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NOMENCLATURE UNDER THE BOTANICAL CODE

A symposium presented at the 4th International Mycological Congress, Regensburg, Germany, on September 3, 1990, Lennart Holm (Uppsala) and Richard P. Korf (Ithaca) co-covenors and co-chairs, chairman and secretary, respectively, of the International Association for Plant Taxonomy's Committee for Fungi and Lichens.

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MYCOTAXON

Volume XL, pp. 1-11 January-March 1991

A PRELIMINARY DISCOMYCETE FLORA OF MACARONESIA: PART 11, SARCOSCYPHINEAE[1]

RICHARD P. KORF[2]
and
WEN-YING ZHUANG[3]

Plant Pathology Herbarium, Cornell University, Ithaca, New York 14853, USA

> "He that high growth on cedars did bestow,
> Gave also lowly mushrumps leave to grow."
> Robert Southwell
> SCORN NOT THE LEAST

Order PEZIZALES
Suborder SARCOSCYPHINEAE

KEY TO THE FAMILIES

1 Apothecia bright colored, usually with carotenoids in the hymenium (in paraphyses), melanin pigments if present confined to hairs on the excipulum, paraphysis cells multinucleate .... Sarcoscyphaceae

1' Apothecia dark colored, excipulum devoid of carotenoids, paraphysis cells uninucleate, rarely binucleate .. ..Sarcosomataceae

Family SARCOSCYPHACEAE Le Gal ex Eckblad 1968

KEY TO THE KNOWN MACARONESIAN GENERA

1 Apothecia 1–4 mm diam, ectal excipulum of textura angularis, ascospores spherical, occurring on needles of Cupressaceae ... Pithya

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[1] The parts of this flora will appear in irregular order. Reprints of individual parts will not be available for distribution. For special features of this flora, see *Mycotaxon* 13: 144. 1981.

[2] Professor of Mycology

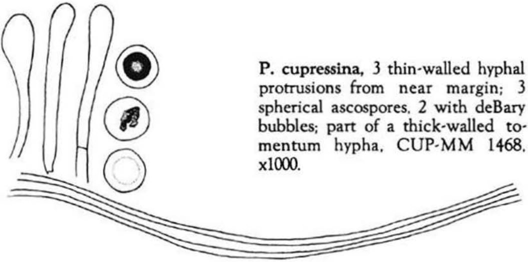
[3] Anna E. Jenkins Postdoctoral Associate

1' Apothecia (3–) 6–40 mm diam, ectal excipulum of textura porrecta to textura prismatica, ascospores ellipsoid, occurring on woody substrata, usually small branches, often in the duff or soil .... **Sarcoscypha**

PITHYA Fuckel 1870

One known Macaronesian species

1. **Pithya cupressina** (Batsch : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 317. 1870.



P. cupressina, 3 thin-walled hyphal protrusions from near margin; 3 spherical ascospores, 2 with deBary bubbles; part of a thick-walled tomentum hypha, CUP-MM 1468, x1000.

RECENT TAXONOMIC TREATMENTS:
Denison (1972), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Jena, Germany was where Batsch collected his specimens, but he cited Micheli's polynomial, described from Italy.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM 1468.

SUBSTRATUM: On needles of *Juniperus phoenicea* L.

Notes: Another spherical-spored discomycete associated with Cupressaceous needles in Tenerife proved to be a new species of *Pulvinula* (Part 16, Mycotaxon **40:** 100. 1991.).

SARCOSCYPHA (Fr. : Fr.) Boudier, 1885

Key to the known Macaronesian species

[1 Apothecia 10-40 (-80) mm diam, ascospores (24.5–) 27–43 (–51) x (10–) 11–14 (–14.5) µm .... **1. S. coccinea**]

1' Apothecia (3–) 6–20 mm diam, ascospores (18.3–) 20.5–28 (–35) x (6.1–) 7.3–11 (–11.7) µm .... **2. S. macaronesica**

1. **Sarcoscypha coccinea** (Jacq. : Fr.) Lambotte, Fl. mycol. Belge, suppl. **1:** 302. 1887.

RECENT TAXONOMIC TREATMENTS:
Baral (1984), Breitenbach & Kränzlin (1984), Harrington (1990).

PREVIOUS MACARONESIAN RECORDS:
†Drouet (1866). [All collections from Madeira and the Canary Islands so far examined are misidentifications, and all represent S. *macaronesica*, q.v.] See also the entry under *Octospora coccinea* in Part 16 of this Preliminary Flora (Mycotaxon **40:** 97-98. 1991).

TYPE LOCALITY: Neotype from Baden-Württemburg, Germany (Baral, 1984).

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
São Miguel. †

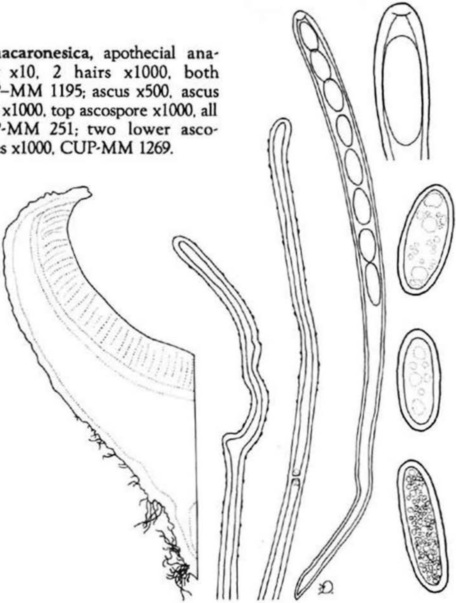
SUBSTRATUM: lignicolous.

Notes: Drouet's collection (as *Peziza coccinea*) is the only one reported from the Azores, and we have been unable to locate it. It is thus possible that he collected the true S. *coccinea*, but he gave no description, and for this reason it is included here as a possible Macaronesian species; all other known Macaronesian collections have proven to be the much smaller species, S. *macaronesica*, with shorter and narrower ascospores. The ascospore measurements given in the key for S. *coccinea* are taken from Baral (1984).

2. **Sarcoscypha macaronesica** Baral & Korf *in* Baral, Z. Mykol. **50:** 124. 1984.

MISAPPLIED NAMES: *Peziza badia* (Montagne, 1840). *Sarcoscypha coccinea* (most recent authors).

S. macaronesica, apothecial anatomy x10, 2 hairs x1000, both CUP–MM 1195; ascus x500, ascus apex x1000, top ascospore x1000, all CUP-MM 251; two lower ascospores x1000, CUP-MM 1269.



RECENT TAXONOMIC TREATMENT:
Baral (1984).

PREVIOUS MACARONESIAN RECORDS [most as *S. coccinea*]:
*Montagne (1840), **Berkeley (1874), *** Baagøe et al. (1971), ****Wildpret et al. (1972), *****Beltrán & Wildpret (1975), ******Baral (1984), †Cool (1924), ††Cool (1925), †††Wildpret et al. (1972) ††††Wildpret & Beltrán (1974), †††††Beltrán (1980), ††††††Beltrán et al. (1987).

TYPE LOCALITY:
Canary Islands, Gomera, south of Vallehermoso, elev. 400-800 m.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM 1496 (TFC), 1506, 1535, 1586, 2259, 2297, 2469, ***2500 (C), ***2503 (C).

CANARY ISLANDS.

Gomera. † CUP-MM 1165 (O), 1166 (O), 1355, *****2520 (TFC), ******2611 [isotype] (TUB), 2628.

Gran Canaria. ††††† CUP-MM *2527 (FI, as *Peziza badia*).

La Palma. †††† †††††† CUP-MM ****2599 (TFC).

Tenerife. †† ††† †††† ††††† †††††† ††††††† CUP-MM 251, 412 (TFC, OSC), 577 (OSC), 1195, 1269, 1271, 1319, **1654 (K), 2249, 2255, 2285, *****2521 (TFC), *2529 (FI, as *Peziza coccinea*), 2600, 2601, 2602.

SUBSTRATA: corticolous, lignicolous, on sticks, branchlet, twigs, on ?*Prunus* sp.

Notes: This has regularly been misidentified as *S. coccinea*. The only extralimital collection of this species known to us is CUP 58136, from Mallorca, Balearic Islands, Spain. Certainly the Iberian peninsula and north Africa should be examined for the presence of this species, so widely spread in the Canary Islands and Madeira. As indicated above, the species is unknown from the Azores, unless the one report of *S. coccinea* from that island for which no voucher specimen has been found should also be this species instead.

Family SARCOSOMATACEAE Kobayasi 1937

KEY TO THE KNOWN MACARONESIAN GENERA

1 Apothecia minute, discoid, with brown setae present on receptacle surface and in the pale hymenium, occurring on needles of *Pinus*. **Desmazierella**

1′ Apothecia usually large, turbinate to deeply cupulate, stalked or sessile, black or nearly so, lacking setae but often with dark hairs giving a woolly aspect to receptacle and base, on woody substrata. **Plectania**

DESMAZIERELLA Libert 1829

One known Macaronesian species

1. **Desmazierella acicola** Libert, Ann. Sci. Nat. (Paris) **17:** 82. 1829.

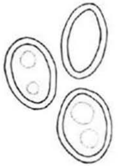
RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Huhtinen and Makinen (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Malmédy, Belgium.

KNOWN MACARONESIAN DISTRIBUTION:
CANARY ISLANDS.
Hierro. CUP-MM 1398 (TFC).

SUBSTRATUM: pine needles in duff.



D. acicola, ascospores, CUP-MM 1398, x1000.

Notes: The hymenial setae, granularly roughened as are the excipular setae, are diagnostic for this genus. Both known species are on conifer needles. Ascospore sizes reported in the literature vary greatly among investigators. The material from Hierro seems to have a lower length/width ratio than that in most reports. Possibly the asci mature their ascospores simultaneously, as has been reported by Huhtinen and Makinen (1984) in *D. piceicola*, which would account for such discrepancies.

PLECTANIA Fuckel 1870

= *Pseudoplectania* Fuckel 1870

Key to the known Macaronesian infrageneric taxa

1 Ascospores symmetrical, smooth-walled 2
1′ Ascospores asymmetrical, flattened, convex surface ornamented with horizontal or anastomosing striations (sect. *Plicosporae*) 3
  2 Ascospores spherical, orange granules lacking at apothecial margin (sect. *Sphaerosporae*) .... **2. P. nigrella**
  2′ Ascospores ellipsoidal, orange granules usually present at apothecial margin (sect. *Plectania*) .... **1. P. melastoma**
3 Ascospores with 8–11 horizontal striations .. **5. P. rhytidia** f. **platensis**
3′ Ascospores with 10–14 horizontal and occasionally anastomosing striations 4
  4 Ascospores in face view mostly 15.4–22 x 9.5–12.4 (–13.2) µm, paraphysis apices strongly contorted .... **3. P. kohnii**
  4′ Ascospores in face view mostly 20.5–24.5 x 10.5–13.2 µm, paraphysis apices usually straight .... **4. P. rhytidia** f. **rhytidia**

1. **Plectania melastoma** (Sow. : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 324. 1870.

≡ *Urnula melastoma* (Sow. : Fr.) Boud., Icon. mycol., Liste prélim. p. [3]. 1904.

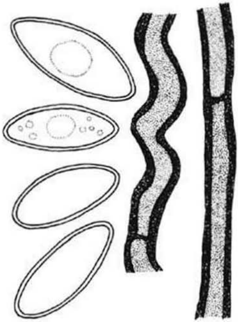
RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Paden (1983).

PREVIOUS MACARONESIAN RECORDS:
†Wildpret et al. (1969), †† Beltrán (1980).

TYPE LOCALITY:
Hexham, England.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
São Miguel. CUP-MM 1749.
MADEIRA.
Madeira. CUP-MM 1550 (immature).
CANARY ISLANDS.
Tenerife. † †† (specimen preserved in formalin and accidentally destroyed, according to information from E. Beltrán).


P. melastoma, 4 ascospores and portions of 2 dark brown hairs, CUP-MM 1749, x1000.

SUBSTRATA: on very rotten roots and litter of *Cryptomeria japonica* (L. f.) D. Don, on stem of *Rubus* sp.

Notes: The record from the Canary Islands is highly suspect, since the species was reported as terricolous rather than on wood or litter. No microscopic features were recorded. The orange granules at the margin are diagnostic for the species, though also known in the allied genus *Korfiella*. These granules dissolve to give a violet solution in aqueous KOH. Even immature Macaronesian specimens can be placed here that show this character. Another useful field character is the presence of a pronounced tuft of dark anchoring hyphae that usually spreads out over the substrate at the base of the apothecium.

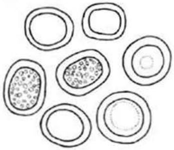
2. **Plectania nigrella** (Pers. : Fr.) Karst., Acta Soc. Fauna Fl. Fenn. **2:** 119. 1885.

≡ *Pseudoplectania nigrella* (Pers. : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 324. 1870.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Paden (1983), Breitenbach and Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Laibach [Ljubljana], Yugoslavia
[von Wulfen (1788), as *Elvela hemisphaerica* Wulf.]



P. nigrella, ascospores, CUP-MM 1265, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. CUP-MM 1162 (O).
Tenerife. CUP-MM 1265 (TFC).

SUBSTRATA: on soil, on mossy soil.

Notes: We follow Paden (1983) in submerging *Pseudoplectania* in *Plectania*.

3. **Plectania kohnii** Korf & Zhuang, *sp. nov.*

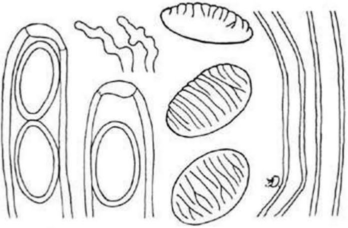
= ? *Urnula torrendii* Boud. var. *madierensis* Torrend, Brotéria, ser. Bot., **11:** 173. 1913.

RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
† (?) Torrend (1913).

Ab *Plectania rhytidia* f. *rhytidia* ascosporis multo brevioribus et planioribus, 15.4–22 x 9.5–12.4 (aspectu frontali) x 4.4–7.3 (aspectu laterali) µm, atque ab *P. rhytidia* f. *platensi* ascosporis brevioribus et latioribus, strias in ascospori superficie 11–13 vice 8–11 possidentibus, differens.

APOTHECIA scattered or gregarious, sessile, deeply cupulate, margin irregularly crenate, 4–9 mm diam when dry. DISC nearly black. RECEPTACLE brownish-black to black, vertically wrinkled when



P. kohnii, 2 ascus apices, 2 paraphysis apices; ascospores in side view, tilted, and face view; 2 hairs, CUP-MM 1842 (holotype), x1000

dry, covered with hairs, especially at base. HAIRS brown to dark brown, irregularly undulate, ca. 3.3–5.8 µm in diam., branched, with few, delicate septa. ECTAL EXCIPULUM of textura angularis, walls light brown near medullary excipulum and dark towards the outside, 110–150 µm thick. MEDULLARY EXCIPULUM of textura intricata, thin at margin and becoming very thick at base of apothecium, hyphae pale yellow to pale brown, immersed in gel. SUBHYMENIUM 65–85 µm thick, brown to dark brown. HYMENIUM ca. 365 µm thick. Asci suboperculate, subcylindrical, 8-spored, (286–) 318–359 (–448) x 13.1–16.8 µm. Ascospores hyaline, ellipsoid, flattened, with 11–13 usually horizontal striae of which a few may anastomose, 15.4–22 (–22.7) x 9.5–12.4 (–13.2) [face view] x 4.4–7.3 [side view] µm. Paraphyses filiform, anastomosing, strongly contorted and frequently densely branched at apex, 1.5–2.5 µm wide, branched apices forming diagnostic, densly enmeshed clusters of neighboring paraphyses.

HOLOTYPE: Azores, São Miguel, on mossy curbing along path, Hickling Park, Furnas, leg. R. P. Korf, L. M. Kohn, N. Korf, & A. Y. Rossman, 4. iv. 1978, CUP-MM 1842 (Isotypes: TFC, OSC).

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

São Miguel. CUP-MM 1842 [holotype] (TFC, OSC), 1843, 1852, 1853 (TFC, OSC, to be issued in Korf & Gruff, Discomycetes Exsiccati).

Terceira. CUP-MM 1922, 1953, 1961.

MADEIRA.

Madeira. [Torrend (1913): n.v.]

SUBSTRATA:

On soil under Cupressaceae, on mossy curbing along path, on mossy soil of bank, on twigs, wood, and branchlets, under

Eucalyptus sp.

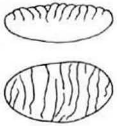
Notes: A possible synonym is *Urnula torrendii* Boud. var. *madierensis* Torrend (1913), for which no type specimen can be found. The new species honors one of the collectors, our colleague, Linda M. Kohn.

4. Plectania rhytidia (Berk. *in* Hook.) Nannf. & Korf *in* Korf, Mycologia **49:** 110. 1957, forma **rhytidia.**

RECENT TAXONOMIC TREATMENTS:
Rifai (1968), Paden (1983), Donadini (1985).

PREVIOUS MACARONESIAN RECORDS:
*Dennis et al. (1977) [as *Urnula platensis*].

TYPE LOCALITY:
New South Wales, New Zealand.



P. rhytidia f. **rhytidia**, ascospores in side and face view, CUP-MM 1668, x1000.

KNOWN MACARONESIAN DISTRIBUTION
AZORES.
Terceira. CUP-MM *1668 (K).
MADEIRA.
Madeira. CUP-MM 2387.
CANARY ISLANDS.
Gomera. CUP-MM 1175, 1612 (TFC).

SUBSTRATA: on branchlet, on *Rubus* sp., at base of trunk of *Eucalyptus globulus*.

5. Plectania rhytidia (Berk. *in* Hook.) Nannf. & Korf *in* Korf forma **platensis** (Speg.) Donadini, Rivista Mycol. **28:** 24. 1985.

≡ *Urnula platensis* Speg., Anal. Mus. Nac. Hist. Buenos Aires **6:** 310. 1899.
≡ *Plectania platensis* (Speg.) Rifai, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect., **57**(3): 29. 1968.

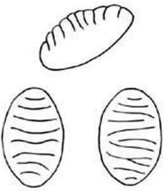
RECENT TAXONOMIC TREATMENTS:
Rifai (1968), Donadini (1985).

PREVIOUS MACARONESIAN RECORDS:
None. [The record by Dennis et al. (1977) appears to be based on a specimen of *P. rhytidia* f. *rhytidia*, q.v.]

TYPE LOCALITY:
La Plata, Argentina.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Gomera. CUP-MM 2642 (TFC). 2647 (TFC).

SUBSTRATA:
On wood and capsules of *Eucalyptus*.



P. rhytidia f. platensis,
ascospores,
CUP-MM 2647, x1000.

Notes: We follow Donadini (1985) in recognizing this form for specimens otherwise similar to *P. rhytidia* f. *rhytidia* but with fewer transverse folds on the ascospores.

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CLYPEISPORA AND ITS MYCOSPHAERELLA TELEOMORPH

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Abstract: *Clypeispora angustifoliorum*, a new Coelomycete, is described and compared to other genera with conidia bearing a noncellular appendage. The microconidial stage, *Asteromella angustifoliorum*, is also described. The teleomorph, *Mycosphaerella angustifoliorum*, is easily distinguished from the other *Mycosphaerella* species on American poplars by its large ascospores.

During September, 1987, an undescribed pycnidial coelomycete was collected in southwestern Colorado on diseased, living leaves from *Populus angustifolia* James. Conidiomata were amphigenous, but on any particular spot were often more numerous on, or restricted to, either the anatomically upper or lower side of the leaf. The unique conidia were allantoid, hyaline, aseptate, and often bore an irregular, caplike appendage at one or both ends.

Clypeispora angustifoliorum g. nov., sp. nov., Fig. 1

Maculae angulares, venis limitatae, aeque rubribrunneae, in superficiebus ambabus folii manifestae, 1.0-6.5 *mm in axe longissimo. Mycelium immersum, hyalinum, septatum, ramosum, ex cellulis ca* 2-3 *μm latis compositum. Conidiomata amphigena, pycnidica, immersa, atra prope paginam hospitis, alibi hyalina vel aurea, sub stomatibus, uniloculata, usque ad* 180 *μm diam, plus minusve globosa sub maturitate, tenuiparietes, ostiolata; paries ex cellulis unistratis parietibus paene hyalinis vel aureis, atris prope paginam hospitis compositus; ostiolum circulare, centrale, mature papillatum, papilla plerumque non adest sub maturitate. Conidiophora carentia. Cellulae conidiogenae parietem conidiomatum formantes, holoblasticae, discretae, determinatae, monosporae, in base paene hyalinae vel aureoparietes;* 4-7 *μm latae in base plus minusve crassiparietes, unaquaeque projectura tenuiparies conica vel filiformis* 8-10 *x* 1-2 *μm in pagina interior unde conidia exoriuntur ferens. Conidia hyalina, allantoidea, laevia, aseptata, in apice et base obtuse rotundata,* (32-)39-50(-58) *x* (4-)5(-6), $\bar{x}$=44.4 *x* 5.1 *μm; plerumque appendicibus irregularibus ad apicem et/vel basem* 4-7 *μm longis et latis. Cirri albi translucentes.*

Spots angular, bounded by veins, uniformly red-brown, visible on both sides of the leaf, 1.0-6.5 mm on the longest axis. Mycelium immersed, hyaline, septate, branched, composed of cells ca 2-3 μm wide. Conidiomata (Fig. 1, A) amphigenous, pycnidial, immersed, black at the surface of the host, hyaline to golden elsewhere, substomatal, unilocular, up to 180 μm in diameter, more or less globose at maturity, thin-walled, ostiolate; wall composed of one layer of cells with nearly hyaline to golden walls, black adjacent to the host epidermis; ostiole circular, central, papillate early, papilla often not present at maturity. Conidiophores absent. Conidiogenous cells (Fig. 1, B) forming the conidiomatal wall, holoblastic, discrete, determinate, monosporous, nearly hyaline to golden-walled at the base; 4-7 μm wide at the more or less thick-walled base, each bearing a thin-walled, conical to threadlike projection up to 8-10 x 1-2 μm on the inner surface from which the conidia arise. Conidia hyaline, allantoid, smooth, aseptate, bluntly rounded at the apex and base, (32-)39-50(-58) x (4-)5(-6), x̄= 44.4 x 5.1 μm; often with an irregular apical and/or basal appendage 4-7 μm long and wide (Fig. 1, C). Cirri translucent white.

Holotypus: *Ex foliis viventibus Populus angustifolia* James, Haflin Creek Trail, La Plata County, Colorado, U.S.A.; September, 1987. A. W. Ramaley BPI# 1102631.

During conidiomatal development, cells surrounding the ostiole form a dark-colored papilla that penetrates the epidermis through a stoma. The papillar opening enlarges as cirri form and the papilla gradually is obliterated in many, perhaps most, conidiomata. The wall is not torn away, but reshaped by the maturing conidial contents.

There are several pycnidial coelomycete genera with mature conidia bearing a noncellular apical and/or basal appendage. These include *Neottiospora* Desmazieres (6, 8), *Pseudorobillarda* Morelet (7), *Tiarospora* Saccardo & Marchal (8, 11), *Neottiosporina* Subramanian (11, 12), *Tiarosporella* Höhnel (8, 13), *Giula* Tassi (8), *Toxosporiopsis* Sutton & Sellar (13), and *Pseudobasidiospora* Dyko & Sutton (1). *Clypeispora* is distinct from these genera in a number of ways.

Whereas *Clypeispora* has monosporous conidiogenous cells, and *Tiarospora* has monosporous (8, 11) or sympodial (8) conidiogenous cells, both *Neottiospora* and *Pseudorobillarda* show phialidic conidiogenous cells producing multiple spores from a single locus. The remaining genera have monosporous conidiogenous cells but, in contrast to *Clypeispora*, the conidiogenous cells form a distinct layer lining the conidiomatal cavity, or are born on thin-walled, septate conidiophores (*Toxosporiopsis*). These genera are compared further in Table 1.

Brown, septate conidia separate *Septoriella*, *Tiarospora*, and *Toxosporiopsis* from *Clypeispora* (Table 1). Like *Clypeispora*, species of *Giulia* and

Tiarosporella have hyaline, aseptate conidia, but their appendages are limited to the conidial apex. Conidial septation differentiates *Neottiosporina* from *Clypeispora*, but *Pseudobasidiospora* cannot be distinguished by any of these conidial characters. However, *Pseudobasidiospora* conidia bear an excentric apiculus ending in a truncate scar, and the conidiogenous cells have a distinctive excentric apex.

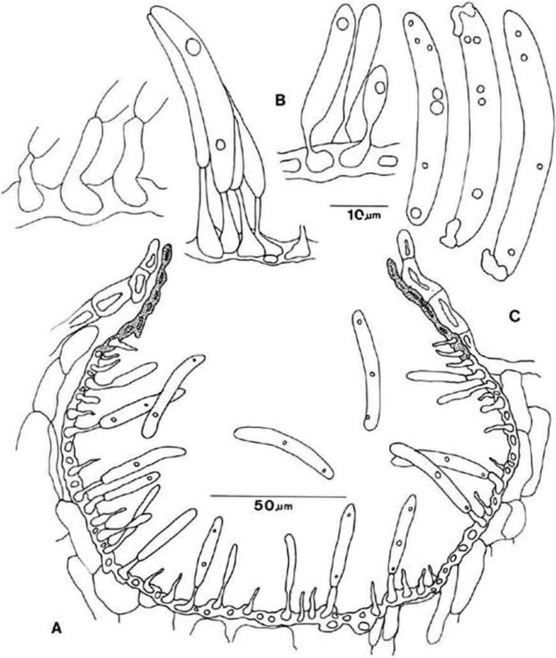

Fig. 1. *Clypeispora angustifoliorum*: (A) conidioma, (B) conidiogenous cells, (C) conidia.

TABLE 1. COMPARISON OF EIGHT COELOMYCETE GENERA WITH CONIDIOGENOUS CELLS THAT EACH PRODUCE A SINGLE, APPENDAGED CONIDIUM.

