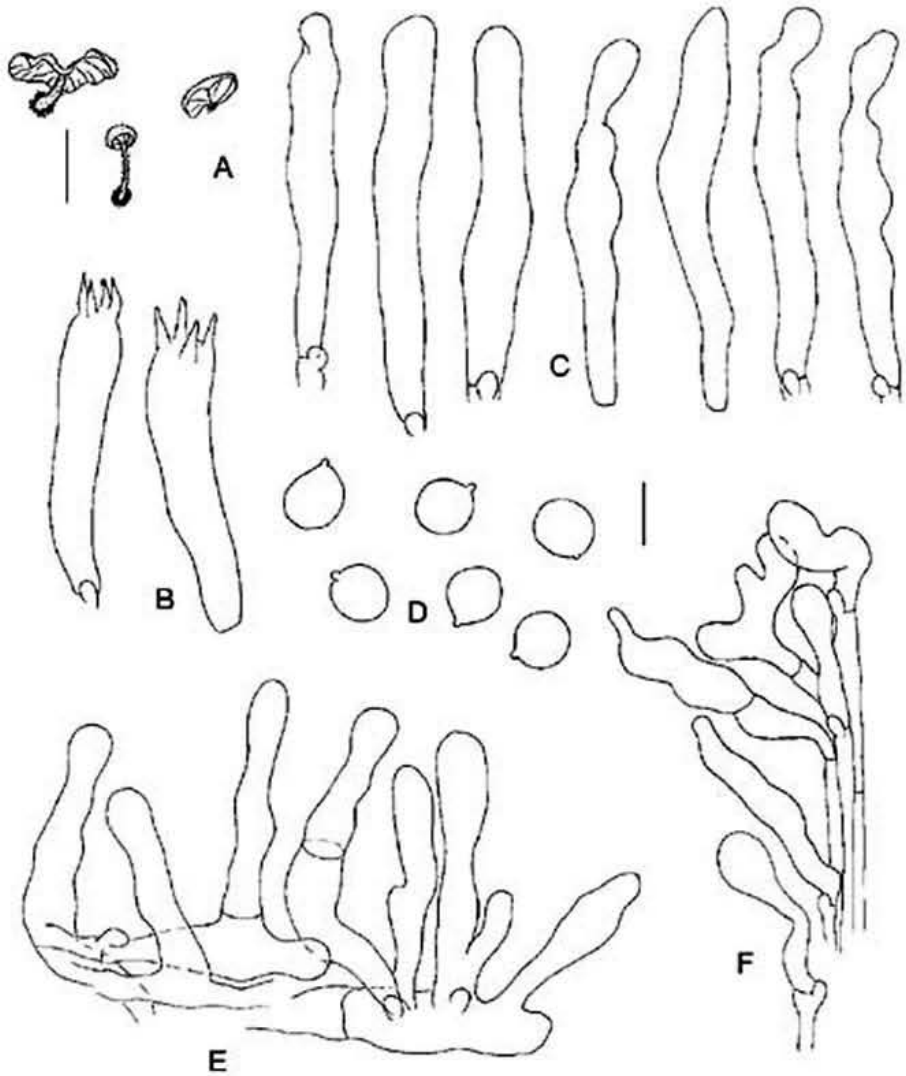

Fig 1.- *Gymnopus sphaerosporus* (AH 31888 holotype). A Habit. B. Basidia. C. Cheilocystidia. D. Basidiospores. E. Pileipellis. F. Caulocystidia. Bars. A: 1 cm; B-F: 10 µm.

composed of abundant multiform caulocystidia 19-55 x 4-8 µm. Hyphae of the stipititrama parallel up to 18 µm broad. Clamp-connections present in all tissues.

Specimens examined: Spain, Ávila, Arenas de San Pedro, 24 Nov. 2004, F. Arenal & M. Villarreal, on decayed bark of *Arbutus unedo*. (AH 31888 *holotypus*)

Discussion

Gymnopoid (collybioid-lentinuloid) euagarics historically have had a problematic and controversial taxonomy (Antonín et al. 1997). Recently, several works have pointed to the polyphyletic origin of *Marasmiellus* Murrill and *Gymnopus* (Pers.) Roussel (Moncalvo et al. 2000, Moncalvo et al. 2002, Mata et al. 2004, Wilson & Desjardin 2005), and stated a major clade integrated of five well-defined subclades within gymnopoid euagarics. The first of them comprises species of *Gymnopus* sect. *Vestipedes* and some species of the genus *Marasmiellus*, including the type species of the genus (*M. juniperinus* Murrill). A second clade integrated by species of *Rhodocollybia* Singer together with a *Gymnopus* species; *Marasmiellus ramealis* (Bull.) Singer and *Campanella eberhardtii* (Pat.) Singer form a parallel group. A third group contains the type species of the genera *Gymnopus*, *Micromphale* Gray and *Setulipes* Antonín. The fourth clade represents the genus *Lentinula* Earle, and the fifth group limits well the resurrected genus *Mycetinis* Earle with the type species *Mycetinis alliaceus* (Jacq.) Earle (≡ *Marasmius alliaceus* (Jacq.) Fr.). A sister clade to the first major clade is dominated by members belonging to *Tetrapyrgos* E. Horak.

The new species traditionally could be placed in the genus *Marasmiellus* on account of its habit, the pileipellis tending to be a trichoderm, a stipe with poorly developed basal mycelium, inamyloid basidiospores and non-dextrinoid context hyphae. However, the actual phylogenetic considerations of the morphological characters for each phylogenetic lineage consist mainly in basidiomes with noninsititious to subinsititious stipe, inamyloid and nondextrinoid basidiospores, and pileipellis composed of a cutis of radially arranged cylindrical, nondiverticulate or weakly diverticulate hyphae which are roughened or covered with annular to zebroid brownish pigment incrustations (Wilson & Desjardin 2005). Based on these morphological characters for each phylogenetic lineage, we consider adequate the taxonomical placement of the new taxon as a member of genus *Gymnopus*.

The newly described taxon, *Gymnopus sphaerosporus*, is characterized by its convex to flabelliform white pileus, globose or subglobose basidiospores, cylindrical and flexuose cheilocystidia and pilei- and stipitipellis forming a pseudotrichoderm, as well as its particular habitat, growing on decayed bark of *Arbutus unedo*. None of the monographic contributions in Europe (Antonín & Noordeloos 1993, 1997), neither of neotropical areas (Singer 1973, 1976), Australasia (Horak & Desjardin 1994) nor North America (Desjardin 1997) of *Marasmiellus*, include a taxon similar to the new species proposed.

Singer (1973) proposed subsect. *Sphaeosporini* Singer for the neotropical species of *Marasmiellus* with broad basidiospores and a Q index between 1-1.5. In this subsection, *M. guzmanii* Singer, described from Mexico, differs from *M. sphaerosporus*, in having broad, diverticulate cheilocystidia, larger

basidiospores, and a different pileipellis structure. Another related species is *M. parlatorei* Singer, described from Argentina, differing from *G. sphaerosporus* in having larger basidiospores (8-12 x 7-11 µm) and a typical *Rameales*-structure in the pileipellis, absent in the newly described taxon here.

The most similar species described in Europe seems to be *Marasmiellus phaeomarasmioides* G. Moreno et al. (Moreno et al. 1997), on account of the similar habit and microscopical features. However, this species differs from the new taxon by the small size of the fruitbodies and their colour which is cream-brown to greyish, as well as the different habitat. Microscopical differences between *M. phaeomarasmioides* and *G. sphaerosporus* are shown in Table I.

Table I. Differences between *Marasmiellus phaeomarasmioides* and *Gymnopus sphaerosporus*.

	Basidiospores (µm)	Pileipellis	Cheilocystidia (µm)	Pigmentation
M. phaeomarasmioides	7-9	*Rameales*-structure	c. 35 x 7	Incrusting
G. sphaerosporus	7-9.5(-10)	Pseudo-trichoderm	32-70 x 5-10	Absent

Members belonging to genus *Gymnopus* (Pers.) Roussel are mainly saprotrophic, growing on leaf litter of different vegetal material; rarely of a lignicolous habitat, as occurs in the newly described species. Only *Gymnopus fusipes* (Bull.: Fr.) Gray and *G. inodorus* (Pat.) Antonín & Noordel. posses this habitat (Antonín & Noordeloos 1997), but these species distinctly differ by their macro- and microscopic features.

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Index of Lichenes Groenlandici Exsiccati fascicles I-XXX with notes on distribution of the taxa in Greenland

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Abstract—The present list of lichens contains 239 lichen taxa that have been distributed from the Botanical Museum, University of Copenhagen during 1972–2005. The series, "Lichenes Groenlandici Exsiccati", consists of 30 fascicles in all and includes lichen collections from all parts of Greenland, even high latitude, difficult-to-access arctic areas. The exsiccate has from the beginning been edited and arranged by the author of this paper. The 30 fascicles comprise the following numbers: I: 1-50; II: 51-110; III: 111-160; IV: 161-210; V: 211-260; VI: 261-310; VII: 311-360; VIII: 361-416; IX: 417-466; X: 467-500; XI: 501-550; XII: 551-600; XIII: 601-625; XIV: 626-650; XV: 651-675; XVI: 676-700; XVII: 701-725; XVIII: 726-750; XIX: 751-775; XX: 776-800; XXI: 801-825; XXII: 826-850; XXIII: 851-875; XXIV: 876-900; XXV: 901-925; XXVI: 926-945; XXVII: 946-965; XXVIII: 966-985; XXIX: 986-1005; XXX: 1006-1024. - In a number of papers dealing with the lichen flora of selected areas recently visited by the author, the exsiccate numbers are stated in the lists of lichens (see the list of references at the end of the present paper).

Introduction

The 239 issued lichens are listed alphabetically together with some synonyms. Nomenclature follows Santesson et al. (2004) and Index Fungorum. Notes are given on the distribution of all taxa in Greenland. The known distribution of many species has changed since the publication of the index of fascicle I-X (Hansen 1995a), because of extensive collecting work in more northern parts of Greenland. At present the Greenland lichen flora consists of c. 1000 species.

List of lichens

Acarospora molybdina (Wahlenb.) Trevis. (Hansen 1995c) - W. Greenland, northwards to Upernavik; E. Greenland, with northern limit at Jørgen Brønlund Fjord: 647.

Alectoria nigricans (Ach.) Nyl. - All over Greenland: 151, 196, 323, 405, 431, 881, 1001, 1024.

A. ochroleuca (Hoffm.) A. Massal. - All over Greenland, but rare in N. Greenland: 18, 87, 256, 265, 298, 358, 408, 422, 506, 556, 813, 835, 878, 910, 918, 929, 1002.

A. sarmentosa subsp. ***vexillifera*** (Nyl.) D. Hawksw. (Syn. *A. vexillifera* (Nyl.) Stizenb.) - W. Greenland, northwards to Disko-Nuussuaq; rare in E. Greenland: 377, 498, 542, 651, 681, 948.

Allantoparmelia alpicola (Th. Fr.) Essl. (Syn. *Parmelia alpicola* Th. Fr.) - W. Greenland, northwards to Qaanaaq; E. Greenland, northwards to Traill Island: 141, 312, 636.

Amygdalaria panaeola (Ach.) Hertel & Brodo - W. Greenland; Central E. Greenland: 168.

Arctocetraria andrejevii (Oksner) Kärnefelt & A. Thell (Syn. *Cetraria andrejevii* Oksner, *C. simmonsii* Krog) (Kärnefelt 1979; Kärnefelt, Mattsson & A. Thell 1993) - W. Greenland, with northern limit at Upernavik; very rare in E. Greenland (Lindenows Fjord and Mesters Vig): 31, 142, 383, 397, 403, 425, 435, 473, 520, 628, 669, 688, 745, 836, 886, 891, 932, 962, 1009.

A. nigricascens (Nyl.) Kärnefelt & A. Thell (Syn. *Cetraria nigricascens* (Nyl.) Elenkin) (Hansen 1997) - N. and N.W. Greenland, southwards to Qasigiannguit; rare in E. Greenland (Ittoqqortoormiit): 302, 356, 361, 464, 495, 791, 893.

Arctoparmelia centrifuga (L.) Hale (Syn. *Parmelia centrifuga* (L.) Ach.) W. Greenland, but rare north of Disko; scattered distribution in E. Greenland, northwards to Kong Oscars Fjord: 41, 375, 445, 471, 551, 989.

A. incurva (Pers.) Hale (Syn. *Parmelia incurva* (Pers.) Fr. (Hansen 2002) - W. Greenland, northwards to Inglefield Land: 178.

A. separata (Th. Fr.) Hale (Hansen 2000, 2002) - W. Greenland, Kangerlussuaq and different localities in Inglefield Land: 783.

Arctopeltis thuleana Poelt - The whole of W. Greenland: 478.

Arthrorhaphis alpina (Schaer.) R. Sant. (Hansen & Obermayer 1999) - All over Greenland: 844.

A. citrinella (Ach.) Poelt - All over Greenland: 342, 565, 981.

Aspicilia candida (Anzi) Hue (Syn. *A. nikrapensis* Darb., *Lecanora candida* (Anzi) Nyl.) (Esslinger & Egan 1995; Hansen 2001, 2002) - W. Greenland, northwards to Thule; N.E. Greenland, northwards to Romer Sø: 525, 777.

Baeomyces placophyllus Ach. - W. Greenland, northwards to Inglefield Land; E. Greenland, northwards to Romer Sø: 246.

B. rufus (Huds.) Rebent. - All over Greenland: 245.

Bellemerea alpina (Sommerf.) Clauzade & Cl. Roux (Syn. *Aspicilia alpina* (Sommerf.) Arnold) - W. Greenland, northwards to Disko-Nuussuaq; E. Greenland, northwards to Ittoqqortoormiit: 324.

Biatora vernalis (L.) Fr. (Syn. *Lecidea vernalis* (L.) Ach.) - All over Greenland: 212.

Brodoa oroarctica (Krog) Goward (Syn. *Hypogymnia oroarctica* Krog) - All over Greenland: 192, 953, 980, 998.

Bryocaulon divergens (Ach.) Kärnefelt (Syn. *Cornicularia divergens* Ach.) - All over Greenland, but rare in E. Greenland (Ittoqqortoormiit, Romer Sø): 125, 136, 140, 156, 209, 272, 328, 673, 707.

Bryoria chalybeiformis (L.) Brodo & D. Hawksw. (Syn. *Alectoria chalybeiformis* (L.) Gray) - All over Greenland, but most frequent in W. Greenland): 51, 118, 133, 307, 326, 415, 450, 518, 543, 593.

B. lanestris (Ach.) Brodo & D. Hawksw. - W. Greenland, northwards to Saqqaq: 890, 946.

B. nitidula (Th. Fr.) Brodo & D. Hawksw. (Syn. *Alectoria nitidula* (Th. Fr.) Vain.) - W. Greenland, northwards to Bonsall Øer, Inglefield Land: 20, 126, 194, 299, 357, 360, 367, 486, 522, 630, 880, 908, 919.

Buellia elegans Poelt (No. 596 has been distributed as "*Buellia epigaea* (Pers.) Tuck. v. *effigurata* (Schaer.) Zahlbr.") (Alstrup et al. 2000; Hansen 2001) - N. and N.E. Greenland: 756, 773.

B. insignis (Nägeli ex Hepp) Th. Fr. (Alstrup et al. 2000) - W. Greenland, northwards to Nuussuaq; E. Greenland, northwards to Bristol Plateau: 492.

Caloplaca alcarum Poelt (Hansen et al. 1987a) (Distributed as "10. *Caloplaca marina* Wedd.") - All over Greenland, northwards to Inglefield Land in W. Greenland and Jørgen Brønlund Fjord in E. Greenland: 10.

C. castellana (Räsänen) Poelt - All over Greenland: 641.

C. decipiens (Arnold) Blomb. & Forssell (Alstrup et al. 2000) - W. Greenland, northwards to Nuussuaq; E. Greenland, northwards to Campanuladal: 625.

C. fraudans (Th. Fr.) H. Olivier (Hansen et al. 1987a) - W. Greenland, northwards to Upernavik; E. Greenland, northwards to Romer Sø: 251, 633.

C. jungermanniae (Vahl) Th. Fr. - All over Greenland, but usually rather sparse on its habitats: 454, 901.

C. tominii L.I. Savicz (Hansen 2000) - Rare in both W. Greenland (Søndre Strømfjord, Disko-Nuussuaq, Inglefield Land) and E. Greenland (Kronprins Christian Land, Peary Land): 338, 455, 610, 722, 734.

Calvitimela aglaea (Sommerf.) Hafellner (Syn. *Tephromela aglaea* (Sommerf.) Hertel & Rambold) - W. Greenland, northern limit at Upernavik; C.E. and N.E. Greenland: . 2, 555.

C. armeniaca (DC.) Hafellner (Syn. *Tephromela armeniaca* (DC.) Hertel & Rambold) - All over Greenland: 150.

Candelariella arctica (Körb.) R. Sant. (Syn. *C. crenulata* (Wahlenb.) Zahlbr.) - W. Greenland, northwards to Disko-Nuussuaq: 248.

C. placodizans (Nyl.) H. Magn. - All over Greenland: 6, 161, 268, 309, 344, 427, 483, 535, 559, 786, 802, 825, 896.

Catapyrenium lachneum (Ach.) R. Sant. (Syn. *Dermatocarpon rufescens* (Ach.) Th. Fr.)(Breuss & Hansen 1988) - All over Greenland: 108, 648, 897.

Cephalophysis leucospila (Anzi) H. Kilias & Scheid. (Syn. *Lecidea ultima* Th. Fr.) (Hansen 2001) - N. and N.E. Greenland: 420.

Cetraria islandica (L.) Ach. - All over Greenland: 36, 53, 316, 359, 547, 691, 739, 840, 849, 883, 914, 963, 974, 977, 1021.

C. muricata (Ach.) Eckfeldt (Syn. *Coelocaulon muricatum* (Ach.) J.R. Laundon) - All over Greenland: 67, 857.

C. nigricans Nyl. - W. Greenland, with northern limit at Qaanaaq: 5, 91, 113, 255, 277, 395, 490, 885, 940.

C. sepincola (Ehrh.) Ach. - S.W. and S.E. Greenland; northern limit at c.66°N: 17, 271.

Cetrariella delisei (Bory ex Schaer.) Kärnefelt & A. Thell (Syn. *Cetraria delisei* (Bory ex Schaer.) Nyl.) (Kärnefelt, Mattsson & A. Thell 1993) - All over Greenland: 34, 55, 158, 197, 301, 319, 368, 378, 434, 449, 567, 581, 615, 689, 744, 812, 821, 841, 856, 882, 915, 959, 992, 1004.

Chaenotheca furfuracea (L.) Tibell (Syn. *Coniocybe furfuracea* (L.) Ach.) - All over Greenland except the northernmost areas: 242.

Cladonia acuminata (Ach.) Norrl. - W. Greenland, with northern limit at Prøven; Central E. Greenland: 138.

C. alaskana A. Evans (Hansen 1995b, 2002) - C.W. and N.W. Greenland: 785.

C. amaurocraea (Flörke) Schaer. - All over Greenland apart from N.E. Greenland north of Zackenberg: 54, 128, 132, 406, 697, 866.

C. arbuscula (Wallr.) Flot. subsp. ***arbuscula*** (Thomson 1984) - S.W. Greenland: 32, 210.

C. arbuscula subsp. ***mitis*** (Sandst.) Ruoss - All over Greenland apart from N. and N.E. Greenland: 27, 88, 381, 437, 568, 677, 711, 843, 855, 887, 913, 966, 984, 1022.

C. bellidiflora (Ach.) Schaer. - W. Greenland, with northern limit at Qaanaq; S.E. Greenland, northwards to Tasiilaq: 25, 164, 182, 376, 436, 447, 709, 917, 947, 987.

C. borealis S. Stenroos - All over Greenland apart from N. Greenland: 204, 538, 741, 858, 965.

C. cariosa (Ach.) Spreng. - All over Greenland apart from the northernmost areas: 104, 139, 262.

C. carneola (Fr.) Fr. - W. Greenland, northwards to Disko; S.E. Greenland, northwards to Tugtilik: 44, 703.

C. cenotea (Ach.) Schaer. (Hansen 1995b) - All over Greenland except N.E. Greenland: 634.

C. cornuta (L.) Hoffm. - All over Greenland except N. Greenland: 393, 654.

C. crispata (Ach.) Flot. - W. Greenland, northwards to Disko; S.E. Greenland, northwards to Tugtilik: 227, 233, 390, 655, 696, 710.

C. cyanipes (Sommerf.) Nyl. (Hansen 2002) - W. Greenland, northwards to Inglefield Land; E. Greenland, northwards to Kejser Franz Joseph Fjord: 111, 394, 517, 638.

C. ecmocyna Leight. - All over Greenland except the northernmost areas: 37, 114, 120, 369, 423, 540, 656, 701, 747, 870, 945, 976.

C. fimbriata (L.) Fr. s.lat. -W. Greenland, with northern limit at Qaanaq; E. Greenland, northwards to Traill Island: 278, 871.

C. gracilis (L.) Willd. (No. 216 = *C. gracilis* subsp. ***nigripes*** (Nyl.) Ahti) - All over Greenland except its northernmost parts: 216.

C. macroceras (Delise) Ahti - All over Greenland except the northernmost areas: 68, 231, 501.

C. macrophylla (Schaer.) Stenh. (Syn. *C. alpicola* (Flot.) Vain.) - All over Greenland except N. and N.W. Greenland: 30, 179, 234, 629.

C. macrophyllodes Nyl. (No. 409 has been distributed as "*Cladonia cervicornis* (Ach.) Flot.") (Hansen 2005) - W. Greenland, northwards to Uummannaq; E. Greenland, northwards to Lamberts Land: 174, 409, 441, 614, 683, 850, 978.

C. phyllophora Hoffm. (Hansen 1995b, 2005) (Syn. *C. degenerans* (Flörke) Spreng.) W. Greenland, northwards to Uummannaq; E. Greenland, northwards to Ittoqqortoortoomiut: 274, 639, 983.

C. pleurota (Flörke) Schaer. - All over Greenland except N. and N.E. Greenland: 26, 72.

C. pocillum (Ach.) O.J. Rich. - All over Greenland, even in Peary Land: 199, 346, 578, 606, 617, 719, 769, 775, 819.

C. pyxidata (L.) Hoffm. - All over Greenland: 63, 458, 554, 667, 941.

C. rangiferina (L.) F.H. Wigg. W. Greenland; E. Greenland (Revision of Greenland material of *Cladonia rangeferina* and *C. stygia* needed): 89.

C. squamosa Hoffm. (Hansen 2002) - W. Greenland, northwards to Inglefield Land; E. Greenland, northwards to Kejser Franz Joseph Fjord: 65.

C. stellaris (Opiz) Pouzar & Vězda - W. Greenland, northwards to Qeqertaq (Nuussuaq): 35, 56, 99, 135, 387, 407, 430, 442, 474, 505, 511, 521, 529, 652, 692, 837, 921, 961.

C. stricta (Nyl.) Nyl. (Syn. *C. lepidota* auct.) - All over Greenland except N. and N.E. Greenland north of c.75°N: 92, 236, 273, 279, 467.

C. stygia (Fr.) Ruoss - W. Greenland; S.E. Greenland: 29, 162, 386, 428, 446, 653, 694, 838, 851, 876, 928, 934, 968, 1013.

C. sulphurina (Michx.) Fr. (Syn. *C. gonecha* (Ach.) Asah.) - W. Greenland, northwards to Qaanaaq; E. Greenland, northwards to Ittoqqortoormiit: 50, 71, 84, 373, 742, 933.

C. trassii Ahti (No. 92, 236, 273, 279, 467, all identified as *C. stricta* (Nyl.) Nyl., belong to this taxon): 658, 746, 875, 944.

C. turgida Hoffm. - S.W. Greenland, northwards to c. 66°N: 533.

C. uncialis (L.) F.H. Wigg. - W. Greenland, northwards to Disko-Nuussuaq: E. Greenland, northwards to c.73°N: 28, 380, 451, 534, 690, 743, 1005.

Collema coccophorum Tuck. (Alstrup et al. 2000) - N.E. Greenland, Kronprins Christian Land: 624.

C. substellatum H. Magn. (Alstrup et al. 2000; Hansen 2001, 2002) - N., N.W. and N.E. Greenland, southwards to 79°N: 599, 758.

Dacampia hookeri (Borrer) A. Massal. - All over Greenland apart from S.E. Greenland: 751, 799.

Dactylina arctica (Hook. f.) Nyl. - All over W. Greenland, but rare towards the south: 100, 112, 122, 306, 488, 805, 820, 930.

D. ramulosa (Hook. f.) Tuck. - N. and N.W. Greenland, southwards to Disko; scattered in N.E. Greenland: 94, 116, 123, 289, 592, 806, 817, 909.

Dermatocarpon miniatum (L.) W. Mann - All over Greenland except N.W. Greenland: 259.

D. rivulorum (Arnold) Dalla Torre & Sarnth. - W. Greenland, northwards to Disko; E. Greenland, northwards to Ittoqqortoormiit: 252.

Dibaeis baeomyces (L. f.) Rambold & Hertel (Syn. *Baeomyces roseus* Pers.) - All over Greenland: 244.

Dimelaena oreina (Ach.) Norman - All over Greenland, but rare in S.E. Greenland: 726, 767.

Diploschistes muscorum (Scop.) R. Sant. - All over Greenland except S.E.

Greenland: 573, 597, 724.

Endocarpon pulvinatum Th. Fr. - All over Greenland, but rare in E. Greenland: 640.

Ephebe hispidula (Ach.) Horw. - W. Greenland, northwards to Disko; E. Greenland (Tasiilaq, Kronprins Christian Land): 675, 973.

E. lanata (L.) Vain. - W. Greenland, northwards to Disko; scattered distributed in E. Greenland (Tasiilaq, Ittoqqortoormiit, Kong Oscars Fjord): 189, 379.

Epilichen scabrosus (Ach.) Clem. (Hansen 2002) - W. Greenland, northwards to Upernavik; E. Greenland (Sermilik, Zackenberg, Kronprins Christian Land): 637.

Farnoldia jurana (Schaer.) Hertel - S.W. Greenland: 503.

Flavocetraria cucullata (Bellardi) Kärnefelt & A. Thell - All over Greenland: 16, 297, 317, 469, 508, 572, 822, 877, 907, 1008.

F. nivalis (L.) Kärnefelt & A. Thell - All over Greenland; extremely widespread: 15, 57, 159, 303, 318, 424, 468, 687, 814, 842, 867, 879, 906, 920, 958, 1003.

Fulgensia bracteata (Hoffm.) Räsänen - All over Greenland except S.W. and S.E. Greenland: 336, 577, 619, 754, 762.

Glypholecia scabra (Pers.) Müll. Arg. (Alstrup et al. 2000) - W. Greenland northwards to Maarmorilik; N.E. Greenland (Kronprins Christian Land, Peary Land): 595.

Gyalecta friesii (A. Massal.) Körb. (Hansen et al. 1987b) - W. Greenland, northwards to Disko: 239.

Hypogymnia austerodes (Nyl.) Räsänen - All over Greenland, but comparatively rare in E. Greenland: 11, 203, 413.

H. physodes (L.) Nyl. - W. Greenland, northwards to Inglefield Land; very rare in E. Greenland (Ittoqqortoormiit): 7, 258, 527, 999.

H. subobscura (Vain.) Poelt - All over Greenland: 784, 800.

Icmadophila ericetorum (L.) Zahlbr. - S.W. and S.E. Greenland: 253, 461, 662, 834.

Illosporium carneum Fr. - All over N. Greenland; more rare in E. Greenland: 643.

Ionaspis odora (Ach.) Th. Fr. (Syn. *I. suaveolens* (Schaer.) Th. Fr.) - S.W., N.W. and N.E. Greenland: 465, 580.

Lasallia pennsylvanica (Hoffm.) Llano (Syn. *Umbilicaria pennsylvanica* Hoffm.) - S.W. Greenland, northwards to Sisimiut . 232, 281, 668.

Lecanora argopholis (Ach.) Ach. - All over Greenland: 645, 852.

L. circumborealis Brodo & Vitik. (Syn. *L. coilocarpa* auct.) - S.W. Greenland: 276.

L. epibryon (Ach.) Ach. - All over Greenland . 217, 332, 462, 755.

L. geophila (Th. Fr.) Poelt (Syn. *L. pachythallina* Lynge) - All over Greenland apart from S.E. Greenland: 345, 571.

L. leptacina Sommerf. - W. Greenland, northwards to Disko; very rare in E. Greenland (Tasiilaq, Mikis Fjord, Ittoqqortoormiit): 186.

L. luteovernalis Brodo - C.W., N.W. and N.E. Greenland: 616, 796.

L. marginata (Schaer.) Hertel & Rambold (Syn. *Lecidea marginata* Schaer., *Lecidea elata* Schaer.; *Lecanora atromarginata* (H. Magn.) Hertel & Rambold possibly also belong to this taxon) (Thomson 1997) - All over Greenland: 339, 584, 626.

L. muralis (Schreb.) Rabenh. - S.W., W. and N.E. Greenland: 22.
L. polytropa (Hoffm.) Rabenh. - All over Greenland: 42, 190, 269, 586.
L. rupicola subsp. *arctoa* Leuckert & Poelt - Central W. Greenland (Disko): 167.
L. straminea Wahlenb. ex Ach. - W. Greenland, northwards to Nuussuaq; S.E. Greenland: 1, 60, 250.
L. swartzii (Ach.) Ach. (Syn. *L. subradiosa* Nyl.) - S.W. Greenland, northwards to Disko; N.E. Greenland: 145.
Lecidea atrobrunnea (Ramond ex Lam. & DC.) Schaer. - All over Greenland: 770.
L. ramulosa Th. Fr. - All over Greenland except S.E. Greenland: 765, 780, 797.
L. tessellata Flörke - All over Greenland: 794.
Lecidella bullata Körb. (Alstrup et al. 2000, Hansen 2001, 2002) - C.W., N.W., N. and N.E. Greenland: 621.
Lempholemma polyanthes (Bernh.) Malme (Syn. *L. myriococcum* (Ach.) Th. Fr.) - W. Greenland, northwards to Thule: 176.
Lepraria frigida J.R. Laundon. - Widely distributed in both W. and E. Greenland: 816, 931, 971.
L. neglecta (Nyl.) Erichsen (Syn. *Crocynia neglecta* (Nyl.) Hue) - All over Greenland: 83, 320.
Leprocaulon subalbicans (I.M. Lamb) I.M. Lamb & A.M. Ward - Widely distributed in both W. and E. Greenland: 219, 411, 544, 927, 938.
Leproloma vouauxii (Hue) J.R. Laundon (Syn. *Lepraria arctica* (Lynge) Wetmore) - All over Greenland except N.W. Greenland: 348, 598, 757.
Leptochidium albociliatum (Desm.) M. Choisy (Syn. *Polychidium albociliatum* (Desm.) Zahlbr.) - Central W. Greenland Disko): 175.
Leptogium lichenoides (L.) Zahlbr. (Hansen 2000) - All over Greenland: 795.
L. saturninum (Dicks.) Nyl. - W. Greenland, northwards to Maarmorilik; rare in E. Greenland (Tasiilaq, Tågefjord): 115, 214, 729.
Lichenomphalia hudsoniana (H.S. Jenn.) Redhead et al. (Syn. *Omphalina hudsoniana* (H.S. Jenn.) H.E. Bigelow, *Coriscium viride* (Ach.) Vain.) - All over Greenland; rare in E. Greenland (Isertoq near Tasiilaq): 452, 485, 537.
Lobaria scrobiculata (Scop.) P. Gaertn. - S.W. Greenland, northwards to Qasigiannguit: 137, 224.
Massalongia carnosa (Dicks.) Körb. - W. Greenland, with northern limit at Upernavik; rare in E. Greenland (Tasiilaq, Ittoqqortoormiit): 220, 487, 523, 665, 699.
Melanelia commixta (Nyl.) A. Thell (Syn. *Cetraria commixta* (Nyl.) Th. Fr.) - W. Greenland, northwards to Disko; S.E. Greenland; very rare in N.E. Greenland: 497.
M. hepatizon (Ach.) A. Thell (Syn. *Cetraria hepatizon* (Ach.) Vain.) - All over Greenland, but very rare in the northernmost areas: 193, 350, 546, 993.
M. infumata (Nyl.) Essl. (Syn. *Parmelia infumata* Nyl.) All over Greenland, even the high arctic areas: 77, 177, 607, 764, 905.
M. septentrionalis (Lynge) Essl. (Syn. *Parmelia septentrionalis* (Lynge) Ahti) - W. Greenland, northwards to Qaumarujuk at Maarmorilik: 180, 275, 660.
M. tominii (Oksner) Essl. - All over W. Greenland; N.E. Greenland: 604.
Micarea assimilata (Nyl.) Coppins (Syn. *Lecidea assimilata* Nyl.) All over Greenland: 172, 247, 401.

Miriquidica atrofulva (Sommerf.) A.J. Schwab & Rambold (Syn. *Lecidea atrofulva* Sommerf.) - W. Greenland, northwards to Upernavik; more rare or neglected in E. Greenland (Tasiilaq): 426.

M. leucophaea (Flörke ex Rabenh.) Hertel & Rambold (Syn. *Lecidea leucophaea* (Flörke ex Rabenh.) Th. Fr.) -W. Greenland, northwards to Nuussuaq; all over E. Greenland: 185.

Mycoblastus alpinus (Fr.) Th. Fr. ex Hellb. - W. Greenland, northwards to Disko; S.E. Greenland (Tasiilaq): 706.

Myxobilimbia lobulata (Sommerf.) Hafellner. - All over Greenland: 766, 861, 997.

Nephroma arcticum (L.) Torss. - W. Greenland, northwards to Nuussuaq; rare in S.E. Greenland (Qaartuluk, Tasiilaq): 33, 86, 181, 183, 370, 388, 472, 514, 532, 664, 700, 748, 830, 832, 922, 967.

N. bellum (Spreng.) Tuck. - S.W. Greenland, northwards to Sisimiut; very rare in S.E. Greenland (Skjoldungen): 661.

N. expallidum (Nyl.) Nyl. - W. Greenland, northwards to Prøven (c.72°N); rare in E. Greenland (Kong Oscars Fjord): 98, 282, 416, 489, 731.

N. parile (Ach.) Ach. - W. Greenland, northwards to Svartenhuk Peninsula; S.E. Greenland, northwards to Tugtilik: 109, 235, 280, 684, 1018.

Ochrolechia frigida (Sw.) Lynge (including *O. lapuënsis* (Vain.) Räsänen) - All over Greenland: 24, 412, 833, 846, 900, 964.

O. grimmiae Lynge - All over Greenland; rare in E. Greenland (Tasiilaq, Tugtilik): 46, 163, 698.

O. tartarea (L.) A. Massal. - S.W. Greenland; rare in S.E. Greenland: 500, 1017.

U. upsaliensis (L.) A. Massal. - All over Greenland: 732.

Ophioparma ventosa (L.) Norman (Syn. *Haematomma ventosum* (L.) A. Massal.) - All over Greenland except the northernmost areas: 631.

Orphniospora moriopsis (A. Massal.) D. Hawksw. (Syn. *Buellia atrata* (Sm.) Anzi) - All over Greenland: 146, 372, 460, 889, 1023.

Parmelia fraudans (Nyl.) Nyl. - W. Greenland, northwards to Disko: 121.

P. omphalodes (L.) Ach. - All over Greenland, but rare in N. and N.E. Greenland: 804.

P. saxatilis (L.) Ach. - All over Greenland, but rare in N. and N.E. Greenland: 19, 195, 385, 484, 847, 954, 986.

P. sulcata Taylor - All over Greenland except N. and N.E. Greenland: 12, 672, 952, 1000.

Parmeliopsis ambigua (Wulfen) Nyl. - W. Greenland, northwards to Qasigiannguit; rare in E. Greenland (Tasiilaq, the inner part of Scoresby Sund): 223, 396.

P. hyperopta (Ach.) Arnold - S.W. Greenland; rare in S.E. Greenland (Skjoldungen): 257.

Peltigera aphthosa (L.) Willd. - All over Greenland, but rare to the north (the Greenland material of *Peltigera is* at present under revision): 13, 81, 392, 429, 569, 659, 725, 937, 1020.

P. canina (L.) Willd. - All over Greenland except N. and N.E. Greenland: 62, 73, 513, 545, 730.

P. collina (Ach.) Röhl. (Syn. *P. scutata* (Dicks.) Duby) - W. Greenland, northwards to Disko: 493.

P. didactyla (With.) J.R. Laundon (Syn. *P. spuria* (Ach.) DC.) - All over Greenland: 74, 399, 643, 892.

P. kristinssonii Vitik. - W. and E. Greenland, but rare to the north: 682.

P. leucophlebia (Nyl.) Gyeln. - All over Greenland, but rare to the north: 198, 453, 470, 516, 594, 736, 801, 808, 936.

P. malacea (Ach.) Funck - All over Greenland except N. and N.E. Greenland north of 75°N: 52, 865.

P. polydactylon (Neck.) Hoffm. - W. and E. Greenland, but lacking in the northernmost areas: 960.

P. rufescens (Weiss) Humb. - All over Greenland. The species is the only *Peltigera* occurring in the extreme high arctic part of Greenland (Vitikainen 1994): 335, 566, 712, 750, 772.

P. scabrosa Th. Fr. - W. Greenland, northwards to Siorapaluk; S.E. Greenland: 391, 475, 548.

P. venosa (L.) Baumg. - All over Greenland except N. Greenland: 206, 418.

Pertusaria coriacea (Th. Fr.) Th. Fr. - All over Greenland: 201, 539, 557.

P. dactylina (Ach.) Nyl. - All over Greenland except N. Greenland: 205, 457.

P. oculata (Dicks.) Th. Fr. - All over Greenland except N. Greenland: 261, 398, 448, 476, 686, 749, 869.

Phaeocalicium compressulum (Nyl. ex Vain.) A.F.W. Schmidt - S.W. Greenland, northwards to c. 66°N: 222.

Phaeophyscia constipata (Norrl. & Nyl.) Moberg. - W. Greenland, northwards to Maarmorilik; N.E. Greenland: 716.

P. sciastra (Ach.) Moberg - All over Greenland: 926.

Physcia caesia (Hoffm.) Fürnr. (Moberg & Hansen 1986) - All over Greenland, even the extreme high arctic areas: 243, 579, 718, 982.

P. dubia (Hoffm.) Lettau - All over Greenland: 635, 671, 717, 782, 873.

P. tenella (Scop.) DC. - W. Greenland, northwards to Ummannaq; rare in S.E. Greenland (Tasiilaq): 649.

Physconia detersa (Nyl.) Poelt - W. Greenland, northwards to Disko-Nuussuaq: 144.

P. muscigena (Ach.) Poelt (Moberg & Hansen 1986) - All over Greenland, even the high arctic areas: 78, 211, 331, 340, 477, 720, 763, 779, 807.

Pilophorus dovrensis (Nyl.) Timdal, Hertel & Rambold (Syn. *Lecidea pallida* Th. Fr.) - W. Greenland, northwards to Disko; E. Greenland, northwards to Kong Oscars Fjord: 169, 249.

Placopsis gelida (L.) Linds. - All over Greenland except its northernmost parts: 207.

Placynthium asperellum (Ach.) Trevis. - All over Greenland: 642, 899.

P. subradiatum (Nyl.) Arnold (Alstrup et al. 2000) - Rare in N.E. Greenland: 620.

Platismatia glauca (L.) W.L. Culb. & C.F. Culb. - S.W. Greenland, northwards to Nuuk: 254, 496, 693.

Polychidium muscicola (Sw.) Gray (Hansen 2002, 2005) - W. Greenland, northwards to Ummannaq; all over E. Greenland except its northernmost parts: 674.

Porpidia flavocaerulescens (Hornem.) Hertel & A.J. Schwab - All over W. Greenland; S.E. Greenland: 969.

P. macrocarpa (DC.) Hertel & A.J. Schwab - All over Greenland except its northernmost parts: 165.

P. melinodes (Körb.) Gowan & Ahti - All over Greenland: 291, 351, 371, 550, 670.

Protoblastenia calva (Dicks.) Zahlbr. - All over W. Greenland; N.E. Greenland: 622.

P. rupestris (Scop.) J. Steiner - All over Greenland except N.W. Greenland: 352.

P. terricola (Anzi) Lynge - All over Greenland except S.W. and S.E. Greenland: 774.

Protoparmelia badia (Hoffm.) Hafellner - All over Greenland except N. Greenland: 644.

Pseudephebe minuscula (Nyl. ex Arnold) Brodo &D. Hawksw. (Syn. *Alectoria minuscula* (Nyl. ex Arnold) Degel.) - All over Greenland: 296, 321, 365, 432, 564, 587, 789, 809, 828, 848, 853, 912.

P. pubescens (L.) M. Choisy (Syn. *Alectoria pubescens* (L.) R. Howe) - All over Greenland, but rare in N. Greenland: 40, 148, 215, 404, 541, 676, 1016.

Psora decipiens (Hedw.) Hoffm. - All over Greenland: 583, 771.

P. rubiformis (Ach.) Hook. (Syn. *Lecidea rubiformis* (Ach.) Wahlenb.) - All over Greenland: 79, 107, 147, 310, 343, 558, 609, 618, 714, 787.

P. vallesiaca (Schaer.) Timdal (Syn. *P. albilabra* (Dufour) Körb.) - S.W., N.W. and N.E. Greenland: 337.

Psoroma hypnorum (Vahl) Gray - All over Greenland, but rare in more northern parts of Greenland, where the species often is replaced by *Psoroma tenue* Henssen: 23, 226, 845, 955, 988.

Psorula rufonigra (Tuck.) Gotth. Schneid. (Syn. *Lecidea rufonigra* (Tuck.) Nyl.) - S.W. Greenland (Narssarsuaq; Kangerlussuaq): 456.

Rhagadostoma lichenicola (De Not.) Keissl. - All over Greenland except N. and N.E. Greenland (vide *Solorina crocea*): 602, 685, 859.

Rhizocarpon atroflavescens Lynge- N.E. Greenland (Peary Land, Kronprins Christian Land): 334.

R. bolanderi (Tuck.) Herre - W. Greenland, northwards to Upernavik: 124.

R. geminatum Körb. (Syn. *R. disporum* auct. non (Nägeli ex Hepp) Müll. Arg.) - All over Greenland: 238, 419, 504, 776, 902.

R. geographicum (L.) DC. - All over Greenland: 58, 184, 191, 327, 362, 650, 733, 950.

R. grande (Flörke) Arnold (Hansen 2001)- All over Greenland except N. Greenland: 61.

R. inarense (Vain.) Vain. - All over W. Greenland; more rare in E. Greenland (the fjords around Tasiilaq; Ittoqqortoormiit, Romer Sø): 438.

R. praebadium (Nyl.) Zahlbr. - All over Greenland: 613.

R. pusillum Runemark - Central and northernmost parts of Greenland: 295, (333), 760.

R. superficiale subsp. *boreale* Runemark (Syn. *R. crystalligenum* Lynge) - All over Greenland: 3, 382, 605.

Rhizoplaca chrysoleuca (Sm.) Zopf (Syn. *Lecanora rubina* (Vill.) Ach.) - W. Greenland, northwards to Maarmorilik: 80, 130, 715.

R. melanophthalma (DC.) Leuckert & Poelt (Syn. *Lecanora melanophthalma* (DC.) Ramond) - All over Greenland: 76, 363, 491, 560, 582, 611, 727.

Santessoniella arctophila (Th. Fr.) Henssen (Syn. *Parmeliella arctophila* (Th. Fr.) Malme) - Disko: 153.

Solorina bispora Nyl. - All over Greenland: 202, 417.

S. crocea (L.) Ach. - All over Greenland except N. and N.E. Greenland north of 75°N: 39, 85, 322, 439, 524, 602, 663, 685, 831, 859, 975.

S. octospora Arnold - W. Greenland, northwards to Disko; between 71°N and 75°N in E. Greenland: 97, 646.

S. saccata (L.) Ach. (Hansen 2001, 2002) - All over Greenland except S.E. Greenland: 479.

Sphaerellothecium cladoniicola E.S. Hansen & Alstrup (Hansen & Alstrup 1995) - All over Greenland except N. and N.E. Greenland north of c. 70°N: 552, 851.

Sphaerophorus fragilis (L.) Pers. - W. Greenland, northwards to Thule; E. Greenland, northwards to Lambert Land: 45, 59, 263, 313, 364, 384, 868, 898, 956.

S. globosus (Huds.) Vain. - All over W. Greenland; E. Greenland, northwards to Lambert Land: 38, 64, 166, 293, 536, 704, 738, 957, 979, 874, 1007.

Sporastatia polyspora (Nyl.) Grummann (Syn. *S. cinerea* (Schaer.) Körb.) - All over Greenland: 157, 480.

S. testudinea (Ach.) A. Massal. - All over Greenland: 149, 294, 333, 347, 563, 589, 759.

Stereocaulon alpinum Laurer - All over Greenland, but rare in N. and N.E. Greenland north of 75°N: 8, 170, 187, 349, 421, 510, 531, 601, 705, 737, 829, 854, 888, 916, 996, 1012, 1019.

S. arcticum Lynge (Distributed as "49. *Stereocaulon vesuvianum* Pers") (Lamb 1977, Hansen 2005) - W. Greenland, northwards to Uummannaq: 49, 292, 355, 528, 860.

S. arenarium (L.I. Savicz) I.M. Lamb - All over Greenland: 213, 400, 811, 991.

S. botryosum Ach. - All over Greenland; common in W. Greenland, but more sparsely distributed in E. Greenland: 208, 440, 632, 792.

S. condensatum Hoffm. - All over Greenland except S.E. Greenland: 173, 481, 728, 923.

S. cumulatum (Sommerf.) Timdal (Syn. *Toninia cumulata* (Sommerf.) Th. Fr.) - All over Greenland : 482.

S. glareosum (L.I. Savicz) H. Magn. (Hansen 2002) - All over Greenland apart from the northernmost part of E. Greenland: 129, 154, 241, 526, 574, 815, 864, 985.

S. paschale (L.) Hoffm. - W. Greenland, northwards to Disko; E. Greenland, northwards to Kong Oscars Fjord: 69, 228, 237, 389, 443, 512, 530, 657, 695, 735, 839, 935.

S. rivulorum H. Magn. - All over Greenland: 341, 499, 588.

S. tomentosum Fr. - W. Greenland, northwards to Disko: 218.

S. vesuvianum Pers. - All over Greenland except N. and N.E. Greenland: 70, 134, 678.

Thamnolia vermicularis (Sw.) Schaer. (including *T. subuliformis* (Ehrh.) W.L. Culb.) - All over Greenland: 101, 509, 570, 612, 781, 911, 995, 1006, 1015.

Toninia arctica Timdal (Timdal 1991) - All over Greenland except S.W. and S.E. Greenland: 585,623,761,798.

T. sedifolia (Scop.) Timdal (Syn. *T. caeruleonigricans* (Lightf.) Th. Fr.) (Timdal 1991) - All over Greenland, but rare in S.E. Greenland: 110, 260, 329.

Trapeliopsis granulosa (Hoffm.) Lumbsch. (Syn. *Lecidea granulosa* (Hoffm.) Ach.) - W. Greenland, northwards to Qaanaaq; rare in S.E. Greenland: 225, 627, 666, 740.

Tremolecia atrata (Ach.) Hertel (Syn. *Lecidea Dicksonii* auct.) - All over Greenland: 43, 290, 311, 803.

Umbilicaria arctica (Ach.) Nyl. - All over Greenland, but rare in the extreme high arctic areas: 47, 131, 200, 374, 872, 894, 943, 949, 990, 1011.

U. cinereorufescens (Schaer.) Frey - S.W. Greenland, northwards to Disko: 127, 549.

U. cylindrica (L.) Delise ex Duby (Some collections, for example, No. 105 and 285, come very close to *Umbilicaria virginis* Schaer.) - All over Greenland: 66, 82, 105, 285, 433, 603, 951.

U. decussata (Vill.) Zahlbr. (Syn. *Omphalodiscus decussatus* (Vill.) Schol.) - All over Greenland: 103, 354, 810, 904.

U. deusta (L.) Baumg. - W. Greenland, northwards to Qaanaaq; E. Greenland, northwards to Kong Oscars Fjord: .106, 119, 553, 970.

U. havaasii Llano - W. Greenland, northwards to Disko-Nuussuaq: 4, 270, 414, 679.

U. hyperborea (Ach.) Hoffm. - All over Greenland, but rare in the northernmost areas: 95, 519, 590, 707, 863, 994.

U. lyngei Schol. (Syn. *Agyrophora lyngei* (Schol.) Llano - All over Greenland: 9, 96, 143, 264, 304, 507, 576, 713, 790, 823, 827, 884.

U. nylanderiana (Zahlbr.) H. Magn. (Hansen 2002, 2004) - C.W. and N.W. Greenland: 1010.

U. polyphylla (L.) Baumg. - W. Greenland, northwards to Disko; S.E. Greenland: 680.

U. proboscidea (L.) Schrad. - All over Greenland: 90, 266, 283, 288, 300, 314.

U. rigida (Du Rietz) Frey (Syn. *Agyrophora rigida* (Du Rietz) Llano) - All over Greenland, but rare in E. Greenland: 402.

U. torrefacta (Lightf.) Schrad. (Hansen 2001) - All over Greenland: 160, 240, 267, 410, 444.

U. vellea (L.) Hoffm. - All over Greenland except N. and N.E. Greenland: 14, 229, 353, 494, 515, 939.

U. virginis Schaer. (Syn. *Omphalodiscus virginis* (Schaer.) Schol.) - All over Greenland: 188, 286, 308, 315, 818, 862, 895, 942, 972.

Usnea sphacelata R. Br. (Syn. *Neuropogon sulphureus* (J. König) Elenkin) - All over Greenland, at higher elevations in S. Greenland. Max. altitude c. 1700 m a.s.l: 102, 152, 284, 287, 325, 466, 562, 591.

Varicellaria rhodocarpa (Körb.) Th. Fr. - S.W. Greenland, northwards to c.66°N: 221.

Verrucaria mucosa Wahlenb. - W. Greenland, northwards to Disko; S.E. Greenland: 117.

V. thalassina (Zahlbr.) Zschacke - S.W. and C.E. Greenland, very rare: 502.

Vulpicida pinastri (Scop.) J.-E. Mattsson & M.-J. Lai (Syn. *Cetraria pinastri* (Scop.) Gray) (Mattsson 1993) - S.W Greenland, northwards to c. 66°N: 230.

V. tilesii (Ach.) J.-E. Mattson & M.-J. Lai (Syn. *Cetraria tilesii* Ach.) - N., N.W. and N.E. Greenland: 463.

Xanthoria borealis R. Sant. & Poelt - All over Greenland, even the extreme high arctic areas: 48, 75, 366, 708, 824.

X. elegans (Link) Th. Fr. - All over Greenland, one of the most common epilithic lichens even in the high arctic areas: 21, 93, 155, 305, 330, 561, 575, 723, 725, 768, 778, 826, 903.

X. elegans var *splendens* (Darb.) M.S. Christ. ex Poelt (Alstrup et al. 2000, Hansen 2001, 2002) - N.W., N.E. and N. Greenland: 608, 793.

X. fulva (Hoffm.) Poelt & Petut. (Hansen 2003) - C.W. Greenland (Kangerlussuaq): 925.

X. sorediata (Vain.) Poelt - All over Greenland, but usually less frequent and in smaller quantities at its localities than *Xanthoria elegans:* 459, 600.

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MYCOTAXON

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Index of Lichenes Danici Exsiccati fascicles I-XX with notes on distribution of the taxa in Denmark

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Abstract - The present list of lichens (and a few lichenicolous fungi) contains 161 lichen taxa, which have been distributed from the Botanical Museum, University of Copenhagen, in the period 1995 to 2006. The series, "Lichenes Danici Exsiccati", comprises 20 fascicles in all and includes lichen collections from most parts of Denmark. The exsiccate has from the beginning been edited and arranged by the author of this paper. The 20 fascicles comprise the following numbers: I: 1-25; II: 26-50; III: 51-75; IV: 76-100; V: 101-125; VI: 126-150; VII: 151-175; VIII: 176-200; IX: 201-225; X: 226-250; XI: 251-275; XII: 276-300; XIII: 301-325; XIV: 326-350; XV: 351-375; XVI: 376-400; XVII: 401-425; XVIII: 426-450; XIX: 451-475; XX: 476-505. Notes on the current frequency and distribution of all Danish taxa are also provided.

Introduction

The 161 issued lichens are listed alphabetically together with some synonyms. Nomenclature follows Santesson et al. (2004) and Index Fungorum. Information on the frequency and distribution of all Danish taxa is provided with distributions abbreviated as noted in Table 1 (Søchting & Alstrup 2002; see also fig 1.).The exsiccate specimens were collected over a 70 year period, from 1936 to 2006. Collecting localities are mapped on fig. 2.

Table 1. Abbreviations: Distribution of exsiccate collecting localities in Denmark

SJ	South Jutland	LFM	Lolland, Falster, & Mon
EJ	East Jutland	SZ	South Zealand
WJ	West Jutland	NWZ	Northwest Zealand
NWJ	Northwest Jutland	NEZ	Northeast Zealand
NEJ	Northeast Jutland	NZ	North Zealand (NEZ+NWZ)
NJ	North Jutland (NEJ+NWJ)	Z	Zealand (NWZ+NEZ+SZ)
MJ	Central Jutland (EJ+WJ)	Ø	The islands (Z+F+LFM)
J	Jutland (NEJ+NWJ+WJ+EJ+SJ)	B	Bornholm
F	Funen and surrounding islands	A	Anholt

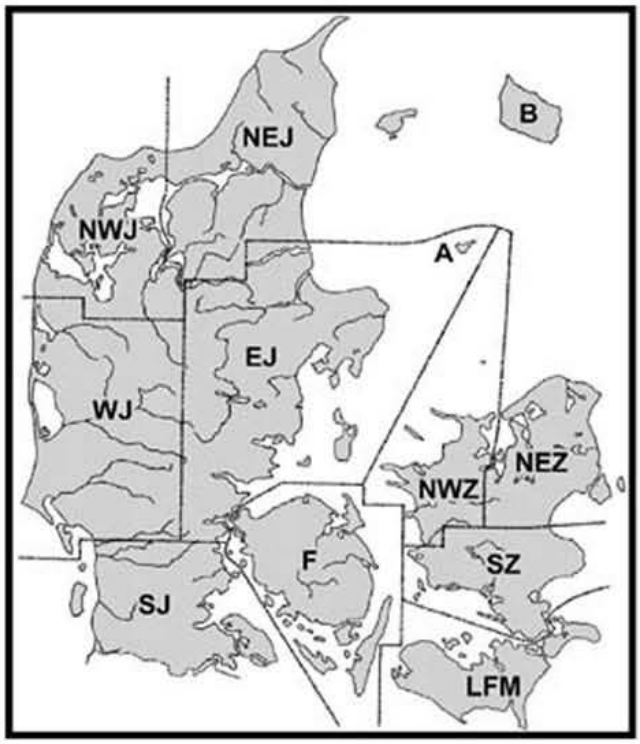

Fig.1. Map of Denmark showing the subdivision in the regions mentioned for the taxa in the species list.

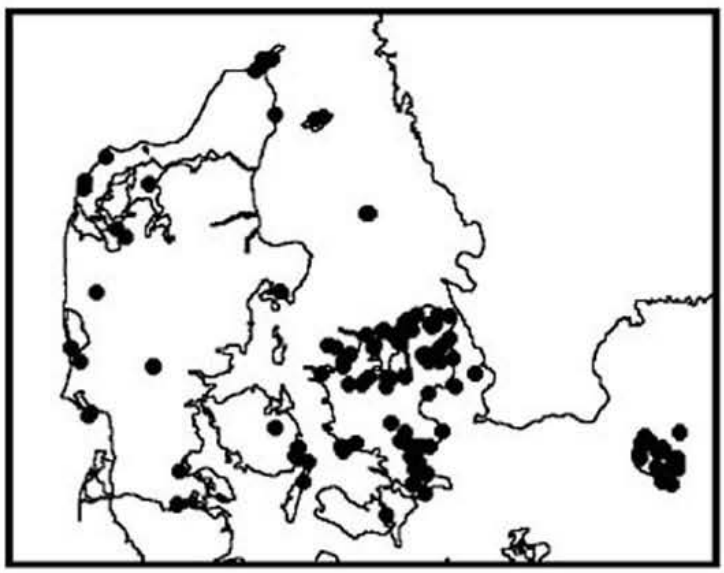

Fig.2. Map of Denmark showing the localities, where the 505 numbers of "Lichenes Danici Exciccati" were collected.

Species list

Amandinea punctata (Hoffm.) Coppins & Scheid. (Syn.: *Buellia punctata* (Hoffm.) A. Massal.) - B,Ø,J; common: 25, 56, 133, 360, 378, 397, 426, 505.

Anaptychia ciliaris var. ***melanosticta*** (Ach.) Harm. - B; rare: 2.

A. runcinata (With.) J. R. Laundon (Syn.: *A. fusca* (Huds.) Vain.) - B,NZ,NEJ; rare: 85.

Arthonia radiata (Pers.) Ach. - B,Ø,J; common: 254.

Bacidia rubella (Hoffm.) A. Massal. - B,Ø,SJ,MJ,NEJ; common: 70.

Baeomyces rufus (Huds.) Rebent. - B,Ø,J; common: 479.

Calicium adspersum Pers. - SZ,NEZ,F,LFM,SJ,EJ,NEJ; endangered: 51.

C. viride Pers. - B,Ø,J; common: 44, 190.

Caloplaca alstrupii Søchting - NEZ; distribution unknown: 126.

C. citrina (Hoffm.) Th. Fr. - B,Ø,J; spreading: 64.

C. holocarpa (Hoffm. ex Ach.) A. E. Wade - B,Ø,J; common: 444.

C. marina (Wedd.) Zahlbr. - B,Z,F,EJ,NEJ; common: 122.

C. thallincola (Wedd.) Du Rietz - B,NWZ,EJ,NEJ; common: 151.

Candelaria concolor (Dicks.) Stein - B,Ø,J; common: 424.

Candelariella vitellina (Hoffm.) Müll. Arg. - B,Ø,J; common: 155.

Cetraria aculeata (Schreb.) Fr. - B,Ø,J; common: 38, 100, 241, 416, 443, 454, 463.

C. islandica subsp. ***crispiformis*** (Räsänen) Kärnefelt - B,Ø,J; common: 227, 301.

C. islandica (L.) Ach. subsp. ***islandica*** – B,Ø,J; common: 119, 226, 244, 467.

C. muricata (Ach.) Eckfeldt - B,Ø,J; common: 37, 109, 202, 473.

Chaenotheca chlorella (Ach.) Müll. Arg. - SZ,NEZ,F,EJ,NJ; vulnerable: 229.

C. ferruginea (Turner ex Sm.) Mig. - B,Ø,J; common: 86, 106, 218, 273, 280, 282, 471.

Chrysothrix candelaris (L.) J.R. Laundon - B,Ø,J; common: 274.

Cladonia arbuscula (Wallr.) Flot. subsp. ***arbuscula*** - B,Ø,J; common: 197.

C. arbuscula subsp. ***mitis*** (Sandst.) Ruoss - B,Ø,J; common: 364, 437.

C. arbuscula subsp. ***squarrosa*** (Wallr.) Ruoss - B,Ø,J; common: 16, 98, 108, 207, 417.

C. caespiticia (Pers.) Flörke - Ø,J; common: 484.

C. cervicornis (Ach.) Flot. subsp. ***cervicornis*** - B,Ø,J; common: 249.

C. chlorophaea (Flörke ex Sommerf.) Spreng. - B,Ø,J; common: 96, 407, 481.

C. ciliata Stirt. f. ***ciliata*** – MJ,NWJ; rare: 99.

C. ciliata f. ***flavicans*** (Flörke) Ahti & De Priest (Syn.: *C. tenuis* (Flörke) Harm.) - B,Ø,J; common: 179, 194, 206, 236, 278, 284, 318, 326, 381, 384, 409, 412, 436, 452, 462, 477.

C. coniocraea (Flörke) Spreng. - B,Ø,J; common: 41, 413.

C. crispata (Ach.) Flot. - B,Ø,J; common: 441.

C. cryptochlorophaea Asahina - SJ,EJ,NJ; rare: 89.

C. digitata (L.) Hoffm. - B,Ø,J; common: 53, 306, 414.

C. diversa Asperges - status B,EJ; distribution unknown: 111, 139, 191, 203, 240, 386.

C. fimbriata (L.) Fr. - B,Ø,J; common: 67, 125, 162, 313, 405, 501.

C. floerkeana (Fr.) Flörke - B,Ø,J; common: 112, 172, 213, 387.

C. foliacea (Huds.) Willd. - B,Ø,J; common: 13, 79, 93, 196, 201, 238, 363, 388, 439, 459.

C. furcata (Huds.) Schrad. - B,Ø,J; common: 14, 55, 83, 132, 166, 167, 192, 210, 211, 234, 239, 251, 270, 296, 319, 327, 382, 408, 442, 455, 464, 474.

C. glauca Flörke - B,Ø,J; common: 33, 94, 204, 235, 245, 268.
C. gracilis (L.) Willd. subsp. *gracilis* - B,Ø,J; common: 28, 107, 110, 170, 178, 193, 208, 243, 366, 415, 438.
C. humilis (With.) J.R. Laundon - NEZ,F,LFM,MJ,NJ; rare: 134, 390.
C. macilenta Hoffm. - B,Ø,J; common: 40, 73.
C. merochlorophaea var. *novochlorophaea* Sipman - B,F,J; common: 115, 195, 277, 279.
C. ochrochlora Flörke - Ø,J; common: 68, 186, 215, 250, 332, 489.
C. polydactyla (Flörke) Spreng. - B,Ø,J; common: 54, 137, 291, 406, 490.
C. portentosa (Dufour) Coem. - B,Ø,J; common: 18, 45, 74, 118, 171, 297, 365, 370, 476.
C. pyxidata (L.) Hoffm. - B,Ø,J; common: 103.
C. ramulosa (With.) J. R. Laundon (Syn.: *C. pityrea* (Flörke) Fr.) - B,Ø,J; common: 47, 214, 299, 451, 466.
C. rangiferina (L.) Weber ex F. H. Wigg. - B,Ø,J; common: 15.
C. rangiformis Hoffm. - B,Ø,J; common: 48, 209, 253, 292, 375, 389.
C. scabriuscula (Delise) Nyl. - B,Ø,J; common: 46, 87, 97, 116, 237, 475.
C. squamosa Hoffm. - B,Ø,J; common: 84, 198.
C. subulata (L.) Weber ex F. H. Wigg. (Syn.: *C. cornutoradiata* (Coem.) Sandst.) - B,Ø,J; common: 95, 138, 465.
C. uncialis (L.) Weber ex F.H. Wigg. subsp. *uncialis* - B,Ø,J; common: 29, 113, 140, 157, 168, 205, 242, 367, 410, 440, 453, 460.
C. zopfii Vain. - B,LFM,NWZ,MJ,NJ; common: 30, 300, 383.
Cliostomum griffithii (Sm.) Coppins (Syn.: *Catillaria griffithii* (Sm.) Malme) - B,Ø,J; common: 36, 62, 266, 310, 494.
Collemopsidium sublitorale (Leight.) Grube & B.D. Ryan (Syn.: *Pyrenocollema sublitorale* (Leight.) R.C. Harris ex A. Fletcher) – NEZ,SJ,EJ; rare: 52.
Evernia prunastri f. *herinii* (P.A. Duvign.) D. Hawksw. - F,NEZ; rare: 72, 105, 180.
E. prunastri (L.) Ach. f. *prunastri* - B,Ø,J; common: 39, 165, 252, 259, 287, 303, 333, 480, 493.
Flavocetraria nivalis (L.) Kärnefelt & A. Thell - B,LFM,Z,MJ,NJ; rare: 101.
Graphis scripta (L.) Ach. - B,Ø,J; common: 257.
Haematomma ochroleucum var. *porphyrium* (Pers.) J.R. Laundon – B,Ø,EJ,NEJ; spreading: 161, 272, 314, 335, 337, 396, 421, 492, 504.
Hypocenomyce scalaris (Ach.) M. Choisy - B,Ø,EJ,NEJ; spreading: 23, 58, 188, 411, 420, 472.
Hypogymnia physodes (L.) Nyl. - B,Ø,J; common: 60, 104, 114, 173, 199, 233, 293, 368, 385.
H. tubulosa (Schaer.) Hav. - B,Ø,J; common: 31, 174, 304.
Imshaugia aleurites (Ach.) S.L.F. Mey. (Syn.: *Parmeliopsis aleurites* (Ach.) Nyl.) - B,Ø,MJ,NEJ; rare: 69.
Lasallia pustulata (L.) Mérat - B,NEJ; endangered: 17, 141, 176.
Lecanactis abietina (Ach.) Körb. - F,J; rare: 231.
Lecanora argentata (Ach.) Malme - B,Ø,J; rare: 129, 255, 308, 328.
L. chlarotera Nyl. - B,Ø,J; common: 286, 353.
L. conizaeoides Nyl. ex Cromb. - B,Ø,J; spreading: 20, 135, 224.
L. dispersa (Pers.) Röhl. - B,Ø,J; common: 65.

L. expallens Ach. - B,Ø,J; spreading: 42, 330, 401, 403, 419.
L. glabrata (Ach.) Malme - B,NEZ,MJ,NEJ; rare: 376.
L. polytropa (Ehrh. ex Hoffm.) Rabenh. - B,Ø,J; common: 153.
L. rupicola (L.) Zahlbr. - B,Ø,J; common: 150.
L. sp. - 377.
L. xanthostoma Cl. Roux ex Fröberg – NEZ,EJ,NEJ; rare: 276.
Lecidella achristotera (Nyl.) Hertel & Leuckert - B,Ø,J; common: 434.
L. elaeochroma (Ach.) M. Choisy - B,Ø,J; common: 131, 185, 187, 221, 263, 355, 447.
L. euphorea (Flörke) Hertel - LFM,Z,MJ,NEJ; rare: 262.
Lepraria incana (L.) Ach. - B,Ø,J; common: 102, 189, 217, 281, 283, 288, 316, 317, 341, 351, 357, 391, 404, 418.
Leproloma membranaceum (Dicks.) Vain. - B,NEJ; rare: 148.
Leptogium lichenoides (L.) Zahlbr. - B,Ø,J; rare: 11.
Lichen sp. - 491.
Lichenoconium xanthoriae M.S.Christ. - B,Ø,J (?); common: 66.
Melanelixia fuliginosa (Fr. ex Duby) O. Blanco et al. subsp. *fuliginosa* - B,Ø,J; common: 152.
M. fuliginosa subsp. *glabratula* (Lamy) J.R. Laundon - B,Ø,J; common: 373, 379, 435, 485, 143, 225, 256, 320.
M. subaurifera (Nyl.) O. Blanco et al. - B,Ø,J; common: 309, 488.
Micarea denigrata (Fr.) Hedl. - B,Z,F,J; common: 285.
Nephroma laevigatum Ach. - B,SZ,NEZ,FJ; vulnerable: 4, 10.
Ochrolechia frigida (Sw.) Lynge - B,J; rare: 181.
O. microstictoides Räsänen - NEZ,NEJ; distribution unknown: 35.
O. turneri (Sm.) Hasselrot - Z,J; common: 123.
Opegrapha atra Pers. - B,Ø,J; common: 354.
O. niveoatra (Borrer) J.R. Laundon - B,Ø,J; rare: 352.
O. rufescens Pers. - B,Ø,SJ,EJ,NEJ; rare: 216, 275, 339.
O. varia Pers. - B,Ø,J; common: 267.
Parmelia omphalodes (L.) Ach. - B,NJ,A; rare: 12, 149, 298.
P. saxatilis (L.) Ach. - B,Ø,SJ,MJ,NEJ; common: 8, 78, 145, 169, 307, 334, 342, 422.
P. sulcata Taylor - B,Ø,J; common: 22, 88, 92, 219, 329, 331, 345, 371, 428, 486, 497.
Parmelina pastillifera (Harm.) Hale (distributed as *Parmelina tiliacea* (Hoffm.) Hale) - B,SZ; endangered: 3 (Hansen 2005).
Parmeliopsis hyperopta (Ach.) Arnold (Syn.: *Foraminella hyperopta* (Ach.) S.L.F. Mey.) - B,NZ,J; rare: 50.
Peltigera hymenina (Ach.) Delise - B,Ø,J; rare: 32, 305.
P. membranacea (Ach.) Nyl. - B,Ø,J; rare: 9, 61, 269.
P. neckeri Hepp ex Müll. Arg. - B,Ø,J; rare: 448.
P. praetextata (Flörke ex Sommerf.) Vain. - B,Ø,J; rare: 63.
P. rufescens (Weiss) Humb. - B,Ø,J; rare: 461.
Pertusaria albescens (Huds.) M. Choisy & Werner - B,Ø,J; common: 356.
P. amara (Ach.) Nyl. - B,Ø,J; common: 128, 336, 446, 487.
P. coccodes (Ach.) Nyl. - B,Ø,J; common: 321, 338.
P. leioplaca DC. - B,Ø,EJ,NEJ,SJ; rare: 127.
P. pertusa (Weigel) Tuck. - B,Ø,J; common: 222, 258, 343, 358.

Phaeophyscia orbicularis (Neck.) Moberg - B,Ø,J; common: 1, 24, 59, 372, 395, 427, 430.

Phlyctis argena (Spreng.) Flot. - B,Ø,J; common: 158, 160, 184, 223, 264, 271, 295, 433, 482, 499.

Physcia adscendens (Fr.) H. Olivier - B,Ø,J; common: 21, 130, 159, 431, 502.

P. caesia (Hoffm.) Fürnr. - B,Ø,J; common: 325.

P. tenella var. ***marina*** (A. Nyl.) Lynge - B,NWZ,EJ,NEJ; rare: 449.

P. tenella (Scop.) DC. var. ***tenella*** - B,Ø,J; common: 26, 163, 228, 265, 294, 349, 392, 402, 425, 495, 498.

Physconia distorta (With.) J. R. Laundon (Syn.: P. *pulverulacea* Moberg) - B,Ø,J; common: 260, 290.

P. enteroxantha (Nyl.) Poelt - B,Ø,J; common: 136.

P. grisea (Lam.) Poelt - B,Ø,J; common: 323, 344, 359, 374, 394.

Placynthiella icmalea (Ach.) Coppins & P. James - B,Ø,J; common: 175, 230.

Platismatia glauca (L.) W.L. Culb. & C.F. Culb. - B,Ø,J; common: 120, 147, 200, 468, 483.

Pleurosticta acetabulum (Neck.) Elix & Lumbsch - B,Ø,J; common: 261, 322, 348, 423 (Hellbom 1890).

Pseudevernia furfuracea (L.) Zopf var. ***furfuracea*** - B,Ø,J; common: 117, 121, 142, 164, 212, 248, 450, 470.

Pseudosagedia aenea (Wallr.) Hafellner & Kalb (Syn.: *Porina aenea* (Wallr.) Zahlbr.) - B,Ø,J; rare: 315, 500.

P. chlorotica (Ach.) Hafellner & Kalb (Syn.: *Porina chlorotica* (Ach.) Müll. Arg.) - B,Ø,J; rare: 432.

Ramalina cuspidata (Ach.) Nyl. - B; common: 77.

R. farinacea (L.) Ach. - B,Ø,J; common: 6, 302, 311.

R. fastigiata (Pers.) Ach. - B,Ø,J; spreading: 124, 289, 312, 361, 380.

R. pollinaria (Westr.) Ach. - B,Ø,J; rare: 247.

R. polymorpha (Lilj.) Ach. - B,SZ,NEZ,F,EJ,NJ; rare: 5.

R. siliquosa (Huds.) A.L. Sm. - B,Ø,J; rare: 7, 246.

Rhizocarpon geographicum (L.) DC. - B,Ø,J; rare: 154.

R. lecanorinum Anders - B,NEZ,F,SJ,MJ,NEJ; rare: 144.

R. obscuratum (Ach.) A. Massal. - B,Ø,J; common: 90.

R. richardii (Lamy ex Nyl.) Zahlbr. (Syn.: *R. constrictum* Malme) - B,F; rare: 81.

Stereocaulon dactylophyllum Flörke - B,NEZ,F,SJ,EJ,NEJ; vulnerable: 458.

S. evolutum Graewe - B,NZ,SJ,MJ,NEJ; rare: 146.

S. nanodes Tuck. - NEZ; rare: 456.

S. saxatile H. Magn. - B,NZ,J; rare: 27.

S. vesuvianum Pers. - NJ,A; rare: 457.

Stigmidium marinum (Deakin) Swinscow – B,NWZ,EJ,NEJ; rare: 177.

Taeniolella cladiniicola Alstrup – NWJ (?); rare: 57.

Tephromela atra (Huds.) Hafellner - B,Ø,J; common: 80.

Trapeliopsis flexuosa (Fr.) Coppins & P. James - B,Ø,J; common: 91.

T. granulosa (Hoffm.) Lumbsch - B,Ø,J; common: 43.

Tuckermanopsis chlorophylla (Willd.) Hale (Syn.: *Cetraria chlorophylla* (Willd.) Vain.) - B,Ø,J; common: 34.

Umbilicaria polyphylla (L.) Baumg. - B,F,MJ,NJ; rare: 82.
Verrucaria maura Wahlenb. - B,Ø,J; common: 156.
V. nigrescens Pers. - B,Ø,J; common: 445.
Xanthoparmelia conspersa (Ach.) Hale - B,Ø,J; rare: 76, 350.
X. loxodes (Nyl.) O. Blanco et al. - B,Ø,J; rare: 346.
X. tinctina (Maheu & A. Gillet) Hale - NEJ; vulnerable: 347.
Xanthoria candelaria (L.) Th. Fr. - B,Ø,J; common: 324, 362, 398, 429, 503.
X. fulva (Hoffm.) Poelt & Petut. – F, EJ; rare: 400.
X. parietina (L.) Th. Fr. - B,Ø,J; common: 19, 75, 183, 340, 369, 393, 469, 478.
X. poeltii S.Y. Kondr. & Kärnefelt - B,Z,F,SJ,EJ,NJ; common: 399.
X. polycarpa (Hoffm.) Th. Fr. ex Rieber - B,Ø,J; common: 49, 182, 220, 232, 496.
Xanthoriicola physciae (Kalchbr.) D. Hawksw. - B,Ø,J (?); common: 71.

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MYCOTAXON

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New species and new record of foliicolous lichenized fungi from Sikkim (India)

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Abstract—*Aderkomyces sikkimensis* and *Thelenella indica* are described from Sikkim, India. *Echinoplaca streimannii* is reported for the first time from India.

Key words—interesting taxa, lichens

Introduction

Sikkim, a small state covering an area ca 7,096 sq. km in the North-Eastern region of India, harbours a rich flora of lichenized fungi (Sinha & Singh 2006). In the course of studies on foliicolous lichen collections made from tropical and subtropical forests of the North-Eastern region, many interesting findings (Singh & Pinokiyo 2003, 2004, Pinokiyo et al. 2004, Pinokiyo & Singh 2004) have already been published. As a part of our ongoing studies, the foliicolous collections from Sikkim area have resulted in the presence of two taxa of lichenized fungi new to science and one taxon as new to lichen flora of India.

Materials and methods

The specimens were collected by the first author (Pinokiyo) in Sikkim Himalaya. The morphological observations were made using a 10x hand lens. Sections of ascocarps were cut by hand with the help of sharp blades and mounted in potassium hydroxide (10% KOH), iodine (I) and lactophenol cotton blue solutions and examined under compound microscope (ELEITZ WETZIAR, Germany) 10x, 45x and 100x (oil immersion) magnifications. All microscopic measurements were taken in 10% KOH.

Result and discussion

The study revealed the following two new foliicolous species, one each of *Thelenella* and *Aderkomyces* and one species of *Echinoplaca* as new record from India.

Aderkomyces sikkimensis Pinokiyo, Kr.P. Singh & Lücking **sp. nov.**

FIGURES 1A & 2A

Thallus foliicolus, tenuis, cinereus, verrucosus; pilis sterilis numerosae albis ad brunneolis et extremum nigricantis. Algae ad Chlorococcaceas pertinens. Apothecia adnata, basi levissime constricta, 0.3–0.5 mm diam., rubra-fuscescentia; disco plano ad minute convexo, epruinoso; margine indistinte. Paraphyses hyalinae, ramosae et anastomosantes. Asci 1-spori. Ascosporae hyalinae, oblongae–ellipsoidae, muriformes, 28–40 × 15–26 µm.

Type: India, Sikkim, South Sikkim district, Damthang, subtropical forest, Pinokiyo, F 430. Holotype: (CAL); West Bengal, Darjeeling district, Tin mile, subtropical forest, Pinokiyo, F 167 A. Paratype: (BSA).

Thallus epiphyllous, thin, grey, centrally continuous, with dispersed peripheral region, verrucose, provided with many sterile hairs, 30–40 mm across, 20–40 µm thick; verrucae with numerous crystals within; sterile hairs tapering, whitish to brownish and finally blackish, 0.5–1 mm long. Photobiont-a species of *Chlorococcaceae*; algal cells rounded, greenish, 8–14 µm in diam.

Apothecia adnate, at least slightly constricted at base, circular, red-brown, developed above thallus layer, 0.3–0.5 mm in diam., 90–100 µm high; algal cells usually absent in the thallus below the apothecium; disc plane to slightly convex, epruinose, margin indistinct; excipulum colourless, made up of hyaline branched fungal hyphae, 20–36 µm thick laterally, usually reduced in central region below the hypothecium, thin, 4 to 8 µm thick; hypothecium pale yellowish, 10–18 µm thick; epithecium brown, 2–4µm thick; hymenium 45–60 µm thick, KI–; paraphyses hyaline, richly branched and anatomosed, ca 1 µm thick. Asci saccate, thin walled, unitunicate, single spored, 32–45 × 18–30 µm. Ascospores colourless, muriform, oblong–ellipsoid, 28–40 × 15–26 µm.

Hyphophores not seen.

Remark: The species can easily be characterized by its finely verrucose thallus and red-brown apothecia. It is closest to *Aderkomyces verrucosus* (Sérus.) Lücking et al. and *A. verrucifer* (Lücking) Lücking et al. (as 'verruciferus') but can be distinguished from *A. verrucosus* by its red brown apothecia and finely verrucose thallus and from *A. verrucifer* by its finely verrucose thallus and longer setae.

Additional specimen examined: India, Sikkim, South Sikkim district, Temi, subtropical forest, Pinokiyo F 398 A (BSA).

Thelenella indica Pinokiyo & Kr.P. Singh **sp. nov.** FIGURES 1B & 2C

Thallus foliicolus, cinereo-brunneus, laevigatus, verrucosus. Algae ad Chlorococcaceas pertinentes. Perithecia immersa, cum thallis concolora, 0.15 –0.18 × 0.09–0.12 µm, lenticularia ad subglobosa; involucrellum absens; hamathecium KI–; paraphyses et periphysodes hyalinae, ramosae et anastomosantes. Asci 4–8-spori, bitunicati. Ascosporae hyalinae, ellipsoidae ad oblongae, submuriformes ad muriformes, (16–) 25–40 × 7– 12 µm.

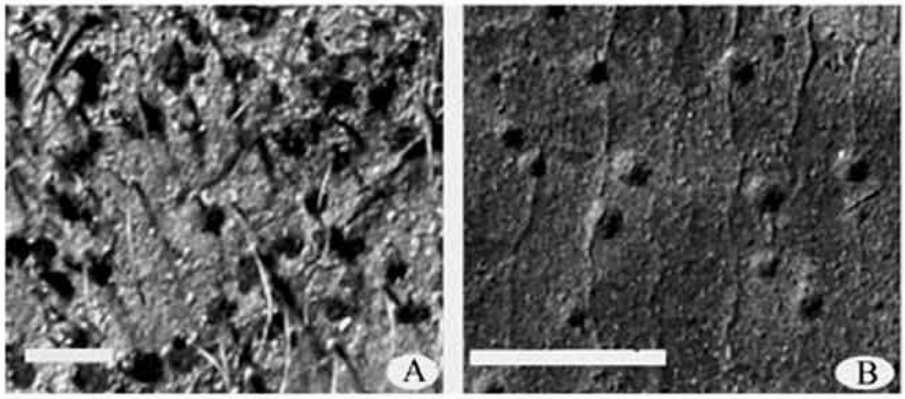

Fig.1. Habits (A) *Aderkomyces sikkimensis* (holotype), (B) *Thelenella indica* (holotype). Scale = 1 mm

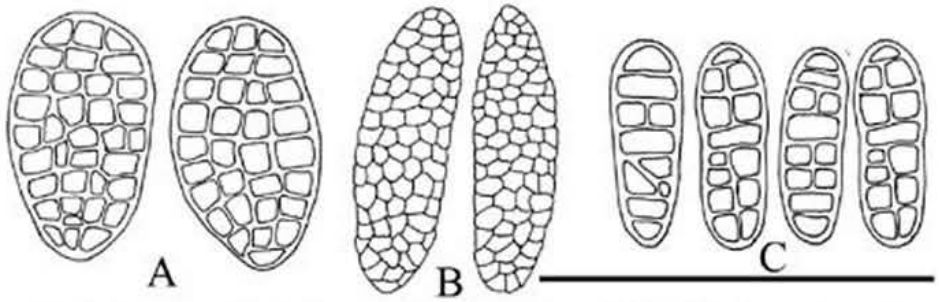

Fig. 2. Ascospores (A) *Aderkomyces sikkimensis* (holotype), (B) *Echinoplaca streimannii* (C) *Thelenella indica* (holotype). Scale = 50 µm.

Type: India, Sikkim, East Sikkim district, Assam-Linzey Road, in tropical forest, on the leaves of a small tree (ca 1m) of *Schima wallichii* (DC.) Korth in sub-shady place, Pinokiyo, F 315 . Holotype: CAL; Isotype: ASSAM, BSA.

Thallus crustaceous, foliicolous, ecorticate, greyish-brown, verrucose, continuous, thicker near perithecium, gradually thinner towards periphery, 20–120 µm thick; fungal hyphae 2–3 µm thick; verrucae small, blackish; hypothallus indistinct. Photobiont a species of *Chlorococcaceae*, cells rounded, 6–12 µm in diam., green, found in groups of 5–18 cells, intermingled with fungal hyphae.

Perithecia covered by thallus, concolorous with the thallus, lens shaped to subglobose, 0.15–0.18 × 0.09–0.12 mm in size; involucrellum absent; excipulum paraplectenchymatous, brownish near apical region, 25–30 µm thick, colourless to brownish laterally and at base, ca 15 µm thick; hamathecium KI–; paraphyses and periphysoides thin, branched and anastomosing, ca 0.7 µm thick. Asci 4–8 spored, clavate, bitunicate, 40–55 × 15–30 µm. Ascospores colourless, ellipsoid to oblong, submuriform to muriform, transversely 3–7-septate, longitudinally 0–2 septate, (16–) 25–40 × 7–12 µm.

Remark: The genus *Thelenella* monographed by Mayrhofer (1987), was characterized by crustose thallus, perithecia immersed in the thalline warts, often absence of an open involucrellum, branched and anastomosing paraphyses and periphysoids, hyaline to brownish, submuriform to muriform ascospores. A single foliicolous species, *Thelenella fusispora* Vězda & H. Mayrhofer, from Tanzania was recorded. The present find of another foliicolous taxon is an interesting addition to the genus. *T. fusispora* is distinguished by its larger (0.3–0.4 mm) perithecia, larger (45–65 × 17–23 µm) muriform ascospores with 11–15 transverse and 2–3 vertical (longitudinal) septa.

Echinoplaca streimannii Sérus. in Aptroot et al., Biblioth. Lichenol. 64: 59, 1997.

FIGURE 2 B

This species can be characterized by continuous, very finely verrucose (silvery grey) thallus without hyphophores and sterile hairs, adnate, greyish brown, 0.2–0.5 mm wide apothecia, 2–4-spored asci and colourless, muriform, oblong-ellipsoid, ascospores.

The Indian material has slightly smaller ascospores (35–40 × 12–14 µm) than described for the species. It belongs in the group centered around *Echinoplaca lucernifera* Kalb & Vězda. This species somewhat resembles *Echinoplaca vezdana* Lücking & Kalb, which has very coarsely verrucose thallus and much larger, lighter apothecia and much more elongate ascospores. The species grows all over the leaf surface or sometimes found associated with *Gyalectidium filicinum* Müll. Arg. and species of *Strigula*. It was described from Papua New Guinea (Aptroot et al. 1997).

Specimens examined: India, Sikkim, South Sikkim dist., subtropical forest, Damthang, Pinokiyo, F 421 A, F 420, F 429, F 455, F 456, 455; Temi, subtropical forest, Pinokiyo, F 401, F 469; West Sikkim dist., Kacheopalri , Pinokiyo F 518, F 509, F 511.

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Notes on taxonomy and distribution of the lichen species *Lepraria ecorticata* comb. nov.

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Abstract—The combination *Lepraria ecorticata* is proposed. This species is reported as new to Asia, and South America and additional records from the Czech Republic and Poland are presented. Earlier records of *Lecanora leuckertiana* from Poland and the Czech Republic represent *L. ecorticata*.

Key words— *Lecanora ecorticata*

Lepraria Ach. is a widely distributed genus and comprises ca. 40 taxa (Laundon 1989, 1992; Tønsberg 1992, 2004; Lohtander 1994, Leuckert et al. 1995, Aptroot et al. 1997, Aptroot 2002, Sipman 2004, Elix 2006a). Anatomy and morphology of the thallus are very simple. It consists of soredia (sometimes called granules) laying on medulla or directly on a layer of hypothalline hyphae (Tønsberg 1992). The edge of the thallus may be diffuse or minutely to markedly lobate. All species are only known in the sterile state (Tønsberg 1992, Sipman 2004). The chemistry is very diverse and substances from many groups have been reported, with the exception of chromones and xanthones (Leuckert et al. 1995, Elix & Tønsberg 2004, Elix 2006b).

After Laundon's revision of *Lepraria* (Laundon 1992), all taxa with usnic acid and a leprarioid thallus were excluded from the genus and referred to *Lecanora* Ach. (Laundon 1992, 2003; Zedda 2000). More recently Sipman (2003) described *Lepraria usnica* with usnic acid from the tropics. He included this taxon in *Lepraria* based on the very similar morphology to other lobate species. He also pointed out that the presence or absence of usnic acid with zeorin is not a good discriminator of lichens at the generic level. He cited the genus *Cladonia* Hill ex P. Browne for comparison as this also includes taxa with and without usnic acid and zeorin in the thallus. Subsequently, Sipman (2004) transferred *Lecanora coriensis* (Hue) J.R. Laundon to *Lepraria*, as *L. coriensis* (Hue) Sipman.

During field studies in Poland the author found a leprarioid lichen with usnic acid and zeorin (and sometimes traces of atranorin detected by TLC),

growing on rocks and more rarely on bark which looked similar to *Lecanora ecorticata*. Although the type collection was not available, other specimens cited by Laundon (2003) were studied. The collections from Poland proved to be identical with the latter in all respects, and it appeared appropriate that this species should be transferred to *Lepraria*.

Lepraria ecorticata (J.R. Laundon) Kukwa **comb. nov.**

Basionym: *Lecanora ecorticata* J.R. Laundon, Nova Hedwigia 76(1–2): 100. 2003.

L. ecorticata has a typical *Lepraria*-like thallus, very similar in appearance to *L. elobata* Tønsberg, and grows in habitats sheltered from direct rain, together with e.g. the former species and *L. rigidula* (de Lesd.) Tønsberg. It is quite similar to *Lecanora* species containing usnic acid and an almost entirely sorediate thallus, e.g. *L. expallens* Ach. or *L. compallens* Herk & Aptroot. However, they differ in the presence of an endo- to episubstratal, usually continuous prothallus and of soredia formed in delimited soralia at least in the young part of the thallus. These characters of *L. ecorticata* confirm the placement in *Lepraria*.

Previously *L. ecorticata* was known from the British Isles and Canada (Laundon 2003), but is now reported as new to continental Europe, South America (Chile) and Asia (China).

In Poland and the Czech Republic this species has previously been recorded as *Lecanora leuckertiana* Zedda (Bayerová & Kukwa 2003, Czarnota 2002). The former authors noted that the morphology of their specimens differed from the type of *L. leuckertiana*, and these specimens can now be identified as *Lepraria ecorticata*. Additional records of *L. ecorticata* from both countries are presented below. In particular, these two species differ in the thallus organisation and the appearance of soredia: *Lecanora leuckertiana* has a woolly, thick and stratified thallus with soredia intermixed with abundant medullary hyphae, whereas *Lepraria ecorticata* usually has a thick, not stratified thallus with most medullary hyphae and soredia well separated from one another.

Lepraria straminea Vain. is another morphologically and chemically (usnic acid and zeorin) similar taxon (Øvstedal & Lewis Smith 2001). However, it differs in having corticate granules and it looks very much like a yellowish member of the *L. neglecta* group. It is considered to be an Antarctic endemic (Øvstedal & Lewis Smith 2001).

SPECIMENS EXAMINED—*Lepraria ecorticata*. **CHILE. Parque Nacional Puyehue**. Anticura, Los Derrumbes, alt. 600 m (72°10'E, 40°40'S), on rock—1986 Coppins, Galloway, Guzmán, James *4643* (BM). **CHINA. Xiamen:** Fujian Province, alt. 100 m, on tree bark—1998 Abbas (UGDA-L-*9170*). **POLAND. Bielska Plain.** Białowieża National Park, forest section No. 370, on *Acer platanoides*—III.2001 Kukwa *180* (UGDA-L-*6511*). forest section No. 256, on *Acer platanoides*—30.III.2001 Kukwa *471* (UGDA-L). forest section No. 371C (23°51'59"E, 52°43'24"N), on *Tilia cordata*—

02.V.2004 Kukwa *3236* (UGDA-L-*10240*). **Gorce Mts.** Gorczański National Park, Łopuszanka valley, alt. ca. 830 m, on sandstone—01.V.1999 Kukwa (UGDA-L-*9666*). **Kaszuby Lakeland.** Kręgi Kamienne nature reserve (17°50'23"E, 54°12'58"N), on stone—07.III.2004 Kukwa *2921* (UGDA-L-*11107*). **Sowie Mts.** Srebrna Góra Mt. (16°38'45"E, 50°34'32"N), on rock—22.IV.2004 Kukwa *3104* (UGDA-L-*10290*). **Karkonoskie Foothils.** Ca. 0.5 km W of Michałowice (15°35'9"E, 50°50'45"N), on stone—09.VII.2003 Czarnota (UGDA-L-*10173*). Vicinity of Michałowice, alt. 560 m (15°34'59"E, 50°50'45"N), on granite—09.VII.2003 Czarnota (UGDA-L-*10509*). **Warmia.** Głuch, on *Alnus glutinosa*—10.V.1976 Olesiński (KRAM-L-*30726*). **Beskid Wyspowy Mts.** Śnieżnica Mt, alt. 970 m, on rock—11.VIII.1966 Nowak (KRAM-L-*5850*). **CZECH REPUBLIC. Rychlebské Hory Mts.** Bílá Voda stream valley, ca. 3 km S of Bílá Voda town, Šafářova skála rock, on rocks—24.IV.2004 Kukwa *3179* (UGDA-L-*11755*). **Protected Landscape Area Křivoklátsko.** Úpořský potok stream valley, National Nature Reserve Týřov (13°48'09"E, 49°57'59"N), on rock—22.IV.2005 Kukwa *3874* (UGDA-L-*11898*). Tyterský stream valley, Valachov nature reserve (13°46'24"E, 50°01'10"N), on rock—23.IV.2005 Kukwa *3894* (UGDA-L-*11907*).

ADDITIONAL SPECIMENS EXAMINED—*Lecanora compallens* (selected specimens; a total number of 17 collections examined). **GERMANY. Bavaria:** Lechauen—pre 1907 s.coll. (BM). **POLAND. Iława Lakeland.** Watkowice Duże, on *Acer platanoides*—01.IX.1997 Kukwa (UGDA-L-*6217*). S of Szadowo (19°03'14"E, 53°46'24"N), on *Ulmus*—12.IV.2004 Kukwa *3054* (UGDA-L-*10265*). **Beskid Mały Mts.** Stream valley by Okręgelak, 500 m, on *Acer pseudoplatanus*—05.X.1962 Nowak (KRAM-L-10015). *Lecanora expallens* (selected specimens; a total number of 142 collections examined). **CZECH REPUBLIC. S Bohemia:** ca. 2.5 km E of Mirochov, on *Acer pseudoplatanus*—12.IV.2002 Kukwa *1402* (UGDA-L-*8737*). **GERMANY. Baden:** Odenwald, Zwingenberg/Neckar, alt. 200 m, on *Acer pseudoplatanus*—27.IV.1978 Wirth 6683 (BM). **POLAND. Sandomierska Basin.** Janowskie forest (22°27'E, 50°37'N), on *Quercus*—08.IX.1999 Bielczyk (KRAM-L-*44976*). **Sławnieńska Plain.** Krzeszewo near Sławno, on *Quercus*—29.VIII.1987 Fałtynowicz, Miądlikowska (SLTC, fertile). **Gnieźnieńskie Lakeland.** Lubostroń, on *Acer pseudoplatanus*—IX.2004 Kukwa *3542* UGDA-L-*11217*, KRAM). **Kaszuby Coast.** Gdańsk Oliwa, Kościerska Street, on *Acer platanoides*—31.V.2003 Kukwa *1826a* (UGDA-L-*10631*). **Iława Lakeland.** 2 km N of Gościszewo, on *Populus nigra*—18.III.2001 M. Kukwa *105* (UGDA-L-*12519*, BG). **Olsztyn Lakeland.** Olsztyn Dajtki, on *Alnus glutinosa*— 30.IX.2002 Kubiak (OLTC). **Słowińskie Coast.** W of Karwia, on *Quercus*—12.VIII.1967 Sulma (UGDA-L-*3815*, fertile). **Wieluń Upland.** Krzemionki Mt., on *Salix*—17.IX.1997 Śliwa, Czarnota, Kukwa, Leśniański, Adamska (LOD-L-*11188*). *Lecanora leuckertiana*. **ITALY. Sardinia:** Illorai, M. Artu, alt. 840 m, on *Quercus pubescens*—09.04.1997 Zedda *1800* (**HOLOTYPE**-B). *Lepraria straminea*. **ANTARCTICA. South Shetland: Admiralty Bay.** Near Port Thomas, near sea level, on soil—21.I.1937 Discovery Exped. *1936-711* (BM).

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An appraisal of the syntype material of *Caloplaca aurantiomurorum* (*Teloschistaceae*, lichenized fungi)

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Abstract—Sample no. 54 of Flagey: Lichenes Algerienses exsiccati represents the syntype of *Placodium aurantiomurorum* (= *Caloplaca aurantiomurorum*). However, the samples of this exsiccatum distributed to FH, H, M, PC and UPS contain different lichen species. The lectotype of *P. aurantiomurorum* is selected here (sample in UPS) and this name is treated as a synonym to *Caloplaca aurantia*. In this exsiccatum, *Candelariella senior* has been identified (in H, FH, and PC), which is reported here as a new species to Algeria. The known distribution of *Can. senior* is described.

Key words—lichens, nomenclature, typification

Introduction

Placodium aurantiomurorum was described by Flagey (1891: 112) from Algeria "Rochers humides de Sidi-Mecid et seulement là") in the exsiccatum "Flagey: Lichenes Algerienses exsiccati (no 54)". This exsiccate collection was distributed to the herbaria FH (nos 1-200), H, M, PC, and UPS (Grummann 1974: 277). The specimen in the herbarium of the University of Helsinki (H) was investigated, it being the only representative of *Caloplaca aurantiomurorum* (Flagey) Zahlbr. in the section. Surprisingly, it clearly belonged to the genus *Candelariella*, which we later determined as *Can. senior* Poelt. Subsequently, we investigated more samples of this exsiccatum (FH, M, PC, UPS) and found that individual exsiccates represent different species of *Caloplaca* (= *Cal.*) and *Candelariella* (= *Can.*).

Materials and Methods

Apart from the investigated exsiccates, reference materials of *Caloplaca aurantia* (Pers.) Hellb., *Cal. flavescens* (Huds.) J.R.Laundon, *Cal. saxicola* (Hoffm.)

Nordin, and *Candelariella senior* from the herbaria CBFS, GZU, M, PRC, and PRM were used. Light microscopy measurements of ascospore characteristics, to an accuracy of 1 µm, were performed on hand-made sections examined in water at a magnification of ×1000. These measurements are given as MIN–X (±SD)–MAX, where X = mean value, SD = standard deviation, and MIN and MAX = extremes. Ten measurements (five ascospores in two apothecia) were examined in all samples except that from H, where the numbers of measurements (n) are given in parentheses.

Results

The material in FH has a yellow-orange, rosette-like thallus with broad and flat lobes. Mature, well-developed ascospores are citriform, 12–14.2 (±1.1)–16 × 8–9.3 (±0.7)–10 µm, with septa 3–4.2 (±0.6)–5 µm wide. This specimen is morphologically identical with typical *Caloplaca aurantia*. *Candelariella senior* (morphologically identical with the material from H) and a small piece of an undetermined *Caloplaca* with a granular thallus are also present in this collection.

The material in H has *Candelariella*-type asci, simple ascospores, and a thallus and apothecia devoid of anthraquinones; therefore it belongs to *Candelariella*, not to *Caloplaca*. This rosette-like lichen was morphologically and anatomically compared with the holotype specimen of *Candelariella senior* (M, 0099854). Both samples are identical in most characters, differences were only observed in the thallus thickness [100–170 (±44)–250 µm (n=12) in "*Cal. aurantiomurorum*" vs. 120–228 (±66)–310 µm (n=10) in *Can. senior*] and in the spore width [10–12.5 (±1.2)–15 × 4–5.3 (±0.6)–6 µm (n=18) in "*Cal. aurantiomurorum*" vs. 10–12.0 (±1.7)–16 × 3–4.0 (±0.5)–5 µm (n=10) in *Can. senior*].

The material in M (M-0100101) has an orange, rosette-like thallus with short broad marginal lobes. Mature ascospores are ellipsoid, never citriform, 10–11.0 (±0.5)–12 × 6–6.1 (±0.3)–7 µm, with septa 3–3.4 (±0.5)–4 µm wide. This specimen is morphologically identical with typical *Caloplaca saxicola*.

The material in PC (PC0107050) is on two pieces of stone (glued on a sheet). The upper one is only covered by a fertile lichen with yellow-orange, rosette-like thallus with broad and flat marginal lobes. Mature, well-developed ascospores are citriform 13–14.1 (±1.2)–16 × 9–10.4 (±1.0)–12 µm, with septa 4–4.5 (±0.7)–6 µm wide. This specimen is morphologically identical with typical *Caloplaca aurantia*. The lichenicolous fungus *Cercidospora caudata* Kernst. occurs in its apothecia. *Cal. aurantia* also prevails on the lower stone, but *Candelariella senior* and an undetermined granulose *Caloplaca* are admixed.

The material in UPS has a yellow-orange, rosette-like thallus with broad and flat lobes. Mature, well-developed ascospores are citriform, 13–14.6 (±0.8)–16

× 8–9.7 (±0.9)–11 µm, with septa 4–4.9 (±0.7)–6 µm wide. This specimen is morphologically identical with typical *Caloplaca aurantia*. This sample is selected here as the lectotype.

Discussion

The short Latin diagnosis of *Placodium aurantiomurorum* (Flagey 1891: 112) is translated as follows: "Thallinal lobes flatter than in *P. murorum* (= *Caloplaca saxicola*); spores 16–18 × 8–9 µm, wider than in *P. murorum* and with a shape as in *Physcia aurantia* (= *Cal. flavescens*)". The extended French description (Flagey 1896: 28), where *Placodium aurantiomurorum* was compared with *P. murorum*, *P. callopismum* (= *Cal. aurantia*) and *P. heppianum* (= *Cal. flavescens*), is translated as follows: "Thallus fairly yellow suede with lobes larger and more flattened than in *P. murorum*, resembling lobes of *P. callopismum*, but with lobes yellow, less reddish. Spores ovoid, 'placodial' 16–18 × 8–9 µm, larger than in *P. murorum*, strongly resembling spores of *P. heppianum*, whose thallus is clearly different".

Based on these descriptions, *Cal. aurantiomurorum* is distinct from *Cal. saxicola* by having a different shape and size of the thallus and a different shape of spores and from *Cal. flavescens* by having a different shape of lobes. However, *Cal. aurantiomurorum* is distinguished from *Cal. aurantia* only by the yellow colour of the thallus. Based on this and the syntype investigation, we decided to place the name *Cal. aurantiomurorum* into the synonymy of *Cal. aurantia*.

In the protologue, Flagey (1891: 112) described one locality but did not designate the holotype. His main herbarium is located in PC and following the usual practice for exsiccates, the sample placed there should be regarded as the holotype and the others as isotypes. In this case, however, due to the heterogeneity of the respective material, we treat all exsiccate samples as syntypes. We have selected the sample in UPS as the lectotype, because it is well-preserved and without any admixture of similar lichen species (cf. the mixture represented by the specimen in PC). The sample in UPS was already revised as *Cal. aurantia* and mentioned in the list of exsiccates of this species by Nordin (1972: 80). This specimen was indicated as an isotype although the typification was not published.

Cal. aurantiomurorum has only been reported on calcareous rocks in Sidi-Mecid near Azéba fort and in Djebel Akar Mts in Algeria (Flagey 1896: 28) and in Upper Galilee, Mt Carmel in Israel (Alon & Galun 1971: 287-288). *Cal. aurantiomurorum* was accepted in two lichen checklists of Israel (Galun & Mukhtar 1996: 152, Kondratyuk et al. 1996: 35), until the voucher material from Israel was redetermined as *Cal. flavescens* (Wasser & Nevo 2005: 100) and the name *Cal. aurantiomurorum* was excluded from the Israel lichen flora

(Wasser & Nevo 2005: 321) and erroneously put into the synonymy of *Cal. flavescens* (Wasser & Nevo 2005: 99).

The sample in H and parts of the samples in FH and PC belong to the lobate species of *Candelariella*. In southern Europe, three lobate species are known, *Can. medians*, *Can. rhodax*, and *Can. senior*. While the two former species are clearly different (Poelt & Vězda 1976, 1977), the latter fits well with the respective samples. The differences in the thallus thickness and spore width between the holotype specimen of *Can. senior* and the sample in H can be easily accounted for by intraspecific variation. Having seen more material of *Can. senior* from GZU, we consider them conspecific with the samples of the investigated exsiccatum. Previously, *Can. senior* was only known from the type locality in Spain (Poelt 1958: 440-441), and from Libya (Thor, unpublished data) and Tunisia (cf. Seaward 1996: 123) so far.