GENUS	CONIDIUM			CONIDIOMA	
	Septate	Color	Appendage	Wall, Color	Ostiole
Clypeispora	no	no	apical and/or basal or none	1 layer thick-walled cells, black near ostiole, rest hyaline to gold	yes
Giulia	no	no	apical, papilla with 3-7 setulae	outer layers thick-walled, inner layers thin-walled, black	yes, neck
Neottiosporina	yes	no	apical, some basal	thin, membranous, pseudoparenchymatous, brown	yes
Pseudobasidiospora	no	no	apical and/or basal or none	5-10 layers thick-walled cells, brown	yes
Septoriella	yes	yes	apical, apical and basal	thick-walled, cells thick-walled, stromatic, brown	yes
Tiarospora	yes	yes	apical and basal	1 layer thick-walled, 1-2 inner layers thin-walled, brown	yes, neck
Tiarosporella	no	no	apical, often tentacular	outer layers thick-walled, inner layers thin-walled, pseudoparenchymatous, dark brown	yes
Toxosporiopsis	yes	yes	apical	3-4 layers thin-walled cells, irregular shape, pale	no

Conidiomata of *Clypeispora* are nearly hyaline to golden, except at the darkened upper surface adjacent to the host epidermis. One layer of usually thick-walled cells makes up the conidioma wall and a thin-walled portion of those cells bears conidia. Most of the other genera compared in Table 1 have brown to black, thick-walled conidiomata. The two exceptions are *Neottiosporina* and *Toxosporiopsis*, but in both genera the wall has several cell layers.

A second type of spot associated with this fungus appeared on fading leaves later in the fall. The spots were larger than those that appeared earlier, and not equally visible on both leaf surfaces. Affected leaf tissue gradually faded from green to brown. Conidiomata on the spots were substomatal, aggregated, and mostly hypophyllous. Small conidia were expelled in translucent white droplets. These conidiomata were concluded to be spermogonia in the life history of *Clypeispora* because both conidiomatal types could occur on the same spot, some conidiomata contained both conidial types, and ascomatal initials appeared among the small-spored conidiomata.

The ascomatal initials developed dark brown to black pigment over the one-cell thick, golden walls early in development. When spermatia were being produced in the spermogonia, the ascomatal initials were approximately spherical but with an apex consisting of a thick hyphal extension ca 50 μm tall by 60 μm wide. Leaves with spermogonia and ascomatal initials were stored under moist conditions in the refrigerator and by February, two species of *Mycosphaerella* were found.

Several species of *Mycosphaerella* have been reported on *Populus* species in America. These include *M. populifolia* (Cooke) House, *M. populnea* (Saccardo) House, *M. populicola* Thompson, *M. populorum* Thompson, *M. populi* (Auerswald) Schroeter, and *M. punctiformis* (Persoon:Fries) Starbäck. Thompson (15) reported the type of *M. populifolia* bore asci in locules in stromata, but did not re-name it. *M. populnea* has ascospores which measure 11-12 x 2 μm, and probably a *Septoria* anamorph (10). *M. populicola* with ascospores measuring 22-32 x 6-6.5 μm, *M. populorum* with ascospores of 16-28 x 4.5-6 μm, and *M. populi*, whose ascospores are 38-45 x 4-5 μm, all have species of *Septoria* as anamorphs (15). *M. punctiformis* has ascospores that are 7-14 x 2-4 μm and a *Ramularia* anamorph. Additionally, *M. orbicularis* (Peck) House, a synonym of *M. macularis* (Fr.) Müller & von Arx, has a *Pollacia* anamorph and belongs in *Venturia* (9). *Clypeispora* is a *Mycosphaerella* anamorph different from any yet described, and the ascospores of the new species are much longer than those of the other *Mycosphaerella* species on poplars.

Mycosphaerella angustifoliorum n. sp., Fig. 2

Ascomata plerumque hypophylla, aggregata, immersa, globosa, ostiolata, brunnescentia vel quasi atra, 125-200 *μm lata x* 150-210 *μm elata cum papilla; ostiolum circulare, centrale, late papillatum, papilla ca* 60 *μm lata x usque ad*

50 μm elata; paries ex cellulis pseudoparenchymatis bi- quadristratis, stratum extremum ex cellulis grandioribus, crassiori-parietibus, parietibus atricoloratis, strati interiores ex cellulis gradatim tenuioribus-parietibus, pallidioribus-coloratis formatis. Asci fasciculati, bitunicati, late cylindrati, breves stipitati, 70-115 *x* 15-25 *μm, relative longiores et angustiores statim ante liberationem ascosporarum, octospori, usque ad ca* 30 *ascomate. Ascosporae conglomeratae in asco, ante liberationem sporarum longistrorsus secedentes, fusiformes, rectae vel curvatae vel sigmoideae, uniseptatae, vix in septo constrictae; cellulae circa aequales magnitudine vel cellula supera aliquantum grandior, hyalinae, laeves,* (45-)51-69(-82) *x* 5-6.5, $\bar{x}$=60.2 *x* 5.8 *μm.*

Ascomata (Fig. 2, A) mostly hypophyllous, aggregated, immersed, globose, ostiolate, dark brown to nearly black, 125-200 μm wide x 150-210 μm tall including papilla; ostiole circular, central, broadly papillate, papilla ca 60 μm wide x up to 50 μm tall; wall composed of 2-4 layers of pseudoparenchymatous cells, the outermost layer of larger, thicker-walled cells with dark-pigmented walls, the inner layers of progressively thinner-walled, lighter-colored cells. Asci (Fig. 2, B) fasciculate, bitunicate, broadly cylindric, short stipitate, 70-115 x 15-25 μm, relatively longer and narrower just befores ascospore release, 8 spored, up to ca 30 per ascoma. Ascospores conglomerate in the ascus (Fig. 2, A,B), separating longitudinally prior to escape of the spores, fusiform, straight to curved or sigmoid, one-septate, scarcely constricted at the septum, cells about equal in size or the upper somewhat larger, hyaline, smooth, (45-)51-69(-82) x 5-6.5, $\bar{x}$=60.2 x 5.8 μm (Fig. 2, C).

Holotypus: Ex foliis emortuis Populus angustifolia James, *inter* 9th Street Bridge *et* Highway 160 West, Roosa Avenue, Durango, La Plata County, Colorado, U.S.A., October 17, 1988, A. W. Ramaley. BPI# 1102629.

Although mature asci and ascospores were commonly observed, maturation and penetration of the ascomatal neck for ascospore release was not seen.

The coelomycete genus *Asteromella* accommodates the spermogonial or microconidial state for many species of *Mycosphaerella* (9, 11). Conidiophores of *Asteromella* recently have been described (11) as branched only at the base, and 1-3 septate. However, in early work on life cycles with a *Mycosphaerella* teleomorph, spermatium formation was found to begin on much-branched hyphae (3, 4, 5) at the center (2, 3, 4) or top (16) of spermogonia and to proceed outward or downward. In *Mycosphaerella angustifoliorum*, spermatia are first formed on approximately central apical and intercalary cells of branched hyphae of the mycelial mass forming the conidioma (Fig. 3, A) and spermatiogenesis is centrifugal. The walls of *Asteromella* species per se, or as *Mycosphaerella* spermogonia, are two to several cell layers thick. However, the conidiomatal walls of *M. angustifoliorum* spermogonia are mostly one cell layer thick, though they may be thicker near the host epidermis. Despite the difference in wall thickness, the spermogonial state will be described as a new species of *Asteromella* since the fungal teleomorph is *Mycosphaerella*.

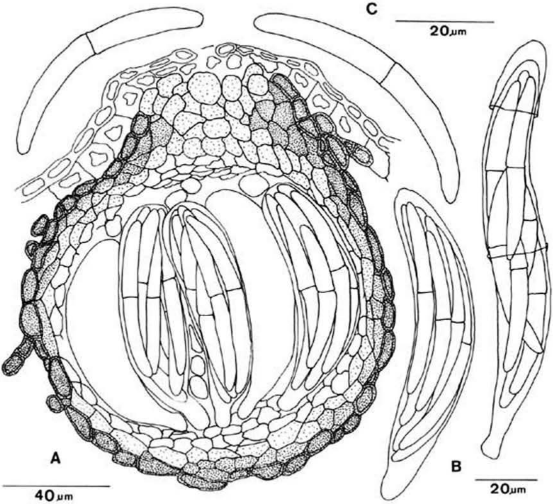

Fig. 2. *Mycosphaerella angustifoliorum*: (A) ascoma, (B) asci, (C) ascospores.

Asteromella angustifoliorum n. sp., Fig. 3

Conidiomata pycnidica, aggregata, immersa, quasi globosa, atra in summo hospite, alibi aurea vel atra, ostiolata, ca 120 *µm diam, tenuiparietes; paries ex cellulis unistratis crassiparietibus aureis vel atris formatus, interdum crassior in epidermide hospitis; ostiolum circulare, centrale, papillatum, papilla plerumque obliterata tempore liberationis conidiorum. Conidiophora parietem conidiomatis omnino obducentia, multicellularia, ad basem et supra ramosa,* *interdum cellulas parietis unistrati conidiomatis includentia. Cellulae conidiogenae determinatae, integratae vel discretae, hyalinae, laeves, per formationem conidii consumptae; conidiogenesis centrifuga. Conidia in terminalibus vel lateralibus parvis projecturis sub septis genita, aseptata, hyalina, laevia, cyindrica vel anguste elliptica vel ossiformia, 4-6 x 1-2 μm.*

Conidiomata pycnidial (Fig. 3, A), aggregated, immersed, approximately spherical, black at host surface, gold to black elsewhere, ostiolate, ca 120 μm diam, thin-walled; wall made up mostly of 1 layer of thick-walled golden to black cells, sometimes thicker at the host epidermis; ostiole circular, central, papillate, the papilla often obliterated as the conidia escape. Conidiophores lining the entire conidiomatal cavity, multicellular (Fig. 3, B), branched at the base and above, sometimes including cells of the one-layered conidiomatal wall. Conidiogenous cells determinate, integrated or discrete, hyaline, smooth, used up in conidium formation, conidiogenesis centrifugal. Conidia born on small terminal or lateral protrusions just below the septa, (Fig. 3, C) aseptate, hyaline, smooth, cylindrical to elongate-ellipsoid to dumbbell-shaped, 4-6 x 1-2 μm.

Holotypus: Ex foliis emortuis Populus angustifolia James, *inter* 9th Street Bridge *et* Highway 160 West, Roosa Drive, Durango, La Plata County, Colorado, U.S.A., October 17, 1987, A. W. Ramaley. BPI# 1102630.

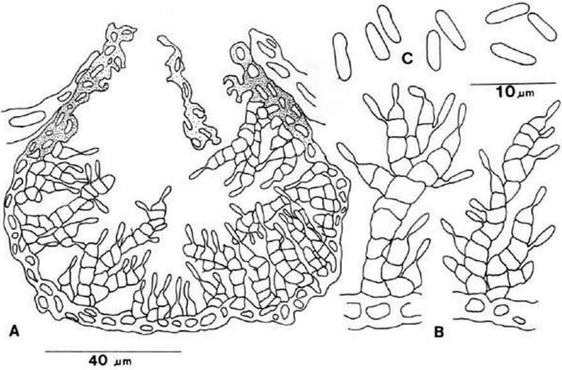

Fig. 3. *Asteromella angustifoliorum*: (A) conidioma, (B) branched conidiophores, (C) conidia.

When the ostiole is formed by degeneration of the central cells of the papilla, one or more cell layers remain at the papillar sides and top. Escape of the microconidia (spermatia) may break these layers and fragments can sometimes be seen at the opening of the conidioma (Fig. 3, A).

The Connection of Clypeispora to Mycosphaerella angustifoliorum

Clypeispora conidia were suspended in a drop of sterile tap water and spread on the surface of commercial potato dextrose agar (PDA) in a petri plate. Single spore isolates were made by removing germlings to another plate of PDA. Cultures were also prepared from both *Mycosphaerella* species commonly found on *Clypeispora*-diseased leaves that had been stored in the refrigerator from October to February. Single ascospore cultures were not prepared because ascospores from the larger-spored *Mycosphaerella* species were fragile. Therefore, entire asci from both species were removed from ascomata, rinsed three times in sterile tap water, and aseptically placed on the surface of PDA in a petri plate. Asci from one of the *Mycosphaerella* species gave rise to a rapidly-growing *Cladosporium* anamorph. Asci from the other *Mycosphaerella* species produced colonies indistinguishable from colonies from *Clypeispora* conidia thereby confirming the connection between *Mycosphaerella angustifoliorum* and *Clypeispora angustifoliorum*.

The first cultures from conidia or asci form pink, smooth, raised, cerebriform colonies that usually darken with age. There is little growth into the agar. The margins of the raised colonies expand laterally via narrow, loose, much-branched, white mycelium. Subsequent cultures from the original isolations are variable. Grown under the same conditions and observed at the same age, the colonies might be: a) pink, raised, cerebriform, and scarcely darkened; covered or not with an investiture of short, branched white, aerial hyphae, or; b) gray to black, raised, mostly covered with a sparse investiture of short, branched, aerial, white hyphae with beads of moisture on the darkened, compact, non-aerial mycelium, often with smooth, pink lobes growing out of the darkened areas. Colonies expand slowly reaching only 10-24 ($\bar{x}=15$) mm diam on PDA in 28 days at room temperature (ca 16-18 C).

Neither conidiomata nor ascomata are formed in the cultures at room temperature or when stored in the refrigerator. As colonies age, the laterally expanding mycelium contains numerous spherical masses of compact mycelium. These mycelial masses also are usually developed on the pink or variously darkened raised portion of the colonies. In fact, most darkening of a colony is associated with the gray-black, or golden brown spherical hyphal masses which act as the sites of most microconidium (spermatium) formation. There are no walls delimiting the spheres from the surrounding sterile mycelium. Cells that produce the microconidia are shorter than those of the vegetative mycelium, and the reproductive hyphae, measuring (1.5-)2-3(-4) μm wide, are more highly branched. Microconidium formation appears to take place as it does in natural conidiomata. Cells resembling macroconidia in size and shape are occasionally seen, but they lack appendages and a basal frill sometimes can be distinguished. In macroconidia from nature, no basal frill can be observed.

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MYCOBIOTA OF BARK ASSOCIATED WITH SEVEN STRAINS OF CRYPHONECTRIA PARASITICA ON TWO HARDWOOD TREE SPECIES

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ABSTRACT

A total of 1,779 fungal isolates were obtained from 1,680 bark plug samples of dead red oak (Quercus rubra L.) and 2,066 were isolated from 1,848 bark plug samples of stressed or dying American chestnut trees (Castanea dentata (Marsh.) Bork.). Almost a third of each of these two groups of fungi were reisolations of six hypovirulent and one virulent strain of Cryphonectria parasitica (Murr.) Barr. (Endothia parasitica (Murr.) And. & And.). The majority of the other fungi identified were members of the Fungi Imperfecti. The most common genera were Coniothyrium, Melanconium, Pestalotia, Sphaeropsis and Trichoderma. Species of Coryneum and Fusicoccum were frequently isolated from the American chestnut stems, but rarely from the red oaks. Bark samples from nine uninoculated oak and chestnuts had fungal populations similar to the inoculated trees. This suggests most fungi that were isolated are common bark inhabiting organisms, and the treatments had minor impact.

Keywords: Endothia parasitica, chestnut blight, hypovirulence

INTRODUCTION

The surface (corky tissue) of living tree bark contains a wide variety of organisms such as bryophytes, yeasts, bacteria and lichens. Fungi have been found, however, to constitute a major portion of the microflora (Bier, 1963 a,b). Butin and Kowalski (1986) identified the mycobiota from five tree species, including an Acer sp., with Ascomycetes and Deuteromycetes (Fungi Imperfecti) being the most commonly found. Cotter and Blanchard (1982) observed that nearly 66% of the fungi isolated from bark of healthy American beech (Fagus grandifolia Ehrh.) were Fungi Imperfecti. Other workers have identified and cataloged the mycobiota of forest trees (Roll-Hanson & Roll-Hanson, 1979; Cox and Hall,

1978) growing on the outer bark surfaces of trees. Three genera of fungi previously observed on American chestnut bark that can be confused with *Cryphonectria parasitica* (Murr.) Barr. are *Calocera*, *Cytospora*, and *Cytosporina* (Metcalf and Collins, 1909). Other fungi identified from American chestnut stems are *Gloeosporium*, *Hypoxylon*, *Melanconium*, *Phoma*, *Cytospora*, *Cytosporina*, and *Phomopsis* (Farr *et al*., 1989), but their association with cankers caused by *Cr*. *parasitica* is unknown. *Ceratocystis microspora* (Davids.) Davidson was also found associated with cankers caused by *Cr*. *parasitica* on American chestnut (Davidson and Kuhlman, 1978). Russin and Shain (1984) reported that *Ce*. *microspora* and *Cryphonectria eucastaneae* Davidson naturally colonized cankers.

Cryphonectria parasitica has been reported to grow on the inner and outer bark of other hardwood tree species (Stipes 1958). The organism can form cankers on suppressed, diseased, or dead red oak (*Quercus rubra* L.) (Clinton, 1913; Rankin, 1914, Shear *et al*., 1917). Many members of the Fungi Imperfecti were isolated from the bark of red oak trees including species of *Cephalosporium*, *Dothiorella*, *Fusarium*, *Gliocladium*, *Graphium*, *Penicillium*, *Trichoderma*, and *Trichothecium* (Shigo, 1958). Also, the Ascomycetes *Ceratocystis* and *Hypoxylon* were cultured from these samples.

Antagonism by bark fungi *in situ* may be an important factor in the survival, growth, and pathogenesis of tree pathogens. Stipes (1958) studied the suppression of *Ceratocytis fagacearum* (Bretz.) Hunt. by other fungi. He isolated 38 genera from red oak trees including *Cephalosporium*, *Hypoxylon*, *Dothiorella*, *Penicillium*, *Gliocladium*, *Sphaeropsis*, and *Spicaria*. He found that *Ce*. *fagacearum* seldom colonized trunk sapwood or formed mycelial mats and pressure pads when *Hypoxylon* was present. Furthermore, Shigo (1958), observed that species of *Gliocladium*, *Trichoderma*, *Penicillium*, and *Hypoxylon* were antagonistic to *Ce*. *fagacearum* in culture, hindering growth and sporulation. Similarly, Weidlich (1978) observed that microorganisms contained in soil compresses, applied to cankers of *Cr*. *parasitica*, were antagonistic to the fungus and stopped canker growth. Some suspected antagonistic fungi were isolated and tested for antagonism against *Cr*. *parasitica in vitro*. In all tests, a culture of *Trichoderma* inhibited the growth of *Cr*. *parasitica*.

Previous research suggests the need to study the interactions of the fungal microflora of bark and their effects on protection of trees to forest pathogens such as *Cr*. *parasitica*. These studies were designed to investigate interactions of fungi in association with seven strains (six hypovirulent) of *Cr*. *parasitica* on stressed or dying red oak and American chestnut.

MATERIALS AND METHODS

Study Area

Field plots were established near Bartow, West Virginia, in a cut-over area containing abundant American chestnut and red oak coppice. All trees were 10 cm or greater in diameter at 1.3 m above the ground and between eight and ten years old.

Strains Tested

The strains of *Cr. parasitica* used in this study included virulent strain 5-9-1B (ATCC #64671) that is pigmented brown in pure culture and was originally obtained from an American chestnut canker near Sugar Grove, West Virginia. The hypovirulent strains Ep 43 (ATCC #38767) (French-Derived American), JR-4 (ATCC #38769), It 54-2, Ep 88 (ATCC #38757), and Ep 209 were obtained from the culture collection at the Connecticut Agriculture Experiment Station. Hypovirulent strain Euro 11, was isolated in 1978 from a *Castanea sativa* Mill. tree growing north of Florence, Italy, by personnel from the Plant Pathology Department, West Virginia University.

Fungal Culture Medium

A glucose-yeast extract medium was employed for slurry inoculum production for field inoculum and laboratory culturing. The ingredients included glucose 10 g, yeast-extract 2 g, KH_2PO_4 1 g, $MgSO_4$ 0.5 g, biotin 1 ml (5 µg/liter), thiamine 1 ml (100 µg/liter), agar 15 g for laboratory work and 4 g for field usage, and distilled H_2O 1000 ml. Microelement solutions were $FeSO_4 \cdot 7H_2O$ 0.2 mg, $ZnSO_4 \cdot 7H_2O$ 0.2 mg, and $MnSO_4 \cdot H2_2O$ 0.1 mg with 1 ml of each per liter. Streptomycin sulfate 8 mg and chlortetracycline 50 mg, were added per liter only when fungi from bark samples were to be cultured. To produce the field inoculum, 50 ml of the medium were dispensed in 250 ml Erlenmeyer flasks and four flasks were inoculated with each strain. After one week incubation in darkness at 25 C, the contents of the four flasks per strain were pooled and blended with 500 ml of sterile distilled water and 500 ml of solidified water agar (1000 ml H_2O and 20g of agar) to form a slurry.

Stem Inoculation Procedures

In July, 1979, the American chestnuts were inoculated with the seven strains of *Cr. parasitica* 45 days prior to the stem girdling procedure to ensure fungal establishment. The red oaks were inoculated with the strains in September, 1979, 45 days after axe-girdling because *Cr. parasitica* was believed to establish more easily on declining red oak trees than healthy ones (Clinton, 1913; Rankin, 1914). Twelve American chestnut and 12 red oak trees were inoculated with each strain, and controls were nine American chestnut and red oak trees. The scratch-wounding was accomplished by employing a scratching tool constructed from a piece of wood containing three screws with thin points exposed. The slurry mixtures (100 ml of inoculum) were applied to 16 cm^2 scratch-wounded areas on the bark of both species between 90 and 150 cm above the ground. A water agar slurry was applied to the scratch-wounded areas on nine American chestnut and red oak control trees.

Girdling of Trees

To simulate stressed and dying of both tree species, artificially girlding was attempted. In August, 1979, 84 red oak trees were killed by axe-girdling them at 30 cm above the ground. A total of 93 American chestnuts were inoculated (see below) with virulent strain 5-9-1B in scratch wounded areas, 30 cm above the ground and 4 cm wide, around the circumference of the stems. It was assumed that this would stress, and eventually kill, the trees. Strain 5-9-1B is highly virulent and was expected to quickly cause phloem tissue necrosis and death of the trees. After six months, the American chestnut trees were still alive and they were then axe-girdled on the main stems to expedite bark sampling for mycofloral assays. All trees remained standing throughout the study even after girdling.

Fungal Isolation

Two sampling dates were used for each tree species; the red oaks at three (November, 1979) and five (January, 1980) months and the American chestnuts at nine (May, 1980) and ten (June, 1980) months after inoculation. Bark samples were collected at set distances from the inoculation areas. The plugs were taken with a 5-mm-diam arch punch up to 5 mm deep that included both dead and living tissues. The sampling scheme included bark cores collected from the center of the 16 cm^2 inoculation area. Each of 4 samples were taken 1 and 3 cm respectively outside this area, and one each 5 cm above and below the inoculation locus. The plugs were placed in microtiter plates so that their original positions on the stem could be identified. All samples were returned to the laboratory, surface disinfected in 0.525% w/v aqueous sodium hypochlorite solution for 10 minutes, rinsed in sterile distilled water, and cultured on the glucose-yeast extract medium in 10 x 1.5 cm petri dishes at 25 C for five days in darkness, followed by 5 days at room temperature exposed to fluorescent and diffuse sunlight. To determine if the isolates of Cr. parasitica recovered from the stems were the same as the ones used for inocula, cultures of the original strains were compared morphologically with those from bark samples. Cryphonectria parasitica and the other genera of fungi that grew from the bark cores were identified and recorded as to their original and final positions on the trees.

A total of 924 bark plug samples (11 per tree) were taken from 84 American chestnut trees (12 trees per strain) on each of the two sampling dates. During the first sampling period for the red oak trees, 756 bark plugs (9 per tree) were removed and 924 plugs (11 per tree) for the second. An additional 45 bark samples (5 per tree) were taken on each date from the 9 control trees.

Statistical Analysis

A randomized complete design was used and the treatments were applied randomly to each tree species. The Likelihood Ratio Chi-square (SAS Institute Inc., 1985) analyses were conducted comparing isolation rates of the most commonly observed fungi within all treatments combined for both sampling dates.

RESULTS AND DISCUSSION

The American chestnut trees were not dying six months after inoculation with the virulent strain 5-9-1B. Therefore, the trees were girdled with an axe to insure data on saprophytic mycobiota. The American chestnuts were dying by the first sampling date (nine months after inoculation). Due to the unusual difficulty in killing the American chestnut trees, sampling dates did not correspond for both tree species. Vigor of individual trees per species varied and sampling was done while they were either stressed, dying or dead. As the trees began to die, it became impossible to visually observe canker size due to bark discoloration. Therefore, canker size and Cr. parasitica locations could not be determined except by culturing and identifying any Cr. parasitica isolates growing from the 5 mm bark disks.

Red Oak

Of the 1,680 red oak bark samples taken during the two sampling dates (Table 1), the majority of the fungi recovered were members of the Deuteromycetes. The Likelihood Ratio Chi-square showed that there were significant differences between the isolations of the fungi on the two sampling dates. The genera most commonly identified were Coniothryium, Melanconium, Pestalotia, and Trichoderma from 45, 53, 60, and 51% respectively, of the trees. On the second sampling date, there was generally an increase in the number of trees and bark samples containing these organisms. Other fungi recovered from the second sampling date, but missing from the first, were isolates of basidiomycetes. The number of basidiomycetes identified was small even eight months

TABLE 1. Population and frequency of fungi isolated from dead red oak stems three (November, 1989) and five (January) months after inoculation with seven strains of *Cryphonectria parasitica*.

	November		January	
Taxa	% trees[a] w/ fungus	% bark[b] samples w/ fungus	% trees[a] w/ fungus	% bark[b] samples w/ fungus
Pestalotia	60	12	61, 7	14, 9
Trichoderma	48, 4[c]	7, <1[d]	57, 2	12, <2
Melanconium	37, 2	7, <1	70, 4	18, <1
Coniothryium	27, 1	5, <1	64	15
Fusarium	28	4	31	5
Penicillium	16, 1	1	17	2, <1
Phomopsis	12	1	1	<1
Graphium	5	1	4	<1
Fusicoccum	5	1	5, 1	<1, <1
Hypoxylon	4	1	14	3
Cytospora	4	1	13	2
Rhizoctonia	4	1	4	<1
Mucor	5	<1	0	0
Rhizopus	5	<1	0	0
Epicoccum	5	<1	2	<1
Geotrichum	2	<1	0	0
Aspergillus	2	<1	0	0
Dothiorella	2	<1	0	0
Phoma	2	<1	0	0
Gonatobotryum	1	<1	0	0
Graphium	6	1	4	<1
Candida	1	<1	1	<1
Sphaeropsis	0	0	35	5
Cephalosporium	0	0	27	3
Basidiomycetes	0	0	8	1
Cladosporium	0	0	2	<1
Alternaria	0	0	2	<1
Bactrodesmium	0	0	1	<1
Unknowns	0	0	14	2
Cryphonectria parasitica	78	32	77	37

* X^2 = 218.578, DF = 28, $P < 0.001$

[a] Isolation from 83 trees.

[b] There were 11 bark samples taken from each tree.

[c] Isolations from nine control trees.

[d] Isolations from total control tree bark samples.

* Likelihood Ratio Chi-square.

after tree death possibly due to the medium employed which contained high sugar contents. The isolates identified from the central trees were similar to the most common ones found in the treated bark samples. The seven strains of Cr. parasitica were isolated more frequently, at a rate of 77%. This is more than any other fungal genus or species for both sampling dates. In January 1980, Cr. parasitica was recovered from a larger number of bark samples than during November 1979, indicating growth of the fungus outward from the inoculation loci, but the number of trees containing each fungal strain remained almost the same. Even though the total population of fungal microflora increased during the second sampling date, there was no apparent effect on the ability of Cr. parasitica to survive and grow.

American Chestnut

The American chestnut trees survived mechanical girdling during the study period, therefore, all data are based on severely stressed or dying trees. The Likelihood Ratio Chi-square showed that the isolation frequencies for the fungi were significantly different for both sampling dates. The fungi isolated from 1,848 American chestnut bark plugs during the May and June 1980, sampling dates are shown in Table 2. A total of 22 genera from the Fungi Imperfecti were recovered during the first sampling date. Of these, the most common were Coryneum and Sphaeropsis isolated from 88 and 58% of the trees, respectively, of the trees. Less frequently recovered genera were Fusicoccum (42%), Fusarium (37%), Melanconium (29%), Pestalotia (38%), and Trichoderma (23%). Other sparsely isolated fungi identified included basidiomycetes and ascomycetes (Table 2). Also, twenty-two genera from the Fungi Imperfecti were isolated on the second sampling date. The most common genera were Fusicoccum and Coryneum isolated from 89 and 82% of the trees, respectively. Within a month there was a change from Sphaeropsis being dominant during May to predominately Fusicoccum in June (Table 2). Coryneum was isolated from a similar number of trees, however, the number of bark samples containing this organism was greatly reduced. The difference in the numbers of Fusicoccum and Sphaeropsis isolations from the two sampling dates may indicate that the mycofloral populations were constantly changing. These population changes may be caused by environmental factors or the presence of parasitic or toxin-producing organisms. Less commonly isolated genera from the June sampling date were Fusicoccum (43%), Fusarium (37%), Melanconium (29%), and Pestalotia (38%). As in the first sampling date, a few isolates of ascomycetes and basidiomycetes were identified (Table 2). The results obtained from the nine control trees for both sampling dates indicated that a similar microflora existed for American chestnut stems whether or not there was an association with Cr.

TABLE 2. Population and frequency of fungi isolated from stressed or dying American chestnut stems nine (May) and ten (June) months after inoculation with seven strains of *Cryphonectria parasitica*.

	May		June	
Taxa	% trees[a] w/ fungus	% bark[b] samples w/ fungus	% trees[a] w/ fungus	% bark[b] samples w/ fungus
Coryneum	89	33	83	20
Shaeropsis	59	14	22	4
Fusicoccum	43, 2[c]	7, <1[d]	90, 1	20, 1
Fusarium	37, 4	6, <1	5, 4	<1, <1
Melanconium	29, 1	6, <2	30, 1	4, <1
Pestalotia	38, 5	5, <1	42	77
Trichoderma	23, 7	3, <1	34, 6	5, 2
Coniothyrium	22	3	28, 1	31, <1
Cephalosporiu	30	3	24, <1	3, <1
Cystospora	20	3	25	3
Candida	20	3	18	2
Gonatobotryum	17	2	13	1
Pencillium	16, 1	2, <1	27, 2	4, <1
Phoma	13	2	0	0
Alternaria	16	2	6	1
Epicoccum	13, 1	1, <1	30	4
Cladosporium	2	1	0	0
Graphium	10	1	7	6
Cytosporella	10	1	0	0
Aureobasidium	6	1	0	0
Gloesporium	7	1	11	2
Chaetomium	5	<1	20	2
Cytosporina	5	<1	0	0
Basidiomycetes	4	<1	2	3
Hypoxylon	2	<1	0	0
Dendrophoma	1	<1	0	0
Botrytis	1	<1	8	8
Chalara	1	<1	1	1
Chloridium	1	<1	0	0
Ceratocystis	1	<1	0	0
Belonium	1	<1	0	0
Unknowns	6	1	7	1
Verticillium	0	0	10	1
Mucor	0	0	1, 2	<1, 1
Bactrodesmium	0	0	1	<1
Cryphonectria parasitica	66	13	79	22

* $X^2 = 370.547$, DF = 35, $P < 0.01$

[a] Isolation from 83 trees.

[b] There were 11 bark samples taken from each tree.

[c] Isolations from nine control trees.

[d] Isolations from total control tree bark samples.

* Likelihood Ratio Chi-square

parasitica. The most common genera of fungi isolated from the control trees were similar as those isolated from stems inoculated with Cr. parasitica for both sampling dates, suggesting that the mycobiota are not influenced by their association with the pathogen on bark. Cryphonectria parasitica was recovered from 65 and 79% of the trees in May and June (Table 2). Only Coryneum was recovered more frequently than Cr. parasitica for the first sampling date. For June 1980, Cr. parasitica was reisolated from more bark samples than any other genus, but Fusicoccum was recovered from more trees.

Many of the genera isolated from the dead red oak and living American chestnut coppice during the study were previously reported by other researchers on the same tree species (Schaffer and Linden, 1932; Carter, 1941). Similar genera of fungi have also been recovered from other hardwood tree species (Kliejunas and Kuntz, 1974; Cotter and Blanchard, 1982). These findings indicate a consistency of common genera from the Fungi Imperfecti inhabiting bark of hardwood trees. Cotter and Blanchard (1982), suggested that a consistent flora of Fungi Imperfecti at the form-genus level might be found on the bark of temperate trees. The results from this study indicate further support for this hypothesis.

The control data indicate that there is a common flora present on red oak and American chestnut bark even in the presence of Cr. parasitica isolates. The pathogen, which grows more than just superficially on the bark, have very little trouble becoming established and colonizing new outer and inner bark tissue. Even though several of the associated mycobiota may be antagonistic to Cr. parasitica, the pathogens ability to grow in the inner bark down to the phloem enables extensive colonization where the other fungi cannot survive.

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SPECIES CONCEPTS OF PHYTOPHTHORA CRYPTOGEA AND P. DRECHSLERI

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ABSTRACT

The taxonomy of Phytophthora cryptogea Pethybridge et Lafferty, P. drechsleri Tucker and other related Phytophthora species is discussed. Phytophthora cryptogea is re-described to broaden its species concept to include the typical forms and most isolates intermediate between P. cryptogea and P. drechsleri whereas P. drechsleri is re-defined to accommodate only isolates that grow well at 35°C with P. cajani Amon et al., P. drechsleri var. cajani Pal et al., P. erythroseptica var. drechsleri Sarejanni, P. melonis Katsura and P. sinensis Yu et Zhuang treated as conspecific.

Considerable controversies exist in literature concerning the identification of a Phytophthora species as P. cryptogea Pethyb. et Laff. or P. drechsleri Tuck. As a result of detailed morphological and physiological comparison of 33 isolates of Phytophthora species available at the American Type Culture Collection (ATCC), Rockville, Maryland, previously identified by various workers as P. cryptogea or P. drechsleri, Ho and Jong (1986) found that most isolates could not be recognized as "typical" P. cryptogea or "typical" P. drechsleri. They concluded that "in view of the large number of intermediate forms, the most practical solution at this point is to merge P. drechsleri with P. cryptogea which has priority" but "prefer to refrain from a formal re-description of P. cryptogea until many isolates of other related species are studied to determine if any further regrouping might be necessary". Ho (1986) compared isolates from cucumber in Iran, Japan, Taiwan and the mainland of China, previously identified as P. drechsleri, P. melonis Katsura, and P. sinensis Yu et Zhuang and suggested that these three taxa were conspecific. The pathogen on pigeon pea was first named as *P. drechsleri* var. *cajani* Pal *et al*. (1970), treated as a new species, *P. cajani* Amin *et al*. (1978) and subsequently relegated to *P. drechsleri* as a forma species (Kannaiyan *et al*. 1980). Gerrettson-Cornell (1989) merged *P. drechsleri* with *P. cryptogea* but retained *P. cajani*, *P. melonis* and *P. sinensis* as distinct species. Earlier, Sarejanni (1936) re-named *P. drechsleri* as *P. erythroseptica* var. *drechsleri* and Bywater (1956) as well as Bywater and Hickman (1959) proposed the grouping of *P. cryptogea*, *P. drechsleri*, *P. erythroseptica* Pethyb., *P. himalayensis* Dast. and *P. richardiae* Buis. under *P. erythroseptica*.

We have completed the study of all *Phytophthora* species producing nonpapillate sporangia and amphigynous antheridia and are now in a better position to re-evaluate the taxonomic status of these controversial species. Undoubtedly, *P. himalayensis* is the same as *P. erythroseptica* sensu stricto (Waterhouse, 1963; Ho & Jong, 1989). *Phytophthora richardiae* has enough distinctive growth and sexual characteristics to be retained as a separate species. Both *P. erythroseptica* sensu stricto and *P. richardiae* are homothallic and can be readily distinguished from *P. cryptogea* and *P. drechsleri* which are heterothallic. Although some isolates of *P. drechsleri* are self-fertile, especially when freshly isolated, they nevertheless behave heterothallically. We propose to broaden the species concept of *P. cryptogea* to include the "typical" forms and most isolates that have characteristics intermediate between *P. cryptogea* and *P. drechsleri*. Only isolates that grow well at 35°C are assigned to *P. drechsleri* which is re-described to accommodate *P. cajani*, *P. drechsleri* var. *cajani*, *P. erythroseptica* var. *drechsleri*, *P. melonis* and *P. sinensis* which are considered as conspecific. Thus, of the 14 isolates of "*P. drechsleri*" studied by Ho and Jong (1986), ATCC 10923 is re-assigned to *P. erythroseptica* based on its homothallism, ATCC 15404, 26756, 28200, 34302, 46723, 58425 and 58597 are reclassified as *P. cryptogea* due to their inability to grow well at 35°C whereas ATCC 48637 "*P. cryptogea*" is treated as *P. drechsleri* on account of its good growth at 35°C.

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Mycelium with no distinct or slightly floral growth pattern on clarified V-8 juice agar medium, slightly fluffy to fairly fluffy; aerial mycelium often profuse on unfiltered yellow corn meal agar medium; main hyphae uniform to uneven 5-7 µm wide, commonly forming in water conspicuous network of small hyphal swellings (under 25 µm), spherical to irregular; sporangia rarely produced on agar but abundantly in water, nonpapillate, nondeciduous, internally proliferating, terminal on unbranched or often close sympodially branched sporangiophores (1-3 µm wide); first formed sporangia regularly obpyriform to ovoid, mostly with rounded base but later formed sporangia tend to be more elongated, asymmetrical or variable in shape; sporangia av. 52 x 30 µm (35-63 x 24-35 µm), L/B ratio 1.7 (1.4-2.3), apex flattening on mounting; sporangia collapse after zoospore release which often requires chilling; exit pore over 8 µm wide, pore/breadth ratio over 0.3; heterothallic though sex organs sometimes formed sparsely in aged culture; oogonia spherical to subspherical, smooth, av. 31 µm (28-37 µm) diam., wall becoming yellowish to brown; oospores plerotic, spherical, av. 27 µm (24-32 µm) diam., wall 2-4 µm thick; antheridia amphigynous, short cylindrical, 14 µm (12-17 µm) x 14 µm (13-17 µm), unicellular; no chlamydospores formed in culture.

Cardinal temperatures for growth: 0-5°C, 20-25°C, 30-35°C; growth rate on clarified V8 agar medium 5-10 mm per day at 20°C.

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= P. melonis Katsura, Trans. Mycol. Soc. Japan 17: 238, 1976.

= P. sinensis Yu et Zhuang, Mycotaxon 14: 183, 1982.

Mycelium with no distinct or slightly floral growth pattern on clarified V-8 juice agar medium, slightly fluffy to fairly fluffy; aerial mycelium usually not profuse on unfiltered yellow corn meal agar medium; main hyphae uniform to arbuscular 5-7 µm wide, sometimes forming in water network of small hyphal swellings (under 25 µm), spherical to irregular; sporangia occasionally produced on agar but more abundantly in water, nonpapillate, nondeciduous, internally proliferating; terminal on unbranched or sometimes lax sympodially branched sporangiosphores (1-3 µm wide); first formed sporangia often variable in shape, broadly obpyriform, ovoid, ellipsoidal or elongated with tapered base; sporangia av. 52 µm (40-71 μm) x 28 μm (22-34 μm), L/B ratio 1.9 (1.4 -2.5), apex flattening on mounting, sporangia release zoospores promptly and then collapse; exit pore over 8 μm wide, pore/breadth ratio over 0.3; heterothallic though some isolates self-fertile especially when freshly isolated; oogonia spherical to subspherical, smooth, av. 33 μm (28-38 μm) diam., wall becoming yellowish to brown; oospores plerotic to aplerotic, spherical, av. 28 (16-37 μm) diam., wall 2-4 μm thick; antheridia amphigynous variable in size but commonly short cylindrical, 15 μm (13-17 μm) x 15 (13-19 μm), unicellular or occasionally bicellular in longer antheridia; no chlamydospores found in culture though chlamydospore-like vesicles may be produced.

Cardinal temperatures for growth: 5-10°C, 25-30°C, 35-37°C; good and steady growth at 35°C (over 3 mm per day); growth rate on clarified V8 agar medium 4-9 mm per day at 20°C.

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NEW SPECIES OF RAMALINA (LICHENIZED ASCOMYCOTINA) FROM AUSTRALASIA AND MALAYSIA

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ABSTRACT: The species *Ramalina cannonii* Elix, Din & Samsudin from Australia and Malaysia, and *Ramalina stevensii* Elix from Norfolk Island are described as new.

Introduction

In her comprehensive revision of the lichen genus *Ramalina* in Australia, Stevens (1987) accepted a total of twenty eight taxa belonging to twenty species for the continent. However one unusual collection from Lake Eacham on the Atherton Tableland in north Queensland was noted as differing from the other Australian species but was not described as futher collections were not forthcoming. Subsequently this taxon was found to be quite common in the Cameron Highlands of Peninsula Malaysia. This species, together with an endemic *Ramalina* from Norfolk Island, are here described as new.

Throughout the present work, chemical constituents were identified by thin layer chromatography (Elix, Johnston & Parker 1987, 1988), high performance liquid chromatography (Lumbsch & Elix 1985) and by comparison with authentic samples.

Ramalina cannonii Elix, Din & Samsudin sp. nov. Figure 1

Species thallo ut in *Ramalina perpusilla* sed thallo latiore et ramis pseudocyphellatis quibus ramulos fragiles versus apices evoluant et acidum homosekikaicum, acidum 4'-*O*-methylnorhomosekikaicum, et acidum hyperhomosekikaicum continente differt. *Type*. Malaysia. Pahang. On branch of rata, Smoke House Hotel, Cameron Highlands, c. 1200 m, *Laily Bin Din 2088*, 13.viii.1990; UKMB-holotype; ANUC, CBG-isotypes.

Thallus fruticose, corticolous, caespitose, erect, grey-green, often with a paler lower surface, 4-6(-8) cm high, lacking soredia; branching subdichotomous to irregular, moderate to intricate and entangled, ± geniculate or often with fragile branchlets towards the apices; branches (0.2-)1.0-3.0 mm wide, variably inflated, from subterete to almost flat, sparingly perforate, the perforations small, ellipsoid, to 1.0 mm long, rarely

extending via cracks along the margin; medullary hyphae sparse and adhering to the inner cortex wall, either loosely or densely compacted in inflated lobes or thick and felted in compressed lobes; cortex matt or shiny, smooth to rugose, with white, raised, punctiform pseudocyphellae along the margins and lamina of the branches; holdfast delimited or diffuse. *Apothecia* sparse to common, subterminal on geniculate branches or terminal on main and short lateral branches, spurred, or in the axils of bifurcating branches; disc 2.0-4.0 mm diam., convex to plane, ± white pruinose; margin entire, well-defined, rarely indistinct; *spores* eight per ascus, colourless, 1-septate, ellipsoid, straight or rarely slightly curved, (12-)14-16 x 4-6(-7) µm.
Chemistry: Thallus K-, KC-, P-. Containing usnic acid, homosekikaic acid (major), sekikaic acid (submajor), 4'-*O*-methylnorhomosekikaic acid (minor), 4'-*O*-methylnorsekikaic acid (trace), 4-*O*-demethylsekikaic acid (± trace), hyperhomosekikaic acid (trace) and ramalinolic acid (trace).

This species is characterized by the intricately branched, irregularly inflated lobes and the medullary homosekikaic-sekikaic acid aggregate. In many respects this new species resembles the common Australian species, *R. perpusilla* Stirton, as both have partially inflated lobes and related chemistries. However, the thalli of *R. cannonii* are much larger with white, raised, punctiform pseudocyphellae along the branches. *R. perpusilla* in contrast has smaller thalli, usually lacks pseudocyphellae and contains medullary divaricatic acid, sekikaic acid (± trace), nordivaricatic acid (± trace) or sekikaic acid, 4-*O*-demethylsekikaic acid (± trace) and an unknown (± trace). *R. cannonii* is quite common on trees in the Cameron Highlands of Peninsula Malaysia but is very rare in Australia.

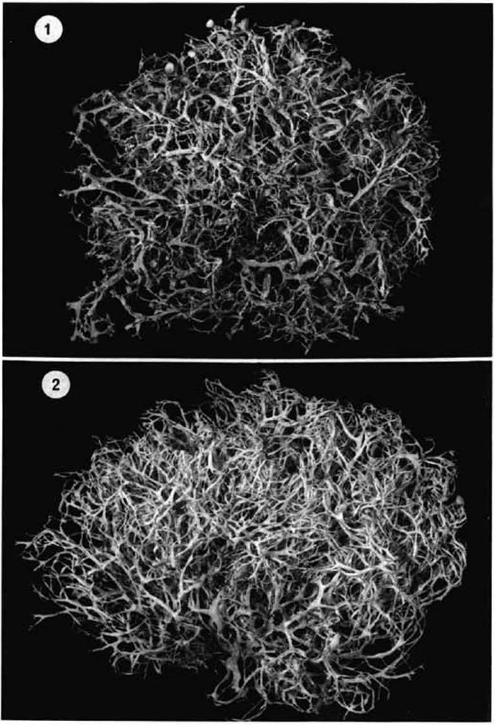
This species is named in honour of Associate Professor J. R. Cannon, Department of Organic Chemistry, University of Western Australia, Chairman of the Network for the Chemistry of Biologically Important Natural Products, who through tireless effort has promoted collaborative research between Australia and Southeast Asia.

Specimens Examined.
AUSTRALIA. Queensland. On tree bordering lake, Lake Eacham National Park, Atherton Tableland, *J. A. Elix 2627*, 27.viii.1976 (ANUC).
MALAYSIA. Pahang. On branches of tree, Cameron Highlands, c. 1200 m, *Laily Bin Din 4000*, iii.1990 (UKMB, ANUC).

Ramalina stevensii Elix sp. nov. Figure 2

Species thallo ut in *Ramalina glaucescens* sed thallo latiore et lobis angustioribus intricatis ramosis et acidum divaricaticum continente differt.
Type: Norfolk Island. On *Citrus limon* in subtropical rainforest, summit trail to Mt Bates, 29°00'30"S, 167°56'30"E, 300 m, *J. A. Elix 18582 & H. Streimann*, 6.xii.1984 (CBG-holotype; MEL-isotype).

Thallus fruticose, corticolous, caespitose, erect or subpendulous, pale grey-green to pale yellow, often with a paler lower surface, 2-8 cm high, lacking soredia; branching subdichotomous to irregular, moderate to dense, with fragile branchlets towards the apices; branches (0.2-)0.5-1.0(-3.0) mm wide, compressed, flat to subcanaliculate, with attenuate apices, rarely with rounded laminal perforations to 0.5 mm diam.; cortex shiny, smooth; holdfast delimited or diffuse. *Apothecia* sparse to common, subterminal on geniculate branches or terminal on main and short lateral branches, spurred, or in the axils of bifurcating branches; disc 1.0-2.5 mm diam., concave to plane; margin entire; *spores* eight per ascus, colourless, 1-septate, ellipsoid, straight or often slightly curved, 10-13(-15) x 4-5 µm.



Figures 1-2. Species of *Ramalina*. 1, *R. cannonii* (holotype in UKMB); 2, *R. stevensii* (holotype in CBG). Scale in mm.

Chemistry: Thallus K-, KC-, P-. Containing usnic acid, divaricatic acid (major), nordivaricatic acid (minor/trace), unknown terpenes (traces).

This species is characterized by compressed, narrow, intricately branched lobes and medullary divaricatic acid. In many respects, it resembles the common Australian species, *R. glaucescens* Krempelh., but these species differ morphologically and chemically. The thalli of *R. stevensii* are larger with narrower, elongate lobes which are more intricately entwined as a result of the denser branching of this species, and produce medullary divaricatic acid. *R. glaucescens* has smaller thalli with broader lobes that are only moderately branched; it contains sekikaic acid or lacks medullary acids. Chemically and in overall form, *R. stevensii* also resembles *R. subfraxinea* Nyl., but the latter is distinguished by the presence of frequent marginal tuberculate pseudocyphellae and laminal punctiform pseudocyphellae. *R. stevensii* appears to be endemic to Norfolk Island and is quite common on forest trees at higher elevations on the island.

This species is named in honour of Dr G. Nell Stevens, Department of Botany, University of Queensland, for her major contribution to the knowledge and understanding of the genus *Ramalina* in Australasia.

Specimens Examined.
NORFOLK ISLAND. On fallen twigs in mixed subtropical rainforest, Mt Pitt Reserve, near Broken Pine, 29°01'30"S, 167°56'20"E, 220 m, *J. A. Elix 18122 & H. Streimann*, 1.xii.1984 (ANUC); on canopy of fallen tree in mixed subtropical rainforest, Mt Pitt Reserve, Filmy Fern Trail, 29°01'20"S, 167°56'40"E, 130 m, *J. A. Elix 18415 & H. Streimann*, 3.xii.1984 (ANUC); on mossy trunk in open regrowth rainforest, Mt Pitt Reserve, just south of summit of Mt Pitt, 29°01'S, 167°56'E, 130 m, *J. A. Elix 18821 & H. Streimann*, 10.xii.1984 (ANUC); on *Citrus limon* in poor forest on ridge, Mt Pitt Reserve, track leading west from Mt Bates, 29°00'30"S, 167°56'45"E, 260 m, *H. Streimann 34301*, 6.xii.1984 (B, CBG); on treelet stem, Mt Pitt Reserve, King Fern Valley, 29°01'S, 167°56'20"E, 220 m, *H. Streimann 34571*, 7.xii.1984 (B, CBG, H); on tree trunk in remnant forest, Prince Phillip Drive, 29°01'S, 167°58'20"E, 100 m, *H. Streimann 36481*, 9.xii.1984 (B, CBG).

ACKNOWLEDGEMENTS

We thank the Australian Development Assistance Bureau for generous financial support through the Network for the Chemistry of Biologically Important Natural Products (to J.A.E.) and Mr H. Streimann (CBG) for his cooperation and assistance in making his collections available to us. We also wish to thank the staff of the Photographic Unit, ANU, for preparing the photographs, Mr D. Verdon for checking the Latin descriptions and Ms J. Johnston for comments concerning this manuscript.

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MYCOTAXON

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SOME NEW SPECIES AND NEW RECORDS OF DISCOMYCETES IN CHINA. IV[1]

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ABSTRACT A new species, *Sarcoscypha striatispora*, and five new records are reported.

NEW TAXON

1. **Sarcoscypha striatispora** W.-y. Zhuang, **sp. nov.** (Figs. 1, 2a)

Ab Sarcoscypha occidentali ascosporis minoribus et minut transversal iterque striatis atque ascis angistioribus differens.

Apothecia discoid, sessile to substipitate, disc reddish orange, receptacle pinkish at upper part and whitish at lower part, outside glabrous, 6-20 mm in diam. Ectal excipulum of textura porrecta, 40-56 µm thick, cells mostly 14-30 x 3.5-6.5 µm, walls hyaline. Medullary excipulum of textura intricata, 120-320 µm thick, hyphal walls hyaline. Subhymenium not distinguishable. Hymenium ca 180-190 µm thick. Asci suboperculate, 8-spored, J– in Melzer's reagent, subcylindrical, thick-walled, walls thickest a portion of attachment to the operculum, ca 160-170 x 11.7-13.0 µm. Ascospores uniseriate, ellipsoid, with blunt ends, slightly asymetrical, with one side flat, hyaline, with two large guttules, walls 1.1-1.3 µm thick, with minute, transverse striations on surface, 15.4-18.3 x 8.3-8.8 µm. Paraphyses subcylindrical, 2 µm wide.

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[1] Supported by the National Natural Science Foundation of China and the Anna E. Jenkins fund, Cornell University, USA.

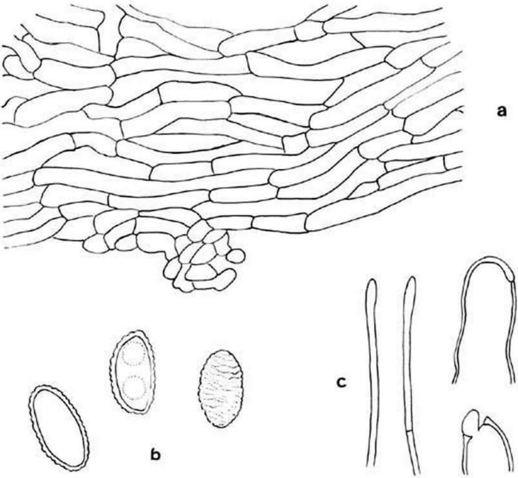

Fig. 1. *Sarcoscypha striatispora:* a, ectal excipular structure; b, ascospores in surface view and optical section; c, paraphysis apices and suboperculate ascus apices; from HMAS 58766, x1000.

Holotype: on wood, Maolan Preserve, Guizhou Province, Y. Li, J.-z. Ying, & Y.-c. Zong (659), 4. VIII. 1988, HMAS 58766.