Other samples of *Can. senior* seen: **Algeria.** on limestone in "d'Azeba" (GZU, intermixed in sample Flagey: Lich. Alg. Exsic. 93, *Rinodina subconfragosa*). **Libya.** On calcareous stone near Derna (Darnah), Thor, 1982 (GZU). **Tunisia.** Douggha, Poelt, 1968 (GZU); Djebel Goraa Mts, between Thibar and Teboursouk, Poelt, 1968 (GZU).

Conclusions

Flagey's exsiccatum of *Placodium aurantiomurorum* is composed of heterogeneous material. The samples in FH, PC and UPS are taxonomically indistinguishable from *Cal. aurantia*, and the sample in M is indistinguishable from *Cal. saxicola*. The sample in UPS is selected here as the lectotype of *Placodium aurantiomurorum* and we propose to put the name *Cal. aurantiomurorum* into the synonymy of *Cal. aurantia*. We consider the sample of *Cal. aurantiomurorum* in H and the admixed lichens in samples from FH and PC conspecific with *Candelariella senior*, which is newly reported from Algeria.

In the light of this work, more attention should be given not only to examining distributed material of this particular exsiccatum in other herbaria, but also to appraising the homogeneity of exsiccati in general.

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Oligoporus balsameus – rare Eurasian species plus notes on some related taxa

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Abstract—*Oligoporus balsameus* is described and illustrated according to material from southern and northern parts of Eurasia, and its taxonomy is discussed. Two closely related species, *O. cerifluus* and *O. floriformis*, are also treated and compared with *O. balsameus*. Recently described *Antrodia* species, *A. bondartsevae* and *A. primaeva*, are combined into the genus *Pilatoporus*, which seems to be a more appropriate place for them. *Spongiporus rhodophilus* sp. nov., is a close relative of *S. undosus*, growing on dead basidiocarps of *Rhodofomes roseus* in old boreal forests and having shorter spores. *Oligoporus cerifluus* is reported as new to Russia.

Key words— polypore, taxonomy

Introduction

The genus *Oligoporus* unites most small-sized resupinate or pileate polypores causing a brown rot of wood. Taxonomy of this genus, as well as the numerous species included, is very difficult. Many species clearly have southern distribution; some of them are known in the boreal zone; however, mycologists are often puzzled by whether or not the same species occur in both the south and north. Such is the case with *Oligoporus balsameus* (Peck) Gilb. & Ryvarden. This species has thin flabelliform basidiocarps, and together with other pileate species of genus [i.e., *O. cerifluus* (Berk. & M.A. Curtis) Ryvarden & Gilb., *O. floriformis* (Quél.) Gilb. & Ryvarden, etc.], constitutes a very complicated species

complex. Since *Oligoporus balsameus* is poorly studied and rare everywhere, we describe it and some its relatives below, and also discuss the taxonomy of the *Oligoporus* genus complex.

Materials and methods

The microscopic characters of polypores were studied in the Karl Zeiss-amplival microscope. The chemical reagents used in the microscopic examination were 5% solution of potassium hydroxide (KOH), Melzer's reagent (IKI), and Cotton Blue (CB). Measurements were made with an immersion objective; a total of 30 spores from each specimen was measured. To present a variation of spore size, 5% of measurements were excluded from each end of the range and are given in parentheses. Type material and specimens are traced in the herbaria of the Institute of Evolution, University of Haifa (Haifa, Israel, HAI), Komarov Botanical Institute, Russian Academy of Sciences (St. Petersburg, Russia, LE), and Finnish Museum of Natural History (Helsinki, Finland, H).

Taxonomic descriptions

The *Oligoporus* generic complex

Here, we treat *Polyporus balsameus* as a member of the genus *Oligoporus*, which we consider as a separate genus that is not synonymous with the epithet *Postia*. Both *Oligoporus* and *Postia* are united under the older name *Postia*, for example, by Rajchenberg (1995), and Hansen & Knudsen (1997). The concept of two independent genera was first proposed by Erkkilä & Niemelä (1986) and Renvall (1992). Recent molecular data (Niemelä 2005, Niemelä et al. 2005) support more sophisticated division in this group of polypores, which may be presented as following:

– ***Oligoporus*** Bref. 1888 (type *Oligoporus farinosus* Bref. = *Polyporus rennyi* Berk. & Broome). This genus comprises primarily brown-rot monomitic polypores having ellipsoid or short-cylindrical spores. Many species have cystidia and are able to produce chlamydospores in culture (Stalpers 2000).

– ***Postia*** Fr. 1874 (type *Polyporus lacteus* Fr.) includes those species with cylindrical or allantoid basidiospores; chlamydospores and cystidia are often absent. Tramal hyphae are parallel and not agglutinated, sometimes very thick-walled and resembling the skeletals. Contextual hyphae bear characteristic finger-like refractive outgrowths; this feature is observed also in the *Tyromyces* species [e.g., *T. chioneus* (Fr.) P. Karst.], which may be the closest relative.

– ***Rhodonia*** Niemelä & K.H. Larss. 2005 (type *Polyporus placenta* Fr.). The genus was established as a result of recent molecular studies (Niemelä et al. 2005) showing *Postia placenta* (Fr.) M.J. Larsen & Lombard to be very distant

from the *Oligoporus–Postia* generic complex, and much closer to *Antrodia* P. Karst. The sole species, *Rhodonia placenta* (Fr.) Niemelä, K.-H. Larsson & Schigel, has strongly amyloid hyphae, varying from thin-walled to subsolid, and then resembling skeletals. Moreover, the microscopic mounts prepared in CB are filled by numerous oily droplets. This feature links *R. placenta* with *Antrodia infirma* Renvall & Niemelä, *A. sandaliae* Bernicchia & Ryvarden, and *O. rancidus* (Bres.) Gilb. & Ryvarden, which should be included in this genus later. The genus *Pilatoporus* Kotl. & Pouzar may be closely related to *Rhodonia*.

– ***Spongiporus*** Murrill 1905 (type *Polyporus leucospongia* Cooke & Harkn.). Three closely related species, *S. leucospongia* (Cooke & Harkn.) Murrill, *S. lowei* (Pilát) A. David, and *S. undosus* (Peck) A. David, belong here. They share tight hyphal structure composed of very thick-walled amyloid and agglutinated generative hyphae; the spores are allantoid or cylindrical. A gelatinous layer is often observed between tubes and subiculum. A new species, *Spongiporus rhodophilus* sp. nov., is included in this paper.

Oligoporus balsameus (Peck) Gilb. & Ryvarden, Mycotaxon 22: 364, 1985. FIG. 1

= *Polyporus balsameus* Peck 1878.
= *Microporus balsameus* (Peck) Kuntze 1898.
= *Coriolus balsameus* (Peck) Murrill 1907.
= *Tyromyces balsameus* (Peck) Murrill 1914.
= *Spongiporus balsameus* (Peck) A. David 1980.
= *Postia balsamea* (Peck) Jülich 1982.
= *Polyporus crispellus* Peck 1885.
= *Tyromyces cutifractus* Murrill 1912.
= *Tyromyces kymatodes* Donk. 1933. an avowed nom. nov. for *Coriolus kymatodes* (Rostk.) Bourdot & Galzin 1925 sensu auct.
= *Leptoporus alma-atensis* Pilát 1937.
= *Polyporus basilaris* Overh. 1941.

Basidiocarps annual, pileate, flabelliform or fan-shaped, with narrowed or resupinate base, fusing together in imbricate groups, often with pleasant meadow-sweet odour when fresh. **Pilei** 0.5–5 cm long, 2–10 mm thick, dense, covered by a thin cuticle. **Upper surface** agglutinated, with rough radially oriented hairs and large indistinct zones, at first white or grayish with reddish tints, later dirty brown. **Margin** sharp, even or only slightly undulate or turning down when drying. **Context** 0.5–2 mm thick, whitish to pale cream, coriaceous, dense. **Tubes** 0.5–4 mm thick, fleshy and white to pale ochraceous in fresh condition, hard and brownish when dry, sometimes with indistinct vinaceous-brown stains; pores angular to lacerate, 5–7 per mm, with thin entire or slightly lacerate dissepiments.

Hyphal system monomitic. Contextual hyphae thick-walled, clamped, 6–10 µm wide, mostly unchanging but sometimes inflating and dissolving in KOH,

rarely with dichotomously branching protuberances 2–2.5 µm in diam having a very narrow (up to 1 µm) lumina. **Trama** subparallel, hyphae thin- to distinctly thick-walled (walls 0.5–2 µm thick), densely arranged, 2.5–4.5(5) µm wide, amyloid (reaction weak in most specimens, moderate to strong in specimen Spirin 2338). Crystals absent. **Leptocystidia** present, conical to bottle-shaped, thick-walled, 18–26 × 6–9 µm, nude or rarely apically encrusted by crystal crown. **Basidia** clavate, clearly constricted, four-spored, 14–24 × 4–6 µm. **Basidiospores** ellipsoid, often guttulate, (3.7)3.9–4.7(4.9) × (2.1)2.2–2.5(2.6) µm, inamyloid, slightly thick-walled, plasma cyanophilous. **Conidial state** known only in vitro (Stalpers 1978, 2000). **Type of rot:** brown.

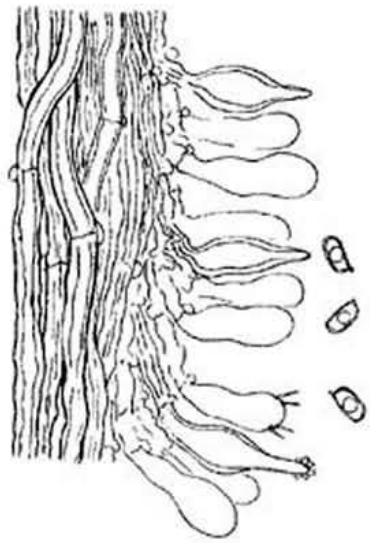

Fig. 1. *Oligoporus balsameus* (Spirin 2338): section through tube dissepiment. Scale bar = 10 µm.

Note—The identification of *O. balsameus* is often difficult. Domański et al. (1973) mentioned that *O. balsameus* is developing forms similar to *O. floriformis*. This latter differs from *O. balsameus* in having thin-walled, usually collapsing hyphae in tube trama, and narrowly ellipsoid spores 3.5–4.4 × 1.9–2.5 µm. Another relative, *O. cerifluus*, has robustly thick-walled hyphae and cylindrical, slightly curved spores with concave ventral side 3.8–5.2 × 2.1–2.7 µm. Both *O. cerifluus* and *O. floriformis* are acystidiate polypores.

The variability of *O. balsameus* proper has been discussed many times (see, for example, Donk 1933; Bondartsev 1953; Domański et al. 1973). The specimens from Israel as well as from Russia, Finland, and Ukraine match

the descriptions by both European and American mycologists (Kotlaba & Pouzar 1968, Domański et al. 1973, Gilbertson & Ryvarden 1987, Ryvarden & Gilbertson 1993, Niemelä et al. 2004; see also colour picture in Niemelä 2005). However, the contemporary concept of *O. balsameus* is very wide and, probably, encompasses more than one species. The best character for splitting of *Oligoporus balsameus* into separate species would be amyloid reaction of cystidia and hyphae (P. Vampola and Z. Pouzar, pers. comm.).

Niemelä et al. (2004) described a new species, *Postia balsamina* Niemelä & Y.C. Dai, which occurs in boreal forests and has mostly resupinate basidiocarps with large pores (3–4 per mm); the next year Niemelä et al. (2005) transferred it to the genus *Oligoporus*.

In a recent paper, Spirin & Shirokov (2002) note that, in the old spruce forests of European Russia, *O. balsameus* grows on dead basidiocarps of *Fomitopsis rosea* (Alb. & Schwein.) P. Karst. [= *Rhodofomes roseus* (Alb. & Schwein.) Kotl. & Pouzar]. After a more detailed study, we decided that we were dealing with a separate species, described below as *Spongiporus rhodophilus*.

SPECIMENS EXAMINED—*Oligoporus balsameus*. **ISRAEL.** Zomet Ealakim viet Wyer Wacol: *Pinus pinea*, 07.I.2001, Wasser (*HAI F 0082*). **RUSSIA. Leningrad Region:** Veps Forest. Res., *Picea abies*, VIII.1999, Zmitrovich (*LE*); **Nizhny Novgorod Region:** Sanki, *Quercus robur* and dead *Hymenochaete rubiginosa*, 7.VIII.2005, Spirin *2338* (*H*, dupl. in *LE* and *WS*.); **Krasnodar Region:** Hosta, *Taxus*, X.1966, Vasilyeva (*LE 27472, LE 27490, LE 27492*). **UKRAINE. Vinnitsa Region:** Satanovskoye, *Pyrus* and *Picea abies*, 10–23.IX.1936, Bondartsev (*LE 27483, LE 27484, LE 27485, LE 27486*). **FINLAND. Uusimaa:** Helsinki, Koskela Hospital Park, *Crataegus douglasii*, 06.X.1999, Niemelä *6669* (*H*).

— *Oligoporus balsaminus*. **FINLAND. Kittilän Lappi:** Kolari, Äkäslompolo, *Picea abies*, 31.VIII.1999, Niemelä *6601* & Dai (holotype, *H*).

— *Oligoporus cerifluus*. **RUSSIA. Nizhny Novgorod Region:** Kilemarsky Nat. Res., *Picea abies* (old building) and *Abies sibirica*, 16–17.VIII.2004, Spirin *2114, 2166* (*H*); Neveyka, *Pinus sylvestris*, 26.VIII.2000, Spirin (*LE 212294*); Razino, *Picea abies*, 12.VIII.1995, Spirin (*LE 212262* – as *O. folliculocystidiatus*). **Mordovia:** Mordovsky Nat. Res., *Picea abies*, 27.VIII.1937, Nikolaeva (*LE 26385*) **(new to Russia)**.

— *Oligoporus floriformis*. **RUSSIA. Nizhny Novgorod Region:** Kilemarsky Nat. Res., *Picea abies*, 19.VIII.2004, Spirin *2231, 2238* (*H*).

The genus *Pilatoporus*

This genus described by Kotlaba & Pouzar (1990) represents a well-defined group of polypores, having annual cheesy-corky trimitic basidiocarps, cylindrical or fusiform spores, and causing a brown rot. Most of the species are tropical or subtropical (Kotlaba & Pouzar 1990, 1998); however, Vampola (1996) found *Pilatoporus ibericus* (Melo & Ryvarden) Kotl. & Pouzar to be widely distributed in temperate zones of Europe (see also Spirin & Zmitrovich 2003).

Renvall & Niemelä (1992) described a new boreal species *Antrodia primaeva*, and demonstrated that some links of this species with the *Fomitopsis iberica* complex (= the genus *Pilatoporus*) exist. However, these authors refrained from assigning this new species to *Pilatoporus*, mainly due to its resupinate growth and poorly pronounced trimitic structure.

Spirin (2002) described a new species *Antrodia bondartsevae*, which is closely related to *Pilatoporus* (especially *P. ibericus*) but which differs mostly by its small-sized fragile effused-reflexed basidiocarps and smaller spores. The hyphal structure of *A. bondartsevae* was also regarded as trimitic; however, skeletal hyphae are less abundant in *A. bondartsevae* (as well as *A. primaeva*) than in core *Antrodia* species and show a clear transition to sclerified thick-walled generative hyphae. The latter feature was stressed by Vampola (1996) as essential to the genus *Pilatoporus*. So, there are evident reasons to transfer both *Antrodia bondartsevae* and *A. primaeva* into *Pilatoporus*.

Pilatoporus bondartsevae (Spirin) Spirin comb. nova (Mycobank number: **MB510248**) – basionym: *Antrodia bondartsevae* Spirin, Mikol. Fitopat. **36:** 33, 2002.

Pilatoporus primaevus (Renvall & Niemelä) Spirin comb. nova, (Mycobank number: **MB510249**) – basionym: *Antrodia primaeva* Renvall & Niemelä, Karstenia **32:** 30, 1992.

SPECIMENS EXAMINED — *Antrodia bondartsevae*. **RUSSIA. Nizhny Novgorod Region:** Kilemarsky Nat. Res., *Tilia cordata*, 24.VIII.2000, Spirin (*LE 209783*, holotype); Razino, *T. cordata*, 5.VIII.1997, Spirin (*LE 208446*, paratype); Podvyazye, *T. cordata*, 30.VII.2005, Spirin *2306* (*H, LE*).

— *Antrodia primaeva*. **RUSSIA. Nizhny Novgorod Region:** Razino, *Picea abies*, 09.VIII.2005, Spirin *2360* (*H*). **FINLAND. Sompion Lappi:** Savukoski, *Pinus sylvestris*, 19.IX.1988, Renvall *1372* & T. Renvall (*H*, holotype).

— *Pilatoporus ibericus*. **IRAN.** Mazandaran, Chalus, *Alnus*, 09.VIII.1972, Kukkonen *7858* (*H*).

Spongiporus rhodophilus Spirin & Zmitr. **sp. nov.** FIGS. 2-3

(Mycobank number: **MB510247**)

Basidiomata annua, pileata, basi angusto adnata, imbricata, carnoso-coriacea in vivo, tactu rubescenti brunnea, coriacea et dura in statu sicco. Pilei undulati, flabelliformi, tenui, 0.5–3 × 0.4–2.5 × 0.1–0.3 cm, superficies concentrice-zonata, rubella, indistincte radialiter-fibrillosa, cuticula tenui tecta. Margo acutatus, subtus fertilis. Contextum 0.5–1 mm crassum, album vel pallide coloratum, coriaceo-fibrillosum. Tubulis ad 2 mm crassis, translucentibus. Poris rotundo-angularibus, 4–6 per mm. Systema hypharum monomiticum. Hyphae generativae fibulatae, ramosae, in subhymenio tenuitunicatae (tunicae ad 1 µm crassae), ad 4 µm latae, in contexto crassitunicatae, ad 8 µm latae. Leptocystidia adsunt, 15–32 × 4–5 µm. Basidia clavata, 14–28 × 4–4.5 µm. Sporae brevicylindricae, biguttulatae, curvae, 3.6–4.8 × 1.7–2.1 µm, inamyloideae. Ad truncis dejectos Piceae abietis et carpophora mortua Rhodofomitis rosei.

Etymology: from the Latin *Rhodofomes* = genus of host fungus.

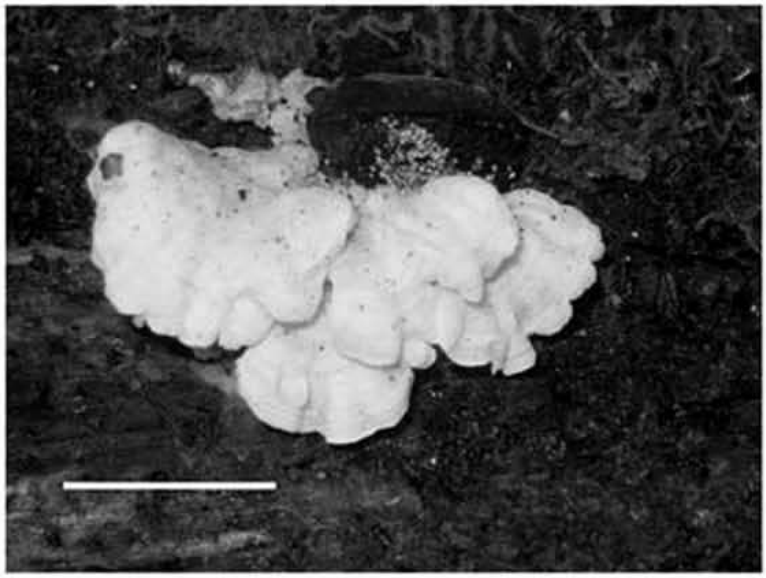

Fig. 2. *Spongiporus rhodophilus* (specimen Spirin *2247*): basidiocarps. Scale bar = 1 cm. Photographed in situ by A. Shirokov.

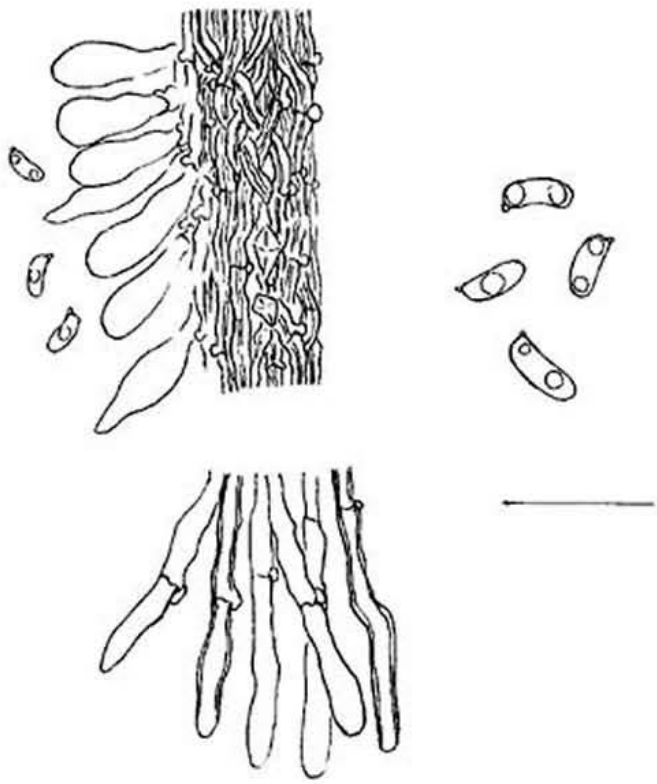

Fig. 3. *Spongiporus rhodophilus* (holotype): hymenium (above left), hyphae of dissepiment edge (below left), and spores (right). Scale bar = 10 µm.

Basidiocarps annual, pileate-flabelliform, often with narrowed base, mostly in imbricate groups, rarely effused-reflexed, with reddish brown stains when bruised. **Pilei** 0.4–2.5 cm long, 1–3 mm thick, dense, undulate, covered by a thin cuticle. **Upper surface** slightly agglued, with small radially orientated hairs and frequent distinct zones, firstly pure white to pale yellow with reddish tints, later with distinct brownish hue, especially at the margin. **Margin** sharp, strongly undulate, distinctly turning down during drying. **Context** 0.5–1 mm thick, creamish to brownish, radially fibrillose, dense, often with brownish gelatinous band. **Tubes** 0.5–2 mm thick, firstly pure white, then dirty gray with clear reddish tints, fleshy-coriaceous and agglutinated in fresh condition, very hard when dry; pores angular to lacerate, (3)4–5 per mm, with thin entire or slightly dentate dissepiments.

Hyphal system monomitic. Contextual hyphae thick-walled, clamped, 4–8 µm wide, with dichotomously branching protuberances 2–3 µm in diam, having a very narrow lumina (up to 1 µm). **Trama** subparallel, hyphae thin- to moderately thick-walled (walls 0.5–1 µm thick), densely arranged, 2.5–4 µm wide, amyloid; some of them having yellowish oily content. **Leptocystidia** present, bottle-shaped, thin-walled, sometimes with clear medial constriction, 15–32 × 4–5 µm. **Basidia** long-clavate, clearly constricted, four-spored, 14–28 × 4–4.5 µm. **Basidiospores** short-cylindrical, often guttulate, slightly bent when mature, (3.4)3.6–4.8(5.1) × (1.6)1.7–2.1(2.2) µm, inamyloid, plasma cyanophilous. **Conidial state** not found. **Type of rot:** not known certainly, presumably brown.

HOLOTYPE, ISOTYPE AND PARATYPES—RUSSIA. NIZHNY NOVGOROD REGION: Kilemarsky Nat. Res., dead basidiocarps of *Rhodofomes roseus* grown on *Picea abies*, 24.VIII.2000, Spirin (*H* – holotype, isotype *LE 211354*). — ibid., *Rhodofomes roseus* and *Picea abies*, 24.VIII.2000, 16–20.VIII.2004, Spirin *2098, 2247, 2248, 2255, 2263* (*LE 211352*, isoparatypes in *H* and *HAI*); Belbazh, *Picea abies* and dead basidiocarps of *Rh. roseus*, 27.VIII.2000, Spirin (*LE 211343*).

Ecology—On dead basidiocarps of *Rhodofomes roseus* and on wood of *Picea abies* in old spruce ('southern taiga' – Spirin & Shirokov 2002) forests.

Note—The species is easily identified by its medium-sized strongly undulate basidiocarps, relatively narrow spores, and peculiar ecological preferences. Its closest relative is evidently *Spongiporus undosus*, which differs by distinctly narrower and longer spores (ca. 4.5–6.1 × 1.1–1.6 µm), and less dense hymenial tissue. *Spongiporus lowei* is almost resupinate, fragile, and its spores are straight (not curved), ca. 4.1–5.3 × 1.7–2.2 µm. The species of the *Oligoporus floriformis* complex, having flabellifrom or fan-shaped basidiocarps (e.g., *O. floriformis* and *O. cerifluus*), are characterized by more fragile fibrillose fruitbodies and a presence of conidial state on pileal surface. They often grow on wood of conifers too, but without any association with other polypores.

ADDITIONAL SPECIMENS EXAMINED—*Spongiporus undosus*. **RUSSIA. Nizhny Novgorod Region:** Kilemarsky Nat. Res., *Picea abies*, 16.VIII.2004, Spirin *2278* (*H*); Razino, *P. abies*, 5.VIII.1998, Spirin (*LE 211351*), *Populus tremula*, 14.VIII.2006, Spirin *2522* (*H*); Kurley, *Quercus robur*, 14.VIII.2005, Spirin *2422* (*H*).

– *Spongiporus lowei*. **FINLAND. Etelä-Häme:** Vesijako, *Pinus sylvestris*, 5.X.1985, Niemelä *3304* (*H*).

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Variability of *Byssomerulius corium* in the Mediterranean

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Abstract—The variability of the common corticioid *Byssomerulius corium* is discussed. Emended descriptions of both species and genus *Byssomerulius* are provided and a xerophilous variety (*B. corium* var. *halileensis*, growing on *Quercus calliprinos* wood in a sub-arid region of the East Mediterranean in Israel) is proposed. Basidiocarps representing the new variety can be diagnosed by their almost smooth or minutely folded hymenium. *B. corium* var. *halileensis* greatly resembles the species *B. armeniacus*, in need of further study.

Key words—xerophilous variety, *Byssomerulius corium* var. *halileensis*

Introduction

The merulioid fungus *Thelephora corium* was described by Persoon in his "Synopsis methodica fungorum" (Persoon 1801), and this name was sanctioned by Fries (1821). Following Fries (1828), most mycologists have placed this fungus in the genus *Merulius*. Because of its variability, the species was redescribed under various names during the 19th and 20th centuries, and its generic position oscillated among *Cladoderris*, *Phlebia*, or *Merulius*.

When Parmasto (1967) established the new genus *Byssomerulius*, he designated *Merulius corium* as type and introduced new combinations for *Merulius ceracellus* Berk. & M.A. Curtis, *M. farlowii* Burt, *M. serpens* Tode: Fr., *M. hirtellus* Burt, and *M. rubicundus* Litsch. At the same time, he described *Byssomerulius armeniacus* as a new species. In its original circumscription, the genus in question was artificial, since it included the species with waxy

and wrinkled hymenophoral strata and byssoid abhymenial surfaces. Later, it became obvious that *Merulius ceracellus* and *M. farlowii* were synonyms for *Merulius serpens* (Ginns 1976), a member of *Lilaceophlebia* (Spirin & Zmitrovich 2004).

As presently circumscribed, the genus *Byssomerulius* includes *B. corium*, *B. hirtellus*, and *B. albostramineus* (Torrend) Hjortstam (= *B. rubicundus*) as core species that are grouped with a set of recently added taxa characterized by a non-merulioid hymenium (e.g., *Odontia pirottae* Bres., *Phanerochaete josé-ferreirae* (D.A. Reid) D.A. Reid, *Ph. avellanea* (Bres.) J. Erikss. & Hjortstam; – see Zmitrovich 2001 and Spirin & Zmitrovich 2004 for a complete list). Despite this, *B. corium* still remains a conglomerate that continues to off many surprises for taxonomists.

The present paper considers some materials collected from subarid areas of the Mediterranean, Caucasus, and southern Russia where *B. corium* occurs.

Materials and methods

Most native material was collected in Upper Galilee (Israel) from *Quercus calliprinos* branches. All samples are preserved in the herbarium of the Institute of Evolution (Haifa, Israel). Holotypes and exsiccates kept in Komarov Botanical Institute (St. Petersburg, Russia, LE) were also studied.

The microscopic characters of merulioid fungi were observed with Karl Zeiss-amplival microscope. Chemical reagents used in the microscopic examinations were 5% solution of potassium hydroxide (KOH), Melzer's reagent (IKI) and Cotton Blue (CB). Measurements were made under oil immersion; 30 spores from each specimen were measured. Spore ranges were calculated excluding the high and low 5% of measurements.

Discussion

Variable morphological characteristics of *Byssomerulius corium*

The fungus forms resupinate basidiocarps as dorsally attached (usually merging) pilei or totally prostrate crusts with wrinkled ceraceous hymenium of cream, pale, or ochraceous colors. However, in a young state the hymenium can be smooth or the folds poorly pronounced.

Microscopically, the basidiocarp is composed of efibulate hyphae, ramified at sharp or almost right angles; hyphae are thin-walled and densely packed in subhymenium, with thickened walls in trama, and thick-walled in abhymenial layer. The hyphal system can thus be characterized by the term "pseudodimitic", like that of *Schizophyllum commune* Fr.: Fr. (Zmitrovich et al. 2004). In resupinate forms, the hyphae of the medullar tissue and abhymenial stratum

are loosely interwoven and form a trichodermoid palisade on the pileus. In older basidiocarps many encrusted hyphae can be observed within all tissues.

The basidia are of merulioid type, i.e. with a definitely expressed medial constriction, located in small clusters. It is interesting that mature basidia are sometimes 1.5-2 times longer than young ones.

Cystidia are not characteristic of the species, but basidioles occasionally protrude cystidia-like from the hymenium as fusoid or capitate structures. Although reported earlier only for '*B. hirtellus*,' this phenomenon was frequently observed by us in *B. corium* (cf. Ginns 1976).

Basidiospores show considerable variation in *B. corium*. Cylindrical spores with certain suprahilar depression (5–7 x 2–3.5 µm) represent the 'average' morphotype. However, spores can be shorter or longer with an outline slightly amygdaloid or sigmoid, depending on basidiocarp age and microhabitats.

Short-spored specimens have, as a rule, hymenia that are smooth (or nearly so) and completely prostrate basidiocarps. Due to low humidity, specimens develop in exposed microhabitats (e.g., on dead branches). As shown by comparative analysis of basidiospore variability (see table), there is a certain overlapping between such xerophilous forms of *B. corium* and *B. armeniacus* (the latter described by Parmasto as an independent species, and later regarded as a synonym of *B. hirtellus*) (Ginns 1976). The authenticity of these taxa deserves much closer study, especially when using mating and molecular methods.

Taxonomic descriptions

Byssomerulius Parmasto, Eesti NSV Tead. Akad. Toim. Biol. **16:** 383, 1967.

Basidiocarps wood-inhabiting or lichenized, merulioid (infundibuliform to resupinate) or corticioid; **hymenophore** folded, raduloid, tuberculate to even, of ceraceous consistence; **trama** irregular to subregular; **context** wadded, rather dense; **hyphal system** pseudodimitic; **hyphae** simple septate or with rare double clamp-connections, thin- to thick-walled, regularly branched at a sharp angle; contextual hyphae uninflated, not exceeding epibasidial segment in width; **cystidia** none; **basidia** long clavate, constricted, thin-walled at the bases, 4-spored; **basidiospores** cylindrical, slightly curved (of suballantoid or sigmoid appearance), in some cases amygdaliform, thin-walled, neither amyloid, nor dextrinoid, acyanophilous. **Type of rot:** white.

GENUS TYPE—*Thelephora corium* (≡ *Byssomerulius corium*). [Refer to Spirin & Zmitrovich (2004) and Zmitrovich et al. (2006) for more details regarding the changing concepts of *Byssomerulius* and *Meruliopsis* after Parmasto (1967).]

Byssomerulius corium (Pers.: Fr.) Parmasto, Eesti NSV Tead. Akad. Toimet. Biol. 16: 383, 1967. **FIG. 1**

= *Thelephora corium* Pers. : Fr. 1821.
= *Merulius corium* (Pers.: Fr.) Fr. 1828.
= *Meruliopsis corium* (Pers.: Fr.) Ginns 1976.
= *Merulius confluens* Schwein.: Fr. 1822.
= *Merulius pallens* Schwein. 1832, non Berk. 1841.
= *Merulius aurantiacus* Klotzsch ex Berk. 1836, non (Wulfen: Fr.) J.F. Gmel. 1792.
= *Merulius haedinus* Berk. & M.A. Curtis 1872.
= *Merulius sordidus* Berk. & M.A. Curtis ex Cooke 1891.
= *Merulius pelliculosus* Cooke 1891.
= *Phlebia deglubens* Berk. & M.A. Curtis ex Cooke 1891.
= *Merulius deglubens* (Berk. & M.A. Curtis ex Cooke) Burt 1917.
= *Phlebia sodiroi* Pat. 1892.
= *Merulius sodiroi* (Pat.) Rick 1960.
= *Merulius moelleri* Bres. & Henn. 1896.
= *Merulius stereoides* Henn. 1901.
= *Merulius ulmi* Peck 1906.
= *Merulius hirsutus* Burt 1917.
= *Merulius cubensis* Burt 1917.
= *Merulius flavescens* Bres. 1920.
= *Merulius ochraceus* Lloyd 1921.
= *Merulius aurantius* Lloyd 1922.
= *Cladoderris rickii* Lloyd 1923.
= *Merulius chilensis* Speg. 1924.
= *Merulius dubiosus* Bres. ex Rick 1938.

Basidiocarps annual or persisting, resupinate – prostrate or pileate, 5–10 × 2–4 × 0.5–6 mm, usually confluent, papery, fragile when dry. Abhymenial surface tomentose to almost glabrous, obscurely zonate, white to grayish. **Context** white, suberose. **Margin** up to 3 mm wide, sterile, white, inrolled or adhered to the substrate. **Hymenium** 0.2–2 mm thick, folded (merulioid), creamish, yellowish, pale, reddish, or pale-ochraceous, with some grayish or violaceous tints in old basidiocarps, of ceraceous consistency.

Hyphal system pseudodimitic. **Hyphae** 2–6(8.5) µm in diam., simple septate or with rare double clamp-connections, thin- to slightly thick-walled, regularly branched at a sharp angle, sparsely encrusted. **Cystidia** none, but with basidioles having in some cases hyphoid or capitate apical proliferation. Basidia long-clavate, constricted, 17–40 × 4–6 µm, 4-spored, simple-septate at base. Spores ellipsoid-cylindrical, with suprahilar depression, in some cases, slightly curved, 4.5–9 × 2.3–4.5 µm, smooth, thin-walled, hyaline, usually with a central oil-drop, inamyloid, slightly cyanophilous when young.

Ecology, range, and distribution—Grows on dry, fallen branches and trunks of leafy trees. Produces a white rot. Found in Europe, Asia, Africa, Australia; North, Central, and South America. The species is widely distributed over the

Fig. 1. *Byssomerulius corium* var. *corium* (*HAI F0083*)
Basidiocarps. Scale bar = 1 cm.

Northern Hemisphere, but distinctly more frequent in subarid areas. In the taiga forests *B. corium* prefers intra-zonal elements of the vegetation cover. The most typical substrate for the species is dry, attached elm branches, but the fungus occurs also on linden, oak, maple, willow, alder, rowan, birch, aspen, plus many subtropical trees and shrubs.

Note—Despite its great variability, *B. corium* is easily distinguished due to characteristic parchment basidiocarps and ceraceous merulioid hymenium with pale ochraceous tints. Sometimes the hymenial folds look like small dummies, and, in some cases, the hymenium has an irpicoid appearance.

These forms were reported by Corner (1971) for the paleotropics, but in 1993 an irpicoid specimen was found in St. Petersburg (northwest Russia). The coloration of the hymenium varies considerably, but an ochraceous-pinkish tint remains rather constant. In some cases, prostrate forms of *B. corium* can be confused with *Lilaceophlebia serpens* (Tode: Fr.) Spirin & Zmitr., which usually differs in having a rather brightly colored hymenium with more or less expressed olive hues.

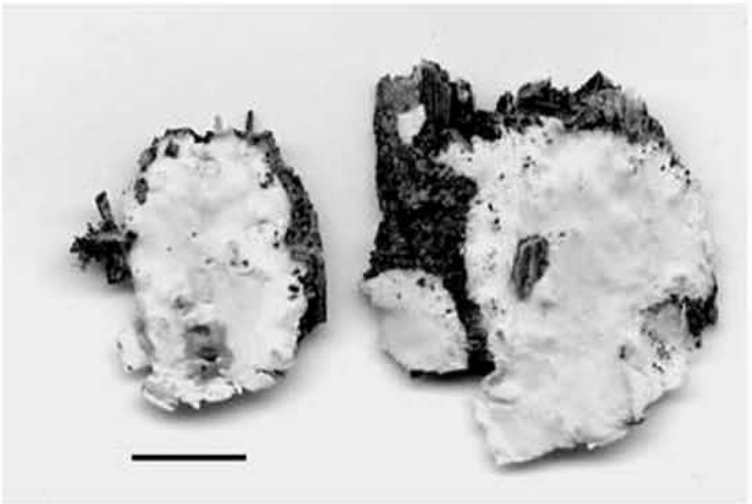

Fig. 2. *Byssomerulius corium* var. *halileensis* (*HAI F0084*) Basidiocarps. Scale bar = 0.5 cm.

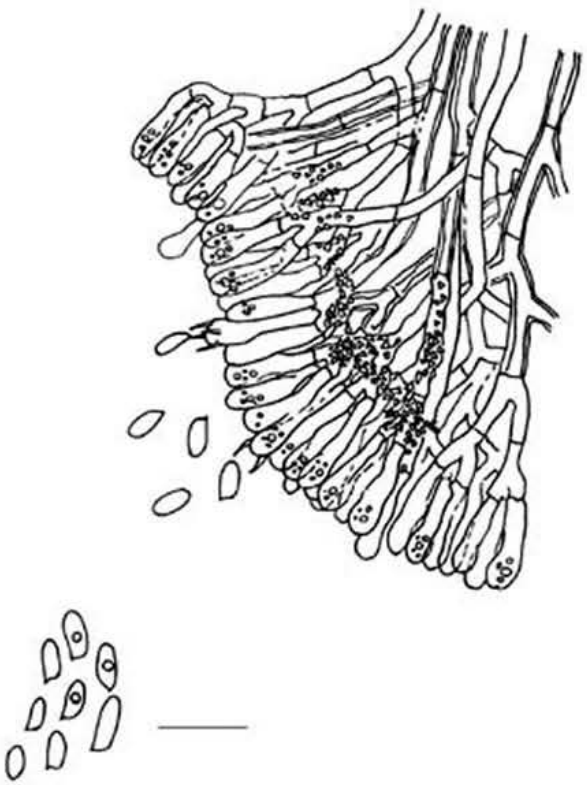

Fig. 3. *Byssomerulius corium* var. *halileensis* (*HAI F0084*): Section through hymenial fold; spores. Scale bar = 10 µm.

Table 1. Spore variability of some xerophilous forms of *Byssomerulius corium* and *B. armeniacus*

Species *Specimen No.*	Spore dimensions (range in µm)	Mean spore length	Mean spore width	Mean spore quotient (Q)
B. corium *HAI F0083*	5.0–9.0 × 2.5–3.5	7.15	2.95	2.42
B. corium *HAI F0084*	4.5–7.5 × 2.3–2.8	5.5	2.56	2.14
B. corium *HAI F0085*	5.0–7.1 × 2.3–2.6	5.6	2.5	2.24
B. corium *HAI F0086*	5.0–7.5 × 2.4–4	5.3	3.2	1.67
B. armeniacus *TAA 16280*	3.8–5.2 × 2.1–2.8	4.5	2.45	1.84

Byssomerulius corium* var. *halileensis Zmitr., Spirin & Wasser **var. nov.** **FIGS. 2, 3**
(Mycobank number: **MB510250**)

A typo hymeniis cremeis sublaevesque et sporis minutis discrepat.

Etymology: from the Latin *Halilea* (= Galilee), a district in Israel.

ORIGINAL MATERIAL: **ISRAEL.** Upper Galilee, *Quercus calliprinos* forest, on trunk of *Quercus calliprinos*, 19.III.2004, leg. & det. I.V. Zmitrovich (Holotype *HAI F0084*).

Basidiocarps 3–15 cm in diam, 0.1–0.8 mm thick, prostrate or slightly pileate (pilei up to 5 cm wide) sometimes cordonic, pale cream. **Hymenium** smooth or minutely folded, pale-cream, almost concolorous with the margin. Hyphae 2–6(18) µm in diam, densely packed in subiculum, moderately or strongly encrusted by amorphous matter. **Cystidia** none. **Basidioles** cylindrical to fusoid, 25–60 × 4–5 µm, enclosed or protruding the hymenium. **Basidia** 15–25 × 4–6 µm, 4-spored. Spores mostly short-cylindrical, 4.5–7.5 × 2.3–2.8 µm.

B. corium var. *halileensis* differs from the type variety by its creamy smooth to minutely wrinkled hymenium and the predominance of shorter spores. Spore measurements are the main means for distinguishing this variety from *B. armeniacus* (see table). Some other differences can be added, too. First, both *B. armeniacus* and *B. hirtellus* have no incrustation on their subhymenial and subicular hyphae. Second, the spores of *B. armeniacus* are less variable in their length (mostly not exceeding 5 µm long), while they are constantly longer and often varying in their size in *B. corium* var. *halileensis*. Moreover, subicular hyphae of *B. armeniacus* have slightly thickened walls, in contrast to clearly thick-walled hyphae of *B. corium* var. *halileensis*. So, we are inclined to address this xerophilous taxon to *B. corium* rather than to *B. armeniacus*.

ADDITIONAL SPECIMENS EXAMINED—*Byssomerulius corium*. **ISRAEL.** Upper Galilee, *Quercus calliprinos* forest, on trunks and branches of *Quercus calliprinos*, 19.III.2004, I.V. Zmitrovich (*HAI F0083, HAI F0084, HAI F0085, HAI F0086*). **REPUBLIC OF SOUTH AFRICA. Western Cape Province:** Stellenbosch, J. Marias nature reserve, on bark of *Quercus suber*, 25.II.2002, V.A. Melnik (*LE 211995*). **AUSTRIA.** Ex Hoehnel Kryptogamae exsiccatae No 1142, *Aesculus rubicundus*, F. Hoehnel. **ESTONIA.** Ex Fungi Estonici Exsiccati, Fasc. I No 13, Tartumaa, *Tilia cordata*, 20.VI.1930, leg. E. Lepik, det. V. Litschauer. **U.S.A.** Ex Ravenel's Fungi Americani Exsiccati No 136, Florida, Nyssa, S. Car. **SWEDEN.** Ex Lundell & Nannfeldt's Fungi Exsiccati Suecici, on dead, fallen branches and trunks of *Populus tremula* and *Salix sp.*, 18.X.1932, S. Lundell. **ITALIA.** Ex Erb. Crit. Ital. Ser. II. 'Sui pali deglisteccati che fiacheggiano I vitali del giardino del cisternone a Livorno', XI.1872, G. Arcangeli. **RUSSIA.** Griby Minusinskoi Flory, Minusinsk, on fallen *Betula* sp., A. Martianoff (*LE 166059*).

—*Byssomerulius armeniacus*. **ARMENIA.** Kaphan, Tsav, *Sambucus ebulus*, 2.X.1962, E. Parmasto (*TAA 16280*).

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Thallus development and the systematics of Chytridiomycota: an additional developmental pattern represented by *Podochytrium*

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Abstract—Use of thallus developmental patterns in the systematics of chytridiomycetous fungi has been controversial, especially regarding the taxonomic rank or level at which use is appropriate. This review analyzes and interprets developmental thallus morphology among a spectrum of Chytridiomycota. Investigation of this topic revealed an additional mode of development, represented by the genus *Podochytrium*, distinct from developmental patterns previously recognized. Some genera that may seem morphologically comparable based on the mature thallus may in fact attain this morphology by different patterns of development. Although thallus development is of questionable macrosystematic and phylogenetic utility among chytrids because of convergence, patterns of thallus development can nonetheless be helpful in distinguishing one chytrid genus from another.

Key words—apophysis, bipolar growth, prosporangium, sporangium, zoospore cyst

Introduction and historical overview

Traditionally, two main, somewhat opposing viewpoints have expressed the optimal means of delimiting major systematic groupings (orders, families, subfamilies) of Chytridiomycetes (especially among eucarpic, monocentric taxa)—that of F. K. Sparrow and of A. J. Whiffen. Sparrow (1933a, p. 63) commented that "the operculum [of the sporangium] impresses one as a morphological structure of some significance." Sparrow (1942, 1943) subsequently emphasized use of sporangial operculation versus inoperculation in delimiting major groupings of chytrids; a similar, if preliminary, view was presented in outline form by Gäumann & Dodge (1928). Secondarily, Sparrow (1943) emphasized habit in classification, i.e., whether the sporangium occurred extramatrically (epibiotic or interbiotic sporangia) or intramatrically (endobiotic sporangia). By comparison, Whiffen (1944) emphasized differences in thallus development for broad systematic purposes in chytrids. Of primary

importance in Whiffen's system is whether the sporangium develops directly from the zoospore cyst or from a portion of the germ tube of the zoospore cyst, a distinction Petersen (1910) briefly noted. Whiffen (1944) did not consider the presence or absence of operculation significant in chytrid macrosytematics; Haskins & Weston (1950) likewise questioned the taxonomic value of operculation. Both Sparrow and Whiffen gave credence, though not identical importance in the general classification of chytrids, to whether the thallus was monocentric or polycentric. In any case, the classifications by Sparrow and Whiffen are not substantially congruent. Sparrow (1943, 1960) recognized three families of eucarpic, monocentric chytrids in *Chytridiales* and two families (three if including the variable *Physodermataceae*) of polycentric members of this order. Whiffen (1944) recognized just two families of eucarpic, monocentric chytrids in *Chytridiales* and only one polycentric family. Karling's (1932) early emphasis on holocarpic versus eucarpic thalli found some consistency of application at the family level, e.g., the *Olpidiaceae* (Sparrow 1960).

Roane & Paterson (1974) supported Whiffen's (1944) viewpoint on the importance of thallus development, expanding on Whiffen's system. Barr (1978) likewise felt that thallus development was more significant than operculation in the systematic delimitation of major groupings of chytrids. However, Barr (1978) placed primary emphasis on whether the nucleus of the zoospore cyst remains within the cyst or migrates into the zoospore germ tube during thallus development. Longcore (2002) pointed out, as demonstrated by Powell & Koch (1977), that migration of the cyst nucleus into the germ tube allows a chytrid to establish zoosporangia endobiotically or intramatrically (i.e., within the substrate); such a migration is thus a feature of biological significance. Barr (1978) in fact viewed such endobiotic chytrids, generally, as derived compared with epibiotic chytrids. Both Barr (1990) and Longcore (2002) used the terms "endogenous" (meaning, zoospore nucleus remaining in the cyst) and "exogenous" (meaning, zoospore nucleus migrating out of the cyst, into the germ tube) in this new context. A problem with this terminology is the possible confusion with older usage of the same terms for general thallus development (Karling 1936, 1977; Sparrow 1943, 1960; Hanson 1946). In traditional usage "exogenous" is equivalent to "extramatrical" (epibiotic or interbiotic) sporangial position, and "endogenous" is equivalent to "intramatrical" (endobiotic) sporangial position. In the common genus *Rhizophydium*, for example, one encounters the apparent contradiction that thallus development is "exogenous," when speaking of sporangial position, but "endogenous" when speaking of the zoospore cyst nucleus (i.e., that the nucleus is retained within the cyst).

Determining whether the zoospore cyst nucleus migrates or not (Powell & Koch 1977, Barr 1978, 1990; Longcore 2002) is crucial to understanding

differences in thallus development. To solve the semantic problem, concerning movement of the cyst nucleus, it is simpler to speak of "non-migratory" in place of "endogenous" (i.e., nucleus retained in the cyst), and "migratory" in place of "exogenous" (i.e., nucleus moves out of the cyst). In the latter case, nuclear migration is usually from the zoospore cyst into the germ tube, as would be understood from Barr and Longcore. However, a different migration of the cyst nucleus may occur. If the zoospore cyst functions as, or develops into, a prosporangium, migration of the nucleus may be into the sporangium from the prosporangium, as in *Polyphagus*. "Prosporangial migration" is important in *Podochytrium* development, as will be seen under our discussion of that developmental type. Thus, replacement terminology ("migratory" and "non-migratory"), regarding the destination of the zoospore cyst nucleus, allows retention of "exogenous" and "endogenous" in original context—i.e., location of sporangial thallus, apophysis, resting spore, etc., relative to the substrate—important, particularly, in describing the unusual progression of development in *Chytridium lagenaria*.

One may extrapolate from Barr (1980) that both traditional points of view (Sparrow 1943, emphasizing operculation; and Whiffen 1944, emphasizing thallus development) have had relevance, and some consistency of application, in delimiting major groupings of chytrids. As Barr suggested, however, these traditional approaches have not provided entirely satisfactory or even mutually compatible, systematic answers. Accordingly, Barr (1980, 1990, 2001) increasingly emphasized zoospore type and fine structure for improved systematic understanding of Chytridiomycota (Longcore 2002, Letcher & Powell 2005). Barr's (1980) delineation of chytrid groupings, based fundamentally on zoospore ultrastructure, derived a classification in which a new order of Chytridiomycota—the *Spizellomycetales*—was recognized. Blackwell et al. (2004) discussed differing points of view on chytrid systematics, concluding that, whereas ultrastructural features of the zoospore are essential as a primary suite of characters in chytrid systematics, arguments can still be made for taxonomic use of both operculation and thallus development. However as Blackwell et al. (2004) indicated, both classical and modern features employed in chytrid systematics are best used in consort, not competitively. A collaborative approach, though, implies detailed assessment of the taxonomic level or levels at which different kinds of taxonomic characters, or suites of characters, are most meaningfully brought to bear. The applicability of traditional features of thallus morphology and thallus development among chytrids now appears to be significant mainly at lower levels of classification (genus, species), and not primarily in deciphering higher ranks or categories (orders, families); this viewpoint is also supported in recent molecular systematic studies (Letcher et al. 2005) and is explained in our Discussion.

Although variation and taxonomic significance of operculation should be thoroughly reinvestigated, the focus of our present paper is thallus development. We pursue this focus because the additional developmental type we recognize is represented in *Podochytrium*, a genus containing only inoperculate species. Thus, herein we consider primarily how insights from examination of thallus development (sensu Whiffen 1944, Roane & Paterson 1974, Barr 1978) may refine the concept of *Podochytrium* and similar genera of Chytridiomycota. This evaluation is best accomplished in the context of a review of known chytrid thallus types to strengthen understanding of thallus development. It will be important to see how improved knowledge of thallus development will interface with the emerging resolution that molecular analyses bring to chytrid phylogeny (James et al. 2000, Letcher & Powell 2005, Letcher et al. 2004, 2005), particularly as these analyses become refined at the generic and specific levels.

Thallus developmental types in Chytridiomycota

In ascribing systematic significance in Chytridiomycetes to thallus development, Whiffen (1944) outlined five basic types of development among monocentric, eucarpic members of the *Chytridiales* (types #1–#5, listed below). A sixth type of development may be surmised (cf. Sparrow 1943; Whiffen 1944) if the category "polycentric" is included (type #6). Whiffen's monocentric developmental patterns were reviewed by Roane & Paterson (1974), who added a putative additional type of monocentric development (type #7). We here recognize yet another monocentric mode of thallus development, exemplified by the development of *Podochytrium* (type #8). Since we are suggesting this "*Podochytrium* pattern" as an additional developmental type among chytrids, substantial detail is provided for this pattern. Since the developmental pattern suggested by Roane & Paterson (type #7), as well as precisely which chytrid taxa exhibit this pattern, are controversial, considerable attention is devoted to this category as well. And, because of its peculiar nature, some extra explanation is also due type #3. For comparability, descriptions, examples, and illustrations are provided for the eight types of chytrid thallus development recognized (Figs. 1–8).

Whiffen's (1944) five developmental patterns in monocentric chytrids

The developmental patterns that Whiffen (1944) recognized are here annotated, expanded, and updated (with respect to information in Karling 1977, Barr 1990, 2001; Longcore 2002 among other references, and based also on our own observations). Examples provided—some additional to those in previous references—are mainly from eucarpic chytrids; but holocarpic examples (e.g., *Olpidium*) are also included, since similar developmental patterns occur. The patterns listed below are not iron-clad for specific taxa. For example, the

well-known, typically interbiotic (extramatrical) genus *Rhizophlyctis*, usually exhibiting a monocentric thallus (and fitting under type #1), may rarely develop in the manner of type #4 (e.g., *Entophlyctis*), or of type #6 (e.g., *Nowakowskiella*), cf. Karling (1947). Also, certain species of *Entophlyctis*, though consistently intramatrical and typically conforming to type #4, may occasionally exhibit thallus development reminiscent of *Rhizophlyctis* (type #1), cf. Powell & Koch (1977). The patterns outlined are thus generalizations, representing the typical situation for the patterns and organisms listed.

Type #1. The encysted zoospore enlarges directly into the sporangium, the cyst nucleus being non-migratory. The sporangial thallus is either epibiotic (*Rhizophydium*, and *Phlyctidium* if considered distinct from *Rhizophydium*) or interbiotic (*Rhizidium* and, typically, *Rhizophlyctis*). This mode of development has been generally construed to be the simplest, most direct, and possibly the most primitive type of development among Chytridiomycota (cf. Barr 1978)

Figure 1

Type #2. The encysted zoospore enlarges, sometimes also becoming altered in shape, to form a prosporangium, from which the sporangium develops. The zoospore cyst nucleus is migratory, from prosporangium to sporangium, this migration occurring after prosporangial expansion. The sporangial thallus is typically interbiotic, only the rhizoid tips being endobiotic; e.g., *Polyphagus*, *Endocoenobium*, *Sporophlyctis*. **Figure 2**

Type #3. An intramatrical swelling of the germ tube enlarges into a relatively large apophysis which functions as a prosporangium, contributing to subsequent extramatrical development of the encysted zoospore into the sporangium. Before significant sporangial expansion, the zoospore cyst nucleus (or one of its immediate division products) may migrate through the penetration tube into the incipient apophysis, resulting in apophyseal expansion. This (migrated) nucleus, or its progeny, can migrate back into the zoospore cyst, leading to further sporangial development. This combined, or at first alternating, mode of development corresponds to Karling's (1936) description of "endo-exogenous" thallus development in *Chytridium lagenaria*. The developing (intramatrical, i.e., endogenous) apophysis is often, for a time at least, larger than the developing (extramatrical, i.e., exogenous) sporangium. Rather than always contributing to sporangial generation, the apophysis may develop as a resting spore. In some

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Note on illustrations on pp. 96, 98, & 103: The eight sets of Figures correspond, in order, to the eight (numbered) types of sporangial development, from the zoospore cyst (see text for details of each type). Arrows indicate the path of nuclear migration. Resting spores are depicted at the far right in each series.

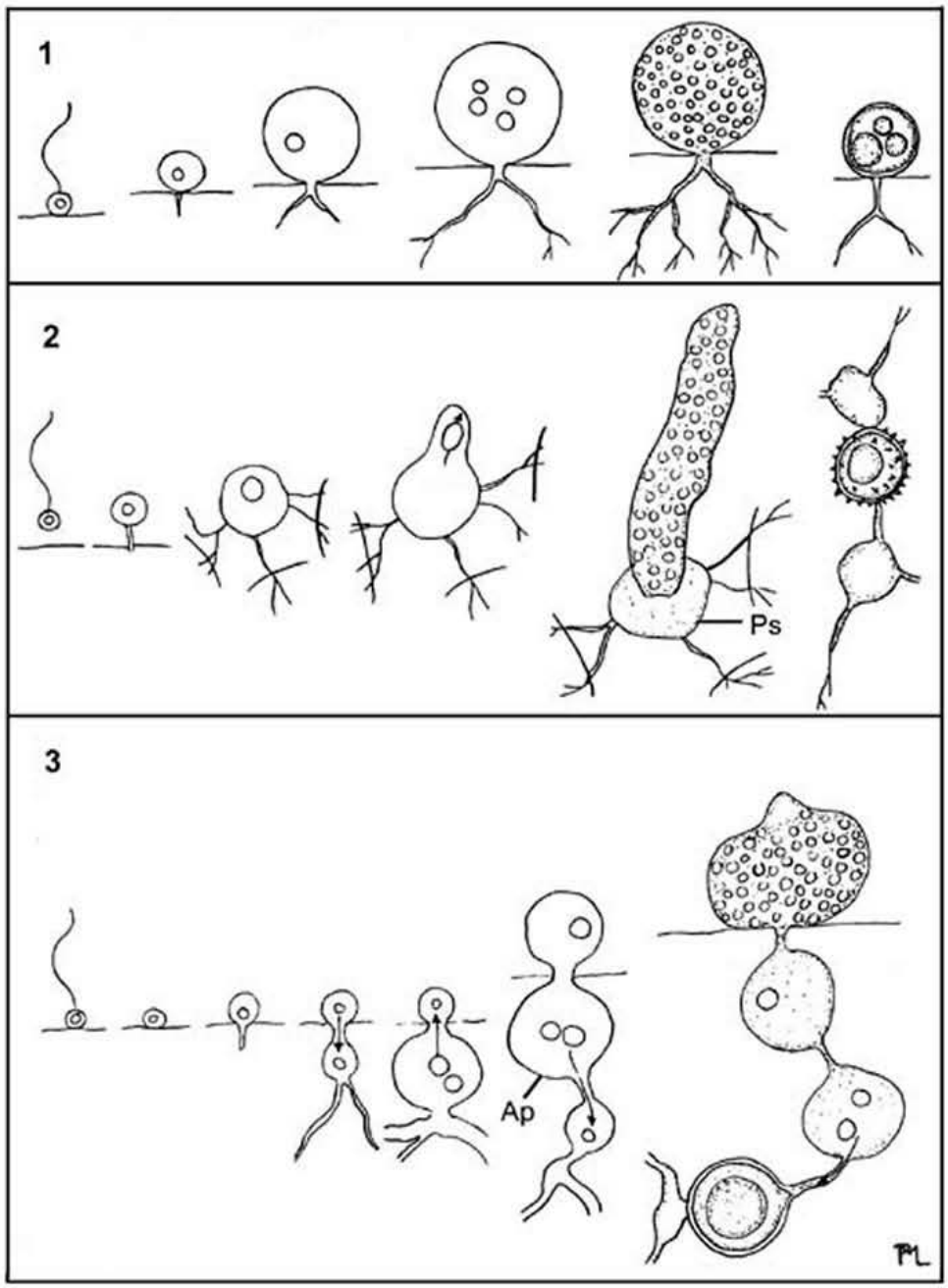

Fig. 1. Type #1 development, in which the zoospore cyst enlarges directly into the sporangium, e.g., *Rhizophydium*.

Fig. 2. Type #2 development, in which the zoospore cyst forms a prosporangium (Ps), which in turn produces the sporangium, e.g., *Polyphagus*.

Fig. 3. Type #3 development, exemplified by the endo-exogenous development of *Chytridium lagenaria*. Typically, an intramatrical apophysis (Ap) enlarges, subsequently contributing to the development of an extramatrical sporangium.

instances the rhizoidal region may develop a series of apophyses, or intramatrical resting spores, with associated rhizoidal connections, approaching a polycentric habit (Blackwell et al. 2002). Occasionally, in *C. lagenaria*, secondary sporangia may be proliferated basally, within the primary sporangium, from continued generative activity of the initial apophysis (Blackwell & Powell 2000). The term "endo-exogenous" in the case of *C. lagenaria* refers specifically to the alternating (generative) activities of the apophysis and sporangium, respectively—not per se to nuclear migration, though this of course may be involved in the activities of generative structures. **Figure 3**

In addition to *Chytridium lagenaria*, *C. oedogonii* (Couch 1938) appears to develop in a generally endo-exogenous fashion (Blackwell et al. 2002). And, it is probable that the genus *Canteria*—described by Karling (1971), based on *Phlyctidium apophysatum* Canter (1947)—also develops in this way (Karling 1971, 1977). According to Hanson (1946), *Catenochytridium* has a mode of development resembling that of *Chytridium lagenaria*. However, Sparrow (1960) noted that the behavior of the zoospore cyst nucleus in *Catenochytridium* apparently differs from that of *Chytridium lagenaria*. Sparrow (1960) considered that "endo-exogenous thallus development" may differ mainly in degree from, or be merely a special case of, the usual acropetal sporangial development, based on a nourishing system of rhizoids, found in many chytrids. However, apparent nuclear "remigrations"—from intramatrical apophysis back to extramatrical sporangium (the two apparently separated structures remain connected by the original germ tube)—and a potential for continued sporangial proliferation based on such migrations (in *C. lagenaria*), support the idea of the distinctive character of this developmental type.

Type #4. The zoospore cyst nucleus migrates into the zoospore germ tube. An intramatrical enlargement of the germ tube, containing the migrated zoospore cyst nucleus, develops into the sporangium; rhizoids can develop from the incipient sporangium and/or the tip of the germ tube. The sporangial thallus is thus typically endobiotic, e.g., the eucarpic genera, *Entophlyctis* and *Endochytrium*. In the holocarpic genus *Olpidium*, lacking rhizoids, the nucleus and cytoplasm migrate (together) out of the zoospore cyst, and are released into the host cytoplasm as a protoplast by means of an injection peg (equivalent, in a comparative morphological sense, to the germ tube of the eucarpic genera mentioned in this category). **Figure 4**

Type #5. The zoospore cyst nucleus migrates into the germ tube. An intramatrical enlargement of the germ tube (containing the migrated nucleus) develops into an apophysis which may function as a prosporangium, producing the sporangium. The zoospore cyst nucleus passes into the developing sporangium, where nuclear divisions result in zoospores. This pattern of development is

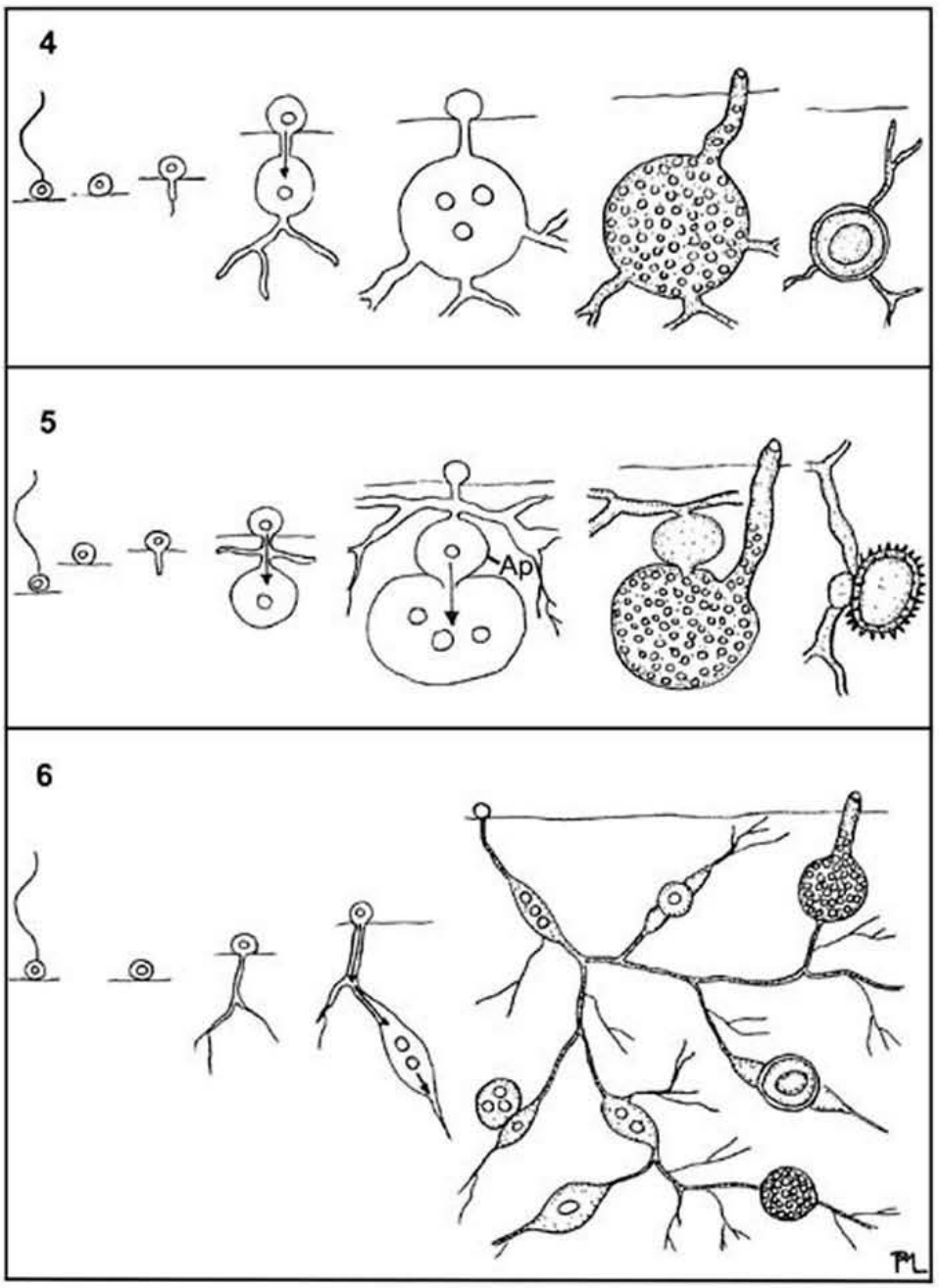

Fig. 4. Type #4 development, in which an intramatrical swelling of the zoospore germ tube becomes the sporangium, e.g., *Entophlyctis*.

Fig. 5. Type #5 development, similar to type #4, but an apophysis (Ap) contributes to sporangial formation, e.g., *Diplophlyctis*.

Fig. 6. Type #6 (polycentric) development. Illustrated here by a rhizomycelial form, *Cladochytrium*, polycentric development spans an array of developmental forms.

considered characteristic of *Diplophlyctis* (Whiffen 1944) but, as Sparrow (1960) discussed, the development of *Diplophlyctis* can be quite variable. In any case, rhizoids typically form from the apophyseal portion of the endobiotic thallus. Both *Nephrochytrium* (endobiotic) and *Asterophlyctis* (epibiotic or interbiotic) exhibit developments bearing some similarity to *Diplophlyctis*. In *Asterophlyctis*, the sporangium typically develops from the germ tube, proximal to the developing apophysis. **Figure 5**

A category recognized by both Sparrow (1943) and Whiffen (1944)

Type #6 (polycentric). The nucleus of the zoospore cyst migrates into the germ tube. The germ tube and proliferated nuclei ultimately give rise to multiple centers of zoospore development (i.e., sporangia), connected by rhizoids. Such a polycentric thallus is typically intramatrical. Polycentric forms may be either operculate or inoperculate (Sparrow 1943, 1960), an indication that the polycentric habit may tell us relatively little about relationships. The classifications of Sparrow (1943) and Whiffen (1944) are somewhat contradictory concerning polycentric forms, although both authors based family status, in one or more cases, on this type of thallus. The polycentric habit probably arose a number of times in different systematic groups (cf. Blackwell et al. 2004), even within genera and species. For example, the monocentric genus *Rhizophlyctis* (see type #1) may rarely exhibit a polycentric form (Karling 1947, Sparrow 1960). *Karlingiomyces*, also fundamentally monocentric, has one species that can show polycentric growth (Blackwell et al. 2004). *Phlyctorhiza variabilis* (Karling 1951), transferred to *Catenophlyctis* by Karling (1965), is monocentric for a time, but may subsequently develop in a polycentric manner; certain strains are apparently more prone to be polycentric than others. Thallus development of *Catenophlyctis* supports Barr's (1978) supposition that the polycentric habit is derived, relative to the monocentric state. The matter of "number of sporangial centers per thallus" is not resolved in all genera; *Endochytrium* is a case in point. Karling (1977, p. 196) discussed *Endochytrium* as the "operculate counterpart of *Entophlyctis*" (a typically monocentric genus). Sparrow (1933a) originally described *Endochytrium* as polycentric, but Karling (1937) believed that *Endochytrium* was exclusively monocentric. Karling (1977, p. 196) eventually concluded, however, that the thallus of *Endochytrium* is "predominantly monocentric."—a conclusion with which we concur, but one that still warrants investigation. **Figure 6**

The polycentric habit of a chytrid, at the level of order and family, is not as defining systematically as once thought. Certain predominantly monocentric chytrids (e.g., *Karlingiomyces*) are now predicted to cluster with clades that are generally polycentric (cf. James et al. 2000, Blackwell et al. 2004). Furthermore, there is considerable variation of thallus, even thallus type, within the general category

of polycentric habit—a topic that should be further investigated. Certainly, not all polycentric thalli are equivalent; in fact, differences in details of polycentric habit among rhizomycelial chytrids are often useful in delimiting genera, e.g., *Cladochytrium* and *Nowakowskiella*. The general category "polycentric chytrids" is thus diverse and difficult to assess. In contrast to monocentric chytrids, which typically exhibit determinate growth, polycentric chytrids often have a more extensive, indeterminate growth form (Sparrow 1960), limited in some cases by the confines of the substrate. Barr (1990), however, conceived of "polycentric" very broadly—to include not only rhizomycelial forms (with indeterminate growth) such as *Nowakowskiella* and *Cladochytrium*, but indeterminate filamentous forms such as *Monoblepharis* and *Gonapodya*, and also determinate colonial forms such as the holocarpic genus *Synchytrium*. Obviously, "polycentric chytrids" are a heterogeneous category, requiring taxonomic refinement through ultrastructural and molecular studies.

The contribution of Roane & Paterson (1974)

Type #7. Roane & Paterson (1974) reviewed Whiffen's (1944) work and provided simple diagrammatic illustrations of developmental patterns, based on the illustrations of Whiffen. Roane & Paterson accepted Whiffen's categorization of five developmental types in eucarpic monocentric *Chytridiales*, but added an additional type of monocentric development, similar to type #3, but in which the apophysis is consistently smaller than the developing sporangium, e.g., *Chytriomyces hyalinus*. Though highlighting *C. hyalinus* in this "new" developmental type, Roane & Paterson mentioned the occurrence of similar forms in *Phlyctochytrium powhatanense* and *Chytridium ottariense*. *Chytriomyces aureus* may also exhibit a relatively small apophysis, i.e., in relation to the sporangium (cf. Karling 1945, Letcher & Powell 2002). **Figure 7**

A problem with this additional category recognized by Roane & Paterson (1974) is that in certain chytrids, e.g., *Chytridium schenkii*, the sporangium and apophysis can develop, and remain, at a comparable size. Some authors (Koch 1957, Miller 1968, Letcher & Powell 2005) found, particularly in the genus *Phlyctochytrium*, that the apophysis is a character of insufficient consistency for definitive taxonomic use. In *Chytriomyces spinosus* (Fay 1947) an apophysis may be present, though it is typically lacking. Beyond the matter of presence or absence, the question of what an apophysis actually represents has never been satisfactorily answered (Blackwell et al. 2002). The apophysis has a strongly generative function in some instances (e.g., Chytridium *lagenaria*), in which it contributes significantly to sporangial development; but, this is not necessarily so in other cases (e.g., *Chytriomyces aureus*, *Phlyctochytrium planicorne*). An apophysis is often intimately associated with rhizoid development, e.g. *Chytridium aggregatum*, *Chytriomyces aureus*, *Chytriomyces*

hyalinus, *Phlyctochytrium planicorne*, and *Podochytrium dentatum*. However, such a subsporangial swelling may occasionally not be associated with rhizoids; *Chytridium inflatum* has what is apparently a distinct apophysis, but rhizoids are not evident (Sparrow 1960); *Caulochytrium* possesses a subsporangial (haustorial) swelling, lacking rhizoids (Powell 1981). Karling (1932) suggested that the apophysis represents a "homeotic" feature—an additional, fundamentally sporangial, structure. While interesting, a thesis of homeosis could be argued mainly in cases in which both sporangium and apophysis originate from the same immediate precursor (i.e., the germ tube), and then only if the apophysis is generative or "prosporangial" in function. *Diplophlyctis* is one of a few possible candidates for this interpretation.

A further difficulty presented by Roane & Paterson's developmental type (type #7 herein) is that the potential for endo-exogenous development (sensu Karling 1936, i.e., type #3), versus primarily exogenous development (as presumably occurs in type #7), is not necessarily differentiated among all chytrids possibly falling in type #7, cf. *Chytridium cejpii* (Fott 1950). *Chytriomyces hyalinus* may in some instances have "catenulate apophyses" (Roane & Paterson 1974, p. 147), suggestive of the sort of endo-exogenous development characteristic of *Chytridium lagenaria* (see discussion under type #3). Another problem with Roane & Paterson's pattern developmental type is that it does not adequately address the position of resting spores—putatively epibiotic in *Chytriomyces*, and endobiotic in species potentially included in *Chytridium* (cf. Karling 1945, Sparrow 1960, Letcher & Powell 2002). Roane & Paterson (1974, p. 147) stated that position (we assume, location with regard to substrate) of the resting spore in *Chytriomyces hyalinus* was "not constant"; however, they did not explain this variability. The boundaries of this type #7 are not clear. Nonetheless, there is a certain utility in continuing to recognize this developmental type.

Polyphlyctis (cf. Karling 1967a, Batko 1975), based on two species placed originally in *Phlyctochytrium* (Willoughby & Townley 1961, Willoughby 1965), is an unusual, variably apophysate genus; the apophyses sometimes develop in a catenulate fashion (as mentioned, occasionally also observed in *Chytriomyces hyalinus*). In *Polyphlyctis*, the zoospore cyst splits longitudinally into two halves or "hemicysts" (Willoughby & Townley 1961, Willoughby 1965); but, the protoplasts of the halves apparently never lose continuity, and an essentially normal, monocentric sporangial development ensues (cf. Willoughby 1965, Fig. 1; Karling 1967a, Plate 15, Fig. 1). Evidence of the earlier "split" development of *Polyphlyctis* remains, though, in the usual persistence of each half of the zoospore cyst wall, often on opposite sides of the sporangium (Willoughby 1965, Karling 1967a, 1977). Both species of *Polyphlyctis* should be re-examined to ascertain if their mode of development represents a variant within type #7, or fits better in type #3, or possibly constitutes a unique mode of development.

Recognition of an additional developmental type (*Podochytrium*)

Type #8. We herein suggest that an additional pattern of thallus development is exhibited in members of *Podochytrium*, including the diatom parasites *Podochytrium clavatum*, *P. lanceolatum*, and *P. cornutum* (cf. Sparrow 1960); possibly in a formally undescribed species of *Podochytrium* found in Iceland (Johnson & Howard 1968); and in the saprotrophic *Podochytrium chitinophilum* (Willoughby 1961). In this "*Podochytrium*-type" of development, the encysted zoospore does not expand appreciably, but undergoes an apparently unique bipolar development. A germ tube forms from the proximal face of the encysted zoospore, penetrates the substrate and develops (intramatrically) into the rhizoidal system. The zoospore cyst also functions, without significant enlargement or change in shape, as a prosporangium, and generates the sporangium. The sporangium, however, is produced in an unusual manner; it develops (enlarges, elongates) only from the apical portion (distal face) of the encysted zoospore. Structurally, the main body of the zoospore cyst does not appear to be involved in this alteration, and remains unchanged, or exhibits only slight expansion or minor wall thickening. This cyst body persists as a sterile basal cell subtending the usually somewhat larger sporangium, from which it is typically delimited by a sub-basal septum. The epibiotic "sporangial apparatus" of *Podochytrium* thus becomes obviously differentiated into a distal zoosporogenous portion (sporangium) and a smaller, proximal, sterile, knob-like structure (the basal cell). The sporangium is inoperculate, usually becomes somewhat longer than broad, and typically opens by a single apical discharge pore. This developmental interpretation of *Podochytrium* is consistent with Pfitzer's (1870) original concept and description of the genus, based primarily on the unequally two-parted sporangial apparatus. **Figure 8**

As for other species of *Podochytrium*, the chitinophilic *P. dentatum* (Longcore 1992) likewise fits type #8, although a limited expansion of the zoospore cyst may occur prior to bipolar development. Following apical budding of the cyst, the resultant young sporangial apex becomes bifid, unusual among Chytriomycota. Additionally, a swelling of the proximal rhizoidal area (i.e., closest to the basal cell of the sporangial apparatus) occurs. However, the apophysis-like rhizoidal structure does not function as a prosporangium or sporangium. This apophyseal region is sometimes delimited from the basal cell of the sporangial apparatus by a wall, and appears only to serve the purpose of proximal connection of rhizoids. *Podochytrium emmanuelense*, a parasite of diatoms, exhibits development as outlined in type #8, but may additionally show a degree of endo-exogenous development (sensu Karling 1936; see illustrations in Karling 1977, Plate 33, Figs. 23-25); it is therefore somewhat comparable to types #3 and #7, as well as type #8.

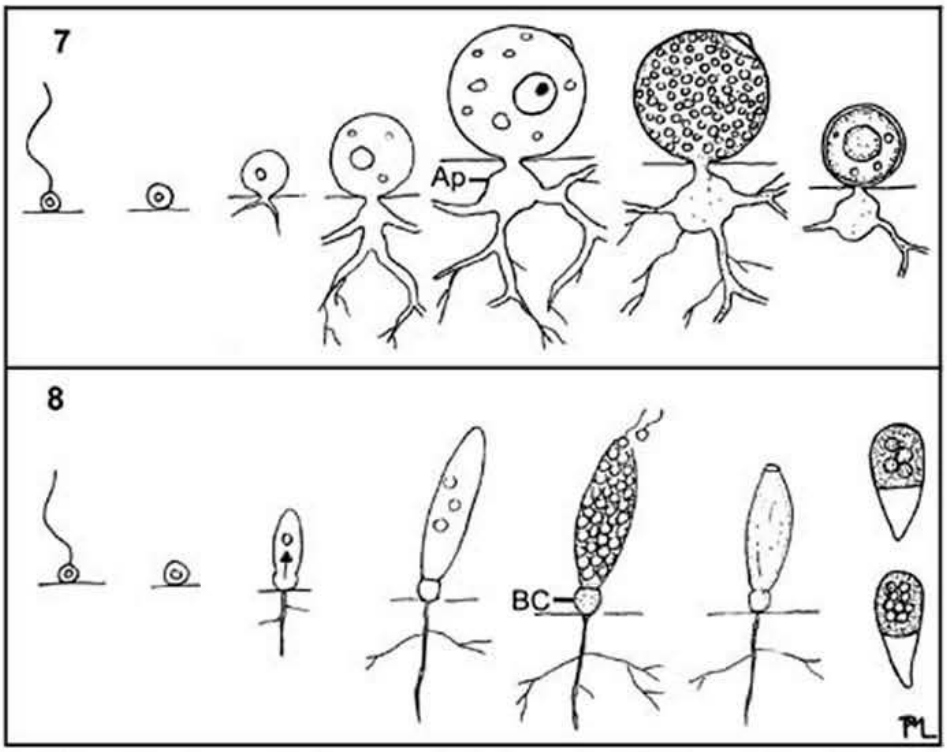

Fig. 7. Type #7 development. Similar to type #3, but the apophysis (Ap) is typically smaller than the developing sporangium, e.g., *Chytriomyces aureus*.

Fig. 8. Type #8 development. An additional developmental type recognized herein, exemplified by *Podochytrium—P. lanceolatum* and *P. clavatum* (resting spore only) are illustrated. Development of the zoospore is bipolar, the sporangium arising from the apical portion of the zoospore cyst. The zoospore cyst usually undergoes little or no enlargement or apparent differentiation, but is retained as a sterile, basal cell (BC).

As Powell & Koch (1977) noted, nuclear migratory behavior in chytrids can be variable among species of a given genus, and even within a single species. In *Podochytrium*, however, the pattern of nuclear migration appears to be similar among the taxa. Development of all *Podochytrium* species, including *P. emmanuelense*, is "endogenous" in the sense of Barr (1990), in that the nucleus of the zoospore cyst does not migrate into the germ tube. As explained in the introduction, Barr's terminology ("exogenous" and "endogenous"), concerning whether the cyst nucleus migrates into the germ tube or not, presents difficulty because of prior use of these terms to describe sporangial position relative to the substrate. Beyond this, *Podochytrium* exemplifies a further developmental/morphological problem associated with the "endogenous/exogenous" terminology and concept, when applied to the zoospore cyst nucleus. In the context of the zoospore cyst, "endogenous" implies a non-migrating cyst

nucleus. But, this can be misleading, because what Barr (1990), Longcore (2002) and others specifically meant by "endogenous" was that the cyst nucleus does not migrate into the germ tube (not that it doesn't migrate at all). The zoospore cyst nucleus of *Podochytrium*, though technically "endogenous"—and indeed not migrating into the germ tube—does, nonetheless, undergo migration. Migration in this case, though, is from the cyst (prosporangium) into the sporangium formed as an apical outgrowth of the cyst. The zoospore cyst is in the process "left behind" as a sterile, supporting structure (basal cell). So, the case of *Podochytrium* and certain other examples (such as the development of *Polyphagus*) are among the reasons why it is preferable (when referring to the zoospore cyst nucleus) to use the broader and less encumbered terms, "migratory" and "non-migratory," instead of "exogenous" and "endogenous." Perhaps it would be helpful to recognize two categories of "migratory," one denoting migration of nucleus from cyst to germ tube (as in typical *Entophlyctis* development), and the other (as in *Podochytrium*) referring to migration from prosporangium to sporangium. In truly non-migratory "behavior," e.g., *Rhizophydium*, the zoospore cyst nucleus does not physically move into another structure of any kind, but remains in the cyst which develops directly into a sporangium.

A readily discernible feature that sets typical *Podochytrium* development apart from other chytrid developmental types is that no significant expansion or change in shape of the zoospore cyst usually occurs, although it functions as a prosporangium. A sporangium simply forms from the apex of the otherwise apparently unaltered cyst. The germ tube forms at the "pole" of the cyst opposite the "sporangial end," and it typically undergoes no appreciable dilation to form any additional sporangial, prosporangial, or apophyseal structure (a rhizoidal dilation may occur in *P. dentatum*, as mentioned). The epibiotic resting spore of *Podochytrium* usually forms from the sporangium proper. The basal cell typically makes no contribution to the structure of the resting spore, but may remain attached to it—in some instances a useful additional recognition character.

Discussion

Whether other genera of monocentric Chytridiomycota conform to the *Podochytrium* type of development, or whether still other developmental types exist, remains to be demonstrated. But, such is worthy of further investigation. The genus *Sporophlyctidium* (Sparrow 1933b) may produce a small thallus superficially similar to that of *Podochytrium*. However, the thallus of *Sporophlyctidium* appears to be derived by a modification of type #1, rather than being formed in the manner of *Podochytrium* (type #8). In

Physorhizophidium, the apparent knob-like base of the sporangium is not developmentally comparable to the basal cell of *Podochytrium*; the epibiotic "knob" (subsporangial swelling) of *Physorhizophidium* is in fact secondarily formed (Sparrow 1943), and not part of the original sporangial apparatus. In *Saccomyces*, a genus with a "two-celled" epibiotic structure (sporangial apparatus) resembling *Podochytrium* (see Sparrow 1960, Karling 1977), the basal portion (cell) is a distinct prosporangium, modified (somewhat in size, but especially in shape) from the zoospore cyst. The prosporangium in *Saccomyces* forms the sporangium, but as a lateral, not apical, elaboration. In mode of development, *Saccomyces*, except for being epibiotic (and endobiotic), is most similar to the interbiotic forms, *Polyphagus*, *Endocoenobium*, and *Sporophlyctis* (see type #2). The two-celled "sporangial" structure in *Septosperma* is actually the resting spore stage, rather than the sporangium (cf. Sparrow 1960, Blackwell & Powell 1991). An apparent two-celled structure in *Rhizophydium ovatum* is a product of sexual reproduction (Couch 1935), not of asexual development and differentiation of the zoospore cyst. Sparrow (1960) likened *R. clinopus* to *Podochytrium*. However, the "basal cell" of *R. clinopus* never separates by a septum from the sporangium (unlike the case of *Podochytrium* where it does), and the entire sporangial apparatus in *R. clinopus* develops in a unitary fashion from the zoospore cyst (type #1), not in the progressive (polar) manner of *Podochytrium* (type #8). *Chytridium cejpii* exhibits a morphology apparently similar to *Rhizophydium clinopus* and to *Podochytrium* (e.g., *P. clavatum*). However, *C. cejpii* is operculate, apophysate, and is seemingly well placed in *Chytridium*. As with *Rhizophydium clinopus*, the apparent "basal cell" of *Chytridium cejpii* is never delimited by a septum from the sporangium (again, a point of distinction from *Podochytrium*). Perhaps these examples serve to exemplify that inclusion of developmental pattern and thallus morphology in studies of chytrids—particularly systematic assessments of chytrid genera, and species—will continue to prove useful.

The occurrence of chytrids with apparently similar, yet developmentally different, thalli underscores not only the complexity of chytrid development but, particularly, the importance of developmental studies in investigations of the systematics of Chytridiomycota. In contrast to Whiffen's (1944) basic suggestion of the use of thallus developmental types in establishing chytrid groupings (families, subfamilies), we consider parameters of thallus development to be more significant in chytrid taxonomy at the genus and species levels than at higher ranks. Barr (1980), as mentioned, doubting the reliability of classical features at higher ranks, shifted emphasis in chytrid systematics from consideration of matters of thallus form and structure to the details of zoospore ultrastructure. This ultrastructural approach was eventually extended (e.g., Barr 1990, 2001; Powell & Roychoudhury 1992) to a definition

of zoospore types for all major chytrid groups. There is no question that Barr's ultrastructural viewpoint greatly progressed knowledge of the systematics of Chytridiomycota, enhancing our understanding of chytrid orders and families. There is also no question that the molecular work of James et al. (2000) and Letcher et al. (2004) further bolstered our understanding of the outlines of chytrid systematics, in both broad and more specific terms. It is clear from the work of Barr and of James et al. that thallus types (and operculation, for that matter) do not necessarily follow major phylogenetic lines. The "*Chytriomyces* clade," for example, encompasses different thallus forms (and both operculate and inoperculate taxa), cf. Letcher et al. (2004). Considerable variation in thallus morphology is found even within the genus *Chytridium* (Blackwell et al. 2002); the eventual inclusiveness of this genus remains uncertain. Critical study of thallus development may eventually help resolve the generic circumscription of *Chytridium* and possibly segregate other apparently related genera.

In the light of improved understanding of chytrid phylogeny based on ultrastructural and molecular information, it does not appear that chytrid thallus morphology will be especially useful in deciphering higher ranks of Chytridiomycota. The fact that thallus morphology and development are not especially informative at macrosystematic levels is due in large part to convergence of thallus forms among larger phylogenetic groupings. However, thallus development can still play an important role in resolving pragmatic questions of chytrid form and distinctiveness at generic and specific levels. We believe, especially, that knowledge of thallus development will assist in addressing questions concerning what features are merely superficially similar and what features truly distinguish the thallus (and development of the zoospore) of one apparently comparable chytrid genus from another. *Podochytrium* is a prime example where developmental information has improved our understanding of the genus, and its delimitation from what might at first seem to be very similar chytrid genera. In possible contrast to higher phylogenetic groupings, detailed knowledge of thallus development may well be seen to interface better with more narrowly targeted ultrastructural and molecular investigations, now in progress, i.e., those involving distinctions of chytrid genera and species.

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A new species of *Phyllachora* (*Phyllachorales*) on *Leguminosae* from China

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Abstract—A new species, *Phyllachora yunnanensis* on *Lespedeza formosa* and *Lespedeza* sp., causing tar spots is reported. Based on the characters of tar spots, ascomata, asci and ascospores, the new species differs from other similar species in the number, the shape and the size of ascospores.

Key words—Sordariomycetidae, tar spot, taxonomy

A new species of *Phyllachora* on leaves of *Lespedeza formosa* was collected from Yunnan Province in the autumn of 2005. So far only one species of *Phyllachora* has been recognized on the genus of *Lespedeza*: *Phyllachora lespedezae* (Schwein.) Sacc. (Saccardo 1883: 614) with ellipsoidal to ovoid and slightly inaequilateral ascospores measuring 11–17 x 5–8.5 µm. According to Cannon (1991) monograph on *Leguminosae*, *Phyllachora lespedezae* is 4-spored. The new species differs from *Phyllachora lespedezae* in having 8-spored asci, smaller ascospores (7–13.5 x 5–9 µm) and ellipsoidal, ovoid or subglobse ascospores.

Petrak & Ahmad (1954) once reported a record of *Phyllachora lespedezae* from Pakistan which is 8-spored. Müller (1986) renamed the specimen as *Diachora lespedezae* E. Müll. Cannon (1991) transferred the species to the genus *Vitreostroma* as *Vitreostroma desmodii* subsp. *lespedezae* (E. Müll.) P. F. Cannon with ellipsoidal to ovoid ascospores measuring 14.5–17 x 8–9 µm which produces mature ascospores from fallen overwintered leaves. The new species differs from *V. desmodii* subsp. *lespedezae* in having smaller ascospores.

* corresponding author

Thus, a new species is described as:

Phyllachora yunnanensis Na Liu & L. Guo, **sp. nov.** **Figs. 1-4**
MB510327

Maculae in epiphyllo, 0.2–0.6 mm diam., nigrae, nitidae. Ascomata 180–380 x 110–200 µm, in mesophyllo folii immersa, subglobosa vel ellipsoidea. Asci 50–88 x 10–20 µm, octospori, clavati, unitunicati, pedunculati. Ascosporae 7–13.5 x 5–9 µm, uniseriatae vel irregulariter biseriatae, unicellulares, hyalinae, ellipsoideae, ovoideae vel subglobosae.

Leaf spot: the included leaf tissue becoming yellow. Blackened regions sparse or aggregated, roughly circular, 0.2–0.6 mm in diam, shining black, rising from the upper leaf surface, 1- to 2- loculate, the ostiole conspicuous, sunken, blackened regions only visible from the adaxial surface.

Anamorph: not seen.

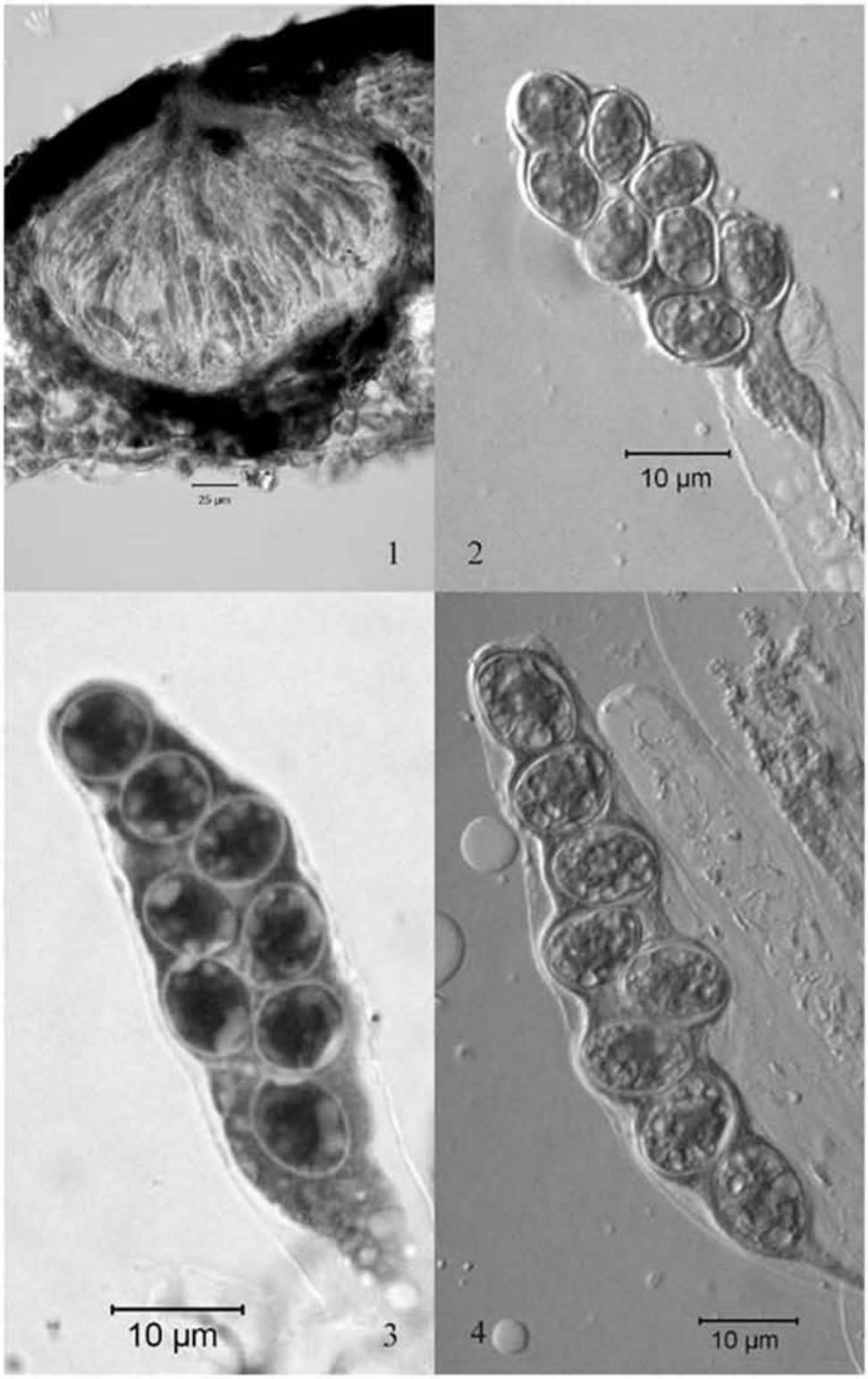
Teleomorph: ascomata 180–380 x 110–200 µm, epigenous, immersed in the mesophyll layer of the leaf, subglobose or ellipsoidal, some irregularly shaped due to compression forces, with a conical neck extending through the host epidermis and cuticle layer to the surface, ostioles conspicuous and with well-developed, hyaline periphyses, asci rising from the basal and lateral wall of the ascoma. Upper wall to 48 µm thick, composed of epidermis cells which are occluded by melanized material. Lower wall to 53 µm thick. Lateral wall to 20 µm thick, composed of thin-walled cells. Paraphyses to 3 µm wide, thin-walled, gradually tapering, branched, septate. Asci 50–88 x 10–20 µm, 8-spored, clavate, obtuse at apex, short pedunculate, thin- walled at maturity, unitunicate. Ascospores arranged uniseriate or irregularly biseriate, 7–13.5 x 5–9 µm, ellipsoidal, ovoid or subglobose, one-celled, hyaline, thin-walled, smooth, guttulatae, without a gelatinous sheath.

Specimens examined—On living leaves of *Lespedeza formosa* (Vogel) Koehne (*Leguminosae*), Yunnan: Lijiang, Haibei, alt. 2560 m, 16 IX 2005, N. Liu, Z.Y. Li & L. Guo 115, HMAS 140198 (holotype); On *Lespedeza* sp., Yunnan: Kunming, VII 1938, R. Xu, HMAS 4689 (paratype).

The HMAS 4689 specimen was wrongly identified as *Phyllachora lespedezae* by Jiang Guangzheng (Tai 1979). Now it is changed to *Phyllachora yunnanensis* as a paratype. *Phyllachora lespedezae* has been recorded by Petrak (1947) and Tai (1979) in China. It has not been examined by the authors, because a specimen was not kept.

So far in China, five *Phyllachora* taxa on *Leguminosae* have been reported: 1) *Phyllachora bauhiniae* (G. Winter) Theiss. & Syd. var. *bauhiniae* [syn. *Phyllachora bauhiniae* Sawada (Sawada 1943)]; 2) *Phyllachora punctum* subsp.

Figs. 1-4. *Phyllachora yunnanensis* on *Lespedeza formosa* (HMAS 140198, holotype). Fig. 1. Section through immersed ascoma. Figs. 2-4. Differential interference micrographs of asci and ascospores.


25 µm
1
10 µm
2
10 µm
3
4
10 µm

dalbergiicola (Henn.) P.F. Cannon [syn. *Phyllachora dalbergiicola* Henn. (Teng 1963)]; 3) *Phyllachora lespedezae* (Petrak 1947); 4) *Phyllachora dolichogena* subsp. *phaseolina* (Syd. & P. Syd.) P.F. Cannon [syn. *Phyllachora phaseolina* Syd. & P. Syd. (Sawada 1943)] and 5) *Phyllachora yunnanensis* (in this paper).

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Repetobasidiopsis gen. nov. (Basidiomycetes) from Eastern Himalaya, India

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Abstract—*Repetobasidiopsis* and the species *Repetobasidiopsis grandisporus* are described from India. The new species is characterized by resupinate, adnate, very thin, non-poroid fruit bodies, monomitic hyphal system, hyphae without clamps forming a compact, gelatinized basal region, a compact, short-celled sub-hymenial zone appearing pseudoparenchymatous, thin-walled, sinuous cystidia, subclavate with suburniform constriction to somewhat sinuous basidia, with linear repetition, and ellipsoid to subfusiform or suballantoid basidiospores. These unique features also support erection of a new genus that shares some features with *Repetobasidiellum*.

Key words—Bamboo, Arunachal Pradesh, Bomdila

During a mycological excursion at Wang Basti (in Bomdila, Arunachal Pradesh, India), very thin, resupinate, non-poroid fruit bodies on decaying bamboos were collected by G.S. Dhingra. A microscopical examination showed monomitic hyphal system, hyphae without clamps forming a compact, gelatinized basal region, a compact, short-celled sub-hymenial zone appearing pseudoparenchymatous, basidia with linear repetition, and ellipsoid to subfusiform basidiospores. Some of the features remind of the genus *Repetobasidiellum* J. Erikss. & Hjorstam, though clearly separate from it. A sample was sent to Prof. Nils Hallenberg for comments, who remarked that it represented a unique collection that could not be assigned to an existing known genus in the *Corticiaceae*. We feel this warrants describing a new species and proposing a new genus, which we name here as *Repetobasidiopsis*. The new genus shares some features with *Repetobasidiellum*, which Eriksson et al. (1981) assigned to the artificial family *Corticiaceae* and where *Repetobasidiopsis* can also be assigned for the present time.

Repetobasidiopsis Dhingra & Avneet P. Singh **gen. nov.**

Fructificatio resupinata, confertim adnata, effussa, hymenio subceracea, laevigata;systema hyphale monomiticum; hyphis tenuitunicatis,non-fibulatis, basilaris hyphis irregulariter ramosus et formo compactus textum, subhymenialis hyphis bracky cellularis, compactus et

visus pseudoparenchymatis; cystidia tenuitunicata, continetur non affico cum sulfovanillin; basidia subclavata ad suburniformae ortendo linearis repetitionis, 4-sterigmatibus; basidiosporae, ellipsoideae ad subfusiformae an suballantoideae, tenuitunicatae, non-amyloideae, non-cyanophileae.

Type species: *Repetobasidiopsis grandisporus* Dhingra & Avneet P. Singh sp. nov.

Etymology: The name of the genus is based on its possession of proliferating (i.e., repeating) basidia, similar to those found in *Repetobasidiellum*.

Fruit body resupinate, closely adnate, effuse, hymenial surface smooth, subceraceous; hyphal system monomitic; generative hyphae without clamps, basal hyphae irregularly branched and interwoven into a dense texture, subhymenial hyphae short-celled and compactly packed and appear like pseudo-parenchymatous tissue; cystidia thin-walled, negative to sulfovanillin; basidia subclavate to suburniform, showing linear repetition, 4-sterigmate; basidiospores ellipsoid to subfusiform, or suballantoid, smooth, thin-walled, acyanophilous, non-amyloid.

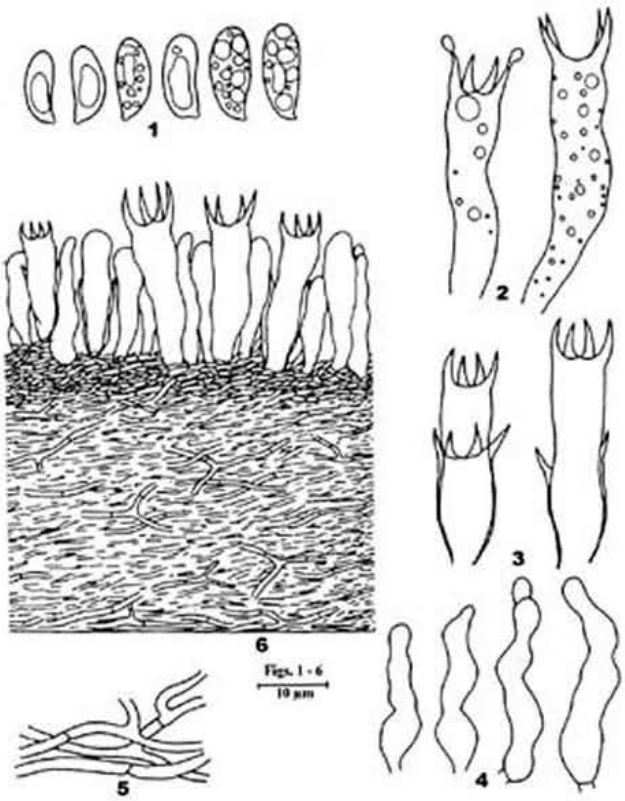
Repetobasidiopsis grandisporus Dhingra & Avneet P. Singh sp. nov. Figs. 1-7

Fructificatio resupinata, confertim adnata, effusa, perexigua, subceracea; superficies hymenialis laevis, cremeus ad alboluteus. Systema hyphale monomiticum; hyphae ad 2.3 µm latum, tenuitunicatum, septatum, fibulis destitutum; basilaris hyphae irregularie ramosum in compactum textum; subhymenialis hyphae bracky cellularis, compaginatus, pseudoparenchymatis aspectus. Cystidii 20-30 x 5-6 µm, tenuitunicatus, sinuosus. Basidii 20-40 x 5.5-8 µm, subclavatus ad suburniformis, raro sinuosus, com linearis repetitionis, fibulis destitutus ad basis, 4-sterigmatibus, multiguttatus. Basidiosporii 10-14 x 4.0-5.8 µm, ellipsoideus ad subfusiformis an suballantoideus, tenuitunicatus, non-amyloideus, non-cyanophiles, cum unus grandis guttulaitus an pluriguttulatus.

Holotypus: India, Arunachal Pradesh, Bomdila, Wang Basti, super putrescens bamboo, G.S. Dhingra 19706 (PAN, GH) Augustus 24, 1981.

Etymology: The name of the species is based on large sized spores in comparison to small sized spores in taxa within *Repetobasidiellum*.