Paratype: *ibid.* (705), 7. VIII. 1988, HMAS.

Notes: *Sarcoscypha striatispora* is distinguished from *S. occidentalis* (Schw.) Sacc. by smaller and minutely striate ascospores and narrower asci (Harrington, 1990). The latter species was described originally from North America (Schwenitz, 1832) and later reported from Gansu, Guangdong, and Jiangxi provinces of China (Tai, 1979). Careful examination of the Chinese specimens identified as *S. occidentalis* is necessary to be certain whether this species occurs both in North America and in Asia.

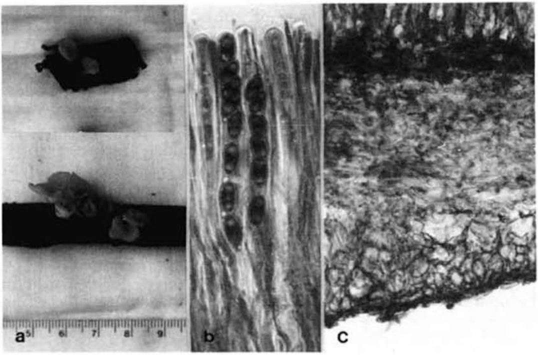

Fig. 2. *Sarcoscypha striatispora* and *Nanoscypha* sp. — *Sarcoscypha striatispora:* a, apothecia on wood, HMAS 58766; *Nanoscypha* sp.: b, asci, ascospores, and paraphyses, x350; c, excipular structure, x175; both from WYZ 550.

NEW RECORDS FOR CHINA

2. Lambertella fructicola Dumont, Mem. New York Bot. Gard. 22(1): 61, 1971.

Diagnostic features: Apothecia discoid, 2-3 mm in diam, margin hairy, disc buff, recetacle ivory, silky, striate, stipe hairy, concolous with receptale, 1 mm long and 0.75 mm in diam; ectal excipulum 100-115 µm thick, cells 16-40 x 11-15 µm, covering layer and inner layer present; subhymenium 25-40 µm thick; hymenium 150 µm thick; asci J+ in Melzer's reagent, with two blue lines and two basal dots darker, 120-135 x 9-11 µm; ascospores brown while still within the ascus, ellipsoid, with one side flat, walls banded, 12.0-14.2 x 6.0-6.8 µm. In culture, producing black line stromata and "apothecial fundaments," exuding brown pigments within medium.

Specimen examined: on petiole of poplar and an unidentified herbaceous stem, Heilongtan, Miyun County, Beijing, R. P. Korf & W.-y. Zhuang, 10. X. 1988, HMAS 58757.

Notes: The ascospores of the Chinese collection are strongly curved on the convex side and somewhat collapsed on the flat side when they are fully mature, which has also been observed in the isotype of *L. fructicola* (CUP 50025). According to Dumont (1971) spermatia produced abundantly in culture, but he saw no apothecial fundaments. The Chinese fungus produces only apothecial fundaments in culture and no spermatia, as was reported in *L. kumaonicus* Tewari & Singh (1972), a name later synonymized with *L. fructicola* by Dumont (1974).

3. Moellerodiscus lentus (Berk. & Br.) Dumont, Mycologia 68: 245, 1976.

Diagnostic features: Apothecia discoid, 0.3-1.0 mm in diam, disc reddish brown, receptacle paler than hymenium, stipe dark at base; ectal excipulum of textura globulosa, 23-36 µm thick, cells subhyaline, pale brown at margin, 5-10 µm in diam; medullary excipulum of loose textura intricata, hyphae subhyaline to pale brown; subhymenium 20-30 µm thick, hyphae light brown; hymenium ca 67 µm thick; asci J+ in Melzer's reagent; ascospores biseriate, ellipsoid with one end narrower, 7-8 x 2.0-2.2 µm.

Specimens examined: on freshy stromatized petals of *Pantadesma butyracea,* Xishuangbanna Botanical Garden, Yunnan Province, R. P. Korf, M. Zang, K.-k. Chen & W.-y. Zhuang, 21. X. 1988, HMAS 58764, 58765.

4. Nanoscypha sp. (Fig. 2b, c)

Diagnostic features: Apothecia discoid, 4 mm in diam, disc reddish orange when dry, apricot when rehydrated, receptacle whitish when dry, stipe 1 mm long; ectal excipulum of textura angularis, 80-90 µm thick, cells hyaline, thin-walled; medullary excipulum of textura intricata, 80-160 µm thick, hyphal walls hyaline; subhymenium ca 40 µm thick; hymenium ca 250 µm thick; asci suboperculate, thick-walled, 8-, 6-, or 4-spored, J– in Melzer's reagent, 14-16 µm wide; ascospores uniseriate, ellipsoid, with one side flat, surface striolate, biguttulate, 15-21 x 9.0-11.7 µm. Paraphyses filiform, septate, 2-3 µm wide.

Specimen examined: on ?petioles, 51 km mark, road Mongyang to Xishuangbanna Botanical Garden, Yunnan Province, R. P. Korf, M. Zang, K.-k. Chen & W.-y. Zhuang (550),

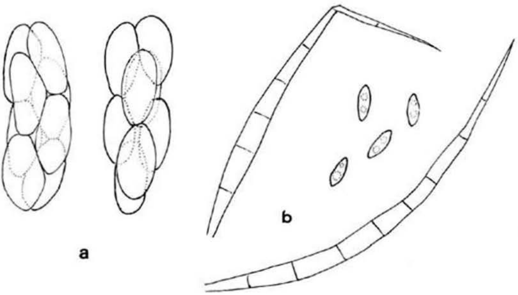

Fig. 3. *Saccobolus truncatus* and *Torrendiella* sp. — a, *Saccobolus truncatus:* ascospore arrangement in spore clusters, from HMAS 58754, x950; b, *Torrendiella* sp.: pointed hairs and subfusoid ascospores, from WYZ 243, x540.

23. X. 1988.

Notes: A single apothecium was found in a mixture collection. The anatomy of this fungus fits well the generic concept of *Nanoscypha* (Denison, 1972) except for the striate ascospores. It is similar to *N. tetraspora* in ascospore shape and size but different in spore number per ascus and the presence of striations on spore surface. It might be new in the genus but the material is too poor to be a type. I present here a brief description and await an ample collection.

5. Saccobolus truncatus Vel., Monogr. Discom. Boh. 1: 370, 1934. (Fig. 3a)

Diagnostic features: Apothecia pulvinate, 0.2-0.4 mm in diam, asci protruding from hymenium surface, hymenium dirty yellow, dull amber to dull golden-yellow when fresh, black when dry, receptacle golden yellow, ca 0.2 mm high; ectal excipulum of textura angularis, 18-34 µm thick, cells isodiametric to ellipsoid, 5.5-10.0 µm in diam; medullary excipulum of textura angularis, 15-17 µm thick, cell walls hyaline; hymenium 95-102 µm thick; asci 8-spored, with a more or less truncate apex, J+ in Melzer's reagent, 76-90 x 16.5-19.0 µm, spore clusters 36-44 x 14-16 µm;

ascospores subellipsoid, slightly asymmetrical, surface finely punctate, dark purplish brown, 14.0-18.0 x 6.2-8.3 μm; paraphyses slightly broader at apex, 2.5-3.5 μm wide.

Specimen examined: on mushroom bed in building, Institute of Microbiology, Academia Sinica, Beijing, H.-a. Wen & B. Li, 11. V. 1990, HMAS 58754.

6. Torrendiella sp. (Fig. 3b)

Diagnostic features: Apothecium discoid, ca 1 mm in diam, disc white, with fringes of dark, long hairs, stipe longer than disc diam, black at base; hairs arising from ectal excipular cells, distributed at flanks near margin, with a narrow base, wide middle portion, and tapering to a pointed apex, brown, slightly thick-walled, 6-9-septate, up to 165 μm long and 7-9 μm wide; ectal excipulum of textura prismatica, cells up to 35 x 21 μm long, walls subhyaline; ascospores subfusoid, sometimes with one end slightly narrower, biguttulate, occasionally with 3 guttules, 10.5-12.5 x 4.0-4.6 μm; paraphyses subcylindrical, ca 1.5 μm wide. In culture producing black line stromata.

Specimen examined: on leaf, 51 km mark, road from Mongyang to Xishuangbanna Botanical Garden, elev. 650 m, R. P. Korf, M. Zang, K.-k. Chen, & W.-y. Zhuang (243), 23. X. 1988.

Notes: This seems different from other species of the genus (Spooner, 1987), unfortunately only one apothecium was found. The fungus produced line stromata in culture (PDA) hardly distinguished from those produced by *Lambertella* species. This is the first record of *Torrendiella* in China.

PREVIOUSLY REPORTED SPECIES
FOR WHICH DIFFERENT NAMES ARE REQUIRED

Four previously reported species (Korf & Zhuang, 1985) need name changes according to updated taxonomic treatments.

7. Dicephalospora rufocornea (Berk. & Br.) Spooner, Bibl. Mycol. 116: 272, 1987.
= *Lanzia rufocornea* (Berk. & Br.) Dumont

Spooner (1987) established the genus *Dicephalospora* to accommodate the sclerotiniaceous fungi which have mucilaginous caps at the poles of ascospores. *Lanzia rufocornea* is one on them.

8. **Gelatinopsis geoglossi** (Ellis & Everh.) Rambold & Triebel, Notes Royal Bot. Gard. Edinb. 46: 377, 1990.
= *Micropyxis geoglossi* (Ellis & Everh.) Seeler

Rambold and Triebel (1990) found that *Micropyxis* Seeler, 1943 is a later homonym of *Micropyxis* Duby in DC., 1844. *Gelatinopsis* was coined to substitute for *Micropyxis* Seeler.

9. **Aleurina imaii** (Korf) Zhuang & Korf, Mycotaxon 26: 374, 1986.
≡ *Jafneadelphus ferrugineus* (Phill. in Cooke) Rifai subsp. *imaii* (Korf) Rifai

Jafneadelphus Rifai is proved to be a later synonym of *Aleurina* Massee (Zhuang & Korf, 1986). The correct generic name for the fungus is *Aleurina*.

10. **Scutellinia crinita** (Bull.) Lamb., Fl. Mycol. Belge, Suppl. 1: 301, 1887.
= *Scutellinia subcervorum* Svrcek

According to the recent monograph of the genus *Scutellinia* (Schumacher, 1990) *S. subcervorum* is a later synonym of *S. crinita*. But *S. crinita* seems not clearly distinguishrd from *S. scutellata* in his treatment.

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The author would like to thank all collectors of the specimens for this study, Dr. William Dress of Bailey Hortorium, Cornell University for providing Latin diagnosis, Dr. Jiri Moravec of Czechoslovakia for consultation, Mr. Kent Loeffler of the Plant Pathology Department, Cornell University for help with the photographs, and Prof. Richard Korf of the same department for making cultures, valuable suggestions, and serving as presubmission reviewer.

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MYCOTAXON

Volume XL, pp. 53-77 January-March 1991

STUDIES ON ECTOMYCORRHIZAE XXXIII[1]

DESCRIPTION OF THREE MYCORRHIZAE SYNTHESIZED ON *PICEA ABIES*

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Summary: Ectomycorrhizae of *Picea abies* with the fungal symbionts *Amphinema byssoides*, *Laccaria bicolor* and *Lactarius mitissimus* were grown nonsterile in culture. The morphological and anatomical structures of these ectomycorrhizae are presented. Characteristics of the synthesized ectomycorrhizae were generally identical with those of conspecific ectomycorrhizae isolated from the soil.

Zusammenfassung: Weiss, M. (1990): Studien an Ektomykorrhizen XXXIII. Beschreibung dreier synthetisierter Mykorrhizen an *Picea abies*. Ektomykorrhizen von *Picea abies* mit den Pilzpartnern *Amphinema byssoides*, *Laccaria bicolor* und *Lactarius mitissimus* wurden in Kultur gebildet. Die Mykorrhizen werden ausführlich charakterisiert. Die synthetisierten Mykorrhizen stimmen mit jenen des Freilands in den meisten der untersuchten Merkmale überein.

Key Words: Ectomycorrhiza, *Amphinema byssoides*, *Laccaria bicolor*, *Lactarius mitissimus*, *Picea abies*, characterization.

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[1]) Studies on Ectomycorrhizae XXXII: Agerer 1990.

Descriptions of ectomycorrhizae, as published in this series, mainly refer to naturally grown mycorrhizae. Synthesized mycorrhizae, as described here, provide an additional method for demonstrating the identity of naturally grown ectomycorrhizae and to examine their variability as well as dependence upon substrate conditions (Duddridge & Read 1984).

Material and Methods

Two-month-old spruce seedlings were used for the syntheses. The inoculum varied by fungus. (1) For *Amphinema byssoides* small pieces of young fruitbodies served as inoculum. (2) For *Laccaria bicolor*, mycelial inoculum was grown on sterile liquid MMN medium (Weiss 1988). *Laccaria bicolor* was isolated from the stipe of the fruitbody on MMN - agar. (3) For *Lactarius mitissimus* mycorrhizae from a natural spruce stand - identified by tracing hyphal connections to the fruitbody - were used as an inoculum. The syntheses were carried out in Petri dishes (Weiss 1990) with a peat - perlite (10:1, v/v) mixture or white-rotted wood (spruce) as substrate. To avoid damage by pests 0.04% Ambush (ICI) was used against Sciaridae and 0.3% Methasystox (BAYER) against mites.

Methods of preparation and investigation of the ectomycorrhizae and terms used in descriptions are summarized in the "Colour Atlas of Ectomycorrhizae" (Agerer 1987 - 1990). In contrast to specimens from natural stands, synthesized mycorrhizae could be investigated in their natural position. Therefore cystidia, emanating hyphae and rhizomorphs could be kept in place and connections to the substrate preserved. For anatomical studies ectomycorrhizae were treated with a glutardialdehyde/formaldehyde fixative and embedded in glycolmethacrylat. For further details see Weiss (1988).

AMPHINEMA BYSSOIDES

(Pers.: Fr.) J. Erikss.

Publications: Weiss & Agerer (1988) (sub nom. Piceirhiza horti-pallida), Weiss (1989).

Specimen studied: W. Germany, Bavaria, Staatliche Samenklenge und Pflanzgarten, 8229 Laufen/ Obb., beneath Picea abies, 24. 9. 87, leg. M. Weiss, in Herb. M. Weiss 138, fruitbody and mycorrhiza from natural stand (s. Weiss 1989) **(Fig. 1)** and from synthesis.

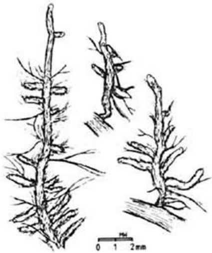


Fig. 1: *Amphinema byssoides.* Ectomycorrhizae (natural stand). (fig. from MW 138).

Morphological characters (Fig. 2)

Mycorrhizae not ramified, up to 2.5 mm long and 0.3 – 0.4 mm in diam; mycorrhizae straight, sometimes slightly bent; mycorrhizae woolly, yellowish white, in older parts the brown colour of cortical cells visible.

Emanating hyphae (Fig. 3, Fig. 5 a)

Intertwined hyphae 2 – 3.5 µm in diam, cells 40 – 90 µm long; walls up to 0.5 µm thick, spinulose, colourless to yellow; all septa with clamps; anastomoses simple or with clamps.

Rhizomorphs could not be observed in culture but are frequent in naturally grown specimens **(Fig. 1)**.

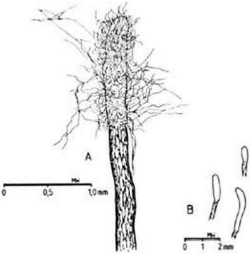


Fig. 2: *Amphinema byssoides* (synthesis). A: Habit of ectomycorrhiza. B: Habit of ectomycorrhizae (outline). (figs. from MW 138).

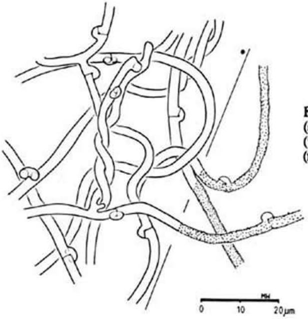


Fig. 3: *Amphinema byssoides* (synthesis). Emanating Hyphae (• walls depicted without warts). (fig. from MW 138).

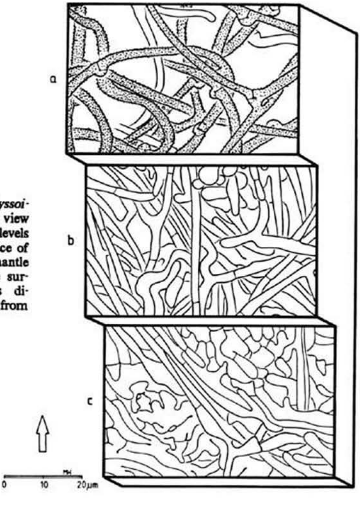


Fig. 4: *Amphinema byssoides* (synthesis). Surface view of mantle in 3 different levels of focus. a: Outer surface of mantle. b: Inner mantle layers. c: Inner mantle surface. (Arrow indicates direction of roottip). (fig. from MW 138).

Mantle

Surface of mantle (Fig. 4 a, Fig. 5 b). Hyphae intertwined loosely plectenchymatous (see emanating hyphae); no clear delimitation between surface of mantle and emanating hyphae.

Inner mantle layers (Fig. 4 b, Fig. 5 c). Densely plectenchymatous; hyphae more or less straight, sometimes irregular in diam; cell-walls smooth, thin; septa without clamps, some with structures resembling dolipores.

Inner mantle surface (Fig. 4 c, Fig. 5 d). Hyphae partially parallel, rather loosely to densely plectenchymatous, with palmetto-like structures; hyphae 1 – 4 µm in diam.

Longitudinal section (Fig. 5 e). Mantle (0)5 – 15(20) µm thick; loosely plectenchymatous, more densely so in inner layers; continuous transition to emanating hyphae.

Hartig net
(Fig. 5 e, f)

Hartig net penetrating to endodermis; diameter of hyphal cells around tannin cells 1 – 5 µm, around cortical cells 2 – 5 µm; lobes of palmettos 1 – 4 µm broad; cortical cells partly with vesicular, thin-walled haustoria up to 10 µm in diam (depicted in Weiss 1989).

Mycorrhiza from natural stand
(Fig. 1) (c.f. Weiss 1989)

Mycorrhizae from natural stand differed from cultivated mycorrhizae in larger dimensions, in partially denser and yellowish mantles and in having numerous yellow rhizomorphs. Emanating hyphae and hyphae of rhizomorphs possessed larger diameter (3 – 4 µm, and 3 – 5 µm in rhizomorphs) and sometimes had thicker walls (up to 1 µm).

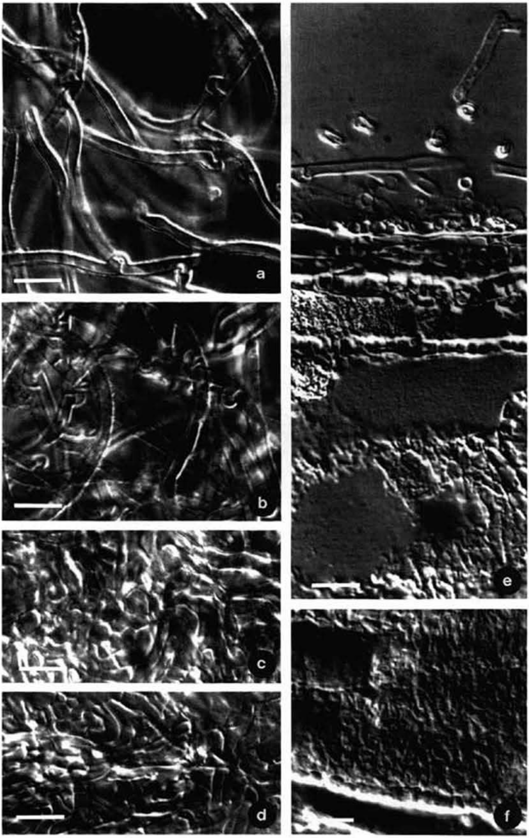
Similar mycorrhizae characterized in the literature

Thomas & Jackson (1979) found an ectomycorrhiza in a nursery designated as type B1 on *Picea sitchensis*. This mycorrhiza is similar to *Amphinema byssoides* on *Picea abies* as described above from a natural stand in all details given by those authors.

Fassi & Vecchi (1962) characterized the ectomycorrhizae of *Amphinema byssoides* on *Pinus strobus* in a nursery in Piedmont. The described characters correspond well to *Amphinema byssoides* from the nursery in Laufen. However, they described a two-layered Hartig net and a dichotomous ramification as is typical for pines.

Weiss & Agerer (1988) described similar ectomycorrhizae on spruce from a nursery in northern Germany as '*Piceirhiza horti-pallida*'. Most of the characters of '*P. horti-pallida*' are the same as shown for *Amphinema byssoides*. '*P. horti-pallida*' differed only in a slightly thinner mantle and somewhat thicker hyphae in the rhizomorphs (4 - 6 µm). The name '*Piceirhiza horti-pallida*' can now be replaced by the name *Amphinema byssoides*.

Fig. 5: *Amphinema byssoides* (synthesis). **a**: Emanating hyphae. **b**: Surface of mantle from emanating hyphae to tannin cells. **c**: Inner mantle layer. **d**: Inner mantle surface. **e**: Longitudinal section of ectomycorrhizae. **f**: Hartig net. Scale = 10 µm. (all figs. from MW 138).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LACCARIA BICOLOR

(R. Mre.) Orton

Specimen studied: W. Germany, Bavaria, Wolferstetter Forst near Freutsmoos, beneath spruce, 24. 10. 87, leg. F. Hettich, in Herb. M. Weiss 158 (fruitbody and synthesized mycorrhiza).

Morphological characters (Fig. 6)

Ramification of mycorrhizae monopodial-pyramidal, up to 6 mm long; unramified ends up to 1.5 mm long and 0.3 – 0.5 mm in diam, straight to sometimes slightly conical; diameter of axes 0.5 – 0.7 mm; surface smooth to finely stringy; young growing tips bluish-violet, older parts light-brown, later becoming brown; mycorrhizae sometimes surrounded by hyphal fans or rhizomorphs; rhizomorphs pale violet when young, whitish to light-grey when old.

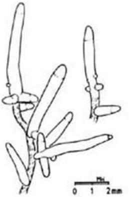


Fig. 6: *Laccaria bicolor* (synthesis). Ectomycorrhizae (outline). (fig. from MW 158).

Emanating hyphae (Fig. 7, Fig. 9 a)

Smooth, 2 – 3 (4) µm in diam; walls thin; septa mostly with clamps; anastomoses simple; emanating hyphae partly bundled to rhizomorphs; sporadically with hyphal coils (Fig. 9 a).

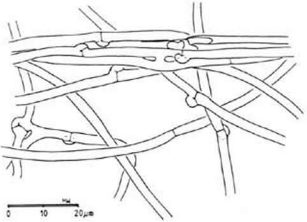


Fig. 7: *Laccaria bicolor* (synthesis). Emanating hyphae. (fig. from MW 158).

Mantle

Hyphae partially with dolipore-like structures; hyphae smooth and thin-walled.

Surface of mantle (Fig. 8 a, b, Fig. 9 a, b). Surface with veil of emanating hyphae; beneath this veil a densely plectenchymatous layer of frequently branched hyphae; hyphae 3 – 5 (8) µm in diam; hyphae partly in a net-like arrangement; sometimes with vesicular elements up to 16 µm in diam; septa simple, in outer layers sometimes with clamps.

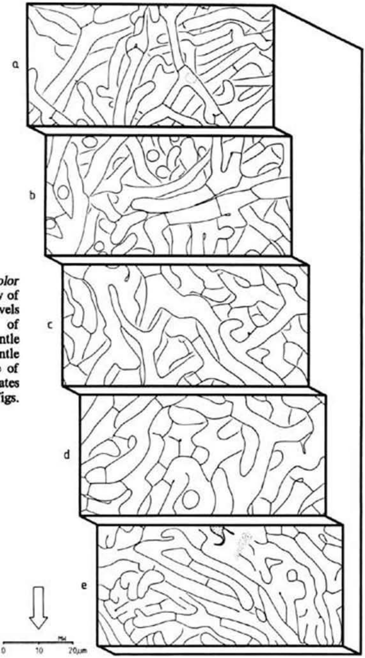
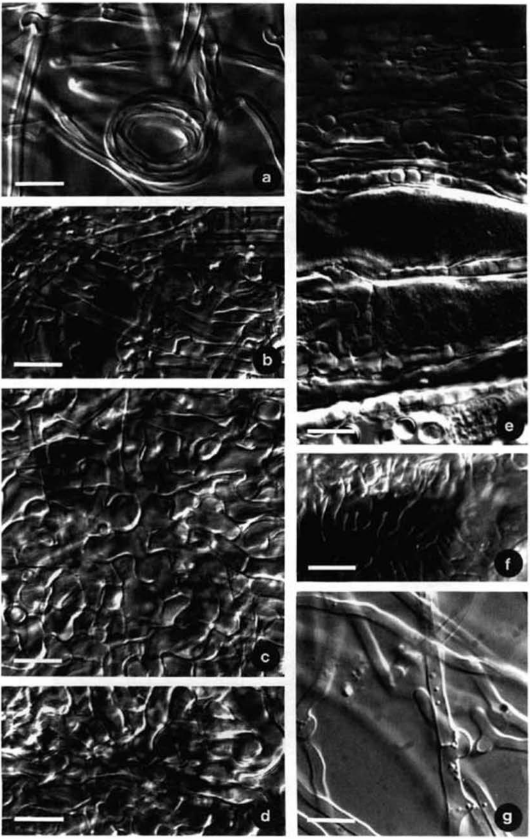


Fig. 8: *Laccaria bicolor* (synthesis). Surface view of mantle in 5 different levels of focus. **a**: Surface of mantle. **b**: Outer mantle layers. **c**, **d**: Inner mantle layers. **e**: Inner surface of mantle. (Arrow indicates direction of root tip). (figs. from MW 158).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Inner mantle layers (Fig. 8 c, d, Fig. 9 c). Densely plectenchymatous, sometimes almost pseudoparenchymatous; septa simple; hyphal cells irregular, partly inflated, straight or bent, partially in a net-like arrangement, 3 – 20 µm in diam; sometimes with pseudoparenchymatous structures (not depicted here).

Inner mantle surface (Fig. 8 e, Fig. 9 d). Hyphae partly growing parallelly, 2 – 6 µm in diam, partly a transition to palmetto-like structures; septa simple.