Fruit body resupinate, closely adnate, effuse, subceraceous; hymenial surface smooth, creamish-white to yellowish-white, continuous when fresh, some cracks developing on drying; margin not well differentiated. Hyphal system monomitic; generative hyphae up to 2.3 µm wide, thin-walled, septate, without clamps; basal zone of gelatinized hyphae irregularly branched and interwoven; subhymenial hyphae short-celled and compactly packed and appear like pseudo-parenchymatous tissue. Cystidia 20-30 x 5-6 µm, thin-walled, sinuous, negative to sulfovanillin. Basidia 20-40 x 5.5-8 µm, subclavate to suburniform, rarely sinuous, with linear repetition, basal clamp is not observed, 4-sterigmate, with oily contents; sterigmata up to 8.5 µm long. Basidiospores 10-14 x 4.0-5.8 µm, ellipsoid to subfusiform, or suballantoid, smooth, thin-walled, acyanophilous, non-amyloid, with one large guttule or many small oil drops.



Figs.1-6. Microscopic structures from basidiocarp of *Repetobasidiopsis grandisporus*: 1. Basidiospores; 2. basidia; 3. proliferating basidia; 4. cystidia; 5. generative hyphae; 6. vertical section of the basidiocarp.

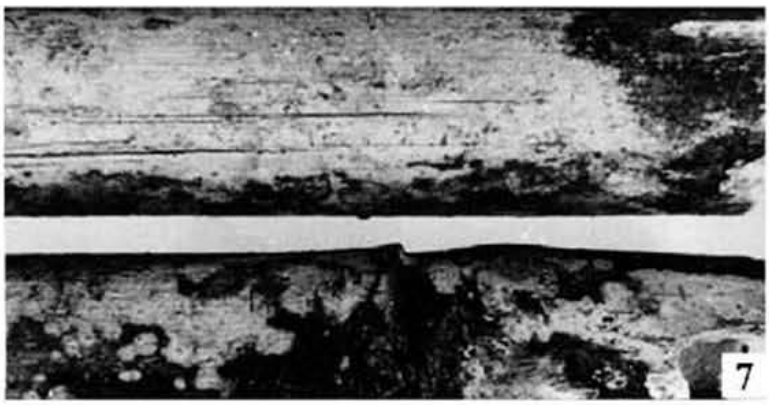


Fig. 7. *Repetobasidiopsis grandisporus* basidiocarp showing hymenial surface.

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Urocystis rostrariae, a new species of smut fungus on *Rostraria* from Jordan

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Abstract—*Urocystis rostrariae* is described and illustrated from infected leaves of *Rostraria cristata* (*Poaceae*) collected in Jordan. The new species is characterized by large spore-balls, comprising mostly 10–20 spores, which are surrounded by a continuous layer of sterile cells. *Urocystis rostrariae* is completely different from six other species of *Urocystis* known on closely related grass genera. This is a second smut fungus on the genus *Rostraria*. The only other smut fungus known on this genus is *Tilletia rostrariae* infecting ovaries of *Rostraria cristata*, and known only from the type locality in Iran.

Key words—Ustilaginomycetes, taxonomy, Middle East, Asia

Introduction

Rostraria Trin. is a small genus of grasses (*Poaceae*), with about 10 species distributed mostly in the Mediterranean and Middle East. According to Clayton & Renvoize (1986) it belongs to the subtribe *Aveninae* of the tribe *Aveneae*, together with 22 other grass genera. Some authors placed *Rostraria* in the subtribe *Koeleriinae* of the tribe *Aveneae* (Tzvelev 1976), together with *Trisetum* Pers., *Trisetaria* Forssk. and *Koeleria* Pers. The only smut fungus known on representative of *Rostraria* was *Tilletia rostrariae* Vánky & Ershad, described from infected ovaries of *Rostraria cristata* collected in Iran (Vánky & Ershad 2002). Between unidentified smut fungi obtained on loan from K there was one other species, infecting leaves of *Rostraria cristata*, collected in Jordan in the Middle East. Microscopic examination revealed that this smut belonged to the genus *Urocystis* Rabenh. ex Fuckel, but cannot be identified with any known species described to date. Therefore it is proposed here as new to science.

Light microscopy and SEM studies were as described by Piątek et al. (2005). The values of the size ranges are the means of 50 spore balls, spores and sterile cells measured in 5% KOH. SEM micrographs were taken in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University, Kraków (Poland).

Fig. 1. Sori of *Urocystis rostrariae* in the leaves of *Rostraria cristata* (Holotype: K(M) 134351). Scale bar = 1 cm.

Taxonomy

Urocystis rostrariae M. Piątek, sp. nov. FIGURES 1–5

[MycoBank MB 510056]

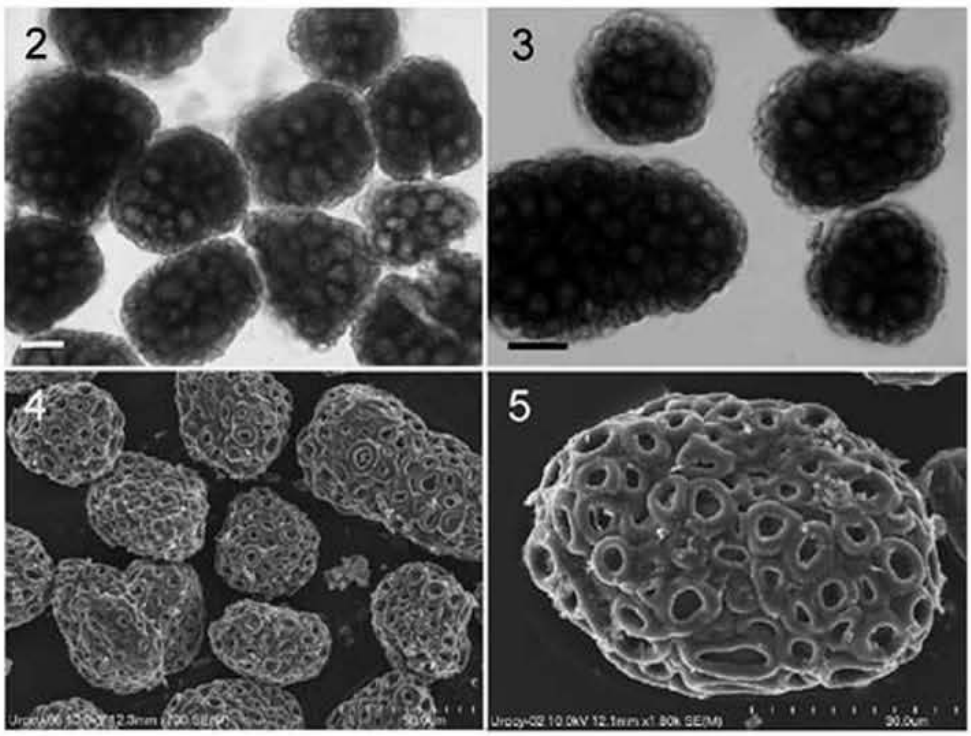
Typus in matrice Rostraria cristata (L.) Tzvelev (=Lophochloa phleoides (Vill.) Rchb.), Jordan, Jebel el Uweinid, W of Azraq, sandy wadi running from E bluff of a hill covered with basalt boulders, 21.IV.1965, C. C. Townsend 65/167 [holotypus: K(M) 134351!].

Sori in foliis, primo epidermide obtectas, deinde rupturas. Glomeruli sporarum subglobosi, ovoidei, ellipsoidales usque irregulares, (50–)60–80(–100) × (40–)50–60(–85) µm, e sporis

(6–)10–20(–40) (–vel plus?) compositi, cellulis sterilibus complete circumdati. Sporae globosae, subglobosae usque ovoideae, rubrobrunneae, (12–)14–18(–19) × (10–)12–15(–16) µm, pariete aequali, 1,0–1,5 µm crasso. Cellulae steriles globosae, subglobosae usque ovoideae, plerumque cum lateribus contactis deplanatis, flavae, (6–)9–13 × 6–10 µm, pariete inaequali, 1–2 µm crasso, levi.

Sori in leaves, forming long striae between the veins, at first lead-coloured and covered by the epidermis, which later ruptures exposing the blackish, powdery mass of spore balls. *Spore balls* subglobose, ovoid, ellipsoidal to irregular, (50–)60–80(–100) × (40–)50–60(–85) µm, composed of (6–)10–20(–40) (–or more?) central spores, completely surrounded by a layer of sterile cells. *Spores* globose, subglobose to ovoid, reddish-brown, (12–)14–18(–19) × (10–)12–15(–16) µm, wall even, 1.0–1.5 µm thick. *Sterile* cells globose, subglobose to ovoid, usually with flattened contact sides, yellow, (6–)9–13 × 6–10 µm, wall uneven, 1–2 µm thick, smooth.

Host and distribution––On *Poaceae*: *Rostraria cristata* (=*Koeleria phleoides* (Vill.) Pers.; *Lophochloa phleoides*); Jordan, Asia. Known only from the type locality.



Figs 2–5. Spores of *Urocystis rostrariae* as seen by LM and SEM (Holotype: K(M) 134351). Scale bars = 20 µm for Figs. 2–3, 50 µm for Fig 4, 30 µm for Fig. 5.

Discussion

Urocystis rostrariae should be compared with other species of the genus *Urocystis* known on grasses included in the subtribe *Aveninae*. On the 22 grass genera included in this subtribe by Clayton & Renvoize (1986) only six species of *Urocystis* have been hitherto described, namely *U. avenae-elatioris* (Kochman) Zundel, type on *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl, *U. avenastri* (Massenot) Nannf., type on *Avenula pubescens* (Huds.) Dumort., *U. behboudii* (Esfand.) Vánky, type on *Arrhenatherum kotschyi* Boiss., *U. koeleriae* L. Guo, type on *Koeleria litvinowii* Domin, *U. rytzii* (Massenot) J. Müll., type on *Avenula versicolor* (Vill.) M. Lainz, and *U. triseti* (Cif.) Zundel, type on *Trisetum spicatum* (L.) K. Richt.

Urocystis rostrariae can be distinguished from these six species by the larger size of spore balls, by number of spores per spore ball and by the host plant species. *U. avenae-elatioris* has spore balls 16–36 µm in diameter, which are composed of 1–3(–4) spores. It is restricted to *Arrhenatherum elatius* and is known only from Europe (Vánky 1994). *U. avenastri* has spore balls 20–35 µm in diameter, with 1–4(–5) central spores, and the only host plant is *Avenula pubescens*. This species is so far known from a few sites in Europe (Vánky 1994). *U. behboudii* forms spore balls 17–50 µm in diameter, and they are composed of 1–3(–4) spores. This smut is known only from the type locality in Iran, where it parasitizes *Arrhenatherum kotschyi* (Esfandiari & Petrak 1950; Vánky 1985). *U. koeleriae*, which was recently described as new from China, has spore balls 19–38 µm in diameter, the number of spores per spore ball is 1–4(–5) and its only known host is *Koeleria litvinowii* (Guo 2005). However, there are also records of "*Urocystis agropyri*" on *Koeleria cristata* Pers. from the U.S.A. (Fischer 1953; Zundel 1953), which are unlikely to belong to *Urocystis agropyri* (Preuss) A. A. Fisch. Waldh., which is restricted to species of *Elymus*. Re-examination of the collections from the U.S.A. is necessary to determine the name of this fungus. *U. rytzii* has spore balls 17–51 µm in diameter, composed of 1–3(–5) spores, its only host plant is *Avenula versicolor*, and the smut is known only from three stations in Europe (Müller 1991). The last known species on the subtribe *Aveninae*, *U. triseti* has spore balls 20–40 µm in diameter, which are composed of 1–6 spores, and the smut parasitizes *Trisetum alpestre* P. Beauv., *T. flavescens* (L.) P. Beauv. and *T. spicatum* in Europe (Vánky 1994).

It should mentioned here that in the literature there is another record of a *Urocystis* species on the subtribe *Aveninae*. Jørstad (1962) reported an unnamed *Urocystis* on *Deschampsia caespitosa* (L.) P. Beauv. from Iceland. This collection is preserved in O and was also examined in connection with the description of *Urocystis rostrariae*. The specimen probably belongs to a separate species that forms sori on leaves as long striae between the veins, and has spore balls 15–40

µm in diameter, which are composed of 1–4(–6) spores. This species will be described and discussed elsewhere.

The large number of spores per spore balls present in *Urocystis rostrariae* is also unusual amongst the remaining ca. 150 species of *Urocystis*. Most species in this genus have less than 10 spores per spore ball (often 1–3), while only a few species have spore balls composed of more than 10 spores. Several examples follow: *U. corsica* (Mayor & Terrier) Vánky on *Stipa capensis* Thunb. (6–15 spores per spore ball), *U. junci* Lagerh. on *Juncus* spp. (1–20 spores per spore ball), *U. paridis* (Unger) Thüm. on *Paris* spp. (1–30 spores per spore ball), *U. schizocaulon* (Ces.) Zundel on *Odontites luteus* (L.) Clairv. (8–30 spores per spore ball), *U. thaxteri* Vánky on *Hypoxis* spp. (5–25 spores per spore ball), and *U. trientalis* (Berk. & Broome) B. Lindeb. on *Trientalis* spp. (6–50 spores per spore ball).

Urocystis rostrariae is known only from the type locality in Jordan in the Middle East. *Tilletia rostrariae*, is the only other smut fungus recorded on the genus *Rostraria*, and is also only known from the type locality in Iran. However, *Rostraria cristata* – the host plant of these two smut fungi, is widely distributed in arid places of Mediterranean Europe and Africa, south-west Asia and as an introduced plant in southern Africa, Australia and America (Henderson & Schäfer 2003). Therefore, it is possible that both *Urocystis rostrariae* and *Tilletia rostrariae* are more common, but overlooked.

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MYCOTAXON

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Trimitiella gen. nov. (Basidiomycetes) from Eastern Himalaya, India

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Abstract—*Trimitiella* is characterized by resupinate, non-poroid fruitbodies with a trimitic hyphal system, large sized basidia and basidiospores, and dendrohyphidia. *Trimitiella indica* from Eastern Himalaya is described as the type species.

Key Words—*Corticiaceae*, Arunachal Pradesh, West Kameng

While exploring the forests in the state of Arunachal Pradesh in Eastern Himalaya, the author collected a loosely attached, grayish colored resupinate fungus on decaying bamboo twigs. A microscopic examination of the collection revealed trimitic hyphal system, large sized basidia and basidiospores along with dendrohyphidia. The taxon could not be placed as new species in *Aleurodiscus* or *Laeticorticium*, also having large sized basidia and basidiospores along with dendrohyphidia, as both those genera have a monomitic hyphal system. A trimitic hyphal system is also found in the genus *Laurilia*, but here the spores and basidia are smaller, encrusted cystidia are present, and dendrohyphidia are lacking. In conclusion, it seems justified to place the new species with trimitic hyphal system in a new genus *Trimitiella*.

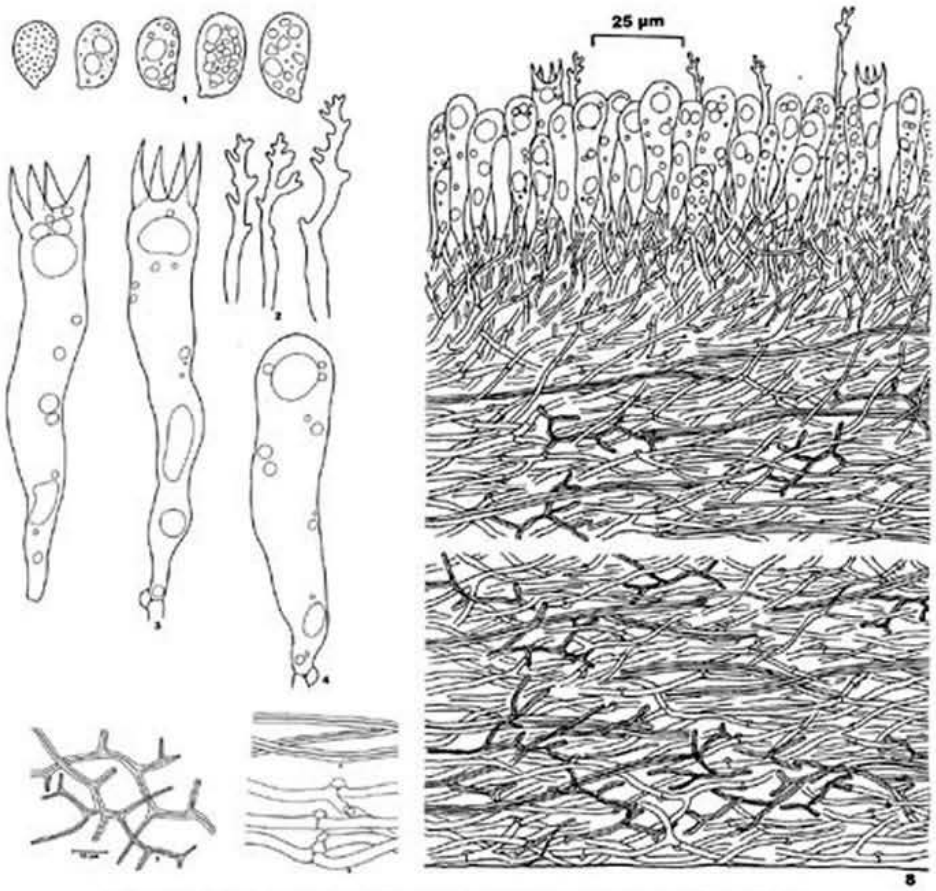
Trimitiella Dhingra, **gen. nov.**

Fructificatio resupinata, adnata, effusa, membranaceus-ceracea, hymenio laevigata margo invicem in aresco; systema hyphale trimiticum; generative hyphis tenuitunicatum, nodoso-septatum; skeletal hyphis crassitunicatus, acyanophilous; binding hyphis ampleramosus, crassitunicatus; contextus constitutus de dense intricatus generative hyphis, skeletal hyphis, et binding hyphis; dendrohyphidia praesens; basidia clavata, fibuligera ad basis, 4-sterigmatibus; basidiosporae late ellipsoideae, tenuitunicatae, non-amyloideae, non-cyanophilae.

Type species: *Trimitiella indica* Dhingra sp. nov.

Etymology – *Trimitiella* refers to possession of a trimitic hyphal system.

Fruitbodies resupinate, adnate, effused, membranous-ceraceous; hymenial surface smooth, margin in turned on drying; hyphal system trimitic; generative hyphae clamped; skeletal hyphae thick-walled, acyanophilous; binding hyphae richly branched, thick-walled; context composed of densely interwoven generative hyphae, skeletal hyphae and binding hyphae; dendrohyphidia present; basidia clavate, with a basal clamp, 4-sterigmate; basidiospores broadly ellipsoid, smooth, thin-walled, non-amyloid, acyanophilous, with numerous oil drops.



Figs.1-8. Microscopic structures from basidiocarp of *Trimitiella indica*.
Clockwise from top left: Figs. 1. Basidiospores; 2. dendrohyphidia; 3. basidia; 4. basidiole; 5. binding hyphae; 6. generative hyphae; 7. skeletal hyphae; 8. vertical section of the basidiocarp.

Trimitiella indica Dhingra, sp. nov. Figs. 1-9

Fructificatio resupinata, adnata, effusa, ad 360 µm crassa in sectione, membranaceus-ceracea; superficies hymenialis laevis ad farinaceus oculo armato, clarus-grisea ad grisea. Systema hyphale trimiticum; generative hyphae latum, tenuitunicatum, nodoso-septatum; skeletal hyphae crassitunicatus, acyanophilous; binding hyphae, ampleramosus,

crassitunicatus; contextus constitutus de dense intricatus generative hyphae, skeletal hyphae, et binding hyphae. Dendrohyphidia praesens. Basidii 55-70 x 10- 12µm, clavatus, subsinuosus, oleosus, 4-sterigmatibus. Basidiosporii 10-15 x 7-8.5µm, late ellipsoideus, multiguttulatus.

Holotypus: India, Arunachal Pradesh, West Kameng, Bomdila, fere 3 Km ex Bomdila in Tawang, epi putrescens bamboo rameus, G.S. Dhingra 19722 (PAN, LY) Augusto 25, 1981.

Etymology – *indica* refers to the species occurrence in India

Fig.9. *Trimitiella indica* basidiocarp showing hymenial surface.

Fruitbody resupinate, adnate, effused, up to 360µm thick in section, membranous, ceraceous; hymenial surface, smooth to farinose under lens, light grey to grey; margin loosely adnate, inturned on drying, thinning, irregular in outline, whitish. Hyphal system trimitic; generative hyphae branched, septate, clamped, thin- to somewhat thick-walled, 2-4µm wide; skeletal hyphae up to 3um wide, mostly unbranched, aseptate without clamps, thick-walled, acyanophilous; binding hyphae up to 2.5µm wide, richly branched, thick-walled; context composed of densely interwoven generative hyphae, skeletal hyphae and binding hyphae; binding hyphae comparatively more in the subiculum. Cystidia absent. Dendrohyphidia branched, thin-walled, basal part up to 3.5 µm wide. Basidia 55-70 x 10-12 µm, clavate, somewhat sinuous, with oily contents and a basal clamp, 4-sterigmate; sterigmata up to 12µm long. Basidiospores 10-15 x 7-8.5 µm, broadly ellipsoid, smooth, thin-walled, non-amyloid, acyanophilous, with numerous oil drops. Spore print white.

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The lichen genus *Megalospora* in Java

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Abstract—A taxonomic study of the genus *Megalospora* (*Megalosporaceae*) in Java was conducted based on morphological, anatomical, and chemical characters. Eight species of *Megalospora* with three subspecies and one variety are reported from Java. Three new species (*M. flavoexcipulata*, *M. javanica*, and *M. albomarginata*) and two new records [*M. campylospora* and *M. pruinata* subsp. *fusca*] are presented. Additional data are given for *M. atrorubicans* subsp. *atrorubicans*, *M. campylospora*, *M. sulphurata* var. *sulphurata*, *M. tuberculosa*, and *M. pruinata* subsp. *lamii*.

Keywords—taxonomy, Indonesia

Introduction

Megalospora is the biggest genus in the family *Megalosporaceae*. It is easily recognized by the crustose thallus, lecideine apothecia, large-sized and thick-walled spores, and oil droplets in the hymenium. A monograph is provided by Sipman (1983). For Java, Overeem & Overeem (1922) were the first to report a species of *Megalospora*, *M. tricolor* (Mont.) Overeem. However, according to Zahlbruckner (1926) this species is a synonym of *Lopadium leucoxanthum* (Spreng.) Zahlbr. (=*Brigantiaea leucoxantha* (Spreng.) R. Sant. & Hafellner). Later, Groenhart (1952, 1958) and Zahlbruckner (1956) reported seven species and a variety of *Megalospora*, namely *M. versicolor* (Fée) Zahlbr., *M. subvigilans* Zahlbr., *M. taitensis*, *M. margininflexa* (Hook. f. & Taylor) Zahlbr., *M. atrorubicans*, *M. sulphurata*, *M. sulphurata* var. *phaeocheila*, and *M. flavidula*. However, *M. subvigilans*, *M. taitensis*, *M. sulphurata*, and *M. sulphurata* var. *phaeocheila* are synonyms of *M. sulphurata* var. *sulphurata*. *M. versicolor* is now regarded as a species of *Catinaria*, *Catinaria versicolor* (Fée) Sipman; *M. margininflexa* is now regarded as a species of *Megaloblastenia*, *Megaloblastenia margininflexa* (Hook. f. & Taylor) Sipman var. *margininflexa*; and *M. flavidula* is a synonym of *M. atrorubicans* subsp. *atrorubicans*. In his worldwide *Megalospora*

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monographic work, Sipman (1983) reported five species, three subspecies and a variety for Java namely *M. atrorubicans* subsp. *atrorubicans*, *M. coccodes* subsp. *nigricans* (Müll. Arg.) Sipman, *M. pruinata* subsp. *lamii*, *M. sulphurata* var. *sulphurata*, and *M. tuberculosa*.

The rich Javanese material of *Megalospora* deposited in the Herbarium Bogoriense numbering 240 specimens has never been subjected to critical examination and it has not been included in Sipman's monographic work. Those are used here for a study of the diversity of Javanese *Megalospora*, and to provide an identification key to its species. Surprisingly, several novelties were detected among these Javanese specimens.

Materials and methods

Materials of study

Herbarium specimens studied are those deposited in Herbarium Bogoriense Bogor (BO), numbering 240 sheets. Most specimens were collected before the year of 1953 and some at the year of 2001 in West Java. Since the specimen of Central and East Java was not available, field observations were made at some areas of Central and East Java (Kawasan Wisata Baturaden - Banyumas, Hutan Lindung Doro - Kab. Pekalongan Timur, and Hutan Lindung Guci - Kab. Pekalongan Barat). Nevertheless, *Megalospora* could not be found from the areas visited.

Method of investigation

External features of the specimens were studied under a stereoscopic microscope (20 - 40x), and the anatomical characters of apothecial and spore morphology were observed under a light microscope (40 - 1000x). Reagent test (=color test or spot test) was made on the medulla of apothecia and thallus with the following reagents i.e. calcium hypochloride (C), potassium hydroxide (K), and paraphenylenediamine (P). The color reaction of hymenia was observed after being immersed in iodine solution. In addition, lichen substances were also investigated with thin layer chromatography (TLC). The chromatogram was developed in solvent system B: n-hexane : diethyl ether : formic acid = 120:90:20 (Culberson & Johnson 1982). After evaporation of the solvent, the chromatogram is sprayed with 10% aqueous solution of sulphuric acid and heated at about 100 - 110 °C for 15 minutes and noted the color of spot and the Rf value. The chromatograms were also examined under UV light (254 A° and 350 A°) for examining the fluorescence of substances. The relation between the detected substances and the reagent test reaction is established by occasional spot color on the TLC spots.

The presence of zeorin could also be established by the presence of P+ and KC– (Miyawaki 1988). The presence of pannarin could be established by the

presence of P+ orange and KC–. Usnic acid is demonstrated by the P– and KC+ pale yellow and by the yellowish tinge of thallus (Kantvilas 1994, Sipman 1983).

The revision of the genus was based on the steps method described by Rifai (1976), Vogel (1987), and Maxted (1992): collecting the herbarium specimens of *Megalospora* of Java for a monographic treatment, making groups of specimens according to their overall resemblance, gathering the literatures, identifying and describing the available specimens, analysis the data, delimitating the taxa, making an identification key, studying the nomenclatures, and conducted a phylogenetic analysis to classify the relationships.

Results

Taxonomic treatment

Megalospora Meyen in Meyen & Flotow, Verhl. Kaiserl. Nova Acta Acad. Leopold.-Carol. 19, Suppl.: 228 (1843)

= *Heterothecium* sect. *Megalospora* (Meyen) Tuck., Synops. North. Amer. Lich. 2: 53 (1888)

= *Lecidea* subgen. *Megalospora* (Meyen) Boistal, Nouv. Flore Lich., 2: 202 (1902). Type species: *Megalospora sulphurata* Meyen.

Thallus crustose, yellowish-, greenish-, grayish- or brownish gray, surface smooth to strongly rugulose, with small, irregular cracks, thin to thick, with or without cylindrical to coralloid isidia, with or without soredia, consisting of a cortical layer, an algal layer and a medullary layer (consisting of free hyphae); **apothecia** lecideine, sessile, adnate, plane to obconical, scattered, concave to flat with prominent margin when young, soon becoming flat to convex with more or less prominent margin; **disc** concave to flat when young soon becoming flat to slightly convex to very convex, glossy to dull, light brown to brown to dark brown to gray to grayish blue to black, and epruinose to pruinose; **margin** prominent or not, thin to thick, dull to glossy, cream to brown to dark brown to black, epruinose to pruinose; **epithecium** orange-brown to yellow-orange to bright dark orange, sometimes with granular substances at top layer, paraphyse tips branched and anastomosing; **hymenium** hyaline to pale brown to pale yellow, I+blue to I–, with wall of the asci and basal asci I+blue, with oil droplets; paraphyses parallel and without anastomoses; ***subhymenium*** hyaline to pale brown to pale yellow, I–; **hypothecium** brownish-, yellowish-, orange- or dark brown or black; **subhypothecium** clear or not; **excipulum** consisting of ectal and medullary excipulum; medullary excipulum arachnoid, often containing crystals of calcium oxalate; **ascus** cylindrical or slightly clavate, and slightly thicker at the apex (lecanora-type); **spores** bilocular-uniseptate, elongate, straight, single in an ascus; or bilocular-uniseptate, short, curved, more or less

reniform, (1-) 8 per ascus; or bacillar-plurilocular, elongate, straight, with (4-)5-11(-13) transverse septa, single in an ascus; or bacillar-plurilocular, elongate, curved, with (4-)5-11(-13) transverse septa, 2-5 per ascus; or muriform, ovoid, straight, single in each ascus. Spores have thick wall, which could be smooth or warted (after Sipman 1983).

Key to the Javanese species

1a. Spore bilocular 2
1b. Spore bacillar-plurilocular 6

2a. Spore straight, always single in an ascus ..... 1. *M. atrorubicans*
2b. Spore more or less curved, (1-)2-8 in each ascus 3

3a. Epispore smooth, thallus containing usnic acid (P– and KC+ pale yellow) 4
3b. Epispore warted, thallus containing pannarin (P+ orange and KC–)
..... 5. *M. campylospora*

4a. Hypothecium brown to black, excipulum yellow or brown to dark brown 5
4b. Hypothecium bright orange, excipulum bright orange ..... 2. *M. javanica*

5a. Excipulum yellow, epithecium yellow, hypothecium brown to dark brown
..... 3. *M. flavoexcipulata*
5b. Excipulum brown to dark brown, epithecium orange-brown to brown,
hypothecium dark brown to black ..... 4. *M. sulphurata*

6a. Spore single in an ascus, straight ..... 6. *M. tuberculosa*
6b. Spore (1-)4(-5) per ascus, more or less curved 7

7a. Apothecia with grayish blue or cyaneous disc and black margin;
epithecium olive green with blackish or dark olive green ..... 7. *M. pruinata*
7b. Apothecia with gray disc and white to cream margin; epithecium orange-brown
..... 8. *M. albomarginata*

[7c.] Apothecia with pale brown to dark brown disc and pale yellowish margin;
epithecium diffusely orange-brown or olivaceous brown ..... *M. coccodes* *

* *M. coccodes* subsp. *nigricans*, recorded by Sipman (1983), was not recognized among the specimens in Herbarium Bogoriense.

Taxonomic Descriptions

1. ***Megalospora atrorubicans*** (Nyl.) Zahlbr. Catal. Lich. Univ. 4: 86 (1927)

≡ *Lecidea marginiflexa* var. *atrorubicans* Nyl., Flora 49: 132 (1866). *Type:* Indonesia, Java, ad corticem arborum circa Toegoe (Puncak), alt 900 m (3000 ped.), Kurz 496, 17 February 1861 (H-Nylander, ISO in M).

= *Megalospora flavidula* Groenh., Reinwardtia 2: 398 (1954). *Type:* Indonesia, West Java, M. Gede, Cibodas, 1450 m on the branchlet of *Psidium cattleyanum*, Groenh. 8746, 24 September 1952 (BO!).

Thallus pale green to grayish green, irregularly shaped, rather thin, nearly smooth with longitudinal cracks to very rugulose with little small irregular cracks, soredia and isidia absent; **chemistry**: usnic acid and zeorin; **apothecia** scattered, adnate, flat, orbicular to oblong and the large ones becoming irregularly shaped, up to 2 mm diam., c. 0.8 mm thick; **disc** concave when young, soon becoming slightly convex to very convex, occasionally flat in the juvenile and adult stage, dull to glossy, reddish brown to dark brown, and epruinose, occasionally scabrid; **margin** prominent, occasionally disappearing by age, thick, glossy, black, epruinose; **epithecium** orange-brown to yellow, 24-67 µm thick; **hymenium** yellow to hyaline, 193- 203(-286) µm high, I+ blue, subhymenium pale yellowish orange, 44-70 µm high; **hypothecium** dark brown, c. 124 µm high, K– to K+ black, P– to P+ black, subhypothecium clear to unclear, paler than hypothecium; **ectal excipulum** brown to black, K–, C–, in the outer layer of the ectal excipulum a layer of algae present.; **medullary excipulum** brown to whitish brown, K– to K+ black, P– to P+ black; **crystals of calcium oxalate** present in the medullary excipulum; **spores** single in the ascus, bilocular, and straight (atrorubicans-type, cf. Sipman 1983: 44), 62-102 x 29-36 µm; **spore wall** c. 3.3 µm thick; **epispore** c. 1.1 µm thick, smooth.

Note: *M. atrorubicans* has three subspecies, each with a different geographical distribution, namely *M. atrorubicans* (Nyl.) Zahlbr. subsp. *atrorubicans*, *M. atrorubicans* subsp. *australis* Sipman, and *M. atrorubicans* subsp. *sendaiensis* (Räsänen) Sipman. In Java, only subspecies *atrorubicans* occurs. This is characterized by the orange-brown color of the epithecium.

Distribution: This subspecies is distributed in the Hawaiian Islands, the Mascarene Islands, Indonesia, the Philippines, Papua New Guinea, and New Caledonia (Sipman 1983). In Java, it was found in Cibodas.

Habitat and ecology: In Java, this species was found in primary and secondary forest at altitudes ranging from 1400-1600 m. All collections were on bark.

SPECIMENS STUDIED – INDONESIA. **West Java: Cibodas.** Gunung Gede (1400 m above sea level) – *Comm. Neervoort 3508, 3510, 3550, 3601* (BO); *Comm. Neervoort & Schröter 4479* (BO); *Comm. Schröter 4005, 5258* (BO).

2. ***Megalospora flavoexcipulata*** Untari **sp. nov.** (Leg. MB510308)

Thallus flavidus, crassus, laevis vel leviter rugulosus, leviter nitidus. Sorediis destitutus, verrucis 0.1-0.2 mm latis, verruculosa-inaequalis verruculis c. 0.05 mm latis et 0.2 mm altis vel isidiis corralliformibus cylindricis 0.1-0.2 mm latis et 0.1-0.5 mm altis. Apothecia ad 3 mm, raro 6 mm lata, adnata vel sat obconica. Discus persistenter concavus vel planus vel deinde convexus, nitidus vel opacus, spadiceus vel fuscus, epruinosus vel nonnunquam leviter pruinosus. Margo prominens, tenuis vel crassus, opacus vel nitidus, fuscus vel niger, dealbatus pruinosus. Epithecium vitellinum, (9-)14-57 µm crassum. Hymenium hyalinum, 106-286 µm crassum, I+ coerulescens in ascis et plerumque in parte basali hymenii. Subhymenium hyaline, (15-)20-98 µm crassum. Hypothecium fuscum vel brunneum, 44-

97 µm, subhypothecio fusco, 24-63 µm. Excipulum flavum vel vitellinum, K– negativum, P– negativum, C+ flavus vel C– negativum. Crystalla calcii-oxalatici provisa. Basis apothecii (110-)197-683 µm latus. Sporae (2-)4-8(-12)-nae, bicellulares, leviter curvatae (typo sulphurata), magnitudine 41-103 x 19-45 µm. Septis pariete c. 2.2 µm crasso, episporio c. 1.1 µm crasso, laeve. Type: Indonesia, Java, Gegerbentang, 6 August 1949, Comm. Neervoort 1351 (Holotypus: BO!).

Thallus grayish green to yellowish green, thick, nearly smooth to rugulose with irregular cracks, with 0.1-0.2 mm diam. warts, and 0.05-0.2 mm diam. wartlets, with cylindrical and coralloid isidia measuring 0.1-0.2 x 0.1-0.5 mm, epruinose, slightly glossy, soredia absent; **chemistry**: usnic acid and zeorin; **apothecia** scattered to dense, sessile to adnate, somewhat obconical, orbicular to oblong and the large ones becoming reniform to irregularly shaped, up to 3 mm diam., rarely up to 6 mm diam., (186-)405-975 um µm thick; **disc** concave to flat when young, the large ones becoming flat to slightly convex, dull to slightly glossy, light brown to dark brown, epruinose but occasionally brownish pruinose; **margin** prominent, thin to thick, dull to glossy, brown to black sometimes typically black at the upper edge and light brown to pale fawn at the side edge and below, epruinose but occasionally covered with whitish pruina; **epithecium** yellow or with a tinge of orange, occasionally with yellow granules on top, (9-)14-57 µm thick; **hymenium** hyaline to greenish yellow to yellowish orange, 106-286 µm high, I+blue to I–, I+blue in the asci, K+yellow, subhymenium hyaline to brownish yellow to yellowish orange, (15-)20-98 µm high, I–; **hypothecium** brown to dark brown, 44-97(-254) µm thick, and subhypothecium brown, occasionally unclear, 24-63(-117) µm thick; **excipulum** yellow to yellow with a tinge of orange, K–, C–, P–; **crystals of calcium oxalate** present in ectal and medullary excipulum; **apothecium base** (101)-197-683 µm; **spores** (2-)4-8 per ascus, bicellular, and usually curved (sulphurata-type, cf. Sipman 1983: 44), 41-103 x 19-45 µm; **spore wall** c. 2.2 µm thick; **epispore** c. 1.1 µm thick, smooth.

Note: The specific epithet refers to the fact that the new taxon is easily recognized by the yellow color of its excipulum and epithecium. In addition, this species deviates from *M. sulphurata* by a tendency of having a smooth thallus and being never found overgrowing mosses.

Distribution: This species was found in Cibodas, Gunung Gede, Gegerbentang, and Sinapeuh.

Habitat and ecology: In Java, this species was found in primary and secondary forest at altitudes ranging from 1400 - 1600 m. It is found on bark.

SPECIMENS STUDIED – INDONESIA. **West Java: Cibodas.** Gunung Gede (1400 m above sea level) – *C. van Woerden 1136, s.n., s.n.* (BO); *K.B. Boedijn 1460* (BO); *Drs. v. Leeuwen Reijnvaan 1213, 12142* (BO); *Comm. Neervoort 3555, 3862* (BO); *Comm. Schröter 4367, 5020, 5359, 5412, 6319* (BO); *Comm. Neervoort & Schröter 4481* (BO); **Rarahan Java** – *Groenh. 8614* (BO); **Gegerbentang** – *Comm. Neervoort 1351, 1404* (BO); **Rawa Gede** – *Comm. Schröter 5069* (BO)

3. *Megalospora javanica* Untari **sp. nov.** (Leg. MB510309)

Thallus flavescenti-fuscus vel cinerascenti-fuscus, crassus, laevis vel paulo rugulosus, nitidus. Sorediis isidiisque destitutus, sed aliquando veruculosa-inaequalis, verrucis c. 0.25 mm latis. Apothecia ad 4 mm lata. Discus persistenter concavus vel deinde planus vel convexus, opacus vel nitidus, porphyreus vel niger, epruinosus. Margo prominens, crassus vel tenuis, opacus vel nitidus, albescens vel niger, epruinosus. Epithecium ferrugineum, c. 52 µm crassum. Hymenium hyalinum, 249-260 µm crassum, I+ coerulescens. Subhymenium vitellinum, 78-104 µm crassum. Hypothecium croceum, 78-166 µm, K+ flavescens, C– negativum, P+ sanguineum; subhypothecium croceum, K+ flavescens, C– negativum, P+ sanguineus. Excipulum croceum, K+ flavescens vel K– negativum, C– negativum, P+ sanguineum, crystallis calcii oxalaticis provisum. Basis apothecii 487-537(-750) µm latus. Sporae 4–6-nae bicellulares, leviter curvatae, (typo sulphurata), magnitudine 59-70 x 19-30 µm, pariete 2.2-3.3 µm crasso, episporio c. 1.1 µm crasso, laeve.. Type: Indonesia, Java, Cibodas, 10 May 1950, Comm. Schröter 5347. (Holotypus: BO!).

Thallus yellowish brown to grayish brown, thick, smooth to slightly rugulose with small, irregular cracks, occasionally with c. 0.25 mm diam. warts, glossy, soredia and isidia absent; **chemistry:** usnic acid and zeorin, **apothecia** scattered, sessile, orbicular and the large ones becoming lobed or reniform, up to 4 mm diam., (848-)1275-1370 µm thick; **disc** concave when young, soon becoming flat to convex, dull to glossy, reddish brown to black, and epruinose; **margin** prominent, thick but in large apothecia becoming thin, glossy to dull, black to cream, epruinose; **epithecium** orange-brown, c. 52 µm thick; **hymenium** hyaline or pale, 249-260 µm high, I+blue; **subhymenium** reddish yellow, 78-104 µm high; **hypothecium** bright orange, 78-166 µm thick, K+ yellow, C–, P+ red; **subhypothecium** bright orange, K+ yellow, C–, P+ red; **excipulum** bright orange, K+ yellow or K–, C–, P+ red; **crystals of calcium oxalate** present in medullary exciple; **apothecium base** 487-537 (-750) µm; **spores** 4-6 per ascus, bicellular, and usually curved (sulphurata-type, cf. Sipman 1983: 44), 59-70 x 19-30 µm; **spore wall** 2.2-3.3 µm thick; **epispore** 1.1 µm thick, smooth.

Note: The specific epithet refers to the collecting locality of this species. This species is characterized by the bright orange color of the hypothecium and excipulum, and the mostly spores found are the wide spores.

Distribution: This species was found in Cibodas and Sinapeuh.

Habitat and ecology: In Java, this species was found in primary and secondary forest at altitudes ranging from 1400-1600 m. This species was growing on bark.

SPECIMENS STUDIED – **INDONESIA. West Java: Cibodas.** Gunung Gede (1400 m above sea level) – *K.B. Boedijn 1417* (BO); *Comm. Schröter 4203, 5016, 4203, 5347, 5360* (BO); *Comm. Neervoort & Schröter 4897, 4850* (BO); *Comm. Neervoort 3714, 3514* (BO); **Sinapeuh** – *Comm. Schröter 5136* (BO).

4. *Megalospora sulphurata* Meyen in Meyen & Flotow, Verhl. Kaiserl. Nova Acta Acad. Leopold.-Carol. 19, Suppl.: 228 (1843). *Type:* Philippines, "crescit in lignis putridis Manillae", F. J. F. Meyen, IX-X. 1841 (G isotype?).

Catillaria sulphurata var. *phaeocheila* Vain., Annal. Acad. Sci. Fenn., ser. A, 15, no. 6: 104 (1921) = *Megalospora sulphurata* var. *phaeocheila* (Vain.) Zahlbr., Catal. Lich. Univ. 4: 91 (1927).

Biatora taitensis Mont., Ann. Sci. Nat., Bot., ser. 3, 10: 126 (1848) = *Heterothecium taitense* (Mont.) Mont. & Bosch. in Junghuhn, Plant. Junghuhn., fasc 4: 462 (1855) = *Blastenia taitensis* (Mont.) Trevis., Linnaea 28: 290 (1856) = *Psorothecium taitense* (Mont.) A. Massal., Atti I. R. Istit. Veneto, ser. 3, 5: 261 (1860) = *Lecidea taitensis* (Mont.) Nyl., Ann. Sci. Nat., Bet., ser. 4, 19: 243 (1863) = *Patellaria taitensis* (Mont.) Müll. Arg., Flora 65: 330 (1882) = *Megalospora taitensis* (Mont.) Overeem, Bull. Jard. Bot. Buitenzorg, ser. 3, 4: 120 (1922). *Type:* Tahiti, J. Lépine 33 (P, iso H). (Teste Sipman 1983).

Patellaria subvigilans Müll. Arg., Flora 65: 329 (1882) = *Biatorina subvigilans* (Müll. Arg.) Hellb., Bih. Kgl. Svensk. Vetensk.-Akad. Handl. 21, afd. 3, 13: 109 (1896) = *Megalospora subvigilans* (Müll. Arg.) Zahlbr. in Rechinger, Denkschr. math.-naturw. Classe K. Ak-ad. Wiss. Wien 81: 251 (1908). *Type:* „Frequens in insula Java (in hb. saepe cum Patell. taitensi commixta)", Java, 350/37, upper right specimen (G Lectotype nov., Iso L). (Teste Sipman 1983).

Thallus pale gray to greenish gray to yellowish green, irregularly shaped, rather thin to rather thick, smooth to very rugulose with irregular, small cracks or with longitudinal, regular cracks, dull to glossy to very glossy, epruinose, occasionally warted or verruculose with 0.1-0.5 mm diam. wartlets, with or without soredia and isidia; **isidia** cylindrical to coralloid, 0.3-0.5 mm long, 0.15-0.3 mm thick; **soredia** granular, c. 60 µm; **chemistry**: usnic acid and zeorin; **apothecia** scattered to dense, sessile, adnate, somewhat obconical, orbicular to oblong and the large ones becoming lobed or irregularly shaped, up to 3 mm diam. when adult, rarely up to 5 mm, 575-975 µm thick; **disc** concave to flat, in large apothecia flat to very convex, dull to glossy, reddish black when young and black when adult or brown to black, and epruinose to whitish pruinose, occasionally scabrid; **margin** prominent, thick, occasionally becoming thin in large apothecia, glossy to dull, light brown to brown (occasionally with a dark brown to black rim around the disc) to dark brown to black or sometimes typically black at the upper edge (adjacent to the disc) and light brown at the side and below, epruinose to grayish pruinose; **epithecium** orange-brown to yellowish orange-brown to brown, (12-)19-37(-73) µm thick; **hymenium** hyaline and with diffuse orange to brownish orange spots, 176-375 µm high, I+ blue or I– with wall of the asci and basal asci I+blue; **subhymenium** hyaline (darker) to light yellow or yellowish orange, (15-)29-63(-111) µm; **hypothecium** olive green to dark brown to black, (41-)97-114(-244) µm; **subhypothecium** usually unclear, occasionally clear, yellowish brown occasionally diffusely olive green to brown to black, 29-58 µm; **excipulum** brown to dark brown or occasionally orange-yellow with diffuse olive green, K+ yellow to K–, C– to C+ yellow at

the medullary excipulum, P– to P+ brown-orange; **crystals of calcium oxalate** present in the ectal and medullary excipulum; **apothecium base** (110-)215-507(-946) µm wide; **spores** (1-)2-6 per ascus, bicellular, and usually curved (sulphurata-type, cf. Sipman 1983: 44), 44-94(-101) x (17-)24-38(-41) µm; **spore wall** 2.2-3.3 µm thick; **epispore** c. 1.1 µm thick, smooth.

Note: *M. sulphurata* has two varieties, which coincide with their geographical distribution: *M. sulphurata* var. *sulphurata* (distributed pantropically) and *M. sulphurata* var. *nigricans* (distributed neotropically). Besides by the geographical distribution, var. *sulphurata* also deviates from var. *nigricans* by the orange-brown color of epithecium. In Java, only var. *sulphurata* occurs.

The Javanese specimens of var. *sulphurata* show a wide variation in thallus morphology, size and apothecium morphology, size of spores, size of the hymenium, pigmentation of the ectal and medullary excipulum and hypothecium, and apothecium chemistry. Since the variability of these characters sometimes could be seen within a single thallus, they do not permit separation of further taxa.

Zahlbruckner (1956) reported *M. subvigilans*, *M. taitensis*, *M. sulphurata*, and *M. sulphurata* var. *phaeocheila* from Java. According to Sipman (1983) these are the synonyms of *M. sulphurata* var. *sulphurata*.

Distribution: *M. sulphurata* Meyen is one of the most widespread species and var. *sulphurata* is distributed in Hawaiian Islands, Tahiti, Samoa, Brazil, Mexico, Jamaica, Tanzania, Mascarene Islands, Ascension, India, Sri Lanka, Malaya, Sabah, Indonesia, Philippines, Japan, Taiwan, Papua New Guinea, Australia, and New Caledonia (Sipman 1983). In Java, this species is also very widely distributed as compared to other species, since it was found in Cibodas, Gunung Gede, Gunung Papandayan, Gegerbentang, Mountain Tjiboga, Rawa Gede, Rawa Panjang, and Mountain Patuha-Telaga Patengan.

Habitat and ecology: In Java, *M. sulphurata* is abundant in rain forest at altitudes of 1000-2000 m above sea level.

SPECIMENS STUDIED – INDONESIA. **West Java: Cibodas.** Gunung Gede (1400 m above sea level) – *C.A.D Overeem 90, 208, s.n.* (BO); *Res. v. Leeuwen Reijnvaan 5673, 5695, 12072, 12137, s.n.* (BO); *C.A.D Overeem & Dakkus. A. Bruggeman 99, 150, s.n.* (BO); *G. Kjellberg 102* (BO); *C.L.L.H van Woerden s.n.* (BO); *Groenhardt 8714* (BO); *Comm. Neervoort 14, 139, 3133, 3132, 3331, 3509, 3555, 3566, 3568, 3581, 3596, 3597, 3607; 3618, 3769, 3776, 3795, 3871, 3906, 3920, 3928, 3954, 3955, 3959* (BO!); *Comm. Schröter 4000, 4004, 4043, 4046, 4106, 4111, 4162, 4191, 4206, 4213, 4229, 4251, 4252, 4289, 4298, 4377, 4404, 5015, 5018, 5019, 5021, 5023, 5025, 5026, 5027, 5037, 5283, 5316, 5336, 5348, 5359, 6319, 5420* (BO); *Comm. Neervoort & Schröter 4471, 4482, 4491, 4495, 4496, 4500, 4534, 4569, 4571, 4595, 4598, 4648, 4656, 4698, 4705, 4711, 4784, 4785, 4849, 4869, 4872, 4896, 4898* (BO); *K.B. Boedijn 1419, 1423, 1458* (BO); **Gegerbentang** – *Comm. Neervoort 976, 981, 1048, 1054, 1238, 1404, 1408, 3009, 3108, 3260, 3286, 3287* (BO); *Comm. Schröter 4962, 4974* (BO); **Mountain Patuha.** Telaga Patengan (1600

m above sea level) – *M.A. Donk 14* (BO); **Mountain Tjiboga** – *Comm. Neervoort 1878* (BO); Rawa Gede, *Comm. Schröter 5077* (BO); **Rawa Pandjang** –, *Comm. Schröter 5097, 5100, 5210, 5216* (BO); **Sinapeuh** – *Comm. Schröter 5113, 5114, 5115* (BO).

5. ***Megalospora campylospora*** (Stirt.) Sipman, Bibliotheca Lichenologica 18:114 (1983)

≡ *Lecidea campylospora* Stirt., Transact. Proc. New Zealand Inst. 6: 238 (1873). ***Type:*** New Zealand, Kaka Hill, *J. Buchanan 11*, December 1871 (WELT).

Thallus brownish gray with irregularly shaped, rather thick, very rugulose with little cracks, glossy, epruinose; **soredia and isidia** absent but a part of the thallus verruculose; **chemistry:** pannarin and zeorin; **apothecia** scattered, sessile, orbicular or oblong and the large ones becoming lobed to reniform to irregularly shaped, up to 3 mm diam., 663-790 µm thick; ***disc*** scabrid, flat when young, soon becoming convex, dull, dark brown, epruinose; **margin** prominent, thin, dull, light brown to cream, epruinose; **epithecium** orange-brown, (19-)27-38 µm thick; ***hymenium*** hyaline, 106-276 µm high, I+ blue; **subhymenium** yellowish brown, 26-42 µm, I–; **hypothecium** brownish yellow, 78-104 µm, K+ hyaline, C+ orange; **subhypothecium** brownish yellow, K+ hyaline; **ectal excipulum** yellowish orange, K+ hyaline, P+ brown, C+ orange; **medullary excipulum** white below the hypothecium, K+ hyaline; **crystals of calcium oxalate** absent; **apothecium base** 35-400 µm wide; **spores** 4-6 per ascus, bilocular, usually curved (sulphurata-type, cf. Sipman 1983: 44), 46-62 x 24-28 µm; **spore wall** c. 2.2 µm thick; **epispore** c. 1.1 µm thick, warted.

Note: The available specimen deviates from Sipman's description (1983) by the epruinose apothecium discs and by the light brown to cream color of the apothecium margins. As more collections become available, it may prove worthy of further study and of a separate taxonomic status.

Distribution: New Zealand, Tasmania, Lord Howe Island, and Indonesia (Java: Cibodas).

Habitat and ecology: The only specimen available was collected at an altitute of average 1400 m. This species was growing on bark.

SPECIMENS STUDIED – INDONESIA. **West Java: Cibodas.** Gunung Gede (1400 m above sea level) – *Comm. Neervoort 3862* (BO).

6. ***Megalospora tuberculosa*** (Fée) Sipman, Bibliotheca Lichenologica 18: 156 (1983).

≡ *Lecidea tuberculosa* Fée, Essai sur les Cryptog. des Ecorc. exotiques Offic. Paris p. 107 (1824) ***Type:*** Ad corticem cinchonarum (in America, herb. Fée, Types no. 268, larger card, larger piece of two in a row (G).

Thallus grayish green to yellowish green to brownish green, irregularly shaped, rather thick, smooth to rugulose with irregular small cracks to horizontal cracks but occasionally little cracks, slightly glossy to very glossy; **soredia and**

isidia absent; **chemistry**: usnic acid and zeorin; **apothecia** sessile, sometimes obconical and much protruding, orbicular or oblong and the large ones becoming lobed to reniform to irregularly shaped, up to 2.5 mm diam., 223-702 µm thick; **disc** concave to flat, in large apothecia slightly convex, dull to slightly glossy to glossy, brown to dark brown to black, epruinose (in *Neervoort 3604* with whitish pruina), often scabrid; **margin** more or less prominent, thin to thick, glossy to very glossy, black or sometimes typically black at the upper edge and light brown at the side and below, epruinose to slightly pruinose; **epithecium** yellowish brown to brown, (12-)29-52(-73) µm thick, K- (except in *Schröter 4230* K+ orange-brown); **hymenium** hyaline to green yellowish, (130-)187-219(-231) µm high, I+ blue; **subhymenium** hyaline to green yellow, (39-)41-73 µm; **hypothecium** pale brown to brown to dark brown, (22-)52-94(-115) µm; **subhypothecium** unclear, or occasionally greenish yellow or paler than the hypothecium to reddish brown, 19-62 µm thick, K–, P–, C–; **excipulum** dark brown to black, K– to K+red, P–, C– to C+yellow; **crystals of calcium oxalate** present in the ectal and medullary excipulum; **apothecium base** 119-537 µm wide; **spores** straight, bacillar-pluriseptate, (tuberculosa-type, cf. Sipman 1983: 44), single in an ascus, 89-137(-169) x 22-52 µm, (3-)5-11(-13) –celled; **spore wall** c. 2.2 µm thick; **epispore** 1.1 µm thick, smooth.

Note: The color of thallus of the available specimens is very variable. The specimens lack soredia, which occur frequently elsewhere. Moreover, some specimens show a brown epithecium, differing from what occurs elsewhere.

Distribution: *M. tuberculosa* is distributed widely in the world: Cuba, Bolivia, Brazil, Ecuador, Burundi, Colombia, Panama, Peru, Costa Rica, Jamaica, Mexico, Rwanda, Madagascar, Mascarene Islands, Germany, Portugal, France, India, Indonesia, Sarawak, Papua New Guinea, Philippines, Japan, and China (Sipman 1983). In Java, this species was found in Cibodas and Gegerbentang.

Habitat and ecology: This species inhabits mostly mountains at an altitude of 1000 to 2000 m.

SPECIMENS STUDIED – INDONESIA. WEST JAVA: **Cibodas.** GUNUNG GEDE (1400 m above sea level) – *Comm. Neervoort 3045, 3537, 3604, 3742, 3776* (BO); *Comm. Schröter 4201, 4223, 4230, 4364, 4369, 4373, 5288, 5351, 5361, 5409* (BO); *Comm. Neervoort & Schröter 4524, 4556, 4639, 4654, 4717, 4780, 4871, 4888, 4903* (BO); **Gegerbentang** – *Comm. Neervoort 1336* (BO); *Comm. Schröter 4977, 4983, 4986, 4988, 4989* (BO).

7. *Megalospora albomarginata* Untari **sp. nov.** (Leg. MB510310)

Thallus cinerascens, tenuis, sat laevis, nitidus, obsitus muscis aut cortice arborum. Sorediis isidiisque destitutus, sed aliquando veruculosa inaequalis, verruculis c. 0.5 mm latis et 0.5 mm altis. Apothecia c. 3.5 mm lata, adnata vel sat obconica, dispersa. Discus planus, leviter nitidus, cinereaceus aut griseus, epruinosus, in parvulis apotheciis albidus pruinosus circum disco, scabridus. Margo prominens, crassus, opacus vel nitidus, albidus vel albescens, epruinosus. Epithecium ferrugineum vel pallido-rufum, 16 - 22 µm crassum.

Hymenium hyalinum, 230-297 µm crassum, I+ coerulescens in ascis et plerumque in parte basali hymenii. Subhymenium sulphureum, 52-68 µm crassum. Hypothecium brunneum vel niger, 104-156 µm crassum, subhypothecio apertum. Excipulum spadiceum, K– negativum, P– negativum, C– negativum. Crystalla calcii oxalatici provisa. Basis apothecii 650-732 µm latus. Sporae 3-6 nae, bacillares, leviter curvatae (typo coccodes), e 8-13 loculis compositae, 61-83 x 19-27 µm, septis tenuibus et pariete c. 1.1 µm crasso, episporio tenuissimo, laeve.

Type: Indonesia, Java, Cibodas, 1400 m above sea level, 18 April 1950, Comm. Neervoort & Comm. Schröter 4545 (Holotypus: BO!).

Thallus gray, thin, nearly smooth with small irregular cracks, glossy; **soredia and isidia** absent but occasionally tubercles present, c. 0.5 mm wide and c. 0.5 mm high; **chemistry**: pannarin and zeorin; ***apothecia*** adnate, somewhat obconical, scattered, orbicular to oblong, up to 3.5 mm diam; **disc** flat, even in small and large apothecia, slightly glossy, gray to dark gray (*Neervoort & Schröter 4643* has a black rim around the disc), epruinose, the young apothecia with a whitish pruinose rim around the disc, scabrid; **margin** prominent, thick, dull to glossy, white to cream, epruinose; **epithecium** orange-brown to brown, 16-22 µm thick; **hymenium** hyaline, 230-297 µm high, I+ bluish-green; **subhymenium** yellowish, 52-68 µm high; **hypothecium** dark brown to black, 10-156 µm thick; **subhypothecium** unclear; **ectal excipulum** pale brown, K–, P–, C–; **medullary excipulum** brown, K–, P–, C–; **crystals of calcium oxalate** present in the ectal and medullary excipulum; **apothecium base** 650-732 µm wide; **spores** bacillar-pluriseptate, straight and occasionally slightly curved, with thin septa (coccodes-type, cf. Sipman 1983: 44), 3 - 6 per ascus, 61-83 x 19-27 µm, 7-12-septate; **spore wall** c. 1.1 µm thick; **epispore** unclear, smooth.

Note: The specific epithet refers to the fact that this new taxon is easily recognized by the white to cream margin and gray to dark gray disc of the apothecia.

Distribution: The present species is known from Cibodas, Gunung Gede, Cibereum, and Sinapeuh.

Habitat and ecology: The present species is found at altitudes ranging from 1400 to 2000 m, on trees in woods.

SPECIMENS STUDIED – INDONESIA. WEST JAVA: **Cibodas.** GUNUNG GEDE (1400 m above sea level) – *C.L.L.H. van Woerden s.n.* (BO); *Comm. Neervoort 3827, 3901* (BO); *Comm. Schröter 4204, 4220, 4222* (BO); *Comm. Neervoort & Schröter 4528, 4545, 4643* (BO); **Sinapeuh** – *Comm. Schröter 5119* (BO); **Cibereum** – *Groenhardt 8641* (BO).

8. *Megalospora pruinata* (Müll. Arg.) Sipman, Bibliotheca Lichenologica 18: 145 (1983).
≡ *Patellaria pruinata* Müll. Arg., Engler Bot. Jahrb. 20:273 (1894) ***Type:*** Tanzania, Usambara, *Holst 1411* (G)

Thallus whitish (pale gray) to gray, thin, epruinose; **soredia and isidia** absent; **chemistry**: pannarin and zeorin; ***apothecia*** dense, sessile, orbicular to oblong,

up to 2.5 mm diam; **disc** surface of apothecia with a bluish color; **spores** bacillar-pluriseptate, straight to slightly curved with thin septa (coccodes-type, cf. Sipman 1983: 44), (1-)4(-5) per ascus.

Key to subspecies of *M. pruinata*

1a. Apothecia with grayish blue disc and black margin, epithecium dark olive green, epruinose, spores more consistently curved ..... a. ***M. pruinata*** subsp. ***fusca***

1b. Apothecia with cyaneus to atro-cyaneus disc and black margin, epithecium olive green blackish, with bluish-white pruina, spores straight to curved ..... b. ***M. pruinata*** subsp. ***lamii***

[1c.] Apothecia with bluish disc and brown to dark brown to black margin, epithecium brown, epruinose, spores straight to curved ..... ***M. pruinata*** subsp. ***pruinata****

**M. pruinata* subsp. *pruinata* was not recognized among the specimens in Herbarium Bogoriense.

8a. ***M. pruinata*** subsp. ***fusca*** Sipman, Bibliotheca Lichenologica 18:141 (1983). *Type:* Papua New Guinea, prov. Chimbu, Pindaunde valley near Mount Wilhelm, in mossy dwarfforest on NE-facing slope along lake Piunde, altitude 3550 m, *H Sipman 15834*, 14. VIII. 1981 (U, ISO in UPNG).

Thallus gray, thin, nearly smooth with irregular cracks, glossy, epruinose; **soredia and isidia** absent; **chemistry**: pannarin and zeorin; ***apothecia*** dense, sessile, orbicular to oblong, up to 2.2 mm diam., 624-663 µm thick; **disc** concave, in large apothecia flat, dull, grayish blue and when young covered by bluish pruina; **margin** prominent, thick, glossy, black, and covered by white-bluish pruina; **epithecium** dark olive-green, 19-30 µm thick; **hymenium** hyaline, colorless, 240-256 µm high, I+blue; **subhymenium** yellow orange, 32-45 µm high; **hypothecium** orange-brown, 89-100 µm thick; **subhypothecium** orange brown, paler than hypothecium, 24-35 µm thick; **excipulum** ferrugineous (yellowish brown-orange), K−, P+ orange; **crystals of calcium oxalate** present in the ectal and medullary excipulum; **apothecium base** 399-439 µm wide; **spores** bacillar-pluriseptate, slightly curved, with thin septa (coccodes-type, cf. Sipman 1983: 44), 1(-4) per ascus, 119-124 x 38-42 µm, (6-)9-13-celled; **spore wall** c. 2.2 µm thick; **epispore** 1.1 µm thick, smooth.

Note: The available specimen deviates from Sipman's description (1983) by the grayish blue color of the disc.

Distribution: Papua New Guinea, Indonesia (Java: Cibodas).

Habitat and ecology: The only specimen of this subspecies available was collected at an altitude of average 1400 m. The present subspecies was growing on bark.

SPECIMENS STUDIED – INDONESIA. WEST JAVA: Cibodas. GUNUNG GEDE (1400 m above sea level) – *Comm. Neervoort & Schröter 4640* (BO).

8b. ***M. pruinata*** subsp. ***lamii*** (Groenh.) Sipman, Bibliotheca Lichenologica 18: 143 (1983).

= *Bombyliospora lamii* Groenh., Blumea suppl. 4: 110 (1958) ***Type:*** Indonesia, West Java, Cibodas, Mt. Gede, in rain forest, on *Turpinia pomifera*, 4 m high, exposed, alt. 1400 m, Nurta & Madrodji in coll. *van Oostroom 14340* (L).

Thallus whitish (pale gray), thin, very rugulose, very glossy, hypothallus blackish, epruinose; **soredia and isidia** absent; **chemistry:** pannarin and zeorin; **apothecia** dense, sessile, orbicular to oblong, up to 2.5 mm diam., 663-702 µm thick; **disc** concave, in large apothecia becoming flat, dull, cyaneous (very dark blue) to atro-cyaneous (black) and covered by bluish-white pruina; **margin** prominent, thick, glossy, black and around the disc covered by bluish-white pruina; **epithecium** olive-green with diffuse blackish, 36-58 µm thick; **hymenium** hyaline, colorless, 270-302 µm high, I+blue; **subhymenium** yellow- orange, 36-58 µm high; **hypothecium** dark brown, 44-55 µm thick, **subhypothecium** dark brown, 32-43 µm thick; **excipulum** brown-orange with a thin darker ectal layer and often covered by an extended attachment layer containing algae, K–, P–, C–; **crystals of calcium oxalate** present in the ectal and medullary excipulum; **apothecium base** 327-349 µm wide; **spores** bacillar-pluriseptate, straight to slightly curved, with thin septa (coccodes-type, cf. Sipman 1983: 44), (1-4(-5) per ascus, 61-100 x 27-38 µm, (4-)7-8-celled; **spore wall** c. 2.2 µm thick; **epispore** 1.1 µm thick, smooth.

Distribution: Sabah, Indonesia (Java: Cibodas)

SPECIMENS STUDIED – INDONESIA. WEST JAVA: Cibodas. GUNUNG GEDE (1400 m above sea level) – *K.B. Boedijn 1458* A (BO).

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Albatrellus yunnanensis, a new species from China

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Abstract—*Albatrellus yunnanensis*, a new species is described and illustrated herein. It is characterized by yellowish to yellowish ochraceous pileus, nearly glabrous or with minute scales, cream tube layer, white context, clamped generative hyphae and non-amyloid, relatively large basidiospores. Differences and similarities between the new species and related species are discussed and a key to *Albatrellus* species known from China is given. *A. mexicanus* is treated as a synonym of *Polyporoletus sublividus* after re-studying its holotype.

Key words—*Albatrellaceae*, taxonomy

Introduction

Up to now, approximately seven species of the genus the genus *Albatrellus* Gray have been recorded from the markets of southwestern China (Liu et al. 1992, Zhang 1999, Wang & Liu 2002, Wang et al. 2004, Zheng et al. 2004). Among them, *A. confluens* (Alb. & Schwein.) Kotl. & Pouzar, *A. dispansus* (Lloyd) Canf. & Gilb. and *A. ellisii* (Berk.) Pouzar are the most common ones. While studying the specimens of *Albatrellus*, we found that four specimens bought from Nanhua county (Yunnan Province) wild mushroom market could not be assigned to any known *Albatrellus* species. The supermarket specimens local market specimens are described, illustrated, and proposed as a new species. Differences and similarities between the new species and closely related species are discussed, and a key to *Albatrellus* species known from China is given.

* *corresponding author*

Materials and methods

All specimens examined are preserved in the Cryptogamic Herbarium, Kunming Institute of Botany, Chinese Academy of Sciences (HKAS).

The macroscopic characters were recorded from fresh specimens or taken from field notes accompany the specimens. Microscopic examinations were carried out on dry specimens, mounting hand cut sections of basidiocarps in 5–10% KOH, Congo red and Melzer's reagent.

Dimensions for basidiospores are given using notation of form (a–) b–c (–d). The range b–c contains a minimum of 90% of the measured values. Extreme values—e.g., a or d—are given in parentheses. Q is used mean 'length/width ratio' of basidiospores in side view, **Q** (in bold face) means average Q of all basidiospores measured ± sample standard deviation (Yang & Zhang 2003).

Taxonomic description

Albatrellus yunnanensis H.D. Zheng & P.G. Liu, **sp. nov.** Figs. 1–7

MYCOBANK # 510285

Fructificatio annua, stipitata, singularis vel confluens. Pilei circularis vel reniformis, subplano vel centro depressus, olivaceus flavus usque ad obscure luteae ochraceae suffusae, 5–20 cm lato, glabrous ad squamulosae. Stipite solido, bulboso, centrali, excentrico vel laterali, 4–7 × 2.5–7 cm. Tubuli decurrentibus, cremeibus, 1–3 per mm, angulatis. Systema hypharum monomiticum, hyphae generatoriae hyalinae fibulatae. Sporae ellipsoideae to subglobae, hyalinae, laeves, nonamyloidea, (7.5–) 7.8–9.9 (–11.8) × (5.3–) 6.0–7.5 (–8.0) µm (182 spores), [Q = (1.13–) 1.21–1.42 (–1.53), Q = 1.31±0.07]. Basidia clavata, 4-sterigmatica, 25–48 × 10–15 µm.

Holotypus: CHINA, Yunnan Prov.: Nanhua county wild mushroom market, 9 Sept. 2000, leg. Xiang-Hua Wang 1154 (HKAS 37107)

Etymology: "yunnanensis" referring to Yunnan, where the holotype was collected.

Basidiocarp annual, stipitate, medium to large, single or confluent.

Pileus circular to kidney-shaped, plane or centrally depressed, olivaceous yellow to dull yellow with ochraceous tints, up to 20 cm in diam. nearly glabrous or cracked into very small scales (about 0.3–0.5 mm wide), margin even or undulated.

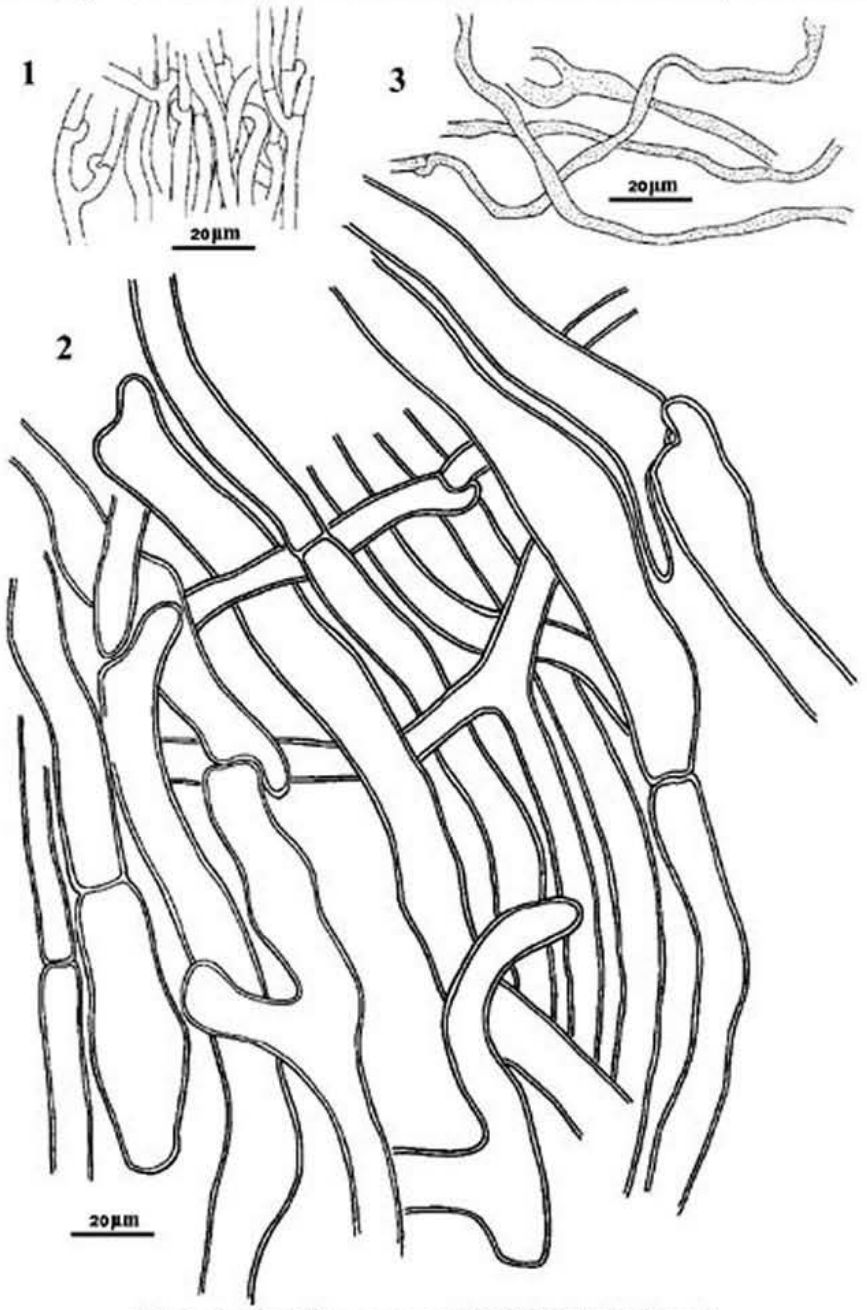
Tube layer 1–5 mm thick, cream when fresh, discoloring flesh-pinkish to red gradually when touched or bruised, becoming pale brownish to reddish brownish after drying, decurrent nearly to the base of the stipe; pores angular, 1–3/mm.

Stipe central, eccentric or lateral, concolorous with the pileus or somewhat darker, bulbous, distinctly inflated at the base, 4–7 × 2.5–7 cm.

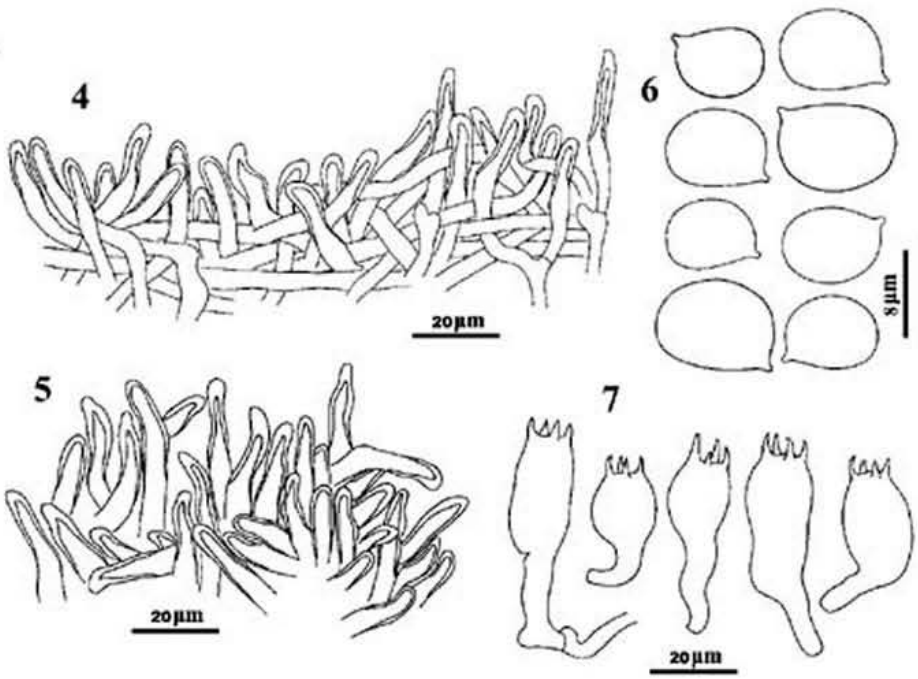
Context white, whitish or cream when fresh, becoming darker after exposed in the air for some time, light yellow to light orange after drying, fleshy, soft, up to

5 cm thick, separated from the tubes by a thin and dark layer in dry specimens, odor pleasant and taste mild.

Hyphal system monomitic, generative hyphae with clamp connections. Tramal hyphae (Fig. 1) 2.0–5.0 μm in diam. thin-walled, with conspicuous clamp



Figs. 1–3: *Albatrellus yunnanensis* (HKAS 37107, holotype)
1. tramal hyphae; 2. contextual hyphae; 3. gloeoplerous hyphae (HKAS 32906)



Figs. 4–7: *Albatrellus yunnanensis* (HKAS 37107, holotype)
4. pileipellis hyphae; 5. stipitipellis hyphae; 6. basidiospores; 7. basidia

connections, occasionally branched. Contextual hyphae (Fig. 2) varying in diam. from 4 μm to 20 μm, thick-walled (0.5–1.0 μm thick), branched. Gloeoplerous hyphae (Fig. 3) present in context and trama, thin-walled, long, with occasional clamp connections. Pileipellis hyphae (Fig. 4) erect, 3.0–5.0 μm in diam. with thick-walled tips, forming a loose palisade. Stipitipellis hyphae similar (Fig.5).

Basidiospores (Fig. 6) ellipsoid to subglobose, hyaline, smooth, non-amyloid, (7.5–) 7.8–9.9 (–11.8) × (5.3–) 6.0–7.5 (–8.0) μm (182 spores), [Q = (1.13–) 1.21–1.42 (–1.53), **Q** = 1.31±0.07].

Basidia (Fig. 7) clavate, with a narrow base and a basal clamp connection, 4-sterigmate, 25–48 × 10–15 μm.

Specimens examined—CHINA, **Yunnan Prov.**: Nanhua county wild mushroom market, 9. Sept. 2000, leg. Xiang-Hua Wang 1154 (HKAS 37107, **holotype**); 3 Aug. 1998, Xiang-Hua Wang 619 (HKAS 32906); 12 July 2001, Xiang-Hua Wang 1231 (HKAS 39167); 16 Aug. 2004, Huan-Di Zheng 585 (HKAS 48311)

Remarks—The combination of the glabrous to more or less squamulose pileal surface, olivaceous yellow to dull ochraceous yellow coloration and non-amyloid, relatively large basidiospores distinguish this species from other members in the genus.

Because the macroscopic characters of *A. yunnanensis* are similar to those of *A. mexicanus* (Laferrière & Gilbertson 1990), we studied the holotype (BPI-US 1107534) of the latter. Our observations on that specimen are as follow:

Pileus circular or nearly so, glabrous, pale buff, tawny or pale brown, up to 9 cm in diam. Stipe up to 5cm long and 2 cm wide, cylindrical with a bulbous base, concolorous with the pileus. Tube yellowish green to reddish brown, angular, 1mm in diam. or even larger. Context pale orangish, 5 mm thick. Basidiospores non-amyloid, subgloboae to broadly ellipsoid, (7.5–) 7.8–9.3 (–9.8) × (5.8–) 6.0–7.2 (–8.0) µm, rough, with a double wall separated by interwall pillars, not glabrous as mentioned in its original description. Hyphal system monomitic, with clamp connections and simple septa.

These features agree with the diagnostic characters of *Polyporoletus sublividus* (Snell 1936, Gilbertson & Ryvarden 1986–1987). Therefore *Albatrellus mexicanus* Laferr. & Gilb. is treated as a synonym of *Polyporoletus sublividus* Snell. Basidiospore morphology helps separate *A. yunnanensis* and *P. sublividus*.

Albatrellus ellisii, *A. pes-caprae* (Pers.) Pouzar, and *A. skamanius* (Murrill) Pouzar have basidiospores of similar size. But they could be distinguished from *A. yunnanensis* by the morphological characters (see the following key). *A. confluens* is similar to *A. yunnanensis* in the size and color of the basidiocarps, but the basidiospores of the former are much smaller and its pileus is usually with orange or pinkish tints and more glabrous.

Key to *Albatrellus* species known from China

1 Hyphae with clamp connections 2

1 Hyphae without clamp connections 8

2 Basidiospores up to 6 µm long 3

2 Basidiospores 7–11 µm long or even longer 5

3 Pileus and stipe yellow, tissue not becoming red in dry specimens, basidiospores non-amyloid, 3.5–4.5 × 2.5–3.5 µm ..... *A. peckianus*

3 Pileus and stipe pinkish buff, pale orange to grayish blue, basidiospores smooth, moderately amyloid, 3.5–5.5 × 3–4.5 µm 4

4 Pileus surface pale orange, usually with olivaceous tint, but no blue tint ..... *A. confluens*

4 Pileus and stipe grayish blue, some place part yellowish green, but the blue color often disappeared in old specimens or during drying, pore surface and context of apricot color ..... *A. flettii*

5 Pileal surface nearly glabrous or cracked into very small scales, olivaceous yellow to dull yellow with ochraceous tints, basidiospores non-amyloid, (7.5–) 7.8–9.9 (–11.8) × (5.3–) 6.0–7.5 (–8.0) µm ..... *A. yunnanensis*

5 Pileal surface apparantely cracked or with very coarse scales 6

6 Pileal surface grayish-brown, fuliginous to nearly black, cracked into small scales, basidiospores non-amyloid, 7–9 × 5–6.5 µm ..... *A. skamanius*

6 Pileal surface yellowish or brownish, with distinct scales 7

7 Pileal surface yellowish, dull yellow or with greenish tints, becoming grassy green when touched or bruised, with thick and coarse scales, basidiospores non-amyloid, 7–10 × 5.5–8 µm..... *A. ellisii*

7 Pileal surface grayish brown to reddish brown, never become grassy green when bruised, with fibrillose scales, basidiospores non-amyloid, 7–10 × 5.5–7 µm ..... *A. pes-caprae*

8 Pileal surface brown to black, viscid, with a resinous cuticle glossy after drying, pore surface white, pileipellis hyphae ends clavate, basidiospores non-amyloid, 4–5.5× 3.5–5 µm..... *A. yasudae*

8 Pileal surface without a viscid resinous cuticle 9

9 Fruitbodies caespitose with numerous petaloid pilei, vivid yellow or with pale brownish tint, basidiospores non-amyloid, 3.5–5× 3–4 µm..... *A. dispansus*

9 Fruitbodies with single or a few confluent pilei..... 10

10 Pileal surface and pore surface with blue or grayish tints, basidiospores non-amyloid, 4–5.5 × 3–4.5 µm ..... *A. caeruleoporus*

10 Pileus white, pale tan, greenish yellow to brownish 11

11 Pileus and stipe greenish yellow, near glabrous or with small scales, pore surface whitish or with yellowish tint, basidiospores non-amyloid to weakly amyloid, 5–7 × 4–5.5 µm ..... *A. cristatus*

11 Pileus surface white, pale tan to brownish 12

12 Pileus pale brown, with distinct small darker scales, stipe apricot with a black base, basidiospores amyloid, 4–5 × 3–4 µm ..... *A. tianschanicus*

12 Fruitbodies whitish, at least when young 13

13 Basidiospores non-amyloid, growing under *Picea* forest ..... *A. ovinus*

13 Basidiosproes amyloid..... 14

14 Basidiospores 4.5–5.5 × 3.5–4.5 µm, pileus first white, turing citric yellow when matured, discoloring yellow when bruised, growing under *Picea* forest ..... *A. citrinus*

14 Basidiospores 4.0–5.0 × 3.0–3.5 µm, pileus white, discoloring orange when bruised, growing under *Pinus* forest ..... *A. subrubescens*

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A new generic approach to the taxonomy of predatory anamorphic *Orbiliaceae* (Ascomycotina)

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Abstract—The types of trapping devices have been extensively accepted as the main morphological criterion for delimitation of the predatory anamorphic genera of orbiliaceous fungi. However, there were a few taxa exceptional. Multigene sequences including rDNA of ITS region and three protein-coding genes were analyzed. Three main clades were formed in the phylogenetic trees. Two clades corresponded to trapping devices of adhesive network (*Arthrobotrys*) and constricting rings (*Drechslerella*), respectively. However, *Dactylellina* forming stalked knobs and non-constricting rings and *Gamsylella* forming sessile adhesive knobs and adhesive columns were clustered into one clade when data were analyzed. Herewith, we propose to combine *Dactylellina* and *Gamsylella* into one genus. The generic concept of *Dactylellina* is emended and three new combinations are proposed.

Key words—predatory fungi, phylogenetic analysis

Introduction

Nematode-trapping hyphomycetes are the representatives of predatory fungi. Traditionally, taxonomy of predatory hyphomycetes was based on the morphology of conidia and conidiophores for delimitation of genera, and has been revised several times (Subramanian 1963, Liu & Zhang 1994, Rubner 1996). However, the evidence from molecular data demonstrated that trapping devices are phylogenetically more informative than the morphological characters of conidia and conidiophores (Persson et al. 1996, Liou & Tzean 1997, Pfister 1997, Ahrén et al. 1998, Hagedorn & Scholler 1999). The phylogenies based on 18S rDNA sequences were neither concordant with the morphology of conidia, nor conidiophores, but rather with the morphology of the trapping devices (Ahrén et al. 1998). Same result was obtained by the analysis of a 1.2 kb long fragment of ribosomal DNA (rDNA) sequence including the 3' of the

18S rDNA and the ITS region. It was therefore suggested to delimit genera of nematode-trapping fungi by using the type of trapping device, while distinguish species with morphological characters of conidiogenous cells and conidia (Liou & Tzean 1997). In line with the above suggestion, a generic conception for predatory anamorphic *Orbiliaceae* has been proposed by Scholler et al. (1999). The predatory fungi were divided into four genera: *Arthrobotrys* Corda forming adhesive networks; *Drechslerella* Subram. forming constricting rings; *Dactylellina* M. Morelet forming stalked adhesive knobs, and *Gamsylella* M. Scholler et al. for species producing adhesive columns and unstalked knobs.

Although the classification of predatory hyphomycetes based on trapping devices has been extensively accepted, *Gamsylella* and *Dactylellina* have the same type of trapping device e.g. adhesive knobs, as well as some taxa such as *Gamsylella phymatopaga* located between those two genera in the phylogenetic tree (Hagedorn & Scholler 1999). More molecular evidence especially protein gene sequence, in addition to rDNA, needs to be analyzed. The purpose of the present study is to get more apprehensive understanding on the taxonomy of predatory orbiliaceous fungi by phylogenetic analyses of three protein-coding gene partial sequences (elongation factor 1-α *ef1-α*; RNA polymerase II subunit, *rpb2*; β tubulin, *bt*) and ITS region in rDNA.

Materials and methods

Biological materials and sequences collection— Twenty-nine fungi were selected in this study, including 28 predatory fungi subjecting to four genera and one strain of *Vermispora fusarina* Burghouts & W. Gams as outgroup. Most strains were isolated from soil samples in China by using soil sprinkling technique (Duddington 1955, Barron 1977) and identified following the system of Scholler et al. (1999). One strain of each *Dactylellina appendiculata* (Anastasiou) M. Scholler et al. (CBS 206.64) and *D. entomopaga* (Drechsler) M. Scholler et al. (CBS 642.80) were from Centraalbureau voor Schimmelcultures (CBS).

The methods for fungal culture, genomic DNA extraction, PCR product purification and sequencing have been described previously (Yang & Liu 2005). The four gene segments selected for phylogenetic analysis were the ribosomal RNA gene in the ITS regions (ITS1-ITS4, White et al., 1990), beta-tubulin gene (*bt*) (Bt2a-Bt2b, Glass & Donaldson 1995), the second subunit of RNA polymerase II gene (*rpb2*) between exon 6 and exon 7 (6F-7R and 5F-7CR, Liu et al. 1999), and elongation factor 1-α gene (*ef1-α*) (526F-1567R, O' Donnell et al. 1998).

Sequence alignment—Nucleotide sequences were aligned using Clustal X 1.81 (Thompson et al. 1997) under the default settings (multiple alignment parameters: gap opening 10.00 and gap extension 0.20) to produce an initial alignment. This process was followed by manual adjustments using BioEdit version 5.0.6 (Tom Hall, Department of Microbiology, North Carolina State University, Raleigh, NC 27695). A large intron of 610 bp within *ef1-α* region was eliminated due to the difficulty in both sequencing

Table 1. Biological materials used in phylogenetic analysis.

Species name	Traps	*bt*	*ef1-α*	*rpb2*	ITS
Arthrobotrys anomala	An	AY773363	AY773393	AY773422	AY773451
Arthrobotrys conoides	An	AY773367	AY773397	AY773426	AY773455
Arthrobotrys eudermata	An	AY773378	AY773407	AY773436	AY773465
Arthrobotrys iridis	An	AY773364	AY773394	AY773423	AY773452
Arthrobotrys janus	An	AY773371	AY773401	AY773430	AY773459
Arthrobotrys musiformis	An	AY773382	AY773411	AY773440	AY773469
Arthrobotrys oligospora	An	AY773374	AY773404	AY773433	AY773462
Arthrobotrys pseudoclavata	An	AY773359	AY773388	AY773417	AY773446
Arthrobotrys pyriformis	An	AY773362	AY773392	AY773421	AY773450
Arthrobotrys sinensis	An	AY773358	AY773387	AY773416	AY773445
Arthrobotrys thaumasia	An	AY773373	AY773403	AY773432	AY773461
Arthrobotrys vermicola	An	AY773366	AY773396	AY773425	AY773454
Dactylellina appendiculata	Sk	AY965822	DQ358227	DQ358229	AF106531
Dactylellina drechsleri	Sk	AY773377	AY773390	AY773419	AY773448
Dactylellina ellipsospora S1	Sk	AY773361	AY773391	AY773420	AY773449
Dactylellina ellipsospora S2	Sk	AY773370	AY773400	AY773429	AY773459
Dactylellina entomopaga	Sk	AY965831	DQ358228	DQ358230	AY965758
Dactylellina parvicollis	Sk	AY773385	AY773414	AY773443	AY773472
Dactylellina haptotyla	Sk & Ncr	AY773383	AY773412	AY773441	AY773470
Dactylellina leptospora	Sk & Ncr	AY773379	AY773408	AY773437	AY773466
Dactylellina cionopaga C1	Ac	AY773380	AY773409	AY773438	AY773467
Dactylellina cionopaga C2	Ac	AY773381	AY773410	AY773439	AY773468
Dactylellina cionopaga C3	Ac	AY773384	AY773413	AY773442	AY773471
Dactylellina cionopaga C4	Ac	AY773386	AY773415	AY773444	AY773473
Drechslerella brochopaga	Cr	AY773368	AY773398	AY773427	AY773456
Drechslerella coelobrocha	Cr	AY773376	AY773406	AY773435	AY773464
Drechslerella dactyloides	Cr	AY773375	AY773405	AY773434	AY773463
Drechslerella stenobrocha	Cr	AY773372	AY773402	AY773431	AY773460
Vermispora fusarina	Outgroup	AY773360	AY773389	AY773418	AY773447

An = adhesive networks; *Sk* = stalked knobs; *Ncr* = non-constricting rings; *Ac* = adhesive columns; *Cr* =constricting rings.

and alignment. Each individual gene region analyses represented similar topological structure, so the four segments were combined into one alignment of 2562 nucleotide sites (including gaps), which consisted of 532 bp from the 5' end of *bt* gene, 703 bp in the exon 6 of *rpb2* gene, 771 bp from the 5' end of *ef1-α* gene, and 556 bp of rDNA in the ITS regions. There were six non-coding regions in this alignment, including three in the *bt* gene, one in the *ef1-α* gene and two in the ITS regions.

Phylogenetic analysis—Preliminary analysis of the obtained data showed that none of individual fragment of the three protein gene sequences was informative enough to give a more reasonable phylogenetic structure. Thus, two sets of data, one with ITS sequences only and the other one with a combined sequences of the four genes, were separately sent to PAUP* 4.0b 10 (Swofford 2000) for the final phylogenetic analysis. Maximum parsimony (MP) analyses were performed with heuristic searches consisting of 1000 random sequence addition replicates with tree bisection-reconnection (TBR) branch swapping. All characters were equally weighted and unordered.

Results

Lineages in predatory fungi—Four fine-scale lineages were identified within predatory hyphomycetes with moderate to strong bootstrap support in ITS region (BP 75–100%), while three lineages with more detail information were obtained by using the combined sequences of ITS, *rpb2*, *ef1-α* and *bt*. The constricting ring group (the genus of *Drechslerella*) was first separated from the predatory hyphomycetes as a paraphyletic clade of the adhesive groups. The adhesive network group evolved into a monophyletic clade with more credible bootstrap supports (BP 90% & 100%). However, the lineage of adhesive column which was labeled with grey resulted in a variable relationship with other adhesive groups in different trees (Fig. 1). Although the knob group has various morphological forms of trapping device, and presents a more relaxed topology with a lower bootstrap support, it is a real monophyletic clade.

Phylogeny based on ITS sequences—The ITS rDNA parsimony analysis resulted in a single most parsimonious tree (Fig. 1A), with a tree length of 895 [consistency index (CI) = 0.5631; retention index (RI) = 0.6370; rescaled consistency index (RC) = 0.3587]. The 50% majority rule consensus phylogram revealed that two lineages of non-adhesive group and adhesive group were well divided with strong bootstrap support (BP 87% & 79%), and three subclades corresponding to three types of trapping devices (adhesive knobs, adhesive networks, and adhesive columns) were clearly indicated in the adhesive group.

Phylogeny based on the combined data of ITS, *bt*, *rpb2* and *ef1-α*—The MP analysis of the combined data produced one tree with a tree length of 4918 steps (CI = 0.4392; RI = 0.5473; RC = 0.2404). The 50% majority rule consensus phylogram (Fig. 1B) also revealed that predatory hyphomycetes were composed of two lineages, non-adhesive group and adhesive group. For the adhesive

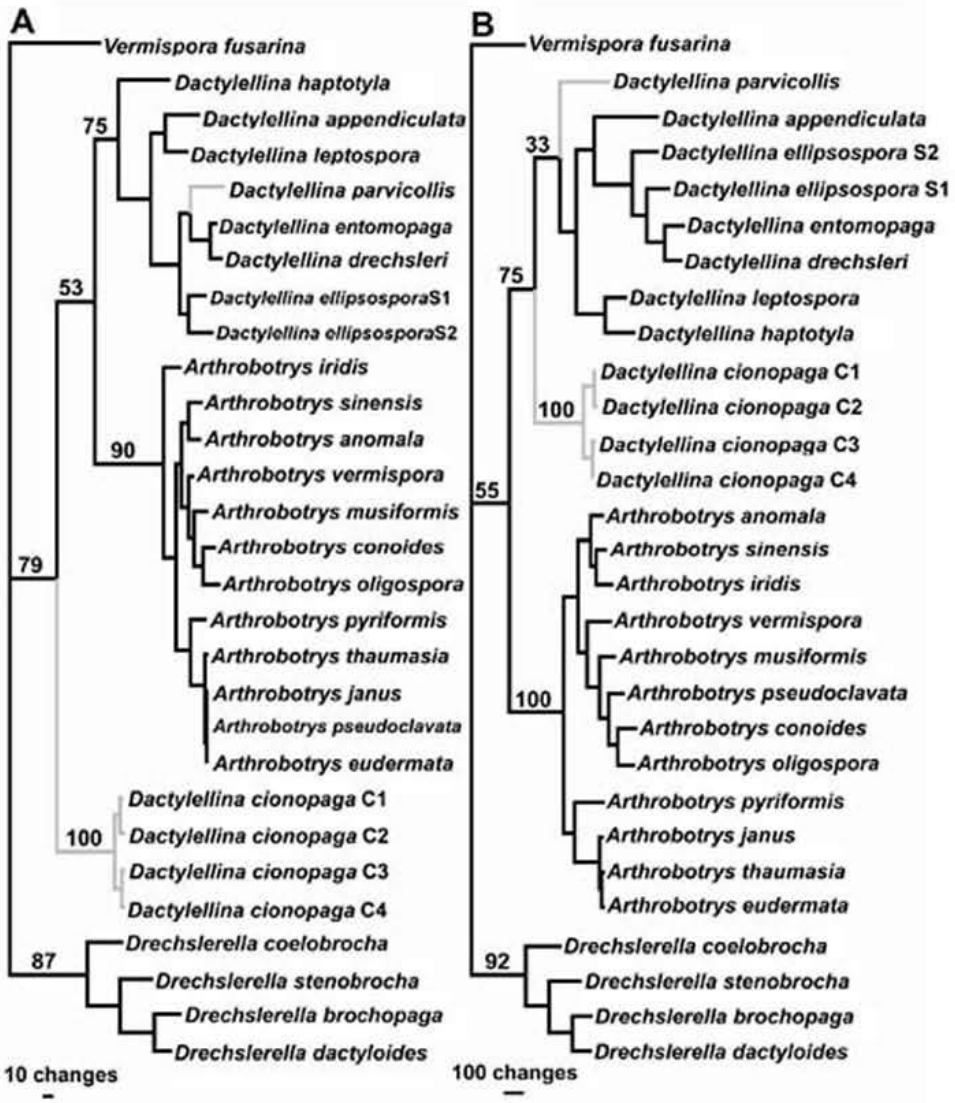

Fig. 1. Phylogram of bootstrap 50% majority-rule consensus tree. The numbers above the branches indicate the bootstrap values obtained for 1000 replicates and only bootstrap values of each groups are shown. A. MP tree of ITS sequences analysis. B. MP tree of combined data analysis.

clade, the adhesive column subclade (*Gamsylella*) and adhesive knob subclade (*Dactylellina*) were clustered into one monophyletic group with 75% bootstrap support and seemed evolving paraphyletically with adhesive network group. It suggested that *Dactylellina* and *Gamsylella* should be combined into one genus. Furthermore, the trapping devices such as stalked adhesive knobs, sessile knobs, and adhesive columns were morphologically similar. We concluded that

Gamsylella was synonym of *Dactylellina* and the generic circumscription of *Dactylellina* was amended.

Taxonomy and nomenclature—*Arthrobotrys*, *Drechslerella* and *Dactylellina* are recognized predatory orbiliaceous hyphomycetes. *Arthrobotrys* is composed of the fungi forming adhesive networks, *Drechslerella* consists of fungi forming constricting rings and *Dactylellina* includes fungi forming adhesive knobs, columns, and non-constricting rings. The species formerly assigned into *Gamsylella* should be transferred into *Dactylellina* and three new combinations were proposed.

Dactylellina M. Morelet emend. Ying Yang & Xing Z. Liu

Type species: *Dactylellina leptospora* (Drechsler) M. Morelet, Bull. Soc. Sci. Nat. Archéol. Toulon Var 178: 6 (1968).

Basionym: *Dactylella leptospora* Drechsler, Mycologia 29: 507 (1937).

Mycelium slow-growing. Hyphae septate, branching, hyaline. Saprotrophic or capturing nematodes or other animals by means of stalked adhesive knobs, sometimes in combination with non-constricting rings, or by means of unstalked non-detachable adhesive knobs or two- to multi-celled columns. Columns constricted at the septa and sometimes forming loops or fusing with a neighboring column. Traps usually formed spontaneously. Conidiophores mostly simple, if branched then often near the apex. Conidiogenous cells monoblastic or multiblastic with short denticles. Conidia holoblastic, formed singly or in clusters on the tip of the conidiogenous cells, hyaline, 1–7(–15)-septate, mostly cylindrical, ellipsoidal, fusiform or spindle-shaped, rarely clavate or obconical. Microconidia and microconidiophores rarely formed. Chlamydospores absent. Teleomorph: *Orbilia* (Liu et al. 2005).

Species transferred into *Dactylellina*

1. ***Dactylellina arcuata*** (Scheuer & J. Webster) Ying Yang & Xing Z. Liu **comb. nov.**
MycoBank Number: MB 510274.

Basionym: *Dactylella arcuata* Scheuer & J. Webster, Mycol. Res. 94: 720 (1990).

2. ***Dactylellina gephyropaga*** (Drechsler) Ying Yang & Xing Z. Liu **comb. nov.**
MycoBank Number: MB 510272.

Basionym: *Dactylella gephyropaga* Drechsler, Mycologia 29: 512 (1937).

3. ***Dactylellina cionopaga*** (Drechsler) Ying Yang & Xing Z. Liu **comb. nov.**
MycoBank Number: MB 510273.

Basionym: *Dactylella cionopaga* Drechsler, Mycologia 42: 30 (1950).

Discussion

The knob-forming species of the nematode-trapping fungi have diverse configurations such as sessile knobs, stalked knobs, a combination of stalked knobs with non-constricting rings, or stalked knobs with proliferated knobs. All of these trapping structures are morphologically similar and their evolutionary radiation has been proposed recently (unpublished). *Dactylellina parvicollis* captures nematodes by means of (short stalked) knobs, which can grow out to form loops (Drechsler 1962). Drechsler (1954) first described that *D. phymatopaga* captured nematodes by sessile knobs, but Rubner (1996), after reexamined many isolates of this species, found that their knobs were not always sessile and tended to develop stalks up to 12 μm long. It means that both *D. phymatopaga* and *D. parvicollis* could produce stalked knobs. Although Scholler et al. (1999) assigned those two species into *Gamsylella*, they have basic characters (stalked knobs) of *Dactylellina*. Liou & Tzean (1997) used *D. phymatopaga* as outgroup in ITS phylogenetic analysis and did not give any concrete description. While in the phylogenetic analysis conducted by Hagedorn & Scholler (1999), *D. phymatopaga* was positioned between the column group and the knob group. Species with unstalked adhesive knobs were considered primitive by Rubner (1996). This group should be at the basal position of the evolution of knob trapping devices (Liou & Tzean 1997, Hagedorn & Scholler 1999). There were six species assigned in *Gamsylella* (Scholler et al. 1999). *D. phymatopaga*, *D. parvicollis*, *D. lobata* and *D. robusta* have been moved to *Dactylellina*, and the other two species in *Gamsylella* forming adhesive columns and sessile knobs were placed in *Arthrobotrys* (Li et al. 2006). The trapping devices produced by these two species are similar to adhesive knobs produced by *Dactylellina*. By our combined data analysis, *D. cionopaga* was closer to *Dactylellina* than *Arthrobotrys*. Both morphological characters and molecular evidences proved that these species should be included in *Dactylellina*.

The *rpb2* exons exhibit a higher percentage of potentially parsimony-informative characters than exons of *bt* and *ef1-α*, both of which exhibit similar amounts. Each of four fragments with their introns has many parsimony-informative characters, but it was not enough for phylogenetic analysis under genus because of the limitation of sequence information. Single gene analysis may not give a resolved strict consensus tree, and not represent the evolution of all genes in organisms. Three genes, which involved in transcription, translation, and cytoskeleton respectively, were combined into one dataset to overcome the limitation of rDNA of the ITS region. Not only the rDNA gene but also protein-coding genes were sent to phylogenetic analysis, the high degree of congruence with complex morphological characters like trapping devices makes us confident that the true species tree will only differ in minor details.

This combined sequence analysis displayed a convincingly approach to the real phylogeny.

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Appendicispora: a new genus in the arbuscular mycorrhiza-forming Glomeromycetes, with a discussion of the genus *Archaeospora*

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Abstract—A new genus of arbuscular mycorrhizal fungi, *Appendicispora* (*Archaeosporaceae*), is described. New species names are: (i) *Ap. appendicula*, the type species derived from the dimorphic *Acaulospora appendicula*, a "synonym" of *Ac. gerdemannii* erroneously thought to represent the acaulosporoid form of *Archaeospora leptoticha*; (ii) *Ap. gerdemannii*, based on *Archaeospora (Glomus) gerdemannii*; and (iii) *Ap. jimgerdemannii*, a nom. nov. for the former *Ac. gerdemannii*. *Archaeospora trappei*, which remains alone in the now monotypic *Archaeospora*, differs from the *Appendicispora* species in spore development, wall morphology, germination, and root colonization structures; its separation is further supported by molecular data. In *Appendicispora*, acaulosporoid spores are all three-walled and have an appendix arising laterally from the hyphal neck of a terminal sporiferous saccule. Distributional data are provided that expand the range of *Appendicispora* species from the Mediterranean and (sub)tropical climates to arbuscular mycorrhizal fungi communities in cold subalpine and alpine areas.

Key words—Glomeromycota, dimorphism

Introduction

In this study, we discuss the genus *Archaeospora* J.B. Morton & D. Redecker (Morton & Redecker 2001) of the *Archaeosporaceae* and erect a new genus in this family of the Glomeromycetes. The history of *Archaeospora* and its three members is rather complicated. The difficulties derive from the dimorphic nature of *Acaulospora appendicula* (Schenck et al. 1984), the first diagnosis of an *Acaulospora* species having two morphs, and from the synonymization by Morton & Redecker (2001) of two distinctly different acaulosporoid spores and a glomoid spore with two *Glomus* species to get to the genus *Archaeospora*,

and from the nomenclature which had to be applied to distinguish between an *Archaeospora* sp. derived from *Glomus gerdemannii* (Rose et al. 1979) and an *Archaeospora* sp. which derived from *Ac. gerdemannii* (Nicolson & Schenck 1979).