Longitudinal Section (Fig. 9 e). Mantle 25 – 40 µm thick, plectenchymatous, denser in inner layers; hyphae 2 – 7 (10) µm in diam.

Hartig net (Fig. 9 e, f)

Hartig net reaching endodermis; around tannin cells 1 – 3 layers of hyphal cells 2 – 7 µm in diam; around cortical cells one layer of hyphal cells 2 – 5 µm in diam; lobes of palmettos 1 – 6 µm wide.

Mycelium grown in liquid medium (Fig. 9 g, Fig. 10)

Cottony, colonies submerged, grey or pale violet; hyphae irregularly thick, straight or bent; 2 – 3(4) µm in diam, cells up to 250 µm long; septa with clamps.

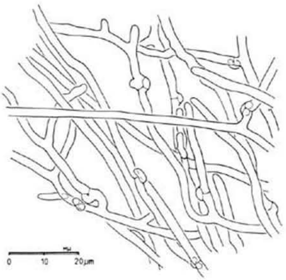


Fig. 10: *Laccaria bicolor.* Mycelium grown in liquid medium. (fig. from MW 158).

Fig. 9: *Laccaria bicolor* (synthesis). a: Emanating hyphae with hyphal coil (hyphal coils rarely found only with emanating hyphae). b: Mantle surface. c: Inner mantle layer. d: Inner surface of mantle. e: Longitudinal section of ectomycorrhiza. f: Hartig net in plan view. g: Mycelium grown in liquid medium. Scale = 10 µm. (all figs. from MW 158).

Similar mycorrhizae characterized in the literature

Godbout & Fortin (1985) described the synthesized mycorrhizae of *Laccaria bicolor* and *Populus tremuloides*. The few characteristics provided by the authors fit my description.

The mycorrhizae synthesized with *Laccaria bicolor* and the closely related *L. amethystina* are difficult to distinguish by morphological and anatomical characteristics. Pseudoparenchymatous structures in inner mantle layers, depicted for *Laccaria amethystina* (Weiss 1988), occur in both species, especially in older mycorrhizae. Investigations of branching patterns of hyphae within rhizomorphs revealed the same structures for both species (S. Raidel, pers. com.).

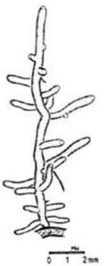
LACTARIUS MITISSIMUS

Fr..

Specimens studied: W. Germany, Bavaria, Landkreis Freising, Kranzberger Forst near Oberberghausen, beneath *Picea abies*, 14. 11. 1988, leg. M. Weiss, in Herb. M. Weiss 164 (fruitbody and mycorrhiza from natural stand, **Fig. 11** and from synthesis). W. Germany, Bavaria, Landkreis München, Forst Kasten, beneath *Picea abies*, 6. 11. 1989, leg. R. Treu, in Herb. M. Weiss 181 (fruitbody and mycorrhiza from natural stand).

Morphological characters (Fig. 12, 18)

Mycorrhizal system monopodial-pyramidal; up to 8 mm long; axes straight to somewhat bent or tortuous, 0.4 – 0.6 mm in diam; unramified ends up to 3 mm long and 0.35 – 0.5 mm in diam; surface of young tips short-spiny **(Fig. 18)**, older parts smooth or finely grainy; mycorrhizae orange-brown with light tips, the older parts darker; sheath sometimes lactating white when broken.



ig. 11: *Lactarius mitissimus* (natural stand). Habit of ectomycorrhiza. (fig. from MW 164).

Emanating hyphae (Fig. 13, Fig. 17 e)

Diameter 2 – 3 µm; walls thin, smooth, colourless or orange-brown; septa simple.

Rhizomorphs (Fig. 14, Fig. 20 c - f)

Rhizomorphs could not be observed in culture, but were frequent with naturally grown specimens.

Rhizomorphs orange-brown; mostly attached to or growing within or around roots, root hairs or soil debris; rhizomorphs up to 300 µm thick; outer part of rhizomorphs of abundantly connected and agglutinated hyphae 2 – 4 µm in diam with walls thin or up to 1.5 µm thick; inner part of rhizomorphs of hyphae with thin walls and up to 8 µm in diam; laticiferous hyphae sometimes in inner part of rhizomorphs; cell walls smooth, orange; septa simple.

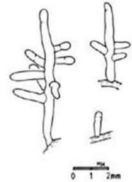


Fig. 12: *Lactarius mitissimus* (synthesis). Ectomycorrhizae (outline). (fig. from MW 164).

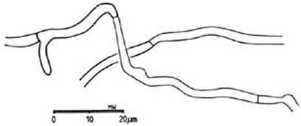


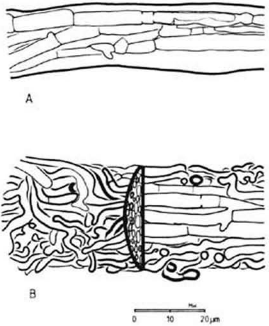
Fig. 13: *Lactarius mitissimus* (synthesis). Emanating hyphae. (fig. from MW 164).

Mantle

Septa simple; dolipore-like structures rarely visible.

Surface of mantle (Fig. 15 a, Fig. 17 a, Fig. 18 Ba, Fig. 19 a). Hyphae lying on surface with thin walls, arranged net-like to ramified star-like; in the apical, younger part of the mycorrhiza with short (6 – 30 µm), thin-walled cystidia, 2 – 5 µm in diam **(Fig. 17 f, Fig. 20 a)**; cystidia visible at a 20x magnification as short stiff hairs **(Fig. 18)**.

Beneath the net of thin-walled hyphae **(Fig. 15 b, b', Fig. 17 b, Fig. 18 Bb, Fig. 19 b, c, f)** a pseudoparenchymatous layer; cells at tip of mycorrhiza almost epidermoid with walls up to 0.5 µm thick **(Fig. 15 b', 19 f)**; in basal part of mycorrhiza cells gradually becoming irregularly shaped **(Fig. 15 b, Fig. 19 c)** to almost



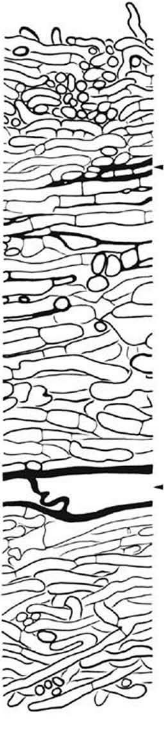


Fig. 14: *Lactarius mitissimus* (natural stand). **A:** Hyphae growing within roothair of dead herbaceous root. **B:** Young rhizomorph; surface view (left) and optical section (right). **C:** Older rhizomorph grown within dead herbaceous root (remnants of root indicated by arrows); longitudinal section. (all figs. from MW 181).

isodiametric **(Fig. 17 b, Fig. 18 Bb, Fig. 19 b)**, the walls up to 2 µm thick; cells 3 – 7 µm (tip) to 4 – 15 µm (basal part) in diam; within a square of 20 x 20 µm 18 (tip) to 13 (basal part) cells visible (partly visible cells included); walls yellowish-orange, thinner in inner layers; continuous transition from pseudoparenchymatous to the underlying plectenchymatous layer **(Fig. 15 c)**.

Inner mantle layers (Fig. 15 d, Fig. 17 c, Fig. 18 Bc, Fig. 19 d, e, g, h). Plectenchymatous layer of irregularly ramified hyphae, hyphae 3 – 5 µm in diam; walls thin, yellowish; laticiferous hyphae **(Fig. 16)** ramified, 5 – 10 µm in

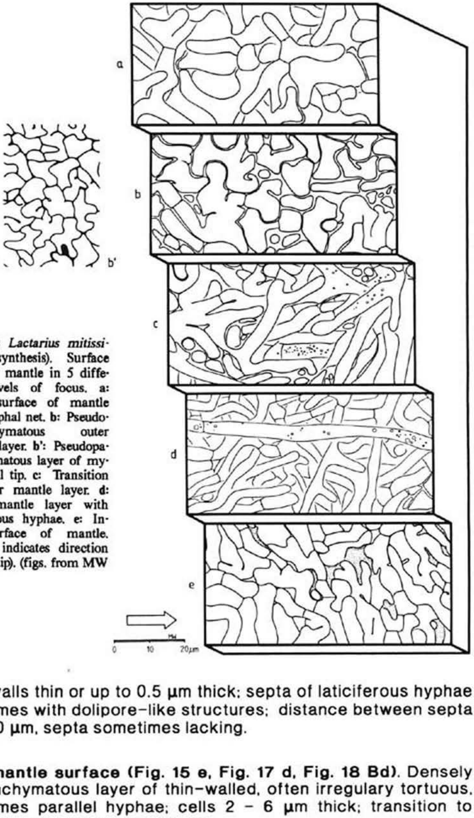


Fig. 15: *Lactarius mitissimus* (synthesis). Surface view of mantle in 5 different levels of focus. **a:** Outer surface of mantle with hyphal net. **b:** Pseudoparenchymatous outer mantle layer. **b':** Pseudoparenchymatous layer of mycorrhizal tip. **c:** Transition to inner mantle layer. **d:** Inner mantle layer with laticiferous hyphae. **e:** Inner surface of mantle. (Arrow indicates direction of root tip). (figs. from MW 164).

diam; walls thin or up to 0.5 µm thick; septa of laticiferous hyphae sometimes with dolipore-like structures; distance between septa 15 - 100 µm, septa sometimes lacking.

Inner mantle surface (Fig. 15 e, Fig. 17 d, Fig. 18 Bd). Densely plectenchymatous layer of thin-walled, often irregulary tortuous, sometimes parallel hyphae; cells 2 - 6 µm thick; transition to palmetto-like structures obvious.

Longitudinal section (Fig. 17 f, Fig. 18 Bs, Fig. 20 a). Mantle 30 - 50 µm thick; mainly in younger parts the surface with a net of thin-walled hyphae in 1 - 2 layers; short hyphae (cystidia) emanating from this hyphal net; cells 1 - 4 µm in diam; next portion of mantle of 3 - 5 layers of larger cells 3 - 9 (12) µm in radial diam, 4 - 15 (20) µm in longitudinal diam); walls up to 1 (- 2) µm thick, yellow-orange; inner part of mantle plectenchymatous, of 5 - 10 layers of hyphae, 1- 3 µm in diam; walls thin, colourless; laticiferous hyphae 8 - 4 µm in radial diam.

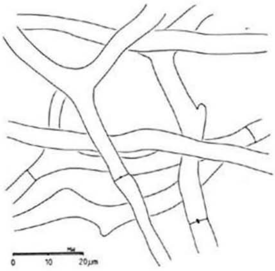


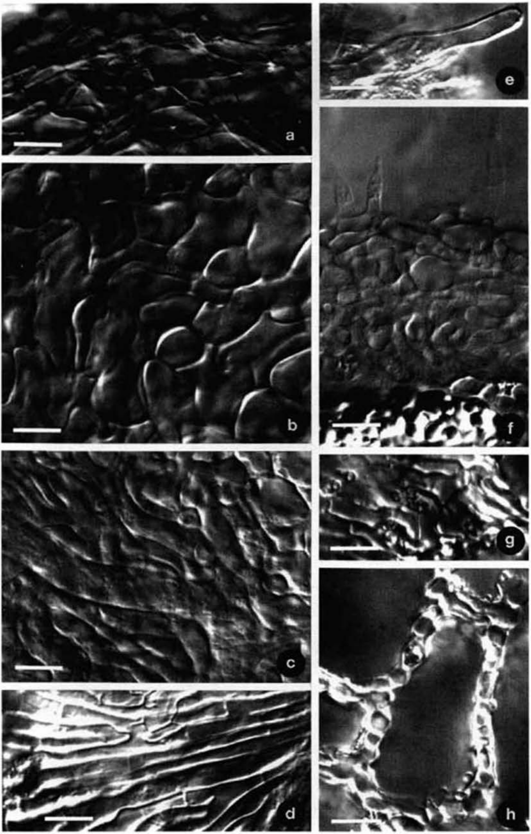
Fig. 16: *Lactarius mitissimus* (synthesis). Laticiferous hyphae (depicted without contents). (fig. from MW 164).

Hartig net (Fig. 17 g, h, 18 Bs, Fig. 20 b)

Hartig net reaching endodermis; around tannin cells with 1 - 3 layers of hyphae 2 - 7 µm in diam; around cortex cells one layer of hyphae 2 - 5 µm in diam; lobes of palmettos 1.5 - 5 µm wide; in older parts of mycorrhizae cortex cells partly with vesicular haustoria originating from the Hartig net, haustoria 1 - 7 µm in diam **(Fig. 17 h)**.

The mantle in basal parts of the mycorrhizae consisted of a dense plectenchyma but no pseudoparenchymatous layer and laticiferous hyphae **(Fig. 18 A)**.

Fig. 17: *Lactarius mitissimus* (synthesis). **a:** Outer surface of mantle with hyphal net. **b:** Pseudoparenchymatous outer layer of mantle. **c:** Inner layer of mantle with laticiferous hyphae. **d:** Inner surface of mantle. **e:** Emanating hyphae. **f:** Longitudinal section of ectomycorrhiza. **g, h:** Hartig net. Scale = 10 µm. (all figs. from MW 164).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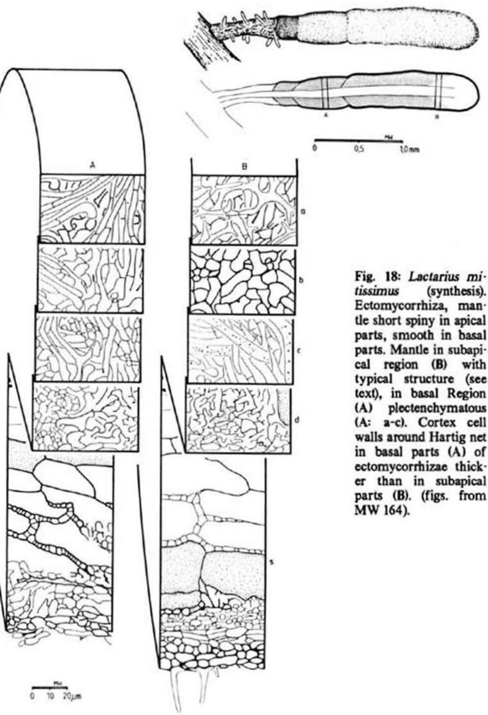
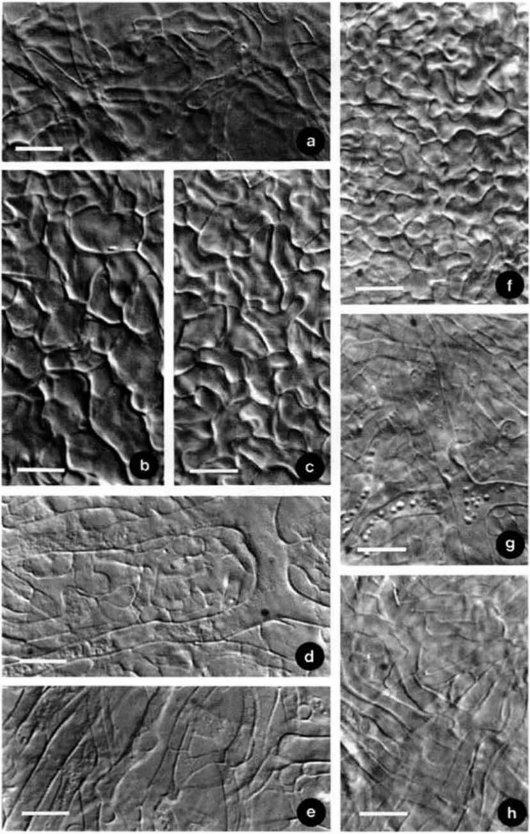


Fig. 18: *Lactarius mitissimus* (synthesis). Ectomycorrhiza, mantle short spiny in apical parts, smooth in basal parts. Mantle in subapical region (B) with typical structure (see text), in basal Region (A) plectenchymatous (A: a-c). Cortex cell walls around Hartig net in basal parts (A) of ectomycorrhizae thicker than in subapical parts (B). (figs. from MW 164).

Fig. 19: *Lactarius mitissimus* (natural stand). **a:** Outer surface of mantle with hyphal net. **b, c:** Pseudoparenchymatous outer layer of mantle (**b:** basal region; **c:** apical region). **d:** Inner layer of mantle with laticiferous hyphae. **e:** Inner surface of mantle (hyphae often more dense than depicted here, see figs. 15, 17). **f - h:** structure of mantle at mycorrhizal tip. **f:** Pseudoparenchymatous outer layer of mantle. **g:** Inner layer of mantle with laticiferous hyphae. **h:** Inner surface of mantle. Scale = 10 µm. (all figs. from MW 181).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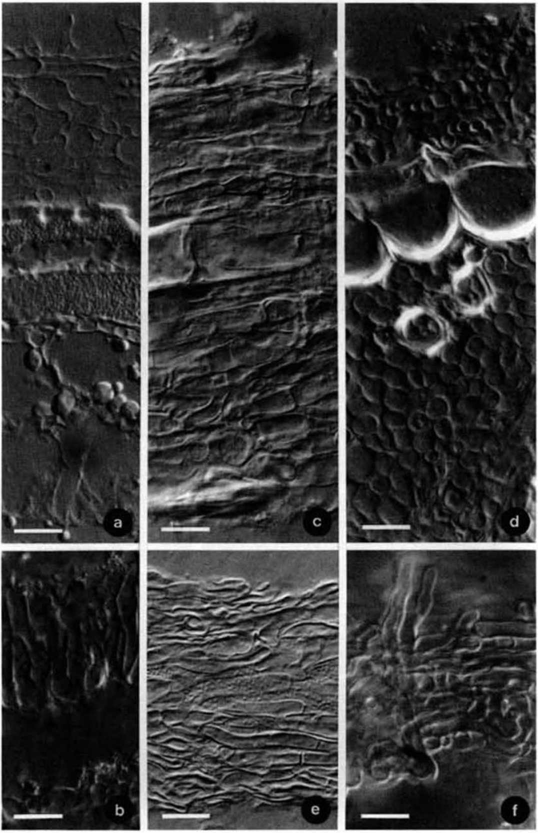
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Mycorrhizae from natural stand

(Fig. 11, 14, 19, 20)

Mycorrhizae of *Lactarius mitissimus*, collected in a natural forest of Norway spruce, resemble the mycorrhizae described from culture in most characters examined, but the synthesized mycorrhizal systems were smaller, had a smooth surface and formed no rhizomorphs.

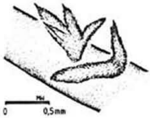

Fig. 21: *Lactarius mitissimus.* Hyphal bundles growing out of inoculum (mycorrhiza from forest site) after 10 days. (fig. from MW 164).

Synthesis of the mycorrhiza

Mycorrhizae from the natural stand (see above) were used for inoculation. Within 10 days white to slightly orange coloured hyphal bundles up to 0.2 mm thick **(Fig. 21)**, grew out of the inoculum. The first mycorrhizae were formed after 25 days, and within 40 days all inoculated plants were colonized.

Mycorrhizae of related species characterized in the literature

A comparative study of ectomycorrhizae of the genus *Lactarius* is given in Agerer et al. (1990). Descriptions of mycorrhizae of species within the section *Russulares* are given for *L. decipiens* and *L. theiogalus* (Gronbach 1988), *L. subdulcis* (Brand & Agerer 1986) and *L. rufus* (Alexander 1981).

The mycorrhizae of *Lactarius decipiens* and *L. theiogalus* on *Picea abies* from soil (Gronbach 1988) resemble the mycorrhizae of the closely related species *L. mitissimus* in most of the characters described above. The occurrence of septa in laticiferous hyphae, used by Gronbach (1988) to distinguish *L. decipiens* and *L. theiogalus*, is variable in *L. mitissimus*.

Fig. 20: *Lactarius mitissimus* (natural stand). **a:** Longitudinal section of ectomycorrhiza. **b:** Hartig net. **c, d:** Older rhizomorph within dead herbaceous root (**c:** longitudinal section, **d:** cross section). **e, f:** Young rhizomorph (**e:** longitudinal section, **f:** surface view.). Scale = 10 µm. (all figs. from MW 181).

Rhizomorphs did not occur in culture but were found on naturally grown specimens of *Lactarius mitissimus*. Similar rhizomorphs were described by Brand & Agerer (l.c.) for *L. subdulcis* and Gronbach (l.c.) for *L. decipiens* and *L. theiogalus* from natural stands. The rhizomorphs of these species resemble each other in most details, but their diameters ranged from 90 µm (*L. decipiens and L. theiogalus*) to 500 µm (*L. subdulcis*). In *L. mitissimus* the maximum diameter was 300 µm. Close connection of rhizomorphs to soil debris as described above was reported for *L. subdulcis* by Brand & Agerer (l.c.).

The hyphal bundles growing out of the mycorrhizae of *Lactarius mitissimus*, used as an inoculum, were likewise observed in *L. subdulcis* and *L. rubrocinctus* (F. Brand, pers. com.). Alexander (1981) mentions corresponding rhizomorphs as connecting inoculum and root surfaces in synthesis trials with *L. rufus*. Similar structures were observed in pure cultures of *Lactarius rufus* (Oort 1981) and *L. subdulcis* (F. Brand, pers. com.).

Alexander (1981) described mycorrhizae of *Lactarius rufus* from a natural stand and from synthesis. In contrast to *L. mitissimus* he found no rhizomorphs in natural stands. He neither mentioned laticiferous hyphae within the sheath nor 'milking' of the broken sheath as reported for *L. subdulcis* by Brand & Agerer (1986) and for *L. mitissimus*. Alexander depicted an epidermoid pattern of the pseudoparenchymatous outer layer of the mantle. In *L. subdulcis* (Brand & Agerer 1986), *L. decipiens* and *L. theiogalus* (Gronbach 1988) and *L. mitissimus* the outer pseudoparenchymatous layer of the mantle has an irregularly isodiametric pattern with an increasing cell diameter from the tip of the mycorrhiza to the basal parts. The spiny surface of the mantle due to the short hyphae observed in apical regions of young mycorrhizae of *L. mitissimus* grown in culture have not been observed in natural stands or reported in other species.

Discussion

The synthesized mycorrhizae and the mycorrhizae from natural stands of *Amphinema byssoides* and *Lactarius mitissimus* respectively, were the same in most characteristics examined. Mycorrhizae from natural stands were larger than those grown in culture. In addition *Amphinema byssoides* and *Lactarius mitissimus* formed rhizomorphs only in forest sites. Further the emanating hyphae of *Amphinema byssoides* had sometimes thinner walls and were thinner in synthesized specimens. Differences between mycorrhizae from natural stand and from synthesis experiments may be due to the younger age of mycorrhizae and to the unnatural soil conditions in culture.

The similarity between mycorrhizae from natural stands and mycorrhizae from culture reported for *Amphinema byssoides* and *Lactarius mitissimus*, respectively, in this paper agrees with the results of other authors. Kottke & Oberwinkler (1986) synthesized the mycorrhiza of *Amanita muscaria* on *Picea abies* and found a prevailing similarity with mycorrhizae from natural stands. Similar results were reported by Kottke (1986) for the mycorrhizae of *Suillus grevillei* on *Larix leptolepis* and *Amanita muscaria* on *Picea abies*. Differences such as a thicker fungal mantle in vitro than in vivo for *Amanita muscaria* may be due to the glucose-containing medium used in that experiment (c.f. Duddridge & Read 1984). Brand & Agerer (1986) synthesized mycorrhizae of *Laccaria amethystina* and *Lactarius subdulcis* on beech and reported that the mycorrhizae from natural stand were larger, which corresponds well to the present results. Agerer & Weiss (1989) compared naturally grown mycorrhizae of *Thelephora terrestris* on *Picea abies* with synthesized ones and found few differences; rhizomorphs formed in synthesis. The same is true of the mycorrhizae of *Dermocybe cinnamomea* and *Laccaria amethystina* formed on *Picea abies* (Weiss 1988). Therefore absence of rhizomorphs in synthesized mycorrhizae seems not to be typical and may depend upon substrate conditions or age of mycorrhizae. As mentioned above the mycorrhizae of *Amphinema byssoides* and *Lactarius mitissimus* did not form rhizomorphs in synthesis, contrary to the findings in natural stand. As rhizomorphs show numerous characteristics important for identification, conditions of cultivation need to be improved for these species. Rhizomorphs and emanating hyphae of mycorrhizae grown in culture can be observed in their natural position, contrary to specimens collected in natural stands.

In these investigations only few and minor differences could be found between mycorrhizae from culture and from natural stands.

That implies the possibility of identifying fungal symbionts of mycorrhizae from natural stands by comprehensive comparison with mycorrhizae synthesized with known symbionts (Agerer & Weiss 1989, Brand & Agerer 1986, Kottke 1986).

Acknowledgments

The author would like to express his gratitude to Prof. Dr. R. Agerer for his useful suggestions. Review of the final manuscript by Prof. Dr. James M. Trappe is also gratefully acknowledged.

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MYCOTAXON

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A PRELIMINARY DISCOMYCETE FLORA OF MACARONESIA: PART 16, OTIDEACEAE, SCUTELLINIOIDEAE[1]

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> "Orthodoxy is my doxy — heterodoxy is another man's doxy."
> William Warburton
> quoted by Joseph Priestly, MEMOIRS, Vol. 1

Order PEZIZALES
Suborder PEZIZINEAE
Family OTIDEACEAE Eckblad 1968
Subfamily SCUTELLINIOIDEAE Clements 1909 (ut 'Scutelliniae')

KEY TO THE KNOWN MACARONESIAN GENERA

1 Apothecia setose 2
1′ Apothecia glabrous or with only hyphoid hairs 7
2(1) Ascospores containing oil drops 3
2′(1) Ascospores devoid of oil drops 4
3(2′) Setae hyaline, base not rooting; bryophilous .... **Neottiella**
3′(2′) Setae brown, usually with a rooting base; not bryophilous. **Scutellinia**
4(2′) Ascospores with a dense cyanophilic reticulum; setae hyaline to yellow, basal, apically hooked, not rooting; on dung .... **Mycoarctium**
4′(2′) Ascospores smooth or variously marked; setae yellow to dark brown, marginal and on flanks, rooting or not rooting 5

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[1] The parts of this flora will appear in irregular order. Reprints of individual parts will not be available for distribution.