Materials and methods

Investigation of type material

We investigated type material of the following epithets: type and isotype material of *Ac. gerdemannii* (#OSC 37,514 and isotype from FH); type material of *Ac. appendicula* (#OSC 41,495) and material from collections maintained by J. L. Spain and E. Sieverding, respectively; type material of *G. gerdemannii* (#OSC 39,476), *G. leptotichum* (#OSC 40,249) and *G. fecundisporum* (#OSC 40,250). Additionally, spores of *Ac. gerdemannii* were isolated from soil samples taken in June 2002 from the Agricultural Research Center at Ona, Florida, a site named by Nicolson & Schenck (1979) where the type specimen was found. Unfortunately, only a few spores of *Ac. gerdemannii* were recovered. Finally, we examined many other specimens of *Ac. appendicula*, *Ac. gerdemannii* and *G. gerdemannii*. These species have been found by the authors of this study during the last 25 years from soils collected from different places in North America, South America, Africa, Asia and more recently (between 2000-2005) from Europe (mainly Switzerland, Germany and France).

Spore wall terminology and analyses

The terminology of the spore wall structure was basically adapted from INVAM (International Culture Collection of Arbuscular and Vesicular-Arbuscular Endomycorrhizal Fungi, see homepage: www.invam.caf.wvu.edu). We recognize three different walls in the new genus, and thus, we adopt the terminology developed for *Acaulospora* spores with three walls (Stürmer & Morton, 1999; Oehl et al. 2006) with some modifications. In detail, we call the three spore walls *'outer spore wall'* (*ow*), *'middle wall'* (*mw*) and *'inner wall'* (*iw*). Most of the analyses of the wall structures were performed on compound microscopes at 400*x* magnification. Photographs in Figs. 1-9 were taken with a digital camera (Olympus model DP70-CU) on a Zeiss Axioplan compound microscope. Photographs in Figs. 10-12 were taken with a SPOT2 camera mounted on a Leica DMRB microscope at the OSC Mycological Herbarium in Corvallis, Oregon, USA. The legends on the photographs were inserted with Adobe Photoshop 6.0.

Mycorrhizal structures

The descriptions of the mycorrhizal root colonization structures are based on observations of roots derived from pure cultures of the former *Acaulospora*

appendicula on *Sorghum bicolor* (L.) Moench, *Pueraria phaseoloides* (Roxb.) Benth., *Manihot esculenta* Crantz or *Allium porrum* L. Cultures were maintained for many years by J. Classen de Miranda and J. L. Spain at the Centro de Pesquisa Agropecuária dos Cerrados, CPAC, Brasilia, Brazil, by J. L. Spain in Corvallis, Oregon, and by E. Sieverding and S. Toro at the Centro Internacional de Agricultura Tropical, CIAT, Cali, Colombia. Trypan blue was used to stain the intraradical mycorrhizal root structures using methods explained by Brundrett et al. (1994). Root colonization structures in Fig. 6 are from plants inoculated with spores from the pot type culture of *Ac. appendicula* grown at CIAT.

Discussion of *Archaeospora*

The following species descriptions must be taken into consideration to understand the history of the genus *Archaeospora* in the *Archaeosporaceae* of the Glomeromycetes:

Schenck et al. (1984) described *Acaulospora appendicula* as a dimorphic arbuscular mycorrhizal species, forming acaulosporoid spores on a short cylindric hyphal appendix (for which Schenck et al. 1984 used the term 'hyphal pedunculate protuberance' and Morton & Redecker 2001 the term 'pedicel') arising laterally from the hyphal neck of the sporiferous saccule, and also glomoid spores and vesicle-like structures on the extraradical mycelium. Morton et al. (1997), believing that *Acaulospora gerdemannii* developed the same morphological characteristics as *Ac. appendicula*, synonymized the two. In the same paper, Morton et al. (1997) also described the glomoid spore of *Ac. appendicula* as identical to *G. leptotichum* N.C. Schenck & G.S. Sm., which they synonymized with *G. fecundisporum* N.C. Schenck & G.S. Sm.

More recently, Morton & Redecker (2001) combined *Ac. gerdemannii* and *G. leptotichum* as *Archaeospora leptoticha* and transferred *Glomus gerdemannii* to *Archaeospora*. Spain (2003), however, recently noted that the type species of *Archaeospora*, *Ar. trappei*, has much smaller spores than *Ar. leptoticha* and *Ar. gerdemannii*, as well as a distinct wall configuration and novel germination structures; it rarely produces glomoid spores.

Salient morphologic features in the diagnoses of *Ac. gerdemannii*, *Ac. appendicula*, *G. leptotichum* and *G. fecundisporum* escaped the attention of Morton and co-workers when they combined the species and subsequently erected the dimorphic genus *Archaeospora*. Acaulosporoid spores of *Ac. gerdemannii* with cerebriform ornamentation on the outer spore wall were combined with *Ac. appendicula*, a taxon with a crazed (fissured, cracked) surface of the outer wall. Type material of *Ac. appendicula* clearly corresponds to the diagnosis. The confusion might have been due to the poor quality of type and isotype material

of *Ac. gerdemannii* in the herbaria. Two of the five original slides of the *Ac. gerdemannii* type material (OSC #41,495) are missing and most of the spores are in very bad condition. However, in 1989, Mohammad Achouri mounted holotype spores of *Ac. gerdemannii*, preserved by Schenck & Nicolson in FAA (formol/acetic acid/alcohol), that clearly show cerebriform ornamentation on the outer spore wall and confirm other morphological details. Isotype material of *Ac. gerdemannii* (F51804 deposited in FLAS) has been missing for several years, and paratype material deposited at the Farlow Herbarium has degraded, and salient features cannot be discerned on this material. Two early taxonomic keys developed for *Acaulospora* species (Walker & Trappe 1981, Schenck et al. 1984) refer to cerebriform ornamentation as the salient diagnostic feature of *Ac. gerdemannii*.

Acaulospora appendicula spores have an outer wall with a crazed appearance and — similar to *Ac. gerdemannii* — a middle wall with alveolate ornamentation. Morton et al. (1997), who acknowledge the crazed wall of *Ac. appendicula*, suggest that the wall appears to develop cerebriform folds on aged spores. We have observed isolates of *Ac. appendicula* from several locations in the world (see distribution below) and have examined spores stored for at least six years at ambient temperature in dry soil at the Centro Internacional de Agricultura Tropical (CIAT) as well as in soil stored at 8° C in a cold room, yet we cannot confirm that the crazed outer spore wall of *Ac. appendicula* develops a cerebriform ornamentation. Both the herbarium slides of *Ac. gerdemannii* mounted by Achouri and our own examination of spores from the type location clearly confirm Schenck & Nicolson's diagnosis: cerebriform ornamentation up to 10-12 µm high does form on the spores in this species. The dark field photograph accompanying the diagnosis also shows cerebriform ornamentation on an apparently young spore attached by an appendix to the sporiferous saccule hypha.

Correspondence of spore morphology in type specimens and vouchers from living cultures was the basis for determining synonymy of *G. leptotichum*, *G. fecundisporum* and the glomoid spore of *Ac. appendicula* (Morton et al. 1997). Schenck & Smith (1982) distinguished *G. leptotichum* with a faint reticulum of ridges most apparent on young spores produced terminally and in an intercalary manner from *G. fecundisporum*, which lacks a reticulum and has generally smaller spores with a yellow to brown wall. Unfortunately, the type material of *G. fecundisporum* shows two very different *Glomus* spore types; both, however, differ from typical *G. leptotichum* spores. Intercalary spore formation has not been reported for the glomoid morph of *Ac. appendicula*, which also does not have a reticulum at any stage. We conclude that *Ac. appendicula* is not synonymous with *G. leptotichum*.

There are also two very different *Glomus* spores on the *G. leptotichum* type slide (OSC #40,249) labeled 'Roots'. Two of several small spores are germinating. There are also three acaulosporoid spores on one of the *G. leptotichum* (OSC #40,249) slides; two are parasitized and lack a spore wall, although they do possess a single alveolate reticular wall and an inner laminated wall. Morton et al. (1997) refer to a single acaulosporoid spore, which they interpreted as an acaulosporoid spore of *Ac. gerdemannii*; this spore lacks the crazed outer wall typical of *Ac. appendicula* but possibly has remnants of cerebriform ornamentation.

Redecker et al. (2000) performed molecular analyses on spores that they attributed to *Ac. gerdemannii* sensu Morton et al. and its glomoid synanamorph, which they called *G. leptotichum*. They analyzed spores produced in pure cultures under controlled conditions, concluding from the biochemical and genetic data that both morphs belonged to one species. However, we feel that the authors used *Ac. appendicula* and the known glomoid morph of this species in their studies instead of *Ac. gerdemannii*, because *Ac. gerdemannii* is not known from pot cultures and its glomoid morph remains unknown. On the other hand, *Ac. appendicula* and its glomoid morph have been propagated many times in pure cultures at CIAT in Colombia. If a glomoid spore of *Ac. appendicula* was erroneously assumed to represent *G. leptotichum*, it is not surprising that the two morphs of *Ac. appendicula* gave the same genetic information.

Morton & Redecker (2001) combined *Ac. trappei*, *Ac. gerdemannii* (the description referring to *Ac. appendicula*), and *G. gerdemannii* in their new genus, *Archaeospora*, based on shared molecular genetic information generated by Redecker et al. (2000). The phylogenetic tree of Redecker et al. (2000) supports *Ac. gerdemannii*, *G. leptotichum* and *G. gerdemannii* as closely related species that clearly differ from *Ac. trappei*. Their data thus also support separation of the four species at the molecular level into two genera. The type species of the genus *Archaeospora*, *Ar. trappei*, differs from the other species of the genus not only in spore size but also in spore development and germination, wall morphology, and root colonization structures. These observations led us to erect a new genus in the *Archaeosporaceae*.

Schenck et al. (1984) included both acaulosporoid and glomoid spores in the diagnosis of *Ac. appendicula*; thus this species is suitable to serve as type for the new genus *Appendicispora*, particularly when the spore morphology and germination are so well known.

Because we propose to transfer two different species with the same specific epithet to our new genus, we must rename the later-named taxon in accordance with Art. 11.3 of the International Code of Botanical Nomenclature (Greuter et al. 2000). *Archaeospora gerdemannii*, first published (as *Glomus gerdemannii*)

on January 13, 1979, has priority over *Ac. gerdemannii* and so is transferred to *Appendicispora* as *Ap. gerdemannii*. We propose the new name, *Ap. jimgerdemannii*, for the later described *Acaulospora gerdemannii*.

Because we consider that the glomoid morph of *Ac. appendicula* is not synonymous with either *G. leptotichum* or *G. fecundisporum*, we exclude the latter two fungal species from the *Archaeosporaceae* and return them to the genus *Glomus*.

Description of new genus

Appendicispora Spain, Oehl & Sieverd. **gen. nov.**
MB510319

Sporae dimorphae vel monomorphae: Sporae acaulosporoideae ternibus tunicis ex appendice formatae, lateraliter ex hypha terminata in sacculo sporifero; germinatio ex tunica interior Ubi presentes sporae glomoideae singulares vel plerique. Arbusculae, vesiculae, hyphaeque mycorrhizarum tinguntur pallidae.

Etymology: from the Latin appendix = appendage, and *spora* = spore.

KEY CHARACTERS—Sporocarp formation unknown; species generally dimorphic with mycorrhizal associations producing both acaulosporoid and glomoid morphs (glomoid morph not known for all species). *Acaulosporoid spores* on short hyphal appendix arising laterally from the hyphal neck of a terminal sporiferous saccule; with outer, middle and inner wall; germinating from the innermost wall with germ tube emerging through the appendix attachment; a germination structure possibly forming between inner and middle wall. *Glomoid spores* formed singly in soil or in loose clusters on the root with external hyphae germinating through the subtending hypha. *Root arbuscles* and *vesicles* stain pale blue with trypan blue.

TYPE SPECIES—*Appendicispora appendicula* (Spain, Sieverd. & N.C. Schenck) Spain, Oehl & Sieverd. comb. nov.

Discussion—The principal characters that differentiate species of *Appendicispora* from species of other Glomeromycetes genera with acaulosporoid spore formation are in the morphology of the acaulosporoid spores as summarized in Table 1. Basically, acaulosporoid spores of *Appendicispora* differ from *Archaeospora* in having three (instead of only two) spore walls. Additionally, the spores germinate from the inner wall through a germ tube that arises from a specific germination structure to penetrate the middle wall at the pore closure, then the appendix pore followed by the outer wall collar. The germination structure of *Archaeospora trappei* emerges through the outer wall. Additionally, *Appendicispora* may form vesicles in the roots. Although Ames & Linderman (1976) also reported vesicles for *Archaeospora trappei*, Morton & Redecker (2001) did not confirm their formation.

Table 1. Principal morphological characteristics separating ***Appendicispora*** gen. nov. from ***Archaeospora*** and ***Acaulospora***

	Appendicispora	*Archaeospora*	*Acaulospora*
Spore dimorphy	Yes, acaulosporoid & glomoid	Yes, acaulosporoid & glomoid	Unknown
Number of walls in acaulosporoid (*ac*) spores	3 (*ow, mw, iw*)	2 (*ow, iw*)	3 (*ow, mw, iw*)
Number of *ac* spore walls arising from hyphal walls	2 (*ow, mw*)	1 (*ow*)	1 (*ow*)
Number of *ac* walls formed as new after spore pore closed	1 (*iw*)	1 (*iw*)	2 (*mw, iw*)
Known types of ornamentation on *ow*	cerebriform	none	cerebriform, pits, reticula, projections
Known types of ornamentation on *mw*	alveolate	-	none
Known types of ornamentation on *iw*	none	none	Characteristic 'beaded' iwl1
Spore pore closure by	Septum arising from *mw*l1 and by *mw*l2	Septum arising from *ow*l2	Laminae arising from *ow*l2 and by *ow*l3
Presence of appendix	Yes	No	No
Germination	From *iw* forming a specific germination structure, through appendix	From *iw* with truncated germ tube through *ow* at any area of surface	From *iw* with specific germination orb, through *mw* and *ow* at any area of surface
Presence of vesicle	Yes	Not described	Yes
Staining of mycorrhizal structures with trypan blue	Faintly to pale blue	Not to faintly	Blue to dark blue

Abbbreviation of spore walls and spore wall layers: outer wall (*ow*), middle wall (*mw*) and inner wall (*iw*) with 1-3 layers (e.g. *ow*l2, *mw*l2).

In *Appendicispora,* acaulosporoid spores form on an appendix, which distinguishes them from *Acaulospora* spores, which sit directly on the hyphal neck of a sporiferous saccule. The *Acaulospora* pore closes by laminae in the outer wall, while the *Appendicispora* pore closes in the middle wall. The *Acaulospora* inner wall contains a 'beaded' wall layer, a character absent in both *Appendicispora* and *Archaeospora.* Finally, the *Acaulospora* intraradical mycorrhizal structures stain blue to dark blue in trypan blue, in contrast to *Appendicispora* (where they stain only faintly to pale blue) and *Archaeospora* (where they stain either faintly or not at all).

Species included in the new genus

Appendicispora appendicula (Spain, Sieverd. & N.C. Schenck) Spain, Oehl & Sieverd. **comb. nov.** FIGURES 1-6

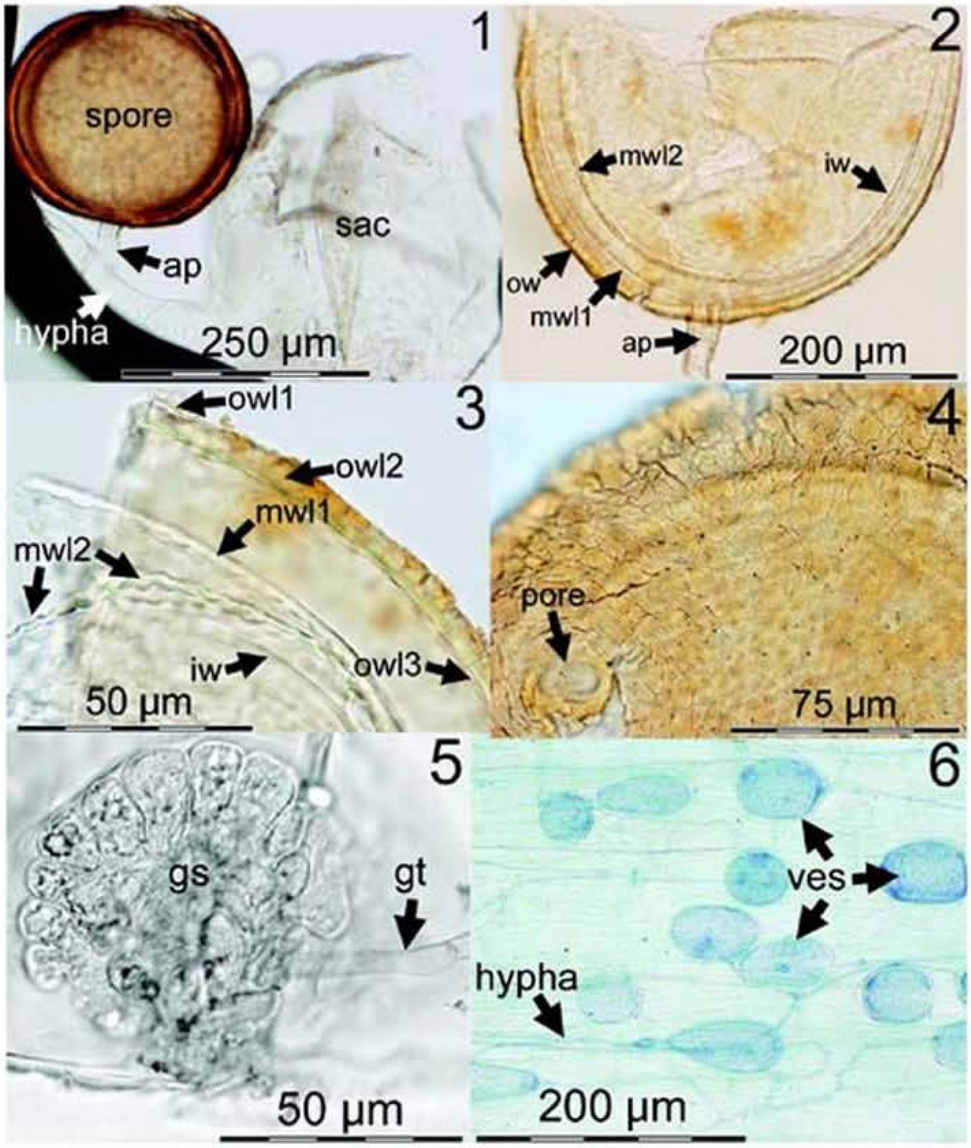
MB510320

Basionym: *Acaulospora appendicula* Spain, Sieverd. & N.C. Schenck, Mycologia 76, 686. August 7, 1984.

Spore formation—Sporocarps unknown. *Acaulosporoid spores* formed singly in the soil upon a short appendix that arises laterally on the tapering hyphal neck of a sporiferous saccule (Fig. 1) and *glomoid spores* formed terminally on hyphae, occurring singly or in loose clusters in the soil. Acaulosporoid sporiferous saccules formed on mycelial hyphae with 1-6 µm thick walls; the thick-walled hyphae often rigid, persistent, 12-20(-25) µm wide, sparsely branched, and giving rise to thinner walled hyphae (6-12 µm diam) bearing thick-walled glomoid spores. Often thin walled swollen hyphal tips form on thinner walled hyphae which readily collapse when mounted in lactophenol or PVLG. Both acaulosporoid and glomoid spores may be found on the same mycelium and both can function as colonization propagules.

Sporiferous saccule—Globose to subglobose to rarely ellipsoid, (190-)250(-380) µm diam, formed terminally on a hypha (Fig. 1). Saccule wall consists of one wall with 2-3 wall layers: one very thin, hyaline outer layer (usually difficult to detect), a second layer of overlapping plate-like structures, and a third membranous inner wall layer. Contents are initially white-opaque, later becoming gray-white to subhyaline until saccule becomes transparent as contents discharge to form a spore. Prior to appendix and spore formation, a septum forms in the tapering hypha distal to the saccule where the hyphal appendix is formed. The sporiferous saccule may persist on young specimens and generally does not collapse when detached from the spore at the junction interface.

Acaulosporoid spores—Borne singly on a short hyphal appendix (Fig. 1). Spores are globose to subglobose, (170-)250(-390) µm diam, white-opaque when young, maturing to dull yellow-cream to orange-tan. Three spore walls are present: outer (*ow*), middle (*mw*), and inner (*iw*). The outer wall, which is continuous with the wall of the outer appendix layers and the sporiferous saccule hyphal neck, comprises three layers in young, fully developed spores (Figs. 2, 3). The outer layer (*ow-l* 1) is hyaline and 0.5-1.0 µm thick and often is lost or degrades during the early stages of spore formation. The second layer (*ow-l* 2), initially white, becoming yellow to brown, firm and difficult to break on young spores, turns orange-red in Melzer's reagent, but with age becoming less rigid and staining less red with Melzer's reagent. The *ow-l* 2 is 8-16(-20) µm



Figs. 1-6: *Appendicispora appendicula.* Fig. 1. Spore formed on an appendix (ap) laterally arising from the hyphal neck of a sporiferous saccule (sac). Fig. 2. Crushed acaulosporoid spore with appendix (ap) and three walls: outer wall (ow), middle wall (mw) and inner wall (iw). Outer wall and outer layer of middle wall (mwl1) continuous with appendix wall. Fig. 3. Broken acaulosporoid spore with three-layered outer wall (owl1, owl2, owl3), two-layered separated alveolate middle wall (mwl1, mwl2), and inner wall (iw). Fig 4. Broken acaulosporoid spore showing the crazed pattern of fine cracks of owl2, and pore after appendix detachment. Fig. 5. Germination structure (gs) on inner wall of acaulosporoid spore with germtube (gt). Fig. 6. Hyphae and vesicles (ves) in root stained pale blue with trypan blue.

thick, somewhat roughened, with an irregular crazed pattern of fine cracks (Fig. 4). The inner layer (*ow-l* 3) usually is hard to observe as it is very thin (about 0.5-1.0 µm) and often tightly adherent to *ow-l* 2. When the appendix is broken off an open pore is formed in the outer wall that is 20-50 µm wide (Fig. 4).

The middle wall comprises two layers: the outer layer (*mw-l* 1), which is continuous with the thick, hyaline layer of the appendix and second layer of the connected hypha + sporiferous saccule, is hyaline, 2-6 µm thick, and with a convex, alveolate reticulum (Fig. 2, 3). The undulations are 7-12 µm wide and ≤ 3–5 µm deep. The *mw-l* 2 is hyaline, 4-8 µm thick, tightly adherent to *mw-l* 1 and thus showing a similar alveolate structure with concave hemispherical depressions on the outer surface that fit into the convex protuberances at the inner surface of *mw-l* 1. Layer *mw-l* 2 may close the pore of the appendix. The layers *mw-l* 1 & 2 separate when pressure ruptures the spore (Figs. 2, 3). *Mw-l* 2 stains yellow in Melzer's reagent.

The inner wall, which is hyaline, smooth, and 2-10 µm thick (Fig. 3), forms only after differentiation and complete formation of the outer and middle walls. A very thin outer layer (*iw-l* 1) and a thin inner layer (*iw-l* 3) appear to adhere to the finely laminated middle layer (*iw-l* 2) in water mounted specimens, but neither *iw-l* 1 nor *iw-l* 3 are usually detected in specimens mounted in PVLG.

The acaulosporoid appendix arises laterally from the hyphal neck of a sporiferous saccule, is often persistent, and resembles a subtending hypha, 30-100 µm long, 20–50 µm wide, cylindric or tapering to 10-25 µm at the distal end from the spore. The wall is continuous with the outer spore wall and with *mw-l* 1 (Fig. 2). The appendix pore is closed by a septum arising from *mw-l* 1 at or a short distance (0–5 µm) from the spore base (Fig. 2). Occasionally a second septum — less often a third — forms 20-50 µm further from the spore base in the appendix. When the septal closure of the pore is not seen, *mw-l* 2 closes the pore.

Acaulosporoid spores germinate with a single or branched germ tube, 6-12 µm in diameter, that emerges from the inner wall and exits through the pore of the appendix. A distinctive germination structure was also observed to form between middle and inner walls in a spore mounted in water from which a germ tube emerged (Fig. 5). Single or loose clusters of swollen hyphal tips often form on the germ hyphae at a short distance (100-200 µm) from the base of the acaulosporoid spore.

Glomoid spores—Hyaline to subhyaline, globose to subglobose, 120–240(-280) µm diam with spore wall (*sw*) consisting of a mucilaginous outer layer *sw-l* 1, 1.5-2.5 µm thick, frequently with adhering debris on the outer surface, and a 2-8(-12) µm thick, laminated inner wall layer (*sw-l* 2). Subtending hypha cylindric to slightly funnel shaped, 7-16(-19 µm) diam at the spore base tapering to 5-12

µm within a distance of 7-20(-30) µm. The bi-layered wall of subtending hypha totals 1.8-3.2 µm thick at the spore base. The pore usually is open, 5-10(-12) µm diam but sometimes a thin septum deriving from the inner hyphal wall layer is seen at a short distance (5-12 µm) from the spore base. Glomoid spores germinate through the subtending hypha.

Mycorrhiza formation—Forming mycorrhiza with arbuscles and vesicles (Fig. 6). Arbuscules, vesicles, and intraradical hyphae stain pale blue with trypan blue.

Discussion—In addition to the above glomoid spores, Schenck et al. (1984) described 'vesicle-like' structures, which we interpret as aborted glomoid spores, because they often accompany loose clusters of glomoid spores. These are thin-walled (1-2 µm), globose (40-80 µm) or ellipsoidal (68-120 x 54-112 µm) swollen hyphal tips that readily collapse when mounted in lactophenol or PVLG.

Distribution—Colombia: in acidic Oxisols under native pastures in Carimagua, Meta Province; under cassava in acidic Ultisols at CIAT Quilichao, at Agua Blanca and at Popayan, all Cauca Province. Florida-USA: isolated from acid soils (pH 5-5.5) near Gainesville and Ona. Costa Rica: reported by Johnson & Wedin (1997). Brazil: in Bahia and Goias found by J.L. Spain, and reported by Weber & Deoliveira (1994) and Carrenho et al. (1998, 2001). Bolivia: tropical forest (Oehl, unpublished). Venezuela: Gran Savanna region (G. Cuenca, pers. com.). Republic of Congo: under cassava in an acidic Oxisol in the South Kivu Region (Sieverding, unpublished). Mexico: agricultural land near Chapingo (Sieverding, unpublished). Thailand: tropical rain forest near Chiang Mai (Sieverding, unpublished). Namibia: reported by Uhlmann et al. (2004). Germany: in grasslands at St. Peter, Schwarzwald. Switzerland: in lowlands near Nenzlingen, mountainous grasslands near Sumvitg-Surrein, and subalpine grassland areas near Grindelwald and Realp (Oehl, unpublished).

SPECIMENS EXAMINED—COLOMBIA. Holotype specimen OSC #41,495 from a pot culture on *P. phaseoloides* at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia, inoculated with spores originally isolated from native grasses and tropical kudzu at Carimagua, Meta province, Colombia; spores from a pot experiment with cassava inoculated with pure holotype culture material, at CIAT, Cali, Colombia (Slides Nr. 3656-3658, Sieverding collection); spores from Carimagua, Meta, Colombia (Slides Nr. 1669 and 1670, Sieverding collection) and from Quilichao, Cauca, Colombia (slides Nr. 727-728, Sieverding collection); BOLIVIA. Spores from a pot culture at the Institute of Botany, University of Basel, Switzerland, inoculated with a natural forest soil derived from Estado Santa Cruz de la Sierra, Bolivia (slides Nr. 51-5101 and 51-5102, Oehl collection, deposited at Z+ZT). SWITZERLAND. Spores from high mountainous grasslands deriving from Sumvitg-Surrein, Kanton Graubünden (slides Nr. 51-5111 and 51-5112, Oehl-collection, deposited at Z+ZT).

Appendicispora gerdemannii (S.L. Rose, B.A. Daniels & Trappe) Spain, Oehl & Sieverd., **comb. nov.** FIGURES **7-9**

MB510321

Basionym: *Glomus gerdemannii* S.L. Rose, B.A. Daniels & Trappe, Mycotaxon 8, 297. January 13, 1979.

= *Archaeospora gerdemannii* (S.L. Rose, B.A. Daniels & Trappe) J.B. Morton & D. Redecker, Mycologia 93, 186-188. 2001.

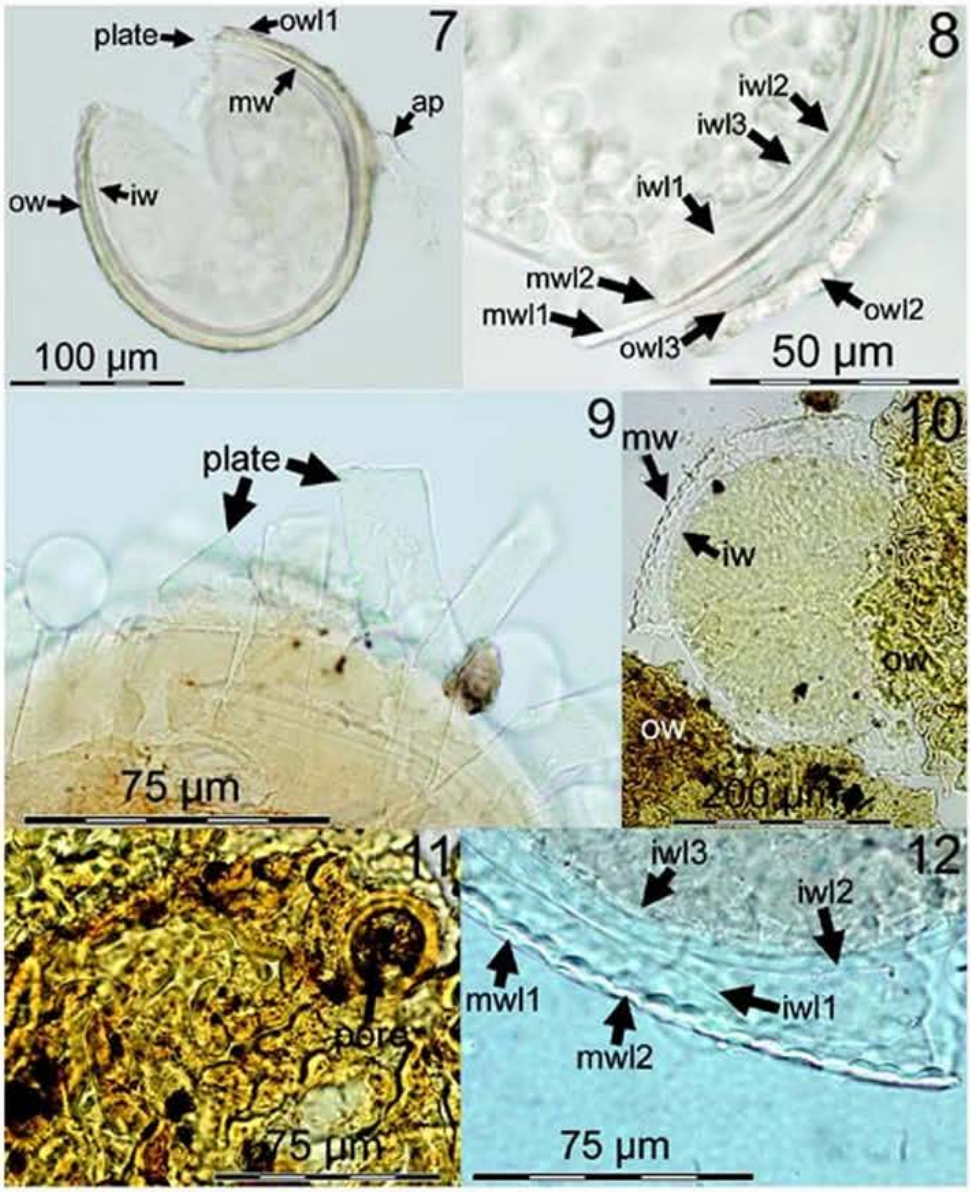
Spore formation—Sporocarps unknown. Acaulosporoid spores formed singly in the soil, glomoid spores formed singly or in loose clusters in the soil. Acaulosporoid spores arise from a a single short appendix which forms on the tapering hyphal neck in some distance from the sporiferous saccule; glomoid spores formed on hyphae in the root external mycelium.

Sporiferous saccule—Globose to subglobose to rarely ellipsoid, 160-310 µm diam, formed terminally on a hypha. The saccule wall is bi-layered, hyaline to subhyaline, in total 3.0-7.0 µm thick. Hyphal neck 25-60 µm wide at the base of the saccule.

Acaulosporoid spores—Formed singly on an appendix (Fig. 7) which emerges from the hyphal neck of a sporiferous saccule. The spores have three walls (Fig. 8): The outer spore wall with three wall layers (*ow-l* 1, *ow-l* 2, *ow-l* 3; called L1 in figures 15-18 of Morton & Redecker 2001) that may sometimes totally be lost. The middle wall is bi-layered (*mw-l* 1 and *mw-l* 2; called L2 and L3 according to the above authors), the inner wall three-layered (*iw-l* 1, *iw-l* 2, *iw-l* 3; called L4 in Fig. 18 of Morton & Redecker 2001).

The *ow-l* 1 is evanescent, only present on young spores; *ow-l* 2 is easily seen, often showing a crazed surface (Fig. 8); *ow-l* 3 is difficult to discern because it is very thin and tightly pressed to *ow-l* 2. In young spores, *ow* and *mw-l* 1 are continuous with the appendix wall; *mw-l* 1 can produce several septa in the appendix. In mature spores where the appendix is broken off, a septum formed by *mw-l* 1 and *mw-l* 2 closes the pore at the appendix base. The fracturing character ('plate-like splitting) of *mw-l* 1 and *mw-l* 2 (Fig. 9) is shown in the holotype material. In some spores isolated from the field and mounted in PVLG, the middle wall was observed to crack in an irregular pattern, not 'plate-like'. The inner wall (*iw*) has three layers. The *iw-l* 1 and *iw-l* 3 are difficult to detect. They are often strongly adherent to the finely laminated *iw-l* 2 (Fig. 8). Germination of acaulosporoid spores of *Ap. gerdemannii* has not yet been observed.

Glomoid spores—Hyaline to subhyaline, globose to subglobose, 40-130 µm diam, with one spore wall (*sw*), consisting of a mucilaginous outer layer *sw-l* 1, about 0.8-1.0 µm thick, frequently with adhering debris on the outer surface; inner wall layer (*sw-l* 2) 1.5-4.0 µm thick, laminated. Subtending hypha cylindric to slightly funnel shaped, 6-13 µm diam at the spore base. Bi-layered



Figs. 7-9: *Appendicispora gerdemannii*. **Fig. 7.** Broken acaulosporoid spore formed on an appendix (ap) with outer wall (owl1 is arrowed), a middle wall (mw) with some plate-like structures, and an inner wall (iw). **Fig. 8.** Crushed acaulosporoid spore showing layers of the outer wall (owl2, owl3), middle wall (mwl1, mwl2) and inner wall (iwl1, iwl2, iwl3). **Fig. 9.** Plate like structures of the middle wall in broken acaulosporoid spore (photo taken from holotype material).

Figs. 10-12: *Appendicispora jimgerdemannii* (photos from holotype material called Achouri slides). **Fig. 10.** Broken acaulosporoid spore with outer wall (ow), middle wall (mw) and inner wall (iw). **Fig. 11.** Cerebriform folds of the outer wall of an acaulosporoid spore; pore of detached appendix visible. **Fig. 12.** Broken acaulosporoid spore - outer layer detached – with two layered alveolated middle wall (mwl1, mwl2) and three-layered inner wall (iwl1, iwl2, iwl3).

wall of subtending hypha is in total 1.4-2.5 µm thick at the spore base. The pore usually is open, but a thin septum deriving from the inner hyphal wall layer is sometimes visible in a short distance from the spore base. Germination of glomoid spores not observed.

Mycorrhiza formation—Described as being very similar to *Ap. appendicula* by Morton & Redecker (2001).

Discussion—In their recent explanation of spore structure and ontogeny, Morton & Redecker (2001) described a second acaulosporoid morph. However, we observe that the outer spore wall of the acaulosporoid spores of *Ap. appendicula* can flake off in the wet sieving process, which leads us to conclude that the same may occasionally happen in *Ap. gerdemannii*. Acaulosporoid spores lacking an outer wall may be wrongly interpreted to be a second acaulosporoid morph. Such spores can have remnants of the appendix whose wall is partly continuous with the middle wall. Morton & Redecker (2001) described the glomoid spores of *Ap. gerdemannii* as somewhat smaller than those of *Ap. appendicula*.

Distribution—This species is known or has been reported from United States (type location), from cultivated acidic soils in Colombia (Sieverding, unpublished) and the Republic of Congo, South Kiwu region (Sieverding, unpublished), and from lowland grasslands in France and Germany (Oehl, unpublished). In Switzerland, most frequently found in the Swiss Alps at 1900-2600 m a.s.l. (Oehl, unpublished).

SPECIMENS EXAMINED— **UNITED STATES. Oregon.** Type specimen OSC #39,476 isolated from Deschutes County. **FRANCE. Alsace.** Spores propagated in a trap culture of AMF communities derived from a decarbonated grassland at Wintzenheim-La Forge (slide Nr. 52-5201, Oehl-collection; deposited at Z+ZT); **SWITZERLAND.** Specimens isolated from a calcareous lowland grassland at Wildenbuch (ZH) and from several mountainous, subalpine and alpine sites in the Swiss Alps (slides Nr. 52-5211; 52-5212; 52-5213, Oehl-collection, deposited at Z+ZT).

Appendicispora jimgerdemannii (N.C. Schenck & T.H. Nicolson) Spain, Oehl & Sieverd., **nom. nov.** FIGURES **10-12**

MB510322

Synonym: *Acaulospora gerdemannii* N.C. Schenck & T.H. Nicolson, Mycologia 71, 193. March 8, 1979.

Etymology: The new species name, *Appendicispora jimgerdemannii*, recognizes T.H. Nicolson's and N.C. Schenck's desire to honor the pioneer taxonomist of arbuscular mycorrhizal fungal species, Dr. Jim Gerdemann, who first described the ontogeny of sporiferous saccules and initial spore formation in the genus *Acaulospora*.

Spore formation—Sporocarps unknown. Acaulosporoid spores arise singly from a short appendix formed on the tapering hypha that terminates in a sporiferous saccule. Glomoid spores are as yet unknown.

Sporiferous saccule—Globose to ellipsoid, 290-365 µm diam, with a subhyaline to (light) brown wall that is 10-12 µm thick. The sporiferous saccule usually persists on young specimens, and it is described by Nicolson & Schenck (1979) as collapsing and detached from the spore after spore maturity.

Acaulosporoid spores—Globose to subglobose, 200-250 µm diam, brown at maturity. They arise singly from a thick-walled rigid appendix, 35-45 µm diam, which is formed on a tapering hypha that terminates in a sporiferous saccule. Acaulosporoid spores have three walls: an outer spore wall (*ow*), a middle wall (*mw*) and an inner wall (*iw*) (Fig. 10). The number of layers in the *ow* cannot readily be determined as all specimens investigated are observed in plan view. The main layer is brown in color, becoming brittle with age. It is approximately (8-)10-14 µm thick showing cerebriform folds (Fig. 11) over a laminated wall layer that is 1-1.5 µm thick. The cerebriform ridges are up to (6-)10-12 µm high and 4-6 µm broad and 1-3 µm apart from each other; the outer spore wall does not react with Melzer's reagent. The *ow* has an open pore, 15-25(-30) µm wide (Fig. 12). When the appendix is detached the pore is closed by the middle wall. The first author (JLS) interprets the middle wall as a single thin hyaline wall ornamented with an alveolate reticulum while the co-authors observed two layers in one spore of the type specimen (*mw-l* 1 and *mw-l* 2; Fig. 12). There, *mw-l* 2 is hyaline, finely laminated, 2-3.5 µm thick, tightly adherent to *mw-l* 1, thus showing the same alveolate structure as *mw-l* 1. The ornamentation is of concave hemispherical depressions, 7-10 µm wide on the outer *mw* surface, with convex protuberances of similar size on the inner *mw* surface (Fig. 12). The middle wall is yellow in Melzer's reagent. The *iw* is hyaline, smooth, 4-6 µm thick. The very thin outer layer (*iw-l* 1) and a very thin inner layer (*iw-l* 3) are difficult to discern (Fig. 12). Both layers are tightly adherent to the finely laminated middle layer (*iw-l* 2), hardly be observed in specimens mounted in PVLG. The *iw* does not stain in Melzer's reagent.

Glomoid spores—So far not yet found or attributed to *Ap. jimgerdemannii*.

Mycorrhiza formation—Forming vesicular-arbuscular mycorrhiza with "unlobed vesicles" (after Nicolson & Schenck, 1979).

Discussion—The notes on the morphology of the acaulosporoid spores of *Ap. jimgerdemannii* are based on the description of *Ac. gerdemannii* by Nicolson & Schenck (1979) and on our own observations of the type material. We also considered the observations of a specimen we isolated from the type location. In this study more acaulosporid spore walls and layers were identified than described by Nicolson & Schenck (1979). They described only those walls of the acaulosporoid spore which we call outer wall and middle wall. We admit that the morphological characterization of the species remains incomplete because of the lack of known living pot cultures.

Distribution—*Ap. jimgerdemannii* is known from USA and Switzerland (see specimens observed), and from Venezuela (Sieverding, unpublished).

SPECIMENS EXAMINED— **UNITED STATES. Florida.** Type specimen OSC #37,417 isolated from *Paspalum notatum* Flügge, at Ona, Florida, October 1977; isotype specimen isolated from the type location in June 2002; **SWITZERLAND. Valais. Grisons.** Specimen isolated from a field sample from Alp Nadels (1930 m a.s.l.), Kanton Graubünden, Switzerland, and from Le Cartogne (2580 m a.s.l.), Canton Valais, Switzerland (slides Nr. 53-5301 and 53-5311, Oehl-collection, deposited at Z+ZT).

Species excluded from the new genus

Archaeospora trappei (R.N. Ames & Linderman) J.B. Morton & D. Redecker, Mycologia 93, 183-184. 2001.

Basionym: *Ac. trappei* R.N. Ames & Linderman. Mycotaxon 3, 566. 1976.
Glomus leptoticha N.C. Schenck & G.S. Sm. Mycologia 74, 82-83. 1982.
≡ *Archaeospora leptoticha* (N.C. Schenck & G.S. Sm.) J.B. Morton & D. Redecker, Mycologia 93, 184-186. 2001.
Glomus fecundisporum N.C. Schenck & G.S. Sm. Mycologia 74, 81-82. 1982.

Discussion

Arbuscular mycorrhizal fungal species of the new genus *Appendicispora* can be distinguished morphologically from all other genera in the Glomeromycetes. At least two species of the new genus, *Ap. appendicula* and *Ap. gerdemannii*, are dimorphic. Mycorrhizal associations can produce both acaulosporoid and glomoid spores. We do not know whether *Ap. jimgerdemannii* is also dimorphic. Even if glomoid spores are not found or observed in samples, *Appendicispora* can easily be identified on the basis of various morphological characteristics of the acaulosporoid morph, as explained below. The formation of spores laterally on the neck of a sporiferous saccule hypha is known only for *Acaulospora* (Gerdemann & Trappe 1974) and for the acaulosporoid spores of *Archaeospora trappei* (Morton & Redecker 2001, Hafeel 2004). The glomoid morph forms terminally on a hypha as in the genera *Glomus* (Gerdemann & Trappe 1974), *Paraglomus* (Morton & Redecker 2001), *Pacispora* (Oehl & Sieverding 2004) and similar to the glomoid morph of *Ar. trappei*. *Appendicispora* spp. share this spore dimorphy only with the single member remaining in the genus *Archaeospora*: *Ar. trappei* which however rarely develops glomoid spores (Spain 2003).

Acaulosporoid spores in *Appendicispora* develop on an appendix that forms laterally on the neck of the sporiferous saccule (Fig. 1). In at least two species of the *Appendicispora*, *Ap. appendicula* and *Ap. gerdemannii*, the appendix wall is continuous not only with the outer spore wall, but also with the prominent outer layer of the middle wall of the spore, a feature unique in the attachments

between acaulosporoid spores and hypha of the Glomeromycetes. In contrast to this, only the outermost layer of the acaulosporoid spore of *Ar. trappei* is continuous with the connected spore bearing hypha (see Fig. 6 in Hafeel 2004). Although the outer spore wall and a layer of the middle wall may arise from the same hyphal and appendix wall, we consider them separate walls. These two walls (*ow* and *mw*) strongly differentiate during spore formation and the outer spore wall and the middle wall easily separate from each other in broken spores.

Germination of the acaulosporoid morph, so far known only from *Ap. appendicula* in the *Appendicispora*, is also unique in the Glomeromycetes. The germ tube emerges through the appendix. It is not known if all germination is from a germination structure formed between the middle and inner walls as was observed in a spore mounted in water (Fig. 5). Observations of spores mounted in PVLG have not elucidated such a germination structure but it is well known that PVLG and other mountants can alter such structures (germination orbs) of *Acaulospora* spp. enough to make them appear ephemeral (Spain 1992, Morton & Benny 1990). The novel germination structure found in *Ap. appendicula* is distinct from that of *Ar. trappei* and from the germination orbs of the *Acaulosporaceae* described by Spain (2003, 1992).

Appendicispora spp. form vesicular-arbuscular mycorrhiza (arbuscules, vesicles, and intra- and extraradical hyphae) that stain light or pale blue with standard methods using trypan blue as a dye (Fig. 6). Interestingly, the pale staining feature is not shared with any of the other genera forming vesicular-arbuscular mycorrhiza. Species of *Glomeraceae*, *Acaulosporaceae*, *Pacisporaceae* and *Entrophosporaceae*, so far as it is known for each species of these families, form mycorrhizal structures in roots that stain deep blue with trypan blue (Morton & Benny 1990, Oehl & Sieverding 2004; Sieverding & Oehl 2006). Mycorrhizal structures of the genera *Scutellospora* (Walker & Sanders 1986) and *Gigaspora* (Gerdemann & Trappe 1974) also stain dark blue but these two genera do not form intraradical vesicles (Morton & Benny 1990). In contrast, mycorrhizal structures of Paraglomus, Archaeospora and Intraspora spp. do not stain or stain only very faintly using trypan blue-based staining protocols, and species of these three genera are believed to not form or only rarely form intraradical vesicles (Morton & Redecker 2001, Sieverding & Oehl 2006).

The three species of the new genus can be easily distinguished from each other by the presence or absence of ornamentation on their spore walls. *Appendicispora jimgerdemannii* has two ornamented walls: a cerebriform outer wall and an alveolate middle wall. *Appendicispora appendicula* has a crazed outer wall and an alveolate middle wall. *Appendicispora gerdemannii* has three non-alveolated walls.

The new genus *Appendicispora* remains currently in the family of the *Archaeosporaceae* based on molecular data presented by Redecker et al. (2000). Further analyses of the genome on additional loci will be necessary to define whether the genus *Appendicispora* belongs to a new family.

Appendicispora spp. have frequently been reported from Mediterranean, subtropical and tropical climates (type locations; Weber & Deoliveira 1994, Johnson & Wedin 1997, Carrenho et al. 1998, 2002, Uhlmann et al. 2004, Wubet et al. 2004). This is in contrast to *Ar. trappei* reported from many different climates and ecosystems all over the world. Our recent studies, especially in the higher elevations of the Alps, reveal that *Appendicispora* spp. can be a common part of arbuscular mycorrhizal fungi communities in cold climates. We found all three species at high mountainous, subalpine and alpine elevations in Switzerland. There they were significantly more frequent and abundant, in spore and species numbers, than in the adjacent temperate Central European lowlands where they were rarely observed (Oehl et al. 2003; Wubet et al. 2003).

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Myxomycetes of Belgrad Forest (Istanbul)

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Abstract—Myxomycetes were collected in the Belgrad Forest, which is located near Istanbul in the Thrace region of Turkey, between February 2002 and January 2003. Sixty-two species of myxomycetes belonging to 21 genera were recorded from field and moist chamber culture collections. A map of the study area, material & method and the checklist are available at the website http://biyoloji.uludag.edu.tr/ergul/Checklist_003.pdf.

Key words— Balkan Peninsula, Myxobiota, systematics, slime moulds

Introduction

The Belgrad Forest covers an area of ca. 5300 hectares in the northern part of the Istanbul Peninsula in the European region of Marmara in the Bahçeköy District (28°54'–29°00'E, 41°09'–41°12'N) of Turkey. The area has a humid Mediterranean climate (Akman & Ketenoğlu 1986). Relatively high annual precipitation around Bahçeköy allows for the development of the deciduous forest that is typical of the vegetation found in oceanic regions in Turkey (Kutluk & Aytuğ 2000). The Belgrad Forest is one of the most important forest areas in Istanbul and is included among the nine Turkish hot spots by the World Wildlife Fund (WWF1 & WWF2 2006). The flora of the Belgrad Forest is essentially Central European; 415 taxa have been recorded from the forest (Yaltırık 1966). The dominant tree genera are *Quercus*, *Castanea*, and *Carpinus*, with a lesser amount of *Fagus*. It is the only old-growth oak-beech natural forest near Istanbul. The forest includes many small streams and seven large aqueducts. The dense plant cover, high canopy, rich detrital material and high relative humidity found in the Belgrad Forest favor the development of myxomycetes. Comprehensive studies on myxomycetes of Anatolian Turkey have been carried out (Ergül et. al. 2005 a,b, Ocak & Hasenekoğlu 2005). In previous studies,

Arcyria cinerea and *Echinostelium minutum* (Härkönen 1987), *Amaurochaete atra* (Sümer 1982) and *Lycogala epidendrum* (Lohwag 1964) were recorded for the first time from the Belgrad Forest and the Bahçeköy District. Oran & Ergül (2004) added 23 species, all new records for Turkey, to the forest's myxobiota. Ergül & Oran (2005) found *Physarum pulcherrimum* in the Belgrad Forest, also a new record for Turkey. In the current study, 62 myxomycete species have been identified for the Belgrad Forest myxobiota.

Results

As a result of the collecting reported here, 62 myxomycete taxa are now known from the Belgrad Forest.

The order *Trichiales* is the best-represented group with 19 species, followed by the *Stemonitales* (16 species), *Liceales* (12 species), *Physarales* (11 species), *Echinosteliales* (3 species), and *Ceratiomyxales* (1 species). The most abundant genera are *Licea* (8 species), *Arcyria* (7 species), *Trichia* (6 species), *Physarum, Stemonitis* (each with 5 species), *Badhamia, Cribraria, Comatricha,* (each with 4 species), *Paradiacheopsis, Perichaena* (each with 3 species), and *Clastoderma* and *Stemonitopsis* (represented by two species each). Only a single species each was found for *Calomyxa, Ceratiomyxa, Diachea, Echinostelium, Enerthenema, Fuligo, Hemitrichia, Macbrideola,* and *Metatrichia.*

The moist chamber technique recovered 251 identifiable myxomycetes. In contrast, only 71 specimens were found sporulating in the field. The most commonly recovered species from Petri dish incubation were *Arcyria cinerea* (75 samples), *Perichaena corticalis* (27 samples), *Enerthenema papillatum* (26 samples), *Macbrideola cornea* (20 samples), and *Echinostelium minutum* (18 samples).

Genera represented by species found sporulating in the forest were *Arcyria* (21 samples), *Comatricha* (15 samples), *Cribraria* (10 samples), *Trichia* (7 samples), *Physarum* (3 samples), *Ceratiomyxa, Metatrichia, Stemonitis* (each with 3 samples), *Fuligo* (2 samples), *Badhamia, Diachea, Hemitrichia,* and *Stemonitopsis* (each with 1 sample). Only five samples of *A. cinerea* were found sporulating in nature whereas seventy-five specimens were recovered from moist chambers.

The myxomycetes most commonly found in the field included *A. cinerea* (5 collections), *A. ferruginea* (5), *A. incarnata, A obvellata* (each 3), *A. denudata, A. minuta* (each 2), *A. versicolor* (1); *Comatricha laxa, C. nigra* (each 6), *C. ellae* (2), *C. tenerrima* (1); *Cribraria aurantiaca* (7), *C. cancellata* (2), *C. microcarpa* (1); *Trichia botrytis* (4), *T. contorta, T. decipiens, T. varia* (each 1), *Physarum album* (2) and *P. flavicomum* and *P. viride* (each 1). Additional species included: *Ceratiomyxa fruticulosa, Metatrichia vesparium* (each 3), *Stemonitis axifera, S. fusca* and *S. smithii* (each 1), *Fuligo septica* (2) and one each of *Badhamia*

versicolor, Diachea leucopodia, Hemitrichia calyculata and *Stemonitopsis typhina.*

Discussion

The high recovery of the corticolous species *Arcyria cinerea* demonstrates high germination potential of its spores, effective dissemination, and its likely adaptation to the dark and moist conditions of the Belgrad Forest. Seasonal occurrence of myxomycete fructifications is moisture dependent (Mitchell et al. 1980). According to Schnittler (2006) myxomycetes are well adapted to fluctuating moisture in the environment. Moist conditions favor development of the amoebal and plasmodial stages, and dry conditions facilitate spore dispersal. This, along with the formation of durable dormant stages, enables myxomycetes to respond rapidly to temporally and spatially changing microhabitats. The high, closed forest canopy contributes to retention of free and atmospheric water in the forest. The substratum, light intensity, temperature, soil characteristics and moisture are factors that influence the occurrance and abundance of myxomycetes (Ing 1994, Schnittler & Novozhilov 1996).

Twenty-nine species of myxomycetes were recovered from bark of *Quercus* incubated in moist chambers, making it the most productive source on myxomycetes of the Belgrad Forest. A much lower number of species were recovered from other angiospermous bark, including *Alnus glutinosa* (5 species), *Acacia* sp. (4), *Carpinus betulus, Castanea sativa, Pinus* spp., *Tilia* sp. (3 species each), *Aesculus hippocastanum, Cupressus* sp., *Cedrus* sp., *Platanus orientalis* (2 species each). No myxomycetes were recovered from incubated bark of species of *Acer* or *Pyrus*. The lower numbers of recovered myxomycete species from bark of genera other than *Quercus* could be due to the fact that for members of each genus the bark is smooth and free of epiphytic bryophytes and lichens. The relative abundance of epiphytes can vary greatly among different types of trees, this factor would seem to have considerable potential for affecting the distribution patterns of corticolous myxomycetes (Stephenson & Stempen 1994). Harkönen et al. (2004) concluded that smooth, basic bark has a low water holding capacity and supported low diversity of myxomycetes, bryophytes and lichens. High water holding capacities may be directly beneficial for corticolous myxomycetes as their active plasmodia are highly dependent on the availability of liquid water. Moreover, Harkönen et al. (2004) concluded that high epiphyte cover did not act to increase diversity of corticolous myxomycetes. Stephenson (1989) concluded that considerable variation exists for the bark microhabitats potentially available for corticolous myxomycetes.

Different tree species exhibit a wide range of variation in the surface physical characteristics of bark (usually referred to as bark texture), with some trees exhibiting relatively smooth bark and others having furrowed and rather rough

bark. McHugh (1998) noted that individual *Quercus* species and *Quercus* forests are the most productive sources for myxomycetes. Spores of some myxomycetes require an exogenous source of carbon or nitrogen for their production of sporocarps (Moore-Landecker 1996). Distribution patterns of myxomycetes can be explained by a combination of both microhabitat and macroclimate requirements (Schnittler 2006).

The closed canopy of the Belgrad Forest limits incident sunlight on the forest floor and retains moisture as free water and high humidity. These physical factors, along with high plant diversity, which is especially rich in *Quercus cerris* and *Q. frainetto*, contribute to an abundant myxomycete biota for the Belgrad Forest.

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The anamorph of *Erysiphe platani* on *Platanus ×hispanica* in Slovakia

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Abstract—A species of powdery mildew new for the Slovak mycoflora, *Erysiphe platani*, which parasitizes on plane trees, is reported. Disease symptoms and morphological characteristics of the anamorph are described. No teleomorph was observed.

Key words—introduced powdery mildew disease, plane trees, hyperparasite

Introduction

Erysiphe platani (syn. *Microsphaera platani*) is a common North American powdery mildew species, widespread on *Platanus occidentalis* L., *P. orientalis* L., *P. ×hispanica* Münchh. (syn. *P. acerifolia* (Ait.) Willd., *P. hybrida* Brot.), *P. racemosa* Nutt. and *P. wrightii* S. Wats. (Hirata 1966, Gorter & Eicker 1985, Braun 1995). This fungus causes deformation and growth reduction of young leaves and shoots of *Platanus* spp. E.C. Howe observed the teleomorph of this fungus for the first time on *Platanus* in the United States in the autumn of 1874. A description of the anamorph was published later by Sumstine (1941). *Erysiphe platani* attacks *Platanus* species in North America (Howe 1874, Sumstine 1941, Hirata 1966, Glawe 2003) and has been introduced in South America, South Africa, Europe, Asia, Australia and New Zealand. Ciferri & Camera (1962) and Gullino & Rapetti (1978) published first records of this fungus from Europe (Italy) on *P. occidentalis* and *P. hybrida*, respectively. The epidemic spread of this North American pathogen has already been reported from Portugal (Sequeira 1981), Romania (Eliade 1985), Montenegro (Mijušković 1993, Ranković 2003), Bulgaria (Fakirova 1985), France (Gullino & Rapetti 1978, Viennot-Bourgin 1982), Spain (Tello et al. 2000), Russia (Golovin 1956), Israel (Halperin 1989), Argentina (Klingner 1982, Braun et al. 2000), Chile (Luisi & San Martin 1987),

Australia (Cunnington 2003) and New Zealand (Boesewinkel 1986). *Erysiphe platani* also was reported (Gorter & Eicker 1985) infecting the leaves of *P. wrightii* in South Africa. Its occurrence was noticed on *P. orientalis* and *P. orientalis* var. *cretica* Dode in several areas in Greece by Pantidou (1973) and Vakalounakis & Klironomou (1995). Anselmi et al. (1994) mapped the incidence of *Erysiphe platani* in European and Mediterranean countries. They (Anselmi et al. 1994) observed differences in susceptibility of *Platanus* species to this pathogen in Europe. Ialongo (1981) suggested that there is a clonal specialization of this fungal species based on the results of its artificial inoculation.

A powdery mildew was collected from London plane tree (*P. ×hispanica*) in Nitra, Slovakia. We determined the causal agent to be the anamorphic state of *Erysiphe platani*. The teleomorph was absent but the anamorph morphology was identical with that described for *Erysiphe platani*. The teleomorph previously was recorded and described by Golovin (1956), Braun (1995), Ranković (2003) and Glawe (2003). This report documents the occurrence of *Erysiphe platani* on *P. ×hispanica* in Slovakia for the first time, and presents information on the taxonomy and identification of this fungus.

Materials and methods

Leaf samples from *P. ×hispanica* with symptoms of a powdery mildew disease were collected in November 2004. The morphological characteristics of *Erysiphe platani* were examined from fresh material. Observation and measuring were made using a standard light microscope (JENAMED2, Carl Zeiss Jena). Measurements of microscopic features were made from slide preparations stained in lactophenol cotton blue. Our measurements correspond to previously published descriptions (Table 1). The fungus was photographically documented using a digital camera Olympus CAMEDIA model C-4000 ZOOM. Representative material was deposited in the mycological herbarium of the Institute of Forest Ecology SAS in Nitra, Slovakia.

Taxonomic description

Erysiphe platani (Howe) U. Braun & S. Takam., Schlechtendalia 4: 12, 2000

Basionym: *Microsphaera platani* Howe, Bull. Torrey Bot. Club 5: 4, 1874

Synonym: *Microsphaera alni* auct. p.p., *Microsphaera penicillata* auct. p.p.

Material examined – Slovakia. Nitra, city district Chrenova, tree-lined avenue, lat: 48°18'15" N, lon: 18°05'58" E, on living leaves of *Platanus ×hispanica*, 3 Nov. 2004, leg. K. Pastirčáková (anamorph, parasited by *Ampelomyces quisqualis*).

Symptoms – Mycelium superficial on both sides of young and older leaves, forming white to gray patches, also on petioles and inflorescences. Affected leaves often distorted, but not showing defoliation.

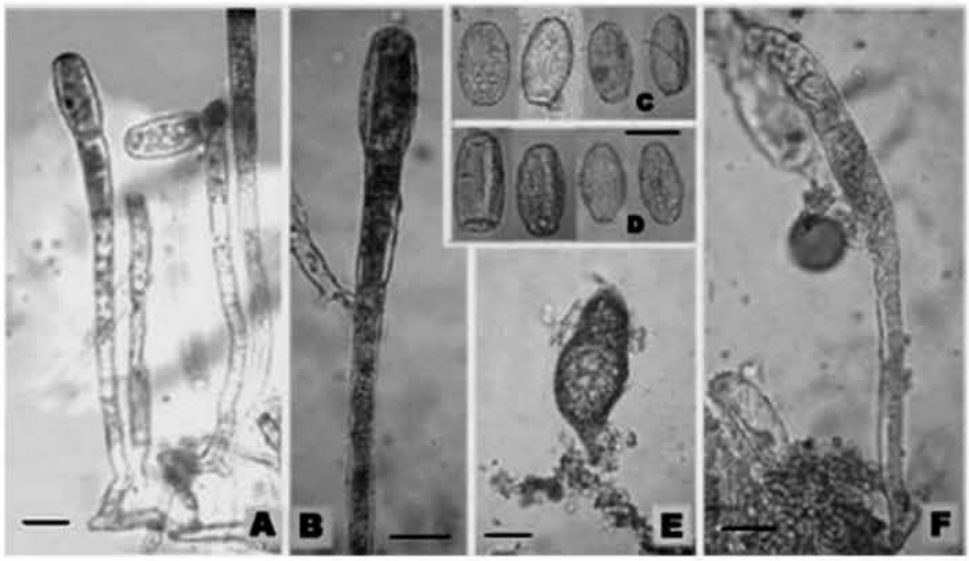

Figure 1. Anamorph of *Erysiphe platani*. (A, B) Conidiophores, (C) Primary conidia, (D) Secondary conidia, (E) Pycnidium of *Ampelomyces quisqualis*, (F) An intracellular hypha of *Ampelomyces quisqualis* growing out from the powdery mildew mycelium. Scale bars = 20 µm.

Microscopic features – Anamorph of *Oidium* (*Pseudoidium*) type. Mycelium amphigenous, dense, white, branched, interwoven; hyphae hyaline, smooth, 5-8 µm wide, penetrating through stomata. Appressoria abundant, lobed. Conidiophores erect, 1-3-septate, hyaline, 90-220 × 7-10 µm, foot-cells straight to flexuous or curved, followed by 1-3 mostly shorter cells. Primary conidia with rounded apex and subtruncate base, 28.5-43 × 14-20 µm. Secondary conidia formed singly, sporadically adhering in chains of 2 to 3, hyaline, ellipsoid to doliiform, with slightly convex symmetric ends, measuring 30-48 × 15.5-22 µm. Boesewinkel (1986) observed extremely long conidiophores, occasionally branched, producing huge conidia. Unusual conidial germination, where the germ tube resembled cleistothecial appendages, was noticed.

On the basis of our measurements of the anamorph and the literature data (Table 1) we identified the fungus as *Erysiphe platani*. This is the first record of this powdery mildew species in Slovakia. Anselmi et al. (1994) stated that the teleomorph had not detected in Europe, but Golovin (1956) and Ranković (2003) recorded mature ascomata (chasmothecia) in Russia and Montenegro, respectively.

We also recorded the hyperparasitic fungus *Ampelomyces quisqualis* Ces. ex Schltdl. (syn. *Cicinobolus cesatii* de Bary) on *Erysiphe platani*. *Ampelomyces quisqualis* was abundant on mycelium and conidiophores of our material. *Ampelomyces quisqualis* may have prevented the formation of ascomata. Himelick & Neely (1959), Scarito Bongarrà (1981) and Eliade (1985) also

Table 1. Biometric characteristics of *Erysiphe platani* (*M. platani* and its other synonyms) on *Platanus* sp. reported by other authors and of the Slovak material examined (µm).

	Conidia	Conidiophores	Ascomata	Asci	Ascospores
Burrill & Earle (1887)	not stated	not stated	80-130	*	20 µm long
Sumstine (1941)	30-50 × 15-20	*	*	*	*
Golovin (1956)	not stated	not stated	75-96	51-63 × 33-48	21-33 × 12-18
Gullino & Rapetti (1978)	36.8-37.9 × 18.1-19.7	*	absent	absent	absent
Ialongo (1981)	28-51 × 16-25	*	absent	absent	absent
Lorenzini & Triolo (1981)	31-49 × 15-25	140 × 7.5	absent	absent	absent
Scarito Bongarrà (1981)	31.7-46.8 × 15.1-22.6	105.7-181.2 × 6.04-9.06	absent	absent	absent
Sequeira (1981)	30-40 × 15-17	170	absent	absent	absent
Klingner (1982)	35-51 × 18-22	131 –286 × 7-10	absent	absent	absent
Eliade (1985)	32-34 × 12-16	*	absent	absent	absent
Fakirova (1985)	23-48 × 12-20	*	absent	absent	absent
Gorter & Eicker (1985)	30-45 × 15-22.5	70-180 × 6.1-11.2	absent	absent	absent
Boesewinkel (1986)	35-45 × 15-22	62-205 (250-500) × 6.5-9	absent	absent	absent
Marziano et al. (1986)	34-46 × 15-21	70-250	absent	absent	absent
Luisi & San Martin (1987)	31.4-39.6 × 15.0-22.4	109.2 × 10.4	absent	absent	absent
Mijušković (1993)	28.1-39.6 × 13.2-19.8	110-175	absent	absent	absent
Braun (1995)	25-50 × 14-22.5	*	80-115	40-60 ×30-50	18-25 × 12-16
Vakalounakis & Klironomou (1995)	30.3-50.8 × 15.7-20.6	*	absent	absent	absent
Sammarco & Torta (1997)	22.5-47 × 15-30	*	absent	absent	absent
Glawe (2003)	19-35 × 10-21	*	54-118	35-53 × 31-42	14-23.5 × 12-21
Ranković (2003)	28-48 × 14-24	*	80-110	43-62 × 33-50	18-24 × 12-16
Slovak material	**30-48 × 15.5-22**	**90-220 × 7-10**	**absent**	**absent**	**absent**

* microstructures were observed without recording their size

noticed the occurrence of this hyperparasite on *Erysiphe platani*. It infects and forms pycnidia within *Erysiphe platani* hyphae and conidiophores. This parasite reduces growth and may eventually kill the powdery mildew colony. The parasitic activity of every single fungal species on host plants is presented as total weakening of its vitality, decreasing of resistance to harmful agents, reduction of growing period of affected organs (leaves). *Ampelomyces quisqualis* has been the subject of numerous investigations on biological control of powdery mildews for over 50 years.

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Evaluation of characters available from herbarium vouchers for the phylogeny of the downy mildew genera (Chromista, *Peronosporales*), with focus on scanning electron microscopy

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Abstract—During the past five years numerous molecular phylogenies of the downy mildews have been computed. However, basic relationships of the *Peronosporaceae* are largely unknown because molecular phylogenies are partly contradicting or do not exhibit sufficient resolution. In this study, all genera of the downy mildews with lasting sporangiophores, which have been classified as belonging to the *Peronosporaceae*, have been investigated. Ultrastructural synapomorphies for the genera and groups of genera are presented. Especially the fine structure of the ultimate branchlets and haustorium morphology proved to be a suitable tool to differentiate between groups of genera, whereas the commonly used criteria of branching complexity or sporangial germination did not.

Key words—DMPH, ultrastructure, taxonomy, evolution

Introduction

The downy mildews (*Peronosporaceae*) are obligate biotrophic parasites of Angiospermae. Due to their osmotrophic way of nutrition and their hyphal growth, they were classified as belonging to the Mycota until the seventies of the past century, when several discrepancies of this classification were discovered (Manton 1965, Dick 1969; for review, see Dick 1997). In recent classifications, the downy mildews have been placed within the order *Peronosporales* of the Peronosporomycetes (Dick 2001a). The Peronosporomycetes (oomycetes) belong to the kingdom Chromista (Cavalier-Smith 1986), which should be given preference over the later-described, smaller kingdom, Straminipila (Dick 2001a), especially because recent investigations (Yoon et al. 2002, Andersson & Roger 2002, Bhattacharya et al. 2003, Harper & Keeling 2003, Keeling 2004) have provided evidence that the oomycetes stem from a photosynthetic ancestor.

The first downy mildew genus, *Peronospora* Corda was described in 1837 (Corda 1837) and was later classified in *Peronosporaceae* (de Bary 1863). During the following 40 years, two more genera (*Bremia* Regel (1843) and *Basidiophora* Roze & Cornu (1869)) were described, mainly on grounds of differences in conidiophore morphology. In 1879, the genus *Sclerospora* J. Schröt. (1879) was described, which was placed within the *Sclerosporaceae* by Dick et al. (1984) because of peculiarities in oospore formation (Dick 1995, Dick et al. 1999, Dick 2001b) and the fact that sporangiophores, as in the related genera *Peronosclerospora* (S. Ito) Hara (Shirai & Hara 1927) and *Sclerophthora* (Sacc.) Thirum. et al. (Thirumalachar et al. 1953), are evanescent (Schröter 1879, Kenneth 1981, Spencer & Dick 2002). Although *Sclerospora* has unequivocally been placed within *Peronosporaceae* in the molecular trees of Riethmüller et al. (2002), Göker et al. (2003), Voglmayr et al. (2004) and Thines et al. (2006), the genera previously assigned to *Sclerosporaceae* have been excluded from this study, also because their sporangiophores are often not preserved on herbarium vouchers.

Before molecular phylogenetic tools were used to study downy mildew phylogeny, eight additional genera of the *Peronosporaceae* were described: *Plasmopara* J. Schröt. (1886), *Pseudoperonospora* Rostovzev (1903), *Rhysotheca* G.W. Wilson (Wilson 1907), *Bremiella* G.W. Wilson (Wilson 1914), *Pseudoplasmopara* Sawada (Sawada 1922), *Paraperonospora* Constant. (Constantinescu 1989) and *Benua* Constant. (Constantinescu 1998). However, *Pseudoplasmopara* and *Rhysotheca* never gained broad acceptance. From the description of *Plasmopara* onwards, the distinguishing features of the newly described genera became more and more subtle and were subject to debate (Skalický 1966). This is reflected by confusing shifts of several taxa to different genera, which still last on into recent years (for reference see Constantinescu (1989) and Yu (1998))

Since the first molecular phylogenetic investigations in the *Peronosporaceae* (Cooke et al. 2000, 2002; Riethmüller et al. 2002; Constantinescu & Fatehi 2002), it became apparent that multiple taxa in the *Peronosporaceae* were in fact polyphyletic or paraphyletic, which was confirmed by subsequent studies (Choi et al. 2003, 2005; Göker et al. 2003, 2004; Voglmayr et al. 2004; Constantinescu et al. 2005; Thines et al. 2006). As a result, six new genera were described in the *Peronosporaceae* (*Graminivora* Thines & Göker, *Hyaloperonospora* Constant., *Perofascia* Constant., *Plasmoverna* Constant. et al., *Protobremia* Voglmayr et al. and *Viennotia* Göker et al.) and the genera *Rhysotheca* and *Bremiella* were relegated to synonymy with *Plasmopara*. In all cases, molecular phylogenetic investigations helped to confirm synapomorphies or morphological characters for differentiation of the newly described genera.

However, above the generic level, such synapomorphies have only seldom been sought after (Voglmayr et al. 2004). Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) have proven to show interesting characteristics of the downy mildews and related organisms (Baretto & Dick 1991, Beakes et al. 1995, Bouterige et al. 2003, Constantinescu 2000, Falloon & Sutherland 1996, Lange et al. 1989, Michelmore et al. 1982, Mims 1991, Royle & Thomas 1971, Sargent 1981, Virányi & Henstra 1976). However, although Hall (1996) pointed to the possible usefulness of ultrastructural characters for classification and taxonomy, no efforts have so far been taken to evaluate the use of TEM or SEM for systematic studies on a broad array of taxa. The use of SEM for this purpose is evaluated here, because SEM investigations can be conducted easily on herbarised material and have already proven to reveal unknown characters in previous studies (Spring & Thines 2004, Thines & Spring 2005, Constantinescu et al. 2005). It is the aim of this study to reveal synapomorphies for the downy mildew genera by evaluating known and new characters of the downy mildews in the light of recent molecular phylogenies.

Materials and Methods

Sample preparation, scanning electron microscopy (SEM) and data analysis

For SEM, approximately 0.1 cm^2 of leave tissue covered with sporangiophores was taken from herbarium vouchers and was mounted on aluminium object holders. After desiccation in a desiccator for two days, samples were sputtered and examined as described previously (Constantinescu et al. 2005).

For Neighbor-joining (Saitou & Nei 1987) analysis, the Mega2 program (Kumar et al. 2002) was used. Distance matrices were calculated using the formula of Jaccard (1908).

Specimens examined

Of 175 specimens examined (*Bremia* 15, *Graminivora* 5, *Hyaloperonospora* 11, *Paraperonospora* 6, *Perofascia* 2, *Peronospora* 40, *Plasmopara* 58, *Plasmoverna* 24, *Protobremia* 3, *Pseudoperonospora* 10, *Viennotia* 1) only those depicted in this study are listed in Table 1 on page 198.

Results

General description of morphological and ultrastructural features observed in the downy mildews

Several features become visible in SEM, such as the presence (Fig. 1M) or absence (Figs. 1J-L) of an annulus at the apical end of the ultimate branchlets, or the area of aggregated structures around the pedicels, which is especially prominent in species of *Bremia* (Fig. 1S) and other Downy Mildews with

Table 1. Peronosporomycete material depicted.

Species	Host	Origin; Collector; Year	Herbarium	Fig.#*
Basidiophora entospora Roze & Cornu	*Conyza canadensis* (L.) Cronquist.	Germany, Bayrischer Wald, Helmberg; leg. Poelt; 1965	GZU 43-82	1
Benua kellermanii (Swingle ex Sacc.) Constant.	*Cyclachaena xanthiifolia* (Nutt.) Fresen.	Moldavia, Lăpuşna; leg. Negrean, 1993	BUCM 127.045	2
Bremia lactucae Regel	*Lactuca serriola* L.	Germany, Ostfildern-Scharnhausen; leg. Thines; 2002	HUH 497	3
Graminivora graminicola (Naumov) Thines & Göker	*Arthraxon hispidus* (Thunb.) Makino	China; leg. anonymous; 1979	YAU	4
Hyaloperonospora parasitica (Pers.) Constant.	*Capsella bursa-pastoris* (L.) Medik.	Germany, Stuttgart-Asemwald; leg. Thines; 2002	HUH 503	5
Hyaloperonospora thlaspeos-arvensis (Gäum.) Göker et al.	*Thlaspi arvense* L.	Germany, Stuttgart-Hohenheim; leg. Thines; 2002	HUH 506	6
Paraperonospora leptosperma (de Bary) Constant.	*Tripleurospermum inodorum* (L.) Sch.-Bip.	Germany, Filderstadt-Bernhausen; leg. Thines; 2002	HUH 512	7
Paraperonospora tanaceti (Gäum.) Constant.	*Tanacetum vulgare* L.	Fennia, Revonlahti; leg. Laila & Roivainen; 1961	BR Myc 080875,74	8
Perofascia lepidii (McAlpine) Constant.	*Lepidium ruderale* L.	Germany, Wendelsheim, near Nebra; leg. Richter & Jage; 2001	TUB 012413	9
Peronospora conglomerata Fuckel	*Erodium cicutarium* (L.) L'Hér.	Austria, Schandau; leg. Krieger; 1907	GZU	10
Peronospora destructor (Berk.) Fr.	*Allium cepa* L.	Austria, Raasdorf; leg. anonymous; 1999	HUH 767	11
Peronospora farinosa (Fr.) Fr.	*Chenopodium album* L.	Germany, Filderstadt-Bernhausen; leg. Spring; 2002	HUH 518	12
Peronospora rumicis Corda	*Rumex acetosa* L.	Germany, Sonnenbühl; leg. Thines; 2005	HUH 806	13
Peronospora tabacina D.B. Adam	*Nicotiana tabacum* L.	Germany, Neuried-Altenheim, Fels; leg. Schwär; 2002	HUH 483	14
Plasmopara epilobii (G.H. Otth) J. Schröt.	*Epilobium parviflorum* Schreb.	Germany, Dahmsdorf; leg. H. Sydow; 1938	BR Myc 082206,47	15
Plasmopara halstedii (Farl.) Berl. & De Toni s.l.	*Helianthus annuus* L.	Laboratory strain; leg. Zipper; 2003	HUH 114	16
Plasmopara nivea (Unger) J. Schröt.	*Aegopodium podagraria* L.	Germany, Tübingen, Steinenberg; leg. Spring; 2002	HUH 452	17
Plasmopara nivea (Unger) J. Schröt.	*Aegopodium podagraria* L.	Belgium, Brabant, Boitsfort; leg. Beeli; 1916	BR Myc 082210,51	18
Plasmopara pusilla (de Bary) J. Schröt.	*Geranium pratense* L.	Germany, Esslingen-Kappishäusern; leg. Spring; 2002	HUH 477	20

Table 1, concluded

Species	Host	Origin; Collector; Year	Herbarium	Fig.#*
Plasmopara ribicola J. Schröt.	*Ribes rubrum* L.	Germany, München-Sendling; leg. Schnabl; 1892	GZU 253	21
Plasmoverna isopyrithalictroides (Săvul. & Rayss) Constant. et al.	*Isopyrum thalictroides* L.	Austria, Lower Austria, Mannersdorf; leg. Voglmayr; 2000	WU	22
Plasmoverna pygmaea (Unger) Constant. et al.	*Anemone nemorosa* L.	Belgium, Namur, Rhisnes; leg. Bommer & Rousseau; 1901	BR Myc 082338,82	23
Plasmoverna pygmaea (Unger) Constant. et al.	*Anemone sulphurea* L.	Austria, Graubünden; leg. Müller; 1970	GZU 281-81	24
Protobremia sphaerosperma (Săvul.) Voglmayr et al.	*Tragopogon pratensis* L.	Germany, Sonnenbühl-Undingen; leg. Thines; 2005	HUH 720	25
Pseudoperonospora cubensis (Berk. & M.A. Curtis) Rostovzev	*Cucumis sativus* L.	Germany, Niederstotzingen; leg. Spring; 2002	HUH 493	26

* Fig. # refers to the numbers in the figure captions.

Pyriform Haustoria (DMPH). In search for characters useful for classification and systematics of the downy mildews, the following structures were evaluated: morphology of the two last ramifications (Figs. 1A, B), mode of ramification for the ultimate branchlets (Figs. 1C-E), morphology of the ultimate branchlets (Figs. 1F-M), anatomy of the site where the ultimate branchlets were attached to the sporangia (Figs. 1N-P), ornamentation of the sporangia at this zone (Figs. 1Q-S) and formation of a wall at the apical end of the sporangia, which is structurally different, compared to the rest of the sporangium wall (Figs. 1T (present) and 1U (absent)). The morphology of the branches at the two last ramifications can either show a distinct broadening towards the point of ramification (Fig. 1A) or not (Fig. 1B). In *Paraperonospora*, the broadening is clearly visible (Constantinescu 1989), whereas in others it is less evident, for example in *Bremia*, *Protobremia* and *Basidiophora*.

A feature also easily accessible in LM is the mode of ramification of the ultimate branchlets. They can be dichotomously branched (Fig. 1C), pseudotrichotomous or trichotomous (Fig. 1D), be irregularly aggregated, as shown in Fig. 1E or regularly aggregated, as shown in Fig. 1I).

The ultimate branchlets can be variously shaped: straight (Fig. 1F), curved (Fig. 1G) and spiral (Fig. 1H). In *Bremia*, no distinct ultimate branchlets are formed (Fig. 1I). The apical end of the ultimate branchlets can either be conical and acute (Fig. 1J), conical and truncate (Fig. 1K), tubular and truncate (Fig. 1L) or tubular and truncate with a distinct annulus (or distal broadening) and the covering wall caving in (Fig. 1M).

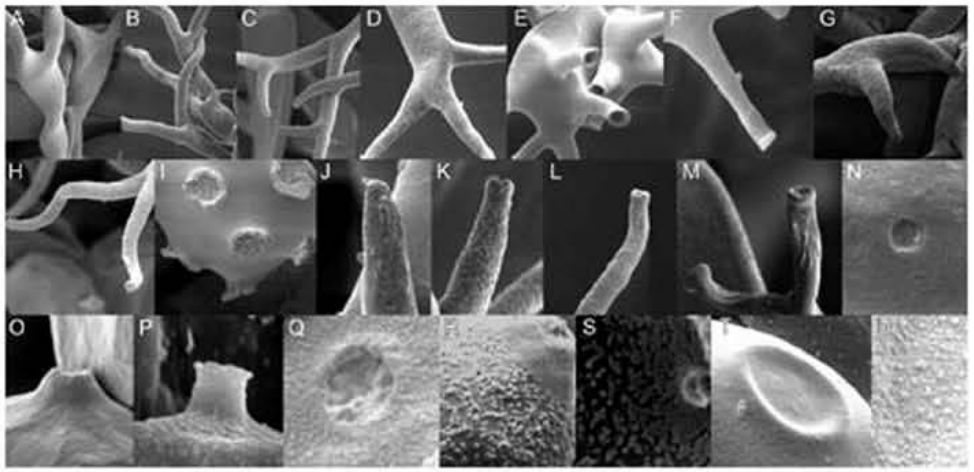

Figure 1. Ultrastructural characters in SEM. A, broadening of the sporangiophores towards the ramifications, as seen in *Paraperonospora tanaceti* (8); B, sporangiophores which do not exhibit a broadening of the sporangiophores towards the ramifications in *Hyaloperonospora parasitica* (6); C, dichotomous branching in *Peronospora destructor* (11); D, pseudotrichotomous branching in *Plasmopara nivea* (17); E, irregular aggregation of ultimate branchlets in *Plasmoverna pygmaea* (24); F, straight ultimate branchlets in *Pl. epilobii* (15); G, curved ultimate branchlets in *Pe. conglomerata* (10); H, spiral ultimate branchlets in *H. parasitica* (5); I, reduced ultimate branchlets in *Benua kellermanii* (2); J, acute, conical ultimate branchlet in *Pe. farinosa* (12), K, truncate, conical ultimate branchlet in *Pe. tabacina* (14); L, truncate, tubular ultimate branchlet without annulus in *H. thlaspeos-arvensis* (6); M, truncate, tubular ultimate branchlet with distinct annulus and caving in wall in *Pl. halstedii* (16); N, flat "pedicel" in *Pe. conglomerata* (10); O, conical pedicel in *Pl. ribicola* (21); P, tubular pedicel in *Pl. nivea* (18); Q, ornamentation pattern without area of aggregated protuberances around the pedicel in *Pv. isopyri-thalictroides* (22); R, area of aggregated protuberances around the pedicel less elevated than remaining protuberances in *Pseudoperonospora cubensis* (23); S, area of aggregated protuberances around the pedicel in *Pl. pusilla* (20); T, papilla clearly visible in *Pl. halstedii* (16); U, no papilla visible in SEM in *Bremia lactucae* (3). Numbers in brackets refer to Fig. # in Table 1 (collection details).

The pedicels of the sporangia are another feature which might be considered for systematic studies of the *Peronosporaceae*. It can be absent (Fig. 1N) or even be replaced by a bowl-like structure (Fig. 1Q), be conical (Fig. 1O) or regular to irregular tubular (Fig. 1P). The surface ornamentation around the pedicel can also be characteristic and either be similar to the rest of the sporangium (Fig. 1Q), form a contiguous plate, which is less elevated than the protuberances of the sporangial surface elsewhere (Fig. 1R) or show an aggregation of protuberances, often leading to a contiguous plate which protrudes from the sporangial surface at the same height as the protuberances (Fig. 1S). The protuberances can be variously shaped, from rounded warts (Fig. 1R) to flattened irregular structures as in Fig. 1S.

The presence (Fig. 1T) or absence (Fig. 1U) of a wall thinning at the apical end—through which, after lysis, zoospores are released or a germ tube emerges—can be observed, because this structure caves in more readily than the

surrounding wall when sporangia dehydrate. If this structure, which is usually termed "papilla", becomes similar in thickness in comparison to the rest of the sporangial wall, it does not cave in so readily as in Fig. 1T, but only forms a portion of the sporangial wall, which is usually more flattened than the rest of it.

Ultrastructural characteristics of the downy mildew genera

In the following, the characters easily accessible in SEM are given for each of the genera of the *Peronosporaceae*, except for *Viennotia*, which was only studied in LM, because only microscopic slides were available. For each of the genera, the characteristics of the type species are given as a representative for the whole genus. Where the characteristics within the genus are highly variable, additional information is given for several species.

In *Basidiophora entospora* Roze & Cornu (Roze & Cornu 1869), the sporangiophores are mostly unbranched. If the sporangiophores show ramification, the sporangiophore trunk is broadened towards it. The ultimate branchlets are regularly aggregated (cephaloid), straight, tubular and with a distinct annulus at their distal ends and a covering wall caving in (Fig. 2A). The pedicels are mostly tubular (Fig. 2B). A 3-6 µm in diameter area of aggregated protuberances is present around the pedicel. Protuberances are less than 0.5 µm in diameter and irregularly shaped. A papilla is visible at the distal end of the sporangia.

In *Benua kellermanii* (Swingle ex Sacc.) Constant. (Constantinescu 1998), sporangiophores are unbranched. The ultimate branchlets are regularly aggregated (cephaloid) and reduced (Fig. 2C). The structures remaining on the sporangiophores appear tubular, an annulus is not present and no covering wall can be observed. The pedicels are usually conical (Fig. 2D). A 4-5 µm diameter area of aggregated protuberances is present around the pedicel. Protuberances are large, with up to 1 µm in diameter and irregularly shaped. A papilla is present at the distal end of the sporangia, but hardly visible in SEM.

In *Bremia lactucae* Regel (Regel 1843), sporangiophores are usually branched dichotomously, especially towards the ultimate branchlets, but irregular branching may also occur. A slight broadening towards the ramification can be observed. The ultimate branchlets are mostly regularly aggregated, although irregular aggregation is not uncommon, in groups of (3)-4-5-(6-7). In other species of *Bremia*, the ultimate branchlets may be aggregated in groups of (4)-5-6-(7). The ultimate branchlets are straight, tubular, covered with a caving in wall and mostly with a distinct annulus at their distal end (Fig. 2E). The pedicels are mostly tubular (Fig. 2F). An area of aggregated protuberances is present around the pedicel, with 2-5 µm in diameter. Protuberances are usually

smaller than 0.5 µm and irregularly shaped. A papilla is not visible in SEM in the vast majority of sporangia.

Sporangiophores in *Graminivora graminicola* (Naumov) Thines & Göker (Thines et al. 2006) are branched dichotomously and do not exhibit a broadening towards the ramification. The ultimate branchlets are agglomerated in groups of (2-3)-4-(5-6). The ultimate branchlets are straight, tubular and do not exhibit an annulus at their apex (Fig. 2G). The pedicels are variously shaped, ranging from flat to tubular pedicels. No area of aggregated protuberances around the pedicel is commonly present. Nevertheless, if present, it is usually about 1.5-2 µm. Protuberances are irregularly shaped and usually smaller than 0.5 µm. A papilla is clearly visible in SEM.

Hyaloperonospora parasitica (Pers.) Constant. (Constantinescu & Fatehi 2002) does not exhibit a broadening of the sporangiophores towards the ramifications (Fig. 2I). Branching of the sporangiophores is usually dichotomous, especially towards the ultimate branchlets, but irregular branching may also occur. The ultimate branchlets are spirally coiled in all species of *Hyaloperonospora* examined, but may vary widely in length. They are usually tubular or longish conical and truncate at the apical end; a distinct annulus is not present, although a slight broadening can be observed in some ultimate branchlets. The pedicels are variously shaped, mostly flat or flat conical (Fig. 2J), but irregular tubular pedicels can also be observed. The area of aggregated protuberances around the pedicel is 2-4 µm in diameter. Protuberances consist of rounded, flattened warts, which are mostly fused into irregular structures of about 0.5 µm. A papilla is not present.

In *Paraperonospora leptosperma* (de Bary) Constant. (Constantinescu 1989), sporangiophores are broadening widely towards the ramification, branching is dichotomous to pseudotrichotomous. Ultimate branchlets are straight, longish conical to tubular, with a distinct annulus at the apex (Fig. 2K). Pedicels are conical, with a caving in wall at the proximal end. An area of aggregated protuberances around the pedicel is usually hardly present and less than 3 µm in diameter. Protuberances are mostly very small and less in 0.2 µm in diameter. A papilla is not visible in SEM.

In *Perofascia lepidii* (McAlpine) Constant. (Constantinescu & Fatehi 2002), a broadening of the sporangiophores towards the ramifications can not be observed. Sporangiophores are usually dichotomously branched in the apical region, but pseudotrichotomous branching also occurs. Ultimate branchlets are curved to spirally coiled (Fig. 2M), longish conical, truncate and do not exhibit a distinct annulus at the apex. Pedicels are flat to conical (Fig. 2N). An area of aggregated protuberances around the pedicel is missing or small, with usually less than 2 µm in diameter. Protuberances are mostly smaller than 0.2 µm. A papilla is not present at the apical end of the sporangia.

Peronospora rumicis Corda (Corda 1837) is the type species of the largest genus of the *Peronosporaceae* (de Bary 1863, Constantinescu 1991). In many respects it can stand exemplary for the genus, although some ultrastructural features, especially regarding ornamentation and ultimate branchlets morphology show a high degree of dissimilarity in some species groups compared to each other (data not shown). In *Peronospora rumicis*, sporangiophores do not broaden towards the ramification. Branching is usually dichotomous, but irregular branching may also occur, especially in the first ramifications. Ultimate branchlets are often straight in *Peronospora rumicis*, although curved ultimate branchlets may also occur. For the bulk of *Peronospora* species, curved ultimate branchlets are characteristic (Fig. 1G). In *Peronospora rumicis*, ultimate branchlets are truncate, conical and do not exhibit a distinct annulus. In the majority of *Peronospora* species examined ultimate branchlets exhibited more or less acute tips. Ultimate branchlets shape varies from short conical to conical-tubular. Pedicels are mostly not present in *Peronospora rumicis*. In other species of the genus, conical pedicels can be observed. The area of aggregated protuberances around the pedicel is usually diffuse and large, up to 6 µm in diameter, but might also be hardly visible. Protuberances are variously shaped, often rounded and sometimes with a slight depression in the middle in *Peronospora rumicis*. Protuberances are often small, with less than 0.5 µm in diameter. In other species of *Peronospora*, other modes of ornamentation may occur, ranging from rounded warts in *Peronospora sparsa* Berk. and *Peronospora destructor* (Berk.) Fr. to very small irregular shaped protuberances in *Peronospora farinosa* (Fr.) Fr. (data not shown). A papilla is not present at the apical end of the sporangia.

In *Plasmopara nivea* (Unger) J. Schröt. (Schröter 1886), sporangiophores do not broaden towards the ramifications; branching is usually pseudotrichotomous to trichotomous, especially towards the ultimate branchlets (Fig. 2Q). Ultimate branchlets are mostly straight, truncate with a caving in covering wall at the apex, longish conical to tubular in *Plasmopara nivea* and mostly tubular in many other species, including *Plasmopara pusilla* (de Bary) J. Schröt. and *Plasmopara viticola* (Berk. & M.A. Curtis) Berl. & De Toni (data not shown). Ultimate branchlets exhibit a distinct annulus in the type species and the vast majority of other *Plasmopara* species examined. Pedicels are conical to tubular in *Plasmopara nivea* (Fig. 2R) and in most other species of the genus. An area of aggregated protuberances around the pedicel is present in all species of the genus examined. In *Plasmopara nivea* it ranges from 3-5 µm in diameter. Protuberances are variously shaped, usually very irregular and about 0.5 µm or less in diameter. A papilla is visible in SEM at the apical end of the sporangia in most species of the genus.

In *Plasmoverna pygmaea* (J. Schröt.) Constant. et al. (Constantinescu et al. 2005), sporangiophores are often slightly broadening towards the ramifications, branching is irregular to trichotomous for the first ramification and irregular for the ultimate branchlets, which are often aggregated in variable number. Ultimate branchlets are broad tubular, often without covering wall at the apex or with a wall deeply caving in, and mostly exhibiting a distinct annulus (Fig. 2S). In some hosts other than *Anemone nemorosa* L., ultimate branchlets may be tubular with a bowl-shaped covering wall (data not shown). Pedicels are flat or even cave in (Fig. 2T). An area of aggregated protuberances around the pedicel is present in few, but missing in the vast majority of sporangia, in contrast to *Plasmopara* species. Protuberances are variously shaped and usually very small, with less than 0.2 µm. A papilla is clearly visible in SEM.

Sporangiophores of *Protobremia sphaerosperma* (Săvul.) Voglmayr et al. (Voglmayr et al. 2004) exhibit a slight broadening of the sporangiophore trunk towards the ramifications. Ramification is pseudotrichotomous to irregular, the ultimate branchlets often becoming aggregated in variable number. Ultimate branchlets are longish conical to straight, truncate at the apex and exhibiting a distinct annulus and a caving in covering wall (Fig. 2U). Pedicels are conical to tubular. An area of aggregated protuberances around the pedicel is clearly visible and mostly 3-5 µm in diameter. Protuberances are variously shaped and often very small, with less than 0.2 µm in diameter. A papilla is hardly visible in SEM at the apical end of a minority of the sporangia.

Pseudoperonospora cubensis (Berk. & Curtis) Rostovzev (Rostovzev 1903) does not exhibit a broadening of the sporangiophores towards the ramifications. Branching is mostly dichotomous (Fig. 2W), but also pseudotrichotomous branching may occur in some samples of this variable species. Ultimate branchlets are usually conical to conical tubular and truncate at the apical end, not exhibiting a distinct annulus. However, in some samples, an annulus might be present. Pedicels are variously shaped, ranging from flat to tubular. An area of aggregated protuberances around the pedicel is present in most sporangia, which is usually less elevated over the mean sporangial surface than the protuberances and varies in diameter, mostly ranging from 2-4 µm. Protuberances are mostly rounded warts (Fig. 2X) with less than 0.5 µm in diameter. A papilla is mostly visible in SEM.

Figure 2 (facing page). Main Ultrastructural characteristics of the genera of the *Peronosporaceae*. First and third column, ultimate branchlets; second and forth column, proximal end of the sporangia. A and B, *Basidiophora entospora* (1); C and D, *Benua kellermanii* (2); E and F, *Bremia lactucae* (3), G and H, *Graminivora graminicola* (4); I and J, *Hyaloperonospora parasitica* (5); K and L, *Paraperonospora leptosperma* (7); M and N, *Perofascia lepidii* (9); O and P, *Peronospora rumicis* (13); Q and R, *Plasmopara nivea* (17); S and T, *Plasmoverna pygmaea* (23); U and V, *Protobremia sphaerosperma* (25); W and X, *Pseudoperonospora cubensis* (26).

Bar = 5µm in all pictures. Numbers in brackets refer to Fig. # in Table 1 (collection details).

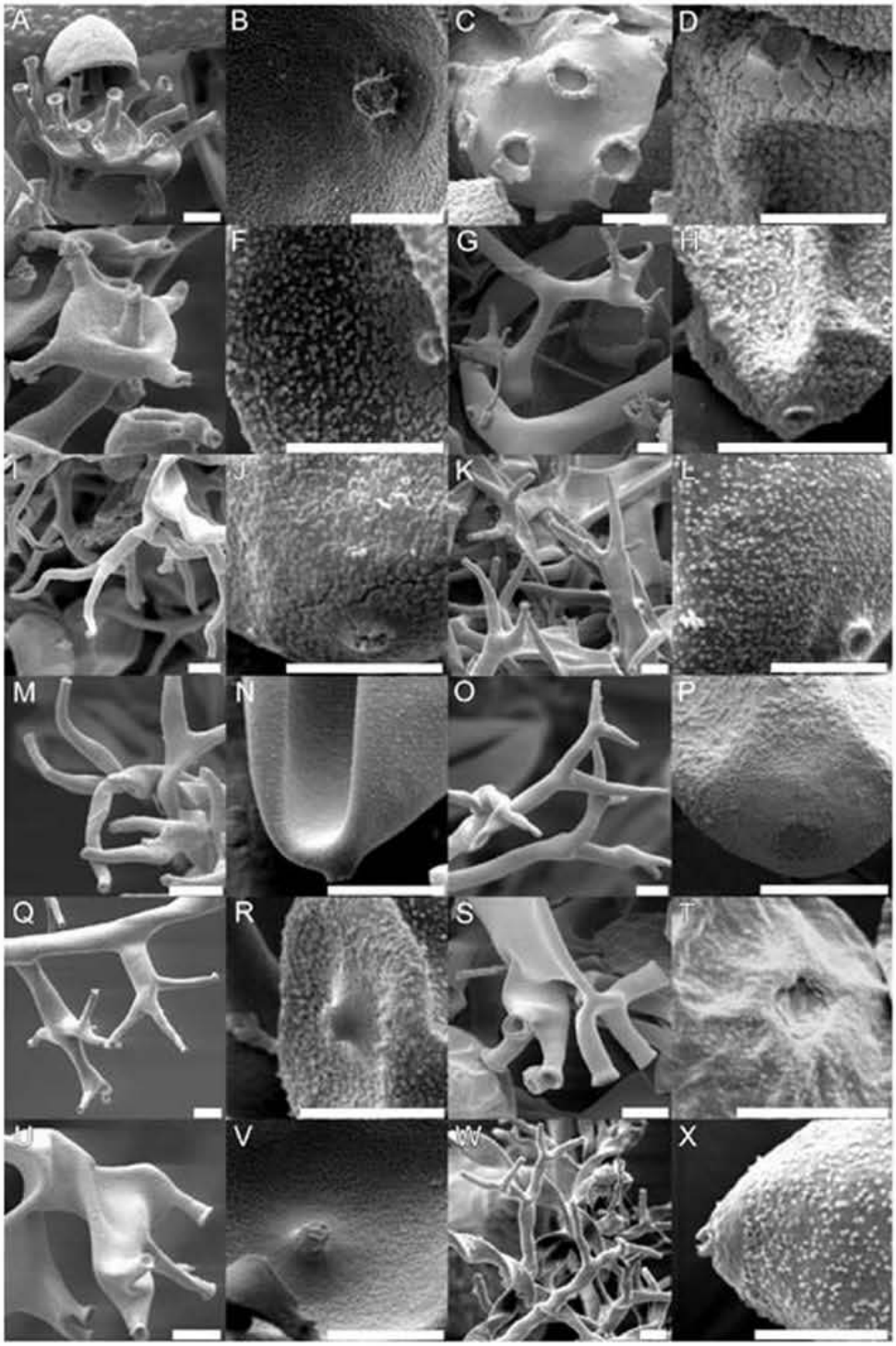
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Table 2. Morphological and ultrastructural characteristics of the downy mildews.

Characteristics		Bas	Ben	Bre	Gra	Hya	Par	Pfa	Per	Pla	Plv	Pro	Psp	Vie	var.
sporangio-phores	distal broadening	+	-	+	-	-	+	-	-	-	+	+	-	-	lm
	no distal broadening	-	-	-	+	+	-	+	+	+	-	-	+	+	lm
ultimate branchlets	no annulus	-	-	-	+	+	-	+	+	-	-	-	+	n	lm
	with annulus	+	+	+	-	-	+	-	-	+	+	+	-	n	lm
	conical	-	-	-	-	-	-	-	+	-	-	-	+	-	lm
	tubular	+	+	+	+	+	+	+	-	+	+	+	-	+	lm
	acute	-	-	-	-	-	-	-	+	-	-	-	-	-	lm
	truncate	+	+	+	+	+	+	+	-	+	+	+	+	+	lm
	flat covering wall	-	-	-	+	+	-	+	+	-	-	-	+	n	lm
	Missing or caving in covering wall	+	+	+	-	-	+	-	-	+	+	+	-	n	lm
	mostly dichotomous	-	-	-	-	+	-	+	+	-	-	-	+	+	lm
	pseudo-trichotom	-	-	-	-	-	+	-	-	+	-	-	-	-	lm
	irregular / aggregated	-	-	+	+	-	-	-	-	-	+	+	-	-	lm
	cephaloid	+	+	-	-	-	-	-	-	-	-	-	-	-	l
	spiral	-	-	-	-	+	-	+	-	-	-	-	-	-	m
	straight	+	+	+	+	-	+	-	-	+	+	+	+	+	m
	curved	-	-	-	-	+	-	+	+	-	-	-	-	-	m
sporangia	coloured	-	-	-	-	-	-	-	+	-	-	-	+	-	lm
	white	+	+	+	+	+	+	+	-	+	+	+	-	+	lm
	with papilla	+	+	-	+	-	-	-	-	+	+	-	+	+	l
	no papilla	-	-	+	-	+	+	+	+	-	-	+	-	-	l
haustoria	branched	-	-	-	-	-	-	-	+	-	-	-	+	-	lm
	unbranched	+	+	+	+	+	+	+	-	+	+	+	-	+	lm
	hyphal	-	-	-	+	-	-	+	+	-	-	-	-	+	lm
	lobate	-	-	-	-	+	-	-	-	-	-	-	-	-	lm
	vesicular	+	+	+	-	-	+	-	-	+	+	+	+	-	lm
pedicels	flat	-	-	-	+	-	-	-	+	-	+	-	-	n	h
	conical	-	+	-	-	+	+	+	-	+	-	-	+	n	mh
	tubular	+	-	+	-	-	-	-	-	-	-	+	-	n	h
area of aggr. prot.	distinct	+	+	+	-	+	+	+	+	+	-	+	+	n	m
	indistict	-	-	-	+	-	-	-	-	-	+	-	-	n	m

Table 2, concluded

Characteristics		Bas	Ben	Bre	Gra	Hya	Par	Pfa	Per	Pla	Plv	Pro	Psp	Vie	var.
ornamentation	rounded	-	-	-	-	+	+	-	+	-	-	-	+	n	m
	irregular	+	+	+	+	-	-	+	-	+	+	+	-	n	m
	fine	+	-	-	-	-	+	+	-	-	-	+	-	n	h
	rough	-	+	+	+	+	-	-	+	+	+	-	+	n	h

Abbreviations in Table 2: area of agg. prot. = area of aggregated protuberances around the pedicel. *Bas* = *Basidiophora*, *Ben* = *Benua*, *Bre* = *Bremia*, *Gra* = *Graminivora*, *Hya* = *Hyaloperonospora*, *Par* = *Paraperonospora*, *Pfa* = *Perofascia*, *Per* = *Peronospora*, *Pla* = *Plasmopara*, *Plv* = *Plasmoverna*, *Pro* = *Protobremia*, *Psp* = *Pseudoperonospora*, *Vie* = *Viennotia*. + = mostly present, - = mostly absent, n = data not available.