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5(4′) Ascospores smooth or roughened, perispore often loosening in heated lactic acid; setae yellow to dark brown, often rooting; on dung, soil, or decaying vegetation . . . . **Cheilymenia**

5′(4′) Ascospores smooth; setae hyaline; on dung 6

6(5′) Asci clearly operculate, usually 8-spored . . . . **Lasiobolus**

6′(5′) Asci rupturing irregularly, usually with 1500 or more ascospores in each of 1 to 3 asci per ascocarp . . . . . **Trichobolus**

7(1′) Ectal excipulum with brown-walled hyphoid hairs or at least brown marginal cells 8

7′(1′) Ectal excipulum smooth or at most with hyaline to yellowish hyphoid hairs 9

8(7) Ascospores smooth, fusoid-elliptic, biguttulate; pyrophilous. **Anthracobia**

8′(7) Ascospores densely spinose, ovoid or spherical, multiguttulate; on soil, not firesites . . . . **Ramsbottomia**

9(7′) Ascospores without guttules, smooth or with cyanophilic markings, perispore often loosening in heated lactic acid; yellowish hyphoid to pointed hairs often present; on dung or decaying vegetation. **Cheilymenia** (including **Coprobia**)

9′(7′) Ascospores guttulate 10

10(9′) Apothecia large (>1 cm diam) . . . . **Aleuria**

10′(9′) Apothecia smaller, rarely exceeding 5 mm diam 11

11(10′) Bryophilous; ascospores smooth or ornamented 12

11′(10′) Not bryophilous, on soil or burn sites; ascospores smooth 13

12(11) Ascospores ovoid, smooth or marked . . . . **Octospora**

12′(11) Ascospores globose, with cyanophilic markings. **Lamprospora**

13(11′) Paraphyses gracile, usually hooked; ascospores globose or more rarely ovoid . . . . **Pulvinula**

13′(11′) Paraphyses stouter, not hooked; ascospores ellipsoid-fusoid. **Byssonectria**

ALEURIA Fuckel 1870

One known Macaronesian species

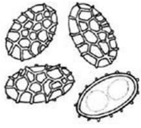
1. **Aleuria aurantia** (Pers. : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 325. 1870.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978); Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
†Wildpret et al. (1969), *Beltrán & Wildpret (1975), †Beltrán (1980).

TYPE LOCALITY:
Göttingen, Germany.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
La Palma. CUP-MM *2519 (TFC).
Tenerife. † CUP-MM 2 (TFC, OSC), 213 (TFC) 1207, *2508 (TFC), *2515 (TFC).



A. aurantia, ascospores, CUP-MM 2, x1000

SUBSTRATUM:
On soil.

NOTES: Probably commoner than our collections indicate, this species occurs usually on disturbed sites and roadfills.

ANTHRACOBIA Boudier 1885

Key to the known Macaronesian species

1 Hairs medium to dark brown, long and slender, not collapsing. **2. A. melaloma**

1´ Hairs light to medium brown, short cylindrical, often collapsing . . . 2

2(1´) Hairs 10–16 µm wide . . . . **3. A. nitida**

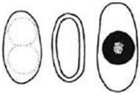
2´(1´) Hairs less than 10 µm wide . . . . **1. A. macrocystis**

1. **Anthracobia macrocystis** (Cooke) Boudier, Hist. classific. discomyc. Europe, p. 65. 1907.

RECENT TAXONOMIC TREATMENTS:
Larsen (1975), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
*Korf & Gruff (1981); **Dybhavn (1990)
[as *Geopyxis carbonaria*].

TYPE LOCALITY:
Shrewsbury, England.



A. macrocystis, 2 left ascospores, CUP-MM 107, right spore, CUP-MM 1569, x1000.

KNOWN MACARONESIAN DISTRIBUTION
MADEIRA.
Madeira. CUP-MM 1569 (TFC,OSC), **2780 (O).

CANARY ISLANDS.

La Palma. CUP-MM 781, 800 (TFC, OSC), 912.
Tenerife. CUP-MM 107, *301 (TFC, OSC, Disc. Exs. #76), 302.

SUBSTRATA:

On fire site, on burn site under *Chaemacyparis* sp., on a burnt *Eucalyptus* sp. clear-cut, on soil.

Notes: By error, presumably a sight identification based on ecology, the recent collection from Madeira (MM 2780) was reported as *Geopyxis carbonaria* (Alb. & Schw. : Fr.) Sacc.

2. **Anthracobia melaloma** (Alb. & Schw. : Fr.) Arnauld, Bull. Soc. Mycol. France 9: 112. 1893.

RECENT TAXONOMIC TREATMENTS:

Larsen (1975), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:

†Bañares et al. (1986), ††Rodríguez et al (1988), †††Bañares (1988), ††††Dennis (1990).

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS. ††††

Gran Canaria. † †††
Tenerife. ††

SUBSTRATUM:

Pyrophilous.

Notes: We have seen neither cited specimen (TFC 1786, TFC 2235) forming the bases for three of the reports from the Canary Islands, and thus cannot confirm the identifications. Dennis (1990) cites no specimens, literature, or particular island. This widespread species would be expected to occur in Macaronesia.

3. **Anthracobia nitida** Boudier, Hist. classific. discomyc. Europe, p. 65. 1907.

RECENT TAXONOMIC TREATMENT:

Larsen (1975).

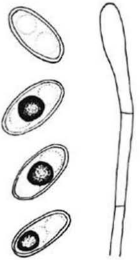
PREVIOUS MACARONESIAN RECORDS:

None.

TYPE LOCALITY:
Montmorency, France.

KNOWN MACARONESIAN DISTRIBUTION
MADEIRA.
Madeira. CUP-MM 1513 (TFC, OSC), 1539 (OSC).
CANARY ISLANDS.
La Palma. CUP-MM 1155 (O).
Tenerife. CUP-MM 1151 (O).

SUBSTRATA:
On burnt wood and burn site, on fire site, on burnt ground.



A. nitida, 3 top ascospores, CUP-MM 1151; lowest ascospore, paraphysis apex, CUP-MM 1539; all x1000.

Notes: Moser (1963) synonymized this species with *A. macrocystis*, but we disagree.

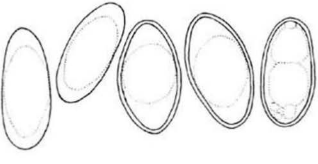
BYSSONECTRIA Karsten 1881

= *Inermisia* Rifai 1968.

One known Macaronesian species

1. **Byssonectria fusispora** (Berk.) Rogerson & Korf in Korf, Phytologia **21**: 202. 1971.

≡ *Inermisia fusispora* (Berk.) Rifai, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect., **57**(3): 198. 1968.
=? *Byssonectria aggregata* (Berk. & Br.) Rogerson & Korf in Korf, Phytologia **24**: 203. 1971 (later homonym of *B. aggregata* Bres.).



B. fusispora, ascospores, left 2 CUP-MM 1029, next 2 CUP-MM 1158, right spore CUP-MM 1476; all x1000.

RECENT TAXONOMIC TREATMENTS:
Rifai (1968), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Van Diemmen's Land, Tasmania, Australia.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. CUP-MM 2674.
Gran Canaria. CUP-MM 1029.
Hierro. CUP-MM 1476 (TFC, OSC).
La Palma. CUP-MM 1158 (O).
Tenerife. CUP-MM 1138 (O), 1140 (O).

SUBSTRATA:
On soil, on soil among liverworts, on burnt ground.

Notes: One collection from Tenerife (CUP-MM 1140), on a burn site, has scattered, somewhat immersed apothecia larger than we have ever seen, up to 7.2 mm diam, but otherwise in all respects is similar to typical *B. fusispora*, which often has gregarious apothecia usually not exceeding 2 mm diam, rarely 3 mm diam. We choose not to erect an infraspecific taxon for this collection. Whether "*B. aggregata*" can be retained as distinct is still problematical; perhaps it is long overdue for species limits in this genus to be reinvestigated.

CHEILYMENIA Boudier 1885

= *Coprobia* Boudier 1885

Key to the known Macaronesian species and varieties

1 At least some hairs rooting at the base 2
1′ Hairs absent or not rooting at the base 7
  2(1) Hairs reddish-brown, thick-walled 3
  2′(1) Hairs subhyaline, yellow, or light brown 5
3(2) Hairs stellately branched .... **4. C. stercorea**
3′(2) Hairs unbranched 4
  4(3′) Hairs 150–510 µm long, up to 25 µm wide; ascospores mostly 22.0–22.7 x 12–13 µm .... **2. C. fimicola**
  4′(3′) Hairs 220–770 µm long, up to 37 µm wide; ascospores mostly 14.6–16.8 x 8.0–9.5 µm .... **1. C. coprinaria**

5(2´) Hairs with a single rootlet, without a basal swollen cell. **8. Cheilymenia sp. 2557**

5´(2´) Hairs with 2 or more rootlets, with a basal swollen cell 6

  6(5´) Ascospores mostly 16–22 x 10.2–13.9 µm. **6. C. theleboloides** var. **theleboloides**

  6´(5´) Ascospores mostly 12–13 x 7–8 µm. **7. C. theleboloides** var. **microspora**

7(1´) Hairs light brown, with a narrow or pointed apex; spores smooth . . 8

7´(1´) Hairs hyphoid or not obvious, or absent; spores smooth or striate . . 9

  8(7) Ascospores 11.3–13.9 x 8.0–8.8 µm. **9. Cheilymenia sp. 2573**

  8´(7) Ascospores 16.1–19.8 x 10.2–11.0 µm. **10. Cheilymenia sp. 2771**

9(7´) Ascospores more or less smooth-walled, minutely longitudinally striate, 13.9–15.6 x 7.3–8.8 µm .... **3. C. granulata**

9´(7´) Ascospores obviously longitudinally striate, 11.7–13.2 x 6.6–7.3 µm. **5. C. striata**

1. **Cheilymenia coprinaria** (Cooke) Boudier, Hist. classific. discomyc. Europe, p. 63. 1907.

RECENT TAXONOMIC TREATMENT:
Moravec (1990).

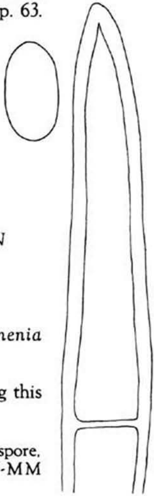
PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Rannoch, Scotland.

KNOWN MACARONESIAN DISTRIBUTION
AZORES.
Terceira. CUP-MM 2002.

SUBSTRATUM:
On cow dung, associated with *Cheilymenia (Coprobia) granulata.*

Notes: We follow Moravec (1990) in recognizing this species as distinct from *C. fimicola.*



C. coprinaria, ascospore, hair apex, CUP-MM 2002, x1000.

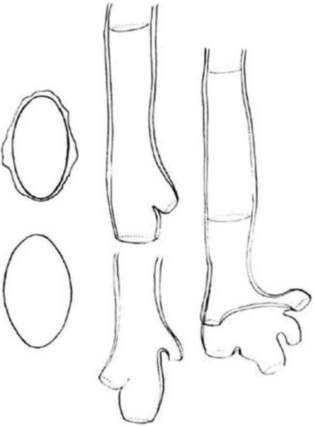
2. **Cheilymenia fimicola** (De Not. & Bagl.) Dennis, British Ascom., ed. 2, p. 45. 1978.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984), Moravec (1990).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Riva, Italy.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS:
Hierro. CUP-MM 2537 (TFC, OSC, also to be issued in Korf & Gruff, Discomycetes Exsiccati).



C. fimicola, ascospores x1000, hair bases x 500, CUP-MM 2537.

SUBSTRATUM:
On cow dung, associated with C. *granulata*.

Notes: According to Moravec (1990), the shorter hairs should distinguish this from C. *coprinaria*, which Dennis (1978) placed in synonymy.

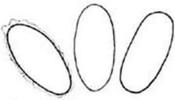
3. **Cheilymenia granulata** (Bull. : Fr.) Moravec, Mycotaxon **38:** 474. 1990.

≡ *Coprobia granulata* (Bull. : Fr.) Boudier, Hist. classific. discomyc. Europe, p. 69. 1907.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984), Moravec (1990).

PREVIOUS MACARONESIAN RECORD:
*Dennis et al. (1977).

TYPE LOCALITY:
France.



C. granulata, ascospores, CUP-MM 1452, x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Terceira. CUP-MM *1680.
CANARY ISLANDS.
Hierro. CUP-MM 1452 (TFC, OSC, to be issued in Korf & Gruff, Discomycetes Exsiccati).

SUBSTRATUM:
On cow dung.

Notes: We follow Moravec (1990) in placing *Coprobia* in synonymy with *Cheilymenia*.

4. Cheilymenia stercorea (Pers. : Fr.) Boudier, Hist. classific. discomyc. Europe, p. 63. 1907.

= *Cheilymenia ciliata* (Bull.) Maas G., Proc. Koninkl. Nederl. Akad. Wetenschappen, Ser. C, **72**: 313. 1969.

RECENT TAXONOMIC TREATMENTS:
Maas Geesteranus (1969), Moravec (1990).

PREVIOUS MACARONESIAN RECORD:
†Torrend (1912) [Madeira].

TYPE LOCALITY:
Sweden [neotypification by Moravec (1990)].

KNOWN MACARONESIAN DISTRIBUTION

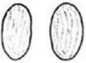
MADEIRA.
Madeira. †

SUBSTRATUM:
On cow dung.

Notes: Torrend's material from Madeira has not been located. The presence of this species in Macaronesia is thus doubtful, but its presence would not be unexpected.

5. **Cheilymenia striata** (Thind, Cash, & Singh) Moravec, Mycotaxon **38**: 474. 1990.

≡ *Ascophanus striatus* Thind, Cash, & Singh, Mycologia **51**: 460. 1959.



C. striata, ascospores, CUP-MM 2581, x1000.

RECENT TAXONOMIC TREATMENT:
Moravec (1990).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Dhanolti, Mussoorie, India.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2581 (UPS).

SUBSTRATUM:
Goat dung.

Notes: The small spores and distinctly 2-layered exciple seem diagnostic.

6. **Cheilymenia theleboloides** (Alb. & Schw. : Fr.) Boudier, Icon. mycol., Expl. pl. **1**(1): [3]. 1904, variety **theleboloides.**

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984), Moravec (1990).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Nisko, Poland.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Flores. CUP-MM 2133, 2170.
São Miguel. CUP-MM 1717 (immature).
Terceira. CUP-MM 2064.

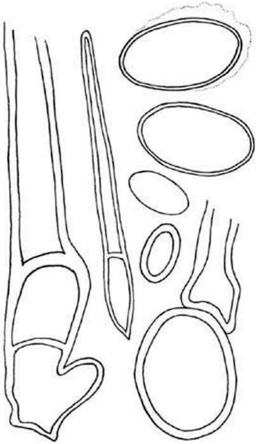
CANARY ISLANDS.

Tenerife. CUP-MM 1134 (O) (immature).

SUBSTRATA:

On stercoreated sacking, on cow dung.

Notes: Several of the Macaronesian collections appear to be larger-spored than is typical of the species, at times up to 22 x 14 µm. Our identifications are thus tentative, and await confirmation in Moravec's monograph in preparation.



C. theleboloides var. **theleboloides**, base of marginal hair, x1000, marginal hair x500, hair base and globose excipular cell x1000, 2 immature ascospores x 1000, CUP-MM 1134; 2 mature ascospores (top right), CUP-MM 2133, x 1000.

7. Cheilymenia theleboloides variety **microspora** Dennis *in* Dennis, Reid, & Spooner, Kew Bull. **32:** 111. 1977.

RECENT TAXONOMIC TREATMENT:

Dennis et al. (1977).

PREVIOUS MACARONESIAN RECORD:

†Dennis et al. (1977).

TYPE LOCALITY:

Monte Brasil, Terceira, Azores.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

Terceira. [†Dennis et al. (1977): n.v.]

SUBSTRATUM:

Cow dung.

Notes: This should differ from the type variety in much smaller ascospores, 12–13 x 7–8 µm. We were unable to borrow Dennis's type from Kew.

8. **Cheilymenia sp. 2557.**

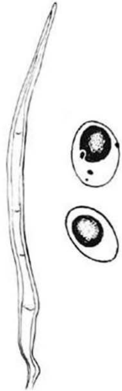
RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
None.

KNOWN MACARONESIAN DISTRIBUTION
MADEIRA.
Madeira. CUP-MM 2557 (UPS).

SUBSTRATUM:
Goat dung.

Notes: APOTHECIUM turbinate to subcylindric when dry, yellow, ca. 430 µm diam. SETAE subhyaline to light brown, septate, thick-walled, with one rootlet, 50–200 x 5.6–7.5 µm. ASCI clavate, 8-spored, ca. 180 x 22 µm. ASCOSPORES ellipsoid, smooth-walled, sometimes with a very few warts on the surface, some with de Bary bubbles, thick-walled and uniseriate to biseriate when young, thin-walled and irregularly biseriate at maturity, 11.7–13.2 (–14.6) x 8.0–8.3 (–10.2) µm. PARAPHYSES filiform, 2 µm wide.



Cheilymenia sp. 2557, hair x 500, ascospores x 1000, CUP-MM 2557.

9. **Cheilymenia sp. 2573.**

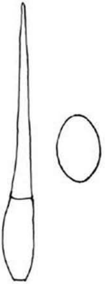
RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
None.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2573 (UPS).

SUBSTRATUM:
Cow dung.

Notes: APOTHECIUM pulvinate when dry, 0.25–0.4 mm diam, covered with brown hairs on the receptacle surface, disc pale beige. HAIRS not rooting, thin-walled, light brown, septate, swollen at the base and tapering to a narrower, pointed apex, 112–243 x 9.5–20 µm. ASCI 8-spored, subcylindrical, 11–14.5 µm wide. ASCOSPORES ellipsoid, uniseriate, contents yellowish and refractive, 11.3–13.9 x 8.0–8.8 µm. PARAPHYSES slightly enlarged at the apex, where ca. 5 µm broad.



Cheilymenia sp. 2573, a thin-walled hair and an ascospore, CUP-MM 2573, x1000.

10. Cheilymenia sp. 2771.

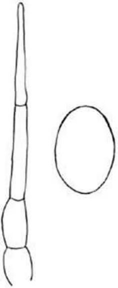
RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
None.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2771 (UPS), 2773 (UPS).

SUBSTRATUM:
Cow dung.

Notes: APOTHECIA up to 0.2 mm diam, receptacle covered with hairs. HAIRS light brown, not rooting, septate, thin-walled, 90–180 x 11–22 µm. ASCI 8-spored, subcylindrical, 16.5–20.5 µm wide. ASCOSPORES uniseriate, smooth-walled, 16.1–19.8 x 10.2–11.7 µm.



Cheilymenia sp. 2771, hair x 500, ascospore x1000, CUP-MM 2771.

LAMPROSPORA De Notaris 1864

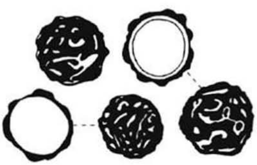
One known Macaronesian species

1. **Lamprospora dicranellae** Benkert, Z. Mykol. **53**: 217. 1987.

RECENT TAXONOMIC TREATMENT:
Benkert (1987).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Smržow, Czechoslovakia.



L. dicranellae, ascospores, CUP-MM 1171, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. CUP-MM 1171 (O).

SUBSTRATUM:
On soil.

Notes: This should differ from *L. ascoboloides* Seaver in much coarser spore markings and association with the moss *Dicranella* (association not noted by the collector). According to Benkert (1987) it has been regularly confused with Seaver's species in the literature.

LASIOBOLUS Saccardo 1884

Key to the known Macaronesian species

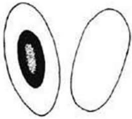
1 Setae up to 52 µm broad .... **1. L. ciliatus**
1′ Setae not over 24 µm broad 2
2(1′) Ascospores mostly 16.1–21.3 x 9.5–12.4 µm ... **2. L. cuniculi**
2′(1′) Ascospores mostly 13.9–17.6 x 8.0–11.7 µm. **3. L. intermedius**

1. **Lasiobolus ciliatus** (Schmidt : Fr.) Boud., Hist. classific. discomyc. Europe, p. 78. 1907.

RECENT TAXONOMIC TREATMENTS:
Bezerra & Kimbrough (1975), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORD:
†Dennis et al. (1977).

TYPE LOCALITY:
Germany.



L. ciliatus, ascospores, CUP-MM 1950, x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Terceira. † CUP-MM 1950, 1957, 2003.
CANARY ISLANDS.
La Palma. CUP-MM 958 (TFC, OSC).

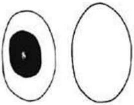
SUBSTRATA:
On dung, on ? goat dung, on cow dung.

Notes: Almost all of the ascospores in the Macaronesian material are under 11 µm wide, while Bezerra & Kimbrough (1975) give a range of (9–) 12–14 (–15) µm wide. The Macaronesian populations may thus differ taxonomically. Various authors have erroneously cited Berkeley as the author of this epithet.

2. **Lasiobolus cuniculi** Velenovsky, Monogr. discom. Bohem. **1:** 363. 1934.

RECENT TAXONOMIC TREATMENT:
Bezerra & Kimbrough (1975).

PREVIOUS MACARONESIAN RECORDS:
None.



L. cuniculi, ascospores, CUP-MM 1045, x1000.

TYPE LOCALITY:
Mnichovice, Czechoslovakia.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2394.
CANARY ISLANDS.
Hierro. CUP-MM 1405 (TFC), 1409.

SUBSTRATA:
On dung of sheep, goats, on dung in association with *Fimaria theioleuca* (Roll.) Brumm.

3. **Lasiobolus intermedius** Bezerra & Kimbrough, Canad. J. Bot. **53:** 1218. 1975.

RECENT TAXONOMIC TREATMENT:
Bezerra & Kimbrough (1975).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Thunder Bay, Ontario, Canada.

KNOWN MACARONESIAN DISTRIBUTION
MADEIRA.
Madeira. CUP-MM 2577 (UPS).
CANARY ISLANDS.
Hierro. CUP-MM 1451.
Tenerife. CUP-MM 2559 (UPS).

SUBSTRATA:
Goat dung, cow dung.

L. intermedius, hair x500, ascospores x 1000, CUP-MM 2559.

MYCOARCTIUM Jain & Cain 1973

One known Macaronesian species

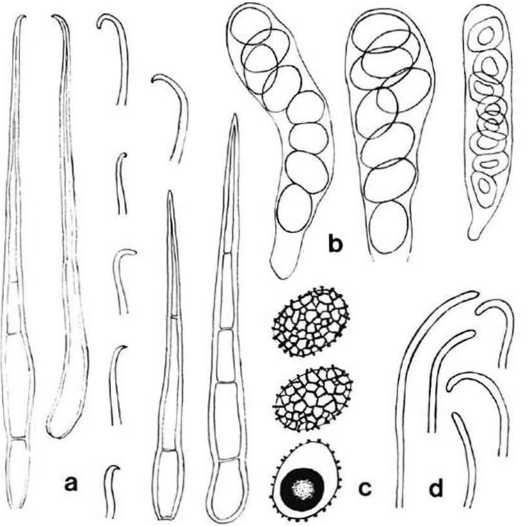
1. **Mycoarctium ciliatum** Jain & Cain, Canad. J. Bot. **51:** 305. 1973.

RECENT TAXONOMIC TREATMENT:
Jain & Cain (1973).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Nederland, Colorado, U.S.A.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2721.



M. ciliatum: a, 4 setae and 6 setal apices x1000; **b,** ascospore arrangement in 3 asci, one young (showing thick-walled young spores), x1000; **c,** 3 ascospores, 2 in surface view, one in optical section showing de Bary bubble, x1430; **d,** 5 paraphysis apices, x1000, CUP-MM 2721.

SUBSTRATUM:
On rodent ? dung.

Notes: This appears to be the first record of this species except for the original report from Colorado and California. Though the genus was originally assigned to the Thelebolaceae, we agree with Cain's suggestion (Systema Mycologicum **6:** 140. 1987) that it should be referred to a position close to *Lasiobolus*. This is the only genus in the *Lasiobolus-Trichobolus-Ochotrichobolus* series that has spores with cyanophilic markings, and that now adds weight to the arguments of Kimbrough and Korf (1983) to place those three genera in the

Scutellinioideae, where marked spores are the rule rather than the exception. We deeply appreciate the advice of Dr. John C. Krug, Toronto University, who saved us embarassment by reminding us of *Mycoarctium* when we thought we had a new genus and species.

NEOTTIELLA (Cooke) Saccardo 1889

Key to the known Macaronesian species

1 Ascospores ellipsoid, surface marked with a fine, irregular reticulum. **1. N. aphanodictyon**

1′ Ascospores narrowed at one end, somewhat pyriform . . **2. N. ricciae**

1. **Neottiella aphanodictyon** (Kobayasi) Diss., Korf, & Siverts. *in* Dissing & Sivertsen, Mycotaxon **16:** 458. 1983.

= *Leucoscypha borealis* Eckblad, Nytt. Mag. Bot. **15:** 52. 1968.

N. aphanodictyon, ascospore, CUP-MM 2778, x1000

RECENT TAXONOMIC TREATMENT:
Dissing & Sivertsen (1983).

PREVIOUS MACARONESIAN RECORD:
*Dybhavn (1990).

TYPE LOCALITY:
Lake Peters, Alaska.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM *2778 (O), 2784 (O).

SUBSTRATUM:
Between shoots of *Polytrichum* sp.

Notes: We confirm the determination by T. Schumacher forming the basis of Dybhavn's (1990) report, and have found a second collection.

2. **Neottiella ricciae** (Crouan & Crouan) Korf & Zhuang, **comb. nov.**

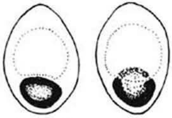
≡ *Peziza ricciae* Crouan & Crouan, Fl. Finistère, p. 54. 1867.

≡ *Leucoscypha ricciae* (Cr. & Cr.) Dennis, Kew Bull. **25:** 340. 1971.

RECENT TAXONOMIC TREATMENT:
Rifai (1968).

PREVIOUS MACARONESIAN RECORD:
*Beltrán et al. (1989).

TYPE LOCALITY:
Finistère, France.



N. ricciae, ascospores,
CUP-MM 264, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM *2621 (TFC).

SUBSTRATUM:
On *Riccia* sp.

Notes: When Beltrán et al. (1989) earlier reported Korf's determination of this fungus, it was ranged in *Leucoscypha*. The occurrence on a hepatic makes the species much more logically placed in *Neottiella*.

OCTOSPORA Hedwig 1789 emend. Korf 1955

Key to the known Macaronesian species

[1 Ascospores fusoid, 21–36 x 8.5–12 µm .... **1. O. coccinea**]
1´ Ascospores elliptic, 19–24 µm long 2
  2(1´) Ascospores strictly uniseriate; with *Polytrichum*. **2. O. humosa**
  2´(1´) Ascospores often biseriate in upper part of ascus; with *Bryum* and other mosses .... **3. O. leucoloma**

1. **Octospora coccinea** (Crouan) Brummelen, Persoonia, Suppl. **1:** 213. 1967.

≡ *Humaria coccinea* (Cr.) Quél., Enchir. fung. p. 289. 1886.

RECENT TAXONOMIC TREATMENTS:
Dennis & Itzerott (1973), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
†Drouet (1866), ††Trelease (1897).

TYPE LOCALITY:
Finistère, France.

REPORTED MACARONESIAN DISTRIBUTION

AZORES.

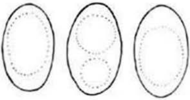
São Miguel. [† ††Drouet (1866): n.v.]

Notes: Trelease (1897) reported this as *Humaria coccinea* (Cr.) Sacc., but his report is clearly merely a restatement of Drouet's (1866) report of *Peziza coccinea* Pers., which we have earlier discussed (Part 11, Mycotaxon **40:** 3. 1991) under *Sarcoscypha coccinea* (Jacq. : Fr.) Lambotte. There is no evidence that Trelease ever examined Drouet's specimens, and probably confused the two "coccinea" epithets. The *Octospora* is thus probably incorrectly reported from Macaronesia.

2. **Octospora humosa** (Fr. : Fr.) Dennis, British Cup Fungi, p. 33. 1960.

RECENT TAXONOMIC TREATMENTS:

Dennis & Itzerott (1973), Dennis (1978), Breitenbach & Kränzlin (1984).



O. humosa, ascospores, CUP-MM 2779, x1000.

PREVIOUS MACARONESIAN RECORD:

*Dybhavn (1990).

TYPE LOCALITY:

Europe.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM *2779 (O).

SUBSTRATUM:

Between shoots of *Polytrichum* sp.

Notes: We confirm T. Schumacher's identification, which is the basis of Dybhavn's (1990) report.

3. **Octospora leucoloma** Hedwig : Fr., Descr. micr.-anal. musc. frond. **2:** 13. 1789.

RECENT TAXONOMIC TREATMENTS:

Rifai (1968), Dennis & Itzerott (1977), Dennis (1978).

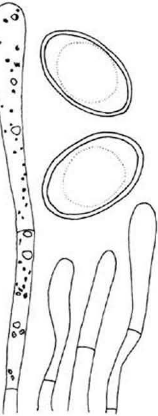
PREVIOUS MACARONESIAN RECORD:
*Korf & Gruff (1978).

TYPE LOCALITY:
Germany.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM *1392 (TFC, OSC, also issued in Korf & Gruff, Discomycetes Exsiccati #68).
La Palma. CUP-MM 1157 (O).

SUBSTRATA:
On soil among mosses, on burnt ground among mosses.



O. leucoloma, paraphysis apex, ascospores, hyphoid marginal hairs, CUP-MM 1392, x1000.

PULVINULA Boudier 1885, *nom. conserv. prop.*

= *Pulparia* Karsten 1866, *nom. rejic. prop.*

Key to the known Macaronesian species

1	Ascospores ellipsoid	**1. P. ovalispora**
1´	Ascospores subspherical	**2. P. subprolata**

1. Pulvinula ovalispora Boudier, Bull. Soc. Mycol. France 33: 16. 1917.

RECENT TAXONOMIC TREATMENTS:
Pfister (1976), Korf & Zhuang (1984).

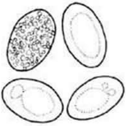
PREVIOUS MACARONESIAN RECORD:
*Korf & Zhuang (1984).

TYPE LOCALITY:
Algeria.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM *139.

SUBSTRATUM:
On soil.



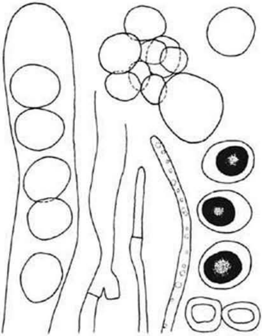
P. ovalispora, ascospores, CUP-MM 139, x1000.

2. Pulvinula subprolata Korf & Zhuang, sp. nov.

RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
None.

Ab Pulvinula laeterubra *ascosporis subprolatis differens.*



P. subprolata, portion of ascus, ascus base, excipular cells, paraphysis apices, 4 mature ascospores and 2 immature, thick-walled ascospores, CUP-MM 1234, x1000.

APOTHECIA discoid to flat, convex when dry, pinkish when fresh and reddish brown when dry, ca. 2.5 mm diam when rehydrated. RECEPTACLE slightly pruinose. ECTAL EXCIPULUM of textura angularis, cells (5–) 7–11 (–13) µm diam. MEDULLARY EXCIPULUM and SUBHYMENIUM not clearly distinguished from ectal excipulum, of textura intricata to textura angularis. HYMENIUM ca. 140–160 µm thick. ASCI cylindrical, 8-spored, rarely 4-spored, arising from a crozier, very thick-walled in youth, 11.5–13.2 µm wide. ASCOSPORES subspherical (subprolate), thick-walled when young, walls smooth, overmature spores becoming irregularly wrinkled and distorted, with a gel sheath, eguttulate, commonly forming a de Bary bubble, (9.5–) 10.2–12.4 (–13.2) x (8.8–) 9.5–11.0 µm. PARAPHYSES gracile, filiform, curved or straight at apex, septate, occasionally branched well below the apex, 1.0–1.5 µm wide.

HOLOTYPE: Canary Islands, Tenerife, on soil [? and on needles of *Cupressus macrocarpa* Hartw.], Casa Forestal, east entrance of Bosque de la Esperanza, leg. R. P. Korf, R. Fogel, G. L. Hennebert, & L. M. Kohn, 29. xii. 1976, CUP-MM 1234.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Tenerife. CUP-MM 1234.

SUBSTRATUM:

On soil [? and needles of Cupressaceae].

Notes: This species recalls *Pulvinula laeterubra* (Rehm) Pfister (see Pfister, 1976), but that species has regularly spherical ascospores.

RAMSBOTTOMIA Buckley 1923 emend. Benkert & Schumacher 1985

Key to the known Macaronesian species

1 Ascospores broadly ellipsoid to subglobose, (16–) 18.3–21 x (13–) 14.6–17.6 µm, spines (1–) 2.0–2.5 (–3.5) µm long ...... **1. R. asperior**

1' Ascospores spherical when fresh, 16.8–19.8 µm diam, often elliptical in material rehydrated after some years and then 15–21 x 13–17 µm, spines mostly 4.0–5.1 µm long .... **2. R. crec'hqueraultii**

1. Ramsbottomia asperior (Nylander) Benkert & Schum., Agarica 6(12): 35. 1985.

≡ *Scutellinia asperior* (Nyl.) Dennis, Kew Bull. **1955:** 571. 1955.

= *Ramsbottomia lamprosporoidea* Buckley, Trans. Brit. Mycol. Soc. **9:** 44. 1909.

= *Sphaerosoma janczewskianum* Rouppert, Bull. Int. Acad. Sci. Cracovie, Cl. Sci. Math. **1908:** 649. 1909.

= *Sphaerospora perplexa* Seaver, North Am. Cup-fungi (Oper.), p. 45. 1928.

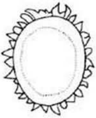
= *Lamprospora ovalispora* (Svr. & Kub.) Eckbl., Nytt. Mag. Bot. **15:** 42. 1968.

RECENT TAXONOMIC TREATMENTS:

Benkert (1976), Dissing & Korf (1980), Benkert & Schumacher (1985).

PREVIOUS MACARONESIAN RECORDS:
None.

LECTOTYPE LOCALITY:
Jalasjärvi, Finland [selected by Denison (1961)].



R. asperior, ascospore, CUP-MM 2443, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2443 (TFC, OSC).

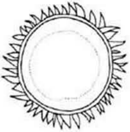
SUBSTRATUM:
On bare soil.

Notes: A much more complete synonymy and discussion of this species which has been placed in many different genera is given in Benkert & Schumacher (1985). The hairs are not always obvious.

2. **Ramsbottomia crec'hqueraultii** (Crouan) Benkert & Schumacher, Agarica **6**(12): 33. 1985.

≡ *Lamprospora crec'hqueraultii* (Cr.) Boud., Icon. Mycol., Liste prélim., p. [3]. 1904.
≡ *Octospora crec'hqueraultii* (Cr.) Caillet & Moyne, Bull. Soc. Mycol. France **96**: 185. 1980.

RECENT TAXONOMIC TREATMENTS:
Benkert (1976), Dennis (1978), Caillet & Moyne (1980), Benkert & Schumacher (1985).



R. crec'hqueraultii, ascospore, CUP-MM 1998, x1000.

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Finistère, France.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Terceira. CUP-MM 1998 (TFC).

SUBSTRATUM:
On soil in path.

Notes: *R. macracantha* (Boud.) Benk. & Schum. has smaller apothecia and spines on the ascospores 3–7 (–10) µm long.

SCUTELLINIA (Cooke) Lambotte 1887

Key to the known Macaronesian species

1 Setae over 1000 µm long .... **1. S. scutellata**
1´ Setae less than 1000 µm long 2
  2(1´) Perispore loosening in heated lactic acid ..... **2. S. superba**
  2´(1´) Perispore not loosening in heated lactic acid 3
3(2´) Ascospores 17.6–21.3 x 12.4–14.6 µm ....**3. S. umbrarum**
3´(2´) Ascospores 15.4–18.3 x 9.5–132. µm .... **4. S. vitreola**

1. **Scutellinia scutellata** (L. : Fr.) Lambotte, Fl. Mycol. Belge, Suppl. **1:** 299. 1887.

= ? *Scutellinia crinita* (Bull. : Fr.) Lamb., Fl. Mycol. Belge, Suppl. **1:** 301. 1887.
= *Scutellinia cervorum* (Vel.) Svrček, Česká Myk. **25:** 83. 1971.
= *Scutellinia subcervorum* Svrček, Česka Myk. **25:** 86. 1971.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Kullman (1982), Breitenbach & Kränzlin (1984), Schumacher (1990).

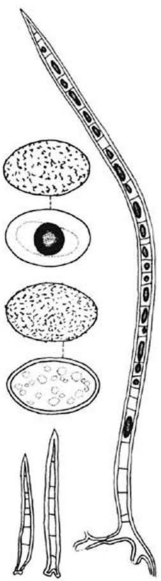
PREVIOUS MACARONESIAN RECORDS:
*Beltrán & Wildpret (1975), †Beltrán (1980), ††Bañares (1987-1988), †††Bañares & Beltrán (1987).

TYPE LOCALITY:
Småland, Sweden.

KNOWN MACARONESIA DISTRIBUTION

AZORES.
São Miguel. CUP-MM 1736, 1737, 1759.

MADEIRA.
Madeira. CUP-MM 2294, 2296, 2417.



S. scutellata, top 2 ascospores CUP-MM 1736, bottom 2 CUP-MM 2294, x1000; hairs, CUP-MM 2294, x100.

CANARY ISLANDS.

Gomera. ††† CUP-MM 2655.
La Palma. † CUP-MM 789 (TFC), 798, 821, 831, *2512 (TFC).
Tenerife. † †† CUP-MM 1224.

SUBSTRATA:

On wood, bark, stems, rotted branch, soil and duff, wet and very wet wood, herbaceous stems.

Notes: We are unable to distinguish *S. crinita* from this species, though Schumacher (1990) does. If there are two taxa, as he believes, most Macaronesian collections would fall in *S. crinita*.

2. **Scutellinia superba** (Vel.) Le Gal, Bull. Soc. Mycol. France **80:** 123. 1964.

= *Scutellinia insignispora* Svr. & Morav., Česká Myk. **23:** 156. 1969.

RECENT TAXONOMIC TREATMENTS:

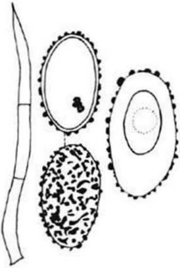
Kullman (1982), Schumacher (1990).

PREVIOUS MACARONESIAN RECORDS:

*Beltrán & Wildpret (1975) [misidentified as *S. scutellata*].

TYPE LOCALITY:

Stránčice, Czechoslovakia.



S. superba, hair x100, 2 ascospores in unheated lactic acid cotton blue, 1 ascospore floating free in loosened perispore in heated lactic acid cotton blue, x1000, CUP-MM 2522.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Tenerife. CUP-MM *2522 (TFC) [as *S. scutellata*].

SUBSTRATUM:

On soil.

Notes: We follow Schumacher's (1990) treatment of this species, not Kullman's (1982) interpretation.

3. **Scutellinia umbrarum** (Fr. : Fr.) Lambotte (ut 'umbrorum'). Fl. Mycol. Belge, Suppl. **1:** 300. 1887.

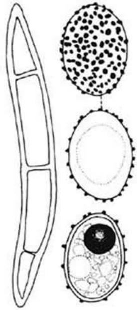
RECENT TAXONOMIC TREATMENTS:
Kullman (1982), Breitenbach & Kränzlin (1984), Schumacher (1990).

PREVIOUS MACARONESIAN RECORD:
*Dennis et al. (1977) [as *Scutellinia* sp.]

TYPE LOCALITY:
Italy [Micheli's locality].

KNOWN MACARONESIAN DISTRIBUTION
AZORES.
São Miguel. CUP-MM 1874.
Terceira. CUP-MM *1667 (K) (immature) [as *Scutellinia* sp.], 1906.
CANARY ISLANDS.
Gomera. CUP-MM 1169 (O).

SUBSTRATA:
On soil, on bare soil.



S. umbrarum, hair, CUP-MM 1667, x500; ascospores, CUP-MM 1169, x1000.

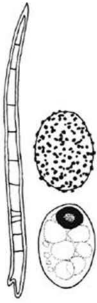
Notes: The epithet is very frequently misspelled "umbrorum" in the literature. See Korf *in* Boudier (1985: p. 228, footnote 372).

4. **Scutellinia vitreola** Kullman, Scripta Mycol. 10: 92. 1982.

RECENT TAXONOMIC TREATMENTS:
Kullman (1982), Schumacher (1990).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Tuva, U.S.S.R.



S. vitreola, hair, x500, ascospores, x1000, CUP- MM 2295.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM 2295.

CANARY ISLANDS:

Gomera. CUP-MM 2667 (TFC).

SUBSTRATA:

On wood, on thin, wet soil over rocks.

Notes: Though this species is close to *S. scutellata*, the shorter hairs, smaller spores, and coarser spore markings are distinctive.

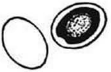
TRICHOBOLUS (Sacc.) Kimbr. & Cain *in* Kimbr. & Korf 1967

One known Macaronesian species

1. **Trichobolus zukalii** (Heimerl) Kimbr. *in* Kimbrough & Korf, Amer. J. Bot. **54:** 21. 1967.

RECENT TAXONOMIC TREATMENT:

Krug (1973).



T. zukalii, ascospores, CUP-MM 2572, x1000.

PREVIOUS MACARONESIAN RECORDS:

None.

TYPE LOCALITY:

Vienna, Austria.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM 2572 (UPS).

SUBSTRATUM:

Goat dung.

Notes: The ascocarps with a single, polysporous ascus and subellipsoidal ascospores with de Bary bubbles are characteristic. We have some difficulty in accepting the two 8-spored species with multiascal ascocarps placed in this genus, *T. octosporus* Krug (1973) and *T. vanbrummelenii* Valldosera & Guarro (1988), and suggest they belong elsewhere in the classification. The lack of an operculum in either seems to rule out their assignment to *Lasiobolus*.

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AN HISTORICAL PERSPECTIVE: MYCOLOGY IN THE DEPARTMENTS OF BOTANY AND OF PLANT PATHOLOGY AT CORNELL UNIVERSITY AND THE GENEVA AGRICULTURAL EXPERIMENT STATION[1]

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Perhaps a better title for this report would have been "An *idiosyncratic* historical perspective," for this is a very personal view of the history and the development of mycology, in particular, within the framework of both the botany and plant pathology departments at Cornell and at the associated Geneva Agricultural Experiment Station. It consists of reminiscences and ramblings, based in part on the best historical records I could locate, in part on my own, not always dependable, memory, laced with a scattering of autobiographical details.

My qualifications for this task derive, much to my surprise, primarily from my age, which has crept up on me almost unawares. For so many years I was "the young kid on the block," finding myself an elder (if not an elder statesman) in the Department was an unexpected awakening. I arrived as a freshman student on the Cornell campus forty-eight years ago this current autumn, just turned 17 years of age, coming from a well-to-do middle class family with homes in Westchester County, New York, and in New Fairfield, Connecticut. I was the product of a prestigious private school, Riverdale Country School[2] in New York City, and chose Cornell University for study with the vague notion that I might like to become a gentleman farmer. My freshman year was an exciting one in which I encountered three of the best teachers I have ever had, a professor in Poultry Science, one in Botany, and one in Theatre Arts. It was the botany professor, Loren C. Petry, who insisted that during my second year I "must take the course from Professor Whetzel upstairs in Plant Pathology." Dutifully I enrolled in H. H. Whetzel's course in Introductory Plant Pathology, the last time that he ever gave that course, in the fall term of 1943, and I became instantly enamored of both "Prof Whetzel" (the fourth of the great teachers I encountered) and of the field of Plant Pathology. I obtained my bachelor's degree in 1946 with a major in botany, and immediately enrolled in the field of Plant Pathology for a Ph.D. with a major in mycology, and minors in genetics and general botany, receiving that degree forty years ago in 1950.

I'd like to start this guided tour with a view of the young University. FIG. 1 is from the *Ten-year Book of Cornell University*, in which you see listed the

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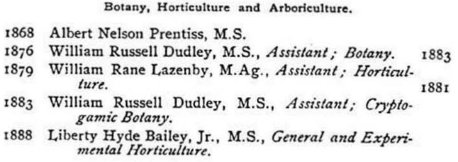
[1] Based on seminars presented to the Departments of Plant Pathology at Cornell University and at the Geneva Agricultural Experiment Station, November 1990.

[2] At the age of 16 I had my first taste of formal teaching when I was placed in full charge of the course in Biology at Riverdale when the master employed to teach it entered the armed services. Many of the students were older than I, and in retrospect I am convinced that this experience had an enormous impact on my future and on my decision to enter the teaching profession.



Botany, Horticulture and Arboriculture.

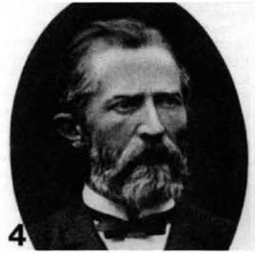
1868	Albert Nelson Prentiss, M.S.	
1876	William Russell Dudley, M.S., *Assistant; Botany.*	1883
1879	William Rane Lazenby, M.Ag., *Assistant; Horticulture.*	1881
1883	William Russell Dudley, M.S., *Assistant; Cryptogamic Botany.*	
1888	Liberty Hyde Bailey, Jr., M.S., *General and Experimental Horticulture.*	

FIG. 1. Faculty in Botany during Cornell's first 20 years
(The Ten-year Book of Cornell University II, 1868-1888).

personnel who comprised the Department of Botany, Horticulture and Aboriculture during the first twenty years. First on the list is Albert N. Prentiss (FIG. 2), appointed as Professor of Botany and head of the Department at the founding of the university in 1868. The first fall Prentiss had four students in his botany course, all advanced students who had transferred to Cornell from other institutions. The next year saw an increase in enrollment to an amazing 144 students, and apparently numbers remained high thereafter. Notable among Prentiss's students was David Starr Jordan, who in his senior year (1871-72) was appointed the first Instructor in Botany. Jordan of course later became President of Stanford University, and also is notable in having received one of the only two honorary degrees ever awarded by Cornell University (the other was to the university's first president, Andrew Dickson White; both received an L.L.B.). Probably the first scientific paper on fungi from the new university was Prentiss's "Puffballs and their kindred," published in 1871 in the *Cornell Era,* a scholarly, instructive essay on the organization and structure of gasteromycete fruitbodies. Prentiss gave the first course of lectures on fungi two years later in 1873, at which time he was assisted by W. R. Dudley (FIG. 3), who as an undergraduate was given the instructorship in 1872 on Jordan's departure. After graduation Dudley was appointed Assistant Professor of Botany from 1876 to 1883, and then Assistant Professor of Cryptogamic Botany until 1892. In 1887 Dudley trained for a year with the famous German mycologist, Anton De Bary (FIG. 4), our only formal tie to that early mycologist and plant pathologist. One of Cornell's most eminent botanists, Liberty Hyde Bailey (FIG. 5), joined the Botany Department in 1888, and was later to become Dean of the newly designated New York State College of Agriculture, and to be instrumental in establishing the Department of Plant Pathology in that College.

Dudley left Cornell in 1892 to go to the new Leland Stanford University, one of the many great teachers who were enticed away by David Starr Jordan in establishing that university. But during his tenure at Cornell he produced five highly influential botanists (TABLE I). One of these, W. A. Kellerman, was a mycologist interested in rusts and smuts, first at Kansas State Agricultural College and later at Ohio State University, who founded the *Journal of Mycology,* predecessor to the current major American mycological journal, *Mycologia.* William Trelease was also a Dudley student, and became one of the most important botanists in America at the Missouri Botanical Garden and later as head of the Botany Department at the University of Illinois.

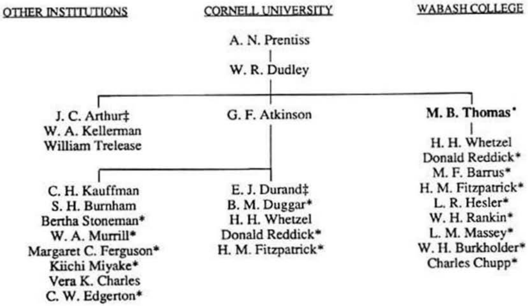
I wish at this point to focus on Joseph Charles Arthur (FIG. 6) who



FIGS. 2–7. 2. A. N. Prentiss. 3. W. R. Dudley. 4. A. De Bary.
5. L. H. Bailey. 6. J. C. Arthur. 7. F. C. Stewart.

TABLE I

Mason B. Thomas and the Cornell University—Wabash College Connection



• All of Thomas's listed students did their graduate work in mycology/plant pathology at Cornell and all later became faculty members of the Plant Pathology Department, Cornell University

‡ Received Cornell D.Sc. degree
* Received Cornell Ph.D. degree

received the first doctorate in mycology from Cornell in 1886. His degree was that of a Doctor of Science, and was an earned, not an honorary degree. (Cornell awarded 108 Ph.D.'s in its first 30 years, 19 earned D.Sc.'s, and one D.V.M. degree.) Arthur is probably best known to most mycologists for his monumental work on American Uredinales, but it is worth pointing out here that he became the first plant pathologist ever appointed to an experiment station when he was given the position of Botanist in 1884 to study plant diseases at the New York State Experiment Station. That station was organized in 1880 at Geneva, New York, some 60 km to the north of Ithaca. His first paper was a plant pathological treatise on pear blight.

This is perhaps as good a point as any to introduce the connections between experiment stations and Cornell University. A year before establishment of the station at Geneva, the Cornell University Experiment Station was founded in Ithaca, and many professors of the university, particularly in agricultural areas, were also given titles and duties in the Experiment Station. By 1887 the federal government's Hatch Act led to a change in the name to the Cornell University Agricultural Experiment Station. It was not till 1888 that the College of Agriculture was established at Cornell (from the old Department of Agriculture), so that the Cornell University Agricultural Experiment Station is actually a year older than the College of Agriculture.

Let us examine now the further development of the Geneva station. After Arthur resigned in 1887, E. S. Goff and M. H. Beckwith took over investigations on plant disease. Then, in 1894, F. C. Stewart (FIG. 7) was appointed Mycologist, and was headquartered in Jamaica, Long Island. In 1898 Stewart was transferred to Geneva, given the title of Botanist, and placed in charge of the new Division of Botany, a position he held for 38 years. The two experiment stations, at Geneva and at Cornell, were merged in the 1920's. Another Cornell-trained plant pathologist, W. H. Rankin (FIG. 8) joined the Geneva staff in 1922, leaving for the New York State Department of Agriculture and Markets in 1934. In 1936 Stewart was named head of the newly created Division (later Department) of Plant Pathology at Geneva. Today graduate students enrolled in Cornell frequently pursue their research at Geneva and take their course work on the Cornell campus, and Geneva professors, who are also professors of the university, direct their research.

At this point I wish to return to our early Cornell history, and to two of W. R. Dudley's other students who had impressive rôles in the development of mycology and plant pathology at this university. Neither obtained a doctorate degree, but at that time such a degree was by no means mandatory for appointment to a professorship.

The first of these two Dudley students I wish to examine in detail is Mason B. Thomas (FIG. 9). He accepted the call to a professorship at Wabash College, in Crawfordsville, Indiana. He was, by all accounts, a truly exceptional teacher, and he maintained ties to Cornell that were to shape the whole future of Cornell's work on fungi and plant diseases. As you will see from TABLE I, from this small college Thomas sent to Cornell for graduate work nine young men, all of whom became members of the Department of Plant Pathology, all but one (Whetzel) earning their Ph.D. degrees here, either under the direction of Atkinson or of Whetzel. How such a contingent of first rate scientists could have been found and selected by Thomas seems incredible. The Wabash College connection to Cornell University probably has no counterpart in American science. (If I may be permitted an aside at this point, I will point out that when I was doing my undergraduate and graduate work at Cornell from 1942-1950, seven of those nine were still professors here! Only W. H. Rankin and L. R. Hesler had moved on to perhaps greener pastures.)

For the rest of this paper I shall devote myself mostly to the mycological side of the history. This will, of necessity, have much relationship to plant pathology, for in the early days all plant pathologists had their training as mycologists first. Any such history must continue with the line of mycology leading from Prentiss, through Dudley, to Dudley's mycological heir at Cornell, his student George F. Atkinson (FIG. 10), who left Cornell on graduation in 1885 after receiving the Ph.B. degree. His interests were then chiefly in zoological subjects, and he became Assistant Professor and then Associate Professor of entomology and zoology at the University of North Carolina, Chapel Hill from 1885 to 1888. He moved on in 1888 to become professor of botany and zoology and botanist of the University of South Carolina, and from 1889 to 1892 was professor of biology and biologist of the Experiment Station at Alabama Polytechnic Institute, where he published his well-known paper on nematodes, and others on cotton and fig diseases, as well as on fungi. When Dudley left Cornell in 1892 Atkinson was recalled to replace him, becoming head of the Department of Botany on Prentiss's retirement in 1896.