Last column indicates the variability (var.) of the characters. h = high variability, about 40% of the samples show variable characteristics; m = medium variability, less then 20% exhibit diverging characteristics; l = low variability, less than 10% variation. Intermediate values are given by combining the letters.

Overview of ultrastructural and morphological characters of the downy mildews

The morphological and ultrastructural characteristics of the downy mildew genera are summarised in Table 2. For the diverse and species-rich genera *Hyaloperonospora*, *Peronospora* and *Plasmopara*, modal values are given which do not necessarily represent all of the species currently classified in the corresponding genus.

A phylogenetic tree computed from a distance matrix based on Table 2 is given in Figure 3. Notably, the genera parasitic to *Poaceae* as well as the genera parasitic to *Brassicaceae* are grouped together, respectively. Also the morphologically very different genera *Basidiophora*, *Benua*, *Bremia*, *Paraperonospora*, *Plasmopara*, *Plasmoverna* and *Protobremia* are grouped together due to similarities in haustorial morphology and ultrastructural characteristics. Furthermore, the downy mildews with coloured sporangia are grouped together. Interestingly, the five genera exclusively parasitic to *Asteraceae* (*Basidiophora*, *Benua*, *Bremia*, *Paraperonospora*, *Protobremia*) form a single group together with *Plasmoverna* (parasitic to *Ranunculaceae*).

Discussion

Until first molecular phylogenetic reconstructions of the downy mildews became available (Riethmüller et al. 2002, Constantinescu & Fatehi 2002), the main reasons for separating the *Peronosporaceae* into several genera where morphological peculiarities in sporangiophore anatomy and biological

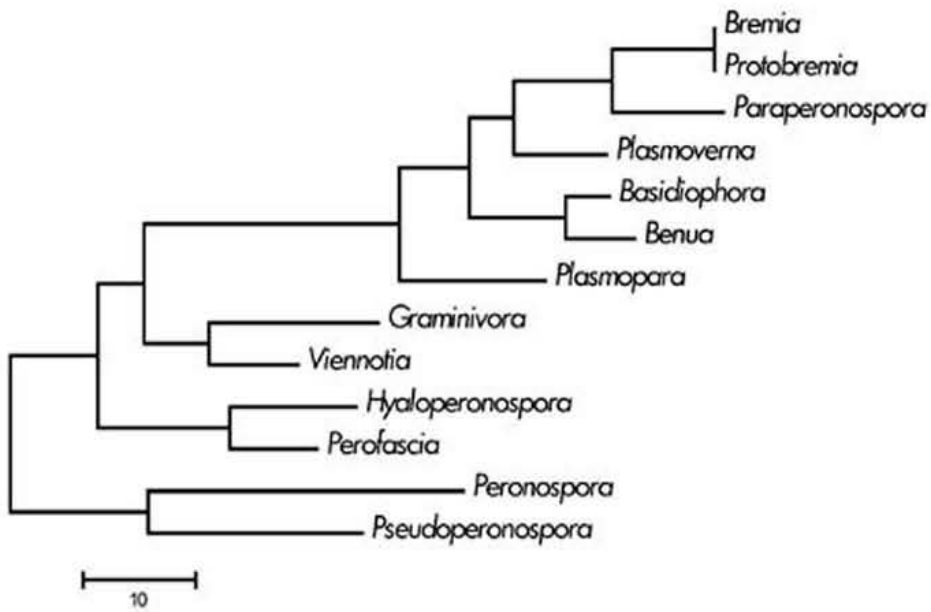


Figure 3. Phylogenetic tree computed from a reduced Matrix of Table 2, covering only characteristics of which variation is usually low. Neighbor-joining analysis (Saitou & Nei 1987) was performed on a distance matrix calculated with the formula of Jaccard (1908). Bar = 10% divergence.

differences, e.g. germination of the mitotically formed sporangia. However, the delimitation of genera by means of these features has often proven to result in polyphyletic assemblages, as revealed in molecular phylogenies for *Plasmopara* (Riethmüller et al. 2002, Göker et al. 2003, Voglmayr et al. 2004, Constantinescu et al. 2005) and *Bremia* (Thines et al. 2006). Also the monophyly of *Peronospora*, with respect to *Pseudoperonospora* has been asserted (Riethmüller et al. 2002, Voglmayr 2003, Thines et al. 2006).

Haustoria

Haustorial shape has been systematically investigated in the *Peronosporaceae* by Fraymouth (1956) and her findings have been confirmed by the recent investigations of Göker et al. (2003) and Voglmayr et al. (2004). Voglmayr et al. (2004) point out that haustorial shape is well in line with molecular phylogenetic reconstructions. In Göker et al. (2003) and Voglmayr et al. (2004) it has been shown that the group of downy mildews with pyriform haustoria (DMPH) form a monophyletic clade. This view is also confirmed by the presence of large, 180 bp repetitions found in the ITS2 in these species, which were first reported for *Plasmopara halstedii* (Farl.) Berl. & De Toni by Thines et al. (2005) and later found to be present in all DMPH (Thines, unpublished results). Likewise, the species with lobate haustoria all belong to the genus *Hyaloperonospora*. The

species with hyphal haustoria do not form a monophyletic group in molecular phylogenetic reconstructions, suggesting the ancestral state for the character "haustoria" is hyphal.

Sporangiophores

The molecular phylogenies of Riethmüller et al. (2002), Göker et al. (2003) and Voglmayr et al. (2004) revealed that the branching type of the sporangiophores is not a character useful for forming taxonomic groups, and let to confusing classifications, especially of the species now placed in *Paraperonospora*. For example, sympodial-looking branching is found in several unrelated genera, such as *Bremia*, *Hyaloperonospora* and *Peronospora*. Furthermore, irregular monopodial branching resulting in sporangiophores with sympodial appearance can also be found in these genera. Also the mode of branching of the ultimate branchlets is not unequivocally useful for phylogenetic considerations, as is revealed by Voglmayr et al. (2004) and Thines et al. (2006). The morphology of the internodial parts of the sporangiophores, however, might be useful for systematic studies. The broadening of the sporangiophores towards the ramifications, which is one of the characteristics of *Paraperonospora* in comparison with *Peronospora* (Constantinescu 1989) can also be found in *Protobremia* and *Bremia*, as well as in the rarely branching genera *Plasmoverna* and *Basidiophora*. In recent molecular phylogenies, these genera form a monophyletic clade (Göker et al. 2003, Voglmayr et al. 2004, Thines et al. 2006).

Ultimate branchlets

The ultimate branchlets in the *Peronosporaceae* show several characteristics which might be used for systematic studies, especially in SEM. The shape of the ultimate branchlets varies from conical to tubular. However, it is sometimes difficult to draw clear lines between these two states, especially if the ultimate branchlets are by the factor of ten or more longer than wide. In these cases, ultimate branchlets have been regarded as tubular, if they are slightly or not tapering to the apical end. Similarly, the shape of the tip of the ultimate branchlets can be used as a differentiating character. However, also in this case it is often not easy to draw the line in between acute and truncate ultimate branchlets. Also in *Peronospora*, where most species have acute ultimate branchlets, some species (including the type species, *Peronospora rumicis*) show truncate ultimate branchlets. Therefore it is uncertain, whether this character is valuable for systematic classification. In the DMPH the wall covering the truncate ultimate branchlets often bulges in (e.g. in *Plasmopara* and *Bremia*) or is even deeply retreated or sometimes missing (Constantinescu et al. 2005), as in *Plasmoverna*. In *Benua* it is not present and the sporangiophores are sealed by a wall below the reduced ultimate branchlets.

A character easily accessible in SEM is the presence or absence of an annulus or a broadening of the ultimate branchlets towards their distal end. This annulus is present in all genera with pyriform haustoria and clearly visible in the genera *Bremia*, *Protobremia*, *Paraperonospora*, *Basidiophora* and *Plasmoverna*. In *Plasmopara* species it is also present, but in some species (e.g. *Plasmopara pusilla*) not as clearly visible as in the other genera. Because of the high degree of reduction of the ultimate branchlets in *Benua*, this character can not be unequivocally accessed there, but the broadening of the remains of the ultimate branchlets towards their distal ends may be seen as a homology to the annulus in the other DMPH. In the other genera of the *Peronosporaceae*, a distinct annulus is not present. Only in *Pseudoperonospora*, and sometimes in *Hyaloperonospora*, ultimate branchlets may show an indistinct annulus in some cases. In the genera *Hyaloperonospora*, *Perofascia*, and *Graminivora*, the ultimate branchlets are truncate and conical-tubular to tubular and im most cases do not exhibit an annulus. Because of the presence of an often indistinct annulus in *Pseudoperonospora* and in some samples of *Hyaloperonospora*, it could be concluded, that the character "annulus" is a plesiomorphy retained in the DMPH.

Pedicels

The use of pedicels at the proximal end of the sporangia for the characterisation of downy mildew genera or even species is not possible. Especially in the genera *Plasmopara* and *Hyaloperonospora*, this character may differ widely, even within one collection. Even more as in case of the sporangial shape, it is hardly possible to draw a clear line between conical and tubular pedicels. However, as in case of *Plasmoverna* in comparison with *Plasmopara*, pedicels may provide some information useful for classification, if combined with other characteristics.

Sporangial germination / dehiscence apparatus and papilla

Germination of the sporangia or the presence or absence of a dehiscence apparatus has often been used as an argument to integrate new taxa into existing genera (e.g. *Plasmopara oplismeni* Vienn.-Bourg., now classified as *Viennotia oplismeni* (Vienn.-Bourg.) Göker et al.) or to segregate genera, in combination with other characteristics; for example *Peronosclerospora* from *Sclerospora* (Shirai & Hara 1927) and *Pseudoperonospora* from *Peronospora* (Rostovzev 1903), as well as *Rhysotheca* from *Plasmopara* (Wilson 1914). However, the mode of germination may be temperature and humidity dependent, which has been described for Phytophthora by Blackwell & Waterhouse (1930). In addition, sporangial germination is often only badly studied and not accessible in herbarised material. For the *Peronospora sparsa* agg., parasitic to *Rosaceae*, zoospore production has been reported (Skalický 1966 and references therein),

possibly pointing to a common evolutional background of *Peronospora sparsa* and *Pseudoperonospora* species, which are, except for the type species, *Pseudoperonospora cubensis*, parasitic to *Rosales* sensu Angiosperm Phylogeny Group (Bremer et al. 1998, Bremer et al. 2003).

The situation is even more complicated when taking into account structures reminiscent of a dehiscence apparatus, as can be observed in some species of *Paraperonospora* (Constantinescu 1989). In addition, it has been shown by the molecular phylogenies mentioned above, that the character "presence or absence of a papilla" is spread rather randomly in the *Peronosporaceae*. In SEM, the papilla is clearly visible in some genera (e.g. *Plasmopara*, *Graminivora*) but can hardly bee seen in others (e.g. *Benua*). The genera *Bremia* and *Protobremia* both reveal a papilla in LM, but this characteristic is not visible in the vast majority of sporangia in SEM. Furthermore, it can not be observed in any collection from these genera. Therefore, it is not feasible to use SEM for investigating this character. The character "presence or absence of a papilla" can be used well for classification, although it is hardly of taxonomic relevance in groups above the generic level. For detailed discussion see Constantinescu (2000).

Sporangial colour

In the downy mildews, sporangia are coloured only in the genera *Pseudoperonospora* and *Peronospora*. In most molecular phylogenies, these two genera are mono- or paraphyletic, indicating that the colouration of the sporangia is a synapomorphy for the species exhibiting this character. However, sporangial colour is not or only hardly present in some species of *Peronospora* parasitic to *Caryophyllaceae* (Gäumann 1923), so sporangial colour alone is not sufficient to characterise species belonging to this group.

Surface ornamentation

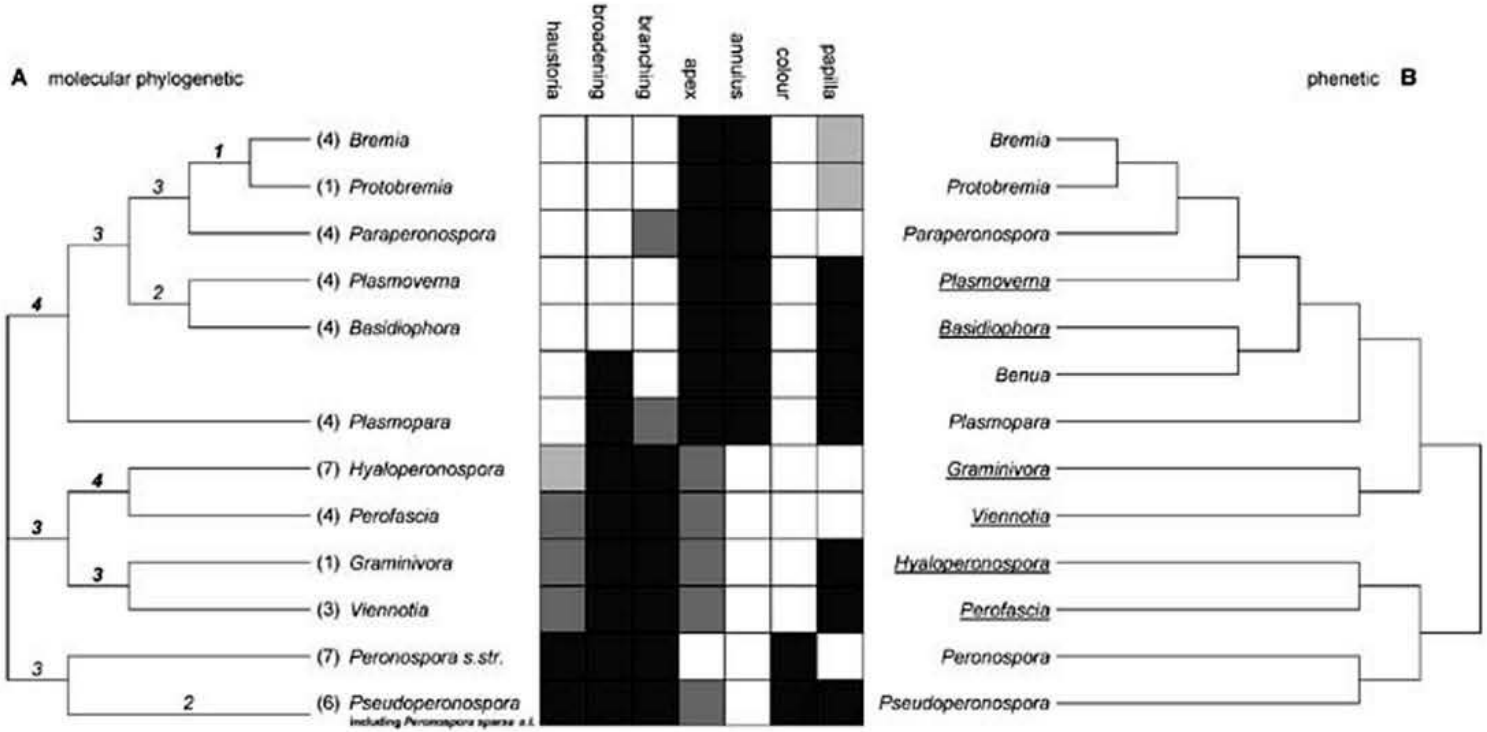
Sporangia of all downy mildews show ornamentation in SEM, although they may appear smooth in LM, as stated for *Hyaloperonospora* by Constantinescu & Fatehi (2002). Ornamentation ranges from very small warts as in *Paraperonospora* to large irregular protuberances in *Benua*. However, the density and diameter of the protuberances may vary greatly between collections of the same species or even within one collection. Therefore, only the shape of the protuberances might be useful for classification in some cases, e.g. the large, rounded warts found in *Pseudoperonospora*. Whether the shape of the protuberances can also be used for the delimitation of other genera is questionable, although the flat, irregular but rounded protuberances in *Hyaloperonospora* are also almost exclusively found in this genus. The area of aggregated protuberances around the pedicel, which may be missing in *Graminivora* and *Plasmoverna* may vary greatly in dimension, even within the same collection. Therefore, this character

should only carefully be used for systematic studies in combination with other characteristics. However, the way the yard is expressed in some genera, e.g. the hardly elevated yard in *Pseudoperonospora*, might constitute a distinct character for this group of species.

Conclusions

Due to lack of resolution and often conflicting evidence, especially due to "rogue taxa" with a long lasting independent evolutionary history, such as *Basidiophora*, molecular phylogenies are often unable to conclude on the correct position of the species examined with the sequence data available (Thines et al. 2006). Ultrastructural features, which have already been successfully applied on the *Albuginaceae* (Thines & Spring 2005, Voglmayr & Riethmüller 2006), have some potential for giving information useful for the characterisation of monophyletic groups, if carefully investigated in the context of molecular phylogenies (Fig. 4). Although some of the genera are placed slightly different in the phenetic analysis in comparison to molecular phylogenetic reconstructions (underlined in Fig. 4), the phenetic analysis is mainly in concordance with the molecular phylogenies.

Figure 4 (facing page). Comparison of the phenetic tree presented in this study with a hypothetical molecular phylogenetic tree combined from the molecular phylogenetic reconstructions of Riethmüller et al. (2002), Constantinescu & Fatehi (2002), Göker et al. (2003), Choi et al. (2003), Voglmayr (2003), Voglmayr et al. (2004), Choi et al. (2005) and Thines et al. (2006). Clades of the hypothetical molecular phylogenetic tree (left) are supported by the majority of the molecular phylogenetic reconstructions. Italic numbers above the branches indicate the number of molecular phylogenies in favour of the corresponding branch. If these numbers are bold italic, no conflicting molecular phylogenetic evidence exists. Italic numbers in brackets before the genus names indicate the number of molecular phylogenies which include the corresponding taxon. Phenetic tree (right) showing a slightly different topology compared to the molecular phylogenetic tree. Genera which are placed differently in the phenetic tree are underlined. Matrix in between the trees shows the main characters useful for systematic studies and characters hitherto commonly used. Same greyscales indicate same expression of a certain character. **Papilla**: dark grey, papilla visible in SEM; light grey, papilla visible only in a minority of sporangia in SEM, but visible in light microscopy (LM); white, no papilla present (in *Paraperonospora*, some atavistic forms of a papilla can sometimes be seen in LM). **Colour**: dark grey, sporangia pigmented; white, sporangia colourless. **Annulus**: dark grey, annulus present; light grey, annulus absent. **Apex**: dark grey, ultimate branchlets truncate, with a caving in wall; light grey, truncate, wall sealing the ultimate branchlets, if at all, only caving in at the midpoint; white, ultimate branchlets mostly acute. **Branching**: dark grey, branching of the outer branches mostly dichotomous; light grey, branching of the ultimate branches mostly pseudotrichotomous; white, ultimate branchlets regular or irregular aggregated. **Broadening**: dark grey, sporangiophores not broadening towards the ramifications; white, broadening of the sporangiophores towards the ramifications present, at least for the last two ramifications. **Haustoria**: dark grey, haustoria branched; light grey, haustoria hyphal; lighter grey, haustoria lobate; white, haustoria globose to pyriform.


A molecular phylogenetic
haustoria
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phenetic B
(4) Bremia
(1) Protobremia
(4) Paraperonospora
(4) Plasmoverna
(4) Basidiophora
(4) Plasmopara
(7) Hyaloperonospora
(4) Perofascia
(1) Graminivora
(3) Viennotia
(7) Peronospora s.str.
(6) Pseudoperonospora
Including Peronospora sparsa a.o.
Bremia
Protobremia
Paraperonospora
Plasmoverna
Basidiophora
Benua
Plasmopara
Graminivora
Viennotia
Hyaloperonospora
Perofascia
Peronospora
Pseudoperonospora

For the genera *Basidiophora*, *Benua*, *Bremia*, *Paraperonospora*, *Plasmopara*, *Plasmoverna* and *Protobremia*, vesicular to pyriform haustoria are characteristic and most likely represent a synapomorphy for these. Likewise, the presence of an annulus or broadening of the ultimate branchlets towards their distal end is characteristic for these genera. *Plasmopara*, which is also placed basal in the molecular phylogenetic reconstructions of Göker et al. (2003), Voglmayr et al. (2004) and Thines et al. (2006), is the only one of the DMPH which does not regularly show a broadening of the sporangiophores towards the ramifications.

Perofascia and *Hyaloperonospora* are grouped together in all molecular phylogenetic reconstructions computed so far. This sister-group relationship is also apparent from phenetic comparisons. Especially the truncate and curved to spiral ultimate branchlets tie these genera together. It is also notable that both genera are (with a few exceptions in *Hyaloperonospora*) parasitic to *Brassicaceae*.

Hyaloperonospora and *Perofascia* are grouped together with the *Poaceae* infecting genera of the *Peronosporaceae* in some molecular phylogenetic reconstructions (Göker et al. 2003). Possibly, the truncate ultimate branchlets without distinct annulus, together with the colourless sporangia can be regarded as a combination of characters tying this group together. In unweighted phenetic analysis, this placement is not supported, however (Fig. 3). The genera *Viennotia* and *Graminivora* are, in spite of some differences in the morphology of the ultimate branchlets and terminal branches torn together by the presence of heavily coiled haustoria and a distinct papilla (Göker et al. 2003, Thines et al. 2006). The genera with uncoloured sporangia and with coloured sporangia each form monophyletic groups in the phenetic analysis presented (Fig. 4).

There is conflicting evidence for a monophyly of the *Peronosporaceae* with regard to *Phytophthora* s.str. and evidence that the *Sclerosporaceae* are almost certainly nested into the *Peronosporaceae* (Riethmüller et al. 2002, Göker et al. 2004, Thines et al. 2006). However, to clarify this situation, a thorough ultrastructural investigation of the *Sclerosporaceae* and *Phytophthora* de Bary has to be conducted.

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MYCOTAXON

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The mycobiota of Itapuã Park, Rio Grande do Sul, Brazil. I. Species of *Strophariaceae* (*Agaricales*)

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Abstract—In a fungal survey of the Itapuã Park, in south Brazil, the agaric family *Strophariaceae* was studied. *Hypholoma aurantiacum*, *H. ericaeum*, *Psilocybe caeruleoannulata*, *P. coprophila*, *P. cubensis*, *P. muscorum*, *P. wrightii*, *Stropharia alcis*, and *S. coronilla* are reported. *Psilocybe muscorum* is reported for the first time in Brazil, while *S. alcis* is a new record in South America.

Key words—macromycete inventory, Basidiomycota, subtropical vegetation

Introduction

Macromycete inventory was carried out in the Itapuã State Park, a protected area in the municipality of Viamão, Rio Grande do Sul, south Brazil. This investigation aims to provide a list of the macrofungi (Homobasidiomycetes) from the area. In this first contribution are presented the results of the agarics belonging to the family *Strophariaceae* Singer & A.H. Sm.

This group includes dark-spored mushrooms occurring in several types of substrate, including litter, decayed wood, dung and mosses (Singer 1986, Watling & Gregory 1987). Previous studies reporting members of *Strophariaceae* from Rio Grande do Sul State were published by Rick (1907, 1939, 1961), Singer (1953), Cortez & Coelho (2004), Guzmán & Cortez (2004, 2005) and Sobestansky (2005).

Materials and methods

Description of the study area – The Itapuã State Park (30°20' - 30°27' S and 50°50' - 51°05' W) is situated in the municipality of Viamão, state of Rio Grande do Sul, Brazil (Fig. 1). Its area is about 53.33 km², and the eastern limit is Patos Lagoon ("Laguna dos Patos"), while the western limit is the Guaíba Lake ("Lago Guaíba"). According to Rambo (1956), this area is situated in the

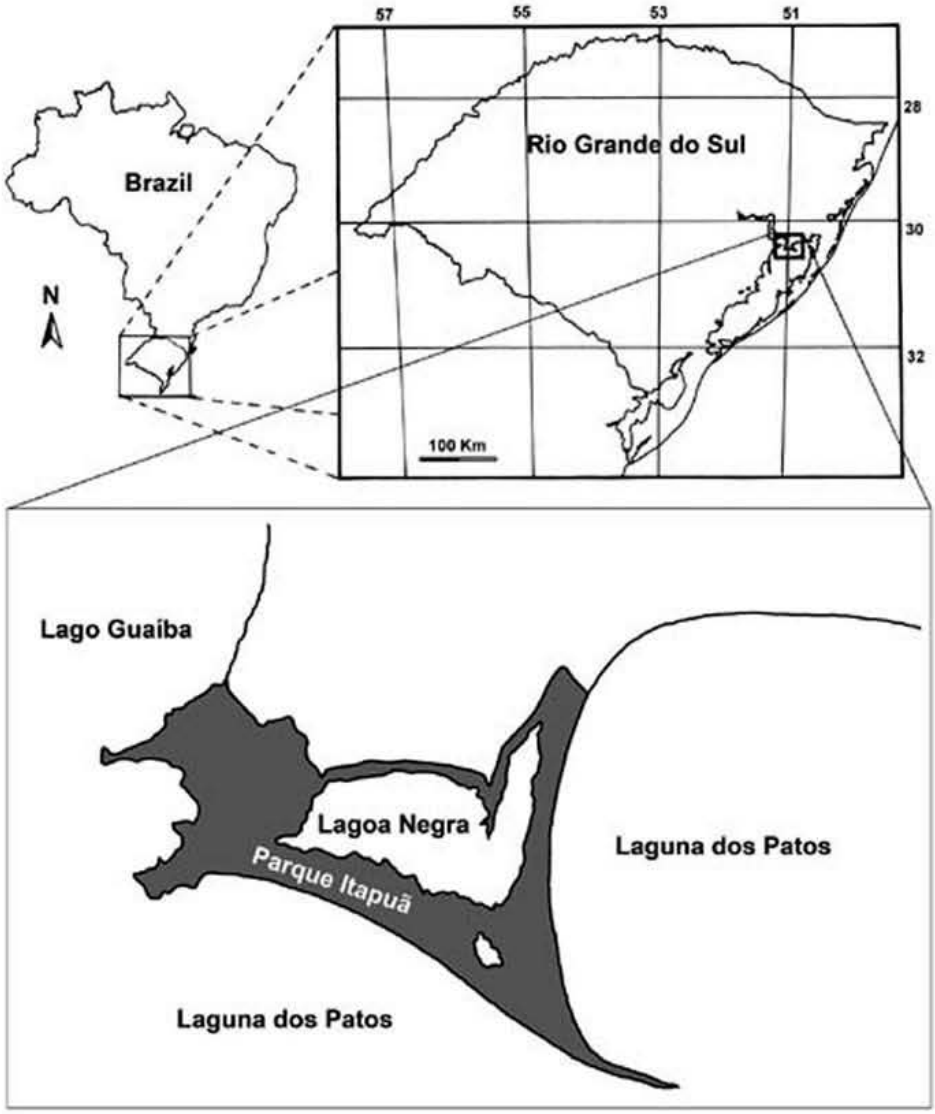

Figure 1. Location of Itapuã Park, in Rio Grande do Sul State, south Brazil.

physiographic region of the Southeast Highlands, which includes the southern montane region of the State. Among the landscape of the Park, there are eight beaches, the Negra Lagoon ("Lagoa Negra") and several ponds, marshes and granitic hills (Irgang 2003).

The relief is formed by granite hills of Crystalline Shield ("Escudo Cristalino"); rocks are represented by sandy and clay materials, deposited during the Quaternary Age. The subtropical climate is of the Cfa type, with annual mean temperature about 17°C, and precipitation between 1100 and

1300 mm, with well distributed rainfall throughout the year (Irgang 2003). The vegetation is mainly composed of forests and meadows, characterized by a great floristic diversity, and is included in the Atlantic Rain Forest domain. The forest vegetation comprises characteristic species such as *Ficus organensis* Miq., *Enterolobium contortisiliquum* (Vell.) Morong, *Luehea divaricata* Mart., and *Lithraea brasiliensis* Marchand. The less common forests are the sand dune forests ("restinga") and the peat forests ("mata paludosa"), with an irregular canopy and typical species such as *Citharexylum myrianthum* Cham., *Cecropia pachystachya* Trécul, *Erythrina crista-galli* L., and *Syagrus romanzoffiana* (Cham.) Glassman. The riparian forests are formed especially by *Pouteria gardneriana* (A. DC.) Radlk., and *Terminalia australis* Cambess. (Brack et al. 1998).

Methods – The specimens were collected during October 2003 to September 2005. Microscopic observations were made after drying, with thin sections mounted in 5% KOH and 1% Congo Red solutions (Largent et al. 1986). Specimens are deposited in the herbarium ICN; additional specimens from HCB were also considered.

Results and discussion

1. *Hypholoma aurantiacum* (Cooke) Faus in Moreno & Faus, Bol. Soc. Micol. Castell. 7: 70, 1982. **FIG. 2-6**

Pileus 18 mm diam., convex to aplanate, reddish brown, slightly darker in the centre, smooth, subviscid, margin exhibiting velar remnants, like white floccose fugacious scales. **Lamellae** adnexed, gray to light violaceous, with entire and whitish edges. **Stipe** 60 x 6 mm, subcylindrical with a curved base, whitish to pale yellow above, reddish orange at the base, fibrous, hollow, with longitudinal grooves, white rhizomorphs present at the base. **Veil** represented by a vestigial annulus represented by white scales about 15 mm below the pileus.

Basidiospores 10-12 x 6-7 µm, ellipsoid to ovoid in face- and side-view, yellowish brown, thick-walled, with a broad and distinct germ pore at apex and a short basal appendage. **Basidia** (23-) 25-34 x 8-11 (-13) µm, clavate, 4- spored, hyaline, thin-walled. **Chrysocystidia** 30-42 x 7-11.5 µm, fusoid, sometimes with mucronate apex, with yellowish amorphous contents. **Cheilocystidia** (22-) 25-35 (-45) x 5-7 µm, cylindrical to ventricose, hyaline. **Hymenophoral trama** regular to subregular, with hyaline hyphae, 7.5-12 µm wide. **Pileipellis** as an ixocutis, with hyaline, filamentous hyphae 3.5-6 µm wide. **Hypodermium** distinctly subcellular, formed by subglobose hyphae with yellowish incrusted walls. **Caulocystidia** 33-55 x 3.5-8 µm, cylindrical to ventricose, hyaline, similar to cheilocystidia.

STUDIED COLLECTION – BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 10.09.2005, *M. Rother 082/05* (ICN 139.172); growing on soil, in subtropical vegetation, near to bamboos.

Remarks: This species is mentioned in European literature (e.g. Orton 1960, Watling & Gregory 1987) as *Stropharia* because of the fibrillose annulus on stipe, but the cellular hypodermium and the absence of acanthocytes on its rhizomorphs exclude it from that genus. The placement in *Hypholoma*/ *Naematoloma* was discussed by Guzmán (1975), Moreno & Faus (1982), and Singer (1986), among others. Rick (1907) made the first record of this species from Rio Grande do Sul State as *Stropharia thrausta* (Schulzer ex Kalchbr.) Sacc. It was also recorded from the states of Paraná (de Meijer 2001) and Rio Grande do Sul (Sobestiansky 2005), both as *S. aurantiaca*.

2. ***Hypholoma ericaeum*** (Pers.: Fr.) Kühner, Bull. Soc. Mycol. Fr. 52: 23, 1936.

FIG. 7-11

Pileus 8-27 mm diam., campanulate to convex, umbonate, yellowish brown in the center, becoming lighter toward edges, smooth, subviscid. **Lamellae** adnexed, gray in younger specimens and violaceous in others, with entire and whitish edges. **Stipe** 60-95 x 4 mm, cylindrical to sinuous, yellow to yellowish brown, with some scales on surface and little longitudinal grooves at apex, fibrous, without rhizomorphs. **Veil** poorly developed, not forming annulus neither marginal remnants on pileus margin.

Basidiospores 12-15 x 6.5-9 µm, ovoid in face-view and ellipsoid in side-view, yellowish brown, with a broad germ pore, thick-walled. **Basidia** 22-35 (-40) x 6-10 µm, subclavate, 4- spored, hyaline, thin-walled. **Chrysocystidia** 30-56 (-65) x 7-15 µm, fusoid to lageniform with mucronate apex, with yellowish amorphous contents. **Cheilocystidia** (22-) 25-35 x 3-7 µm, lageniform to subcapitate, hyaline, numerous. **Hymenophoral trama** regular, with hyaline hyphae 7-18 µm wide. **Pileipellis** as an ixocutis, with filamentous and hyaline hyphae 4-8 µm wide. **Hypodermium** composed of filamentous hyphae with incrusted walls. **Caulocystidia** 22-38 x 4-8 µm, lageniform to subcapitate, similar to cheilocystidia.

STUDIED COLLECTIONS – BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 17.08.2004, *P.S. Silva 093/04* (ICN 139.080), *P.S. Silva 094/04* (ICN 139.081); 30.04.2005, *P.S. Silva 122/05* (ICN 139.082); 24.05.1988, *Maria* (HCB 1572 – as *Psilocybe sabulosa* Peck); growing on sandy and moist soil, among grasses and mosses.

Remarks: Noordeloos (1999) considered this species as *Psilocybe ericaea* (Pers.: Fr.) Quél. belonging to section *Psilocyboides* (Singer) Noordel., subsection *Ericaeae* Noordel. In Brazil, *H. ericaeum* was recorded by de Meijer (2001) for the state of Paraná, and by Singer (1953 – as *Naematoloma subumbonatescens* (Murrill) Singer) and Rick (1961 – as *P. ericaea*) from Rio Grande do Sul. It is

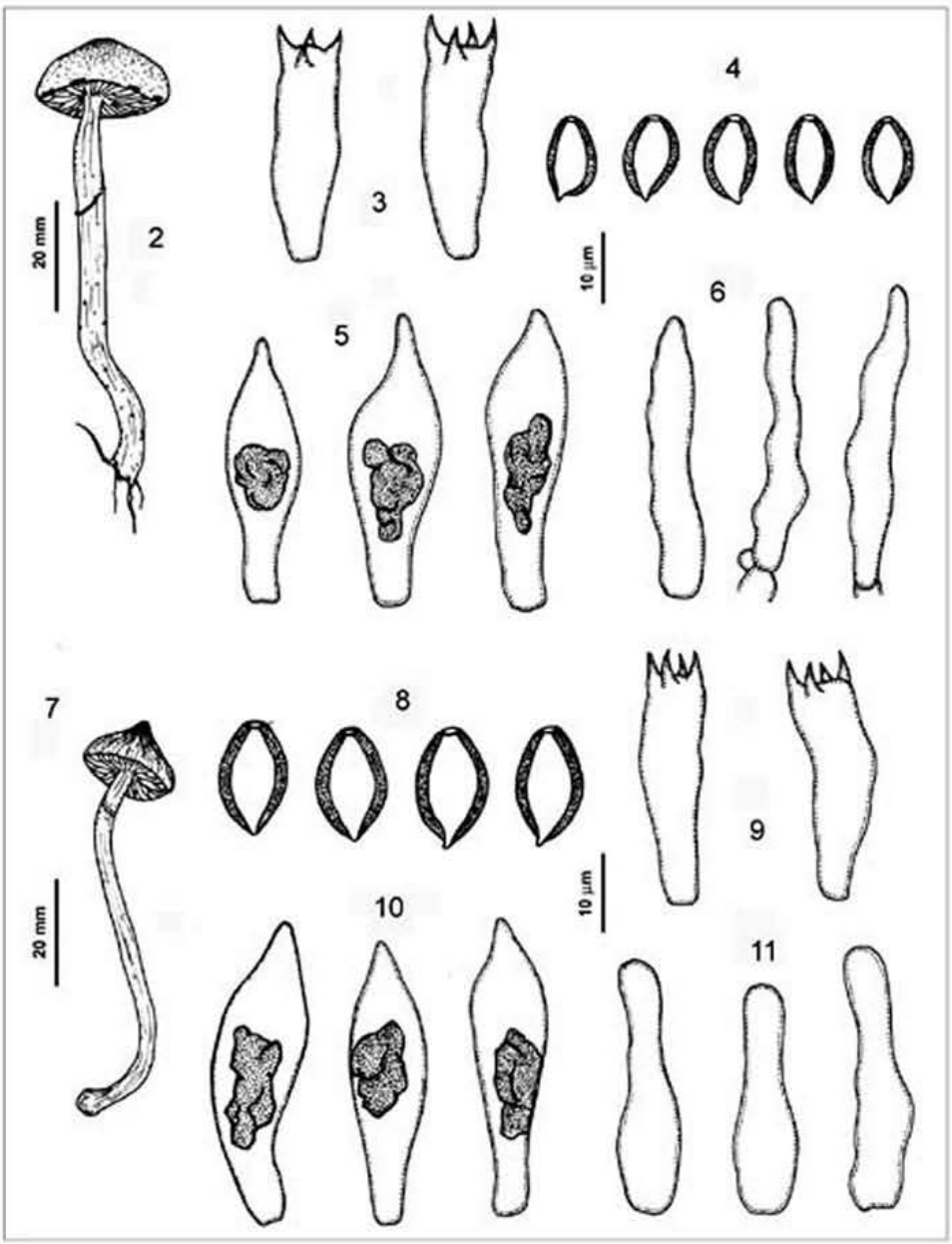

Figure 2-11. 2-6: *Hypholoma aurantiacum*. 2. Basidiome. 3. Basidia. 4. Basidiospores. 5. Chrysocystidia. 6. Cheilocystidia.
7-11. *Hypholoma ericaeum*. 7. Basidiome. 8. Basidiospores. 9. Basidia. 10. Chrysocystidia. 11. Cheilocystidia.

a common species occurring in the area, being frequently collected in humid places.

3. *Psilocybe caeruleoannulata* Singer ex Guzmán, Mycotaxon 7: 235, 1978.

STUDIED COLLECTION – BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 16.04.2005, *P.S. Silva 110/05* (ICN 139.084), growing on soil and litter into the subtropical forest.

Remarks: This species was recently reported from Rio Grande do Sul by Guzmán & Cortez (2004), who considered *P. uruguayensis* Singer ex Guzmán as a synonym. A complete description of this bluing mushroom is found in Guzmán (1983) and Guzmán & Cortez (2004).

4. *Psilocybe coprophila* (Bull.: Fr.) P. Kumm., Führ. Pilzk.: 71, 1871.

STUDIED COLLECTION – BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 19.10.1987, *Batista* (HCB 15.218), on dung.

Remarks: This widespread coprophilous species has not been found in the area after the exclusion of cattle and horses from the area for conservation purposes. A full description of south Brazilian specimens is found in Cortez & Coelho (2004).

5. *Psilocybe cubensis* (Earle) Singer, Sydowia 2: 37, 1948.

STUDIED COLLECTION – BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 05.04.1988, *A.B. Pereira* (HCB 15.236), on cow dung.

Remarks: As the previous species, this hallucinogenic mushroom was found only before the inoccupation of the area. With the exclusion of the cattle and horse, coprophilous species has been not found. See descriptions and discussion in Guzmán (1983) and Cortez & Coelho (2004).

6. *Psilocybe muscorum* (P.D. Orton) M. M. Moser, Kleine Kryptogamenflora Ed. 3, II b/2: 239, 1967. **FIG. 12-16**

Pileus 4-10.5 mm diam., convex to hemispheric, becoming applanate or expanded to slightly depressed, dark brown to pale yellowish brown towards the margin, slightly moist, translucent-striate, with a separable pellicle, context thin, membranous, pale brownish. **Lamellae** adnate, subdistant, yellowish brown, edge regular and whitish. **Stipe** 14-27 x 1-2 mm, central, cylindrical, with the base slightly thickened, yellowish brown, turning to whitish in maturity, smooth to pruinose, dry to moist, hollow, fibrous. **Veil** forming a fibrous annular zone.

Basidiospores 7-9 x 4.5-5 µm, ovoid to ellipsoid, slightly rhomboid in face-view, sub-ellipsoid in side view, yellowish brown, thin-walled, with a reduced germ pore. **Basidia** 20-26 x 6-7.5 µm, ventricose, 4-spored, hyaline. **Pleurocystidia**

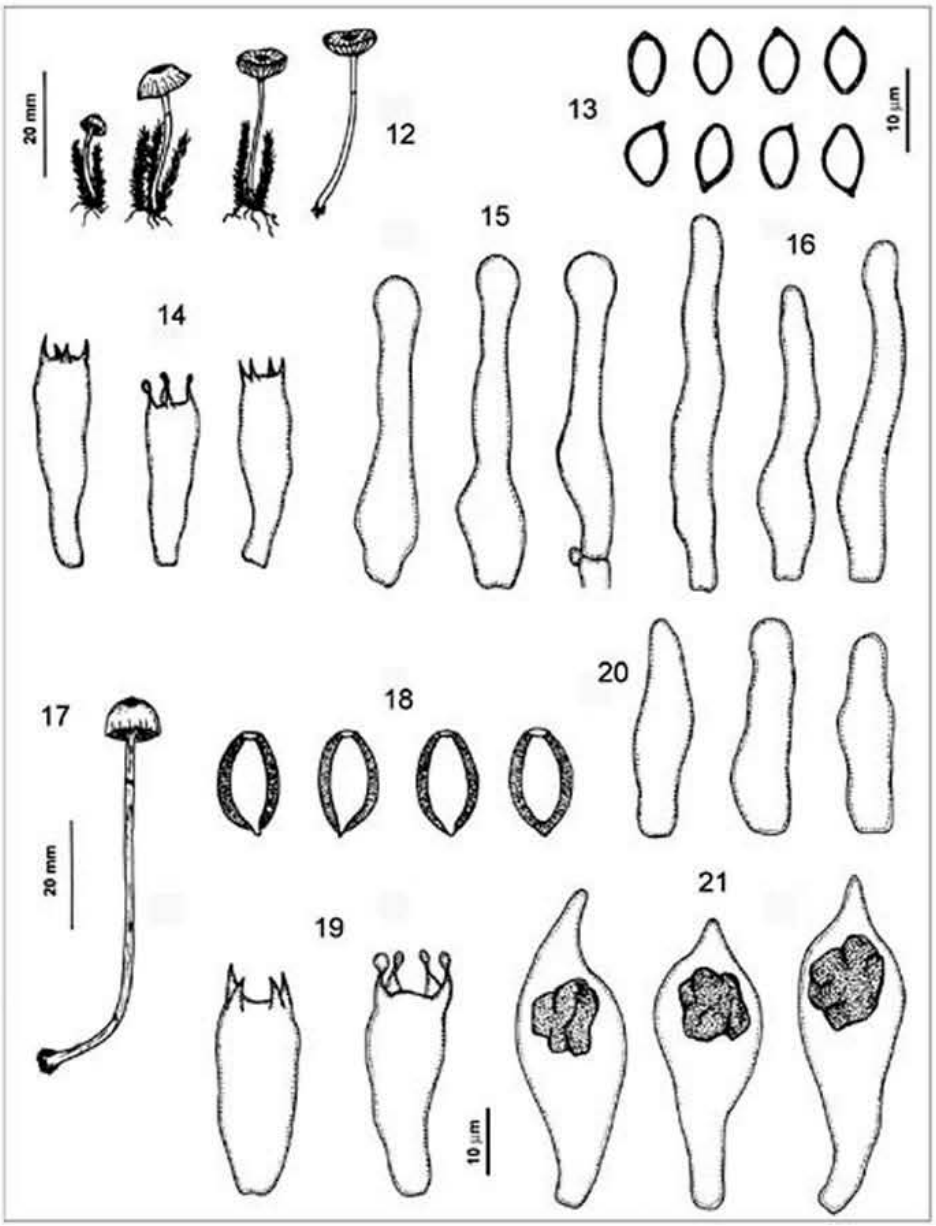

Figure 12-21. 12-16. *Psilocybe muscorum.* 12. Basidiomes. 13. Basidiospores. 14. Basidia. 15. Cheilocystidia. 16. Caulocystidia.
17-21. *Stropharia alcis.* 17. Basidiome. 18. Basidiospores. 19. Basidia. 20. Cheilocystidia. 21. Pleurocystidia.

absent. **Cheilocystidia** 25-56 x 5-9 µm, cylindrical to lageniform, hyaline, thin-walled, forming a sterile band in the gill edge. **Hymenophoral trama** subregular, with hyaline hyphae 5.5-8 µm wide. **Pileipellis** as an ixocutis composed of hyaline and gelatinized hyphae, thin-walled, elongated, 3-5 µm wide. **Hypodermium** formed of filamentous to subglobose hyphae, with hyaline to little encrusted walls. **Stipepellis** formed by parallel, hyaline and thin-walled hyphae, 8.5-14 µm wide. **Caulocystidia** 30-55 x 4-6.5 µm, cylindrical to lageniform, also subcapitate, similar to the cheilocystidia, clustered on the stipe apex.

STUDIED COLLECTION - BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 17.08.2004, *Cortez 048/04* (ICN); among mosses on sandy soil.

Remarks: According to Watling & Gregory (1987), the distribution of this species is unclear because of the taxonomic confusion with other musciculous members of the genus, especially *P. montana* (Pers.: Fr.) P. Kumm. Following Guzmán (1983, 1995), *P. muscorum* exhibits thin-walled basidiospores and belongs to section *Pratensis* Guzmán. *Psilocybe montana* has thick-walled basidiospores and is placed in section *Psilocybe*. *Psilocybe muscorum* was reported by several authors from Europe (e.g., Guzmán et al. 2002, Noordeloos 1999, Orton 1960), and Guzmán (1995) reported it for the first time in South America from Venezuela, at 3.600 m elevation. Our specimens agrees in several aspects with the description given by Guzmán (1983) and Watling & Gregory (1987), however the Brazilian specimens were collected in a subtropical place almost in sea-level, growing associated to mosses in sandy soil. *Psilocybe muscorum* is reported for the first time in Brazil.

7. ***Psilocybe wrightii*** Guzmán, Mycotaxon 7: 251, 1978.

STUDIED COLLECTIONS - BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 08.05.2004, *P.S. Silva 061/04* (ICN 139.068), *P.S. Silva 062/04* (ICN 139.069); 22.05.2004, *P.S. Silva 085/04* (ICN 139.070), on soil, into the subtropical forest, all the specimens near to a stream.

Remarks: This bluing and probably hallucinogenic species was recently reported from Rio Grande do Sul by Guzmán & Cortez (2004). It has been collected frequently in subtropical forests of Rio Grande do Sul, growing on humid soils. For a complete description and discussion see the above cited work.

8. ***Stropharia alcis*** Kytöv., Karstenia 39: 17, 1999. **FIG. 17-21**

Pileus 8 mm diam., hemispheric, slightly umbonate, yellowish toward the margin to orange-brown in the center, smooth and viscid, margin striate. Lamellae adnexed, dark brown, with entire and whitish edges. Stipe 60 x 2 mm, cylindrical, uniform, yellowish, smooth or with some scales on the base. Veil as a vestigial dark brown annulus, represented by little glutinous fibrils about 7 mm below the pileus.

Basidiospores 13-14 x 7-9 µm, ovoid to ellipsoid in face view and ellipsoid in side view, yellowish brown, thick-walled, with a broad germ pore. **Basidia** 24-29 x 10-12 µm, clavate to ventricose, 4-spored, hyaline. **Pleurocystidia** 30-50 (-54) x 9-15 µm, as chrysocystidia, fusoid, with mucronate apex, and yellowish brown amorphous contents. **Cheilocystidia** 23-35 x 5-8 µm, cylindrical, narrow, hyaline. **Hymenophoral trama** regular, composed of hyaline hyphae 7-13 µm wide. **Pileipellis** as an ixocutis with hyaline and gelatinized hyphae, 6-11 µm wide. **Stipepellis** formed of parallel, hyaline and thin-walled hyphae, 7-14 µm wide. **Caulocystidia** 30-45 x 4-8 µm, cylindrical to sublageniform, some subcapitate, similar to the cheilocystidia, observed on the stipe apex.

STUDIED COLLECTIONS - BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 16.04.2005, *P.S. Silva 109/05* (ICN 139.083), on soil of subtropical forest. ADDITIONAL SPECIMEN EXAMINED: SWEDEN. Province of Dalarnas, St. Kopparberg, 20.09.1980, *S. Jacobsson* (ICN), on elk dung in spruce forest.

Remarks: Kytövuori (1999) described *S. alcis* from the region of Fennoscandia, Finland and his study supported the close relationship of *S. alcis* with elk dung, where it grows alone or mixed with other coprophilous agarics. Kytövuori (1999) also suggested that the distribution of the species must go on toward North America due the presence of the elk there, being rare or absent in south Europe. Our studied material was identified as *S. alcis* because of strongly viscid surface of pileus, long stipe, basidiospore size and cheilocystidia size/shape, in agreement to the description by Kytövuori (1999). However, the Brazilian studied material was collected on soil instead of elk dung. We propose that this species is not restricted to elk dung. Comparative study of Swedish material collected on elk dung did not presented any significant morphological differences, supporting the identification. In this way, *Stropharia alcis* is recorded for the first time for South America and on soil.

9. ***Stropharia coronilla*** (Bull. ex DC.: Fr.) Quél., Mém. Soc. D'Emul. Mont. Ser. II, 5: 255, 1872.

STUDIED COLLECTIONS - BRAZIL. Rio Grande do Sul State, Viamão, Itapuã Park, 08.05.2004, *P.S. Silva 063/04* (ICN 139.075), *P.S. Silva 064/04* (ICN 139.076), *P.S. Silva 065/04* (ICN 139.077), *P.S. Silva 067/04* (ICN 139.078); 09.04.2005 *P.S. Silva 098/05* (ICN 139.073), *P.S. Silva 099/05* (ICN 139.072), *P.S. Silva 100/05* (ICN 139.074) and *P.S. Silva 114/05* (ICN 139.079), in meadows, among grasses on soil.

Remarks: This is the most common species of the family in the area, frequently collected in meadows. A description of this mushroom is found in Cortez & Coelho (2004).

Acknowledgments

Special thanks to CNPq for financial support and to SEMA-RS for facilities during this study. Thanks to the colleagues Mateus A. Reck, Marcelo S. Rother and Ângela Pawlowski for photos and collected material. Dr. Jorge L. Waechter (UFRGS) is acknowledged for providing the description of the study area. We also thank to Mr. Jairo who helped us during the collections. Prof. Gastón Guzmán (Instituto de Ecología, Mexico) and Prof. Roy Watling (Edinburgh, UK) are greatly acknowledged for critical review of this paper. The editorial and nomenclatural assistance of Dr. Lorelei L. Norvell and Dr. Shaun Pennycook is thanked.

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MYCOTAXON

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Validation of *Auritella* (*Inocybaceae, Agaricales*)

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Abstract—In their original publication, *Auritella geoaustralis*, *A. serpentinocystis*, *A. chamaecephala*, and *A. dolichocystis* (type) were designated as provisional names. To ensure the validity of the generic name *Auritella* and three recombinations into the genus, the four provisional names are validated in accordance with ICBN Article 34.1.

Key words—*Inocybe*, nomenclature

Introduction

A new genus of *Agaricales* in the family *Inocybaceae*, *Auritella*, in which seven species were recognized, was recently published (Matheny & Bougher 2006). Detailed morphological descriptions, Latin diagnoses, DNA sequences, and type designations were provided in this publication, however, the names of the type (*A. dolichocystis*) and three other newly described species were unintentionally designated as provisional names ("nom. prov." instead of "sp. nov."). According to ICBN Article 34.1(b) (Greuter et al. 2000), these four names were not validly published. Consequently, the generic name was not properly typified and is also invalid (Art. 6.3, 10.1, 10.3, 12.1, 37.1), resulting in the invalidity of the new combinations based upon previously described taxa. Here we accept all of the taxa and validate all of their names. Per Art. 36.1 it is unncessary to repeat the Latin descriptions but refer to those published in Matheny & Bougher (2006).

Materials and methods

Herbarium abbreviations follow Holmgren et al. (1990).

Taxonomy

Auritella Matheny & Bougher, **gen. nov.**

"*Auritella*", Mycol. Prog. 5: 5, figs. 2–4. 2006 (inval. Art. 10.1, 10.3, 37.1).

Typus Auritella dolichocystis Matheny, Trappe & Bougher

Auritella aureoplumosa (Watling) Matheny, **comb. nov.**

Inocybe aureoplumosa Watling, Czech Mycology 52: 331. 2001 (basionym).

"*Auritella aureopluma*", Mycol. Prog. 5: 5. 2006 (inval. Art. 43.1).

Auritella erythroxa (De Seynes) Matheny, **comb. nov.**

Inocybe erythroxa De Seynes, Rech. Champ. Congo Fr. 1: 2. 1897 (basionym).

"*Auritella erythroxa*", Mycol. Prog. 5: 7. 2006 (inval. Art. 43.1).

Auritella geoaustralis Matheny & Bougher, **sp. nov.**

"*Auritella geoaustralis*", Mycol. Prog. 5: 7. 2006 (inval. Art. 34.1).

Holotypus in PERTH (H7344), isotypus in WTU.

Auritella arenicolens (Cleland) Matheny & Bougher, **comb. nov.**

Naucoria arenacolens Cleland, Trans. R. Soc.S. Australia 57: 193. 1933 (basionym).
Inocybe arenacolens (Cleland) E. Horak, Persoonia 11: 6. 1980.

"*Auritella arenacolens*" Mycol. Prog. 5: 8. 2006 (inval. Art. 43.1).

NOTE: The spelling of the specific epithet "*arenacolens*" is an orthographic error, which is corrected to "*arenicolens*" according to Art. 60.8 and Recommendation 60G1(a).

Auritella serpentinocystis Matheny, Trappe & Bougher, **sp. nov.**

"*Auritella serpentinocystis*", Mycol. Prog. 5: 9. 2006 (inval. Art. 34.1).

Holotypus in PERTH (Trappe 25080), isotypus in WTU.

Auritella dolichocystis Matheny, Trappe & Bougher, **sp. nov.**

"*Auritella dolichocystis*", Mycol. Prog. 5: 9. 2006 (inval. Art. 34.1).

Holotypus in PERTH (Trappe 24838), isotypus in WTU.

Auritella chamaecephala Matheny, O. K. Mill. & Bougher, **sp. nov.**

"*Auritella chamaecephala*", Mycol. Prog. 5: 11. 2006 (inval. Art. 34.1).

Holotypus in VPI (OKM 23901), isotypus in WTU.

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Cordyceps mrciensis sp. nov. from a spider in Thailand

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Abstract—A fungus associated with a spider collected from the Mushroom Research Centre, Chiang Mai, Thailand was found to represent a new species of the genus *Cordyceps*. It is described as *C. mrciensis* sp. nov. *C. mrciensis* differs from other species occurring on spiders in that the stromata have a fertile part with a distinctive sterile appendage, superficial perithecia and ascospores that do not break into secondary partspores.

Key words—entomogenous fungi

Introduction

Cordyceps is a morphologically and ecologically well-defined group of parasites on arthropods (insects, spiders and mites) and hypogeous fungi (Kobayasi 1941, 1982, Mains 1954, 1957, Kobayasi & Shimizu 1960, 1977, Evans 1982, Zhang et al. 2004, Stensrud et al. 2005). This genus is one of the two most important genera of invertebrate pathogens (Hywel-Jones 2001) and is cosmopolitan in

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distribution (Hawksworth et al. 1995). Kirk et al. (2001) suggested that there are 100 *Cordyceps* species, although 280 species were listed by Kobayasi (1982). According to Index Fungorum (www. Indexfungorum. org), more than 500 epithets are assigned to *Cordyceps*, however, many are known to be taxonomic synonyms.

In Thailand, 26 species of *Cordyceps* have been identified, including four species on spiders (Hywel-Jones 2001). Kobayasi (1962) recorded five *Cordyceps* species parasitizing spiders (Arachnida) worldwide. Mains (1954) listed eight species of *Cordyceps* known to parasitize spiders.

While collecting entomogenous fungi in northern Thailand forests, a new *Cordyceps* species was found parasitizing a spider. This species is distinct from all other *Cordyceps* species and represents a novel taxon.

Materials and methods

Collections were made at the Mushroom Research Centre (MRC) in northern Thailand. Soil, litter, herbs, and trees, including the under sides of leaves were examined and dead and infected insects were collected. Specimens were stored in plastic containers and transported on the same day to the laboratory for identification. The holotype is now deposited in the Thai Mycological Association Herbarium (TMAH).

Taxonomic description

Cordyceps mrciensis Aung, J.C. Kang, Z.Q. Liang, Soytong & K.D. Hyde **sp. nov.**
[MB 510252] FIGURES 1 & 2

Stromata e abdomine hospitis oriunda, ramosa, filiformia, 5-12 mm longa. Pars fertilis nigrescens. Appendix apicalis filiformis 4 mm longa. Perithecia superficialia, elongata vel ellipsoidea, 210-375 × 150-180 µm. Asci 135-306 × 9-15 µm, capitibus 5.4-8.4 µm in diam. Ascosporae 185-435 × 3-5 µm, multiseptatae, cellulis 3.6-21 µm longis, non-separabilis.

Etymology: mrciensis = refers to the Mushroom Research Centre (MRC), the locality where the specimen was found.

Holotype: Thailand, Chiang Mai, Mae Taeng, T. Pa Pae, Bahn Pha Daeng, 128 Moo 3, Mushroom Research Centre, from spider (Arachnida) attached to a rotten bamboo culm, 17 September 2005, Ohnmar Myo Aung TMAH 0001. The holotype is deposited in Thai Mycological Association Herbarium (TMAH).

Stomata arising from abdomen of infected spider, filiform, 5-12 mm long, light brown, branching. **Fertile part** black, with a 4 mm long sterile appendage. **Perithecia** superficial, elongate to ellipsoid, 210-375 × 150-180 µm, some with a short neck, about 120 × 30 µm. **Asci** filiform, 8-spored, 135-305 × 9-15 µm; caps of asci 4.2-6.6 µm high, 5.4-8.4 µm wide. **Ascospores** filiform, 185-435 × 3-5 µm, not breaking into secondary ascospores, septate at 3.6-21 µm intervals.

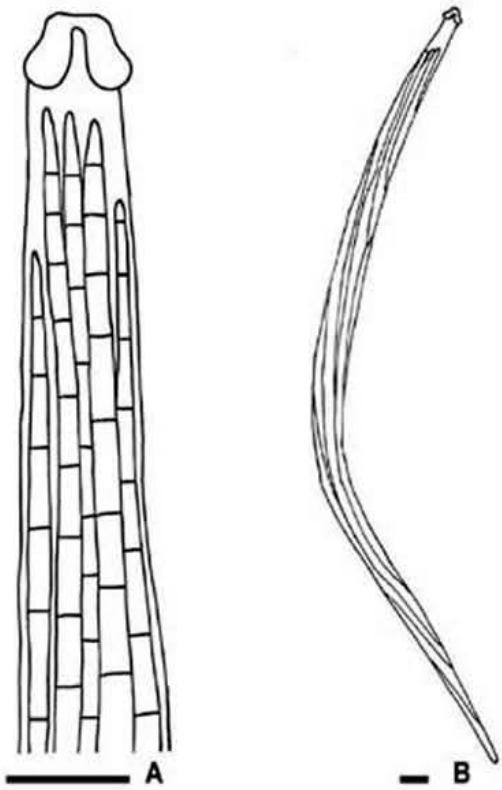

Fig 1. *Cordyceps mrciensis A. Upper part of* an ascus with mature ascospores. B. An ascus with filiform ascospores. Bars = 5 µm.

Discussion

Cordyceps mrciensis was associated with a single infected spider, attached to a rotten bamboo culm, collected at Mushroom Research Centre, Chiang Mai, Thailand.

Most *Cordyceps* species are believed to be specific to various arthropod groups, such as spiders with the degree of specificity differing from species to species (Nikoh & Fukatsu 2000). Therefore, our discussion will be based only on *Cordyceps* species associated with spiders (Arachnida).

According to Mains (1954) only eight species of *Cordyceps* have been recorded in association with spiders. *Cordyceps mrciensis* can be distinguished from these known species in having stromata with a fertile part and a stipe that continues as a distinctive sterile appendage, superficial perithecia and ascospores that do not break into partspores. There are only two species, *C. thaxteri* Mains and *C. engleriana* Henn., that have superficial perithecia. In *C. thaxteri* the perithecia are scattered, free, narrowly ovoid, and large (960-1200 x 300-360 µm, Mains,

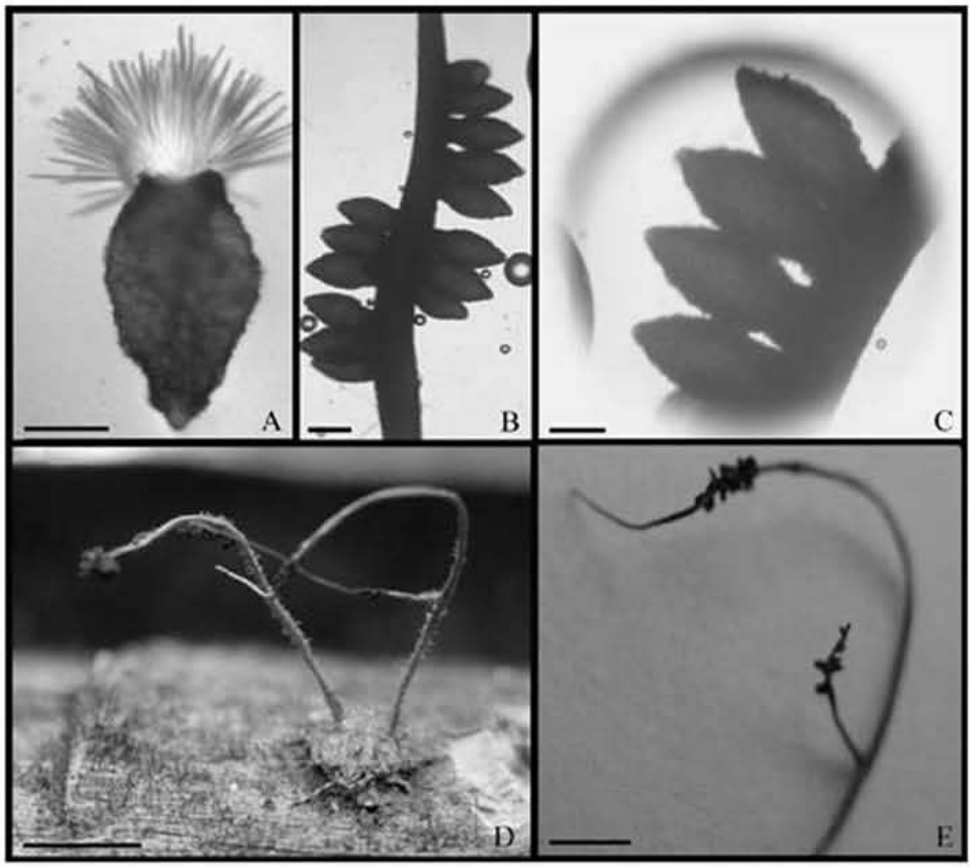

Fig 2. *Cordyceps mrciensis* (from holotype). A. A perithecium and asci. B. Superficial perithecia. C. Perithecia. D. Small spider bearing two stromata with superficial perithecia E. Appendage. Bars: A & C = 100 µm, B = 200 µm, D & E = 2.5 mm.

1954). The perithecia of *C. engleriana* are also superficial, but crowded at the apex of the stromata and ovoid or flask-shaped (Mains 1954). *Cordyceps mrciensis* also has superficial perithecia but they are elongate to ellipsoid, small, 210-375 × 150-180 µm and some have short necks. The ascospores of *C. thaxteri* and *C. engleriana* break into partspores, whereas those of *C. mrciensis* do not. *Cordyceps caloceroides* Berk. & M.A. Curtis and *C. grenadensis* Mains, also associated with spiders, posses ascospores that do not break into secondary partspores. *Cordyceps caloceroides* has immersed perithecia with slightly protruding ostioles, while *C. grenadensis* has partly imbedded, ovoid perithecia. The perithecia of *C. mrciensis* are entirely superficial and somewhat scattered on the stipe.

Besides the above characters, the distinctive fertile part of the stroma with a distinctive sterile appendage is sufficient to distinguish *C. mrciensis* from the known *Cordyceps* species from spiders (Table 1).

Table 1. Comparison of the characteristics of *Cordyceps* species associated with spiders

Species	Stroma	Perithecia (range in µm)	Ascospores (range in µm)	Reference
C. arachneicola	Cylindric, 50 × 2 mm	Completely embedded ellipsoid	-	Kobayasi 1941. Tokyo Bun. Daig. 5 no. 84: 123-125
C. caloceroides	Bright red, furcate, nearly 5 in long, ≤ 1 line thick	Immersed, prominent ostioles, ovoid, 215-250 × 100-150	Not breaking into partspores	Berk. & M.A. Curtis 1868. Jour. Linn. Soc. Bot. 10: 375
C. cylindrica	Cylindric, capitate, twisted-rounded apex 15 × 1.5-2.0 mm	Entirely embedded to the surface or at right angles to the surface 850-1200 × 220-270	-	Petch 1937. Trans British Myc. Soc. 21: 46
C. engleriana	Many, 15 × 0.25 mm	Superficial, crowded, free, ovoid or flask shaped, 600 × 300	Breaking into 22-25 × 1.5-2 µm cylindric fragments	Henn. 1897. Engler Bot. Jahrb. 23: 538
C. grenadensis	2, ovoid, cylindric 10-12 mm	Partly embedded, ovoid, 336-360 × 156-216	Not breaking into partspores	Mains 1954. Bull. Torrey Bot. Club 81: 492–500
C. ignota	Simple, branched, slender, 60 × 0.5-1.5 mm	Slightly embedded, very crowded, ovoid 100-140 × 60-75	-	Marchion. 1945. Physis 20: 17
C. mrciensis	2, branching, filiform, 5-12 mm	Superficial, elongate, ellipsoid, some with short neck, 210-375 × 150-180, 4 mm sterile appendage	Not breaking into partspores	sp. nov.
C. singeri	Clavate, subcapitate, 3-12 mm	Embedded, ovoid, 325-550 × 200-500	Breaking into one-cell segments- 3-4 × 0.7-1	Mains 1954. Bull. Torrey Bot. Club 81: 492–500
C. thaxteri	Subcylindric, 1.5-2.5 × 0.1-0.2 mm	Superficial, few, narrowly ovoid, 960-1200 × 300-360	Breaking into one-cell segments	Mains 1939. Jour. Elisha Mitchell Soc. 55: 120

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MYCOTAXON

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A new entomopathogenic species, *Hymenostilbe furcata*, parasitic on a hemipteran nymph in northern Thailand

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Abstract—*Hymenostilbe furcata* sp. nov., parasitic on a hemipteran nymph in a northern Thailand forest is described and illustrated. Its morphology is compared with that of other species with forked denticles.

Key words—hyphomycete genus

Introduction

The entomopathogenic hyphomycete genus *Hymenostilbe* was introduced by Petch (1931) to accommodate *H. muscarium* Petch, a species parasitic on dipteran insects. It was described as having cylindrical synnemata covered by a hymenium-like layer of conidiogenous cells (Samson &Evans 1975). It was later found to be the anamorph of *Cordyceps forquignonii* Quél. (Petch 1948). *Hymenostilbe* species can be distinguished from *Akanthomyces* species, also parasitic on insects and spiders, as the conidia of *Akanthomyces* form in chains on phialides, while those of *Hymenostilbe* are solitary, polyblastic and form on a denticle (Petch 1932c, Mains 1950, Samson & Evans 1975). *Akanthomyces*

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and *Hymenostilbe* produce synnemata that are more or less cylindric and often are somewhat attenuated towards the apex. In *Hymenostilbe* the synnemata are composed of more or less parallel, longitudinal hyphae, usually forming a compact bundle. The longitudinal hyphae produce conidiogenous cells at their ends, especially in the upper portions of the synnemata. Most of the conidiogenous cells, however, are produced either as lateral cells or frequently as terminal cells of short lateral branches produced along the entire length of the outer hyphae of the synnemata. This results in a hymenial layer that covers the surface of the synnemata. In most species there is abundant production of conidiogenous cells resulting in a compact hymenial layer. In some species the conidiogenous cells are scattered and well separated from each other (Mains 1950).

Samson & Evans (1975) reviewed *Hymenostilbe* accepting nine species and excluding 11 doubtful species. *Hymenostilbe* species parasitize arachnids and dipteran, orthopteran and hymenopteran insects. *Hymenostilbe longispora* Samson & H.C. Evans is commonly found on several ant species of the subfamilies Ponerinae and Myrmicinae. *H. ghanensis* Samson & H.C. Evans was collected on a spider. Several species of *Hymenostilbe* have been associated with a *Cordyceps* teleomorph. For instance, *H. dipterigena* Petch is the anamorph of *Cordyceps dipterigena* Berk. & Broome (Petch 1932a), *H. nutans* Samson & H.C. Evans is the anamorph of *C. nutans* Pat. and *H. fragilis* Petch is the anamorph of *C. uleana* Henn. (Petch 1932b). Three species of *Hymenostilbe* have been recorded in Thailand; *H. ventricosa* Hywel-Jones was rarely found as an entomopathogen of cockroach nymphs (Hywel-Jones 1995), while *H. aurantiaca* Hywel-Jones was found on formicine ants in the same location as *C.* cf. *myrmecophila* Ces. (Hywel-Jones 1996).

Based on the previous records and distinctive morphological characteristics, the fungus described in this paper is accommodated in *Hymenostilbe* as a new species.

Materials and methods

A general survey of entomopathogenic fungi was carried out in northern Thailand forests from May to October 2005. The collection sites included in this survey were Mushroom Research Centre (MRC), Doi Suthep National Park, Mokfa Waterfall and Toung Jaw Village, Chiang Mai. Soils, litter, herbaceous plants, and tree leaves were examined for dead insects, which were collected and transported the same day to the laboratory in plastic containers for identification and isolation. Conidial isolations were made on potato dextrose agar (PDA). The holotype is deposited in Thai Mycological Association Herbarium (TMAH).

Taxonomic description

Hymenostilbe furcata Aung, J.C. Kang, Z.Q. Liang, Soytong & K.D. Hyde **sp. nov.**
[MB 510253] FIGURES 1-2

Synnemata multiplicata, oriunda corpa, alba, cylindrica, 10-14 mm longa, 94-120 µm crassa. Cellulae conidiogenae 5-18 × 3.5-6.5 µm, polyblasticae, clavata vel cylindricae, sursum denticulis furcatis 0.6-2.4 µm longis dense obtectae. Conidia solitaria, levia, hyalina, fusiformis, 8.5-15 µm longa, 3-4.5 µm crassa.

Etymology: The species name refers to the forked sterigmata-like projections from the conidiogenous cells.

Holotype: Thailand, Chiang Mai, Mae Taeng, T. Pa Pae, Bahn Pha Daeng, 128 Moo 3, Mushroom Research Centre, from hemipteran nymph (Hemiptera) attached to the underside of a leaf in forest, 25 June 2005, Ohnmar Myo Aung TMAH 0002.

Synnemata slender, 10-14 mm long, 94-120 µm wide, arising from head and thorax of insect, cylindrical, white; central core of parallel hyphae composed of cells 3-55 × 2.5-4 µm; covered by an outer hymenium-like layer of conidiogenous cells with basal cells 7.5-20 × 2.5-5 µm. Conidiogenous cells 5-18 × 3.5-6.5 µm, polyblastic, clavate or cylindrical, apically with 2-7 furcellate denticles, 0.6-2.4 µm. Conidia 8.5-15 × 3- 4.5 µm, solitary, smooth, hyaline, fusiform.

Unfortunately, attempts to culture *H. furcata* on agar were unsuccessful.

Discussion

Species in the entomopathogenic genus *Hymenostilbe* are rarely encountered in the tropics (Hywel-Jones 1995). *Hymenostilbe furcata* was collected only once on a hemipteran nymph in the rain forests in Thailand. It can be separated from *H. sulphurea* and *H. nutans*, which also occur on hemipteran insects, by the creamy white synnemata and the two to seven, forked denticles on the conidiogenous cells. *Hymenostilbe sulphurea* Samson & H.C. Evans has sulphur-yellow synnemata and subglobose to ellipsoidal, rough-walled conidia, while *H. furcata* has smooth, fusiform conidia. *Hymenostilbe nutans* has fusoid conidia but they are smaller than those of *H. furcata* (6-10 x 3.2-4 µm vs. 8.5-15 x 3-4.5 µm). The conidiogenous cells of *H. furcata* are clavate or cylindrical while those of *H. nutans* are cylindrical, apically pointed and the denticles are crowded at the apex. The conidiogenous cells of *H. furcata* are 5-18 µm long × 3.5-6.5 µm wide, whereas those of *H. nutans* are 15-24 µm long × 4.5-6.5 µm wide. Those of *H. sulphurea* are cylindrical to clavate, 15-25 x 5-6.5 µm and the denticles are crowded at the apex (Samson & Evans 1975).

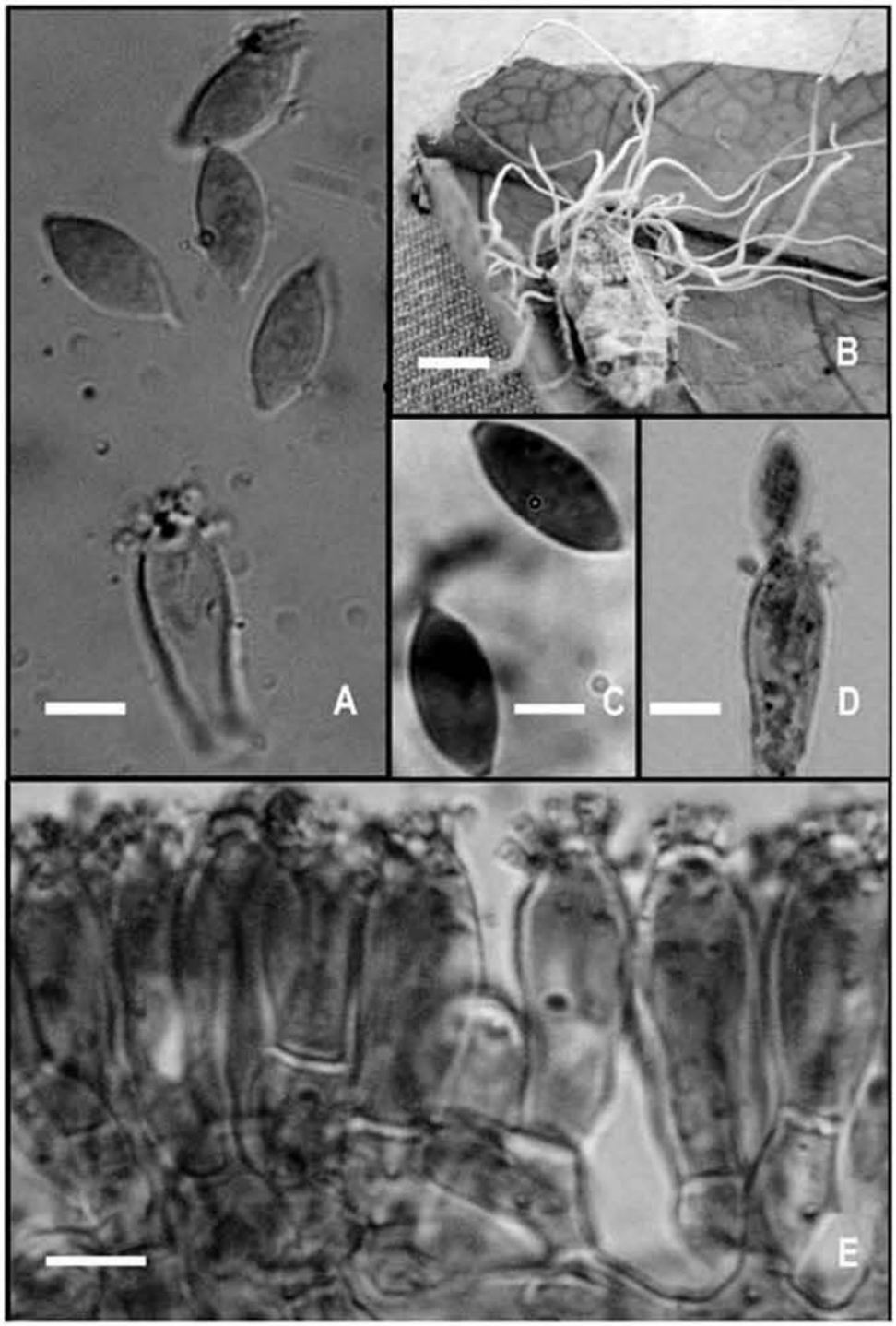

Fig.1: *Hymenostilbe furcata* (from holotype). A. Detached conidia. B. Infected hemipteran insect with synnemata. C. Conidia D. Conidiogenous cell with forked denticles and conidium. E. Conidiogenous cells forming a hymenium-like layer. Scale bars: A, C, D & E = 5 µm, B = 5 mm.

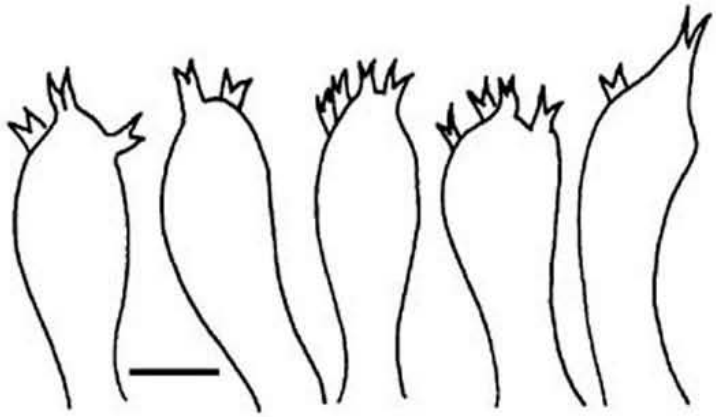

Fig. 2: Conidiogenous cells of *Hymenostilbe furcata* (from holotype). Scale bar = 5 µm.

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The genus *Neoerysiphe* in Israel: species composition, host range and distribution

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Abstract—Information on the distribution of *Neoerysiphe* species (*N. cumminsiana*, *N. galeopsidis*, and *N. galii*) is given. It is clearly shown that *N. cumminsiana* is a common species in Israel. Collections of this species were previously referred to *Erysiphe cichoracearum*. Hence, it can be supposed that *Neoerysiphe cumminsiana* is probably widespread in other Mediterranean countries. Therefore, all samples of powdery mildews collected on species of the *Asteraceae* should be critically revised.

Key words—*Erysiphales*, *Neoerysiphe*, species composition

Introduction

Based on the results of molecular investigations, significant nomenclature changes in the system of *Erysiphales* have recently been made (Takamatsu et al. 1998, 1999, 2000; Saenz & Taylor 1999; Mori et al. 2000), including the introduction of the new genus *Neoerysiphe* U. Braun for the former *Erysiphe* sect. *Galeopsidis* U. Braun. Five species of *Erysiphe* s.l. (*E. chelones* Schwein., *E. cumminsiana* U. Braun, *E. galeopsidis* DC., *E. galii* S. Blumer, and *E. geranii* Y. Nomura) were transferred to the new genus (Braun 1999). According to molecular phylogenetic data, these five species form a separate clade (Saenz & Taylor 1999) and they have a specific anamorph type, *Oidium* subgen. *Striatoidium* R.T.A. Cook et al., with striate conidial walls (Gorter 1987; Cook et al. 1997). Furthermore, species of this genus have some biological feature such as chasmothecia which became mature only after overwintering. *Neoerysiphe* species are differentiated by some morphological characters and different

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host ranges. Thus, *N. cumminsiana* infects species of the *Asteraceae* belonging to *Arctotheca, Bidens, Cacalia, Crepis, Eupatorium, Heliopsis, Ligularia, Phagnalon, Rhagadiolus, Senecio, Tagetes,* and *Taraxacum* (Amano 1986; Braun 1987; Heluta 1999; Voityuk et al. 2004a). *Neoerysiphe galii* is confined to species of *Galium* (*Rubiaceae*) (Braun 1987; Voytyuk et al. 2004b), and *N. galeopsidis*, affects, according to Braun (1987), species of the genera *Ballota, Betonica, Chelonopsis, Clinopodium, Comanthosphace, Elsholtzia, Galeobdolon, Galeopsis, Gleochoma, Isodon, Lagopsis, Lamium, Leonurus, Leucas, Lycopus, Marrubium, Melissa, Melittis, Monarda, Nepeta, Origanum, Phlomis, Physostegia, Plectranthus, Prunella, Rosmarinus, Salvia, Satureja, Scutellaria, Sideritis, Stachyopsis, Stachys, Thymus, Ziziphora* (*Lamiaceae*). In Israel, only species of the genus *Golovinomyces* (U. Braun) Heluta have been collected on hosts of the genera *Lycopus, Monarda, Nepeta, Rosmarinus, Salvia, Thymus* and *Ziziphora*. Therefore, the occurrence of *N. galeopsidis* on hosts of these genera is somewhat doubtful and should be proven. *Neoerysiphe chelones* (Schwein.) U. Braun is only known from *Chelone glabra* (*Scrophulariaceae*), and *N. geranii* (Y. Nomura) U. Braun is confined to the genus *Geranium* (*Geraniaceae*) (Braun 1987; Heluta 2001).

Among species of *Neoerysiphe*, the most widespread are *N. galeopsidis* (nearly circumglobal) and *N. galii* (all of Europe, Central Asia, China, Balearic and Canary Islands). *Neoerysiphe chelones* is known only in North America, and *N. cumminsiana* is recorded from North America and Japan (Braun 1987). However, as shown by Heluta (1999), the later species occurs also in Europe (Ukraine). Heluta (2001) discovered *N. geranii*, previously only known from Japan and New Zealand, in the Ukraine, showing that this species is much more widespread than hitherto assumed. These results were the reason for our detailed examinations of *Neoerysiphe* species in Israel.

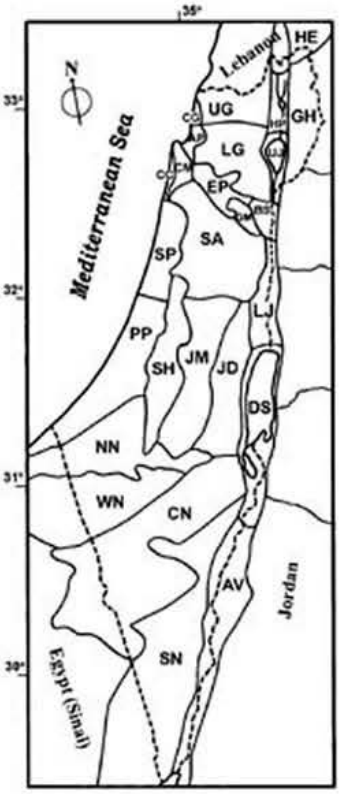

Figure 1: Accepted abbreviations of nature regions of Israel: **AP** – Akko Plain; **AV** – Arava Valley; **BS** – Beit Shean Valley; **CC** – Carmel Coast; **CG** – Coast Galilee; **CM** – Carmel Mount; **CN** – Central Negev; **DS** – Dead Sea Area; **EP** – Esdraelon (Yizre'el) Plain; **GH** – Golan Heights; **GM** – Gilboa Mount; **HE** – Hermon Mount; **HP** – Hula Plain; **JD** – Judean Desert; **JM** – Judean Mts.; **LG** – Lower Galilee; **LJ** – Lower Jordan Valley; **NN** – Northern Negev; **PP** – Philistean Plain; **SA** – Samaria; **SH** – Shefela; **SN** – South Negev; **SP** – Sharon Plain; **UG** – Upper Galilee; **UJ** – Upper Jordan Valley; **WN** – Western Negev (Feinbrun-Dothan & Danin 1998).

Materials and methods

In this research samples from the herbarium of the Hebrew University of Jerusalem (HUJ) and specimens collected by the authors themselves in Israel between 2002 and 2005 were used. A map showing the nature regions of Israel (Fig. 1), used as base to demonstrate the distribution of each species in this country, is provided. Morphological features of the *Neoerysiphe* species were examined by using light dark-field (Carl Zeiss Axiostar 1122-100, Germany) and scanning microscopes (JSM-35C and Jeol JSM-6060LA, Japan). Names of host plants are given according to Feinbrun-Dothan and Danin (1998).

Results and discussion

As a result of field investigations, *N. cumminsiana* was recorded from several localities in Israel (Voityuk et al. 2004a). Later *N. galii* was also found for the first time in this country (Voytyuk et al. 2004b). A preliminary analysis of literature data (Rayss 1940, 1947, 1953, 1959; Chorin & Palti 1962) showed that *N. cumminsiana* was probably misidentified as *Erysiphe cichoracearum* DC. In order to check this hypothesis, all herbarium samples collected in the last century in Israel and kept in the herbarium of the Jerusalem Hebrew University (HUJ) were re-examined. In addition, different regions of the country were searched for *Neoerysiphe* spp. Finally, it was demonstrated that three species of the genus *Neoerysiphe* are distributed in Israel: *N. cumminsiana*, *N. galeopsidis* and *N. galii*. Numerous samples of *N. cumminsiana* and *N. galeopsidis* referred to as *Erysiphe cichoracearum*, *E. biocellata* Ehrenb., *E. fischeri* S. Blumer, *E. galeopsidis*, and *Oidium gigasporum* Scalia were found in herbarium HUJ. One of the samples of *N. cumminsiana* on *Phagnalon rupestre* was originally identified as *Leveillula taurica* (Lév.) G. Arnaud.

Numerous additional localities of *Neoerysiphe* species in Israel as well as new host plants were found, e.g., *Carthamus tenuis*, *Filago eriocephala*, *Hedypnois cretica*, *Lagoseris sancta*, *Picris altissima*, *P. amalecitana*, *P. galilaea*, *Tolpis virgata* and *Thrincia tuberosa*, for *N. cumminsiana*, and *Prasium majus* new for *E. galeopsidis*.

The following descriptions, illustrations and distribution maps of all *Neoerysiphe* species known from Israel are generally based on the collections examined and cited.

Neoerysiphe cumminsiana (U. Braun) U. Braun, Schlechtendalia 3: 50 (1999) **(Fig. 3)**

Mycelium on stems, leaves, effuse or in patches, evanescent to subpersistent. Hyphae septate, 4–10 µm in wide. Appressoria mainly lobed. Anamorph *Oidium* s. str. Conidiophores erect, 150–190 µm (fresh material), foot-cells

straight, cylindrical, (35–) 37–70 × 11–14 µm. Conidia in chains, ellipsoid, after drying cylindrical-ellipsoid to vase-like, 25–38 × (10–) 13–20 µm (dry material), 30–40 × 17–25 µm (fresh material). Chasmothecia scattered or in large groups, hemispheric, depressed in the lower part, 80–170 µm in diam. Peridium cells polyangular, 2–15 (–19) µm in diam. Appendages in the lower part of the ascocarp, number variable, few to numerous, (0.25–) 0.5–1.5 times as long as the chasmothecia diam, often shorter than the chasmothecium diam, 4–10 µm in wide, thin-walled, mycelium-like, septate, hyaline, later yellowish. Asci numerous, 6–16, thin-walled, stalked, 40–67 (–75) × 20–35 (–40) µm. Ascospores not developed.

Distribution in Israel (Fig. 2):

On *Carthamus tenuis* (Boiss. & Blanche) Bornm. – **JM:** Jerusalem, 26.05.1945, E. Zwirn (HUJ 7027) (Rayss 1947).

On *Crepis aculeata* (DC.) Boiss. – **PP:** Rehovot, 24.03.1951, T. Rayss (HUJ 301/9 94S). – **SA:** Herzliyya, 29.03.1951, T. Rayss (HUJ 301/9 97S). – Israel (Amano 1986).

On *Crepis aspera* L. – **CC:** 'Atlit, Coast Sea, 32°42'N, 34°56'E, 26.03., 05.04., 21.04., 27.04.2004, S.O. Voytyuk – **CM:** Canyon between Haifa and 'Atlit (road to the Mediterranean Sea from University of Haifa), 31°24'N, 34°52'E, 27.04.2004, S.O. Voytyuk; Haifa, University of Haifa, near Institute of Evolution, 22.04.2004, S.O. Voytyuk. – **JM:** Jerusalem, 05.06.1950, T. Rayss (HUJ 301/9 96S); Jerusalem, 17.05.1940, T. Rayss (HUJ 657) (Rayss 1940); Moza (5 km west of Jerusalem), 18.04.1939, T. Rayss (HUJ 665) (Rayss 1940). – **PP:** Petah Tiqwa (10 km east of Tel-Aviv), 26.04.1930, T. Rayss (HUJ 301/12 109S); Qevuzat Yavne, 09.04.1938, T. Rayss (HUJ 7710), 12.04.1946, T. Rayss (HUJ 7219); Tel-Aviv, 17.04.1946, T. Rayss (HUJ 7223). – **SP:** Herzliyya (between Tel-Aviv and Netanya), 06.04.1939, M. Futurian (HUJ 663) (Rayss 1940); Pardes Hanna-Karkur, 05.04.1939, S. Duvdevani (HUJ 664) (Rayss 1940); Herzliyya Pituah, 32°12'N, 34°48'E, 21.04.2004, S.O. Voytyuk. – **JV:** Nahalal (7 km southeast of Qiryat Tiv'on), 29.03.1942, T. Rayss (HUJ 4431). – Israel (Amano 1986).

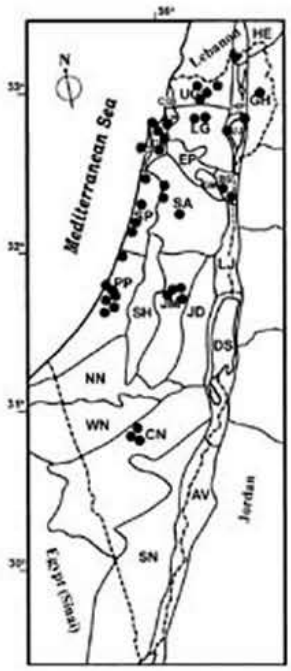

Figure 2: Distribution of *Neoerysiphe cumminsiana* in Israel

On *Crepis bulbosa* (L.) Tausch – **JM:** Jerusalem, 23.05.1957, T. Rayss (HUJ 301/13 113S).

On *Crepis palestina* (Boiss.) Bornm. – **UG:** Wadi Qurein (Qarn), 04.05.1942, T. Rayss (HUJ 4851) (Rayss 1947). – Israel (Amano 1986).

On *Crepis sancta* (L.) Bornm. (= *Lagoseris sancta* (L.) K. Maly) – **LG:** Mi'ilya (near Ma'alot), 33°00'N, 35°08'E, 25.03.2004, S.O. Voytyuk – **PP:** Rehovot, 24.03.1951, T. Rayss (HUJ 301/9 93S; HUJ 301/10 100S). – Israel (Amano 1986).

On *Crepis* sp. – **CC:** 'Atlit, 19.03.2002, V.P. Heluta. – **CM:** Haifa, 15.03.2002, V.P. Heluta (Voityuk et al. 2004a). – **SP:** Pardes Hanna-Karkur, 12.04.2002, E. Nevo

On *Filago eriocephala* Guss. (= *F. germanica* (L.) Huds.) – **JM:** Jerusalem, 15.05.1939, J. Stettner (HUJ 655) (Rayss 1940). – Israel (Amano 1986).

On *Hedypnois cretica* (L.) Dum.-Courset – **CC:** near 'Atlit, 31°24'N, 34°52'E, 27.04.2004, S.O. Voytyuk. – **CM:** Bet Oren, 04.04.1943, T. Rayss (HUJ 6332); Daliyat el Carmiel, 14.04.1941, T. Rayss (HUJ 660); Haifa, 28.03.1936, T. Rayss (HUJ 688). – **JV:** between Mehola and Bet She'an (7 km from Bet Shean), 32°21'N, 35°32'E, 02.05.2004, S.O. Voytyuk. – **Negev:** 'En Hawwa (15 km southeast of 'Avedat), 13.03.1945, T. Rayss (HUJ 6849). – **PP:** Bene Beraq (between Ramat Gan and Petah Tiqwa), 09.03.1938, T. Rayss (HUJ 679). – **SA:** 05.04.1943, T. Rayss (HUJ 6184). – **UG:** near 'En Kamonnim, near the road from the Rama village, 32°54'N, 35°26'E, 02.05.2004, S.O. Voytyuk; Mazzuva (kibbutz) (1 km southeast of Hanita Junction), 21.03.1953, T. Rayss (HUJ 301/12 107S); Metulla (on the Lebanon border), 23.04.1935, T. Rayss (HUJ 698). – **UJ:** 'En Gev (kibbutz on eastern shore of Lake Kinneret), 07.04.1945, T. Rayss (HUJ 7014); Tiberias (on shore of Lake Kinneret), 18.03.1938, T. Rayss (HUJ 678). – Israel, 21.03.1942, T. Rayss (HUJ 4844).

On *Phagnalon rupestre* (L.) DC. – **GH:** Yehudiyya, near the road, 32°56'N, 35°41'E, 17.05.2004, S.O. Voytyuk. – **UG:** Mt. Meron, Nahal Keziv, 18.03.2002, T. Andrianova; Zefat (= Safed), 22.08.1953, T. Rayss (HUJ 301/111 147S). – Israel (Amano 1986).

On *Picris altissima* Delile (= *P. sprengeriana* (L.) Chaix) – **GH:** Avné Etan (near Ramat Magshimim), 32°49'N, 35°46'E, 02.03.2004, S.O. Voytyuk (anamorph). – **JM:** Qiryat 'Anavim, 28.04.1939, T. Rayss (Rayss 1940). – Israel (Amano 1986).

On *Picris amalecitana* (Boiss.) Eig. – **SP:** Kefar Vitkin (6 km north of Netanya), 09.03.1940, T. Rayss (HUJ 658) (Rayss 1940). – Mi'ilya, 33°00'N, 35°08'E, 25.03.2004, S.O. Voytyuk. – Israel (Amano 1986).

On *Picris galilaea* (Boiss.) Eig. – **CM:** Bet Oren, 05.04.1943, T. Rayss (HUJ 5562) (Rayss 1947). – **JM:** Qiryat 'Anavim (near Abu Ghosh village), 28.04.1939, T. Rayss (HUJ 667). – Israel (Amano 1986).

On *Rhagadiolus stellatus* DC. – **CM:** Haifa, 29.03.1936, T. Rayss (HUJ 686) (Rayss 1940). – **JM:** Jerusalem, 06.04.1937, T. Rayss (HUJ 687), 24.03.1937, T. Rayss (Rayss 1940). – **NN:** near Lahav, 31°24'N, 34°52'E, 21.03.2004, S.O. Voytyuk – **UJ:** Tiberias (on shore of Lake Kinneret), 18.03.1938, T. Rayss (HUJ 669) (Rayss 1940). – Israel (Amano 1986).

On *Senecio vernalis* Waldst. & Kit. – **CM:** Nahal Oren, 32°49'N, 35°46'E, 21.06.2004, S.O. Voytyuk. – **CN:** 'En Hawwa, 13.03.1945, T. Rayss (HUJ 6910). – **PP:** Giv'at Brenner, 22.03.1945, T. Rayss (HUJ 7084); Tel-Aviv, 03.01.1935, N. Naftolski (HUJ 301/157 140S); Qevuzat Yavne, 30.03.1945, T. Rayss (HUJ 6865); Rehovot, 05.03.1935, T. Rayss (HUJ 733), 24.03.1951, T. Rayss (HUJ 301/157 138S). – **SA:** Netanya, 01.03.1937, T. Rayss (HUJ 732); Pardes Hanna-Karkur, 08.04.1945, A. Zurion-Hirsh (HUJ 897), 20.03.1951, T. Rayss (HUJ 301/157 139S). – Israel (Amano 1986).

On *Thrincia tuberosa* (L.) DC. (= *Leontodon tuberosus* L.) – **CM:** Muchraka, 17.03.2004, S.O. Voytyuk. – **LG:** the forest near Alloné Abba (near Qirat Tiv'on), 18.04.2004, S.O. Voytyuk. – **PP:** Ghiv'at Brenner, 15.03.1945, T. Rayss (HUJ 7712) (Rayss 1947). – **JM:** Moza (5 km west of Jerusalem), 19.01.1939, T. Rayss (Rayss 1947), 30.03.1957, T. Rayss (HUJ 301/12 110S); Qiryat 'Anavim, 18.04.1936, T. Rayss (Rayss 1947). – Israel (Amano 1986).

On *Tolpis virgata* (Desf.) Bertol. – **LG:** the forest near Alloné Abba (near Qiryat Tiv'on), 18.04.2004, S.O. Voytyuk. – **UG:** near 'En Kamonnim, near the road from the Rama village, 32°54'N, 35°26'E, 02.05.2004, S.O. Voytyuk. – Israel, 21.03.1942, T. Rayss (HUJ 4909).

General distribution: Europe (Ukraine), **Asia** (Israel, Japan), **North America**.

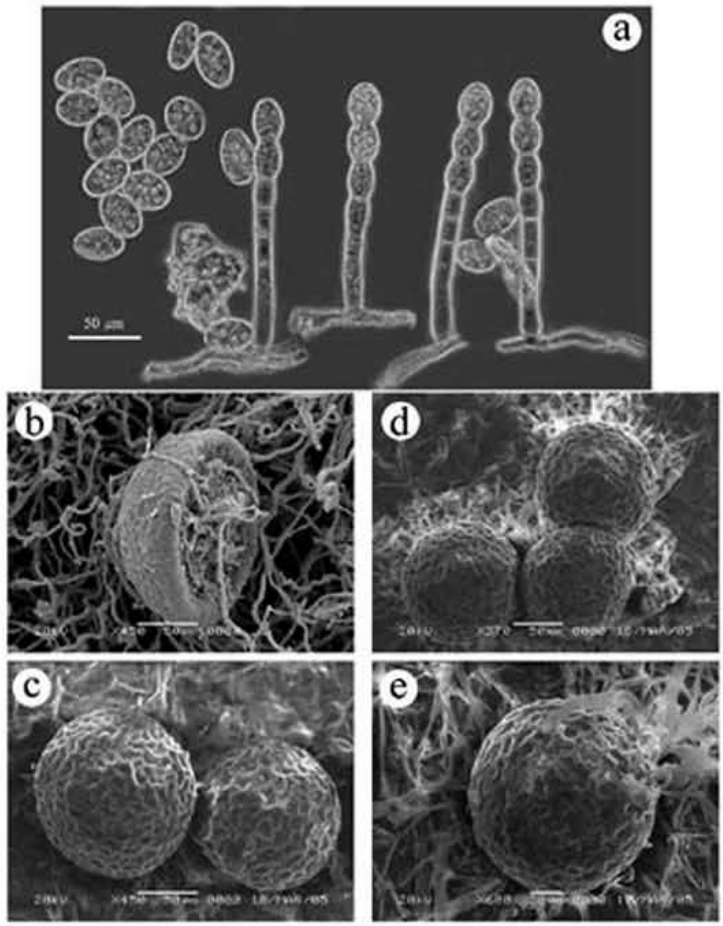

Figure 3: Anamorph (a) and teleomorph (b–e) of ***Neoerysiphe cumminsiana***: a – conidiophores and conidia on *Tolpis virgata*, b–e – chasmothecia: b – on *Phagnalon rupestre*, c – on *Hedypnois cretica*, d – on *Picris altissima*, e – on *Tolpis virgata*

Notes: *N. cumminsiana* was previously noted for Israel as *Erysiphe cichoracearum* (Amano 1986; Chorin & Palti 1962, Rayss 1940, 1947, 1953, 1959), *E. fischeri* (Rayss 1946; Chorin & Palti 1962), and *Leveillula taurica* (Rayss 1959; Chorin & Palti 1962).

Chasmothecia of this fungus on *Phagnalon rupestre* were much bigger than those on other host plants. The diameter varied from 130 to 170 µm, average 160 µm. The chasmothecia diameter of the other samples were 80–140 µm in diam. Furthermore, the chasmothecia of the fungus found on *P. rupestre* had smaller peridial cells.

The development of the fungus starts in winter (December to January), and continues until early May when mass production of chasmothecia can be observed.

Neoerysiphe galeopsidis (DC.) U. Braun, Schlechtendalia 3: 50 (1999) (Fig. 6a-c)

Mycelium amphigenous, white, sometimes grayish, well-developed on stems, leaves, effuse or in patches, evanescent to subpersistent. Hyphae septate, 4–6 (–8) µm in wide. Appressoria lobed. Anamorph *Oidium* s. str. Conidiophores erect, 95–165 (–180) µm, foot-cells straight, cylindrical, 40–70 × 10–16 µm (fresh material). Conidia in chains, ellipsoid-ovoid, 19–24 (–30) × 10–13 (–18) µm (dry material), 25–34 (–40) × 17–22 µm (fresh material). Chasmothecia numerous, scattered or in groups, 80–140 (–160) µm in diam. Appendages in the basal part of the ascocarp, number variable, few to numerous, 0.5–2 times as long as the chasmothecia diam, often shorter than the chasmothecium diam, 2–8 (–9) µm in wide, thin-walled, mycelium-like, septate, hyaline, later yellowish to brown. Asci 4–12, ellipsoid, shortstalked, 48–85 × 20–40 µm. Ascospores were not developed.

Distribution in Israel (Fig. 4):

On *Ballota saxatilis* Sieber – JM: Jerusalem, 10.04.1937, T. Rayss (HUJ 740) (Rayss 1940); Jerusalem, Kefar HaShiloah, 24.01.1943, T. Rayss (HUJ 5358) (Rayss 1947). – UG: Rosh Pinna, 27.04.1937, T. Rayss (HUJ 745) (Rayss 1940). – Israel (Rayss 1940, 1947; Amano 1986).

On *Lamium amplexicaule* L. – CM: Haifa, University of Haifa, 10.03.2004, S.O. Voytyuk.

On *Lamium moschatum* Mill. – CC: Bat Shelomo, 12.03.1940, H. Blumenfeld (Rayss 1940). – CM: Bet Oren (kibbutz), 04.04.1943, T. Rayss (HUJ 5515); Nahal Oren, 32°49'N, 35°46'E, 20.04.2004, S.O. Voytyuk; Zikhron Ya'aqov, 25.03.1954, T. Rayss (HUJ 301/46 47S). – HP: Dan (kibbutz, 10 km northeast of Qiryat Shemona), 20.03.1941, T. Rayss (HUJ 734). – JM: Deir esh Sheikh, 12.03.1941, T. Rayss (HUJ 735); Jerusalem, 'En Kerem, 13.04.1950, T. Rayss (HUJ 301/46 50S); Kefar HaShiloah, 09.01.1943, T. Rayss (HUJ 5346); Qiryat 'Anavim (near Abu Ghosh village), 03.04.1941, T. Rayss (HUJ 736). – SA: Hadera, 29.04.1953, T. Rayss (HUJ 301/46 48S). – UG: Zefat, 10.04.1951, T. Rayss (HUJ 301/46 49S). – Israel, 10.04.1946, T. Rayss (HUJ 7215); (Amano 1986).

On *Melissa officinalis* L. – CM: Haifa, University of Haifa, 02.03.2004, S.O. Voytyuk (anamorph). – Israel (Amano 1986).

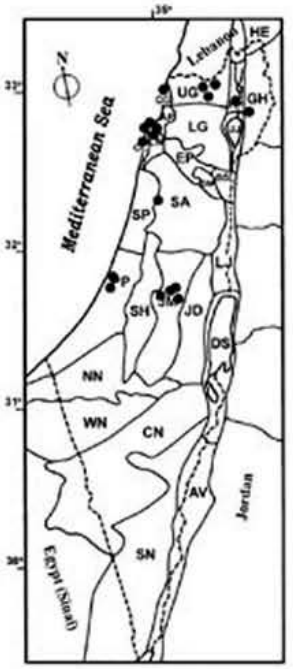

Figure 4: Distribution of *Neoerysiphe galeopsidis* in Israel

On *Prasium majus* L. – CC: 'Atlit, 32°42'N, 34°56'E, 21.04.2004, S.O. Voytyuk. – CG: Akhziv Beach (near Naharyya), 33°02'N, 35°05'E, 21.04.2004, S.O. Voytyuk. – CM: Nahal Oren, 13.03.2002 (anamorph), V.P. Heluta. – PP: Tel-Aviv, University of Tel-Aviv, Botanical Garden, 32°06'N, 34°48'E, 21.04.2004, S.O. Voytyuk.

On *Stachys distans* Benth. – CC: 'Atlit, 32°42'N, 34°56'E, 26.03., 21.04., 27.04.2004, S.O. Voytyuk. – CM: Bet Oren (kibbutz), 04.04.1943, T. Rayss (HUJ 5678) (Rayss 1947). – JV: Megiddo (kibbutz), 32°35'N, 35°11'E, 21.06.2004, S.O. Voytyuk. – UG: Mazzuva, 20.03.1953, T. Rayss (HUJ 301/46 46S). – Israel (Amano 1986).

General distribution: Europe (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Greece, Hungary, Italy, Norway, Poland, Romania, European part of Russia, Slovak Republic, Spain, Sweden, Switzerland, Ukraine), **Asia** (Afghanistan, China, India, Iran, Iraq, Israel, Japan, Kazakhstan, Far East of Russia, Turkey), **Africa** (Canary Islands, Morocco, Republic of South Africa, western Sahara), **North America** (Bermuda Islands, Canada, USA), **New Zealand**.

Notes: This species was recorded from Israel as *Erysiphe galeopsidis*, *E. biocellata*, *E. cichoracearum* and *Oidium gigasporum* (Rayss 1940, 1947; Chorin & Palti 1962; Amano 1986).

Neoerysiphe galeopsidis is common and widespread in Israel. Development of the fungus starts during late February and early March, and numerous chasmothecia with dark pigmented appendages are formed on the surface of leaves and stems in early May.

Neoerysiphe galii (S. Blumer) U. Braun, Schlechtendalia 3: 50 (1999) (Fig. 6d)

Mycelium on stems, leaves, effuse or in patches, evanescent to subpersistent. Hyphae septate, (1–) 4–7 (–9) µm in wide. Appressoria nipple-shaped to slightly lobed. Anamorph *Oidium* s. str. Conidiophores erect, foot-cells straight, cylindrical. Conidia in chains, cylindrical to doliform, 19–25 (–38) × (8–) 10–15 (–18) µm. Chasmothecia scattered, (100–) 120–170 µm in diam. Appendages in the lower part of the ascocarp, number variable, few to numerous, (0.25–) 0.5–1.5 times as long as the chasmothecia diam, often shorter than the chasmothecium diam, 2–9 (–10) µm in wide, thin-walled, mycelium-like, septate, hyaline, later faintly pigmented. Asci 4–10, short-stalked, 30–40 (55) × (18–) 22–38 µm. Ascospores were not developed.

Distribution in Israel (Fig. 5):

On *Galium aparine* L. – **UJ**: Qiryat-Tiv'on, Simtat Alivne St., 12.05.2004, S.O. Voytyuk (Voytyuk et al. 2004b).

General distribution: Europe (Austria, Belgium, Bulgaria, Czech Republic, Finland, France, German, Great Britain, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Romania, European part of Russia, Spain, Switzerland, Sweden, Ukraine), **Asia** (Afghanistan, China, India, Iran, Israel, Korea).

Notes: Fungus was found in Israel only once. In further investigations, no additional location for this species was found.

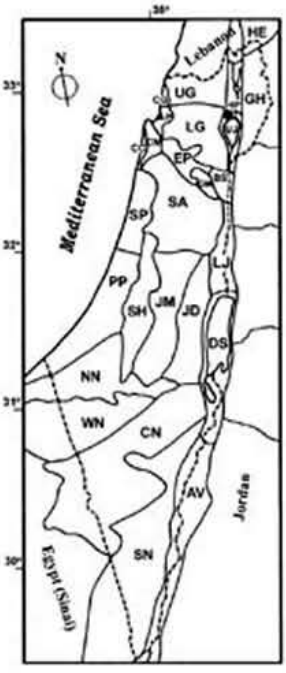

Figure 5: Distribution of *Neoerysiphe galii* in Israel

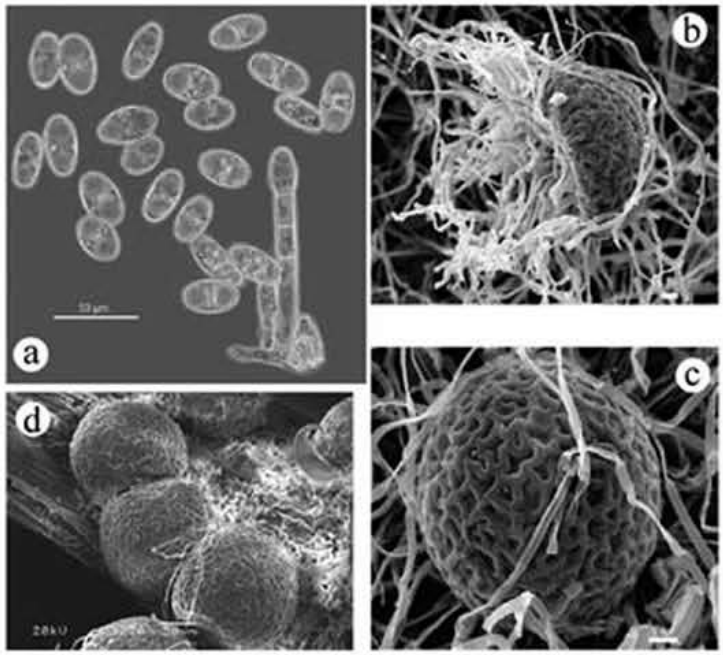

Figure 6: ***Neoerysiphe galeopsidis***: a – conidiophore and conidia on *Lamium moschatum*; b, c – chasmothecia on *Prasium majus*; ***N. galii***: d – chasmothecia on *Galium aparine*

Conclusions

The results of our investigations have shown that *Neoerysiphe* species are very common in Israel, especially *N. cumminsiana*. Considering the fact that this species is fairly common in the Southern Ukraine and in Israel, we conclude that *N. cumminsiana* is possibly widespread in other Mediterranean countries. Therefore, comprehensive re-examinations of collections on composites from arid regions of Eurasia referred to *Erysiphe cichoracearum* are necessary to point out the genuine host range and distribution of *N. cumminsiana*.

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Characterization of three species of the genus *Coprotus* (Ascomycota) by isozyme analysis

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Abstract—Identification of *Coprotus* species has never been an easy task. Their morphological and cultural characteristics are very similar and this often makes species delimitation very difficult. In this study we first identified 44 monosporic strains of three species of the genus (*C. lacteus, C. niveus, C. sexdecimsporus*) by using exclusively morphological and cultural characters; then, an extensive isozyme analysis was performed as an additional taxonomical technique. Eleven isozyme systems were tested. Six of them were chosen for the following analysis. The phenogram (UPGMA) and the 3D graphic (ordination technique) clearly separated the three species. The results of this study support the utilization of isozyme patterns as a valuable additional tool in delimiting *Coprotus* species based on traditional taxonomical methods.

Keywords—fungi, taxonomy, phenetics

Introduction

The genus *Coprotus* Korf ex Korf & Kimbr. comprises homothallic species previously placed in *Ascophanus* Boud. and *Ryparobius* Boud. (Kimbrough 1966, Kimbrough et al. 1972). It was originally placed in the tribe *Theleboleae* (Bref.) Kimbr. (=*Pseudoascoboleae* Boud.) of the *Pezizaceae* Dumort., but in more recent studies the tribe was raised to family rank (Kimbrough & Gibson 1980). Since 1974, when Kish suggested transferring *Coprotus* to *Pyronemataceae* Corda, based on cytological and developmental studies, many other arguments have been found that strongly ratify this movement.

Coprotus includes those species of coprophilous discomycetes with non-amyloid operculate asci containing hyaline, smooth, elliptic ascospores that usually develop one de Bary bubble. Apothecia are small, superficial, sessile, white to bright orange, and pulvinate to discoid in shape. Paraphyses are always septate, simple or branched, and usually curved in the apex. Traditional identification of *Coprotus* species is exclusively based on cytological and

morphological characters, such as the number of ascospores per ascus, the presence or absence of pigments in paraphyses and excipulum, and the size and shape of asci, ascospores and sterile elements. However, difficulties often arise while attempting to identify *Coprotus* species, as they are morphologically very similar and characters frequently overlap.

In the last few decades, there has been a clear tendency towards the utilization of biochemical and molecular characters as a complement to the classic methods of fungal species identification. Morphological, cytological and developmental characters are not always sufficient to allow clear species identification, especially in taxonomical groups with overlapping characters, or simply in polymorphic fungi that change the size, shape and pigmentation of their structures according to the variation of environmental factors.

Isozymes are multiple forms of an enzyme that share a common substrate and catalyse the same reaction (Markert & Moller 1959). They can exist in the same individual or in different individuals of the same species or taxon, and catalyse reactions either in separate cellular compartments or tissues, or in different metabolic conditions (Markert 1975).

Isozyme analysis is one of the most commonly employed techniques to evaluate genetic variation at population and species level. This technique may provide essential data to clarify evolution and taxonomical problems, and it is particularly useful in classifying problematical groups, such as synmorphic species (Ferreyra 2000). In the past twenty years, isozyme analysis has been satisfactorily employed to delimit fungal taxa and to identify unknown fungi at species or subspecies level (Micales et al. 1992). Several authors have delineated fungal species using isozymes: *Puccinia* (Burdon et al. 1983, Newton et al. 1985), *Penicillium* (Cruickshank & Pitt 1987), *Rhizopogon* (Ho & Trappe 1987), *Agaricus* (Kerrigan & Ross 1988), *Glomus* (Hepper et al. 1988), *Phytophthora* (Erselius & de Vallavieille 1984, Bielenin et al. 1988, Blaha et al. 1994, McHau & Coffey 1995), *Pleurotus* (Boisselier-Dubayle 1983, May & Royse 1988), *Tremella* (Hanson & Kenneth 1991), *Arthrobotrys* (Araújo et al. 1997), *Ganoderma* (Gottlieb et al. 1998), *Saccobolus* (Ramos et al. 1999, Ramos et al. 2000), *Mucor* (Vagvolgyi et al. 2001), *Fusarium* (Laday & Szecsi 2002, Aly et al. 2003), *Polyporus* (Borges da Silveira et al. 2003), *Zygosaccharomyces* (Duarte et al. 2004), and *Ascobolus* (Dokmetzian et al. 2005).

Taking into account the difficulties that frequently arise when identifying *Coprotus* species by traditional methods, as well as the fact that it has been well proved that isozymes are useful for delimiting fungal species, we performed an extensive isozyme analysis to characterize three species of the genus. The particular purposes of this analysis were to establish the degrees of intra- and interspecific similarity and also to evaluate the phenetic relations between strains in order to confirm our previous species identification.

Materials and methods

Monosporic strains

Forty-four monosporic strains of three species of the genus *Coprotus* (*C. lacteus* (Cooke & W. Phillips) Kimbr. et al. (1972), *C. niveus* (Fuckel) Kimbr. et al. (1972) and *C. sexdecimsporus* (P. Crouan & H. Crouan) Kimbr. & Korf (1967) were obtained from individual ascospore germinations, following the procedure indicated by Gamundí & Ranalli (1964). They were all deposited in the BAFC Herbarium & Culture Collection of the Departamento de Biodiversidad y Biología Experimental, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires. Table 1 shows a list of the strains with their geographical location, substrate and BAFC number. Cultures of all of the monosporic strains were regularly kept in PF medium (yeast extract, 3 g; agar 18 g; distilled water, 1000 ml; a slice of filter paper) (Ranalli & Forchiassin 1974) at 5°C.

Table 1. List of strains with their geographical location, substrate and BAFC number.

Strain	Geographical location	Substrate	BAFC	Strain	Geographical location	Substrate	BAFC
Coprotus lacteus				*Coprotus niveus*			
lacA1	Agronomía	cow dung	874	nivE1	Bahía Ensenada	cow dung	1956
lacA2	Agronomía	cow dung	1936	nivE2	Bahía Ensenada	cow dung	982
lacA3	Agronomía	cow dung	1937	nivE3	Bahía Ensenada	cow dung	1957
lacA4	Agronomía	cow dung	1938	nivE4	Bahía Ensenada	cow dung	1958
lacA5	Agronomía	cow dung	1939	nivE5	Bahía Ensenada	cow dung	1959
lacA6	Agronomía	cow dung	1940	nivC2	Campana	cow dung	1960
lacA10	Agronomía	cow dung	1941	nivC3	Campana	cow dung	1961
lacA13	Agronomía	cow dung	1942	nivC4	Campana	cow dung	1962
lacA14	Agronomía	cow dung	1943	nivC5	Campana	cow dung	1963
lacL1	Villa Lugano	cow dung	1944	nivU1	Ciudad Universitaria	horse dung	1964
lacL3	Villa Lugano	cow dung	1945	nivU3	Ciudad Universitaria	horse dung	1965
lacL4	Villa Lugano	cow dung	1946	nivU6	Ciudad Universitaria	horse dung	1966
lacL6	Villa Lugano	cow dung	1947	nivU7	Ciudad Universitaria	horse dung	1967
Coprotus sexdecimsporus				nivU8	Ciudad Universitaria	horse dung	1968
sexG1	Los Gigantes	cow dung	1948	nivBC1	Bahía Craft	cow dung	1969
sexG2	Los Gigantes	cow dung	873	nivBC2	Bahía Craft	cow dung	1970
sexG3	Los Gigantes	cow dung	1949	nivBC3	Bahía Craft	cow dung	1971
sexG4	Los Gigantes	cow dung	1950	nivBC4	Bahía Craft	cow dung	1972
sexG7	Los Gigantes	cow dung	1951	nivL1	Villa Lugano	cow dung	1973
sexU1	Ciudad Universitaria	horse dung	1952	nivL3	Villa Lugano	cow dung	1974
sexU2	Ciudad Universitaria	horse dung	1953	nivL4	Villa Lugano	cow dung	1975
sexU4	Ciudad Universitaria	horse dung	1954	nivL5	Villa Lugano	cow dung	1976
sexU5	Ciudad Universitaria	horse dung	1955				

Bahía Craft = Villa La Angostura, Neuquén province; *Bahía Ensenada* = Tierra del Fuego province; *Campana* = Buenos Aires province; *Los Gigantes* = Córdoba province. *Agronomía*, *Ciudad Universitaria* and *Villa Lugano* are different locations in Buenos Aires city.

Identification of species

Morphological and cultural studies were carried out in order to identify the species. The former included diverse characteristics of apothecia, ascospores, asci, and paraphyses characteristics, whereas the latter emphasized the time and percentage of NaOH, incubation time at 37°C and the time in ET and solid GA media required for ascospore germination.

The key proposed by Kimbrough et al. (1972) was used for the identification of the species.

Growth media and culture conditions

Erlenmeyer flasks containing 50 ml of liquid growth medium GA (glucose, 10 g; asparagine, 4 g; $MgSO_4.7H_2O$, 0.5 g; KH_2PO_4, 0.5 g; K_2HPO_4, 0.6 g; $CuSO_4.5H_2O$, 0.4 mg; $MnCl.4H_2O$, 0.09 mg; H_3BO_3, 0.07 mg; $NaMoO_2.2H_2O$, 0.02 mg; $FeCl_3$, 1 mg; $ZnCl_2$, 10 mg; biotine, 5 µg; thiamine-HCl 0.1 mg; bidistilled water to complete 1 litre) (Galvagno 1976), were inoculated with a 5 mm^2 squares taken from a 5 to 10-day-old colony of monosporic strains growing in solid GA medium (glucose, 10 g; agar, 18-20 g; L-asparagine, 1.35 g, $MgSO_4.7H_2O$, 0.5 g; KH_2PO_4, 0.5 g; K_2HPO_4, 0.6 g; $CuSO_4.5H_2O$, 0.4 mg; $MnCl.4H_2O$, 0.09 mg; H_3BO_3, 0.07 mg; $NaMoO_2.2H_2O$, 0.02 mg; $FeCl_3$, 1 mg; $ZnCl_2$, 10 mg; biotine, 5 µg; thiamine-HCl 0.1 mg; bidistilled water to complete 1 litre) (Galvagno 1976).

Liquid and solid cultures were both incubated in a New Brunswick Psicrotherm G-27 chamber, at 23°C, permanently lit by four fluorescent tubes of 20 W each; liquid cultures were placed in a rotary shaker at 125 rpm during incubation.

Growth media were sterilized at 121°C and 1.2 atm for 20 minutes.

Preparation of extracts

Mycelia were harvested from liquid cultures one to two days before they reached maximum growth, which was established by growth curves previously charted for each species.

Mycelia were vacuum filtered in a Buchner funnel, through Whatman GP filter paper, washed several times with bi-distilled water, dried with filter paper and stored at –70°C until used (Dessauer et al. 1984).

Extracts were prepared by freezing the mycelia with liquid nitrogen and crushing it several times in a steel mortar, and crushing it once again adding extraction buffer (0.1 M Tris-HCl buffer, pH 7.5); 0.1% v/v 2-mercaptoethanol; 0.001 M ethylenediaminetetraac etic acid (EDTA); 0.01 M KCl; 0.01 M $MgCl_2.6H_2O$; 10% p/v polyvinyl polypyrrolidone (PVP) 10.000) (Soltis et al., 1983). Homogenates were divided into small fractions and stored at –70°C (Dessauer et al. 1984).

Electrophoresis and enzymatic dying

A horizontal electrophoresis technique (Beckman & Johnson 1964) was performed to test eleven isozyme systems. Native gels were prepared using a 7% concentration of polyacrylamide (Saidman 1985). Table 2 shows a list of the eleven isozyme systems tested with their abbreviation and EC number as stated in IUPAC-IUB, Enzyme Nomenclature (1984).

Buffer solutions (gel buffer (a) and electrode buffer (b)) varied according to the specific isozyme system tested. Buffer: (a) Lithium borate pH 8.1 and (b) Lithium borate pH 8.5 (Scandalios 1969, modified by Saidman 1985) was used for AAT, EST and SOD; Buffer: (a) Tris-citrate pH 6.5 and (b) Tris-citrate pH 7 (Selander et al. 1971, modified by Saidman 1985) was employed for ACP, ALP, G6PD, GDH and IDH; and Buffer: (a) and (b) Tris-citrate pH 8 (Soltis et al. 1983) was chosen for the LAP, MDH and SKD systems.

Rectangles of 2 x 4 mm of Whatman N°3 paper were soaked in the protein extracts after thawing the samples, and were introduced into grooves made in the gel (20 per gel). Bromophenol-blue (4 mg/ml) was used as dye marker. Electrophoreses were carried out at 4°C and 100 volts for three to four hours, until the dye marker was at 3-4 cm from the end of the gel.

Staining procedures were performed according to Manchenko (1994) for ACP, ALP, G6PD, IDH and SKD; Soltis et al. (1983) for LAP; Wendel & Weeden (1989) for EST, GDH, MDH and SOD; and Vallejos (1983) for AAT. Once stained, gels were photographed and fixed with a solution of ethanol/ water/ acetic acid (5: 5: 1). Gels were finally transferred to a plastic bag, heat-sealed and kept at room temperature.

The relative position (Rf) of each band of enzymatic activity was determined as the ratio between the migration distance of each band from origin and the migration distance of the dye marker from origin.

Electrophoresis was repeated at least twice for every isozyme system for each strain. Electromorphs were drawn with the average Rf for each band.

Table 2. Isozyme systems tested, their abbreviation and EC number

Isozyme system	Abbreviation	EC number
Aspartate aminotransferase	AAT	2.6.1.1
Acid phosphatase	ACP	3.1.3.2
Alkaline phosphatase	ALP	3.1.3.1
Esterases	EST	3.1.1...
Glucose-6-phosphate dehydrogenase	G6PD	1.1.1.49
Glutamate dehydrogenase	GDH	1.4.1.3
Isocitrate dehydrogenase (NADP)	IDH	1.1.1.42
Leucine aminopeptidase	LAP	1.4.1.9
Malate dehydrogenase (NAD)	MDH	1.1.1.37
Shikimate dehydrogenase	SKD	1.1.1.25
Superoxide dismutase	SOD	1.15.1.1

Numerical analysis

Statistical analyses were performed using the NTSYS-PC version 1.8 program (Rohlf 1993). The nine geographical groups of strains (groups of strains of the same species from the same geographical location) constituted the operative taxonomic units (OTUs), as no isoenzymatic differences were found between monosporic strains from the same geographical location.

Table 3. Morphological and cultural characters of the three *Coprotus* species

Character / Species	*C. lacteus*	*C. sexdecimsporus*	*C. niveus*
1. Apothecia			
Type of growth in the substrate	Solitary or gregarious	Solitary or gregarious	Solitary or gregarious
Colour when young	Translucid to white	Translucid to whitish	White or translucid
Colour when mature	Yellowish	Yellow to orange	Slightly yellowish
Form	Discoid to cupulate	Pulvinate	Discoid to cupulate
Diameter (µm)	200-500	500-1000	200-500
Other characteristics	Superficial, sessile, glabrous	Superficial, sessile, glabrous	Superficial, sessile, glabrous
2. Apothecial excipulum			
Texture	Angularis to globulosa	Globulosa	Globulosa to angularis
Staining	Cyanophilous and dextrinoid	Dextrinoid	Slightly cyanophilous
3. Asci			
Length (µm)	65-85	106-123	86-164
Width (µm)	15-20	23-28	29-41
Form	Clavate cylindrical	Clavate	Broadly clavate
Number of spores	8	16	64
Apex	Round or cupulate, central operculum	Round or cupulate, central operculum	Round, with a prominent central operculum
4. Ascospores			
Length (µm)	9.5-11	11.7-12.35	9.1-12.7
Width (µm)	5.8-6.5	7.8-9.1	5.9-7.3
Form	Elliptical	Elliptical	Elliptical
Colour	Hyaline	Hyaline	Hyaline
Exosporium	Smooth	Smooth	Smooth
Arrangement within the asci	Uniseriate or biseriate	Regularly biseriate, sometimes in threes in the apex	Irregularly arranged in the apical portion or occupying all the volume in small asci
5. Paraphyses			
Diameter (µm)	1.5-2	1.7-2.6	1.8-2.7
Form	Filamentous	Club	Filamentous
Branching	Simple or branched	Simple or bifurcated below	Simple or branched
Apex	Curved	Hooked	Curved
Other characteristics	Septate, slightly inflated	Hyaline, septate	Septate, hyaline, without oil droplets
6. Ascospore germination			
Optimum NaOH %	0.3	0.3	0.4
Treatment time with NaOH	30 minutes	30 minutes	20 minutes
Incubation time at 37°C	48-72 hours	48 hours	48 hours
7. Culture			
Mature fructifications in ET media	15 days	15-16 days	15 days
Mature fructifications in GA media	10 days	15-16 days	12 days

A data matrix was constructed by coding the presence (1) and absence (0) of bands (characters). A similarity matrix was then obtained by using the Simple Matching Coefficient (Sneath & Sokal 1973). Both a clustering method (Unweighted pair-group method using arithmetic averages, UPGMA) and an ordination technique (Principal Coordinates) were performed. With the former method, a phenogram was obtained, and the distortion produced during the grouping analysis was calculated with the cophenetic correlation coefficient (r) (Sokal & Rohlf 1962). A three-dimensional graphic was obtained with the ordination method.

Results

Morphological and cultural studies

Table 3 gives the morphological characters and cultural aspects observed for each *Coprotus* species. Overlapping of several qualitative and quantitative characters can be clearly seen in this table. For this reason, in many cases considerable difficulty was experienced in identifying the strains. A greater similarity between *C. lacteus* and *C. niveus* was observed.

Isozyme analysis

Only six of the eleven systems tested showed a good activity band resolution for every strain: AAT, ALP, EST, G6PD, IDH and SOD. The remaining systems (ACP, GDH, LAP, MDH and SKD) showed poor resolution, or none at all, and were therefore excluded from the following statistical analyses.

No isoenzymatic differences were found between strains from the same geographical location, and only EST revealed differences between geographical groups of the same species, thus proving the existence of a high intraspecific similarity.

Seventeen electromorphs were detected for the six systems chosen. Photographs of gels and zymograms of each electrophoretical phenotype are shown in Figures 1 and 2.

Two electromorphs were found for the AAT, IDH and SOD systems. In each case, all geographical groups of *Coprotus lacteus* and *C. niveus* shared an electromorph (A), while the two geographical groups of *C. sexdecimsporus* displayed a different pattern (B). Only one activity-band characterized the two electromorphs of AAT and IDH, while four bands were revealed in the two patterns found for SOD.

The ALP system was the only one that revealed a diagnostic pattern for each species (A-C), the three of them with only one band of enzymatic activity.

The G6PD system did not show differences between geographical groups or between species. Only one electromorph was found, with one band of Rf 16.

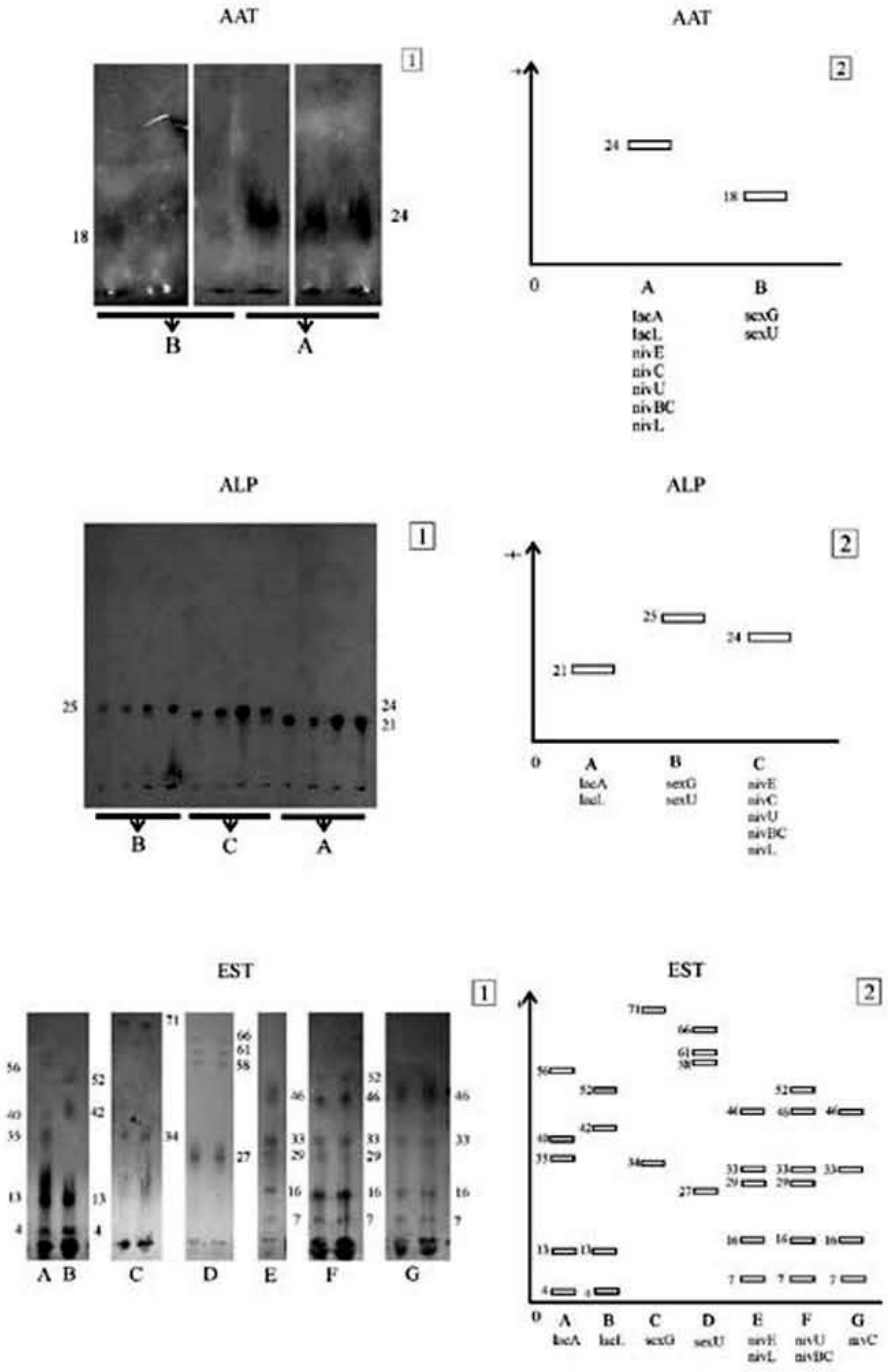

Figure 1. Gels photographs (1) and zymograms (2) of each electrophoretic phenotype found for AAT, ALP and EST isozyme systems. The geographical groups corresponding to each electromorph are indicated in (2).

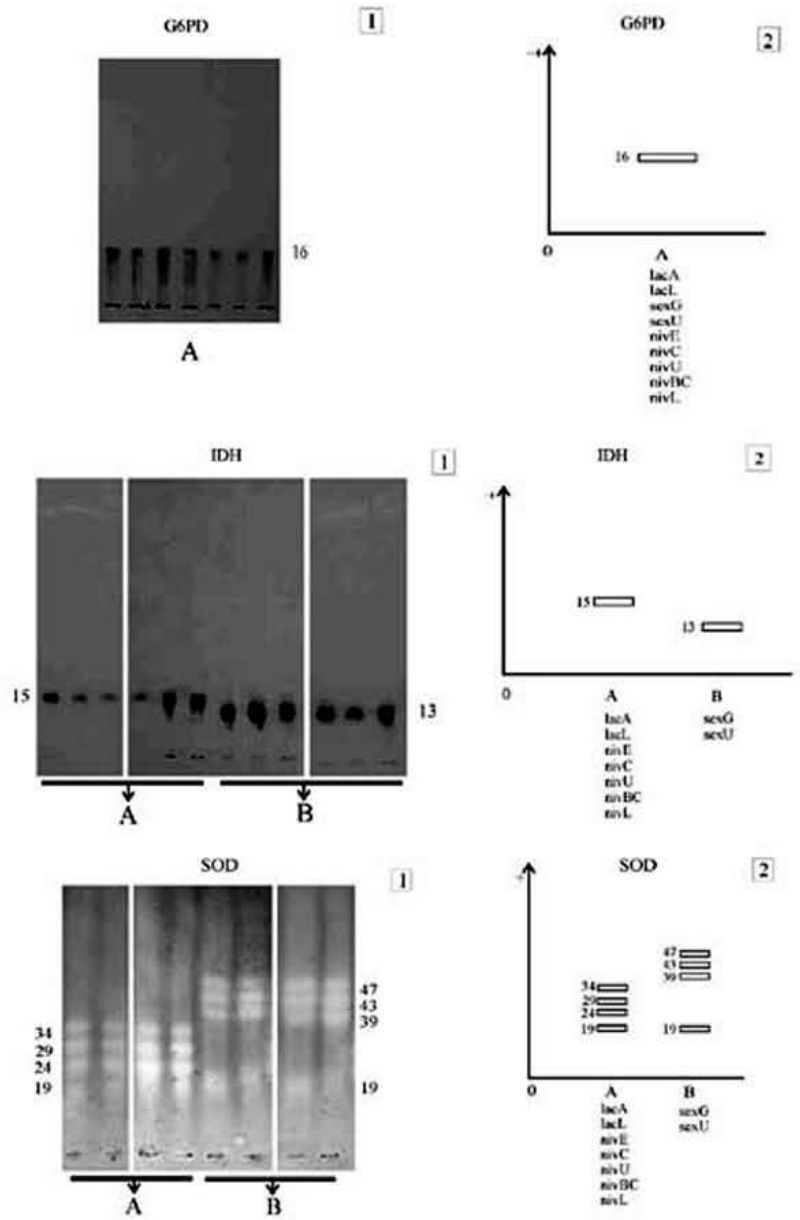

Figure 2. Gels photographs (1) and zymograms (2) of each electrophoretic phenotype found for G6PD, IDH and SOD isozyme systems. The geographical groups corresponding to each electromorph are indicated in (2).

On the contrary, EST was the system that revealed the greatest number of activity-bands and also the only one that allowed us to distinguish between geographical groups of the same species. The two geographical groups of *C. lacteus*, as well as the two of *C. sexdecimsporus*, showed a characteristic band pattern for EST (patterns A to D). The strains of *C. niveus* from Bahía Ensenada and Villa Lugano displayed another band pattern (E), and the same happened with those from Ciudad Universitaria and Bahía Craft, characterized by another electromorph (F). The group of strains from Campana revealed the seventh pattern (G) found for esterases for this species.

The phenogram obtained using the UPGMA clustering method is shown in Figure 3. Little distortion occurred while constructing this dendrogram, as implied by the value of the cophenetic correlation index (r=0.992). The three species are clearly separated in the phenogram. Apart from that, two main clusters of OTUs are distinctly seen: one of them covers the two geographical groups of *C. sexdecimsporus* with a similarity index of 80%, while the other includes all of the geographical groups of *C. niveus* and *C. lacteus*. This result reveals a higher isoenzymatic resemblance between these two species, which are associated by an index of 63%. The group of *C. sexdecimsporus* strains is associated to the other species by a remarkably low degree of similarity (33%). All the geographical groups corresponding to *C. niveus* proved to be practically identical, as in the phenogram they are related by a similarity index of 95%. The geographical groups of *C. lacteus* are associated to each other by an index of 84%, evidence of further isoenzymatic differences.

The three-dimensional graphic produced by the ordination technique (Figure 4) shows the same relations between different geographical groups and between species as the phenogram. It displays three main sets of OTUs separated in axes 1 and 2. The first one includes the two geographical groups of *Coprotus lacteus*, a little differentiated in axis 1 but very closely attached in the other two axes. The second set shows the five geographical groups of *C. niveus* joined closely together in the three axes, thus revealing a high degree of similarity. The third and last main set of OTUs comprises the two geographical groups of *C. sexdecimsporus*, which are very close to each other in axes 1 and 2, but are largely separated in axis 3. The differences among species as a unit also agree with the associations obtained with the phenogram: *C. lacteus* and *C. niveus* separate from each other in axes 1 and 2, but in axis 3 they are practically at the same level. *C. sexdecimsporus* separates itself from the other two species in the three axes, thus proving a higher isoenzymatic differentiation.

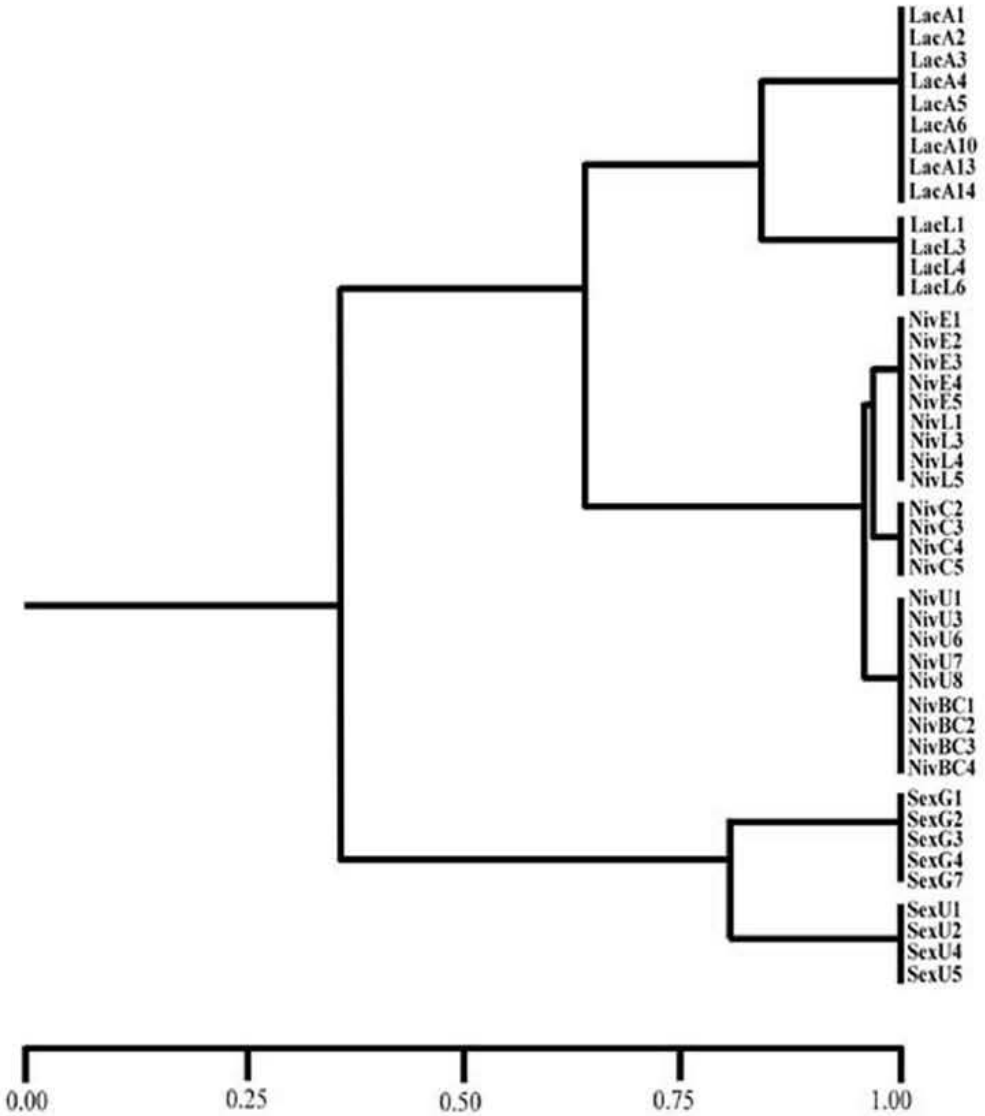

Figure 3. Phenogram obtained using UPGMA clustering method. For details on the strains, see Table 1.

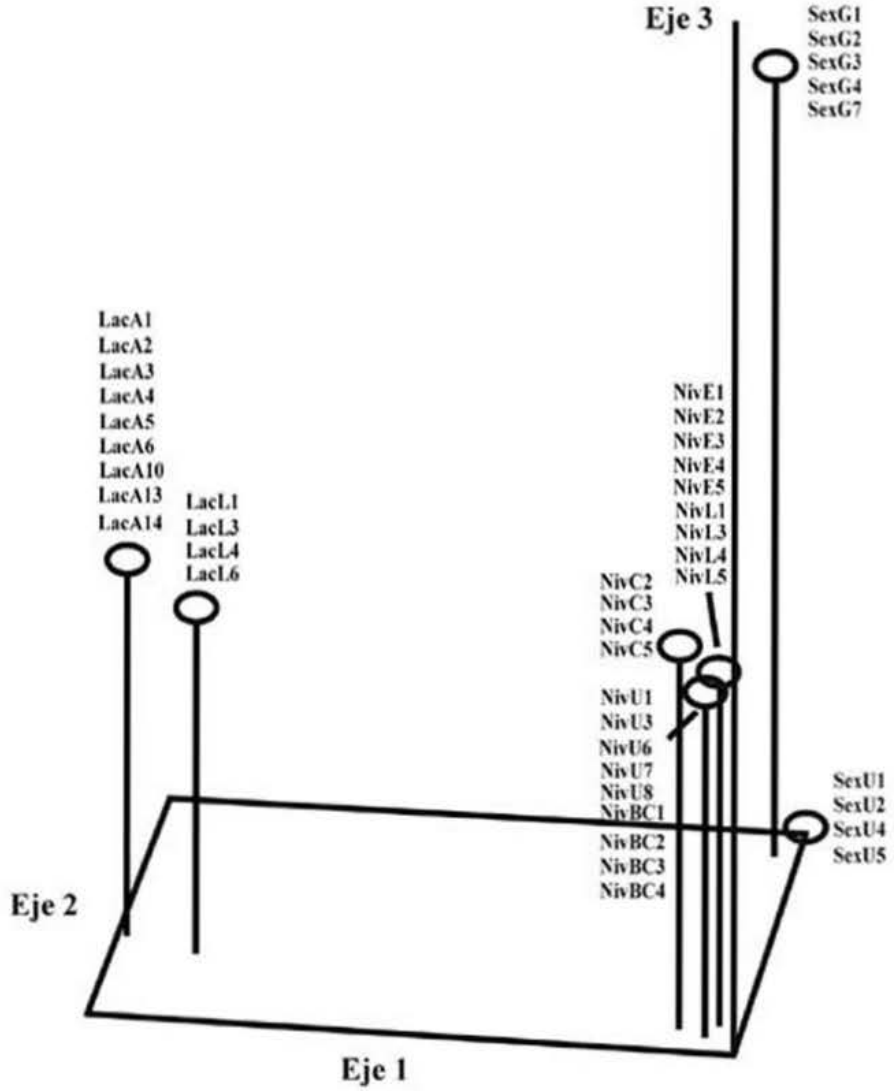

Figure 4. Three-dimensional graphic obtained with Principal Coordinates ordination technique. For details on the strains see Table 1.

Discussion

Although identification of the species was possible, morphological and cultural characterization of the strains proved the high similarity and coincidences in many of the characters traditionally used for identifying *Coprotus* species. Harrington & Rizzo (1999) suggest that the most important diagnostic characters to delineate fungal species would be those phenotypic characters

associated with the ecological niche, as they would play a decisive role in developing and maintaining fungal species through evolution. Hence, species should be delineated considering not only morphological but also other phenotypic characters, such as physiological and biochemical characteristics, including isozymes.

Another interesting result from cultural and morphological observations is that both qualitative and quantitative characters show that *C. lacteus* is more similar to *C. niveus* than to *C. sexdecimsporus*.

The isoenzymatic results confirmed the previous identification of the strains using morphological and cultural characters. Both the phenogram and the ordination graphic showed the same three clearly separated clusters of OTUs (geographical groups), each of them corresponding to one of the three species. The phenogram also showed that there is a greater isoenzymatic resemblance between *C. lacteus* and *C. niveus*, and this result is consistent with previous morphological observations.

The scarce intraspecific variability encountered during isozyme analysis highlighted interspecific differences. This was crucial for our work, because when high intraspecific variability exists it overshadows the differences between species, thus reducing the efficiency of the technique used to separate them. Studies using enzymes that detect high levels of intraspecific variability are incapable of distinguishing species (Racine & Langley 1980). Different types of enzymes show different levels of intraspecific variation according to the selection forces they are subjected to (Johnson 1974). Regulatory enzymes of the energetic metabolism, and even the enzymes that regulate the intermediate metabolism, generally evidence a lower variability than non-regulatory enzymes such as esterases. Despite the slight overestimation of the differences they may cause between OTUs, isozyme systems that generally reveal intraspecific variability, such as EST, are also crucial in achieving correct species characterization. Both types of enzymes (regulatory and non-regulatory) are therefore necessary to prevent overestimation and underestimation of isozyme variability within and between populations.

ALP was the only system that showed a diagnostic electromorph for each species. Hence, this was the most useful system in confirming our previous species identification. In any study that uses isozymes to identify species this is the expected kind of result, as they reveal a clear and easy species distinction.

The existence of band patterns shared by two or more species is consistent with the high overlapping in morphological characters associated with them. In addition, the fact that only one band for each species in the majority of the systems analyzed was obtained is in accordance with the fact that *Coprotus* species are haploid fungi with only one locus per enzyme (Ramos 1998).

The generally low intraspecific variability found may be related to habitat and the type of sexual reproduction of the *Coprotus* species. They are homothallic organisms, which is not unusual among coprophilous fungi. As they live in pieces of dung (island substrate), they undergo reproductive isolation. In these cases, homothallism allows them to complete their biological cycle and to reproduce sexually without requiring another thallus. Mutations are the principal source of genetic variation in a haploid homothallic organism, which explains the relatively scarce intraspecific isoenzymatic variability found in this study. The correlation between the degree of enzymatic variability and the type of reproduction and the habitat of organisms has been studied by several authors in recent decades. Burdon et al. (1983) found that there was no isoenzymatic variability in *Puccinia graminis* f. sp. *tritici* when it reproduces asexually. The same behaviour was observed in *Phakopsora pachyrhizi* (Bonde et al. 1988) and *Puccinia striiformis* (Newton et al. 1985), both pathogens that do not reproduce sexually. Harrington et al. (1996) observed very low isoenzymatic variability in homothallic *Ceratocystis* species and a much higher variability in those heterothallic species of the genus. Ramos (1998) worked with *Saccobolus* species, homothallic coprophilous fungi, also obtaining low isoenzymatic variability. This was the case for Dokmetzian (1999) while working with *Ascobolus*: as these are heterothallic and coprophilous fungi, the low variability may be due in this particular case to homogeneous environmental conditions rather than to the type of reproduction. In a heterogeneous environment, the optimum evolutionary strategy for enzymes would be the existence of multiple forms of the enzyme, rather than only one alternative with high capacity (Johnson 1974). Heterogeneity of enzymes provides organisms with metabolic versatility, thus generating a higher biological efficiency in heterogeneous environments (Zeidler 2000). As regards coprophilous environments, which are often quite homogeneous, it would seem that coprophilous fungi do not require a high isoenzymatic variability to survive. However, the dung microhabitat is slightly conditioned by climatic factors, plant cover and soil properties, which determine the temperature and humidity of the substrate, factors that in turn indirectly influence metabolic activities and the competitive capacity of organisms (Wicklow 1981). Therefore, having different isozyme systems, at least in non-regulatory systems (such as EST), is always a benefit for these fungi.

Principal Coordinates analysis revealed the same groupings as the phenogram and even the same intraspecific differences. This provides much greater reliability in the relationships among species and among populations found in this study.

Considering that isozyme characterization of the three *Coprotus* species allowed us to clearly identify each geographical population and each species, and that it confirmed our previous identification, this technique may be considered

an important additional tool to the traditional taxonomic methods, particularly in problematical groups as *Coprotus*, in which overlapping of characters and high interspecific similarity usually make species identification difficult.

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MYCOTAXON

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Schadonia indica, a new corticolous species from tropical India

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Abstract–*Schadonia indica* is described as new to science. It is a corticolous species, with *Bacidia*-type, eight-spored asci, ellipsoidal to ovoid, hyaline, muriform ascospores, occurring in the tropical region.

Key words–*Bacidiaceae*, crustose lichen

Introduction

The genus *Schadonia* is characterized by having crustose thallus, lecidioid apothecia with dark hypothecium, thin, branched and anastomosed paraphyses, cylindrical-clavate, *Bacidia*-type, 2–8 spored asci with strongly I+ blue tholus, and hyaline, muriform ascospores. It superficially similar to *Lopadium* with respect to lecidioid apothecia, hyaline, muriform ascospore and hence there is a chance for confusion between the two genera. However, *Lopadium* differs in having simple paraphyses with dark brown conical caps and single-spored asci that lack distinct apical dome (Purvis et al. 1992). The new species *Schadonia indica* is the first representation of this genus from the country. All the other species of *Schadonia* described elsewhere from the world are reported to grow on mosses in temperate to alpine regions, whereas *S. indica* was found growing in tropical regions of central India, at the base of mature *Shorea robusta* trees together with mosses.

Materials and methods

Specimens were examined morphologically, anatomically and chemically. Thin hand sections of apothecia and thalli were mounted in plain water, cotton blue, 5% KOH, or iodine solution and observed under a compound microscope. For chemical spot reaction the usual reagents of K, C and PD were used. TLC was performed in solvent system A following Walker & James (1990).

Schadonia indica Upreti & Nayaka sp. nov. Fig. 1-5

MYCOBANK #: MB 510306

Thallus corticolus, crustaceus, granulosus vel coralloideus, viridulo-fuscus, continuus, haud limitatus, ecorticatus, cellulis algarum chlorococcoideuis, prothallo nullo instructus. Apothecia dispersa, sessilia, basim constricta, orbicularia, 0.5–1.2 mm lata; discus fuscus vel badiofuscus, planus demum concavus vel raro convexus, epruinosus; marginibus distinctis, concoloris disco vel paulum pallidioris. Excipulum lecidinum, hyphis radiantibus, cellulis ± isodiametricis, pseudoparenchymaticis, K–; epihymenium luteolum vel brunneolum, K–; hymenium hyalinum, 70–80 µm crassum, I+ caeruleum; subhymenium hyalinum, 40–45 µm crassum, I+ caeruleum; hypothecium fuscum, K–. Asci 8-spori, clavati, 40–45 µm longi, 6–8(–10) µm lati, tholus I+ caeruleus, typo "Bacidia" dicto. Ascosporae hyalinae, muriformae, ellipsoideae vel ovoideae, 14–17 x 4–7 µm. Paraphyses ramosi et anastamosi.

Etymology: From India, the country from where the first collection is described.

Holotypus: INDIA, Madhya Pradesh, Dinodri district, 8 km before Kabir from Chauradadar, 650 m, 06-07-2005, Upreti, Nayaka & Satya 05-005712/A (LWG–holotype).

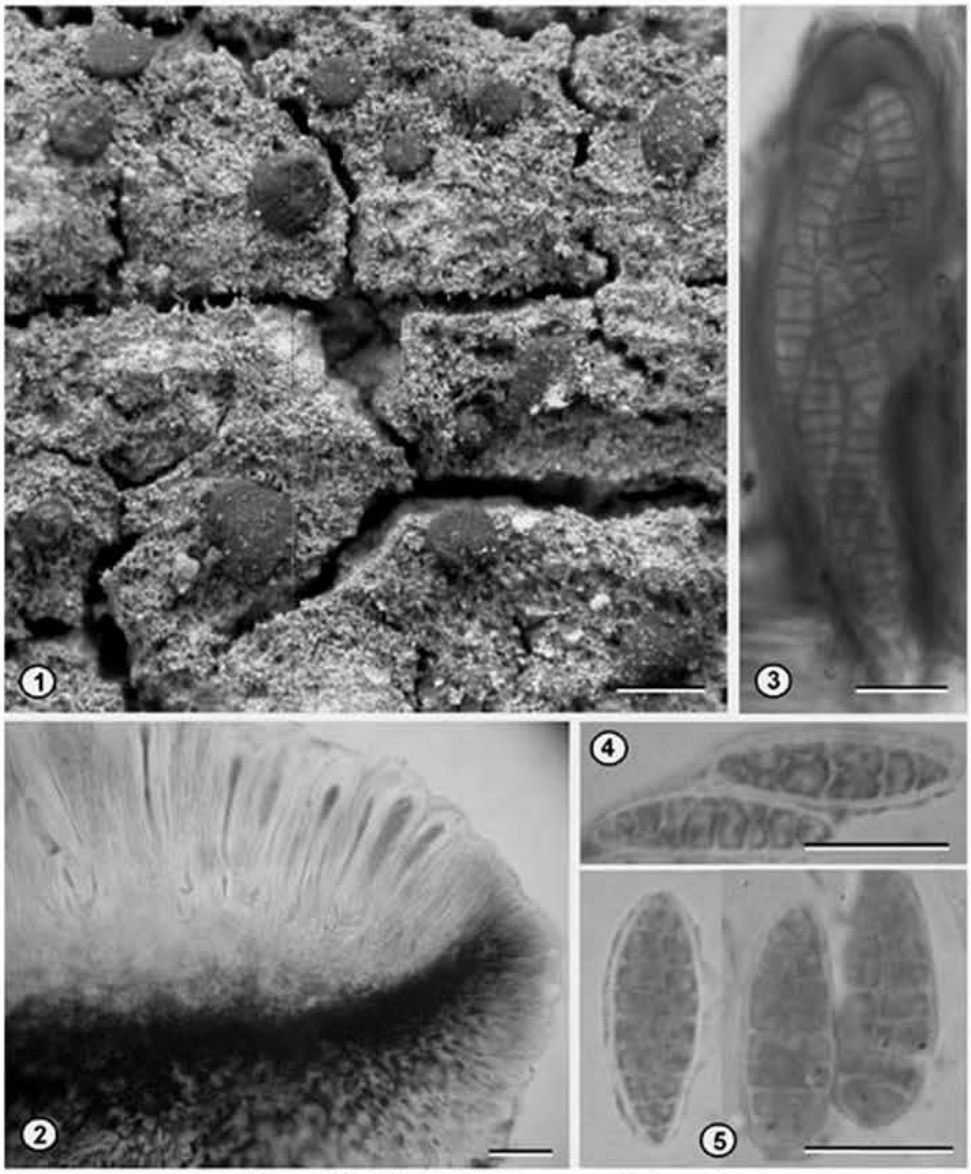
Thallus corticolous, crustose, scurfy, granular to coralloid, greenish brown, continuous, not delimited; ecorticate, photobiont chlorococcoid; prothallus absent.

Ascomata apothecia, scattered, sessile, constricted at base, roundish, 0.5–1.2 mm in diam.; disc brown to dark brown, plane to concave or rarely convex, epruinose; margin prominent, thick, concolorous with the disc or slightly paler. Exciple in section lecidine, darker towards base and inner side; hyphae radially oriented; cells more or less isodiametric, pseudoparanchymatous, K–; epihymenium yellowish to brownish, K–; hymenium hyaline, 75–80 µm high, I+ blue; subhymenium hyaline, 40–45 µm, I+ blue; hypothecium pale to dark brown, K–. Asci 8 spored, clavate, 40–55 x 10–22 µm; tholus I+ blue, *Bacidia*-type; ascospores hyaline, muriform, with 6–8(10) transverse septa, 1–2 vertical septa, with 15–20 cells arranged in 5–6 tyres, 14–17 x 4–7 µm, ellipsoid to ovoid; immature spores sometimes only transversely septate; paraphyses branched and anastomosed, thin, apical cell slightly swollen (in K).

Chemistry: K+ red, C–, KC+ red, P–. No lichen substances in TLC.

Distribution and ecology: All the three recognized species of *Schadonia* (*S. alpina* Körb., *S. fecunda* (Th. Fr.) Vězda & Poelt, and *S. subobscurata* (Vain.) Kalb.) are temperate species and growing over mosses. However, *S. indica* is a corticolous species growing luxuriantly on the bark of old *Shorea robusta* among mosses on trees at altitudes of 500–700 m.

Remarks: Schadonia indica is characterized by a corticolous, scurfy, granular thallus, brown apothecia, and ellipsoid to ovoid, muriform ascospores. It is close to *S. fecunda* with respect to thallus morphology, ascus and ascospore characters. However, *S. fecunda* differs in having black apothecia, a K+



Figure–1-5. *Schadonia indica* sp. nov. (holotype)
1. Habit; **2.** L.S. of apothecia;
3. Ascus with spores and I+ blue tholus;
4. Immature ascospores with vertical septa; **5.** Mature ascospores.
(Bars, Fig. 1 = 2 mm, 2 = 20 µm, 3,4&5 = 10 µm)

purplish-brown epihymenium and a K+ deep red-brown hymenium (Purvis et al. 1992).

ADDITIONAL SPECIMENS EXAMINED–MADHYA PRADESH: Dinodri district, 8 km before Kabir from Chauradadar, 650 m, 06-07-2005, Upreti, Nayaka & Satya 05-005706 (LWG); near Kabir, 600 m, 08-07-2005, Upreti, Nayaka & Satya 05-005807 (LWG).

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MYCOTAXON

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Phylacia mexicana sp. nov. and consideration of other species with emphasis on Mexico

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Abstract—The known species of *Phylacia* in Mexico are discussed. *Phylacia mexicana* is described as a new species from the states of Chiapas and Veracruz. A key to the known species is included. The affinities among *Phylacia* and other genera are considered.

Key words—Ascomycotina, *Xylariaceae*, *Phylaciaceae*, *Pulveria*

Introduction

Phylacia is a genus of large cleistocarpous pyrenomycetes of uncertain affinities. The genus is found mostly (perhaps entirely) in the American tropics. Dennis (1957) discussed and depicted six species and Speer (1980) described an additional two species. Rodrigues & Samuels (1989) described a large-spored variety of *P. bomba* Patouillard (1913) described *P. pusilla* Pat. from Asia; Hawksworth (1977) did not consider this to be a *Phylacia*.

In Mexico, only one study has been conducted on *Phylacia* (Pérez-Silva 1972), along with some isolated references that cite species from certain parts of the country (Welden & Guzman 1978, Varela & Cifuentes 1979, Díaz-Barriga et al. 1988). The objective of the present study is to examine *Phylacia*, principally in Mexico, and to describe *P. mexicana* as a new species. Material from other regions was also reviewed and new records are noted from the Bahamas, Belize, and Cuba. A key to described species is presented.

Materials and methods

Preparations in, 5% KOH, cotton blue, and Melzer's solution were employed to enhance microscopic examination. All material studied is deposited in the

Fungi Collection of the Herbarium of the Instituto de Ecología (XAL). Some are duplicates from the following herbaria: Escuela Nacional de Ciencias Biológicas (ENCB), Universidad de Guadalajara (IBUG), Universidad Autónoma Metropolitana (UAMIZ), and the personal herbarium of M.A. Vincent. Furthermore, the *P. turbinata* type from the Royal Botanical Gardens (K) was examined. Scanning electron micrographs were taken of the ascospores of most of the species studied.

The genus *Phylacia*

Phylacia Lév., Ann. Sci. Nat. Bot. Sér. 3, 3: 61. 1845.

Stromata solitary or gregarious, lignicolous, cleistocarpous, hemispherical, globose, pyriform, clavate or turbinate, apex rounded, sunken, or flattened, the interior of the upper parts composed of elongated tubular chambers in which asci are produced, disintegrating with age and leaving the mass of ascospores exposed. Stromata carbonaceous, dark brown to black, sessile or stipitate, 2-17 mm diameter, with surface rough or with slight ridges that create a rough appearance especially near the base, or with surface smooth. Asci globose, lacking stipe and apical apparatus, disintegrating with age, originating directly from the geniculated ascogenous hypha. Ascospores oblong-ellipsoid, ellipsoid, fusoid with rounded or somewhat tapered ends, yellowish, olive, olive-brown, or pale brown, lacking germ slits or perhaps easily discernible slits, with thin or thick wall; those of some species reaching a thickness of up to 1 µm. Paraphyses filiform, hyaline, abundant, with or apparently without septa.

Anamorph: *Geniculosporium* Chesters & Greenh. (Rodrigues & Samuels 1989).

Distribution: Tropical America. One species reported from Asia.

Phylacia species known in Mexico

Phylacia bomba (Mont.) Pat., in Duss, Énum. Champ. Guadeloupe: 74. 1903.

FIG. 1

The stromata are hemispherical to pulvinate and sessile in this species, along with ascospores (10–13 x 5–7µm) fide Dennis (1957, 1971) and Rodrigues & Samuels (1989). According to the material cited here, the diameter of stromata reaches up to 9 mm broad. Our observations suggest that this is the only species of the genus without a conspicuous entostroma. In Mexico, the species has only been previously reported from Veracruz (Pérez-Silva 1972).

Distribution: The Bahamas, Cuba, Mexico, Venezuela.

Specimens examined—THE BAHAMAS. ANDROS ISLAND, on dead upright wood of *Exothia paniculata*, 22-V-1988, Vincent 2796 (XAL).—MEXICO. COLIMA, Archipelago

Revillagigedo, Isla Socorro, *Ficus* and *Psidium* forest, on *Zantoxylum insulare*, 19-IV-1995, Gomez *876* (XAL).TABASCO, municipality of Huimanguillo, Colegio Superior de Agricultura Tropical, cocoa plantation, 14-IX-1982, Rodriguez *890* (UAMIZ, dupl. XAL). QUINTANA ROO, trail to the sea from the Puerto Morelos-Tulum highway after the turn-off to Vallarta, disturbed tropical deciduous forest, 10-XI-1981, López *1795, 1796* (XAL), 15 km from Coba, highway to Xcan, disturbed deciduous forest, 12-XI-1981, López *1915* (XAL). VERACRUZ, Catemaco-Las Margaritas, Tebanca, 3 km from Coyame, pasture with tropical trees, 2-XI-1982, Chacon *867* (XAL), Los Tuxtlas region, near the UNAM Biological Station, 30-I-1988, Chacon *4035* (XAL), road to Montepío; Botanical Garden of the UNAM Biological Station tropical vegetation, 26-VII-1981, Guzman *19841* (ENCB, XAL); municipality of Catemaco, Cerro El Marinero, Ejido López Mateos, evergreen forest, 28-VI-1987, Mata *178* (XAL); Cordoba region, municipality of Ixtaczoquitlán, Metlac Bridge, montane rain forest, 28-IX-1996, Tapia *1540*, Huatusco-Maromilla highway near Puentecilla, 23-VIII-1984, Chacón *2366* (XAL); municipality of Las Choapas, 'El Milagro' Ranch, 5 km SW of Nueva Tabasqueña, 9-XII-2005, R. Medel *1191, 1194, 1201* (XAL).

Phylacia bomba var. ***macrospora*** K.F. Rodrigues & Samuels, Mem. New York Botanical Garden. 49: 293. 1989.

The larger ascospores 13.5–15.5 (–16.2) x 5.4–7 (–7.2) µm distinguish this variety from the type variety. The ascospores of the studied material were up to 7.2 µm wide. *Phylacia bomba* var. *macrospora* has not previously been recorded in Mexico.

Distribution: Guyana, Mexico.

Specimens examined—MEXICO. JALISCO, municipality of Casimiro Castillo, Autlán-Malaque highway, 20 km from Autlán, El Tigre, montane rain forest, 6-I-1985, *Fanti 468* (IBUG, dupl. XAL); VERACRUZ, Ixtaczoquitlán municipality, near Metlac ravine, 11.IX-1994, Navarro *593* (XAL).

Phylacia globosa Lév., Ann. Sci. Nat. Bot. Ser. 3, 3: 61. 1845.

FIGS. 2, 9

Stromata subglobose, sometimes pyriform, stipitate, (Dennis 1957, 1971; Rodrigues & Samuels 1989). In all the material examined the stromata were 4–6 (–10) mm diameter, smaller than the range 8–15 mm, reported by Rodrigues &Samuels 1989), spores size 9–15 x 5–7.5 (–8.5) µm. It is known in the Mexican states of Chiapas, Nuevo Leon, Puebla, Quintana Roo (Pérez-Silva 1972) and Veracruz (Welden & Guzmán 1978).

Distribution: Argentina, Brazil, Columbia, Guadalupe, Mexico, Venezuela.

Specimens examined—MEXICO. CHIAPAS, municipality of Ocozocuautla, El Ocote Ecological Reserve, disturbed evergreen forest, 14-II-1986, Carrión *795* (XAL), municipality of Palenque, Michol-Ha Waterfalls, high deciduous forest, 22-XII-1985, Chacón *3304* (XAL). Hidalgo, Km. 237 Tamanzunchale-Jacala highway, intersection with Miraflores, montane rain forest, 14-VIII-1980, Valenzuela *290* (ENCB, XAL). QUINTANA ROO, Puerto Morelos, CIQRO Botanical Garden, disturbed tropical

forest, 13-XI-1983, Escalante *191* (XAL); Puerto Morelos, semideciduous forest, 6-III-1990, Ancona *77* (XAL); **VERACRUZ**, between the Zacoapan and El Mirador, 5-V-1982, Brown *388* (XAL); municipality of Actopan, El Morro de la Mancha Ecological Reserve (CICOLMA) 19-V-1994, Rico *192* (XAL); municipality of Catemaco, Los Tuxtlas region, Santa Martha Road toward Bastonal, tropical forest, 9-III-1997, Mata *123* (XAL); between Catemaco and Sontecomapan, coffee plantation, 11-VII-1978, Guzmán *17146* (XAL); municipality of Coatepec, La Orduña, coffee plantation, 15-X-1983 Villarreal *975* (XAL); municipality of Coatepec, El Grande, coffee plantation, 16-V-2000, Jarvio *519* (XAL).

Phylacia mexicana Medel, J.D. Rogers & Guzmán **sp. nov.**
MB510251 **FIGS. 7-8, 14**

Stromata gregaria, corticibus erumpentibus, superficiaria, pseudoturbinata cum ambitibus rotundis praeditae, 5–10 mm alta x 4–10 mm diam., sessilia, plus minusve stipitata, fusca vel nigra, carbonacea, superficie aspro apicem versus. Apex stromatis latus, usque ad maturitatem fatiscentem; ascosporae cum orificio liberatis. Perithecia cylindrica ca. 2 mm longitudine, multa, compacta. Asci saccata, 24–27 x 9.5–10 µm, octopsori. Ascosporae luteae vel brunneolae, oblongo-ellipsoideae, leves, 8–9 (–10) x 4–5 µm, pariete usque ad 0.8 µm crassae, sine rima germinativa praeditae.

Holotype: Mexico, Chiapas, Palenque ruins, evergreen forest, 19-XII-1985, Chacón *3295* (XAL).

Stromata gregarious, erumpent through bark, superficial, pseudoturbinate, with rounded stromatal edges, 5–10 mm high x 4–10 mm in diameter, sessile or vaguely or definitely stipitate, dark brown to black, carbonaceous surface rough principally toward the apex, apex wide, disintegrating with age and leaving an orifice through which spores are expelled. Perithecia cylindrical ca. 2 mm in length, numerous, compact. Asci saccate, 24–27 x 9.5–10 µm, octosporous. Ascospores oblong-elliptical, 8–9 (–10) x 4–5 µm, yellowish-olive to pale brown, wall thick, up to 0.8 µm, smooth, lacking germ slit.

Habitat and distribution: gregarious on dead wood in evergreen and cloud forests, Mexico

Additional specimens examined—**MEXICO. VERACRUZ**, Los Tuxtlas region, limits of the UNAM Biological Station, tropical evergreen forest, 17-XII-1985, Chacón *3256* (XAL). Barranca San Miguel, near bridge, highway Fortin-Orizaba, 8-VII-1983, Guzmán 23369. Actopan muncipality, Ecological Refugee La Mancha, 7-XII-1994, Leal 487 (XAL)

Comments—As observed in Table 1, the material studied did not match any *Phylacia* species previously described. This fungus is characterized by its stromatal shape and ascospore size; furthermore, the ascospores have a thick wall and the globose asci are small. *Phylacia mexicana* is similar to *P. glandulina* Speer in that both species have small spores, but the former reach up to 9 µm while the latter reach 11 µm. Speer (1980) also observed that *P. glandulina* has navicular spores like those of some species of *Xylaria* Hill ex Schrank, whereas in *P. mexicana*, they are oblong-elliptical. Unfortunately, comparison to the *P.*

Table 1. Comparative characters of *Phylacia* species

Species	Spores	Wall	Spore shape	Asci	Stroma shape	Refs.
P. bomba	10–13 x 5–7		oblong	not seen	hemispherical	2,3,4,5
P. bomba var. *macrospora*	13.5–15.5 (–16.2) x 5.4–7 (–7.2)		oblong	(13.5–)15–18 x 13.6–16	hemispherical	5
P. glandulina	7.5–11 x 5–6		navicular	20–25 x 10–15	clavate	6
P. globosa	9–15 x 5–7.5 (–8.5)	0.5-1	oblong	22–25.5 x 15–17.3	subglobose	2,3,4,5
P. mexicana	8–9 (–10) x4–5	0.8	oblong	24–27 x 9.5–10	clavate, flat top	
P. poculiformis	7-12.5(–15) x 5.5–7.5 (–9)	0.5-1	elliptic	25–30 x 10–13	pyriform	2,3,4,5
P. pseudohypoxylon	14–15 x 4.5–5		elliptic	45 x 14	cylindric	6
P. pusilla	8–9 x 4.5		ovoid	not seen	cylindric	7
P. sagraena	9.5–11 x 4.5–5.5		elliptic	21–28 x 10–14	pyriform	1,2,3
P. surinamensis	12–13 x 6–7		elliptic	not seen	cylindric	2
P. turbinata	11–13 x 5–6		elliptic	24–35 x 12–15	turbinate	2

References: 1) Ellis & Everhart, 1892; 2) Dennis, 1957; 3) Dennis 1971; 4) Pérez-Silva,1972, 5) Rodrigues & Samuels,1989) 6) Speer 1980; 7) Patoulliard,1913.

glandulina type was not possible, as it was not available in PC. With regard to stromatal shape in *P. mexicana*, it is clavate or somewhat obconic with an applanate apex and obtuse edges. A species that has similar characteristics is *P. turbinata*, although its stromata are definitely turbinate with sharp borders and larger, measuring up to 17 mm. According to the type, *P. mexicana* is a small species that only reaches 10 mm in diameter. In its thick-walled ascospores it resembles *P. globosa* and *P. poculiformis*. However, the former has globose stromata and large ascospores up to 15 µm, while in the latter the stroma is pyriform and the spores are large, up to 15 µm. Asci are also somewhat larger (25–30 x 10–13 µm) than those of *P. mexicana*.

Phylacia poculiformis (Kunze) Mont., Ann. Sci. Nat. Bot. Ser. 4, 3: 135. 1855.

FIGS. 3, 10

Stromata globose-pyriform with a narrow apex, stipitate and with thick- walled spores 7–12.5 (–15) x 5.5–7.5 (–9) µm and with wall up to 1 µm thick (see Dennis 1957, 1971; Silveira & Rodrigues 1985; Rodrigues & Samuels 1989). The stromatal size of the examined material agrees with Dennis (1957). It was described earlier from Baja California, Chiapas, Hidalgo, Michoacán, Puebla, Tabasco, and Veracruz (Pérez-Silva 1972, Frutis & Guzmán 1983; Díaz-Barriga et al. 1988).

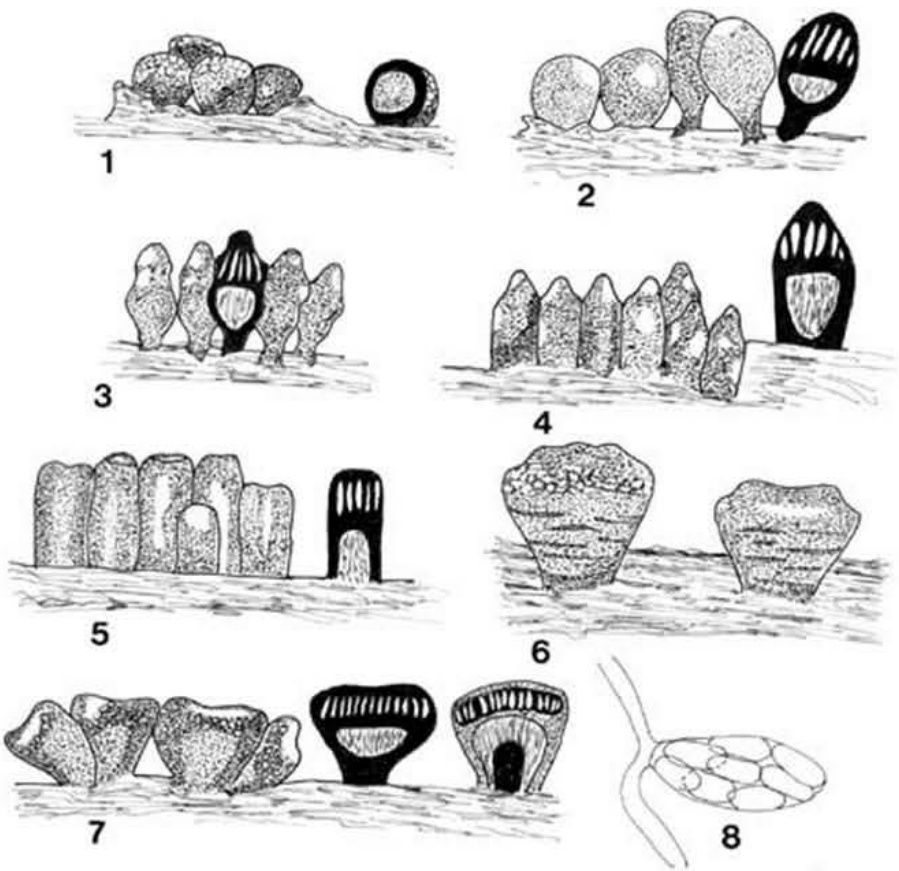
Distribution: Belize, Brazil, Columbia, Ecuador, Guyana, British Guyana, French Guyana, Mexico, Panama, Suriname, Venezuela.

Specimens examined—BELIZE, Stan Creek, Possum Point Biological Station near Sittee Village along Sittee River, on dead log, 14-VI-1992, Vincent *5309* (XAL). MEXICO. CAMPECHE, El Tormento Experimental Site for Tropical Forestry, 18-XI-1980, Chio *220* (ENCB, dupl. XAL); municipality of Calkini, Petenes Zone between El Remate and Punta Arenas, 19-XI-1981, Guzmán *21273* (XAL). CHIAPAS, Rosario Izapa Experimental Agricultural Field, Km 18 Tapachula-Cacahuatan highway, municipality of Tuxtla Chico, various fruit orchards, 15-XII-1995, Chacón *4979* (XAL); Km 40, Palenque-Ocosingo highway, evergreen forest, 20-XII-1985, *Chacón 3478* (XAL); municipality of Ocosingo, 2 km south of the Plan de Ayutla Bridge, evergreen forest, 22-I-1984, Sampieri *773* (XAL). OAXACA, pine plantation for the Tuxtepec paper factory, tropical zone, 21-VIII-1976, Betancourt *161* (ENCB, dupl. XAL). YUCATAN, Felipe Carrillo, Puerto Laguna Cana, 4-V-1990, *Ancona 85* (XAL). Veracruz, El Morro de la Mancha Biological Station, VERACRUZ, municipality of Actopan, 14-IX-1989, Bandala *1742* (XAL); sandy tropical forest, 26-VIII-1983, Chacón *1454* (XAL); Jalcomulco municipality, La Gotera ravine, cloud forest, 23-12-2000, Jarvio *860* (XAL); municipality of Las Choapas, 'El Milagro' Ranch, 5 km SW of Nueva Tabasqueña, 9-XII-2005, R. Medel *1195, 1198, 1206* (XAL)

Phylacia sagraeana (Mont.) Mont., Syll. Gen. Spec. Crypt.: 259. 1856.

FIGS. 4, 11

Stromata pyriform with a wide base, 1.5–3 mm wide and 2.6–6 mm high and ascospores 9.5–11 x 4.5–5.5 µm; these are salient characteristics of this species,



Figs. 1–8. 1: *Phylacia bomba* stromata and longitudinal view showing endostroma; 2: *P. globosa* stromata and longitudinal view showing endostroma; 3: *P. poculiformis* stromata and longitudinal view showing endostroma; 4: *P. sagraeana* stromata and longitudinal view showing endostroma; 5: *P. surinamensis* stromata and longitudinal view showing endostroma; 6: *P. turbinata*, stromata; 7-8 *P. mexicana*. 7: stromata and longitudinal view showing endostroma; 8: asci and ascospores.

according our observations and fide Dennis (1957). Rogers has observed what appear to be germ slits in a collection from Costa Rica (unpublished data). The stromata of the studied material are 2-6 mm broad and 1.5–6 mm high. This species is known from Mexico from the states of Tabasco and Veracruz (Pérez-Silva 1972).

Distribution: Cuba, Mexico, Nicaragua, Panama, Venezuela.

Specimens examined—CUBA. Mirador Biosphere Reserve, MAB region, Sierra del Rosario, Pinar Del Río, subtropical *Pinus* and *Quercus* rainforest , 27-X-1996, Guzmán *31736* (XAL). MEXICO. CHIAPAS, municipality of Ocosingo, Lacanjá-Chanzayab,

evergreen forest, 14-I-1984, Sampieri *608*, 20-XII-1985, Chacón *3445* (XAL). **NUEVO LEON**, municipality of Allende, Potrero del Alamo Ranch, tropical deciduous forest, 16-V-1994, Medel *619* (XAL). **OAXACA**, Putla de Guerrero, 25-V-1969, Zavala *s.n.* (ENCB, dupl. XAL). **QUINTANA ROO**, 20 km south of Km 77, Chetumal-Escarcega highway, road to Tomas Garrido before the turn-off to Tres Garantías, 8-XI-1981, Guzmán *20950* (XAL). **VERACRUZ**, municipality of Actopan, El Morro de la Mancha Ecological Reserve (CICOLMA), tropical deciduous forest, Chacón *5081* (XAL); Fortín de las Flores (Posada de la Loma), 9-VII-1983 Guzmán *23376* (XAL); Los Tuxtlas region, municipality of Catemaco Ejido López Mateos, tropical deciduous forest, 28-VI-1987 Chacón *4003* (XAL).

Phylacia surinamensis (Berk. & M.A. Curtis) Dennis, Kew Bull 12: 325. 1957.

FIGS. 5, 12

Stromata cylindrical, with center of stromatal apex concave, ascospores 12–13 x 6–7 µm, according to Dennis (1957) and Silveira & Rodrigues (1985). There are no data about stromata size in the literature, but the stromata of the material examined are 1.5–3 mm broad and 2.5–6 mm high. *P. surinamensis* is previously unreported for Mexico.

Distribution: Brazil, Guatemala, Mexico, Suriname.

Specimens examined—**MEXICO. OAXACA**, Cerro Cebastopol, 10 km south east of Tuxtepec, tropical zone, 2-VIII-1976, Betancourt *12* (ENCB, dupl.. XAL). **VERACRUZ**, municipality of Hidalgotitlán, Los Tuxtlas region, district of Uxpanapa, south west of highway 104, south east of Hermanos Cedillo, tropical forest, 17-III-1976, Guzmán *15527* (ENCB, dupl. XAL).

Phylacia turbinata (Berk.) Dennis, Kew Bull. 12: 323. 1957.

FIGS. 6, 13

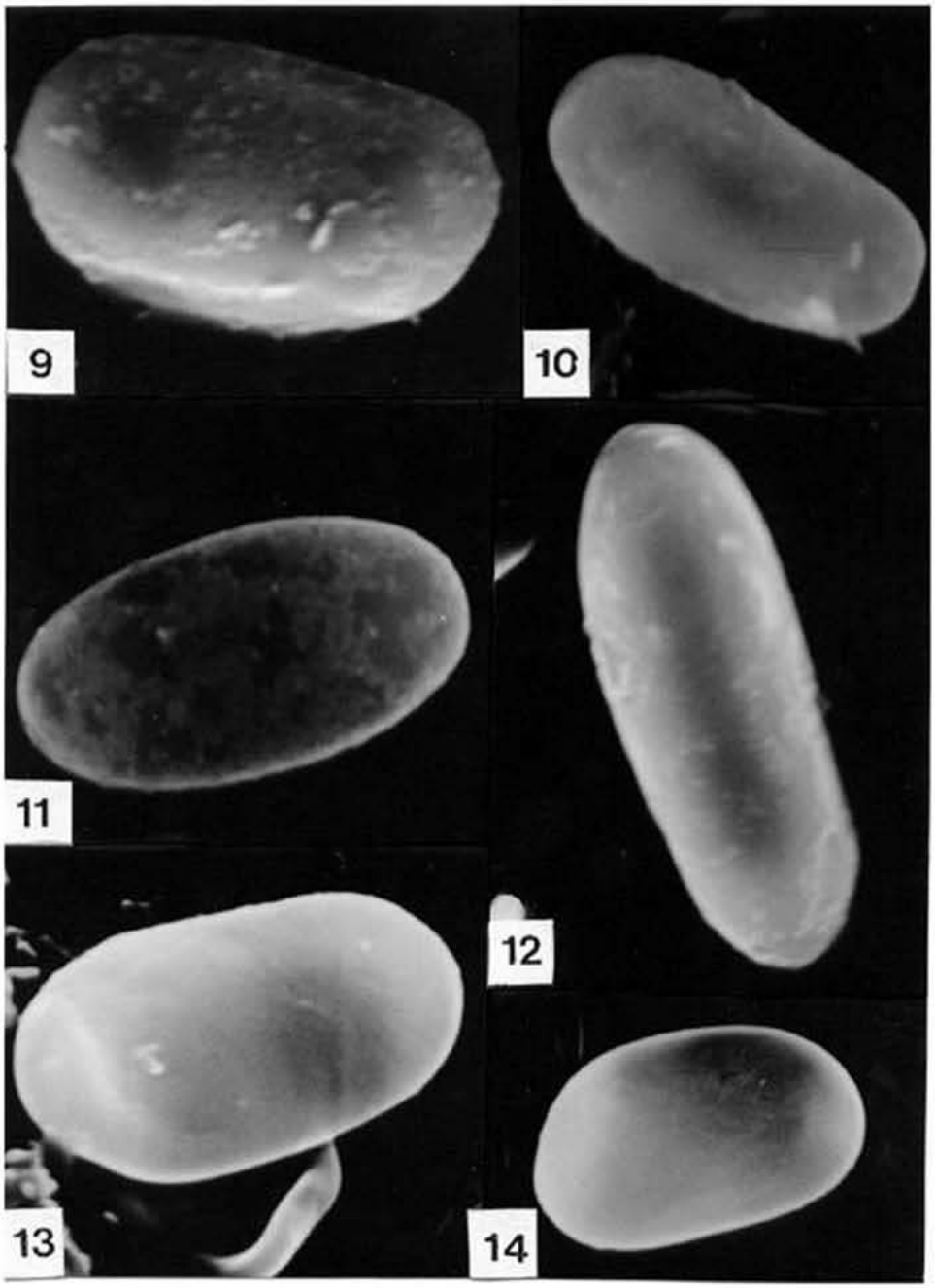
Stromata turbinate widening underneath the fertile part, ascospores 11–13 x 5–6 µm, fide Dennis (1957, 1971) and Silveira & Rodrigues (1985). According to our observation this is the largest species in the genus, reaching up to 17 mm diameter. Known from Mexico in Puebla, Quintana Roo, and Veracruz (Perez-Silva 1972).

Distribution: Brazil, Mexico, Paraguay.

Specimens examined—**BRAZIL**, Bahía, Challenger Expedition, Sao Leopoldo, Santa Catherina, 1879, Theissen s.n. (K, TYPE); Mata de Cantareira, Instituto Florestal Parque Estadual de Cantareira, near Sao Paulo, 5-III-1971, Guzmán *8865* (ENCB, dupl. XAL).

Phylacia species not examined

We were unable to evaluate type material of *P. glandulina, P. pseudohypoxylon* at PC and *P. pusilla* at FH since material was unavailable for study. We do include them in our key for completeness.



Figs 9–14. Scanning electron micrographs of spores (scale: 4000×).
9: *P. globosa*; 10: *P. poculiformis*; 11: *P. sagraeana*;
12: *P. surinamensis*; 13: *P. turbinata*; 14: *P. mexicana*.

Generic affinities of *Phylacia*

The affinities of *Phylacia* are unclear. Speer (1980) erected family *Phylaciaceae* to include *Pulveria* Malloch & Rogerson (Malloch & Rogerson 1977) and *Phylacia* based primarily on the cleistocarpous habit and globoid asci of these genera. Rodrigues & Samuels (1989) reported *Geniculosporium* anamorphs for two *Phylacia* species and considered this as evidence supporting inclusion of *Phylacia* in family *Xylariaceae*. Stadler et al. (2005) put *Pulveria* into synonymy with *Pyrenomyxa* Morgan emend. M. Stadler et al. These authors did not regard *Phylacia* and *Pyrenomyxa* as closely related genera. In our opinion there is no evidence to support a relationship between *Phylacia* and *Pyrenomyxa*. Although both genera feature cleistocarps, those of *Phylacia* bear multiple tubular structures that produce asci in morphologically discrete structures. Those of *Pyrenomyxa* produce ellipsoid to fusoid ascocarps in an effusive hypoxyloid stroma. Ascospores of *Pyrenomyxa* are inequilateral and bear definite germ slits (Stadler et al. 2005). Those of *Phylacia* are more or less equilateral (except for taxa described by Speer 1980) and are apparently devoid of germ slits (but see earlier remarks of *P. sagraeana* herein). Ju et al. (1997) suggested a possible connection between *Pulveria* (=*Pyrenomyxa*) and *Rhopalostroma* D. Hawksw. Stadler et al. (2005) found similar metabolites in *Rhopalostroma* and *Phylacia*. They suggested that *Phylacia* is possibly related to *Rhopalostroma*, *Thamnomyces* Ehrenb., and *Daldinia* Ces. & de Not. In our opinion, the understanding of taxonomic affinities of *Phylacia* awaits molecular data.

Key to known *Phylacia* species

1. Stromata sessile 2
1. Stromata stipitate or pseudostipitate 5

2 Stroma hemispherical 3
2 Stroma cylindrical, with a concave center 4

3. Ascospores less than 14 µm long ..... *P. bomba*
3. Ascospores more than 14 µm long ..... *P. bomba* var. *macrospora*

4. Ascospores 12-13 x 6-7 µm ..... *P. surinamensis*
4. Ascospores 8-9 x 4-5 µm ..... *P. pusilla*

5. Stromata obpyriform or pyriform 6
5. Stromata other than pyriform 7

6. Stromata more or less obpyriform. Ascospores up to 11µm long, thin-walled ..... *P sagraeana*
6. Stromata roughly pyriform. Ascospores up to 15 µm long, thick-walled ..... *P. poculiformis*

7. Stromata more or less cylindrical ..... *P. pseudohypoxylon*
7.Stromata other than cylindrical 8

8. Stromata globose to clavate. Ascospores thick-walled ..... *P. globosa*
8.Stromata clavate, turbinate, or glanduliform (acorn-shaped) 9

9. Stromata turbinate, up to 17 mm diam ..... *P. turbinata*
9.Stromata glanduliform or clavate 10

10. Stromata glanduliform ..... *P. glandulina*
10. Stromata clavate, up to 10 mm diam ..... *P. mexicana*

Final comments

With the inclusion of *P. mexicana*, there are ten species and one variety ascribed to this genus, of which 7 species and one variety are present in Mexico and the others, *P. pseudohypoxylon* and *P. glandulina*, are found in Brazil and Ecuador, respectively. The latter two have only been recorded in literature (Speer 1980), and the types were unavailable in PC. On the other hand *P. pusilla* is a doubtful species, fide Hawksworth (1977). However, if it were shown to be a *Phylacia* it would be the first report of a species from Asia and, indeed, from outside the Americas.

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The typification of *Lecanora dispersa* and *L. albescens*

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Abstract—The nomenclature, citation, and typification of the names *Lecanora dispersa* and *L. albescens* are discussed, and neotypes are designated for both species epithets in order to maintain current usage. In addition, descriptions and information on exsiccates examined are presented.

Key words—*Ascomycota*, *Lecanorales*, lichens, nomenclature

Introduction

The *Lecanora dispersa* group is considered as the most difficult in its genus (Laundon 2003), and its taxonomy has been struggled over for almost over 50 years (Laundon 1958, Fröberg 1989, 1997, Poelt et al. 1995). The species are superficially quite similar and characterized by an endolithic or endophloedic (rarely superficial) thallus, small apothecia with mostly white thalline exciples, and either with xanthones present or secondary compounds not being detected by TLC. The first attempt towards a modern taxonomy of the group was that of Poelt et al. (1995), who considered the saxicolous species in the eastern Alps. Those authors precisely circumscribed 11 species based on combinations of anatomical and chemical characters. None of the names adopted, however, were typified in that work. Moreover, some taxa, e.g. *Lecanora flotoviana*, remained ambiguous. Poelt et al. (1995) pointed out some problems with species delimitation, especially from poorly developed forms of *L. dispersa* as well as its' unclear relationship to *L. xanthostoma*. Fröberg (1997) studied the species of south Sweden, validated the name *L. xanthostoma*, and described a new species, *L. perpruinosa*; however, concerning older names, he did not refer to any original collections. The adoption and attribution of the name *L. flotoviana* by Fröberg is intriguing. Contrary to a previous publication (Fröberg 1989), in his 1997 treatment Fröberg (1997) adopted the epithet "*flotoviana*" for saxicolous morphs of *L. dispersa* auct. and retained the name *L. dispersa*

exclusively for corticolous representatives of the complex. This interpretation caused differing applications of the two names in recent years, and further confusion as to species concepts. More recently, Laundon (2003), in a work primarily on the status of *L. zosterae* in Great Britain and Ireland, briefly discussed the whole group of species, lectotypified *L. umbrina*, and proposed the name be used for *L. hagenii* auct., a name that proved to have been misapplied. A formal proposal to enable the name *L. hagenii* to be retained by conservation is being made separately (Śliwa & Hawksworth 2006).

This paper is part of a broader study intended as a revision of the North American collection of the *L. dispersa* group and related species (Ryan et al. 2004, Śliwa, unpubl.). The majority of available names within this group of taxa are based on European types, and therefore in most cases material from both continents had to be compared. The study is based on material from the following North American herbaria: ASU, CANL, COLO, FH, NY, MICH, MIN, MSC, OMA, OSC, US, WIS, and herb. Spribille. Types and/or historical materials of most of the 33 names at the rank of species and below were examined, as well as other reference specimens from many important European herbaria: B, BM, GOET, GZU, H, KRAM, L, LD, LE, M, S, and UPS. In total, about 1900 specimens were studied morphologically, microscopically, and many of them chemically. An effort to trace available original collections led to many interesting discoveries and taxonomic conclusions.

Especially pertinent is the exclusion of *L. flotoviana* from the *L. dispersa* group, based on original material of the species recently discovered at B and GOET. The collections differ in morphology and chemistry from the entity usually known by that name. Indeed, the taxon does not even belong to the *L. dispersa* complex. Instead, *Lecanora semipallida* is the correct name for the common, widespread member of the *L. dispersa* group hitherto known as *L. flotoviana* (auct. non Spreng.). Full details of the status and application of the names are being published separately. Typifications of the two oldest names in the complex, *L. dispersa* and *L. albescens*, are presented here. Since the protologues of the species are very short and of very general character, the selection of material for the typification was made to preserve the current usage of the names as defined by Poelt et al. (1995).

Typifications

Lecanora dispersa (Pers.) Sommerf., Suppl. Fl. Lapp.: 96 (1826).

Basionym: *Lichen dispersus* Pers., Neue Ann. Bot. 1 [Ann. Bot. 7]: 27 (1794).

Type: [Germany, Hessen] "Mitteldeutschland, Bez. Nordhessen: kleinflächig an licht- undwindoffenen, aber teilweise regengeschützten Stirn- und Überhangflächen stark ausgearbeiteter Dolomitfelsen im *Caloplacetum saxicolae* Du Rietz, 300 m, SO-SW, ph 7,5, naturnaher Trockenrasen auf dem Höhenzug in der Werraschleife von

Albungen südlich Hitzerode. Leg. et det. G. Follmann und B. A. Follmann (IV/1977). Follmann" [Follmann, Lich. Exsicc. Selecti 387, sub *L. albescens*] (MIN! – **neotypus hic designatus**; ASU!, BM!, COLO!, WIS! – isoneotypi). [This exsiccate collection was also distributed to: B, BRA, CANL, FH, GZU, H, L, LD, MAF, M, NY, TNS, US, W, etc. (Follmann 1983)].

Synonym:

Lecanora subluta var. *perspersa* Nyl., Flora 59: 233 (1876).

Type: [Ireland] "Hibernia, Dawros Bridge, 1875, leg. C. Larbalestier 19" (H-NYL 28069! – **lectoypus hic designatus**; BM! – 2 isolectotypi).

Thallus mostly endolithic, or sometimes superficial but indistinct, very thin, ecorticate (except with some corticate granules near the apothecia); pale grey. **Apothecia** occurring singly, or clustered in groups, sessile, or constricted at the base, concave, flat when mature or soon convex, 0.3–0.9 mm; disc pale brown, dark brown or almost black, smooth, epruinose or rarely slightly pruinose; thalline exciple prominent, raised or even with disc, uniform, epruinose or pruinose, even, or slightly flexuose, white, or concolorous with thallus, rarely concolorous with disc, not crenulate; amphithecium present, with algae filling the medulla or algae sparse, algal layer often discontinuous below hypothecium, (60–)90–200 µm thick, corticate; cortex indistinctly delimited, ±uniform in thickness, or slightly thicker at the base than at the sides, 30–80 µm thick laterally and 35–120 µm thick at base, composed of adglutinated hyphae to apparently cellular, ±obscured by granules (pol+, insoluble in K, soluble in N); parathecium indistinct to well delimited and to 30 µm wide; epihymenium shades of yellow or brown, granular (pol+), granules superficial and between paraphyses tips, or also inspersed in the whole hymenium, fine (insoluble in K and insoluble in N), sometimes with an epipsamma (insoluble in K and soluble in N); hymenium hyaline, or pale yellow, 45–70 µm high; subhymenium indistinct; hypothecium hyaline or almost so, 40–120 µm thick, composed of adglutinated hyphae to apparently cellular, often with some granules. **Paraphyses** slender, somewhat branched throughout, with few anastomoses, not expanded and usually not pigmented, coherent in K. **Asci** clavate, 40–60 × 10–15 µm, 8-spored. **Ascospores** hyaline, simple, ellipsoid, (7.5–)9–12 × (4.5–)5–6 µm. **Pycnidia** not seen. **Spot tests**: apothecial margin K–, C–, KC–, PD– or PD+ orange (±75%); disc K–, C–, KC–, PD–; apothecia UV negative or ±pale yellow or green. **Secondary compounds**: 2,7-dichlorlichexanthone, ±pannarin; or no lichen substances detected by TLC.

Habitat: On a wide range of substrata including calcareous and siliceous rocks, concrete and mortar, dust contaminated bark, lignum and many manufactured substrata including asbestos, metal, leather, rubber; also commensalistically on other lichens.

World distribution: widespread, especially in temperate region.

ADDITIONAL EXSICCATA EXAMINED – Arnold, Lich. Exsicc. 1703 (as *L. albescens*, lignicolous) (M, MIN); Arnold, Lich. Monac. Exsicc. 142 (as *L. albescens*, lignicolous) (M); Arnold, Lich. Monac. Exsicc. 232 (as *L. dispersa*) (M); Arnold, Lich. Monac. Exsicc. 432 (as *L. albescens*, lignicolous) (M); Arnold, Lich. Monac. Exsicc. 433 (as *L. dispersa*) (M); Arnold, Lich. Monac. Exsicc. 513 (as *L. dispersa*) (M, MIN); Cummings, Decad. N. Am. Lich. 300 (as *L. hagenii*) (WIS); Cummings & al., Lich. Boreali-Am. 249 (as *L. hagenii*) (COLO, FH 2x, MICH); Erbar. Crittogam. Ital. Ser. II. 615 (as *L. flotowiana*) (MIN); Hasse, Lich. Exsicc. 240 (as *L. hagenii*) (COLO); Malme, Lich. Suecici Exsicc. 496 (as *L. hagenii*) (WIS); Merril, Lich. Exsicc. 113 (as *L. hagenii*) (COLO, FH 2x, MICH); Nowak, Lich. Polon. Merid. Exsicc. 223 (as *L. umbrina*) (KRAM, MIN); Rabenhorst, Lich. Eur. 624 (as *L. hagenii* f. *lithophila*) (KRAM).

SYNOPSIS OF MATERIAL SEEN – Antarctica (Śliwa & Olech 2002), Armenia (COLO), Australia (COLO, MIN), Austria (GZU, KRAM), Canada (ASU, CANL, COLO, FH, H, MICH, MIN, NY, OMA, WIS), Chile (COLO), Estonia (KRAM), Germany (COLO, GOET, L, MSC, WIS), Hungary (NY), Mexico (ASU, COLO), Poland (KRAM), Romania (KRAM), Sweden (ASU, COLO, LD, NY, WIS), Switzerland (COLO), UK (KRAM, NY), Ukraine (KRAM), USA (ASU, CANL, COLO, FH, KRAM, NY, MICH, MIN, MSC, US, WIS).

Comments – In the Persoon herbarium in L there is now no collection of *Lecanora dispersa* (Gerard Thijsse, pers. comm.). Nor could any Persoon specimen of the taxon be traced in the Acharius herbarium in Helsinki. However, there is material in BM that purports to be authentic which was collected in Jena in 1798 and has the number "27", the page on which Persoon's name was published, but it is in poor condition so unsuitable for choice as neotype; the handwriting may well be the coarse script of Persoon, but the specimen was evidently annotated even later than 1798 as the genus name *Parmelia* is used, a combination not published until 1803 by Acharius. In H-ACH there is a single packet of *Lecanora dispersa* (H-ACH 1228) bearing four specimens, which represent three different species: (1) *L. crenulata* Hook., one specimen originating from "Suecia"; (2) *L. crenulata* Hook., a second specimen with no locality provided; (3) *L. semipallida* H. Magn., with the locality indication "Anglia"; and (4) a very small and poorly developed specimen of *L. dispersa* with no further indications. The last collection has nothing to link it with Persoon and appears unsuitable for neotypification as it is so poor. Other herbaria supposedly holding Persoon's material were contacted unsuccessfully. Apparently all original material has been lost. In such a situation exsiccate collections were assessed as candidates for neotypification so as to supply easily accessible reference collection. Priority was given to collections originating from Germany as the following locality directions were indicated in the Persoon's work: Meissner Mountains (south-east of Kassel and south-west of Leipzig, Germany). Furthermore, Persoon indicated his material was from calcareous rocks. The selection was not an easy task, taking into account the species' considerable variability and wide range of occupied substrata. Finally, the Follmann exsiccatum was chosen as the

best specimen of those seen as it was best developed and on calcareous rock. The collection was originally determined as *L. albescens*. However, no proper thalline areole were observed on any of examined specimens, but there were granular-looking young apothecia, which I suspect Follmann misinterpreted as thallus tissue and led to a misidentification.

Lecanora albescens (Hoffm.) Flörke, in Flotow, Flora 11: 633 (1828).

Basionym: *Psora albescens* Hoffm., Deutschl. Fl. 2: 165 (1796).

Type: [Germany, München] "Auf Ziegeln der Kirchhofmauer in Thalkirchen; München, Dezember 1891, Arnold und Schnabl". [Arnold, Lich. Monac. Exsicc. 212; sub *L. albescens*] (H! – **neotypus hic designatus**; M!, MIN! – isoneotypi).

Synonyms:

Lecanora galactina Ach., Lichenogr. Univers.: 424 (1810).

Parmelia galactina Ach., Method. Lich.: 190 (1803); nom. illegit. (Art. 52.1).

Lecanora urbana (Nyl.) Leight., Ann. Mag. Nat. Hist., ser. 4, 2: 247 (1868).

Lecanora galactina [subsp.] *urbana* Nyl., Bull. Soc. Bot. France 13: 368 (1866).

Type: [France] "Gallia. Paris: rue de l'Ouest, sur les murs. 1866, leg. W. Nylander" (H-NYL 28057! – holotype).

Thallus clearly visible, often forming distinct rosettes, thick or thin, areolate, edge distinctly lobate and mostly continuous, surface pruinose; pale grey, cream or chalk-white. **Apothecia** clustered in groups on thallus areoles, sessile or slightly immersed, flat when mature, 0.4–1.4 mm; disc yellowish to pale brown, slightly to heavily pruinose; thalline exciple prominent, smooth, uniform, epruinose, even, or flexuose, concolorous with thallus; amphithecium present, with algae filling the medulla or algae sparse, algal layer continuous below the hypothecium, 90–270 µm thick, corticate; cortex indistinctly delimited, or distinctly delimited, ±uniform in thickness, or slightly thicker at the base than at the sides, ca. 30 µm thick laterally and ca. 60 µm thick at base, prosoplectenchymatous, gelatinous, obscured by granules and larger crystals (pol+, insoluble in K, slowly soluble in N); parathecium indistinct to well delimited and up to 30 µm wide; epihymenium shades of yellow or brown, granular (pol+), granules superficial and between paraphyses tips, also inspersed in whole hymenium, coarse, or fine (insoluble in K and insoluble in N), usually with an epipsamma (insoluble in K and soluble in N); hymenium hyaline, or yellowish, 60–90 µm high; subhymenium distinct; hypothecium hyaline or almost so, 60–130 µm thick, composed of prosoplectenchyma, without granules. **Paraphyses** slender, somewhat branched throughout, with few anastomoses, not expanded and not pigmented, ±coherent in KOH. **Asci** clavate, 50–60(–65) × 10–15 µm, 8-spored. **Ascospores** hyaline, simple, ellipsoid (9–)10.5–13(–15) × 4.5–6(–7.5) µm. **Pycnidia** not seen. **Spot tests**: apothecial margin K–, C–, KC–, PD– or PD+ orange; disc K–, C–, KC–, PD–; apothecia UV negative. **Secondary compounds**: 2,7-dichlorlichexanthone, ±pannarin; or no lichen substances detected by TLC.

Habitat: Directly on calcareous rocks, especially hard limestone, and also on concrete and mortar.

World distribution: Frequent in Europe (from boreal to Mediterranean regions) and scattered on the northern-east coast of North America.

ADDITIONAL EXSICCATA EXAMINED – Arnold, Lich. Monac. Exsicc. 29 (as *L. albescens*) (M); Flörke, Deutsche Lich. 89 (as *L. angulosa* var. *galactina*) (M); Hepp, Lich. Helvet. Exsicc. 900 (as *L. galactina*) (NY); Malme, Lich. Suecici Exsicc. 869 (as *L. galactina*) (COLO, WIS); Mereschkowsky, Lich. Rossiae Exsicc. 9 (as *L. crenulata*) (COLO); Nowak, Lich. Polon. Merid. Exsicc. 63 (as *L. albescens*) (COLO, KRAM, MIN); Rabenhorst, Lich. Eur. 596 (as *L. albescens* f. *murorum*) (COLO).

SYNOPSIS OF MATERIAL SEEN – Austria (ASU, GZU, MIN), Canada (CANL, H, MICH, MIN, US), Denmark (MIN, WIS), Estonia (KRAM), Finland (COLO), Germany (GOET), Malta (NY), Poland (KRAM), Romania (KRAM), Sweden (COLO, LD, MIN, WIS), Switzerland (NY), UK (COLO, KRAM, MSC, NY), Ukraine (KRAM), USA (NY).

Comments – As no original Hoffmann collection could be located in B, GOET or MW, the herbarium in Helsinki was checked to trace any relevant material appropriate for typification. However, no authentic *L. albescens* was found there, although original collections of the species' later synonyms, *L. galactina* and *L. urbana* were located. The Acharian collection of *L. galactina* is included on one sheet and bears several specimens originating from "Gallia", "Helvetia" and "Suecia". *Lecanora urbana* is represented in H-NYL by two collections, one of which has an original label indicating a locality conforming to the species protologue, and also bearing some drawings and notes. Since it is rather unlikely that any other original collection exists, this last specimen is recognized as the holotype for Nylander's name here. Both *L. galactina* and *L. urbana* are identifiable as the species to which the name *L. albescens* is currently applied.

Regarding neotypification of *L. albescens*, priority was given again to exsiccates, and especially those collected in Germany since Hoffmann material would have originated from that country. The Arnold exsiccatum is selected as neotype for Hoffmann's name here because it corresponds exactly with the current concept of this species and unequivocally fixes its application; copies are also widely distributed. Branth & Rostrup (1869: 196) are commonly given as the authors of the combination *L. albescens*, while many earlier lichenologists attributed the name to Flörke. However, although Flotow did not accept Flörke's combination but regarded it as a synonym of *L. flotoviana* Spreng., he published Flörke's text from a manuscript and then commented on it. The case is identical to that of Art. 34.1 Ex. 3 introduced into the Vienna Code and Flörke's combination now has to be accepted as valid under the Code.

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A taxonomic study of *Protoparmelia montagnei* (syn. *P. psarophana*) centered in the Eastern Iberian Peninsula

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Abstract—A comparative study of collections of *Protoparmelia montagnei* and *P. psarophana* from the Eastern Iberian Peninsula has been made on the basis of their morphology, chemistry, habitat and distribution. Some additional specimens from adjacent Mediterranean regions have also been studied for comparison purposes. Four chemotypes of *P. montagnei* have been detected: chemotypes I, II and III, were previously known for this species but are reported for the first time from the study area. Additional secondary metabolites have now been detected in chemotypes I and II and a fourth chemotype characterized by the presence of a chemosyndrome of fatty acids is described. *Protoparmelia psarophana* is now placed into synonymy with *P. montagnei*. A comprehensive description of *P. montagnei* is presented (including several new characters) together with illustrations and a distribution map of the chemotypes in the study area.

Key words—lichenized ascomycetes, taxonomy, ecology

Introduction

As part of a comprehensive revision of the genus *Protoparmelia* M. Choisy in the Iberian Peninsula we have studied the type specimens of *P. montagnei* (syn. *Parmelia montagnei*; *Lecanora montagnei*) and *P. psarophana* (syn. *Lecanora psarophana*) as well as additional specimens labelled as *P. montagnei*, *P. psarophana* var. *psarophana*, *P. psarophana* var. *aquilina*, and *P. psarophana* var. *reagens* (syn. *Lecanora psarophana* var. *reagens*) from the eastern Iberian Peninsula and adjacent Mediterranean regions.

Of the c. 10 species of *Protoparmelia* described previously (see Hafellner 1984, Purvis et al. 1992, Poelt & Leuckert 1991, Poelt & Grube 1992), the silicicolous

Protoparmelia montagnei and *P. psarophana* closely resemble *P. badia* (Hoffm.) Hafellner, the type species of the genus. All three taxa are characterized by a brown thallus, a cupular exciple, pleurogenously born, bacilliform conidia and ± *Lecanora*-type asci with narrow ascospores (ascospores which are sharply fusiform in *P. badia* but with rounded apices in *P. montagnei* and *P. psarophana*). Additional differences are found in the chemistry, ecology and distribution of the three species. *Protoparmelia badia* contains lobaric acid, zeorin, several unknowns and sometimes accessory usnic acid (Ryan et al. 2005), and has a worldwide distribution in montane to alpine habitats, whereas *P. montagnei* and *P. psarophana* contain lobaric, gyrophoric, lecanoric and fatty acids (depending on the respective chemotypes), and have a Mediterranean-Macaronesian distribution in coastal and low mountains habitats.

The differences between *P. montagnei* and *P. psarophana* have been discussed at length, especially by lichenologists working on Mediterranean species, but their distinction remains somewhat controversial. An historical review of their status according to previous workers follows.

Ozenda & Clauzade (1970) and Clauzade & Roux (1985) distinguished *Protoparmelia montagnei* from *P. psarophana* morphologically, by the presence of marginal thalline lobes and larger ascospores, and ecologically, by its preference for warmer localities.

Many studies on silicicolous lichens in the eastern Iberian Peninsula (e.g. Egea & Llimona 1981a, b, c, 1982, 1983) have recognized both taxa, treating them as altitudinal vicariants, *P. montagnei* occurring in coastal areas and *P. psarophana* in hinterland ranges. In our opinion this ecological view was overemphasized when Egea & Llimona (1987) described the alliances *Lecanorion montagnei* and *Pertusarion leucosorae* on siliceous rocks from the Murciano-Almeriense chorological region (SE Spain), assigning different phytocoenological behaviour to *L. montagnei* and *L. psarophana*. In their view *Lecanora montagnei* was the characteristic species of the former syntaxon which included typically thermophylous coastal communities whereas *L. psarophana* was better represented in associations belonging to the second syntaxon containing less thermophylous and xerotolerant communities in hinterland or higher altitude localities with higher rainfall and lower winter temperatures.

The taxonomic study on Iberian *Protoparmelia* carried out by Sancho & Crespo (1987), treat somewhat superficially *Lecanora montagnei* and *L. psarophana* and invalidly transferred them into the genus *Protoparmelia*. The combination *Protoparmelia montagnei* was validly published by Nimis & Poelt (1987). In the latter study *Lecanora psarophana* (incl. var. *aquilina*) and several other Mediterranean taxa (e.g. *Placodium fuscopallens* Kremp. and *Lecanora stenospora* Hue) were synonymized with *P. montagnei*. According to these authors there were "no real differences" between *P. montagnei* and *P. psarophana*, they being morphologically very similar albeit chemically distinct.

However, in a subsequent floristic study centred in the Island of Capraia (Italy), Nimis et al. (1990) stated that material of *Protoparmelia montagnei* s.l. definitely included two taxa, *P. montagnei* with sublobate and thicker thallus and *P. psarophana* with crustose and non-effigurate thallus and that intermediate forms were absent. They concluded that the entire group should be distinguished on the basis of chemical characters.

Following a morphological and chemical study of French collections Ménard & Roux (1991) considered the two taxa to be synonymous. Nevertheless, they preferred to maintain both taxa because their synonymy would have syntaxonomic consequences, as *Protoparmelia montagnei* is the characteristic species of the alliance *Lecanorion montagnei*. In addition, these authors considered that *P. psarophana* var. *aquilina* merited conservation because of its distinctive chemistry (it contains only gyrophoric acid).

Purvis et al. (1992) like Nimis & Poelt (1987), considered *P. psarophana* and *P. montagnei* to be conspecific but distinguished three chemotypes within this species: (1) with lobaric and gyrophoric acids; (2) with lobaric acid; and (3) with gyrophoric and lecanoric acids.

Notwithstanding this, Nimis (1993) recognized both species and validated the combination *Protoparmelia psarophana* initially proposed by Sancho & Crespo (1987). Although subsequent investigators (Sipman & Raus 1995, 1999, 2002) were aware that a thorough comparative study was necessary to decide whether *P. montagnei* and *P. psarophana* were synonymous, they preferred to maintain both taxa as separate species for the interim.

The main aim of the present investigation was to study the morphological and chemical variability and the ecological behaviour of *P. montagnei* and *P. psarophana* in the eastern Iberian Peninsula where both "species" are well represented, and by so doing, attempt to clarify whether they should be regarded as synonyms or not.

Materials and methods

The present study was based on field investigations and the examination of approximately 100 collections of fresh and herbarium material housed in: B, BCC, H, MAF, MUB, UPS, VAB and the herbarium of Claude Roux.

All specimens were analysed by standard techniques with stereoscopic and compound microscopes. Current mycological terminology generally follows Kirk et al. (2001). The terminology used for the asci follows Hafellner (1984) and for the conidiophores and conidia, Vobis (1980). Only free ascospores and conidia lying outside the asci and pycnidia, respectively, have been measured. Measurements were made in water at 1000x magnification. Mean value (M) and standard deviation (SD) were calculated. In the text the results are given

as (minimum value observed) M ± SD (maximum value observed). M, SD and n (the total number of ascospores or conidia measured) are given within parentheses.

Acetone insoluble lichen pigments were tested following the protocol of Meyer & Printzen (2000). Chemical constituents were identified by thin layer chromatography (TLC) (Culberson & Ammann 1979, Culberson et al. 1981, Culberson & Johnson 1982, Elix & Ernst-Russell 1993), high performance liquid chromatography (HPLC) (Elix et al. 2003, Feige et al. 1993) and comparison with authentic samples. The numeration given for the chemotypes follows Purvis et al. (1992).

General description of the species

Protoparmelia montagnei (Fr.) Poelt & Nimis Figs. 1 - 5

[In Nimis & Poelt] Studia Geobot. 7(1): 188 (1987). *Parmelia montagnei* Fr., Lichenogr. Eur. Ref.: 107 (1831); *Lecanora montagnei* (Fr.) Schaer., Enumeratio Critica Lich. Europ. : 62 (1850). Type: Gallia, Provence, îles d'Hyères, 1820-1830?, Montagne (UPS (L-08014) 19666—holotype!).

Synonym (revalidated here): *Protoparmelia psarophana* (Nyl.) Sancho & A. Crespo [in Nimis], Mus. Reg. Scienc. Nat. Torino: 576 (1993). *Lecanora psarophana* Nyl., Bull. Soc. Linn. Normand., 2e sér., Tom. VII: 10, 1872. Type: France, Pyr. Orient., col de Pall, 900 m, 1872, Nylander (H—Nyl. 25687—lectotype!).

New synonyms: *Protoparmelia psarophana* var. *reagens* (Servít) Sipman, Willdenowia 29: 278 (1999). *Lecanora psarophana* var. *reagens* Servít, Ann. Naturhist. Mus. Wien 46: 85 (1931). Type: Kykladen, Naxos, auf Gneiss, Berg Ozia, Rechinger 1619, 1620 (not seen); *Lecanora psarophana* var. *aquilina* Clauzade & Cl. Roux, Bull. Soc. Bot. Centre-Ouest, Nouv. Sér. Num. Spéc. 7: 823 (1985). Type: France: Provenco, Bouches-du-Rhône, la Ciotat, golfeto de Figuerolles, sur apudmara krutajo NNW- orientiga, el turonia pudingo (shtonoj el nekalka, kvarcita grejso; cementajho apenau kalka), 10 m. 10/7/76, Roux (Hb Roux-holotype!, isotypes!).

Thallus crustose, continuous, very variable, thin and rimose-areolate or areolate, to thick, strongly warted to bullate or even subsquamulose, from (0.25-)0.75-1.5(-2.5) mm thick; usually chesnut-brown to grey-brown or reddish (coppery)-brown, ± dark brown, sometimes pale grey, cream, olivaceous or brownish black; uniformly coloured or mottled, epruinose or very rarely pruinose, glossy or not; determinate, sometimes radiate with an outer sterile part radially structured and sometimes showing tendency to form marginal lobes (effigurate); especially young thalli delimited by a blackish hypothalline line. Central cracks or areolae, irregularly shaped, ± round or irregularly polygonal, 0.2-2.5 mm across, flat to subconvex or convex, surface smooth, warted to coarsely warted, sometimes somewhat ridged with the edges of the crests whitish. Marginal areolae smooth to uneven but very rarely warted, subconvex or sometimes swollen-folded and lobe-like, of identical colour to that of central areolae except in greyish and mottled thalli where they tend to

be less mottled and to conserve better the brownish colour and the glossiness. Cortex 20-30(-40) µm, composed of anticlinally arranged hyphae terminated by brown pigmented caps, interspersed with small, ± elongated, brown crystals of lobaric acid dissolving in K (chemotypes I, II), minuscule, granulose colourless crystals of gyrophoric and lecanoric acids reacting C+ red with C (chemotype I, III) (both refringent under polarized light) or not interspersed (chemotype IV) (without refringence under polarized light); epinecral layer usually well developed, hyaline, of (5-)10-15(-25) µm thick. Medulla white or dirty white, containing numerous lobaric (Chemotype I and II) and/or gyrophoric and lecanoric acid crystals (chemotype I and III) and of additional crystals of irregular shape and size which do not dissolve in K (chemotypes I, II, III and IV); algal layer, 60-100 µm, algal cells c. 10 µm in diam.

Apothecia usually scattered, rarely numerous and crowded, sometimes absent, lecanorine, immersed to adnate or sessile and constricted at the base, round to flexuose or subangular when crowded, (0.5-)0.75-1.75(-2.5) mm in diam.; disc pale brown, chestnut brown to dark reddish brown, rarely brownish black, concave, plane to very convex, usually darker than the margin, epruinose, usually shiny; margin distinct, concolorous or darker than the thallus, thick, entire to crenulate, shiny, usually persistent, excluded only in very convex apothecia. Thalline exciple (50-)100(-200) µm wide, with a well defined cortex similar to thalline one but overlain by a thinner epinecral layer, with a distinct medulla filled with algal cells. Proper exciple forming a thick cupular layer (cf. Miyawaki 1991, Henssen 1995) up to 100 µm thick below the hypothecium and of 30-60 µm at the epihymenium level, interspersed with elongated or granulose crystals which are refringent under polarized light (chemotypes I, II and III) or not so (chemotype IV). Epihymenium diffusely yellowish brown to dark brown, 20-30 µm thick, covered by a layer which is continuous with the epinecral layer of the thalline margin. Hymenium hyaline or yellowish, (50-)60-70(-90) µm tall, ± interspersed with elongated or granulose crystals except in chemotype IV. Subhymenium usually distinct, c. 15-20 µm thick. Paraphyses firmly coherent in water, distinct in K, c. 2-2.5 µm thick, with slightly wider apices each covered by a swollen gelatinous "hood" that may or may not contain a brown cap, poorly branched. Hypothecium hyaline or pale yellow, up to 100 µm thick.

Asci clavate, 40-60 x 12-15 µm, ± *Lecanora*-type (cf. Hafellner 1984: 293), with an ocular chamber and a distinct non-amyloid apical cushion, 8-spored; **ascospores** hyaline, simple, oblong-ellipsoid to narrowly ellipsoid with rounded ends, thin walled, of (7.5-)9.5-13(-16) x (2.5-)3-4(-4.5) µm, with some very thin hyaline setae [2-3(-4-6)] at each end (according to Calatayud (1998) they are similar to those present in the spores of several lichenicolous fungi as *Lichenopeltella*).

Pycnidia always present, usually very abundant, immersed, ostiole dark brown to black, punctiform, in section globose to oblong, wall brown-pigmented only around the ostiole. Conidiophores of type VI (Vobis 1980); **conidia** pleurogenously formed, hyaline, simple, bacilliform, straight to slightly curved, from (5-)7-11(-14) x ± 1 µm.

Chemistry. *Spot tests:* medulla Pd-, I-, K+ pale to dirty yellow, C- or C+ pink to red, KC- or KC+ red to violet, UV+ white, UV± pale whitish or UV-; the brown pigment in the cortex, the pycnidial wall around the ostiole and the epihymenium reacts C+ fleeting bluish-grey followed by very pale pink, K+ yellowish-brown, KC+ grey, KCK+ pale brown, N+ fleeting dark blue followed by persistent reddish violet, NK+ pale reddish violet; NKC+ orange. This brown pigment is not described in Meyer & Printzen (2000). *Secondary metabolites:* lobaric acid (and several related substances), gyrophoric acid, lecanoric acid and several fatty acids. Traces of norstictic acid have sometimes been detected (present results, Sipman & Raus 1995, 1999). This is most probably due to other lichen species containing this substance that have been overgrown by *P. montagnei*.

Habitat and distribution. Given the synonymy of *P. montagnei* and *P. psaroplana* established in the present study, *P. montagnei* loses its marked thermomediterranean character reported by Egea & Llimona (1987). It must now be considered a Mediterranean-Macaronesian species which is silicicolous and rather heliophobous, growing from sea level to c. 1500 m altitude in the Canary Islands, Andalusia and north Africa to the last Mediterranean coastal enclave in Bulgaria (Vězda 1975). It also appears sporadically along the Atlantic coast of the Iberian Peninsula and reaches southern England.

In Eastern Iberian Peninsula, where it is locally abundant, *P. montagnei* occurs from the thermomediterranean to the mesomediterrenan belt, from sea level, to littoral, pre-littoral or more inland mountains localities to 1300 m altitude. It grows on diverse, hard siliceous rocks (granitic, volcanic, schistose), on more exposed and sunny situations in inland and higher altitude locations.

The species is found in two well-differentiated groups of lichen communities on north facing siliceous rock surfaces (**Table 1**).

(1) *Pertusarietum gallicae* on acid lava in Sierra del Cabo de Gata (Almería) (Egea & Llimona 1994). (2) The same community in volcanic outcrops and islands of Mar Menor (Murcia) (Llimona & Egea 1984). (3) The same community, on siliceous, non-volcanic lowland rocks in SE Spain (Egea & Llimona 1987). (4) *Pertusarietum rupestris*, in Filabres and Alhamilla ranges (Almería, 1000-1300 m), on siliceous rocks (Egea & Llimona 1987). Presence index (P): V: in 80-100 % of the releves, IV: in 80-60 %, and so on. Coverage (R): average value, in % of the plot surfaces covered by the taxon. For more details about the adapted Klement's methodology of obtention and treatment of the releves, see Egea & Llimona (1987, p. 16-20).

TABLE 1. Ecology of *Protoparmelia montagnei*, defined by the synthetic tables of three groups of releves from lower hills of SW Spain and a group of releves from two mountain ranges in the same region.

	Pert. gallicae Cabo de Gata 26 releves (1)		*Pert. gallicae* Mar Menor 19 releves (2)		*Pert. gallicae* Silic. non-volcan. 9 releves (3)		*Pert. rupestris* Filabres-Alhamilla 12 releves (4)	
	P	R	P	R	P	R	P	R
Protoparmelia montagnei	V	7,6	V	8,0	IV	5,8	III	5,2
Lecanora schistina	V	11,0	III	14,7	V	17,8		
Pertusaria pluripuncta	V	25,6	V	8,8	IV	16,7		
Ramalina requienii	IV	15,6	IV	6,5	III	2,2		
Buellia tesserata	IV	6,5	II	1,4	II	2,0		
Buellia subdisciformis	IV	1,1	III	4,5	IV	3,0	I	0,4
Rinodina santorinensis	II	4,0	III	6,7	IV	16,1		
Pertusaria teneriffensis	III	10,3	II	7,5				
Rhizocarpon lusitanicum	II	1,3			II	0,1		
Ramalina clementeana	III	2,7			II	0,6		
Ramalina rosacea	II	3,4	II	1,8				
Rinodina alba	II	0,8	II	1,1	II	0,3		
Caloplaca scoriophila	I	0,3	II	0,5				
Pertusaria pertusa var. *rupestris*							IV	12,1
Parmelia tiliacea							IV	9,2
Lecanora rupicola							III	3,1
Pertusaria leucosora							III	2,1
Rhizocarpon distinctum							III	1,5
Lecidella carpathica							III	2,3
Anaptychia ciliaris							III	0,8
Physcia caesia var. *caesiella*							III	0,3
Physcia magnussonii							II	2,9
Aspicilia excipularis							II	2,7
Rinodina confragosa							II	0,4
Pertusaria pseudocorallina							I	0,2
Dimelaena oreina							I	0,2
Aspicilia intermutans	IV	6,3	III	9,5	III	2,5	IV	7,9
Candelariella vitellina	IV	2,6	IV	3,4	IV	1,1	IV	0,7
Xanthoria calcicola	IV	4,7	V	6,9	II	0,6	III	0,1
Caloplaca crenularia	III	3,3	III	1,8	IV	4,2	II	2,7
Tephromela atra	III	2,4			I	1,7	III	3,9
Neofuscelia pulla	III	5,0	II	1,7	III	1,7	II	0.1
Lecidella asema	II	0,4	II	0,3	III	2,5	III	1,0
Ochrolechia parella	II	3,7					II	0,6
Lecanora rupicola var. *sulphurata*	II	1,1					III	3,1
Lecanora sulphurea	I	0,7	I	0,3	II	0,3	III	3,1
Lecanora gangaleoides	I	0,3	III	0,4	IV	0,1		
Rhizocarpon geographicum	I	0,6					IV	4,6
Diploschistes actinostomus			II	6,6	I	0,3		
Lecidella elaeochromoides					II	0,6		
Lecanora rupicola ssp. *subplanata*			I	1,0				
Rinodina beccariana			II	2,5				

The first group of communities, well documented from SE Spain (Llimona & Egea 1984, Egea & Llimona 1987, 1994) is characterized by the presence of markedly thermophilous species such as *Pertusaria pluripuncta, Lecanora schistina, Buellia tesserata, Rinodina santorinensis* and *Rhizocarpon lusitanicum.* This group of communities has been included in the alliance *Lecanorion montagnei* Llimona (Egea & Llimona 1987: 69). We propose to conserve this alliance with the same name. It exhibits its optimal development in the thermomediterranean bioclimatic stage, with scattered extensions to the coast at Cap de Creus, îles d'Hyères, Sardinia and North Africa.

The second group of communities where *Protoparmelia montagnei* is usually present is characterized by the presence of clearly less thermophilous species, such as *Pertusaria rupicola, P. pertusa* var. *rupestris, P. leucosora, P. monogona, P. pseudocorallina* and *Anaptychia runcinata.* Its centre of distribution is in the siliceous hills of Catalonia (NE Spain), at 50 to 700 m altitude. This second group of communities has been included in the alliance *Pertusarion leucosorae* Egea & Llimona (1987: 74), which we propose to conserve under the same name. It exhibits its optimal development in the mesomediterranean bioclimatic stage relatively close to the sea in most of the septentrional Mediterraean region.

A well-known group of silicicolous species is shared by both groups of communities, namely *Aspicilia intermutans, Candelariella vitellina, Caloplaca crenularia, Ochrolechia parella, Lecidella asema, L. elaeochromoides* and *Tephromela atra.*

Description of the chemotypes

Chemotype I *(lobaric and gyrophoric acids)* **Figs. 3 & 4**

Morphology. Thallus grey, cream or usually chestnut brown and glossy, sometimes very finely pruinose, warted to coarsely warted or subsquamulose, rarely mottled and dull. Apothecia becoming constricted sessile, with thick and persistent thalline margins and flat to subconvex, rarely very convex discs. Thalline and apothecial tissues interspersed with very small, brown, ± elongated crystals (lobaric acid) and minuscule granulose crystals of gyrophoric acid. Ascospores (8.5-)10-13.5(-16) x 3-4(-5) µm (M= 11.6; 3.5 µm; SD= 1.6; 0.4 µm; n= 85). Conidia (6-)7.5-10.5(-14) x ±1 µm (M= 8.8 µm; SD= 1.5 µm; n= 113).

Chemistry. *Spot tests:* medulla C- or C+ pink to red, KC+ red to red violet to violet, UV-, UV± pale whitish or UV+ white. Reactions with C, KC and UV vary depending on the concentration of gyrophoric acid. The higher the concentration the clearer are the results UV-, C+ and KC+. Lower concentration of gyrophoric acid can be detected in section under the microscope by the application of C (C+ red). *Secondary metabolites:* lobaric acid (major, very rarely minor), norlobaridone (minor or absent), gyrophoric acid (minor or very rarely major), unknown substance X (minor or absent), by TLC and

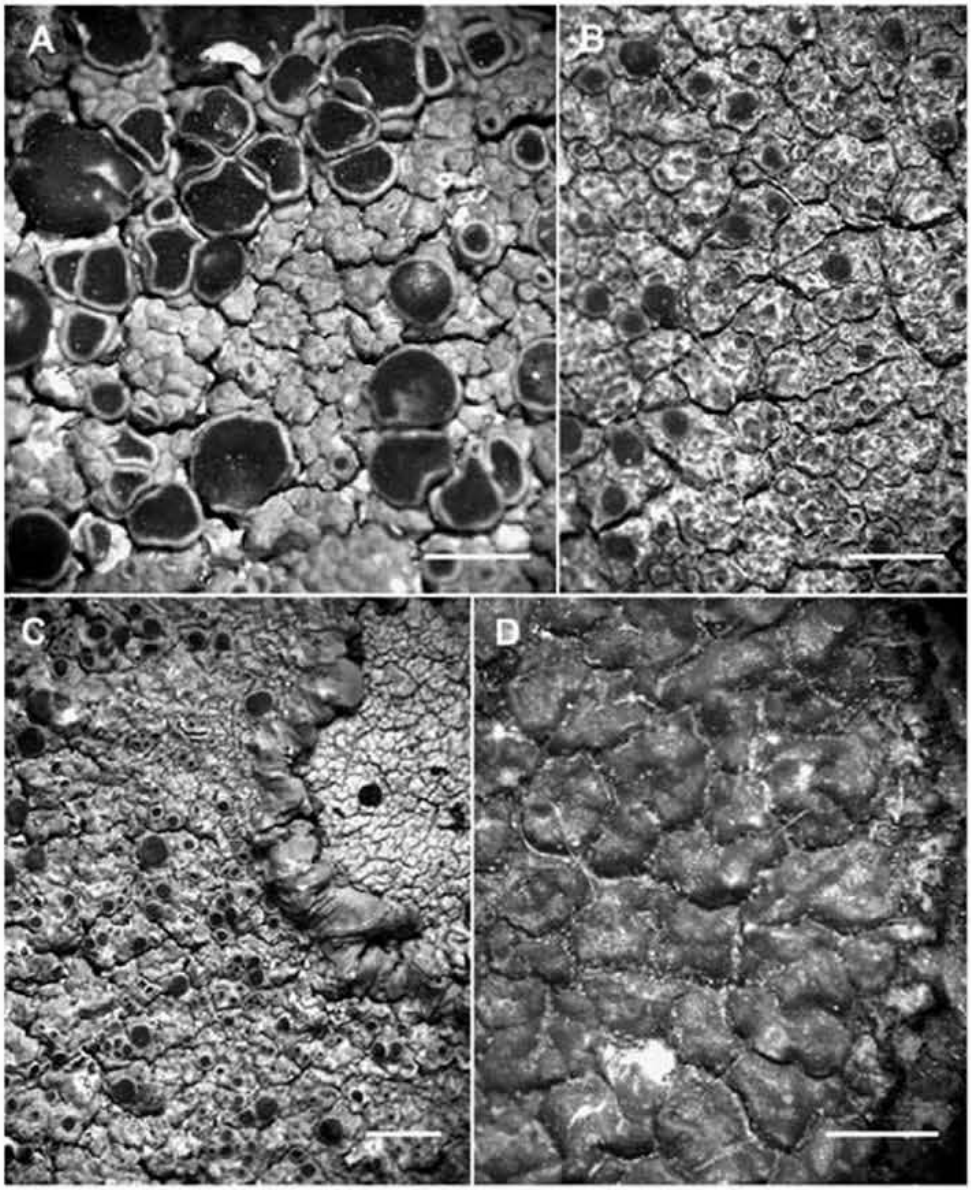

FIG. 1. Habit and thallus margin variability of *Protoparmelia montagnei*. A-D, Chemotype II. A, Warted areolae and sessile constricted apothecia of the *montagnei*-morphotype (BCC *13757*); B, Uneven, mottled areolae and adnate apothecia of the *psaraphana*-morphotype (Sipman *42840*); C, Lobate thallus margin (BCC *13768*); D, Non-lobate thallus margin delimited by a blackish hypothalline line (UPS *19666*-Holotype). Scales: A, B & C = 2 mm; D = 1 mm.

HPLC. The unknown substance X (related to lobaric acid) is reported for the first time from this chemotype. When substance X is present it is visible under short wavelength ultraviolet light on TLC plates using the solvent systems A, B' and C (R_F classes 3/5/5).

Distribution. This is the most abundant and widespread chemotype in the study area and is especially abundant in southern and coastal localities. It occurs from sea level in coastal sites to 540 m altitude in littoral or pre-littoral mountains, where it can be accompanied by specimens of chemotype III. In one locality (Albacete) it occurs at an altitude of 1000-1100 m. It has also been reported from Menorca (Balearic Islands) (Lumbsch & Feige 1996), Provence (Ménard & Roux 1991), the south-eastern Aegean Islands (Sipman & Raus 2002) and the Channel Islands (Purvis et al. 1992).

Observations. The thallus morphology is not useful for identifying specimens belonging to this chemotype since most are very similar in habit to specimens belonging to chemotypes II and III. The most useful distinguishing character is the crystals of lobaric acid: being more abundant in chemotype II and absent in chemotype III. The lack of spot test reactions and cortical crystals readily distinguishes specimens of chemotype IV.

SELECTED SPECIMENS EXAMINED. SPAIN. **Albacete:** Alcaraz, Reolid, (30SWG3619), 1000-1100 m, pizarras y cuarcitas, 24 iii 1978, Egea (MUB *1201*). **Almería:** Sierra del Cabo de Gata, pico del Fraile (30SWF8271), 400 m, andesita, 29 xii 1972, Llimona (BCC); Sierra del Cabo de Gata, Cerro de San Miguel (30SWF7265), 340 m, andesita, 14 iv 1973, Llimona (BCC); Sierra del Cabo de Gata, Collado de Vela Blanca (30SWF7464), 200 m, andesita, 13 ix 1982, Egea (MUB *1269*); Sierra del Cabo de Gata, El Monsul (30SWF7567), 120 m, andesita, 30 xii 1970, Llimona (BCC); Sierra del Cabo de Gata, Cerro Cuevas (30SWF7968), 130 m, 19 iii 1972, Llimona (MUB *1511*); Sierra Almagrera, Los Lobos, Collado de la Casa Nueva (30SXG1128), 370 m, 6 iv 1977, Egea, (MUB *1207*). **Barcelona:** Maresme, Òrrius, Turó de Sèllecs (31TDG4501), 534 m, 11 ii 1993 and 23 i 02, Barbero & Llimona (BCC, BCC *13780*); Baix Llobregat, Castellví de Rosanes (31TDF0888), 400 m, 3 v 1997, Valverde (BCC). **Murcia:** Cabo de Palos, Isla del Ciervo (30SXG9970), 46 m, andesitas ortopiroxénicas, 25 xi 1979, Llimona & Egea (MUB-*8650, 1699*); Cabo de Palos, Isla Grosa (30SYG0278), 102 m, andesitas ortopiroxénicas, 8 iv 1978, Llimona & Egea (MUB *1701, 8644*); Cabo de palos, Carmolí (30SXG8973), 117 m, andesitas ortopiroxénicas, 12 iv 1973, Llimona & Egea and 17 v 1979, Egea (MUB *8647, 1698*); Cabo de Palos, Isla Major, 30SXG9675, 100 m, 25 iii 1975, Llimona (MUB *1701*); Cabo de Palos, Atalayón (30SYG0165), 180 m, microesquistos y cuarcitas, 5 iv 1977, Egea (MUB *1206*); Cabo de Palos, Isla Perdiguera (30SXG9375), 46 m, 23 i 1981 and 4 iii 1984, Egea (MUB *1700, 3155*).

Chemotype II *(lobaric acid)* **Figs. 1, 3 & 4**

Morphology. The thallus morphology of this chemotype is very variable and includes specimens identical to those of chemotypes I, III or IV or intermediates between them. Thalline and apothecial false tissues are totally interspersed with the typical crystals of lobaric acid. Ascospores (7.5-)9.5-12(-14) x (2-)3-4(-4.5) µm (M= 10.5; 3.3 µm; SD= 1.2; 0.5 µm; n= 77). Conidia (5-)7-9.5(-13) x ±1 µm (M= 8.2 µm; SD= 1.3 µm; n= 194).

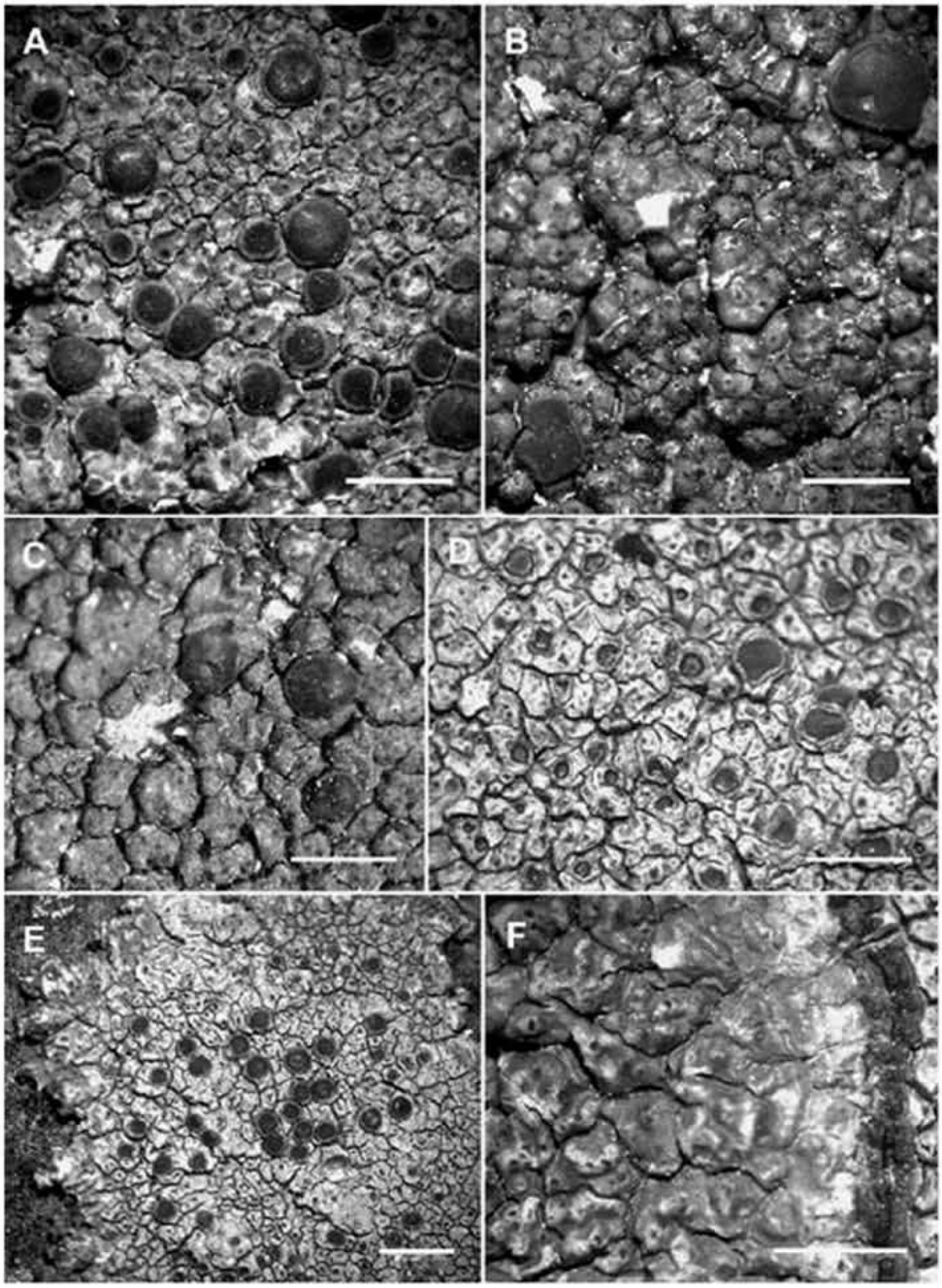

FIG. 2. Habit and thallus margin variability of *Protoparmelia montagnei*. A & B, Chemotype III. A, *psarophana*-morphotype (Hb. Roux-Holotype); B, *montagnei*-morphotype (Sipman *42529*); C-F, Chemotype IV. C, *montagnei*-morphotype (1 iv 1972, Llimona); D, *psarophana*-morphotype (BCC *13772*); E: Lobate thallus margin (BCC *13772*); F, Non-lobate thallus margin with mottled areolae delimited by a black hypothalline line (BCC *13772*). Scales = 2 mm.

Chemistry. *Spot tests:* medulla C-, KC+ violet, UV+ white. The KC+ violet reaction is always present but sometimes only by places. *Secondary metabolites:* lobaric acid (major), norlobaridone (minor or absent), unknown substance Y (minor or absent) and oxolobaric acid (trace or absent), by TLC and HPLC. Oxolobaric acid, norlobaridone and the unknown substance Y (related to lobaric acid) are reported for the first time from this chemotype. When substance Y is present it is visible under short wavelength ultraviolet light on TLC plates using the solvent systems A, B' and C (R_F classes 3/5/4).

Distribution. Chemotype II occurs from sea level in coastal localities to c. 400 m altitude in littoral or pre-littoral mountains, co-occurring with chemotype IV in northern localities (Cap de Creus). It is also known from several coastal sites at sea level in Provence (type locality of *P. montagnei*) growing together with chemotype I, III and IV (present results; Ménard & Roux 1991), Corsica (present results) and Sardinia (Kümmerling 1991), and from coastal and mountain sites up to 700 m in Paros and Antiparos (Greece) accompanied by chemotype III (present results; Sipman & Raus 1999). It has also been reported from Santorini and the south eastern Aegean Islands (Greece) (Sipman & Raus 1995, 2002), and the Channel Islands (Purvis et al. 1992).

Observations. This chemotype is readily distinguished by the C-, KC+ violet and UV+ white medullary reactions. Nevertheless, specimens of chemotype I with low concentration of gyrophoric acid may give the same results. The high density of lobaric acid crystals in all thalline and apothecial tissues is then diagnostic. This character enabled us to assign the type specimen of *P. montagnei* to this chemotype (TLC analysis was avoided because of the sparse material).

SELECTED SPECIMENS EXAMINED. **Spain. Almería:** Sierra del Cabo de Gata, Horticihuela (30SWF8581), 362 m, dacita,17 iv 1981, Llimona (BCC); Sierra del Cabo de Gata, Cortijo de los López (30SWF7772), 330 m, andesita, 16 iv 1973, Llimona (BCC); Sierra del Cabo de Gata, Cerro de la Loma, entre Rodalquilar y las Negras (30SWF8680), 138 m, dacita, Llimona (BCC); Níjar, Serrata de Níjar, Repetidor de Atochares (30SWF7581), 260 m, andesita, 12 ix 1975, Llimona (BCC). **Girona:** Cap de Creus, Cadaqués, Racó de la Claveguera (31TEG2686), 0-20 m, 13 ii 01, Llimona, Barbero & Gómez-Bolea (BCC *13755, 13757, 13766, 13768, 13769*); Cap de Creus, Cadaqués, sota el Far (31TEG2686), 20-50 m, Llimona (MUB *1513*).- **France. Corsica:** Ajaccio, Scopulus La Parata dictus, 10-20 m, on maritime granite rocks, 3 vii 1969, Lambinon, Rondon & Vězda (Vězda Lich. Sel Exs *812*, BCC).- **Greece. Cyclades Archipelago:** Antiparos, NW of Hagios Georgios (36°58.5'N, 25°01.5'E), 50 m, on schistose rock, 16 vi 1998, Sipman & Raus, Sipman *42840* (B); Antiparos, Cap Kavos Skilos, near Faneromeni chapel (36°56.5'N, 25°04.5'E), 5 m, on weathered volcanic rocks, 19 vi 1998, Sipman & Raus, Sipman *43134* (B); Antiparos, Mt. Agios Ilias, in center of island, near chapel (36°59.5'N, 25°03'E), 290 m, on schistose rocks, 19 vi 1998, Sipman & Raus, Sipman *43085* (B); Paros, Kolymbithres, 2 km W of Naoussa, S-side of Mt. Vigla (37°07.5'N, 25°13'E), 25 m, on granitic rock, 12 vi 1998, Sipman

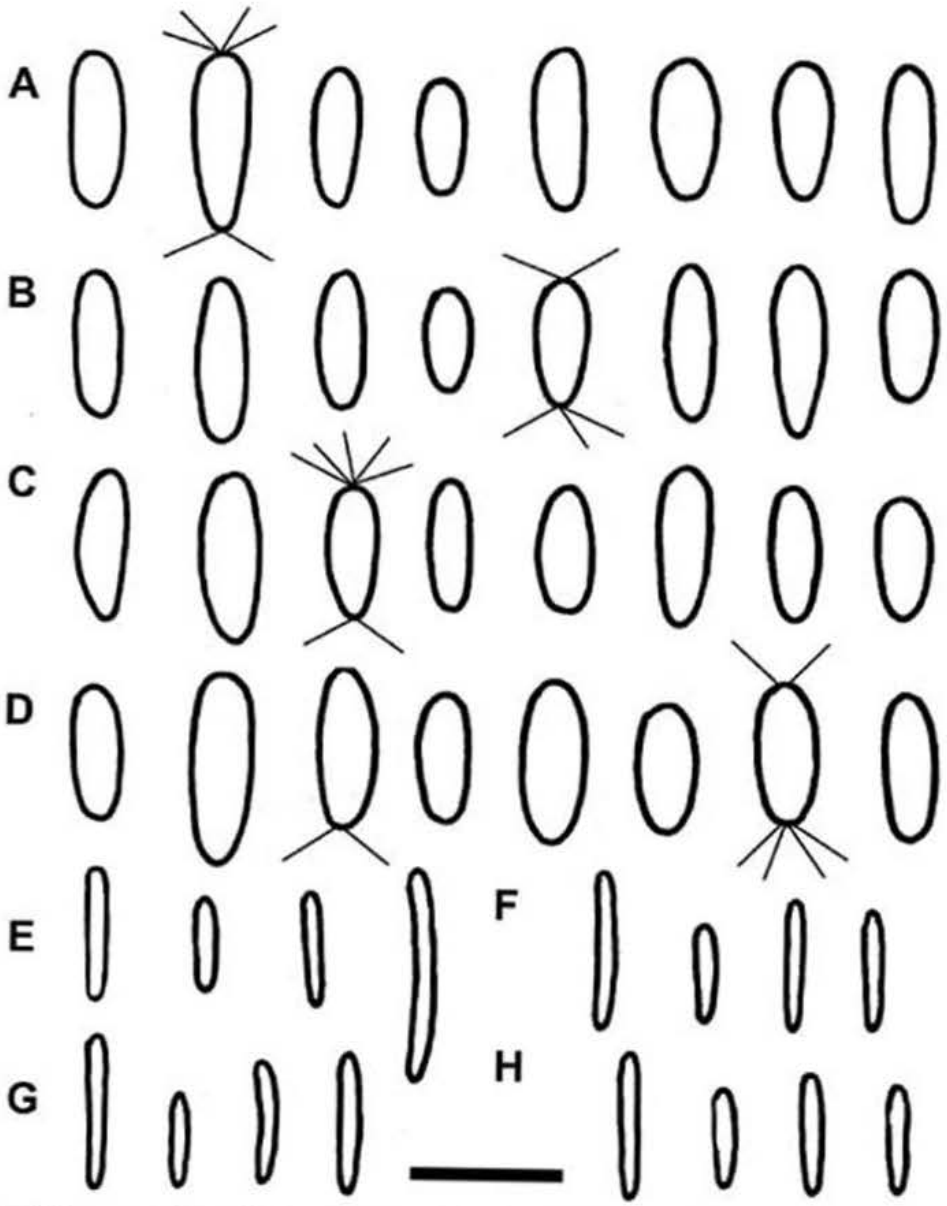

FIG. 3. Ascospores (some showing the apical hyaline setae) and conidia of *Protoparmelia montagnei*. A & E, Chemotype I (BCC *13780* & 29 xii 1972, Llimona); B & F, Chemotype II (BCC *13766* & Sipman *42525*); C & G, Chemotype III (Sipman *43229* & 29 xii 1972, Llimona); D & H, Chemotype IV (BCC *13774* & VAB *2687*). Scale = 10 µm.

& Raus, Sipman *42525* (B); Paros, E-FLANK OF NT. AGIOS ANTONIOS, near Marpissa, 37°03'N, 25°16'E, 80 m, on volcanic rock, 14 vi 1998, Sipman & Raus, Sipman *42698* (B); Paros, MT. AGIOI PANTES (37°02'N, 25°11.5'E), 700m, on gneiss, 13 vi 1998, Sipman & Raus, Sipman *42631* (B).

Chemotype III *(Gyrophoric and lecanoric acids)* **Figs. 2, 3 & 4**

Morphology. The thallus morphology of this chemotype is also very variable and includes specimens identical to those of chemotype I, II or IV or intermediates between them. The only distinguishing feature is the medullary chemistry. This can be recognized by the absence of the small brown ± elongated crystals of lobaric acid together with the presence of minute granulose crystals reacting C+ red (gyrophoric and lecanoric acids) in all thalline and apothecial false tissues. Ascospores (9-)10-13(-15) x (3-)3.5-4(-4.5) µm (M= 11.5; 3.8 µm; SD= 1.5; 0.3 µm; n= 54). Conidia (6-)8.5-10(-12.5) x ± 1 µm (M= 9.2 µm; SD= 1 µm; n= 104).

Chemistry. *Spot tests:* medulla C+ and KC+ red, UV-. *Secondary metabolites:* gyrophoric (major) and lecanoric (minor) acids, by TLC.

Distribution. This is the least frequent chemotype in the study area and occurs only in the southern locality, Cabo de Gata (Almería), growing at 300-400 m altitude in coastal mountains where it is accompanied by specimens of chemotype I. However, it does occur elsewhere at northern latitudes, in south-west England and south Wales (Purvis et al. 1992) and Provence (south-eastern France) (present results; Ménard & Roux 1991). It is also known from Paros and Antiparos (Greece) where it occurs from sea level to 700 m together with chemotype II (present results; Sipman & Raus 1999), and from Santorini and the south eastern Aegean Islands (Greece) (Sipman & Raus 1995, 2002).

Observations. The intense C+ red, KC+ red and UV- reactions readily distinguishes specimens belonging to chemotype III and they could only be confused with specimens of chemotype I with high concentrations of gyrophoric acid. In such cases, the absence of the typical lobaric acid crystals in apothecial and thalline tissue is diagnostic. We assume that the type specimen of *P. psarophana* var. *reagens* (not seen) belongs to this chemotype as established by Sipman & Raus (1999), and can confirm that *P. psarophana* var. *aquilina* is also a member of chemotype III. As a consequence, both are reduced to synonymy with *P. montagnei*.

SELECTED SPECIMENS EXAMINED. **Spain. Almería:** Sierra del Cabo de Gata, PICO DEL FRAILE (30SWF8271), 400 m, andesita, 29 xii 1972 and 23 iii 1972, Llimona (BCC); Sierra del Cabo de Gata, CERRO DE SAN MIGUEL (30SWF7265), 340 m, andesita, 14 iv 1973, Llimona (BCC).- **France. Provenco:** Bouches-du-Rhône, la Ciotat, GOLFETO DE FIGUEROLLES, sur apudmara krutajho NNW-orientigha, el turonia pudingo (shtonoj el nekalka, kvarcita grejso; cementajho apenau kalka), 10 m, 10 vii 1976, Roux (Hb. Roux).- **Greece. Cyclades Archipelago:** Antiparos, S-point of the island, CAP KAVOS SKILOS, near Faneromeni chapel (36°56.5'N, 25°04.5'E), 5 m, weathered volcanic rock, 19 vi 1998, Sipman & Raus, Sipman *43124* (B); Paros, KOLYMBITHRES, 2 km W of Naoussa, S-side of Mt. Vigla (37°07.5'N, 25°13'E), 25 m, on granitic rock, 12 vi 1998, Sipman & Raus, Sipman *42529* (B); Paros, MT. AGIOI PANTES, highest point of island,

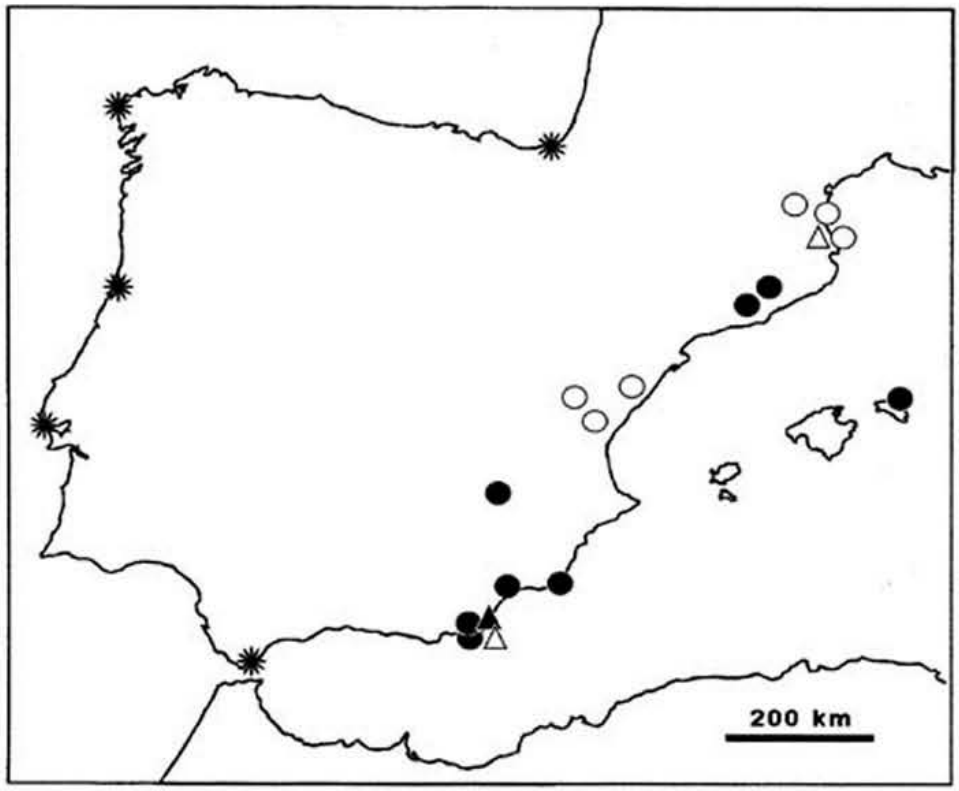

FIG. 4. Distribution of *Protoparmelia montagnei* in the Iberian Peninsula. ● Chemotype I; △ Chemotype II; ▲ Chemotype III; ○ Chemotype IV; * Selected bibliographic data of *P. montagnei* of unknown chemotype.

S-side (37°02'N, 25°11.5E), 700m, on gneiss, 22 vi 1998, Sipman & Raus, Sipman *43316* (B); Paros, BETWEEN LEFKES AND MT. AGIOI PANTES (37°02.5'N, 25°12.5'E), 450m, on gneiss, 15 vi 1998, Sipman & Raus, Sipman *42817* (B); Paros, HILL GORAKAS, 4 km NE of Paros-town (37°07.5'N, 25°11.5'E), 150-200 m, schistose rock, 21 vi 1998, Sipman & Raus, Sipman *43229* (B).

Chemotype IV *(chemosyndrome of fatty acids)* **Figs. 2, 3 & 4**

Morphology. Thallus grey-brown to dark brown, with central areolae, usually ± mottled white due to a thick, ± eroded epinecral layer, flat, smooth to uneven but rarely strongly warted; marginal areolae less mottled, more glossy and chestnut brown. No crystals are present in the thalline and apothecial cortices. Apothecia immersed-urceolate to adnate, rarely sessile constricted, often becoming convex and with ± excluded thalline margins. Ascospores (9-)10.5-12.5(-14) x 3-4(-5) µm (M= 11.3; 3.6 µm; SD= 1; 0.4 µm; n= 67). Conidia (6-)8-10.5(-14) x ± 1µm (M= 9.4 µm; SD= 1.3; n= 156).

Chemistry. *Spot tests:* medulla: C-, KC- UV-. *Secondary metabolites:* protoconstipatic acid (major), constipatic acid (major), dehydroconstipactic acid (minor), dehydroprotoconstipactic acid (minor) and an unknown fatty acid (major) by TLC and HPLC. Sometimes not all of these substances can be detected by TLC but they are reported for the first time for this species. Additional information on these secondary lichen substances are given in Chester & Elix (1979).

Distribution. This seems to be the more northerly, montane chemotype present in the study area. It occurs at sea level in northern coastal localities (Cap de Creus), where it grows together with chemotype II, to mid (300-600 m) or higher elevations (up to 1300 m) in the far south. It is also known from the Albères Mountains (Pyrénées-Orientales, including type locality of *P. psaroplana*; present results) and from Provence (France) (Ménard & Roux 1991). Hitherto it has not been detected far south of València nor from Provence in the north-west.

Observations. The thallus morphology of this chemotype is rather homogenous, although some specimens are close to or intermediate between specimens belonging to other chemotypes. Nevertheless, the general habit as described above is not exclusive to this chemotype as it is also frequent in chemotypes II and III. The absence of C, KC and UV spot test reactions and of crystals in cortices, provide diagnostic characters for distinguishing this chemotype. The type specimen of *P. psaroplana* var. *psaroplana* belongs to this chemotype. Although TLC was not carried out in order to conserve type material, the lack of positive tests with C, KC and UV, the absence of crystals in cortices and the presence of 2 additional specimens belonging to chemotype IV in a site close to the type locality (H-Nyl. *25686* and *25691*), confirmed that the type specimen is a member of this chemotype.

SELECTED SPECIMENS EXAMINED. **Spain. Castelló:** Pina de Montalgrao, Sta. Bárbara (30SYK0233), 1300 m, arenisca ortocuarcítica, 12 x 1989, Calatayud, Atienza, Puche and 21 iii 1992, Calatayud (VAB *2687, 2629, 2630*); Benicàssim, Parreta Alta (31TBE4538), 390 m, arenisca ortocuarcítica, 22 iv 1993, Calatayud (VAB *2948*); Benicàssim, Villa Comba (30TBE4840), 300 m, arenisca ortocuarcítica 22 iv 1993, Calatayud (VAB *7037*). **Girona:** Cap de Creus, Cadaqués, vora Mas de Rabassers de Baix (31TEG2486), 100 m, 18 v 1997, Llimona (BCC *13179, 13772, 13774, 13777*); Cap de Creus, Cadaqués, Riera de Jonquet (31TEG2585), 30-50 m, 1 iv 1972, Llimona and 13 ii 2001, Llimona, Barbero & Gómez-Bolea (MUB *1506*, BCC *13770*); Cap de Creus, Cadaqués, Vora Mas Duràn, sobre Port Lligat (31TEG2383), 100 m, 4 viii 1972, Wirth & Llimona (BCC); Cap de Creus, Cadaqués, Sant Salvador, sureda de Sant Sebastià (31TEG2181), 300 m, 1 iv 1972, Llimona (BCC); Cap de Creus, El Port de la Selva, sobre la cala Tamariua, grans blocs d'esquists al costat del camí dels masos (31TEG1887), 100 m, 5 viii 1972, Llimona (BCC); El Port de la Selva, Puig Vaquer (31TEG1488), 380-400 m, 27 viii 1974, Llimona (BCC); Cap de Creus, El Port de la

TABLE 2. Differential features of the four chemotypes of *Protoparmelia montagnei* in the eastern Iberian Peninsula (the ranges include frequent measurements and exclude extreme values; [M] = Mean value)

	Chemotype I (lobaric and gyrophoric)	Chemotype II (lobaric acid)	Chemotype III (gyrophoric and lecanoric)	Chemotype IV (fatty acids)
psarophiana-morphotype	Absent	Frequent	Frequent	Dominant
montagnei-morphotype	Dominant	Dominant	Frequent	Absent
Deviating or intermediates morphotypes	Present	Present	Present	Present
Ascospore length and breadth & [M] (µm)	10-13.5 x 3-4 [11.6 x 3.5]	9.5-12 x 3-4 [10.5 x 3.3]	10-13 x 3.5-4 [11.5 x 3.8]	10.5-12.5 x 3-4 [11.3 x 3.6]
Conidia length & [M] (µm)	7.5-10.5 [8.8]	7-9.5 [8.2]	8.5-10 [9.2]	8-10.5 [9.4]
Tests in medulla	C+ red or C- KC+ red, KC+ red violet or KC+violet UV-, UV± pale white or UV+ white	C- KC+violet (sometimes by places) UV+ white	C+ red KC+ red UV-	C- KC- UV-
Small, ± elongated, brown crystals of lobaric acid	Present; mainly in cortices	Very abundant; in cortices and apothecial false tissues	Absent	Absent

Selva, Serra Carbonera (31TEG1788), 125 m, 29 iii 1997, Llimona (BCC *13180*); Cap de Creus, El Port de la Selva, Sr. Pere de Roda, 5 viii 1972, Llimona (BCC); Roses, vora la Creu de'n Cobertella (31TEG1679), 50 m, 25 ii 1984, Llimona (BCC); Port Bou, Querroig (31TEG1098), 650 m, 12 viii 1975, Llimona (MUB *1514*). **València:** Serra El Garbí, Estivella, 30SYJ2597, 575 m, arenisca ortocuarcítica, 15 iv 1992, Calatayud (VAB *2632, 2853*).- **France:** **Pyrénées-Orientales:** Força Real, 400 m, 16 vii 1872, Nylander-*25686, 25691* (H); tour de la Massane, 700 m, 16 vii. 1872, Nylander *25689* (H).

Discussion and conclusions

The type specimens of *Protoparmelia montagnei* and *P. psarophana* are macroscopically very similar. The main differences observed are in the colour and surface of the thallus and in the attachment of the apothecia. Thus the upper surface of *P. montagnei* is chesnut-glossy, composed of convex to warted areolae and having sessile, constricted apothecia. The upper surface of *P. psarophana* on the other hand is grey-brown, mottled and mat, being composed of flat to uneven areoale with adnate apothecia. Neither of the type specimens has marginal thalline lobes, which is a distinguishing character according to several authors. Furthermore, except for the presence/absence of crystals in cortices, the two type specimens are indistinguishable microscopically (**Table 2, Fig. 3**).

Among the specimens studied, we encountered various morphotypes including specimens which closely resemble the type of *P. montagnei* (*montagnei*-morphotype), specimens close to the type of *P. psarophana* (*psarophana*-morphotype) and intermediate specimens difficult to assign to either morphotype (**Figs. 1 & 2**).

As regards the chemistry, the type specimen of *P. montagnei* contains lobaric acid whereas that of *P. psarophana* a chemosyndrome of fatty acids (see above).

The specimens examined could be assigned to one of the following well characterized chemical races: (I) lobaric and gyrophoric acids; (II) lobaric acid; (III) gyrophoric and lecanoric acids; and (IV) chemosyndrome of fatty acids. Specimens belonging to the *montagnei*-morphotype, the *psarophana*-morphotype, or intermediate and divergent specimens, were represented in all chemotypes (compare **Figs. 1 & 2, Table 1**). Nevertheless, *montagnei*-morphotype was dominant in chemotype I and the *psarophana*- morphotype in chemotype IV. Chemotypes II and III are the most variable and included all morphotypes.

Consequently, we conclude that the differences in thalline growth habit are unrelated to thallus chemistry but are due to other factors such as microclimatic conditions, ageing processes, or the nature, surface or enrichment of the substrate. For instance, very young thalli overgrowing aged thalli have been observed in all morpho- and chemotypes. They always have the same appearance

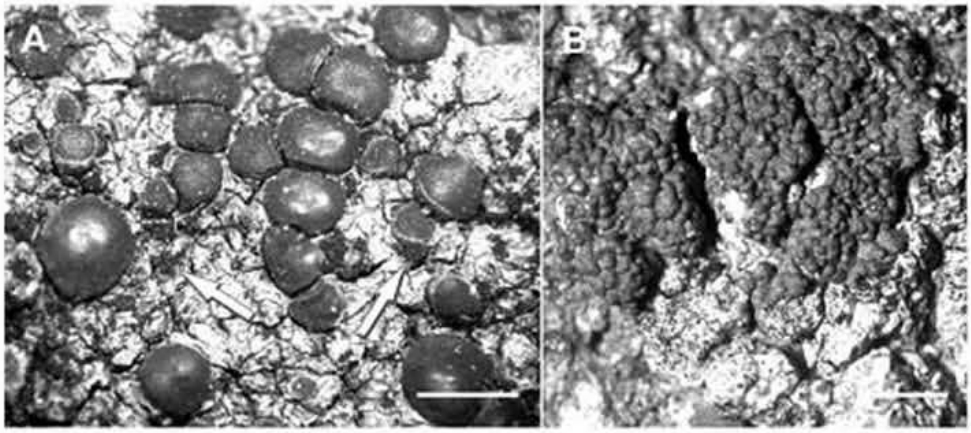

FIG. 5. A, The lichenicolous fungus cf. *Lichenothelia* sp. (arrows) overgrowing *P. montagnei* (5 viii 1972, Llimona); B, Two young thalli of *Protoparmelia montagnei* of typical *montagnei*-morphotype overgrowing a 'parent' thallus of the *psarophana*-morphotype (25 ii 1984, Llimona). Scales: 2 mm.

(close to the *montagnei*-morphotype) but are concordant with the chemistry of the 'parent' thallus (verified through the spot tests) (**Fig. 5B**). In *Dimelaena oreina* (Calatayud & Rico 1999) the variations in thickness and sublobulation of the thallus and in the prominence of the apothecia and thalline margins may be caused by substrate eutrophication from marine bird depositions, and similar circumstances may prevail here.

We consider that the different morpho- and chemotypes observed are variations within a single species and have concluded that *P. montagnei* and *P. psarophana* are conspecific. In particular, because: (1) the macroscopic differences observed between *montagnei*-morphotype and the *psarophana*-morphotype are too subtle and are inconsistent; (2) the presence of intermediate and deviant morphotypes among the specimens studied; (3) the absence of additional characters such as ascospore and conidia shape and size, characters frequently used to separate species of *Protoparmelia*; and (4) the lack of any correlation between morphological and chemical characters.

Furthermore, the lichenicolous fungus cf. *Lichenothelia* sp. (currently being studied) has been found growing on all morpho- and chemotypes without any discrimination (**Fig. 5A**).

Nevertheless, the four chemotypes do exhibit different ecological and distributional preferences within the study area. Whereas chemotype I is the most abundant and widespread, chemotype II is only locally abundant in extreme southern (Cabo de Gata) and northern (Cap de Creus) localities. Both chemotypes range from sea level in coastal sites to mid altitudes in hinterland mountains. In the study area chemotype III occurs only in the southern localities (Cabo de Gata) at mid altitudes in coastal mountains, but elsewhere

it is abundant at more northerly latitudes (in south-eastern France, south-west England and south Wales). Chemotype IV is most abundant in montane, northerly locations, although it also grows at sea level in northern localities (**Fig. 4**).

Finally, we want to comment on the presence of several setae at the ends of the ascospores of *P. montagnei*. This character, together with the presence/absence of a cupular exciple, conidia-, coniophores- and ascus-types, clearly separate the species of *P. badia* group (incl. *P. montagnei*) from those of *P. atriseda* group, thus confirming that the genus *Protoparmelia* is heterogeneous (Rambold 1989, Poelt & Leuckert 1991, Poelt & Grube 1992) and of uncertain taxonomic position within the *Lecanoraceae* (e.g. Ryan et al. 2005) or the *Parmeliaceae* (e.g. Miyawaki 1991, Henssen 1995, Kirk et al. 2001).

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Three new Chinese records of *Phyllachora* (*Phyllachorales*)

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Abstract—Three new Chinese records of *Phyllachora* are reported: *Phyllachora ehrhartae* on *Poa* sp., *Phyllachora paspalicola* on *Isachne tenuis* and *Phyllachora fimbristylidicola* on *Fimbristylis dichotoma*. These specimens were collected from Gansu and Yunnan Provinces.

Key words—*Sordariomycetidae*, tar spot, taxonomy

Introduction

The first report of *Phyllachora* in China was by Kalchbrenner & Thümen (1881) who listed *Phyllachora angelicae* (Fr.) Fuckel collected from Inner Mongolia. Yates (1917) reported some *Phyllachora* species collected from southern China. Sydow & Sydow (1920) also reported some *Phyllachora* species from southern China and described a new species: *Phyllachora cantonensis* Syd. & P. Syd. Sawada (1919, 1928, 1943, 1944, 1959) reported some new species from Taiwan. In the following years, many foreign and Chinese scientists reported the distributions of *Phyllachora* in China (Tai 1979). Luo (1984) made a detailed study about *Phyllachora* inhabitating *Poaceae*. Wang et al. (1991) listed all *Phyllachora* species from Taiwan. Recently, Zhang et al. (2003, 2005) and Qin et al. (2003) reported some new Chinese records. So far, about 82 species have been reported in China, including 55 species on *Poaceae* and 2 species on *Cyperaceae*.

Phyllachora on *Poa*

There are five taxa reported on *Poa*: 1) *Phyllachora antarctica* Speg. with ellipsoid to ovoid ascospores measuring 12–14 x 6–8 µm (Trotter 1972); 2) *Phyllachora bromi* Fuckel with globose to ovoid ascospores measuring 12–14 x 7–8 µm

**corresponding author*

(Saccardo 1883); 3) *Phyllachora graminis* (Pers.) Fuckel [syn. *Phyllachora poae* (Fuckel) Sacc. (Saccardo 1883)] with ovoid ascospores measuring 7–14 x 4–7 µm; 4) *Phyllachora sylvatica* Sacc. & Speg. with ovoid, ellipsoid or semiellipsoid ascospores measuring 12–22 x 4.5–8 µm (Parbery 1967) and 5) *Phyllachora scanica* Starbäck (Parbery 1967) with broadly ovoid to ellipsoid ascospores measuring 11–14 x 6–7 µm. The type of *Phyllachora ehrhartae* is parasitic on *Ehrharta erecta* Lam. with subglobose to broadly oval ascospores measuring 6.5–13 x 5–6.5 µm from South Africa. The specimen collected by us is identified as *Phyllachora ehrhartae* based on the size and shape of ascospores and the length of asci.

Phyllachora ehrhartae Marasas, Bothalia 9: 208, 1966. **Figs. 1-2**

Leaf spot: blackened regions sparse, rarely aggregated, long ellipsoidal, 0.7–2.3 x 0.3–0.8 mm, shining black, rising from the upper leaf surface, multi-loculate, the ostiole inconspicuous, blackened regions can be visible from both sides of the leaves.

Anamorph: not seen.

Teleomorph: ascomata 115–240 x 140–250 µm, epigenous, immersed in the mesophyll layer of the leaves, subglobose or ellipsoidal, with well-developed, hyaline periphyses, asci rising from the basal and lateral wall of the ascoma. Upper wall up to 48 µm thick, composed of epidermis cells which are occluded by melanized material. Lower wall up to 45 µm thick. Lateral wall up to 30 µm thick. Paraphyses 1.5–2 µm wide, tapering, thin-walled, septate. Asci 68–93 x 8.5–10 µm, with a apical ring, 8-spored, clavate, short pedunculate, thin-walled at maturity, unitunicate. Ascospores arranged uniseriate, 5–13 x 4–6.3 µm, subglobose, oval, one-celled, hyaline, smooth, without a gelatinous sheath.

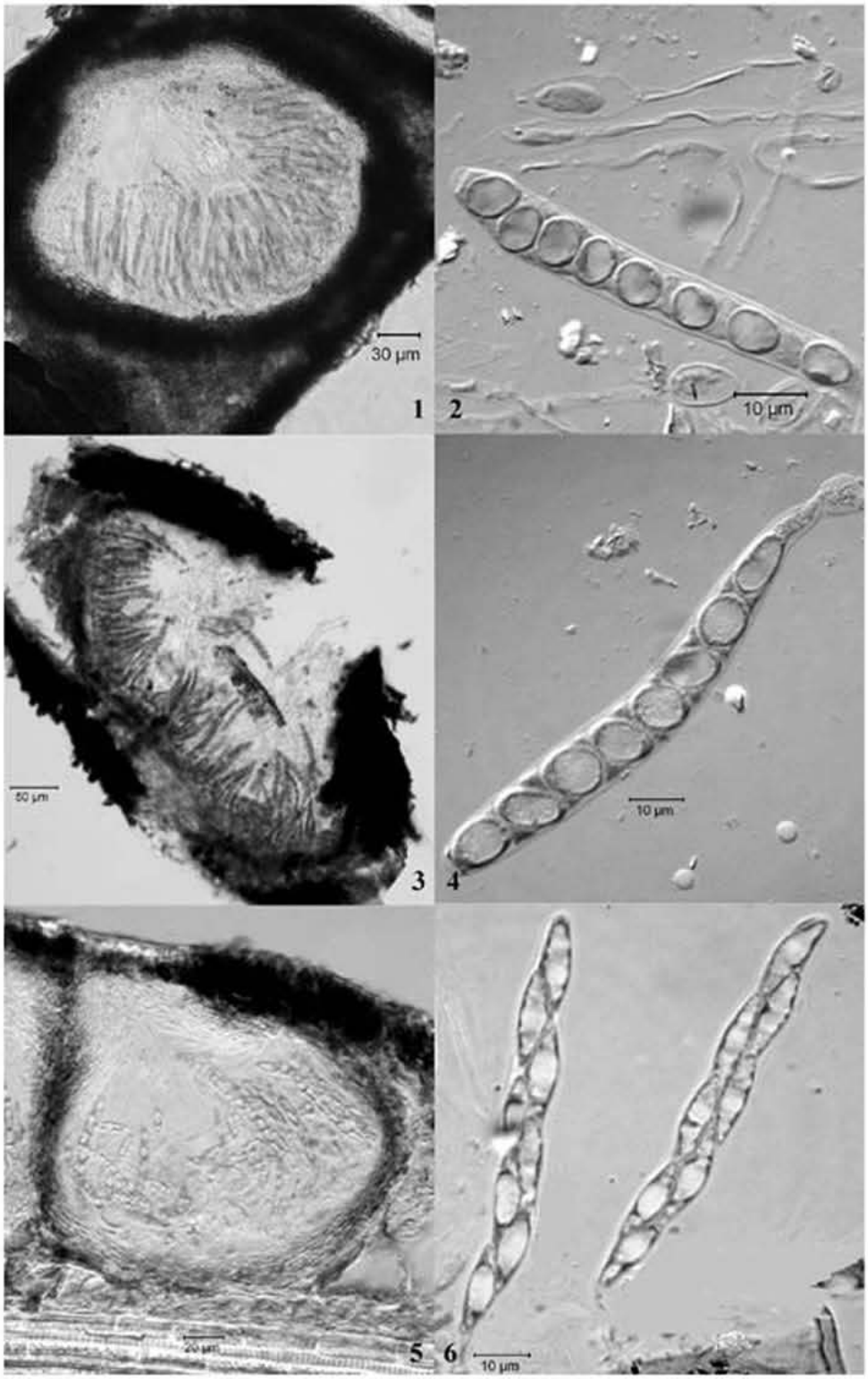
On leaves of *Poa* sp. (*Poaceae*), Gansu: Hezheng, Taizi Mountain, alt. 2560 m, 17 VI 2005, N. Liu, Z.Y. Li & L. Guo 21, HMAS 143656.

Until now, only *Phyllachora bromi* and *Phyllachora sylvatica*, have been reported on *Poa* in China. *Phyllachora ehrhartae* is reported here on *Poa* for the first time.

Phyllachora on *Isachnes*

Sawada (1959) reported *Phyllachora isachnes* Sawada on *Isachne debilis* Rendle with fusoid ascospores measuring 14–17 x 3–4 µm. Parbery (1967) considered

Figs. 1-2. *Phyllachora ehrhartae* on *Poa* sp. (HMAS 143656). Fig. 1. Section through immersed ascoma. Fig. 2. Differential interference micrograph of ascus and ascospores. Figs. 3-4. *Phyllachora paspalicola* on *Isachne tenuis* (HMAS 143934). Fig. 3. Section through immersed ascoma. Fig. 4. Differential interference micrograph of ascus and ascospores. Figs. 5-6. *Phyllachora fimbristylidicola* on *Fimbristylis dichotoma* (HMAS 135468). Fig. 5. Section through immersed ascoma. Fig. 6. Differential interference micrograph of asci and ascospores.


30 µm
1
2
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10 µm
20 µm
5
6
10 µm

the species a synonym of *Phyllachora urvilleana* Speg. with fusoid ascospores measuring 18–20 x 4–7 µm. The fusoid ascospores are very different from our specimen. The type of *Phyllachora paspalicola* is on *Paspalum* sp. According to Parbery (1967), the species was also parasitic on *Isachne australis* R. Br. and had a wider geographic distribution. The recently collected speciemen on *Isachne* is identified as *Phyllachora paspalicola* because it has the same shape and size of ascospores.

Phyllachora paspalicola Henn., Hedwigia 48: 106, 1908. **Figs. 3-4**

=*Phyllachora winkleri* Syd. & P. Syd., Ann. Mycol. 10: 80, 1912.
=*Phyllachora exigua* Theiss. & Syd., Ann. Mycol. 13: 449, 1915.
=*Phyllachora ophiuri* Syd. & P. Syd., Ann. Mycol. 15: 226, 1917.
=*Phyllachora digitariae* Syd., Bothalia 1: 220, 1924.
=*Phyllachora chardonii* Orton, Sci. Surv. Porto Rico & Virgin Island 8: 51, 1926.
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=*Phyllachora insularis* Chardón, J. Dept. Agric. Porto Rico 13: 13, 1929.
=*Phyllachora vaginata* Chardón, J. Dept. Agric. Porto Rico 16: 172, 1932.
=*Phyllachora wilsonii* Orton, Mycologia 36: 33, 1944.

Leaf spot: the included leaves becoming yellow. Blackened regions aggregated, roughly circular, 0.5–1.5 x 0.3–0.7 mm, shining black, rising from the upper leaf surface, 1- to 3-luculate, the ostiole inconspicuous, blackened regions can be visible from both sides of the leaves.

Anamorph: not seen.

Teleomorph: ascomata 85–250 x 140–475 µm, epigenous, immersed in the mesophyll layer of the leaves, ellipsoidal, with neck extending through the host epidermis and cuticle layer to the surface, with well-developed, hyaline periphyses, asci rising from the basal and lateral wall of the ascoma. Upper wall up to 90 µm thick, becoming thicker around the ostioles, composed of epidermis cells which are occluded by melanized material. Lower wall up to 40 µm thick. Lateral wall up to 22 µm thick, composed of thin-walled cells. Paraphyses 2 µm wide, filiform, longer than asci, thin-walled, aseptate. Asci 70–120 x 9–15 µm, 8-spored, cylindric, short pedunculate, thin- walled at maturity, unitunicate. Ascospores arranged uniseriate, 8–15 x 5–8.5 µm, ovoid, broadly ellipsoid or subglobose, guttulate, one-celled, hyaline, smooth, without a gelatinous sheath.

On living leaves of *Isachne tenuis* Keng f. (*Poaceae*), Yunnan: Tengchong, Xiaodifang, alt. 2100 m, 19 IX 2005, N. Liu, Z.Y. Li & L. Guo 131, HMAS 143934.

So far, there are two species, *Phyllachora urvilleana* and *Phyllachora paspalicola*, that have been reported on *Isachne* in China.

Phyllachora on *Fimbristylis*

Two species have been recognized on *Fimbristylis*: 1) *Phyllachora fimbristylidis* (Berk. & Broome) Sacc. [Saccardo 1891; syn. *Phyllachora fimbristylidis* Sawada (Sawada 1943, Tai 1979)] with fusiform ascospores measuring 17–18 x 2–3 µm; 2) *Phyllachora fimbristylidicola* with subfusoid ascospores measuring 14–20 x 4–6 µm (Saccardo & Trotter 1913). By comparing the size and shape of ascospores, the recently collected specimen was identified as *Phyllachora fimbristylidicola*. It is new to China.

Phyllachora fimbristylidicola Speg., Anal. Mus. Nac. Buenos Aires 19: 417, 1909, as *'fimbristylicola'*. Figs. 5-6

Leaf spot: blackened regions sparsed, roughly circular or ellipsoidal, 0.5–2.5×0.3–1 mm, shining black, rising from the surface, mainly visible on upper surface of the leaf, 1- to 2-loculate.

Anamorph: not seen.

Telemorph: ascomata 100–200×125–350 µm, epigenous, immersed in upper epidermal layer of the leaves, subglobose or ellipsoidal, with flattened base, neck extending through the host cuticle layer to the surface, with well-developed, hyaline periphyses. Upper wall to 42 µm thick. Lateral wall to 25 µm thick, composed of thin-walled hyaline host cells and hyphae. Paraphyses 2 µm wide, thin-walled, septate, no branch. Asci 65–88×6–8 µm, 8-spored, cylindric, acute at apex, short pedunculate, thin-walled at maturity, unitunicate, with an inconspicuous apical ring. Ascospores arranged uniseriate or biseriate, 10–18×4–6.3 µm, fusoid or narrowly ellipsoid, one-celled, hyline, guttulatae, smooth.

On living leaves of *Fimbristylis dichotoma* (L.) Vahl (*Cyperaceae*), Yunnan: Tengchong, alt. 1600 m, 20 IX 2005, N. Liu, Z.Y. Li & L. Guo 145, HMAS 135468.

So far, three species have been reported on *Cyperaceae* in China: *Phyllachora fimbristylidis* and *Phyllachora fimbristylidicola* on *Fimbristylis*, and *Phyllachora marisci-sieberiani* Sawada ex Z.Y. Zhang & X.X. Zeng on *Mariscus*.

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Proposed synonyms in *Cyathus*

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Abstract—Based on the morphological analyses of 48 taxa of *Cyathus*, including 30 type specimens, three *Cyathus* species were found to represent synonyms of existing species. *Cyathus cheliensis*, *C. gansuensis* and *C. megasporus* are herein accepted as synonyms of *C. limbatus*, *C. pygmaeus* and *C. poeppigii*, respectively. The latter three species are redescribed and illustrated.

Key words—bird's nest fungi, *Nidulariaceae*, taxonomy

Introduction

The genus *Cyathus* (*Nidulariaceae, Nidulariales*) was established by Haller in 1768. The first monograph on *Cyathus* was published by Lloyd (1906), and later Brodie (1975, 1984) published two monographs on Bird's Nest Fungi wherein he included four genera (*Crucibulum* Tul. & C. Tul., *Cyathus* Haller, *Nidula* V.S. White and *Nidularia* Fr.) and forty nine species of *Cyathus*. Although Brodie's monographs have been followed by most mycologists, some *Cyathus* species in his monographs are questionable, because he did not examine all type specimens. In addition, since the last monograph of Brodie was published in 1984, twenty two additional species of *Cyathus* and five varieties have been published, many of which await critical comparisons with extant type specimens.

A systematic study of the genus *Cyathus* was conducted using morphological and molecular approaches (molecular phylogenies will be published elsewhere). The morphological analyses revealed that three recently described *Cyathus* species represent synonyms of older epithets. Although attempts were made to sequence all six taxa referred to in this paper, we were unsuccessful in obtaining useful sequences for *C. megasporus*, *C. limbatus* and *C. pygmaeus*. Our taxonomic conclusions are therefore based on data obtained from examinations of holotype specimens and authentic specimens identified by Brodie.

Materials and Methods

One hundred and fifteen specimens representing forth eight species of *Cyathus*, included thirty type specimens, were borrowed from five herbaria (BPI, DAOM, HMAS, MICH and SWFC; Holmgren & Holmgren 1998) and examined critically following Brodie's (1975) protocols. Pertinent data on peridia and peridiole features, and basidiospore size and shape were documented. A minimum of twenty basidiospores were measured per specimen.

Taxonomy

Cyathus limbatus Tul. & C. Tul., Ann. Sci. Nat., Bot. III, 1: 78, 1844. **Figure 1**
= ***Cyathus cheliensis*** F.L. Tai & Hung, Sci. Rep. Nat. Tsing Hua Univ. B, 3: 161, 1948.

Fruiting bodies obconical, mostly incurved at the mouth, constricting abruptly at the base, 6-10 mm high, 5-7 mm wide at mouth; exterior surface of peridium brown, reddish-brown or dark brown, some appearing lighter in color after the hairs are rubbed off; hairs congregated into tufts, appearing hirsute; plications distinct; interior surface of peridium mostly grey, sometimes brownish-grey to dark grey, distinctly striate; lip fimbriate, dark brown; base usually attached to the substrate by a conspicuous mass of mycelia. *Peridioles* mostly circular or subcircular in face view, sometimes broadly ellipsoid, 1.5-2.5 mm diam., with double cortexes 80-100 µm thick, without a tunica. *Basidiospores* hyaline, smooth, ellipsoid to broadly ellipsoid, both ends rounded, thick-walled, 17-23 x 11-14 (-16) µm.

Habit: gregarious on dead wood.

Known distribution: widely distributed in warm countries. Africa, British Guiana (type origin), China, Hawaiian Islands, India, Pacific Island, South America, Thailand, West Indies.

Material examined: One specimen of *C. cheliensis*: CHINA, Yunnan Province, Jinhong, 1939, H.S. Yao, HMAS 02755 (**Holotype**). Eight specimens of *C. limbatus*: CHINA, Yunnan Province, 11 Sept. 1994, T. X. Zhou, SWFC 20009; Congo, Katanga, 24 Nov. 1960, Schmity Lavecgue, DAOM 200492 (identified by Brodie); place unknown, 1899,

collector unknown, DAOM 200494 (identified by Brodie); JAMAICA, Wedcombe, 3 Sept. 1955, D.A. Powell, BPI 727165 (identified by Brodie); JAMAICA, Kingston, 14 Jan. 1966, H. J. Brodie, BPI 727167 (identified by Brodie); KENYA, Naisafi, Nov. 1953, R. M. Nattiaes, DAOM 200496 (identified by Brodie); UGANDA, time unknown, R. A. Dummer, BPI 727166 (identified by Brodie); USA, Kansas, Neola, 29 Aug. 1956, collector unknown, DAOM 200493 (identified by Brodie).

Notes: *Cyathus limbatus* is characterized by the following combination of features: darkly pigmented fruiting bodies with distinct plications on both peridial surfaces; mouths that are mostly incurved; thick and double cortexes on peridioles; and ellipsoid spores that measure "15 × 10 µm in the type, but 16-22 × 10-12 µm in other collections" (Brodie 1975). Morphological analyses of seven specimens identified by Brodie and of the holotype specimen of *C. cheliensis* indicated that the two taxa are anatomically indistinguishable (See Table 1). We therefore consider *C. cheliensis* to represent a synonym of *C. limbatus*.

Table 1. The comparison of mainly morphological characters between *Cyathus limbatus* and its synonym *Cyathus cheliensis*

Characters	*C. limbatus*	*C. cheliensis*
Shape of fruiting bodies	Obconic, base abruptly constrict, some mouth incurved	Obconic, broadly obconic, base abruptly constrict
Size of fruiting bodies	6-10 × 5-7 mm	7-9 × 7-8 mm
Color of exterior surface of peridium	Brown, reddish brown, dark brown	Russet, reddish brown, brown
Hairs on peridium	Gathered into tufts, hirsute	Gathered into tufts
Plications on peridium	Distinct at exterior and inner surfaces	Distinct at exterior and inner surfaces
Lip of fruiting bodies	fimbriate	fimbriate
Size of peridioles	1.5-2.5 mm in diam.	1.5-1.8 mm in diam.
Structure of peridioles	Double cortexes	Double cortexes
Shape of basidiospores	Ellipsoid, broadly ellipsoid, both ends round	Ellipsoid, broadly ellipsoid, both ends rounded
Size of basidiospores	17-23 × 11-14 (-16) µm	15-20 × 7.8-12.5 µm
Materials source	7 specimens identified by Brodie	Holotype

Tai (1979) omitted structural characters of the peridioles in his description of *C. cheliensis*, which is one of the crucial characters for the determination of *Cyathus* species. *Cyathus olivaceobrunneus* was the only species that was compared with *C. cheliensis* by Tai (1979), which differed from *C. cheliensis* in having lighter colored fruiting bodies, a smooth lip and smaller spores. Affinities of *Cyathus limbatus* to *C. cheliensis* were not addressed by Tai (1979).

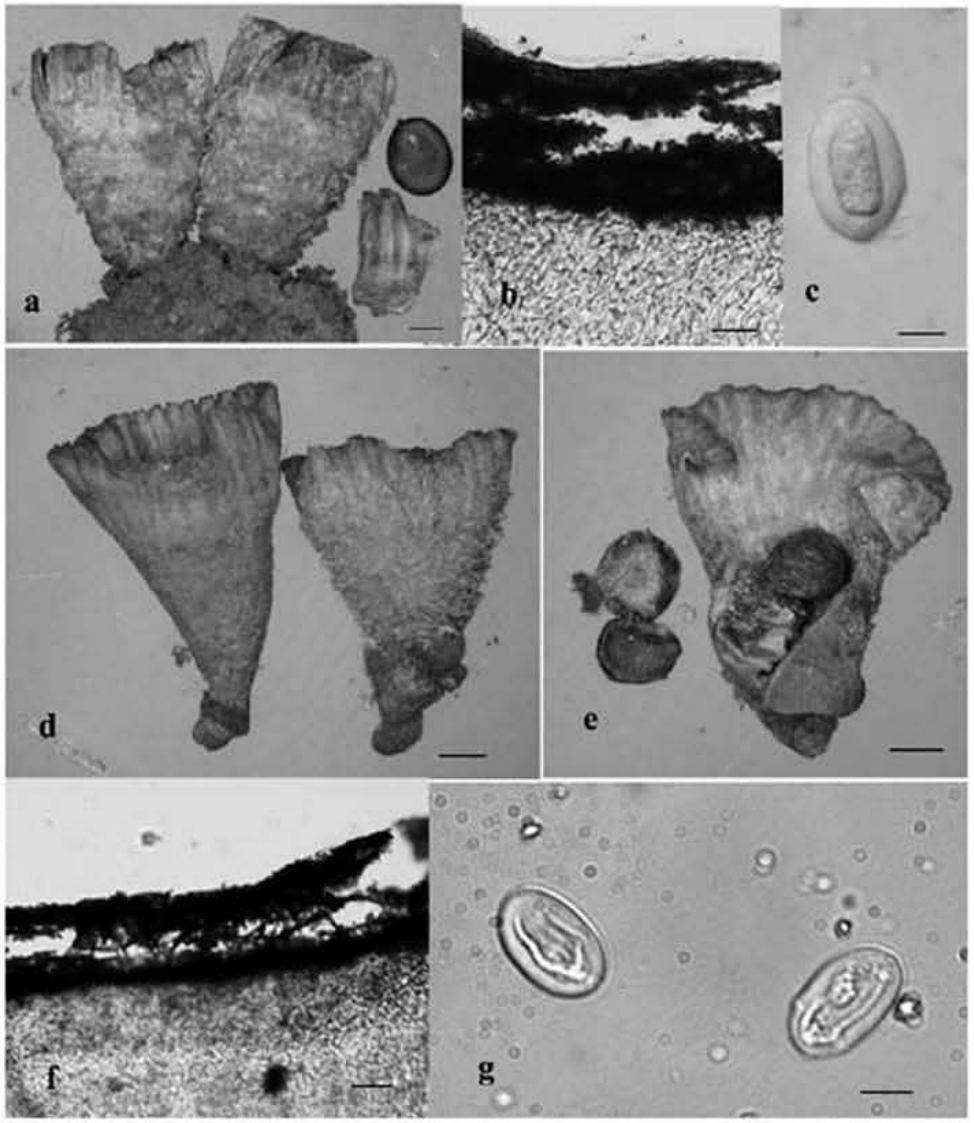

FIGURE 1. Comparison between a-c [*Cyathus limbatus* (DAOM 200496, identified by Brodie)] and proposed synonym d-g [*Cyathus cheliensis* (HMAS 02755 Holotype)]. *a, d, e*—Fruiting bodies, bars = 2 mm; *b & f*—Section of peridioles, double cortex, bars = 25 µm; *c & g*—Basidiospores, bars = 5 µm.

Cyathus pygmaeus Lloyd, Mycological Writings 2, The *Nidulariaceae*: 26, 1906.

Figure 2

= ***Cyathus gansuensis*** B. Yang, J. Yu & T.X. Zhou, Mycosystema 21:313, 2002.

Fruiting bodies variable in shape, obconical with a slender, short stipe or crucible-shaped without a distinct stipe, 3.5-5 mm high, 4-5 mm wide at the straight mouth; exterior surface of peridium light brown, lacking placations,

with hairs soft, short, aggregated into tufts, apex of tufts bleached, felt-like; interior surface of peridium dark gray, smooth, lacking plications; lip smooth; attached to the substrate without a conspicuous mass of mycelia. *Peridioles* circular to broadly ellipsoid, dark grey, 0.8-1.2 mm diam., with a single cortex 16-24 µm thick, and a tunica 16-20 µm thick. *Basidiospores* hyaline, smooth, broadly ellipsoid to ovoid, 11-15(-16) x 8-10 µm.

Habit: gregarious on dead twigs.

Known distribution: Chile, China, USA, typically found in arid habitats.

Material examined: Three specimens of *C. pygmaeus*: CHILE, Santiago, collection time unknown, M. R. Espinosa, BPI 703513 (identified by Lloyd); USA, California, collection time unknown, Stewart S. Towne, BPI 703515 (identified by Lloyd); USA, Washington, June 1909, J. S. Cotton, BPI 703514 (**Holotype**). One specimen of *C. gansuensis*: CHINA, Gansu Province, Xinglongshan Mountain, 1999, L.Z. Zhao, SWFC 20880 (**Holotype**).

Table 2. The comparison of mainly morphological characters between *Cyathus pygmaeus* and its synonym *Cyathus gansuensis*

Characters	*C. pygmaeus*	*C. gansuensis*
Shape of fruiting bodies	Obconic with slender, short stipe or crucible-shaped without distinct stipe	Obconic, abruptly constricted at the base
Size of fruiting bodies	3.5-5 × 4-5 mm	2-7 × 4-8 mm
Color of exterior surface of peridium	Light brown	Brown, grayish brown
Color of interior surface of peridium	Dark brown	Dark brown
Hairs on peridium	Tufts aggregated by thick tomenta	Tufts aggregated by tomenta
Plications on peridium	No plications	No plications
Lip of fruiting bodies	Smooth	Smooth
Size of peridioles	0.8-1 mm in diameter	1-1.5 mm in diameter
Structure of peridioles	Single cortex with tunica	Single cortex with tunica
Shape of basidiospores	Broad ellipsoid, ovoid	Ovoid, broadly ellipsoid
Size of basidiospores	12-15 (-16) × 8-10 µm	10-13 × 7.5-10 µm
Materials source	Holotype and 2 specimens identified by Lloyd	Holotype

Notes: *Cyathus pygmaeus* is one of the smallest known *Cyathus* species in terms of fruiting body size. Brodie (1975) stated that three other characters should be used to distinguish *C. pygmaeus* from similar taxa: i) flared rim of fruiting bodies; ii) very dark interior of the cup; and iii) the white, durable epiphragm. Examination of the holotype of *C. pygmaeus* showed that fruiting bodies did not have flared mouths, although a second specimen, BPI 703515 identified by

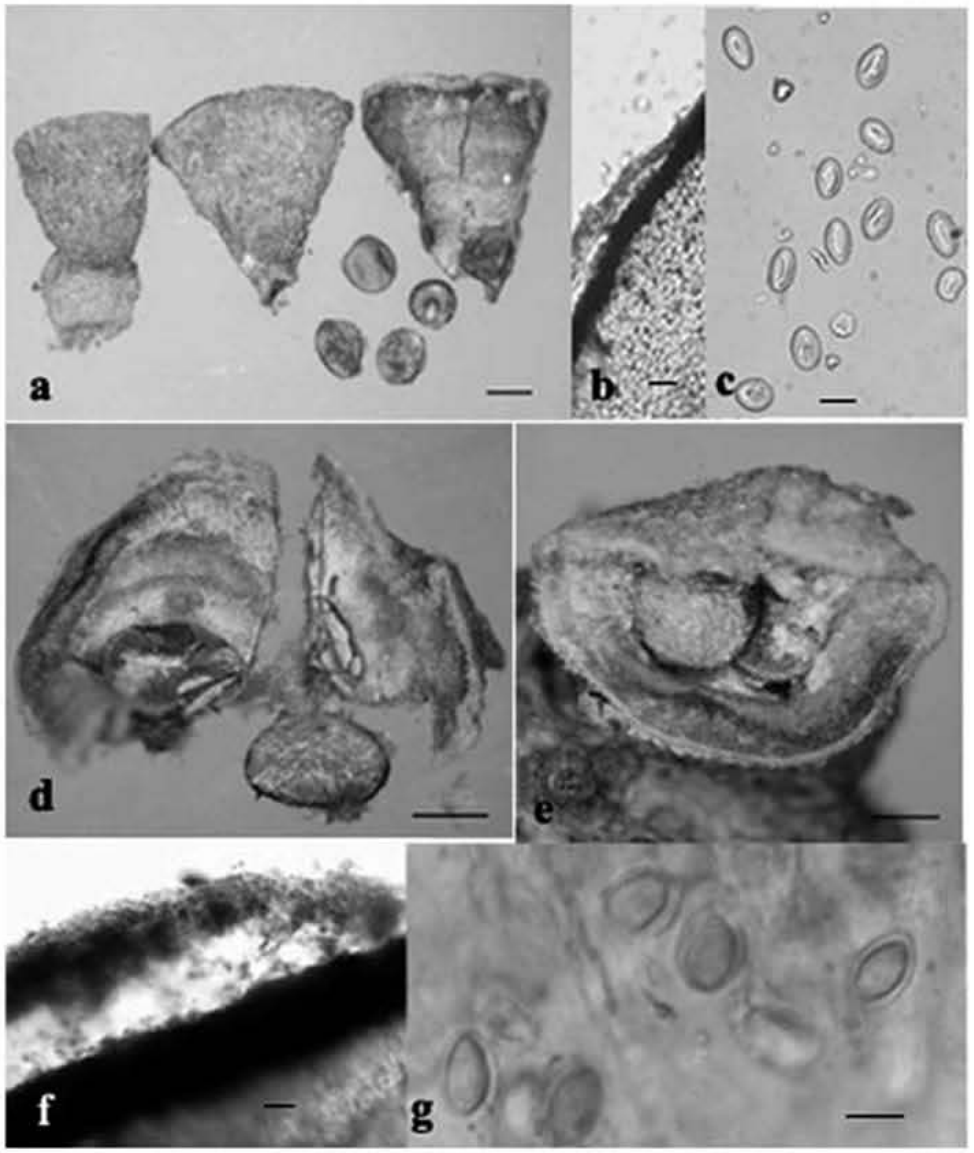

FIGURE 2. Comparison between **a-c** [*Cyathus pygmaeus* (BPI 703514 Holotype)] and proposed synonym **d-g** [*Cyathus gansuensis* (SWFC 20880 Holotype)]. *a*—Fruiting bodies, bar = 1.4 mm; *b*—Section of peridiole, one cortex with tunica, bar = 20 µm; *c*—Basidiospores, bar = 9 µm; *d* & *e*—Fruiting bodies, bars = 1 mm; *f*—Section of peridiole, one cortex with tunica, bar = 10 µm; *g*—Basidiospores, bar = 10 µm.

Lloyd, showed a flared mouth on its single fruiting body. Presence of a flared mouth is therefore a variable character in this species. The tiny fruiting bodies, in combination with a dark internal surface of the peridium, however, are reliable characters for species diagnosis. Moreover, the habitat of *C. pygmaeus* in arid areas is also a good diagnostic feature (Brodie 1975).

When *C. gansuensis* was introduced by Yang et al. (2002), it was stated to differ from *C. pygmaeus* in having larger fruiting bodies (4-6 (-9) mm high, (3.5) 5-8 (-9.5) mm wide), larger peridioles (1.5-2 mm long, 0.8-1.5 mm wide) and being darker on the inner surface of peridium. Based on our observations, the fruiting bodies and peridioles of *C. gansuensis* are of similar size to those of *C. pygmaeus*, and inner peridial surfaces are also dark brown. Furthermore the morphology of the peridioles and spores are indistinguishable from those of *C. pygmaeus* (Table 2). *Cyathus gansuensis* was collected from an arid area on Xinglongshan Mountain, Gansu Province. We therefore consider *C. gansuensis* to be synonymous with *C. pygmaeus*.

Cyathus poeppigii Tul. & C. Tul., Ann. Sci. Nat., Bot. III, 1: 77, 1844. **Figure 3**
= ***Cyathus megasporus*** W. Ren & T.X. Zhou, Acta Mycol. Sin. 11: 25, 1992.

Fruiting bodies obconical or narrowly obconical, some with mouths incurved, constricting abruptly at the base and forming a slender stipe, 6-8 mm high, 4-5 mm wide; exterior surface of peridium dark brown to reddish-brownwith hairs long, appearing shaggy or hirsute; ridges distinct; internal surface of peridium dark brown to dark grey, deeply plicate, some splitting along the fluted lip; lip fimbriate, dark brown. *Peridioles* circular to subcircular, dark brown, 1.5-2 mm

Table 3. The comparison of mainly morphological characters between *Cyathus poeppigii* and its synonym *Cyathus megasporus*

Characters	*C. poeppigii*	*C. megasporus*
Shape of fruiting bodies	Cup-shaped with slender stipe	Long obconic with slender stipe
Size of fruiting bodies	5-8 × 4-5 mm	5-11 × 3.5-6.5 mm
Color of exterior surface of peridium	Brown, dark brown	Dark brown
Hairs on peridium	Aggregated into long tufts, some shaggy	Shaggy
Plications on peridium	Distinct on exterior and inner surfaces of peridium	Distinct on exterior and inner surfaces of peridium
Lip of fruiting bodies	Smooth or fimbriate	Fimbriate
Size of peridioles	1.5-2 mm in diam.	1.5-2 mm in diam.
Structure of peridioles	Double cortexes	Double cortexes
Shape of basidiospores	Ellipsoid, ovoid	Ellipsoid
Size of basidiospores	(20-)30-45(-50)× (15-)18-30 µm Brodie: 30-42 × 20-28 µm	25-30 × 15-16 µm Ren & Zhou: (24-)31-55(-68) × (15-)18-36.5(-47) µm
Materials source	2 specimens identified by us	Holotype

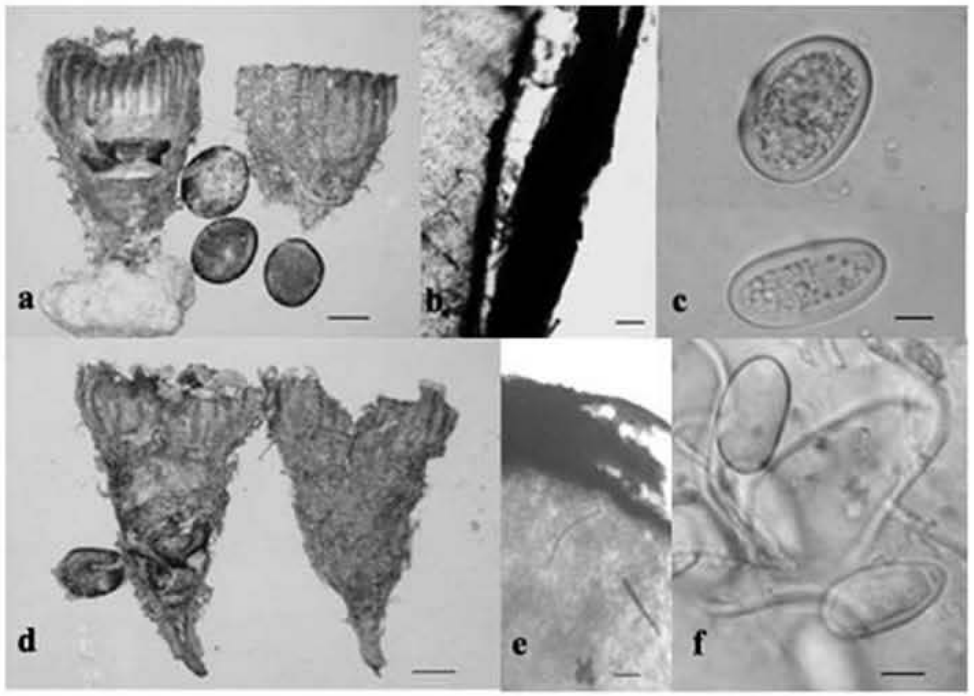

FIGURE 3. Comparison between **a-c** [*Cyathus poeppigii* (SWFC 21357)] and proposed synonym **d-f** [*Cyathus megasporus* (SWFC 20448 Holotype)].

a—Fruiting bodies, bar = 2 mm; *b*—Section of peridiole, double cortex, bar = 15 µm; *c*—Basidiospores, bar = 20 µm; *d*—Fruitng bodies, bar = 1.5 mm; *e*—Section of peridiole, double cortex without tunica, bar = 20 µm; *f*—Basidiospores, bar = 16 µm.

diam.; double cortex 50-75 µm thick, composed of interwoven reddish-brown hyphae, without a tunica. *Basidiospores* hyaline, smooth, broadly ellipsoid to ovoid, rounded at both ends, thick or thin walled, (20-)30-45(-50) x (15-)18-30 µm.

Known distribution: Common in tropical areas of Africa, China, Hawaiian Islands, South America and the West Indies (type location: Cuba).

Material examined: Two specimens of *C. poeppigii*: CHINA, Hunan province, Jiuyishan Mountain, 4 Jan. 2001, L.Z. Zhao, SWFC 21400; CHINA, Yunnan Province, Longchuan, 5 July 2000, L.Z. Zhao, SWFC 21357. One specimen of *C. megasporus*: CHINA, Yunnan Province, Kunming, 23 Nov. 1987, X. Xing, SWFC 20448 **(Holotype)**.

Notes: Cyathus poeppigii is characterized by deep plications on the inner peridium, dark brown or reddish brown color, double cortexes in the peridioles and very large basidiospores. The principal variation observed among the collections examined is in basidiospore size. Brodie (1975) stated: "spores of *C. poeppigii* are always large and variable", and "when other characteristics are remarkably constant, the author does not feel that spore size ought to be unduly emphasized as a diagnostic feature of *C. poeppigii*".

Cyathus megasporus was described as a new species by Ren & Zhou (1992) based primarily on its large spore size, reported as (24-) 31-55 (-68) x (15-) 18-36.5 (-47) µm. This is larger than those of *C. poeppigii* whose spores are 30-42 µm x 20-28 µm (Brodie 1975). Re-examination of the holotype of *C. megasporus* revealed that the basidiospores measured 25-30 x 15-16 µm, and other morphological characters were indistinguishable from those of *C poeppigii* (Table 3). We therefore consider *C. megasporus* to be a synonym of *C. poeppigii*.

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A new species of *Bactrodesmium* from Lithuania

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Abstract--*Bactrodesmium pusillum*, a new species of dematiaceous hyphomycete, collected on unidentified decaying wood and on wood of *Quercus robur* and *Picea abies* in forest litter in Lithuania, is described and illustrated. The fungus differs from known species of the genus by the size of the conidiophores and by the shape, size, septation and colour of the conidia.

Keywords--anamorphic fungi, taxonomy

Introduction

The genus *Bactrodesmium* Cooke was established for species with small, sparsely scattered or clustered and effused, dark brown or black sporodochia. The generic name was proposed by Cooke (1883) for two species of the genus *Sporidesmium*: *S. abruptum* Berk. & Broome and *S. spilomeum* Berk. & Broome with clavate multiseptate conidia, but without correct nomenclatural changes. The valid nomenclatural changes were made later by Mason & Hughes. For the first time Mason & Hughes proposed new combination for *Bactrodesmium abruptum* (Berk. & Broome) E. W. Mason & S. Hughes in Rimington (1953), but it was invalidly published. Hughes (1958) validated the combination and proposed *B. abruptum* as lectotype. The new combination of *Bactrodesmium spilomeum* (Berk. & Broome) E. W. Mason & S. Hughes was validly published in Hughes (1953). The genus has been expanded and nomenclatural changes have been made by Cooke & Harkness (1884), Sutton (1967, 1977), Ellis (1959, 1971, 1976), Holubová-Jechová (1972), Borowska (1975), Matsushima (1981, 1993, 1995), Palm & Stewart (1982), Hughes (1983), Hughes & White (1983a-e), Kirk (1983, 1986), Rao (1983), Castañeda & Arnold (1985), Rao & de Hoog (1986), Udaiyan (1991), Révay (1993), Mercado et al. (1995), Zucconi & Lunghini (1997) and Cooper (2005).

At present time about 40 species are recognized in the genus, but the type of conidial secession in the genus for many species is still dubious. Prior to 1997

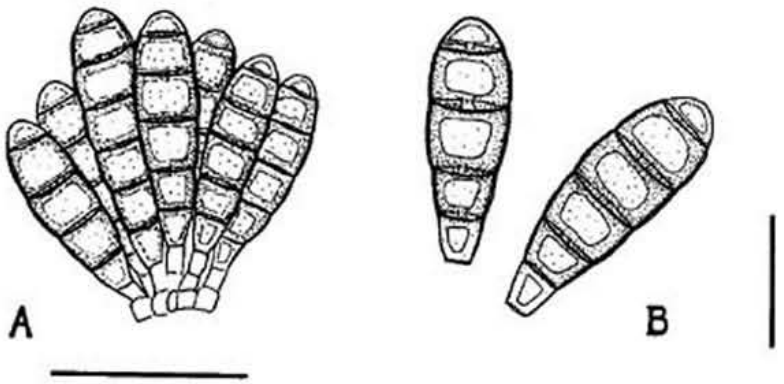

Fig. 1. *Bactrodesmium pusillum* (from holotype). **A.** Conidiophores with conidia. **B.** Conidia. Bars: A = 20 µm; B = 10 µm.

the nature of conidial seccession, schizolytic or rhexolytic, in *Bactrodesmium* was under discussion. This character sometimes is very difficult to determine; some authors (Palm & Stewart 1982, Zucconi & Lunghini 1997, Cooper 2005) noted that a breach in the wall of conidiogenous cell in separate species may remain as a frill at the base of schizolytically seceding conidia. Zucconi & Lunghini (1997) critically examined type material preserved (RO, No 1163) as *Sporidesmium abruptum* and suggested that the genus should be characterized by schizolytic conidial secession. Thus species described as having rhexolytic conidial secession or those who the nature of secession is dubious need further taxonomical study.

Materials and methods

The material was collected in spruce (*Picea abies*)-dominated Jagelonys forest (Trakai district) of Lithuania. Samples of decaying wood of unidentified tree species and of *Picea abies* and *Quercus robur*, containing fungi were dried and preserved. Description and illustration of the new species *Bactrodesmium pusillum* were made from fresh preparations in distilled water and in 25% lactic acid. Representative specimens of the fungus are deposited in the herbarium of the Institute of Botany, Vilnius, Lithuania (BILAS); some duplicates are deposited in the Komarov Botanical Institute, St. Petersburg, Russia (LE).

Taxonomic Description

Bactrodesmium pusillum Markovskaja sp. nov. Fig. 1-7

MycoBank MB 510340

Sporodochia punctiformia, dispersa, effusae, pulvinata, nitida, fusco brunnea. Mycelium plerumque immersum, ex hyphis ramosis, septatis, subhyalinis vel dilute brunneis, 1-2.5

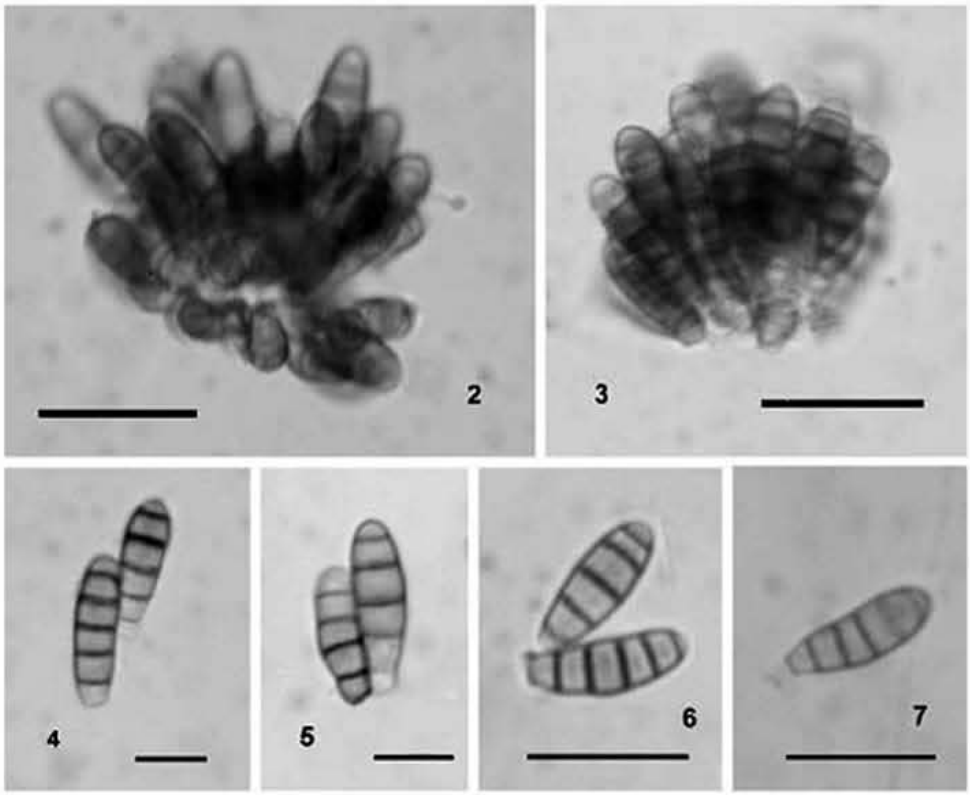

Fig. 2-7. *Bactrodesmium pusillum* (from holotype). **2-3.** Sporodochia. **4-6.** Conidia. **7.** Conidiophore with conidia. Scale bars: 2-3 = 20 µm; 4-5 = 10 µm; 6-7 = 20 µm.

µm latis compositum. Conidiophora solitaria, semi-macronematica, simplicia, laevia, ex 1-2 cellulis composites, ramosa, hyalina vel subhyalina, 7.5-10 µm longis, 2-3 µm latis. Cellulae conidiogenae holoblasticae, monoblasticae, integratae, terminales, determinatae, cylindricae vel clavatae. Conidia acrogena, solitaria, laevia, anguste ellipsoidea vel clavata, (4-) 5 (-6) septatis, ad septa leviter constricta, (18-) 20-23 (-25) µm longis and 6.5-7.5 µm latis, pallide brunnea, cellula apicale subhyalina et rotundata, cellula basali subhyalina vel hyalina, tenuata et truncata, 2-2.5 µm latis. Conidiorum secessio schizolytica. Teleomorphosis ignota.

Holotype--LITHUANIA. TRAKAI DISTR., Jagelonys forest (54°41'23"N, 23°34'54"E), on decaying unidentified wood, collected 10 September 2003, S. Markovskaja, (HOLOTYPE-BILAS 34904).

Etymology: from the Latin, *pusillus* -- referring to small size of sporodochia and conidia.

Sporodochia on wood scattered or clustered, effuse, pulvinate, dark brown. Mycelium immersed and superficial, composed of branched, septate, smooth, subhyaline or pale brown hyphae, 1-2.5 µm diam. Conidiophores simple, semi-

macronematous composed of 1-2 cells, thin-walled, hyaline to pale brown, 7.5-10 µm long, 2-3 µm broad. Conidiogenous cells holoblastic, monoblastic, integrated, determinate, terminal, hyaline, cylindrical to clavate. Conidia acrogenous, solitary, smooth, elongate ellipsoid to clavate, (4-) 5 (-6), slightly constricted at the septa, (18-) 20-23 (-25) µm long and 6.5-7.5 µm broad, pale brown, apical cell subhyaline and rounded, basal cell subhyaline to hyaline, tapering and truncate, 2-2.5 µm wide. Conidial secession schizolytic.

Teleomorph unknown.

OTHER SPECIMENS EXAMINED—on decaying wood of (*?Quercus*), LITHUANIA, **Trakai district**, Jagelonys forest, (54°41'23"N, 23°34'54"E), 10 September 2003, S. Markovskaja, BILAS 34907 (duplicate in LE 230711); on decaying wood of *Quercus robur*, LITHUANIA, **Trakai district**, Jagelonys forest, (54°41'23"N, 23°34'54"E), 7 September 2004, S. Markovskaja, BILAS 34905; on decaying wood of *Picea abies*, LITHUANIA, **Trakai district**, Jagelonys forest, (54°41'23"N, 23°34'54"E), 7 September 2004, S. Markovskaja, BILAS 34906.

Discussion

Bactrodesmium pusillum morphologically is similar to *B. spilomeum*, *B. pallidum* M.B. Ellis, *B. biformatum* (Höhn.) S. Hughes, *B. submoniliforme* Hol.-Jech., *B. traversianum* (Peyronel) M.B. Ellis and *B. indicum* P. Rag. Rao, but the combination of its diagnostic characters does not agree with any of the published descriptions of these species (Table 1). The new species is readily distinguished from all other species by the size of its conidiophores and by the shape, size, septation and colour of its conidia. The new species is closest to *B. spilomeum*, *B. pallidum* and *B. biformatum* in shape of conidia, constriction at the septa and lacking thick bands, and differs mainly by smaller, almost sessile conidia with a conspicuous porus in the middle of each septum (Ellis 1959, 1971, Holubová-Jechová 1972, Hughes 1983, Révay 1993, Ellis & Ellis 1997). Holubová-Jechová (1972) noted that *B. pallidum* probably is a synonym of *B. spilomeum*, but other authors (Ellis & Ellis 1997, Tsui et al. 2003) and Index Fungorum (http://www.indexfungorum.org/Names?Names.asp 2004) recognize *B. pallidum* as a separate species. The newly described species is very close to *B. pallidum* in having pale brown pigmentation of conidia. According to Hughes (1983) *B. submoniliforme* is a synonym of *B. biformatum*, but in *B. biformatum* conidiophores and conidia are only very slightly constricted at the septa. *Bactrodesmium pusillum* resembles *B. traversianum* and *B. indicum* in shape and septation of conidia, but conidia of the latter two species were described as not constricted at the septa and are larger.

Conidial secession in *B. pusillum* was determined as schizolytic, although sometimes conidia bear a basal frill, the remnants of conidiogenous cells, as have been noted in *B. moenitum* (J.L. Crane & Shearer) M.E. Palm & E.L.

Table 1. Comparison of morphological characters between *B. pusillum* and similar species

Species	Conidiophores morphology and size (µm)	Conidial morphology	Septation and size of conidia (µm)	Colour of conidia
Bactrodesmium pusillum	Simple, 0-1 septate, 7.5-10 × 2-3	Elongate ellipsoidal to clavate	(4-) 5 (-6) septate, (18-) 20-23 (-25) × 6.5-7.5	Pale brown, apical and basal cells subhyaline
B. biformatum (Hughes 1983, Révay 1993)	Branched, septate, 10-25(-38) × 2.5-6.5	Elongate ellipsoidal to fusiform	(5-) 7-8 (-10) septate, (20-) 25-30 (-42) × 6-7(-10)	Pale brown to brown, apical and basal cells subhyaline
B. indicum (Rao 1983)	Simple, 0-3 septate, 6-15 × 3-5	Clavate to cylindrical	4-5 septate, 35-52 × 7-11	Yellowish to golden brown, basal cell subhyaline
B. pallidum (Ellis 1971, Ellis & Ellis 1997, Tsui et al. 2003)	Branched, septate, 20-65 × 2-3	Elongate ellipsoidal to cylindrical	5-6 septate, 35-55 × 9-12 (-18)	Pale brown to brown
B. spilomeum (Ellis 1959, 1971, Holubová-Jechová 1972)	Irregulary branched, septate, 25-34 (-75) × 2-3	Elongate ellipsoidal to clavate	(2-) 3-5(-6) septate, 22-40 (-45) × (6-) 10-12 (-14)	Pale brown to mid brown
B. submoniliforme (Hughes 1983, Holubová-Jechová 1972)	Branched, septate, constricted at the septa, 6.5-25 (-38) × 2.5-6.5	Elongate ellipsoidal to fusiform	(5-) 8-10 septate, conspicuously constricted at the septa	Pale brown to brown
B. traversianum (Ellis 1959, 1971)	Branched, 1-4 septate, 20-40 × 2-3	Ellipsoidal to clavate	3-6 septate, 20-37 × 8-12	Brown to dark brown, basal cell subhyaline

Stewart, *B. cubense* (R.F. Castañeda & G.R.W. Arnold) Zucconi & Lunghini and *B. nothofagi* J.A. Cooper (Palm & Stewart 1982, Zucconi & Lunghini 1997, Cooper 2005).

Apart from the newly described *Bactrodesmium pusillum*, five additional species of the genus *Bactrodesmium* were collected on decaying wood of different trees in various forests in Lithuania: *B. betulicola* M.B. Ellis, *B. biformatum*, *B. obovatum* (Oudem.) M.B. Ellis, *B. pallidum* and *B. spilomeum*. *Bactrodesmium spilomeum* is common in Lithuania, meanwhile *B. biformatum* is rare, collected only twice on decaying wood of *Corylus avellana*. *Bactrodesmium obovatum*, *B. pallidum* and *B. betulicola* are frequent wood saprobes, the latter was collected exceptionally on *Betula*.

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MYCOTAXON

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Three new lichens from Turkey

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Abstract—Three species of lichenized fungi – *Cladonia rei, Lecidea lithophila* and *Porpidia soredizodes* – are reported as new to the lichen flora of Turkey. For each a short description is presented.

Keywords—Ascomycetes, biodiversity, Trabzon

Although the lichen flora of Turkey is largely unknown and many regions have yet to be investigated, in recent years there has been a substantial increase in the attention paid to this country (Aslan 2000, Aslan et al. 2002a,b, John 1995, John & Breuss 2004, Yazıcı 1999a,b, Yazıcı & Aslan 2002, 2003, 2006, Yazıcı et al. 2004).

The present report is based on samples collected on three different stations in Trabzon between 15 August 2004 and 15 May 2005. A stereo microscope, a compound microscope and the standard spot tests were used in the identification of the samples, together with the following references: Clauzade & Roux (1985), Fryday (2005), Poelt (1974), Purvis et al. (1992) and Wirth (1995). Vouchers have been stored in the herbarium of Biology Department, Giresun Science and Art Faculty, Karadeniz Technical University.

Results

Cladonia rei Schaer.

Podetia to 3.5 cm high, to 3.3 mm across, tapering upwards to a point, mostly green-gray sometimes green-brown, usually edge of aged cups longitudinally split, mostly simple; granular soredia discontinuous, from basal to podetial disc and also in cups, not on basal portion, sometimes squamulose patches present from basal up to cups, but mostly only in the base; basal portion of podetia not all blackening; cups slightly constricted at the base, margins not

proliferating. Apothecia brown and rare. Podetia Pd– or red, medulla Pd– or Pd + yellow, orange, or red, UV+ dull bluish (HTLC: homosekikaic, sekikaic and fumarprotocetraric acids).

Found growing over sandy and often somewhat base rich soil, also over mossy rocks, in open inland sites at lower altitudes, especially disturbed sites; also known from maritime localities.

Known from Asia (Iran), Australia and New Zealand, Europe (Belgium, England, Luxembourg, Netherlands, Denmark, Germany, Slovakia, Slovenia), and the USA (Rhode Island, California, Pennsylvania).

Trabzon: Akçaabat; Bozdoğan köyü, on mosses, at 250m, 40° 59' 55" N, 39° 28' 45" E, 15 May 2005, Yazici 1278.

Remarks—*Cladonia rei* resembles *Cladonia subulata* and *Cladonia glauca*. *Cladonia rei* has less branched podetia and often have deformed cups that proliferate only infrequently; those in *C. subulata* are differently coloured (red-brown), branch more frequently, and have podetia with red –brown apothecia that are often irregularly branched, appear antler-like, and often proliferate. Both *C. rei* and *C. subulata* possess fumarprotocetraric acid, but only *C. rei* has homesekikaic. Of three similar species, only *C. glauca* possesses squamatic acid. *C. rei* is dirty or drab green-brown, but *C. subulata* is dull to bright grey-green (Purvis et al. 1992).

Lecidea lithophila (Ach.) Ach.

Thallus thin, slightly warted, ± continuous to irregularly cracked-areolate, to slightly warted, pale grey to slightly blue-grey, often partly rust-red, medulla I–; prothallus generally indistinct. Apothecia (0.15–)0.55–2.2(–2.4) mm diam., staying in groups of 1 to 3, dark brown to black, disc black-brown, brown when wet, ± margin the same colour, immersed in the early stages; disc ± flat, convex in later stages, not constricted below; true exciple persistent, raised, ± with greenish tinge, internally pale brown to ± colourless, K–; epihymenium olive-brown, K–; hymenium (40–)50–75 µm tall; hypothecium colourless. Paraphyses anastomosing and sparsely branched with brownish apices. Asci elongate-clavate, Lecidea-type. Ascospores 10–15 x 5–6(–7) µm, ellipsoid. Thallus and medulla Pd–, K–, KC–, C– (HTLC: 4-O-demethylplanaic and ± planaic acids).

Found on exposed siliceous rocks, stones and pebbles, especially those rich in iron.

Known throughout Europe, North America, and southeast China.

Trabzon: Düzköy; Beypınar high plateau, on siliceous rock, at 700 m, 40° 48' N, 39° 20' E, 15 August 2004, Yazici 1281.

Remarks—*L. lithophila* is similar to *L. plana*. But *L. plana* has a predominantly immersed thallus that is pale-grey, not rust-coloured as in *L. lithophila*. *L. plana* has smaller ascospores and apothecia with a shorter hymenium and a greenish, not brownish, epithecium. In fresh specimens of *L. plana*, the disc remains black in comparison to the brown colors of *L. lithophila*. Finally, the apices of the paraphyses are dark-green in *L. plana*, not brownish (Purvis et al. 1992).

Porpidia soredizodes (Lamy ex Nyl.) J.R. Laundon

Thallus generally small, sometimes spreading (to 7–8 cm diam.), 0.5(–0.6) mm thick, dirty creamish grey, subcontinuous rimose, subareolate to somewhat scurfy and indistinct; prothallus black, arachnoid, often visible between areoles; medulla I–. Soralia to 0.3–0.6(–0.7) mm diam., scattered, round or some irregular, usually tuberculate, punctiform; soredia white to yellow-greenish white, farinose to granular. Apothecia rare, scattered, to 0.9 mm diam., mostly solitary, sometimes contiguous in groups of 2 to 3, mostly ± immersed, round to irregular; true exciple thick (0.15–0.20 mm), black; disc black or brownish black, not pruinose, flat, matt; epithecium brown. Ascospores 13–18(–21) x 6–8(–9) µm. Hymenium 90–150(–160) µm tall. Thallus K + yellow, Pd + orange, soralia Pd + orange, K + yellow (HTLC: stictic acid).

Grows on siliceous rocks, stonework pebbles and slate in lowlands.

Known throughout Europe (British Isles, Italy, Austria) and Australia.

Trabzon: Düzköy; Beypınar high plateau, on siliceous rock, at 700 m, 40° 48' N, 39° 20' E, 15 August 2004, Yazici 1275.

Remarks— A generally smaller, thinner and darker thallus helps differentiate *P. soredizodes* from *P. tubulosa*. *P. soredizodes* has a taller hymenium, smaller soralia and apothecia, but larger ascospores. *P. soredizodes* has a brown epithecium while the epithecium in *P. tubulosa* is brown-olive. On the other hand, *P. soredizodes* has brownish-black, flat, shiny and smooth discs while those in *P. tubulosa* are black, subconvex, matt and sometimes pruinose (Purvis et al. 1992).

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Phytophthora inundata isolated from diseased alfalfa roots in Southern California

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Abstract—*Phytophthora inundata* was isolated from diseased alfalfa roots in Imperial County (Imperial Valley) of California. It is characterized by non-papillate, non-deciduous, internally proliferating ovoid to obpyriform sporangia, relatively large oogonia (av. 43 µm) with thick-walled, aplerotic oospores, predominantly or entirely amphigynous antheridia, spherical hyphal swellings with radiating hyphae and cardinal temperatures of 5, 27-28, and 36°C. The similarity in morphology and cultural characteristics between the alfalfa isolate and *P. inundata* was confirmed by single-strand conformation polymorphism (SSCP) and DNA sequence analyses. This is the second world record of *P. inundata* found outside UK and Europe and although it is the first report of its association with diseased alfalfa roots, it was weakly pathogenic to alfalfa seedlings. The significance of this new discovery is discussed.

Keywords—Oomycetes, *Medicago sativa*, Pythiaceous fungi, Stramenopile, root rot

Introduction

In September 1997 the third author, as a favor for an alfalfa plant breeder, made isolations from rotten roots of alfalfa (*Medicago sativa* L.) plants suspected to be affected by *Rhizoctonia* root rot canker (Smith 1943). They were collected from a 2 year-old stand of alfalfa that was flood irrigated and located in the Imperial Valley of Southern California (Imperial County), a region in which high temperatures prevail in the summer. However, when portions of the rotted root tissue were plated on the *Phytophthora* selective medium one interesting *Phytophthora* isolate was obtained which appeared to differ slightly from *P.*

medicaginis E.M. Hansen & D.P. Maxwell and the high temperature variant of *P. megasperma* Drechsler (Ribeiro et al. 1978) which caused root rot of alfalfa in California. The classification of the new isolate was difficult. At first it produced only spherical hyphal swellings in water but eventually, techniques were developed to induce the production of sporangia and sex organs successfully. Still this isolate could not be assigned to any known *Phytophthora* species listed by Erwin & Ribeiro (1996) based on morphology.

As early as 1970, an unidentified *Phytophthora* species had been isolated from rotted roots of horse chestnut (*Aesculus hippocastanum* L.) and willow (*Salix matsudana* Koidzumi) by Brasier et al. (1993). They considered these isolates to be a new taxon which they designated as 'O-group'. Sanchez-Hernandez et al. (2001) in Spain reported that *Phytophthora* 'B group' isolates from olive (*Olea europaea* L.) closely resembled those in 'O group' and were 'severely aggressive' when roots of olive trees were inoculated. In 2003 Brasier et al. formally described the 'O group' isolates as a new species: *Phytophthora inundata* Brasier et al. It appeared that the new isolate from alfalfa closely matched the description of *P. inundata*. Subsequently, we were able to secure four isolates of *P. inundata* and compare them with the isolate of *Phytophthora* from alfalfa along with two more similar *Phytophthora* species. The classification of the new isolate was based both on morphological and molecular studies.

Materials and Methods

Isolates and cultures

Diseased alfalfa roots were washed in running tap water, surface disinfected with 10% sodium hypochlorite, washed, and blotted dry. Small pieces of rotted root tissue were plated on Difco cornmeal agar containing (ppm) pimaricin (10), ampicillin (130), rifampicin (20), pentachloronitrobenzene (100) and hymexazole (40) (PARPH). The alfalfa isolate, P3.10.4 (= Hong's 28F2), was maintained on 10% clarified V-8 agar slants or screw-capped tubes of sterile distilled water. Morphological studies of P3.10.4 were made on 10% V-8 agar medium. Campbell's V-8 juice was used directly or was clarified by filtering through 4 layers of cheese cloth and one layer of coarse filter paper. Seven additional isolates representing three similar *Phytophthora* species also were included for comparison (Table 1). Stock cultures of these isolates were maintained at Hong's laboratory using a similar method.

Production of sporangia

Three small mycelial agar discs (ca 5 mm square) were cut from the advancing margin (hyphal tips included) of a 3-day old colony, grown at 25°C, were transferred to a sterile disposable 60 mm diam Petri dish containing either

Table 1. Isolates examined in this study

Species	*Track #*	*Host/substrate*	*Location*	*Year*	*Supplier (#)*[§]
P. inundata	30J3	*Olea* roots	Spain	1996	CB (P894)
	30J4	*Salix matsudana* roots	UK	1972	CB (P246B)
	32F5	*Aesculus hippocastanum* roots	UK	1970	MC (P8478)
	28F2	*Medicago sativa* roots	USA		DE (P3.10.4)
P. humicola	32F8	*Citrus* soil	Taiwan	1976	MC (P3826)
P. medicaginis	23A4	*M. sativa* roots	USA		MG (P37)
	28F1	*M. sativa* roots	USA		DE (EP1057)
	29B1	*M. sativa* roots	USA	1982	EH (29)

[§] CB=Clive Brasier; DE=Donald Erwin; EH=Everett Hansen; MC=Michael Coffey; MG=Mannon Gallegly. Listed in the parenthesis are alternative identifiers used by isolate suppliers.

freshly collected stream/pond water or stream/pond water sterilized by filtration through a Millipore membrane (0.45µm pore size). The agar discs were barely covered by water. A 20×40 mm cover slip sterilized by dipping in 90% ethanol followed by flaming was placed on the bottom of the Petri dish to collect encysted zoospores. The dishes were incubated under continuous fluorescent light at 24-25°C and checked for sporangial production and encysted zoospores after 24-48 hours.

Production of sex organs

Isolate P3.10.4 was grown either on 20% regular or clarified V-8 agar (supplemented with 30 mg/l sitosterol) in 60 mm diam Petri dishes, sealed with two layers of parafilm and incubated at 25°C in darkness for at least 2-3 months. P3.10.4 was also paired with M.D. Coffey's (University of California, Riverside, CA) isolates of A1 (P2100, P2399) and A2 (P2040) mating types of *P. cinnamomi* Rands from avocado (*Persea americana* Mill.) in California and with a sterile isolate of *P. cryptogea* Pethyb. & Laff. (Gi9961) from *Gerbera jamesonii* Bolus in Hainan, China (Zeng et al. 2003). Cultures were incubated at 25°C in darkness for 3 weeks. The locations of the sex organs formed by P3.10.4 on the bottom of the Petri dish were marked with a fine felt pen after they were observed by bright field microscopy.

Morphological studies

Small agar discs bearing the reproductive structures of P3.10.4 were either mounted directly on a glass slide or first boiled briefly in distilled water to remove the agar. After the mycelia and oorgonia were carefully minced and

spread out evenly in a drop of 0.05 % cotton blue/lactophenol with a pair of 1 ml syringe needles, a 20x50 mm cover slip was placed on top of a glass slide, and the reproductive structures were observed and photographed with a Nikon Eclipse E800 research light microscope by interference contrast microscopy. Encysted zoospores, which had formed on a submerged 20x40 cover slip, were observed after staining with a small drop of 0.05% aniline blue/lactophenol. Twenty five measurements were made for each reproductive structure at a magnification of 400×. Only normal, fully mature sporangia and sex organs were recorded.

Temperature response

Comparative studies of P3.10.4 were done with a type isolate of *P. inundata* (Brasier's isolate P894 = Hong's 30J3) on carrot agar (Erwin & Ribeiro 1996) in 9 cm diam Petri dishes on which the initial inoculum was transferred from the margin of a growing colony to the center of the carrot agar plate. Three replicates of each isolate were tested at each temperature (5, 10, 15, 20, 25, 30, 36, or 37°C). The growth chambers were calibrated at the respective temperatures prior to the assay. Two colony diameters were measured through the center of each plate after 4 days of incubation in darkness and the averages were recorded.

PCR-SSCP analysis

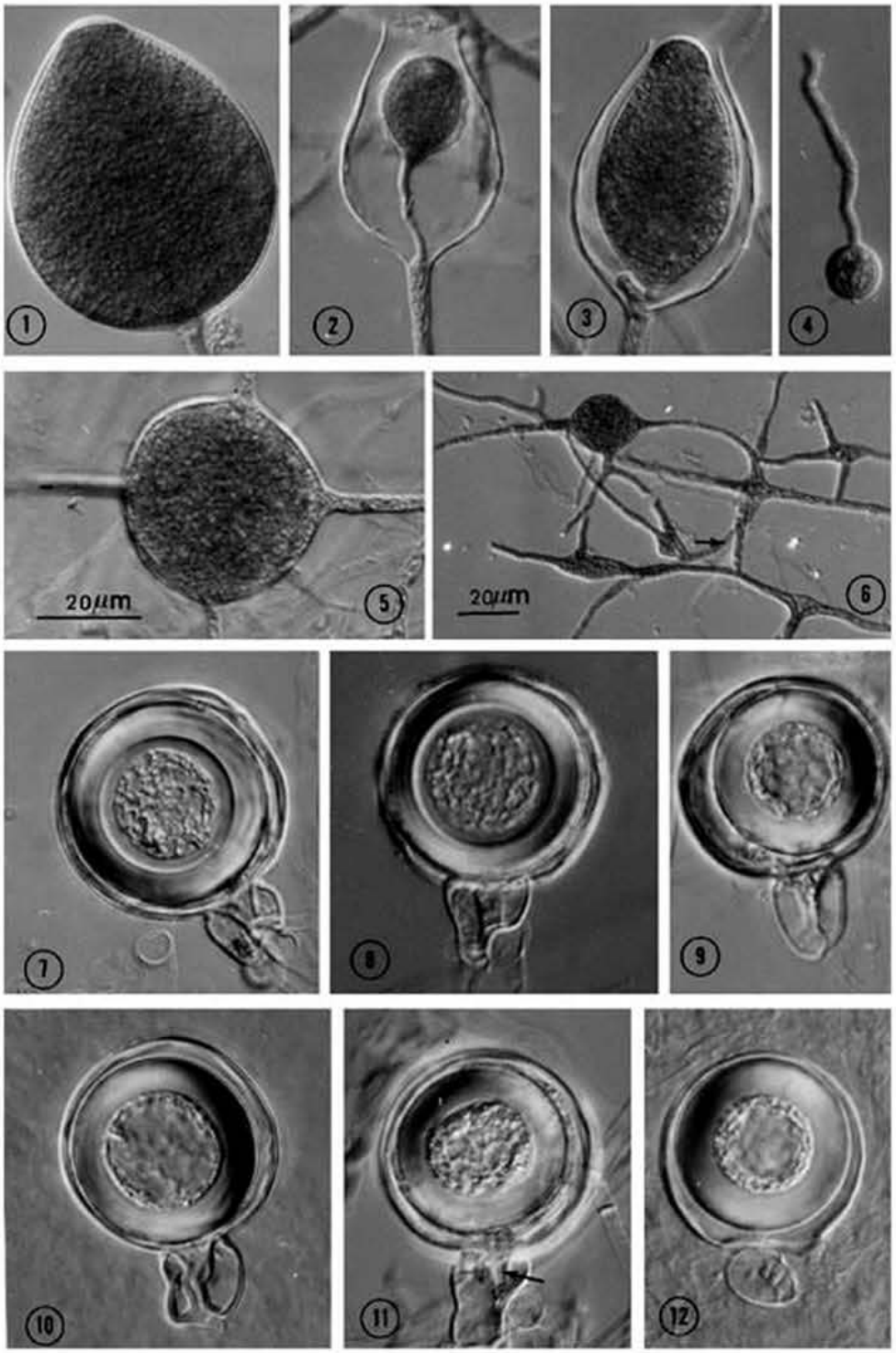
The alfalfa isolate P3.10.4 was compared with seven other *Phytophthora* isolates (Table 1). Culture DNA of individual isolates was prepared using a boiling method (Kong et al. 2003a). PCR was performed using forward primer ITS6 and reverse primer ITS7 to amplify ribosomal DNA, and the resultant PCR products were electrophoresed in a polyacrylamide gel (Kong et al. 2003b, 2004).

DNA sequence analysis

The PCR product of the alfalfa isolate P3.10.4 was purified using the Promega Wizard PCR Prep DNA purification system (Cat # A7170). The fragment was eluted in 50 µl ultrapure dH2O and sequenced by MWG Biotech in High Point, NC. Sequencing was performed in both directions using forward primer ITS6 and reverse primer ITS7. The resultant sequence was compared with those deposited in Genbank at www.ncbi.nlm.nih.gov/blast/Blast.cgi.

(*Phytophthora inundata*). Fig.1. Non-papillate sporangium, Figs 2,3. Internal proliferation of sporangia, Fig. 4. Encysted zoospore germintating directly by a germ tube, Fig. 5. Hyphal swelling, Fig. 6. Hyphal swelling and mycelium, Figs. 7-10. Smooth walled spherical oogonia containing thick-walled oospores and amphigynous antheridia, Fig. 11. Oogonium with the stalk (arrow) eccentric, Fig. 12. Oogonium with a paragynous antheridium.

All figures, except Fig. 6 were enlarged at the same magnification, shown in Fig. 5.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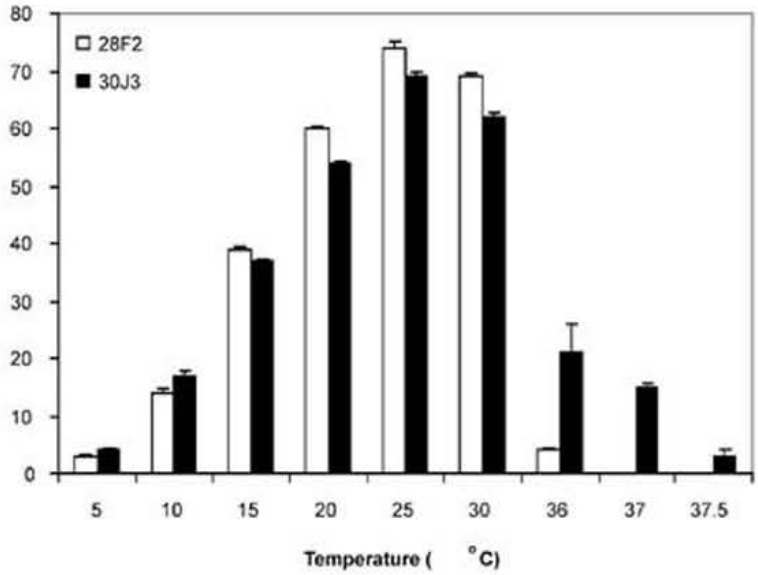

Figure 13. Colony diameters of the alfalfa isolate P3.10.4 (=28F2) and *Phytophthora inundata* (P894 = 30J3) after 4 days incubation on carrot agar at various temperatures. Each column is a mean of three replicates (six measurements), topped by a standard error bar.

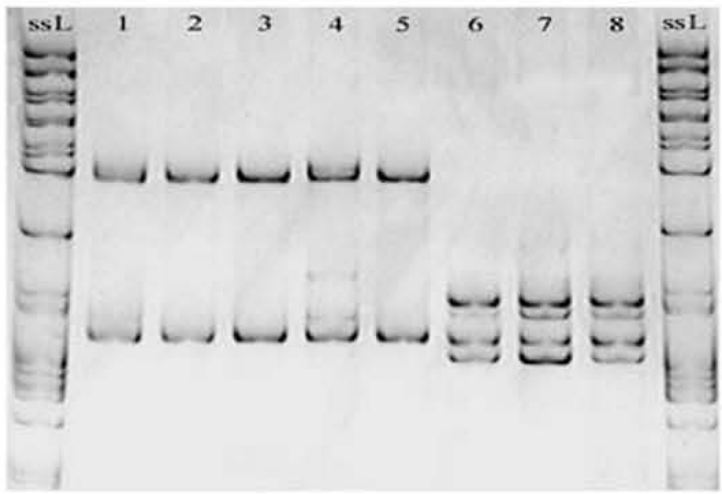

Figure 14. Polyacrylamide gel electrophoresis of amplified ribosomal DNA using forward primer ITS 6 and reverse primer ITS 7 to show the similarity of the alfalfa isolate P3.10.4 (=28F2, lane 4) to isolates of *P. inundata* (30J3, 30J4, 32F5 in lanes 1 to 3) and *P. humicola* (32F8, lane 5) and differences from *P. medicaginis* (23A4, 28F1, 29B1 in lanes 6 to 8) using forward primer ITS 6 and reverse primer ITS7. A single-stranded DNA ladder [6] was included in the left and right lanes.

Results

Morphology

The colony of P3.10.4 on V-8 agar was fluffy with no distinct growth pattern. The mycelium was hyaline, freely branched, smooth-walled, uniform, nonsepate or septate with age, and 5–6 µm wide. Sporangiophores were produced only in water, undifferentiated, unbranched, internally proliferating or rarely lax sympodially branched. Sporangia (Figs. 3-5) were terminal, non-deciduous, hyaline, ovoid or obpyriform measuring (37–) 66 (–86) µm in length and (29–) 49 (–61) µm in breadth. The length/ breadth ratio was (1.2–) 1.35 (–1.67). Encysted zoospores were spherical, 12–13 µm diam germinating by (1–4) germ tubes (Fig.4). Repeated emergence of zoospores was not observed. Hyphal swellings in water were angular, oval to mostly spherical (17–) 36 (–42) µm in diam with radiating hyphae (Figs. 1,2), either singly or catenulate. Sex organs (Figs. 7-12) were formed in aged cultures around the inoculum and in localized areas on the V-8 agar plates. The pairing with A1 and A2 isolates of *P. cinnamomi* was erratic and inconclusive. However, abundant sex organs were induced by pairing the P3.10.4 alfalfa isolate with a sterile isolate of *P. cryptogea* from *Gerbera* in Hainan, China. Oogonia were formed at the juncture where the two colonies met and on the P3.10.4 isolate side of the agar plate. The morphology of these sex organs was similar to those produced in aged cultures. The oogonia were globose, smooth-walled, hyaline to light brown, (38–) 43 (–48) µm in diam, each containing aplerotic, single, globose, smooth, hyaline to yellowish oospores (30–) 37 (–40) µm diam. The oospore wall was (5–) 7 (–9) µm thick and the antheridia were predominantly or entirely amphigynous, cylindrical to short (8–) 14 (–20) × (7–) 13 (–18) µm with the oogonial stalk sometimes distinctly eccentric entering the amphigynous antherdium at a point close to the oogonium (Fig. 11). Paragynous antheridia (Fig. 12) were rarely found. Chlamydospores were not observed.

Temperature response

On carrot agar, the alfalfa isolate (P3.10.4) closely resembled the type isolate of *P. inundata* (Hong's 30J3) by production of distinctly broadly lobed colonies and with similar growth/temperature relations (Fig. 13). The minimum temperature for growth was 5°C, optimum 27-28°C and the maximum 36°C for 28F2 and 37.5°C for 30J3.

PCR-SSCP and DNA sequence analyses

The alfalfa isolate P3.10.4 produced an SSCP pattern identical to that of *P. inundata* and *P. humicola* W.H. Ko & Ann but clearly distinct from that of *P. medicaginis* (Figure 14). The amplified DNA fragment is 226 bp in length. Its sequence is almost identical to that (AF266791) of the type isolate of *P. inundata* with only one base deletion. Surprisingly, this sequence did not produce good

alignment with those of *P. humicola* (none among the top 100 blast hits), indicating that P3.10.4 is different from *P. humicola*.

Discussion

Although *P. medicaginis* is the major cause of root rot of alfalfa and is found in most of the alfalfa producing regions of the world, five other species have been reported to be causal agents of root rot of alfalfa: *P. citricola* Sawada, *P. drechsleri* Tucker, *P. megasperma*, *P. nicotianae* Breda de Haan (Erwin & Ribeiro 1996) and the high temperature variant of *P. megasperma* (Ribeiro et al. 1978) that was reclassified by Ann & Ko (1994) as *P. insolita* Ann & W.H. Ko. The new isolate P3.10.4 from alfalfa from Imperial County of California can be easily distinguished from *P. citricola* and *P. nicotianae* which on agar medium produce respectively, semi-papillate and papillate sporangia. *Phytophthora drechsleri* produces variably shaped sporangia that are often elongated with a tapering base and smaller oogonia with amphigynous antheridia; *P. medicaginis* has a slower growth rate and smaller oogonia with a varying proportion of paragynous and amphigynous antheridia; *P. megasperma* produces larger oogonia and its maximal temperature for growth is much lower; *P. insolita* produces a distinct appressed chrysanthemum-like colony on V-8 agar with a maximum temperature of 39-40°C for growth. In contrast, the P3.10.4 alfalfa isolate was only weakly pathogenic to alfalfa seedlings by artificial inoculation.

Both P3.10.4 and *P. inundata* respectively, produce nonpapillate, internally proliferating sporangia of similar size (av 66 × 49 µm vs 64.5 × 47.7µm) and shape (length : breadth ratio 1.2–1.67 vs 1.2–1.5) and similar oogonia av 43 vs 49.1 µm diam containing thick walled (7.0 vs 5.4 µm) aplerotic oospores (av 37 vs 35.7 µm diam) and predominantly or entirely amphigynous antheridia (length av 14 vs 16.5 µm; width av 13 vs 15.9 µm). The alfalfa isolate P3.10.4 and a typical isolate of *P. inundata* produced similar broadly lobed colonies on carrot agar medium and the cardinal temperatures and growth rates were similar in both although *P. inundata* had a slightly higher maximum temperature growth (37.5°C) than P3.10.4 (36°C). Brasier et al. (2003) determined the upper temperature limit for growth for *P. inundata* as 35°C (3 isolates), 36°C (2 isolates) and 37°C (3 isolates). Although not mentioned in the original paper by Brasier et al. (2003), spherical hyphal swellings produced by P3.10.4 were similar to those of our isolates of *P. inundata*. The alfalfa isolate was similar to two isolates of *P. inundata* in being unpredictably and chimerically self-fertile (Brasier et al. 2003). The results of PCR-SSCP and sequence analyses support the placement of this alfalfa isolate in *P. inundata*. Although *P. inundata* and *P. humicola* have a similar SSCP pattern, *P. humicola* can be distinguished morphologically from *P. inundata* by its smaller oogonia with long oogonial

stalks and predominantly paragynous antheridia as well as a much lower maximal temperature for growth.

Phytophthora inundata is a difficult species to classify. In general, with the exception of *P. insolita* which is self-fertile producing oospores without antheridia, all *Phytophthora* species are either heterothallic producing amphigynous antheridia or homothallic forming antheridia which are either paragynous, amphigynous or a combination of both (Erwin & Ribeiro 1996). However, Brasier et al. (2003) demonstrated that isolates of *P. inundata* could be heterothallic, weakly heterothallic or 'sporadically and unpredictably self fertile' producing amphyigynous or predominantly amphigynous antheridia and they used the term 'part heterothallic' to describe the mating system of this species (Brasier et al. 2003). One isolate in 'Group B' which should be now renamed as *P. inundata* produced as much as 27% paragynous antheridia (Sanchez-Hernandez et al. 2001). Although '*P.* sp. Group 0' was considered a new taxon (Brasier et al. 1993) it took almost a decade before Brasier et al. (2003) described it as a new species: *P. inundata*. We have experienced similar problems in identifying the new isolate from alfalfa. Although it was isolated in 1997 we were puzzled about its classification. Based on morphology, it could not be assigned with certainty to any known *Phytophthora* species at that time (Erwin & Ribeiro 1996). The publication of *P. inundata* as a new species by Brasier et al. (2003) brought to light the similarities between the alfalfa isolate and *P. inundata*. Our present comparative studies using traditional morphological criteria and two different molecular biology techniques have proved that the new isolate of *Phytophthora* P310.4 from diseased alfalfa roots in Imperial Valley of California should indeed be assigned to *P. inundata*. P3.10.4 has been deposited in ATCC with the accession number MYA-3663.

To date, *P. inundata* has been isolated from roots of diseased trees and shrubs in UK and Europe and is considered to be "a parasite of woody hosts in riparian ecosystems, able to cause sporadic but severe disease outbreaks on susceptible hosts such as the ornamental *Aesculus* and *Salix*, or the commercially cultivated *Olea* or *Prunus*, after soil flooding or waterlogging" (Brasier et al. 2003). The isolation of *P. inundata* from diseased alfalfa roots in California not only has broadened its host range to include a herbaceous plant but also widened its geographic distribution to North America. The weak pathogenicity of the alfalfa isolate of *P. inundata* is puzzling because nearly all *Phytophthora* isolates are pathogens of the host from which they are isolated. There is a possibility that the alfalfa isolate might survive as a saprophyte in irrigation water and could be capable of attacking alfalfa roots only under predisposing environmental conditions, such as high soil moisture and at high temperatures. It would be of interest to determine its potential pathogenicity to woody hosts reported to be susceptible to *P. inundata* by Brasier et al. (2003).

Acknowledgments

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Blastocladia bonaerensis (*Blastocladiales, Chytridiomycetes*), a new species from an Argentine channel

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Abstract—*Blastocladia bonaerensis* sp. nov. was found in water containing litter (floating dead twigs, roots and leaves) in an artificial eutrophic channel, in Buenos Aires province (Argentina). The species is described, illustrated, and compared with other species of the genus; it produces mainly a small columnar and branched basal cell, which develops on lobes expanded distally, characteristic obpyriform zoosporangia with a long neck.

Key words—*Chytridiomycota, Fungi*, systematics

Introduction

The genus *Blastocladia* (*Blastocladiales, Chytridiomycetes*) was established by Reinsch (1878) to accommodate a single species, *B. pringsheimii*; it was included among the doubtful genera of *Saprolegniaceae* by Fischer (1892) and remained there until Petersen (1909) erected the order *Blastocladiales* with *Blastocladia* as the only genus. Since then many species have been added by various workers in the field (Sparrow 1960, Dasgupta & John 1989). Kirk et al. (2001) estimate the number of acceptable species with 13 species, but Index Fungorum presently lists 36 taxa (including 4 varieties + 1 excluded synonym, thus at most 31 species).

During a survey of zoosporic organisms occurring in polluted water and organic matter in Playa 66, an artificial channel near La Plata city, Partido de Berisso (Buenos Aires Province, Argentina), the authors found a species belonging to *Blastocladia* with distinctive features separating it from other species in the genus. It is here named *B. bonaerensis*.

Blastocladia globosa Kanouse and *B. pringsheimii* Reinsch were previously found in other polluted habitats at Partido de Chascomús (Steciow 1999) whereas *B. incrassata* Indoh, *B. sparrowii* Indoh, *B. tenuis* Kanouse and

B. ramosa Thaxt. were got at Partido de Ensenada, also located in Buenos Aires Province, Argentina (Steciow et al. 2001, Steciow & Elíades 2002).

Material and Methods

Samples of surface water containing organic litter (from twigs and leaves of the local vegetation) were collected from the site named "Playa 66", located in Partido de Berisso (Buenos Aires Province, Argentina) and were brought to the laboratory in sterile flasks. They were subsequently divided into 2 subsamples; one was used for chemical analysis while the other was left untreated so that live organisms could be observed and identified. The collection site is a water course that receives substantial discharges of both domestic sewage (from La Plata city and surrounding areas) and industrial effluents. At its margins profuse macrophyte vegetation of *Scirpus californicus* is growing.

At the sampling time, the following water quality data were recorded: pH = 7; turbidity = 58 UTN; conductivity = 822 μS cm^{-1}; BOD = 82 mg L^{-1}; COD = 414 mg L^{-1}; P = 1.363 mg P L^{-1}; NO_3^- = 12.51 mg N L^{-1}; NO_2^- = 0.136 mg N L^{-1}; NH_4^+ = 1,865 (determined according to Mackereth et al. 1978). The high organic matter content classifies the channel as eutrophic.

Blastocladiales are known to grow saprotrophically on submerged fruits and twigs. The method for collection described by Sparrow (1960), Dasgupta & John (1988), and Khulbe (2001) was used. Samples were placed in sterile flasks containing distilled water; rose fruits were used as baits and incubated at room temperature (15-20°C).

The dried type specimen is deposited in the Mycological Herbarium of Spegazzini Institute in La Plata (LPS). Because the original material was scarce on rose fruits, the fungus could not be isolated on agar media.

Measurements and observations were made using an Olympus BX 40 microscope (Olympus Optical CO., LTD, Tokyo, Japan) equipped with phase contrast optics.

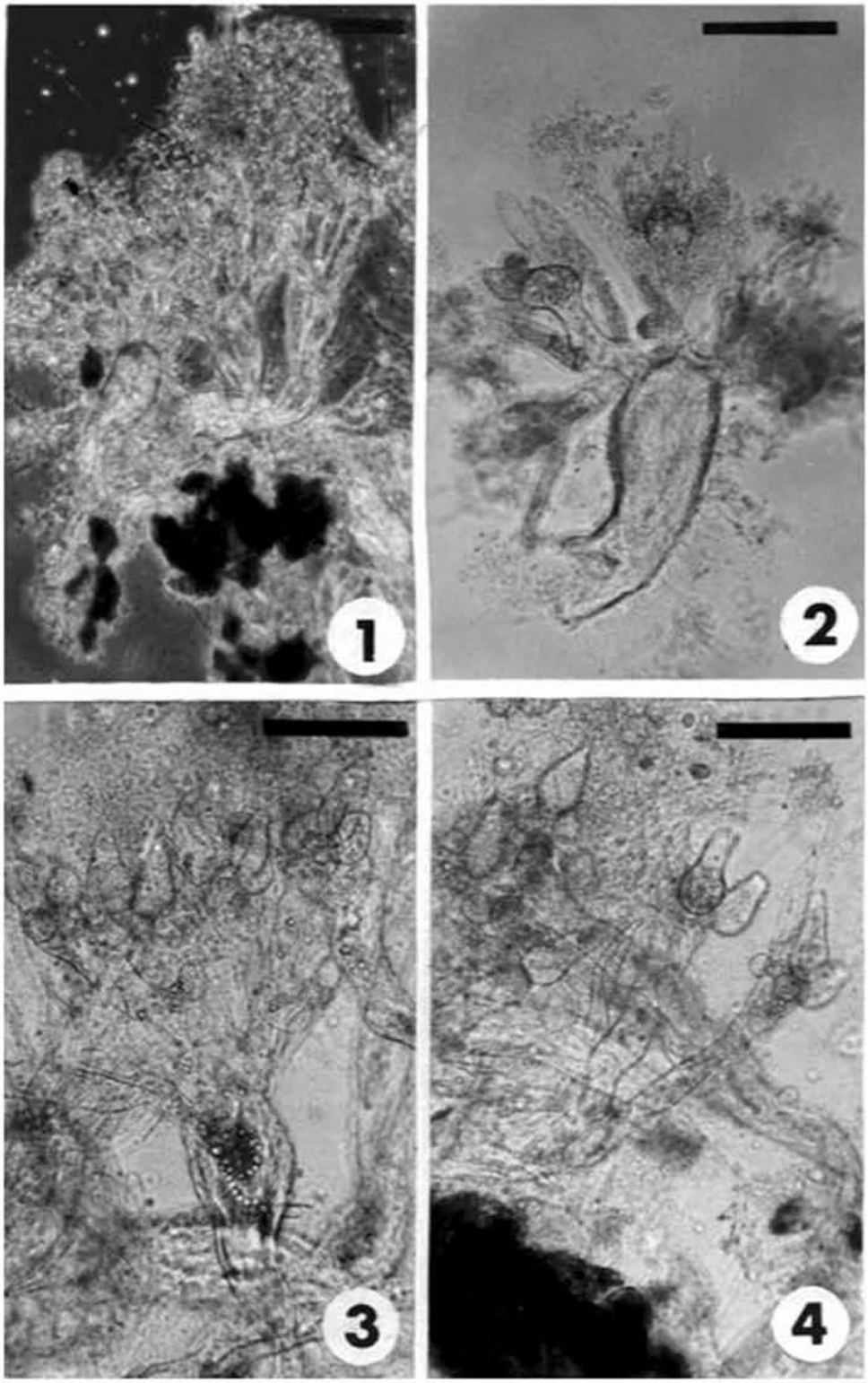
Taxonomy

Blastocladia bonaerensis Steciow & Marano, **sp. nov.** **Figs 1-11**

Mycobank MB 510331

Thalli cellula basilaris habitu et statura variabilis, saepe columnaris bene ramosa, (175-)225-320(-354) x 50-80 μm, pariete laevi vel rugosa tenui vel crassa, expansa ad apicem, simplici vel ramos cylindricos; rami usque ad 240-400 μm longi, ad apicem dichotomi vel in umbellis vel irregulariter dispositi. Pars basilaris valde ramose. Totus thallus 300-575 μm longus. Zoosporangia sessilia ad apicem ramorum vel super loborum dilatatorum

Figs. 1-4. *Blastocladia bonaerensis.* **Fig. 1.** Aspect of the pustules on rose fruits. **Fig. 2.** Thallus columnar trunk with dichotomous branching with the zoosporangia of different size and shape, surmounted the swollen branches on the tips of the thallus. **Figs. 3-4.** Aspect of dense pustules with details of obpyriform sessile zoosporangia with a long neck, borne on the branches or lobes with setae. Scale bars, Fig. 1 = 100 μm; Figs. 2-4 = 50 μm.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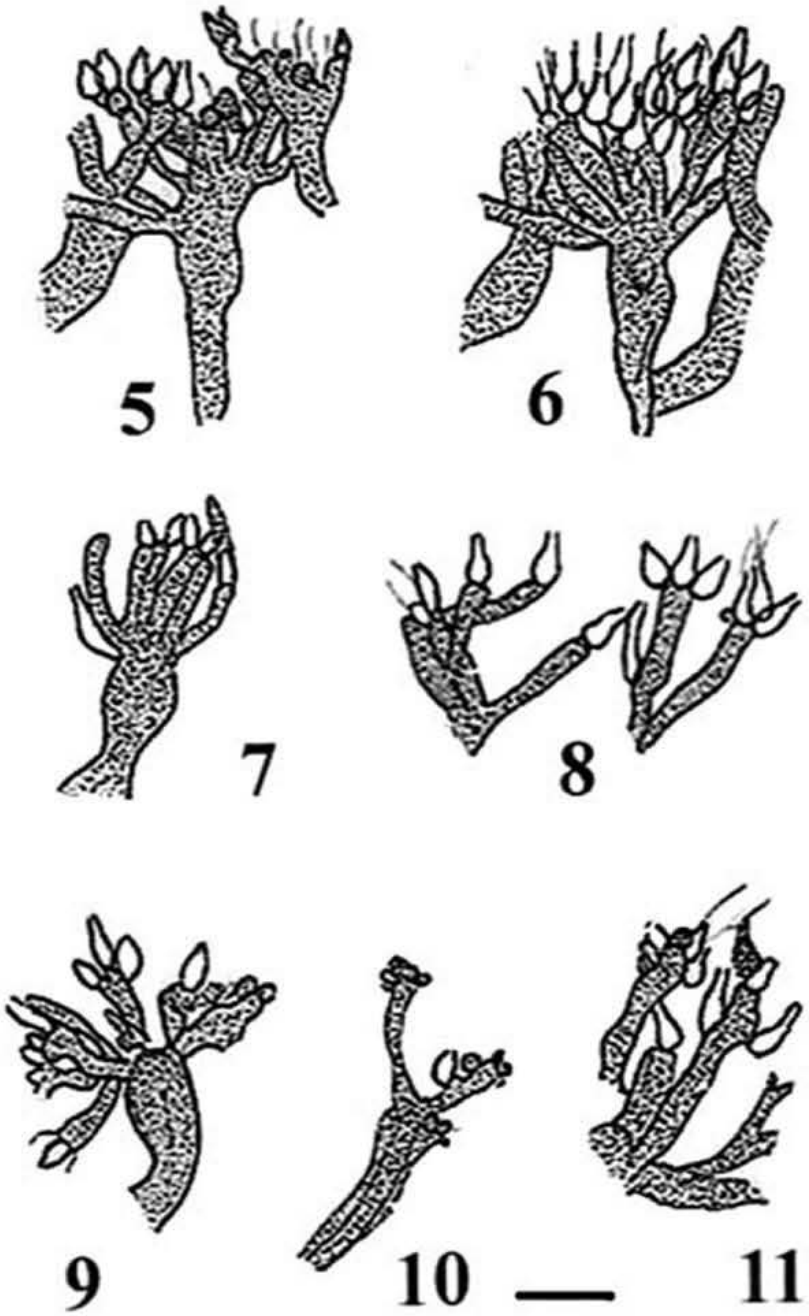

Figs. 5-11. *Blastocladia bonaerensis*. Figs. 5-6. Details of pustules with obpyriform zoosporangia with a long neck borne on dichotomously, umbellately, or irregularly arranged branches; setae present or scarse. Figs. 7-11. Young thalli. Scale bar = 50 µm.

superficie portata, saepe obpyriformia interdum fusiformia vel cylindrica vel naviculata vel obovata, (25-)32-75 µm x 17-37 µm; zoosporae ovoideae vel sphaericae 6-9 µm x 3-6 µm. Sporangia vacua non decidua. Sporangia quiescentia non observata.

Etymology: The name refers to the province (Buenos Aires) where this new species was found.

Basal cell variable in shape and size, generally columnar, sometimes clavate, often densely branched, (175-)225-320(-354) x 50-80 µm, **wall** smooth or rough, expanded distally and simple or giving rise to cylindrical, apically, dichotomously, umbellately, or irregularly arranged branches or broad lobes up to 240-400 x 80-160 µm; **setae** present or scarse, 2-6 µm wide; **holdfasts** richly branched, the **whole thallus** 300-575 µm long. **Zoosporangia** sessile, borne along the tips of the branches or over the surface of the swollen lobes, predominantly obpyriform with a prominent and characteristic apical beak, sometimes fusiform, cylindrical, naviculate and obovate, (25-)32-75 x 17-37 µm; **zoospores** ovoid and 6-9 x 5-6 µm, or spherical and 12-15 µm diam, emerging individually or in a columnar or pyriform group surrounded by an evanescent vesicle wall bearing an apical, persistent plug (the remains of the discharge papilla), empty sporangia not deciduous; **resting spores** not observed.

Saprotrophic; after 15-30 days appearing as small pustules on the surface of *Rosa* sp. fruits used as bait.

Holotype: ARGENTINA. Buenos Aires Province: Berisso, Channel 66 (artificial channel), in water with floating vegetable debris and organic pollution, June 2003, *Paula Hualde* (LPS N° 472171), dried material deposited at Spegazzini Institute.

Discussion

Of the 31 described species, our new Argentine species appears similar in its habit to *Blastocladia pringsheimii*, *B. globosa*, *B. ramosa*, *B. sparrowii*, *B. fruticosa* S.N. Dasgupta & R. John, and *B. pileota* S.N. Dasgupta & R. John. Principal characters of these related species are detailed in Table 1. Among these species *B. bonaerensis* is unique because of their smooth or thick-walled, cylindrical or clavate basal cell, with dichotomously, umbellately, or irregularly arranged branches or swollen apices up to 400 µm. The whole thallus only reaches 575 µm in length. Setae can be present or scarce. The zoosporangia are characteristically sessile, obpyriform, with a prominent apical beak borne along the tips of the branches or over the surface of the swollen lobes; they can also be fusiform, cylindrical, naviculate and obovate. Resting spores are lacking.

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Table 1. Comparison of principal characters in *B. bonaerensis* and related species.

	B. pringsheimii	*B. globosa*	*B. ramosa*	*B. sparrowii*	*B. fruticosa*	*B. pileota*	***B. bonaerensis***
Thallus size (µm)	up to 2,000	120-400	260-1,000	up to 620	150-250	up to 460	300-575
Basal cell size	400-1,000 X 30-90	120-350 X 200	up to 400 X 14-80	312-468 X 13-31	60-75 X 30-50	160-230 X 50-60	(175-) 225-320/(-354) X 50-80
Basal cell shape	cylindrical or clavate	globose or subglobose, with expanded distal portion	cylindrical	cylindrical with swollen distal portion	cylindrical	cylindrical	cylindrical or clavate
Basal cell branching	dichotomous, umbellate or irregularly with swollen apices	unbranched or with expanded lobes	dichotomously (2-several axes branched sympodial or irregularly)	lobed or not	dichotomously (2-several axes branched sympodial or irregularly)	dichotomously (3-4 axes branched dichotomously once or twice)	dichotomous, umbellate or irregularly
Zoosporangial shape	cylindrical or narrowly clavate, ellipsoidal, fusiform, long ovoid or siliquiform	cylindrical or broadly cylindrical	ovoid, with a narrow truncate base or broadly fusiform	cylindrical, with internal proliferation	pyriform or cylindrical	ovoid, pitcher-shaped with a neck ending	obpyriform, with a prominent beak; sometimes fusiform, cylindrical, naviculate & obovate
Zoosporangio size (µm)	70-350 X 13-70	55-160 X 15-60	30-85 X 7-24	73-143 X 13-31	28-30 X 15-17 (pyrif.)/25-30 X 9-10 (cylind.)	40-68 X 20-30	(25-) 32- 75 X 17-37
Resting spore shape	ellipsoidal, ovoidal or spherical	subspherical, ovoid or subpyriform	broadly ovoid, narrowly clavate or spatulate	lacking	spherical or ovoid	lacking	lacking
Resting spore size (µm)	40-99 X 30-50	25-70 X 27-50	18-38 X 11-28		15-25/20-22 X 17		
Setae	scarce or absent	scarce or absent	lacking	present, branched or not	lacking	lacking	scarce or absent

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New species and combinations in *Cortinarius* subgenus *Phlegmacium* section *Calochroi*

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Abstract — Based on morphological and molecular phylogenetic studies we present two new species and one new combination in *Cortinarius*. Species descriptions are provided, along with discussions of phylogenetic and morphological affinities to similar taxa. All species belong to section *Calochroi* (incl. section *Fulvi* and *Laeticolores* s. auct.). *Cortinarius osloensis* and *Cortinarius piceae* spp. nov. are described, and *Cortinarius barbaricus* comb. nov. is introduced. The first taxon is a fulvoid species (i.e. contain anthraquinonoid pigments), and the two latter are calochroid (non-anthraquinonoid). *Cortinarius piceae* is described to cover the species most often treated as *Cortinarius calochrous* var. *coniferarum*.

Keywords — taxonomy, ectomycorrhizal fungi

Introduction

Species level taxonomy for the species traditionally treated in *Cortinarius* subgenus *Phlegmacium* section *Calochroi* (incl. *Fulvi* and *Laeticolores*) is difficult, and controversy exists both relating to the number and status of taxa

and the application of names. Until recently, the species level taxonomy has almost entirely relied on gross morphology and ecology, and has not resulted in a broadly acceptable consensus taxonomy. The inclusion of more anatomical characters in taxonomical studies have proven valuable for establishing a more coherent taxonomy for several groups of *Cortinarius* (Brandrud 1996a, Brandrud 1996b, Brandrud 1998, Melot 1990). More recently DNA sequence data have been employed in studies of phylogeny and taxonomy in diverse groups of Agaricales. Many studies of *Cortinarius* have employed phylogenetic analyses of nuclear ribosomal gene sequence data (Frøslev et al. 2005, Garnica et al. 2003a, Garnica et al. 2003b, Garnica et al. 2005, Høiland & Holst-Jensen 2000, Kytövuori et al. 2005, Liu et al. 1997, Moser & Peintner 2002, Peintner et al. 2001, Peintner et al. 2002, Peintner et al. 2004, Peintner et al. 2003, Seidl 2000). However, most of these included few collections within species.

Frøslev et al. (unpublished) identified independently evolving lineages in the section *Calochroi* by phylogenetic inference and comparison of ITS sequences from more than 400 collections, which represent most of the known European morphological, geographical and ecological diversity. More than 70 independently evolving lineages were identified, and the majority of these lineages comply with a morphological species concept (including pigment characters and ecological characters). Seven of these have already been described as new (Frøslev et al. 2006). Further two species are here described as new, and one taxon is being given specific rank.

Material and methods

The taxonomic descriptions are primarily based on the material studied by the authors. The measurements of macro morphological characters are based on expanded, but never old (and then often aberrant) basidiocarps. Macro chemical reagents applied were 2% and 40% KOH. The terminology of characters follows Brandrud et al. (1990) with minor adjustments (see Brandrud 1996a). Microscopical structures were observed partly from fresh material mounted in H2O, often with a drop of 40% KOH subsequently added, and partly from dried material mounted in H2O and then KOH. The descriptions of the pigment topography are based largely on observations from H2O mounts of fresh, preferentially young material. The spores were studied and measured in 2 % KOH, with a 100 x oil immersion lens. From each basidiocarp, a random selection of mature spores obtained from cortina remnants were measured excluding apiculus and ornamentation. Young, immature basidiocarps were avoided. For species with a lot of available specimens ten spores were measured per specimen. For species with few available collections thirty or more spores were measured per specimen. Mean values (MV) of spore length and width as

well as Q-values (length/width ratio) were then calculated for each specimen. MVs for each taxon were calculated. The pileipellis was studied from radial (longitudinal), free hand sections, preferentially from fresh material. Wedge-like sections, ultra thin at the one end, were obtained by cutting at a slightly oblique angle. The sections were cut from c. 5 x 5 x 3 mm large pieces taken from young but expanded pilei, and at a position midway to the centre. Methanol extractable, anthraquinonoid pigments of *C. osloensis* were investigated by thin layer chromatography (TLC), from dried material, and developed in a water-saturated solvent-mixture of ethyl formiate:formic acid:toluene (50:15:35) on silica gel aluminum plates. ITS sequence data of the holotype of *C. osloensis* (GenBank accession: DQ996975) was amplified and sequenced for this study according to the methods in Frøslev et al. (2005).

The species treated here are phylogenetically well delimited and the phylogenetic separation as indicated by the analyses of Frøslev et al. (unpublished) is discussed. Herbarium acronyms follow Holmgren et al. (1990). The following acronyms are used in collection numbers DB=Balint Dima, TEB=Tor Erik Brandrud, TF=Tobias Guldberg Frøslev and TSJ=Thomas Stjernegaard Jeppesen. All mentioned binomials (unless otherwise indicated) correspond to species that were identified in the study by Frøslev et al. (unpublished) and can be delimited by morphological characters. Colour photographs of most species and many of the collections cited here are available on www.cortinarius.com (Frøslev & Jeppesen 1999-2006).

Taxonomic descriptions

Cortinarius osloensis Brandrud, T.S. Jeppesen & Frøslev, **sp. nov.**

Mycobank: 510236

Pileo 30–60 mm lato, hemisphaerico, dein plano-convexo, glutinoso, a centro ochraceo-brunneo, ad marginem ochraceo-luteo, KOH ope sub-nullo. Velo universale sparso, pallido. Lamellis emarginatis, pallide luteis. Stipite in juventute albido-luteo dein albido, bulboso, bulbo distincte marginato. Facie externa mycelioque alba, KOH ope nullo. Velo partiale albido. Caro albida, odor ingratus, KOH ope nullo. Sporis limoniformibus, grosse verrucosis, 11–12.5 x 6.5–7.5 µm. Typus: NORWAY: Oslo: Bygdøy, Reinsdyrlia, TEB 559–04 (holotype O, isotype S).

Pileus 3–6(–7) cm, (hemi-)spherical, then plano-convex, glutinous, glabrous and glossy, dull when dry, and centre then sometimes slightly appressed tomentose; often distinctly bicolorous, outer half ochre yellow, centre ochre brown, the involute margin whitish yellow when (very) young, soon ochraceous, colours otherwise changing little with age. Universal veil remnants fairly sparse, sometimes leaving some whitish, large, diffuse, patches at centre, darkening with age. **Lamellae**, L = 60–90, crowded, 3–6 mm broad, pale yellowish, straw yellow (K 80–85) to greyish yellow, sometimes with a faint greenish yellow tinge

towards edge, soon ochre yellow, edge often distinctly crenulate-serrulate. **Stipe** 4–6 x 0.8–1.2(–1.5) cm, with a marginate bulb (up to 3 cm), whitish yellow when (very) young, then whitish, with age tinged ochre yellow from base. Universal veil on the bulb margin sparse to fairly abundant and volva-like, slightly viscid, when young yellowish to yellowish white at bulb margin, with age slightly brownish. Cortina fairly abundant, whitish. Basal mycelium usually sparse, white, sometimes with yellowish white mycelial strands. **Context** when young whitish with greyish yellow tinged hygrophanous spots in stipe apex, with age sometimes spotted with brown in the bulb, sometimes saffron brown where eaten by snails. **Macrochemical reactions:** 2% and 40% KOH negative (pale brownish) in context, sometimes faintly vinaceous grey on pileus when very young. **Smell** distinctly raddish-like, earth-like to dust-like, strong with age, especially on the lamellae. **Taste** raddish-like. **Dried material** ochre brown.

Extractable pigments: Small to (in pileipellis) moderate amounts of the greenish yellow flavomannin-6,6',8-trimethylether.

Spores 11–12.5 x 6.5–7.5 µm (MV = 11.85 x 7.18 µm), Q = 1.65 (n=130, 13 specimens), citriform, very distinctly and coarsely verrucose, suprahilar plague more or less distinct. **Basidia** 9–11 µm wide, 4-spored, some with yellowish content; some pigment from exsiccates purplish with KOH. **Lamella edge** more or less fertile, with some indistinct, clavate-cylindrical sterile cells. **Lamella trama** of (3–)4–20 µm wide, mainly hyaline hyphae, some hyphae (especially of subhymenium) with initially dissolved, cytoplasmatic, then intracellular, yellowish granular pigment. **Universal veil** on pileus in patches of ca. 5–10 layers, hyphae 3–5(–6) µm wide (up to 8 µm at centre), mainly hyaline, some with intracellular, yellow granules or more yellow brown confluent-diffracted to oleiferous pigment, some very finely verrucose with KOH; veil on the bulb margin of 2–5(–8) µm wide hyphae, some hyphae with yellowish, granular to oleiferous pigment. **Pileipellis** simplex: Cutis thick, of ca. (20–)25–30 hyphal layers. At surface ca. 5–10 gelatinous layers of (2.5–)3–5 µm wide, loosely erect-entangled hyphae, hyaline or sometimes with pale yellow, refractive, cytoplasmatic pigment, some collapsed terminal hyphae with yellow, oleiferous pigment. The basal part of cutis of 15–25, parallel to slightly interwoven hyphal layers, hyphae (3–)4–7(–9) µm wide, partly in subparallel, ±interconnected bundles; pigment mainly intracellular, initially pale (greenish) yellow, dissolved in cytoplasma, then yellow brown, granular, with KOH oleiferous; some hyphae with faintly verrucose, yellow walls with KOH; some extracellular granules observed on young specimens; pigment from exsiccates usually yellowish brown with KOH. **Trama** ±hyaline. **Mycelial strands** of 3–5 µm wide, entangled-subparallel hyphae at surface, up to 12(–15) µm wide and parallel hyphae centrally, hyphae hyaline, sometimes with (greenish) yellow,

intracellular, granular pigment, hyaline, diffractive, extracellular granules occur scattered.

Ecology and distribution: Boreo-nemoral to montane deciduous forests. Associated with *Tilia cordata* and probably also *Corylus avellana* on shallow, dry, calcareous soil with little or no humus and leaf litter, including more or less unstable scree soil on slopes. Growing under large *Tilia cordata* trees, and a connection by mycelial strands to *T. cordata* mycorrhizas has been observed. Extremely rare. Known only from two localities in the innermost Oslofjord area, Bygdøy within Oslo (including two different, but closely situated forests) and Ringerike area (Bendiksen et al. 1998), both localities being extremely rich in rare and endangered species of *Phlegmacium*. The species is included in the red data list of Norway as critically endangered (cf. Bendiksen et al., 1998; new red list in prep.).

Specimens studied – (*including macro characters): NORWAY: Oslo: Bygdøy, Reinsdyrlia, 26 Sept. 2004, *T.E.B., TEB 559–04** (holotype, herb. O, isotype herb. S); *loc. cit.*, 5 Oct. 2004, *T.E.B., TEB 608–04* (herb. O); Bygdøy, Dronningberget *T.E.B., TEB 506–80** (herb. O); loc. cit., 12 Sept. 1982, *T.E.B., TEB 199–82** (herb. O); loc. cit., 21 Aug. 1992, *T.E.B., TEB 18–92** (herb. O); *loc. cit.*, 16 Aug. 1993, *T.E.B.*, TEB 36–93* (herb. O); *loc. cit.*, 20 Aug. 1993, *T.E.B., TEB 49–93** (herb. O); *loc.cit.*, 23 Sept. 1994, *T.E.B., TEB 93–94** (herb. O); *loc. cit.* 21 Sept. 2005, *T.S.J. & TEB., TSJ2005–026** (herb. C). Buskerud: Hole, Nes, 11 Sept. 1985, *T.E.B., TEB 268–85** (herb. O); *loc. cit.*, 31 Aug. 1993, *T.E.B., TEB 96–93** (herb. O); *loc. cit.*, 11 Sept 1994, *T.E.B., TEB 41–94** (O), *loc. cit., T.E.B., TEB 42–94**.

Comments — *Cortinarius osloensis* is characterized by its small basidiocarps, earth-like smell and its ochre yellow colours without any greenish yellow or olivaceous tinges. The species looks like a *C. calochrous* with yellowish lamellae. *Cortinarius osloensis* resembles *C. humolens* Brandrud (= *C. claroflavus* sensu M.M. Moser) and was included in the description of *C. claroflavus* sensu M.M. Moser by Brandrud (Brandrud 1982). *C. humolens* possess the same radish or earth-like smell and taste as *C. osloensis*, but differs by its larger basidiocarps, smaller spores, often greenish yellow or olivaceous tinges on the pileus and veil, more coloured stipe, a larger, more flattened bulb, a more pronounced saffron discolouring in insect damaged tissue, a partly different KOH-reaction and smaller spores. *Cortinarius humolens* furthermore occurs in organic soils, mainly in forests with deep leaf litter with *Quercus ilex* and more rarely *Fagus sylvatica*. Young specimens of *C. langeorum* Frøslev & T.S. Jeppesen have a pileus colour similar to that of *C. osloensis* and the spore size and shape are very similar between the two species. *C. langeorum* differs, however, by a deep red-brown to dark red reaction on pileus with KOH, by the greyish lamellae without any yellow pigmentation and by the (greenish) yellow bulbipellis. *Cortinarius osloensis*, *C. alcalinophilus* (darker pileus, yellow context) and *C. olearioides* (with saffron-orange tinges) are the only species among the (greenish)

yellow-gilled, anthraquinone pigment-containing taxa of *Phlegmacium* (sect. *Fulvi*) which normally lack greenish or olive tinges. The main pigment in *C. osloensis*, flavomannin-6,6',8-methylether, is greenish yellow, but it occurs in low amounts in the basidiocarps, and the greenish tinge apparently somehow becomes masked by other pigments, although such additional pigments are not apparent from microscope examination nor by TLC-extraction.

Phylogenetic analyses based on ITS, RPB1 and RPB2 data (Frøslev et al., unpublished) place *C. osloensis* as a sister taxon to a small group containing *C. saporatus* Britzelm. and *C. caroviolaceus* P.D. Orton in a well-supported lineage of non-anthraquinoid and pigment poor species also including *C. pseudoglaucopus* (Jul. Schäff. ex M.M. Moser) Quadr. and *C. humolens*, which is morphologically similar to *C. osloensis*. More than 25 nucleotide differences in the ITS region separates *C. osloensis* from these related species. Based on the main pigment, flavomannin-6,6',8-methylether, *C. osloensis* and *C. humolens* were placed in subsection *Elegantiores* along with *C. alcalinophilus*, *C. elegantior*, *C. quercus-ilicis*, *C. murellensis* (listed as *C. balearicus* ined.), *C. olearioides* and *C. splendificus* (Brandrud 1998). These latter species, however, form an evolutionary separate lineage and share the presence of flavomannin-dimethylether not found in *C. osloensis* and *C. humolens*.

Cortinarius osloensis is recorded in mixed stands of *Tilia cordata* and *Corylus avellana*, dominated by *Tilia* (Oslo and Hole). *Tilia* and possibly *Corylus* seem to be the preferential hosts of this species. With present knowledge, *C. osloensis* appears to be one of the rarest species of *Phlegmacium* having been found only within the Oslofjord area in Norway.

The type locality of *C. osloensis* (Oslo, Bygdøy) has been studied yearly 1979–1998, and most of the succeeding years. Basidiocarps of the species have appeared irregularly confined to the moist years 1980, 1982, 1992, 1993, 1994, 1997, 1999, 2004, 2005 (9 out of 28 years), fruiting from 5–6 different mycelia.

An ITS sequence of the holotype of *C. osloensis* (TEB 559–04) is available on GenBank (accession DQ996975)

Cortinarius piceae Frøslev, T.S. Jeppesen & Brandrud, **sp. nov.**
Mycobank: 510237

Pileo 30–60 mm lato, hemisphaerico, dein plano-convexo, glutinoso, primo luteo, dein a centro ochraceo-luteo vel brunneo, centro e velo brunneo maculato, KOH ope brunneo. Velo universale albido-luteo vel luteo-brunneo. Lamellis emarginatis, pallide violaceis. Stipite in juventute albido dein albido-luteo, bulboso, bulbo distincte marginato. Facie externa mycelioque alba, KOH ope nullo. Velo partiale albido. Caro albida, odor sub-nullo, KOH ope nullo. Sporis amygdaliformibus, grosse verrucosis, 9.5-11 x 6-7 µm. Typus: SWEDEN: Västergötland: Gössäter, TF2004-026 (holotype C).

Pileus 3–6(–7) cm, (hemi-)spherical, then plano-convex, glutinous, glabrous and glossy, dull when dry, and centre then sometimes slightly appressed tomentose, yellow, Universal veil leaves small brownish to blackish spots especially at centre, towards margin more diffusely brownish in streaks, the involute margin yellow. **Lamellae** crowded, pale violaceous to almost grey, soon ochre (-violaceous). **Stipe** 4–6 x 0.7–1.2 cm, with a marginate bulb (up to 2,5 cm), whitish when young, then more or less yellowish to brownish. Universal veil on the bulb margin sparse to fairly abundant, slightly viscid, when young yellowish to yellowish white at bulb margin, with age slightly brownish. Cortina fairly abundant, whitish. Bulbipellis white. **Context** when young whitish with pale brownish tinged hygrophanous spots and stripes in stipe apex, later whitish. **Macrochemical reactions:** 2% and 40% KOH negative (pale rose-brownish) in context, distinctly brownish (not red or pink) on pileus, negative on bulbipellis. **Smell** earth/dust like. **Taste** indistinct. **Dried material** yellowish on pileus, otherwise pale brownish.

Spores 9.5-11 x 6-7 µm (= 10.3 x 6.4 µm), Q = 1.62 (n=140, five specimens), amygdaliform, distinctly and coarsely verrucose, suprahilar plague more or less distinct. **Basidia** 9–11 µm wide, 4-spored. **Lamella edge** more or less fertile. **Lamella trama** of (3–)4–20 µm wide, mainly hyaline hyphae. **Pileipellis** simplex: Cutis thick, of ca. 25 hyphal layers. At surface ca. 5–10 gelatinous layers of ca. 4 µm wide, loosely erect-entangled hyphae, hyaline. The basal part of cutis of ca. 20, parallel to slightly interwoven hyphal layers, hyphae ca. 5 µm wide. **Trama** ±hyaline.

Ecology and distribution — *Cortinarius piceae* occurs in boreo-nemoral, montane and subalpine coniferous forests. Associated with *Picea abies* and *Abies alba*. On calcareous, dry to seasonally moist soil. *Cortinarius piceae* is rare, but one of the more common calochroid species in calcareous coniferous forests, and is widely distributed in suitable habitats throughout Europe.

Specimens studied – (*including macro characters): ITALY: Trento: Trentino-Alto Adige, Diga di Paneveggio, 28 Sept 2001, *G. Consiglio, P. Ceccon & S. Pedergnana* (herb Cons.). — NORWAY: Oppland: Lunner, 23 Sept 2006, *T.E.B., T.S.J. & T.F., TF2006-120** (herb C); *loc. cit.*, 24. Sept 2006, *T.E.B., T.S.J. & T.F., TF2006-121** (herb C). — SWEDEN: Västergotland, Kinnekulle, Gössäter, 11 Sept. 2004, T.S.J. & T.F., *TSJ2004-006** (herb C); *loc.cit.*, 23 Sept. 2004, T.S.J. & T.F., *TSJ2004-020** (herb. C); *loc. cit.*, *TF2004-025** (herb C); *loc. cit.*, *TF2004-026** (holotype herb C); *loc. cit.*, Medelplana, 16 Sept 1986, *T.E.B., H. Lindström, H. Marklund, J. Melot & S. Muskos, CFP508** (herb S)

Comments — *Cortinarius piceae* is characterized by the warmly yellow colours on the pileus, which becomes darker brownish yellow, very pale violaceous colours of the lamellae, a pale stipe, and a brownish alkaline reaction on the pileus and a negative reaction on the bulbipellis. It is separated from most other co-occurring calochroid species by the thoroughly coloured pileus (including

the margin) and the non-pink alkaline reaction of bulbipellis and pileus. *C. barbarorum* Bidaud et al. and *C. barbaricus* differ by a lighter and persistently yellowish coloured pileus with larger (or lacking) and paler velum scales, more pronounced violaceous colours of stipe and/or lamellae, and a strongly pinkish red alkaline reaction on the pileus and a pink alkaline reaction on the bulbipellis. Generally the basidiocarps of *C. piceae* are smaller.

Phylogenetic analyses based on ITS, RPB1 and RPB2 (unpublished data) place *C. piceae* as a weakly supported sister species to *C. dalecarlicus* Brandrud with which it share several morphological and ecological characters. They are separated consistently separated by 18 nucleotide differences. Despite morphological resemblance, it is not closely related to neither *C. barbarorum* nor *C. barbaricus* (unpublished data).

The species described here corresponds to the taxon often treated as a variety of *C. calochrous* – i.e. *C. calochrous* var. *coniferarum* (M.M. Moser) Quadr. (e.g. in Brandrud et al. 1990). Molecular phylogenetic studies and morphology, however, indicate that this taxon should be treated as an independent species. For several reasons we chose to describe the taxon as a new species not connected to the type of *Phlegmacium calochroum* var. *coniferarum* M.M. Moser. First of all, it seems that the description of Moser (1960) covers both *C. piceae* and at least one other calochroid coniferous forest taxon (i.e. *C. barbarorum* or *C. barbaricus*). These taxa are impossible to unambiguously morphologically identify from exsiccates and DNA amplification of old type material (the type is from 1948) is difficult (and we have not been able to obtain the type from München for study). Secondly, the name *C. coniferarum* is preoccupied by a taxon in the *C. multiformis* group (i.e. *Phlegmacium multiformis* var. *coniferarum* M.M. Moser = *Cortinarius coniferarum* (M.M. Moser) Moënne-Locc. & Reumaux), so the introduction of a nomen novum is inevitable. Thirdly, the name *C. barbarorum* was introduced by Bidaud et al. (2001) intended as a new name for *Phlegmacium calochroum* var. *coniferarum*, but a new type was deposited and the basionym not cited, and the description must thus be treated as covering a new species not connected to the type of *P. calochroum* var. *coniferarum*. Looking at the illustrations of *C. barbarorum* in Bidaud et al. (2001), it is evident that more than one species is illustrated, among these also *C. piceae*. The type of *C. barbarorum*, however, belongs to another species than *C. piceae* (unpublished data). Thus we chose to describe the taxon as a new species.

Cortinarius homomorphus Kühner was published invalidly by Kühner (1960) and later validated (Kühner 1989). Kühner describes a species with a yellow pileus with darker scales, violaceous lamellae, a pronounced violaceous stipe, violaceous context in the stipe, and a brown-red KOH reaction. The description combines characters of *C. barbarorum*, *C. barbaricus* and *C. piceae* with those

of *C. haasii* (M.M. Moser) M.M. Moser. Kühner emphasizes the violaceous stipe, which hardly correspond with *C. piceae* but rather *C. haasii*. He states that he knows the species from both coniferous forest and beech forest, but current knowledge indicates that no calochroid species grow with both frondose trees and conifers. The epithet was (originally) introduced at a time where the concept of *C. calochrous* covered at least 15 species, and the possibility that Kühner's description covers at least two species is great. The type specimen consists of a few small fragments, and DNA extraction of the type has not succeeded yet (Frøslev et al., unpublished). The epithet has rarely been used and despite a very thorough description in Kühner (1960) it presently seems difficult to unambiguously apply to any of the presently recognized species. Bidaud et al. (2001) applied the name *C. homomorphus* (and also *C. pansa*) for the species they describe as *C. barbarorum* in the same publication (unpublished data). Further molecular studies would be needed to clarify if the type specimen of *C. homomorphus* represents an older epithet for e.g. *C. barbarorum* or more likely a junior synonym of *C. haasii*.

An ITS sequence of the holotype of *C. piceae* (TF2004-026) is available on GenBank (accession DQ663378).

Cortinarius barbaricus (Brandrud) Frøslev, T.S. Jeppesen & Brandrud, **comb. nov.**
Basionym: *Cortinarius calochrous* var. *barbaricus* Brandrud, in Cortinarius, Flora Photographica 3: 27 (1994). Holotype: *CFP504* (herb S).

Comments — Phylogenetic analyses (Frøslev et al., unpublished) have shown that this taxon is well separated from other resembling calochroid species, and thus deserves to be treated at specific rank. The three specimens of *C. barbaricus* sequenced are identical in the ITS region, and it is placed as a sister species to *C. barbarorum* from which it is separated by 12 nucleotide differences in the ITS region. The two species are morphologically almost inseparable. It seems that *C. barbaricus* has a more distinct yellow cap colour than *C. barbarorum*, and a more violaceous colouration of the stipe (apex), and a more distinct colouration of the stipe than lamellae, which is opposite for *C. barbarorum*. The smell of *C. barbaricus* is mild and somewhat like *C. sulphurinus* Quél. (i.e. parsley), whereas *C. barbarorum* has a stronger and more unpleasant smell of dust/earth. Further morphological and phylogenetic studies are needed to find unambiguous morphological differences between these species.

The more common and widespread *C. piceae* differs by a more coloured pileus with small brown spot like scales, (almost) colourless lamellae and almost negative KOH reactions, and is phylogenetically well separated from the two other taxa.

An ITS sequence of the holotype of *C. barbaricus* (CFP504) is available on GenBank (accession DQ663234).

Acknowledgments

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MYCOTAXON

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A new species and a new Chinese record of *Exobasidium* (*Exobasidiales*) from China

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Abstract—A new species, *Exobasidium lyoniae* causing leaf spots on *Lyonia ovalifolia* var. *lanceolata* and a new Chinese record, *Exobasidium euryae* on *Camellia oleifera* are reported. The new species was collected from Yunnan Province, China. The new record was discovered from Hunnan Province, China. The new species is characterized by the number of sterigmata and the size of basidiospores.

Key words—Ustilaginomycetes, symptom, taxonomy

A new species of *Exobasidium* on *Lyonia ovalifolia* var. *lanceolata* was collected from Tengchong, Yunnan Province in 2005. The new species is parasitic on young leaves, causing leaf spots, usually one and sometimes more on each leaf, 5–12 mm in diameter, red above and white with hymenium beneath. The transverse section of the diseased leaf shows no differentiation between the palisade and mesophyll cells. There is not hypertrophy or hyperplasia of plant cells. Intercellular hyphae protrude between epidermal cells, forming a continuous layer on the undersurface of the leaves at maturity. This recently collected *Exobasidium* species has 2–5 sterigmata, and its basidiospores measure (9–)10–15(–16) x 2.8–4.5 µm. When comparing the morphology of the validly described taxa on *Ericaceae* plants, *Exobasidium pieridis-ovalifoliae* (Ezuka 1991) on *Lyonia ovalifolia* var. *elliptica* (Siebold & Zucc.) Hand.-Mazz. shows similarities on the symptom and the number of septa of basidiospores. The new species is different from *E. pieridis-ovalifoliae* in the number of sterigmata and size of basidiospores, the latter having 2–3(–4) sterigmata and basidiospores measuring 15–20(–22) x 4–6.5 µm.

**corresponding author*

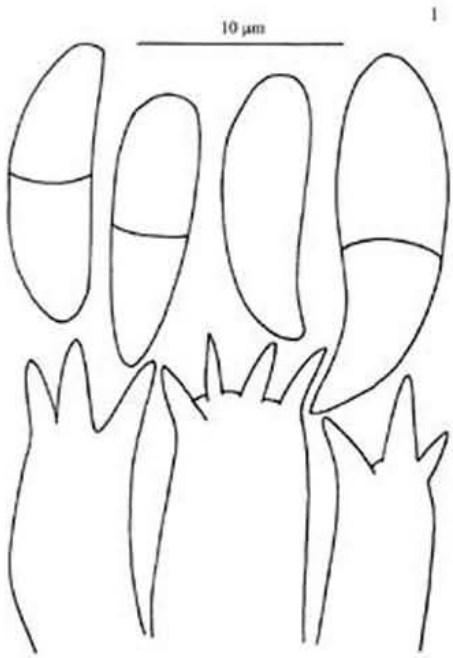

Fig. 1. Basidia, sterigmata and basidiospores of *Exobasidium lyoniae* on *Lyonia ovalifolia* var. *lanceolata* (HMAS 140551, holotype).

Exobasidium lyoniae Z.Y. Li & L. Guo, **sp. nov.** **Figs. 1, 3-5**

MycoBank MB510328

Hymenium hypophyllum. Basidia hyalina, clavata vel cylindrica, 34–50 x 5–7(–8) µm, terminaliter 2–5 sterigmatibus (2–)3–5 x 1–1.5(–2) µm praedita. Basidiosporae ellipsoideae vel curvae, (9–)10–15(–16) x 2.8–4.5 µm, hyalinae, laeves, primo continuae, dein 1–3-septatae.

Hymenium hypophyllous and white. Basidia with 2–5 sterigmata, clavate or cylindrical, 34–50 x 5–7(–8) µm. Sterigmata, conical, (2–)3–5 x 1–1.5(–2) µm. Basidiospores ellipsoidal, (9–)10–15(–16) x 2.8–4.5 µm, hyaline, smooth, at first continuous, then 1–3-septate, and slightly curved.

Specimen examined—On *Lyonia ovalifolia* var. *lanceolata* (Wall.) Hand.-Mazz. (*Ericaceae*), Yunnan: Tengchong, Xiaodifang, alt. 2180 m, 19 IX 2005, Z.Y. Li, L. Guo & N. Liu 206, HMAS 140551 (**holotype**).

A new Chinese record of *Exobasidium* on *Camellia oleifera* was collected from Hunan Province in 2005. This species is parasitic on the apical buds causing deformation and forming a peach-like hollow gall with spongy texture, measuring 30–50 mm in diameter. When maturing the hymenium sloughed off the epidermis and exposed outside. The hymenium is white, continuous, and the hyphae are intercellular. Transverse section of the diseased bud shows hypertrophy and hyperplasia of plant cells and there is no differentiation

between the palisade and mesophyll cells. The species causing bud galls on *C. oleifera* was identified as *Exobasidium camelliae* by Yang (in Siang 1957), as *E. vexans* by Liu et al. (2002) and as *E. gracile* by Wang et al. (2004). But *E. camelliae* has bigger basidiospores of 15–25 x 5–7.5 µm, *E. vexans* causes only leaf spots and has only 2 sterigmata, *E. gracile* causes only leaf hypertrophy and its colony was smooth and composed of conidia only. The species causing bud galls was identified as *E. euryae* (Sydow et al. 1912) which is new to China. *E. euryae* was first reported to cause hollow bud galls of *Eurya acuminata* DC. from Katmandu, Nepal, having 2–4 sterigmata and basidia measuring 60 x 5–10 µm, basidiospores 14–17 x 4 µm.

Exobasidium euryae Syd., P. Syd. & E.J. Butler, Ann. Mycol. 10: 275, 1912.

Figs. 2, 6-8

Basidia with 2–4 sterigmata, clavate or cylindrical, 101–138(–151) x 5–11 µm. Sterigmata conical 2–4 x 1–2 µm. Basidiospores are obovoid, subclavate or musiform, (10–)12–17.6 x 3–4.8 µm, hyaline, smooth, at first continuous, then becoming septate with 1–4 septa, and slightly curved at the base. Germ tubes of the basidiospores emerge from both ends and septal regions of each cell. Conidia bud to produce daughter cells. Conidia, produced on PDA in 21 days incubation are linear, hyaline and measure 2–6 x 0.5–1.2 µm.

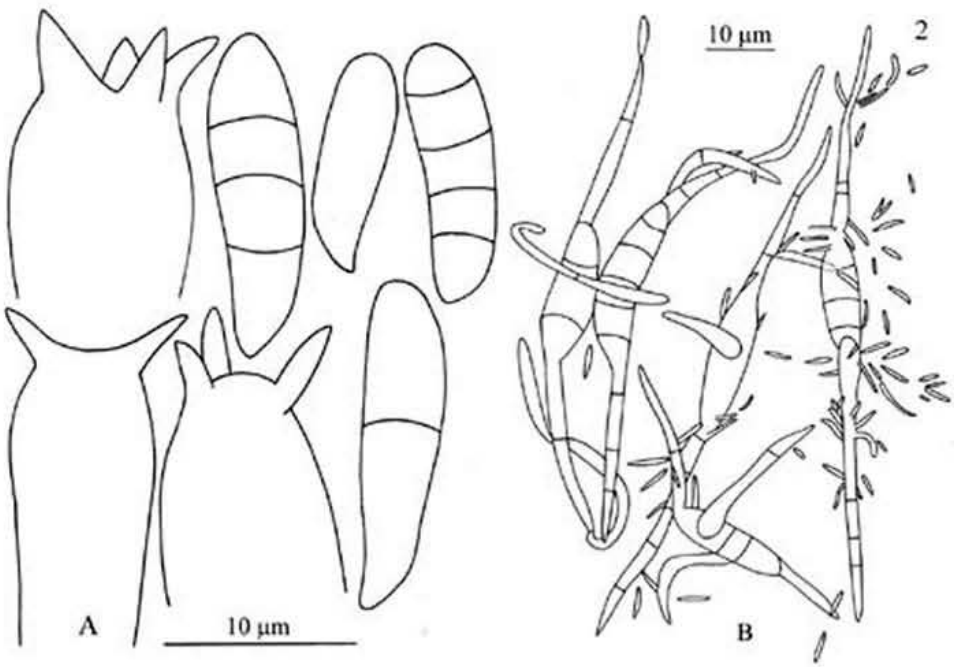

Fig. 2. *Exobasidium euryae* on *Camellia oleifera* (HMAS 97947).
A. Basidia, sterigmata and basidiospores. B. Basidiospore germination.

Colonies on PDA grew gradually, to a maximum 12 mm diameter in 21-day incubation at 25°C. The surface of the colony was yellow, corrugate and the periphery slightly wrinkled. Colonies did not fix on the agar surface. Formed conidia did not produce a powdery appearance. Colonies were composed of hyphae and conidia.

Specimen examined—On *Camellia oleifera* Abel (*Theaceae*), Hunan: Changde, Maoligangcun, alt. 50 m, 17 IV 2005, Z.Y. Li & L. Guo 2, HMAS 97947.

So far 20 species of *Exobasidium* have been recorded in China (Tai 1979, Sawada 1922, Li & Guo 2006). Three species are parasitic on *Lyonia* plants: 1) *Exobasidium lyoniae* causing leaf spots (in this paper), 2) *E. pieridis* Henn. causing hypertrophy and deformation, 3) *E. pieridis-ovalifoliae* Sawada causing leaf spots. Six species are parasitic on *Theaceae* plants: 1) *E. camelliae* Shirai causing hypertrophy of flower buds, foliar buds, leaves and fruits, 2) *E. euryae* causing hollow bud galls (in this paper), 3) *E. gracile* (Shirai) Syd. & P. Syd. causing hypertrophy of young leaves and shoots, 4) *E. monosporum* Sawada causing leaf spots, 5) *E. reticulatum* S. Ito & Sawada causing net-like leaf spots, 6) *E. vexans* Massee causing leaf spots.

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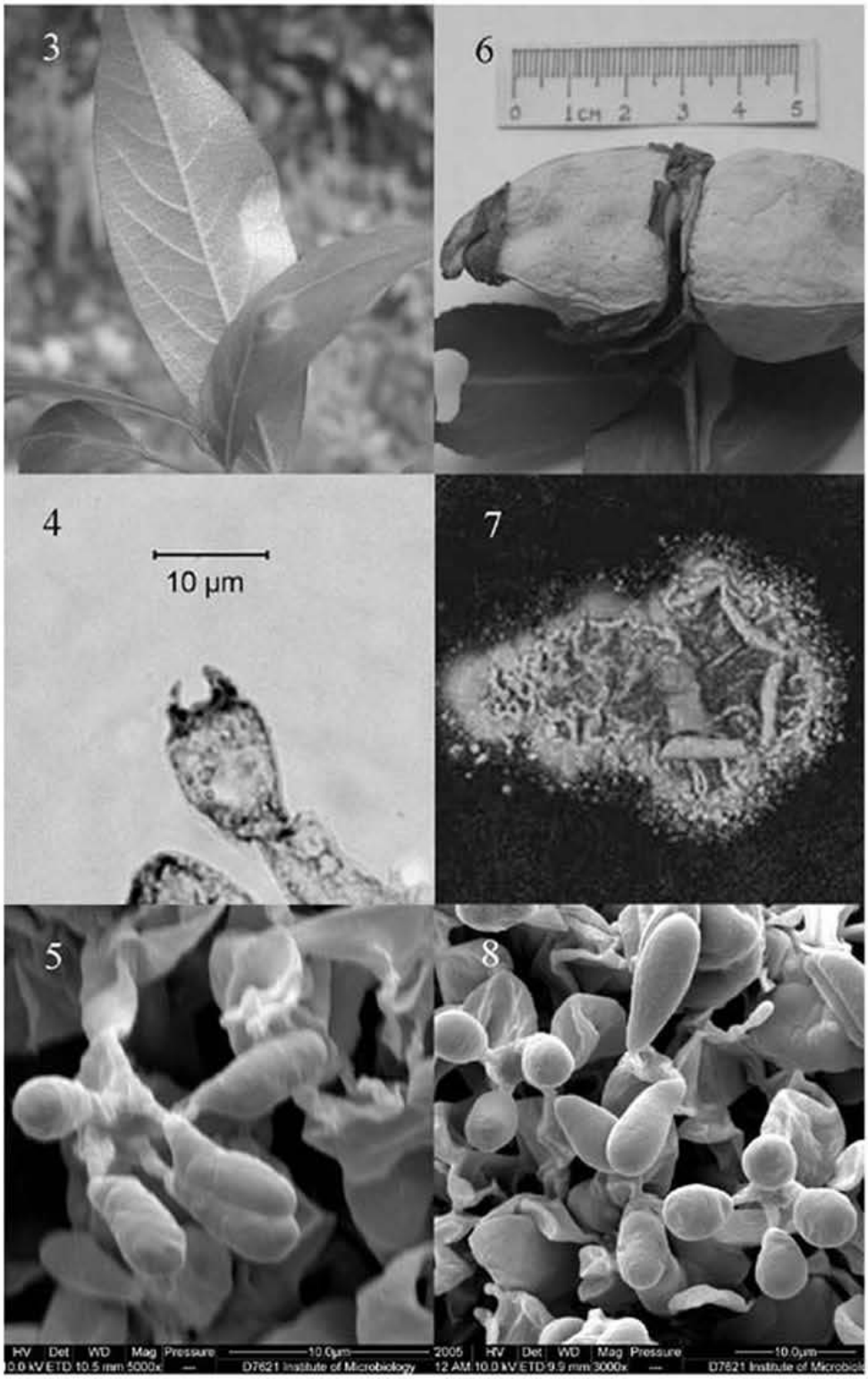
Figs. 3-5. *Exobasidium lyoniae* on *Lyonia ovalifolia* var. *lanceolata* (HMAS 140194, holotype). Fig. 3. Symptom. Fig. 4. Basidium and sterigmata as seen by LM (light microscopy). Fig. 5. Basidia, sterigmata and basidiospores as seen by SEM (scanning electron microscopy).

Figs 6-8. *Exobasidium euryae* on *Camellia oleifera* (HMAS 97947). Fig. 6 Symptom. Fig. 7. Colony cultured on Potato Dextrose Agar (PDA) for 21 days. Fig. 8. Basidia, sterigmata and basidiospores as seen by SEM (scanning electron microscopy).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Albatrellus yunnanensis H.D. Zheng & P.G. Liu , p. 146
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Appendicispora appendicula (Spain, Sieverd. & N.C. Schenck) Spain, Oehl & Sieverd., p. 170
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Appendicispora jimgerdemannii (N.C. Schenck & T.H. Nicolson) Spain, Oehl & Sieverd., p. 176
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Auritella chamaecephala Matheny, O.K. Mill. & Bougher, p. 232
Auritella dolichocystis Matheny, Trappe & Bougher, p. 232
Auritella erythroxa (De Seynes) Matheny, p. 232
Auritella geoaustralis Matheny & Bougher, p. 232
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Reviewers, Volume Ninety-seven

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.

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From the *Editor-in-Chief*

To our Readers

This volume of Mycotaxon marks the end of our transition to a fully electronically submitted and prepared journal.

Part of that transition has been to streamline the journal's appearance without changing a format that has served it well for over thirty years. Color—which returned in January after a 20-year hitaus—continues to entice the reader's eye: note, for instance, Zhuang & Yang's macrophoto of a wood-loving *Agyrium* (96: 171) or Spain & al.'s stunning *Appendicispora* microphotos (this volume: 171, 175).

An informal meeting of Mycotaxon Editors at IMC8 in Cairns determined a less eye-catching, but equally important, change: we agreed unanimously to increase primary text font size to 10-pt. (Typographical experts agree that 10-pt is optimal for Mycotaxon's 11 × 17.5 cm print page.) Although this seemingly minor decision delayed volume 97's publication by over a month, we are quite confident that our readers will resoundingly approve the increased legibility of the printed page.

Despite such recent cosmetic innovations, however, Mycotaxon cheerfully remains a text-heavy scientific journal. As such, we continue to foster taxonomic rigor and nomenclatural accuracy while encouraging erudite discourses more lengthy than those permitted by most modern scientific magazines.

While we do discourage needless repetition—a common editorial irritation being the needless duplication of a lengthy English technical description in Latin (in lieu of the more useful short Latin diagnosis)—our pages welcome well-considered exploration and syntheses of seemingly disparate parts in our pages. Who among us has not marveled over the keen insight of a Buller, who lived in a time without EDTA, electron microscopes, and hard-drives but who possessed that most precious scientific tool of all — a discriminating human brain?

Insights such as Buller's take both time and space to develop. Mycotaxon encourages publicaton of more lengthy monographic studies and reflective treatises of a more philosophical nature. Hence, we have raised our annual 'free' page limit from 64 to 100 pages in anticipation of several exciting longer papers now in the early stage.

To our Authors: the '4-step' Mycotaxon submission process

Please download all necessary files and guides from the Instructions to Authors webpage on **www.mycotaxon.com** before preparing a paper for submission to our journal. An abbreviated set of instructions was most recenty published in Mycotaxon 94: 401–411 (2005/2006), and all files are also available as Email attachments from the *Editor-in-Chief* <editor@mycotaxon.com> on request.

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 for nomenclatural review.

Step 2—NOMENCLATURAL & FRENCH LANGUAGE REVIEW: After considering 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*.

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