Atkinson's students (TABLE I) were among the elite of mycologists and botanists. C. H. Kauffman, whose work on the Agaricaceae of Michigan is still a

FIGS. 8–13. 8. W. H. Rankin. 9. M. B. Thomas. 10. G. F. Atkinson. 11. S. H. Burnham. 12. E. J. Durand. 13. B. M. Duggar

classic, and Stewart H.Burnham (FIG. 11) both studied under Atkinson. Burnham later did graduate work under Atkinson's teacher, W. R. Dudley, at Stanford University. Bertha Stoneman received her Ph.D. from Atkinson for studies of anthracnose diseases, and then went to South Africa as a botanist. William A. Murrill took his doctorate under Atkinson, and became one of the world's foremost agaricologists at the New York Botanical Garden. Margaret Ferguson received her Ph.D. under Atkinson and became Head of the Botany Department at Wellesley College. Kiichi Miyake also obtained his Ph.D. under Atkinson, returning to Japan to become a professor at Imperial University, Tokyo. Vera K. Charles and C. W. Edgerton were also Atkinson students wielding influence on the development of the science of plant pathology.

Back at Cornell, an Atkinson student who was appointed to the staff and remained here for an extended period was Elias J. Durand (FIG. 12), one of the most respected mycologists of his era, and a specialist in Discomycetes. He was an Assistant Professor under Atkinson for fourteen years before leaving for posts at Missouri University in 1910, and later at the University of Minnesota, where he died in 1922. His extensive herbarium of Discomycetes, including portions of the types of nearly all American species described prior to 1920, and his mycological library were purchased by Cornell's Department of Plant Pathology after his death (and is one of the major reasons I was so delighted to accept appointment here in 1951, since my research, too, is primarily with discomycetes, and the Durand collections are exceptionally useful for such taxonomic work).

B. M. Duggar (FIG. 13), who first studied with Atkinson in Alabama, came to Cornell and received the Ph.D. under him in 1898, and occupies an important place in the history of American phytopathology. He returned to Cornell in 1907, when he was named head of the Department of Plant Physiology, until he left again in 1912 for the Missouri Botanical Garden. In 1909 he published in Ithaca the first American book on plant pathology, *Fungous diseases of plants*.

But it was, of course, Herbert Hice Whetzel (FIG. 14) who figured most prominently in the development of plant pathology at Cornell.

The first course in the "more important parasitic fungi" (Botany II – Mycology) had much earlier been offered by Atkinson and Durand in the Department of Botany, and by 1906-1907 a course in Methods of Research in Plant Pathology was also offered in that department. In the same year a course was listed in the new College of Agriculture's Department of Agricultural Botany as 2a – Plant Diseases, offered by Whetzel. In 1907 Whetzel convinced Dean Bailey to rename the department Plant Pathology, and his title was changed to Assistant Professor of Plant Pathology. Two courses were offered in 1907-1908, 1a – Plant Pathology and 2a – Methods in Plant Pathology, both taught by Whetzel and Donald Reddick, one of the "Wabash boys." By 1908-1909 five courses, plus seminar and research, were offered by Whetzel, Reddick, and another of the Wabash group, Barrus.

Whetzel was an exceptionally talented and energetic man, and frictions amongst the rapidly expanding department members and Whetzel developed to the point where by the early 1920's there was open rebellion within the Department. In 1921 Whetzel stepped down as department head, and was succeeded by his student, yet another Wabash product, L. M. Massey, who remained head of the Department until 1950.

Whetzel would be an anomaly among leaders in phytopathology today, for he was trained as a mycologist, brought the science of plant pathology to fruition as no other did, and yet remained a mycologist till his dying day. His idea of training plant pathologists was to take them out into the field and woods to collect fungi. His early interest in sclerotial fungi led him to become the world

14. Herbert Hice Whetzel.

authority on the group of Discomycetes for which he was to coin the family name Sclerotiniaceae, and to work with students such as F. L. Drayton, W. Lawrence White, and Thomas L. Sproston on these fungi.

One of Whetzel's first actions was the establishment of a department herbarium, which he considered the backbone of documentation for both mycology and plant pathology. The herbarium at first consisted of the donation of his own mycological herbarium of over 5000 numbers, and that herbarium has grown over the years till it now encompasses over 300,000 collections, and is probably the fourth largest fungus collection in the United States. Many important exsiccati sets were purchased from departmental funds. Staff members constantly accessioned new materials, and a huge photographic record was backed up by the actual specimen photographed. A strong interest in Latin American collecting by Whetzel and his students, with trips as well to the Caribbean and Bermuda, make up special collections unrivalled elsewhere. At that time the station at Geneva also maintained a more modest but significant herbarium, in large part consisting of F. C. Stewart's personal herbarium and many published exsiccati sets that had been purchased, as well as materials deposited by station members. These collections were eventually transferred to the Cornell University Plant Pathology Herbarium during my tenure as mycologist, when they were deemed to be seldom consulted and to be occupying too much valuable space at Geneva. Once the new Plant Science Building was occupied by Plant Pathology in the early 1930's, the old Botany Department herbarium consisting of Atkinson's and his students' collections and photographs were transferred to and incorporated in the Plant Pathology

Herbarium as a special collection. Also many of Stewart Burnham's New York collections ended up in our herbarium when his phanerogamic collections were given to the Wiegand Herbarium at his death. Other significant accessions include the *Chaetomium* collections of A. H. Chivers, a Harvard Ph.D. who became a professor at Dartmouth College, shown here (FIG. 15) on the left, together with Julian H. Miller, a Cornell Ph.D. whose doctorate work on pyrenomycetes at Cornell led to his becoming a world authority. Miller was named head of the Department of Botany and Plant Pathology at the University of Georgia. The third person shown in FIG. 15 is S. C. Teng, from China, who studied here in the 1920's, and who single-handedly spirited about one-fourth of the Chinese National Fungal Herbarium out of China in the face of the Japanese invasion in the 1930's. Some of that material was divided, half of each collection at Cornell and half at the Bureau of Plant Industry, Beltsville, while the rest of the material was deposited only at Cornell, where it is still maintained.

Side by side with the development of the herbarium was Whetzel's continuation of the purchase of mycological and phytopathological books for the Cornell and Plant Pathology libraries. Many trips to Europe were devoted in part to browsing through antiquarian book stores and sending back rarities — an extension of the efforts of the first university president, Andrew Dickson White, and of the botanists from Prentiss through Dudley and Durand. Whetzel was convinced his new science could not grow without a major herbarium and a world-class botanical library (and Cornell's library then and now is surely only equalled in this country by those at Harvard University, the New York Botanical Garden, and the Library of Congress).

On founding the Plant Pathology department Whetzel understandably sent all the plant pathology students down to the Arts College to take their mycology from Atkinson, but Atkinson's greater and greater preoccupation with the agarics led to a somewhat distorted course offering. When Harry M. Fitzpatrick (FIG. 16), who while at Wabash had been thoroughly indoctrinated and encouraged by Whetzel, completed his doctorate under Atkinson in 1912, Whetzel installed him in the Plant Pathology department to teach mycology. From 1912 on Fitzpatrick taught the mycology courses (a year-long introductory mycology course, and a two-year-long advanced mycology course) in the College of Agriculture, while Atkinson continued to teach in the College of Arts and Science's Botany Department. In 1917 Atkinson was relieved of teaching by the university trustees in order to complete his proposed illustrated monograph of North American Agaricaceae. (Atkinson had long championed photography, and won many awards for his photographs; his illustrations in his book, *Studies of American fungi: mushrooms, edible, poisonous, etc.*, first published in 1900, with later editions, are renowned.) On a collecting trip to the western US a year later Atkinson died during an influenza epidemic. His position as mycologist in the Botany Department was never refilled, and thus the work on mycology permanently "moved" from the College of Arts and Sciences to the College of Agriculture.

Five more of the Wabash group completed their doctorates shortly thereafter. L. R. Hesler (FIG. 17) remained at Cornell for some years as a plant pathologist before ending up at the University of Tennessee as mycologist and world-renowned agaricologist; W. H. Rankin also stayed on the Cornell faculty some six years before moving to Canada and shortly thereafter to the Geneva Agricultural Experiment Station; L. M. Massey, who replaced Whetzel as head of the department in 1921, Walter H. Burkholder, and Charles Chupp all stayed on as professors in the department after completion of their Ph.D.'s under Whetzel.

FIGS. 15–19. 15. A. H. Chivers, J. H. Miller, and S. C. Teng. 16. H. M. Fitzpatrick. 17. L. R. Hesler. 18. A. E. Jenkins. 19. C. G. Lloyd.

There were many distinguished students in the department over the years, but I am compelled to single one out. Anna E. Jenkins (FIG. 18) was a New York State native who obtained her bachelor's, master's, and doctorate degrees from Cornell in 1911, 1923, and 1927. Anna worked all her life for the federal government in the Bureau of Plant Industry as a mycologist, first appointed in 1912, with particular interest in the Myriangiales. She had very fond memories of Cornell, and visited here often during Fitzpatrick's life, and also after his death during my tenure as mycologist. On her death her estate was bequeathed to the Department to assist in the mycology programs, and through her generosity it has been possible to support many students and visiting scientists in the department as Anna E. Jenkins predoctoral fellows, postdoctoral fellows and associates, and visiting professors.

One other "character" in mycology should be mentioned here, Curtis Gates Lloyd (FIG. 19), an eccentric, wealthy, self-taught mycologist. Lloyd had many peculiarities, among them an early aversion to citing the names of authors after Latin names. He called such citations "advertising," and railed against name "jugglers" that he conceived as having self-interest in changing names and creating some of the new combinations that were being published, to which their names were appended. He had apparently been scorned by one or more academicians early in his career, and thus never published in any journals except his own privately printed ones. These could not be obtained on subscription but only by barter for fungus specimens sent to him by correspondents. Lloyd created a tongue-in-cheek fictional character, "Professor N. J. McGinty," whose greatest joy seemed to be making name changes, many of which Lloyd published with McGinty cited as the combining author. Some have held that McGinty was modelled on G. F. Atkinson, but I have been unable to trace such a connection. Lloyd would often change from esteem of a scientist to scorn, and he did not hesitate to publish his at times scurrilous opinions. For reasons quite incomprehensible to me Lloyd coined the generic name *Jugglerandia* to "honor" Elias J. Durand, who had had the audacity to change the name of a species of *Holwaya* (Discomycetes); a short while before Lloyd had had nothing but praise for Durand. Since Durand made very few name changes throughout his career, Lloyd's barb seems singularly misplaced. Nonetheless, there is another, and for us brighter, side to Lloyd's character. He was a lifelong bachelor, and in the early 1920's visited Cornell University where his nephew was enrolled in the entomology program. Fitzpatrick heard that Lloyd was in town, contacted him, and invited Lloyd to lecture to his students and to accompany them on a number of field trips in the area. Fitzpatrick's kindnesses, and for Lloyd perhaps unexpected "acceptance" in academia, led Lloyd to purchase, unbeknownst to anyone in the Department, three major collecting grounds, which he then gave to the University. These are now called the Lloyd-Cornell Preserves at Ringwood, McLean, and Slaterville Springs, to this day some of the best areas in which to collect fungi within a 50 km radius of Ithaca.

This now brings us up to the time that I arrived in the Department, forty-seven years ago. What remains is a quick rogues gallery of the people who were here at that time, and a select few who arrived later.

In 1943 my first encounter with plant pathology was with that fabulous teacher who so changed my life, Herbert Hice Whetzel, the professor in the introductory plant pathology course, shown here (FIG. 20) at the age I first saw him. My laboratory instructor in that course was a young man just finishing up his Ph.D. with Whetzel, John S. Niederhauser (FIG. 21), later briefly appointed as an assistant professor in the Department, who was recently named the 1990 World Food Prize Laureate, and is affectionately nicknamed "Mr. Potato."

One of the most unusual and to my mind most important features of Whetzel's course was that each student was held to complete 16 oral examinations, each on one week's work. These examinations were given both by laboratory instructors and by those professors in the department who might have worked with the disease studied that week. By virtue of Whetzel's commanding and demanding personality, almost every professor in the department took part in these oral examinations, usually lasting 20 to 30 minutes in that professor's office. As a first-term sophomore student I thus met on a one-to-one basis most of the people I will now mention. The few I did not meet in this way soon became acquaintances through the regular departmental afternoon coffee hour, attendance at which was "expected" by Whetzel, whose sonorous, booming, clarion call, on a rising and then declining pitch, "Coffee, coffee!," shook the whole building daily. For simplicity's sake, I shall go through the roster in alphabetical order.

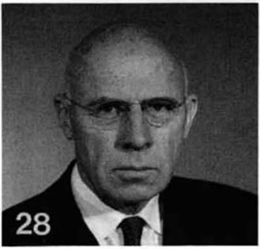
M. F. Barrus (FIG. 22), a gentle, delightful man, had worked with diseases of beans, potatoes, and fruit. F. M. Blodgett (FIG. 23), somewhat terrifying to a young student, but in reality kind and helpful, who had also been briefly at the Geneva Station, was yet another potato disease man by this time in his career, and Walter H. Burkholder (FIG. 24) was our bacteriologist, perhaps best known as "Burkie" and as a friend of graduate students and an inveterate party-goer. Arthur B. Burrell (FIG. 25) was a fruit pathologist, primarily working with apples, and Charles Chupp (FIG. 26) was one of the most beloved of the professors, always cheery, filled with fun, a vegetable pathologist with a lifelong interest in the taxonomy of the genus *Cercospora*, whose 1954 book, a monograph of the genus, is still in demand today. Another sweetheart in the department was A. Watt Dimock (FIG. 27), floricultural pathologist, whose dedication to students and to the Department was outstanding.

Karl H. Fernow (FIG. 28) was in charge of the New York State seed potato certification program, and by the summer of my junior year I found myself employed first as a roguer for seed potato plots, and soon after as a full-fledged potato inspector. This was during World War II. Many of the potato inspectors had been drafted or had enlisted in the armed services, which resulted in my meteoric rise in stature in the certification program. Because of these circumstances Johnny Niederhauser and I came to be lifelong friends, since we were both potato inspectors for the program at the same time. At age 19 I was throwing out large acreage fields of potatoes for such problems as excess potato leaf-roll virus, for example, to the great dismay of the growers whose income was threatened thereby. Understandably they would call up Fernow and ask him to reinspect the fields I had rejected. That he did, and despite obvious wholesale roguing by the grower between my visit and that of Fernow, he always found enough left of whatever pathogen I had marked in excess that he was able to confirm rejection of the field.

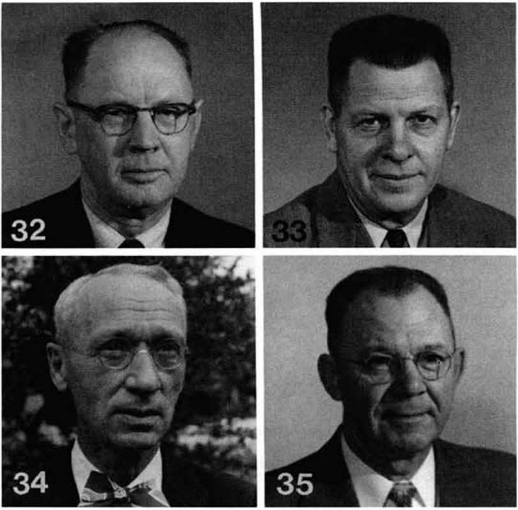
An exceptionally awesome figure to a young undergraduate was the rather dour department head, L. M. Massey (FIG. 29), whose work on rose diseases in particular brought us to his office for an examination. W. D. "Bill" Mills (FIG. 30), who worked on many fruit diseases, was the one to develop a forecast system for apple scab, a disease almost all of us studied in the introductory course.

Next on my laundry list is the inveterate A. G. Newhall (FIG. 31), extension vegetable pathologist par excellence, raconteur, who is still with us at 96 years of age, and still as sharp as a tack. Al made an effort to contact every graduate student and to host each in his home. Ken Parker (FIG. 32) was also a

FIGS. 20–25. 20. H. H. Whetzel. 21. J. S. Niederhauser. 22. M. F. Barrus 23. F. M. Blodgett. 24. W. H. Burkholder. 25. A. B. Burrell.



FIGS. 26–31. 26. C. Chupp. 27. A. W. Dimock. 28. K. H. Fernow.
29. L. M. Massey. 30. W. D. Mills. 31. A. G. Newhall.



FIGS. 32–35. 32. K. G. Parker. 33. L. C. Peterson.
34. D. Reddick. 35. D. S. Welch.

fruit expert, while L. C. Petersen (FIG. 33) was another of the potato men, primarily concerned with late blight resistance and the potato breeding program. (It was he who confided to me years later, when I returned to the faculty and canvassed the professors about what the mycology courses should be in their opinion, that though he had taken Professor Fitzpatrick's two-year course in mycology, Fitz had never once mentioned the fungus that Petersen had spent the rest of his life studying.)

Then there was Donald Reddick (FIG. 34), a potato breeder, an internationally known pathologist and the purported ringleader of the revolt against Whetzel's chairmanship that rocked the department in the early 20's. And finally there was Donald S. Welch (FIG. 35), always a gentleman, a student Fitzpatrick had convinced to come from Harvard to work with him. Welch pursued a mycology major with a taxonomic monograph on the genus *Cucurbitaria*, and by the time I met him was the shade-tree and shrub pathologist here. I owe him a particular debt, since my major professor, H. M. Fitzpatrick, died during the final

36. Harry Morton Fitzpatrick.

stages of my thesis preparation, and it was Professor Welch who saw the thesis to final completion (along with that of my fellow-student mycologist, Clark T. Rogerson).

So at long last it is time to talk about Harry Morton Fitzpatrick (FIG. 36), my professor, a brilliant teacher, and a historian.[3] I met "Prof Fitz" for the first time when, in the second term of my sophomore year, I enrolled in the introductory mycology course (by this time a one-term course), and at the same time in Welch's course on plant disease control. I quickly discovered that what had so excited me about Whetzel's plant pathology course was not so much the diseases themselves, or their control, but the fungi that caused plant disease. And in the field trips I quickly learned that many equally fascinating fungi don't cause disease at all, but may be significant in other ways, or even just delightful to examine. Prof Fitz was a consummate field man, having been well-trained by Atkinson, and was provided with a enviable photographic memory. He never used notes for lectures, relying always on his memory to fill blackboard after blackboard with classifications, diagrams of fungal structures, and life-histories. He was a meticulous man, to excess, which contributed to his eventual health problems and death. I can remember his office well: it seemed there was an acre of carefully polished desk top, for he had desks all around the walls of his office, and all were pristine. On the desk at which he sat were usually three pencils, carefully lined up, and a note pad. When I consider the clutter in which I

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[3] Without Fitzpatrick's meticulously preserved documents and notes, this paper could not have been realized.

normally work, I remain amazed that Fitzpatrick ever accepted me as a student.[4] He was often considered morose, but in fact had a deep sense of humor, though he could often be put off. He was said to have been a champion at pitching pennies in the hallways, a departmental pastime in which he is reputed to have relieved many a graduate student of his or her horde of pennies. During the war his greatest tragedy was not being able to drive his car very far during the days of gas rationing. Those of us with a few extra coupons often helped Prof Fitz realize his desires to drive into the country. I cannot resist quoting two "tales seldom told" collected by G. C. Kent and A. G. Newhall back in 1983, which shed some light on Fitz and on Prof Whetzel as well:

> "Fitzpatrick was a good tennis player and enjoyed playing with students. However, it was commonly known among students that they should never beat Fitz the day before an exam.
>
> "Fitz hated cigar smoke and Whetzel smoked much of the time. He particularly liked to stand in Fitzpatrick's doorway and TALK AND PUFF and watch Fitz squirm. Fitz would later slam open the door and window and then go for a walk."

Lest this story leave you with the notion that Fitz held any animosity towards Whetzel, I think it prudent to point out that Fitz's opinion of Whetzel's work as a mycologist was one of unbridled praise. The cigar smoke may have offended Fitz, but when Whetzel died in late 1944 and left his major mycological opus half-completed, it was Fitz who painstakingly completed it and saw it to publication in *Mycologia* in 1945 as Whetzel's *A synopsis of the genera and species of the Sclerotiniaceae, a family of stromatic inoperculate discomycetes.*

Between 1943 and when I obtained my Ph.D. degree in 1950 a few others came to the Department and stayed to become professors. To teach the course in Plant Disease Control came Leon J. Tyler (FIG. 37), whom I was to know particularly well during the last three years of my graduate work, since I was

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[4] Fitzpatrick had had ample opportunity to observe me further as an undergraduate, for in my junior year I enrolled in the year-long advanced mycology course, normally open only to graduate students, and in both semesters of my senior year I enrolled in undergraduate research in mycology, where I began taxonomic studies of the discomycete genera *Chlorosplenium* and *Cyathicula.*

In addition to a lack of neatness, I had at least two other attributes that Fitzpatrick certainly found annoying. At the time I was a thoroughly addicted pipe smoker, and I smoked from morning till night (except in Fitz's laboratories, where smoking was prohibited). The other annoyance for him was my consuming interest in the theatre and in acting. Almost the first day I arrived on campus I had come under the influence of a truly great drama teacher and director, Professor Alexander M. Drummond. I had been acting in plays all my childhood, and during my undergraduate days I cannot remember even a two-week period when I was not busy learning lines, rehearsing, performing, or writing drama reviews for the *Cornell Era.* Prof Fitz thoroughly disapproved and thought I should devote all my time in my graduate school years to mycology. I had no intention of giving up my favorite avocation, so for the next four years I resorted to subterfuge. Whenever I appeared on the Cornell or Ithaca stages or in radio dramas over the local radio station, it was under the pseudonym "Jonah Webster," just in case Fitz happened to listen to the radio or to read a theatre review of a play in which I was performing. My connection to Cornell and Ithaca theatre groups continued after my return to the Cornell faculty, and culminated in 1985-1986 when, for a year, I was loaned to and appointed half-time as the chairman of the Theatre Arts Department in the College of Arts and Sciences when that department was in the throes of "Sturm und Drang."

FIGS. 37–42. 37. L. J. Tyler. 38. W. F. Mai. 39. A. F. Ross. 40. G. C. Kent. 41. C. W. Boothroyd. 42. S. A. Hutchinson.

appointed teaching assistant for the course that he taught.[5] Our nematologist from 1946-1983, William "Bill" Mai (FIG. 38), taught the first plant nematology course at Cornell and trained 27 Ph.D. students who have significantly influenced the development of plant nematology in the US and developing countries. A. Frank Ross (FIG. 39) joined the staff as virologist in 1946. George C. Kent (FIG. 40) arrived from the mid-west the same year to teach the introductory plant pathology courses. In 1950 he was named head, to replace Massey, who retired at his own request. Carl W. Boothroyd (FIG. 41) was a student while I was an undergraduate, began his Ph.D. under Whetzel and completed it under Welch, with teaching assistantships in mycology (under Fitzpatrick) and in plant pathology. He then joined the staff in extension, and in 1950 was appointed to teach our introductory plant pathology courses.

One of Kent's early actions was to invite me back to Cornell in 1951 after my first year of teaching, at Glasgow University in Scotland. The man whose job in Scotland I was filling, Steven Hutchinson (FIG. 42), was Acting Professor of Plant Pathology and taught a mycology course here in 1950-51.

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[5] Prof. Massey came up to me one day and announced that beginning in the fall, whether I liked it or not, I was to be the plant disease control teaching assistant; because there was a shortage of TA's I would just have to fill in if I wanted to continue my graduate work in mycology.

The place of Cornell University in the historical development of Plant Pathology[6] is secure, for surely it is and has always been one of the leading departments in this country. What may not be as widely known is Cornell's influence on the science of mycology. For, as our most eminent mycological historian, Donald P. Rogers, acknowledged to me, Cornell has far outstripped any other university in producing mycologists, many, indeed, taxonomists, and many of them of truly world stature. In this vein I have prepared a seven-generation genealogy of Cornell mycologists (and I have left off many of the plant pathologists who might equally well consider themselves mycologists), an updating and partial correction of a similar family tree I prepared on the occasion of a history of mycology exhibit at one of the meetings of the Mycological Society of America a decade ago (TABLE II).

ACKNOWLEDGEMENTS

I wish to thank our departmental photographer, Kent Loeffler, for preparing the photographs used to illustrate this account, Susan Gruff of the Plant Pathology Herbarium for much and varied help, George Abawi, Herbert Aldwinkle, and Jeanne Samimy of the Geneva Agricultural Station for pointing me to the right sources for information on that organization, Mr. Robert Dirig, of the Bailey Hortorium, Cornell University, for sharing some historical slides he used in his recent history of that institution, and the Cornell University Archives. William R. Burk, University of North Carolina, called Prentiss's early mycological paper to my attention. Former students of the departments, and also Meredith Blackwell, Louisiana State University, and Donald P. Rogers, Emeritus Professor, University of Illinois, have also been helpful in running down leads for the genealogy. These have been good years for me. Thanks for sharing my reminiscences.

MAJOR SOURCES

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[6] I must admit to my great dismay at the breaking of one formal tie between plant pathology and mycology in 1970, when the major phytopathological abstracting journal, *Review of Applied Mycology,* changed its name to *Review of Plant Pathology.*

TABLE II

A SEVEN–GENERATION GENEALOGY OF CORNELL MYCOLOGY: GENERATIONS I–IV, PRENTISS—DUDLEY—ATKINSON AND THEIR STUDENTS

[Sites of major mycological publications and/or later affiliation(s) are noted in square brackets]

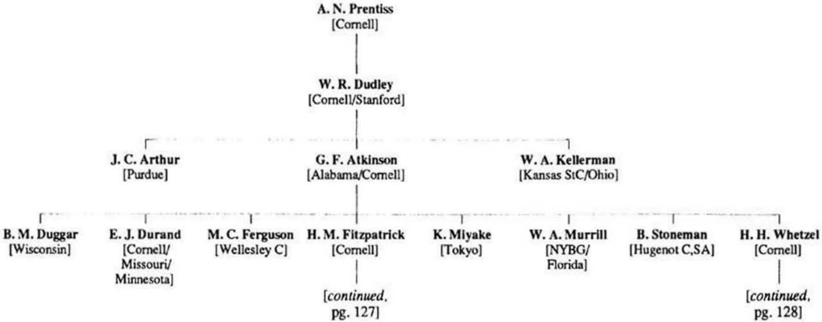
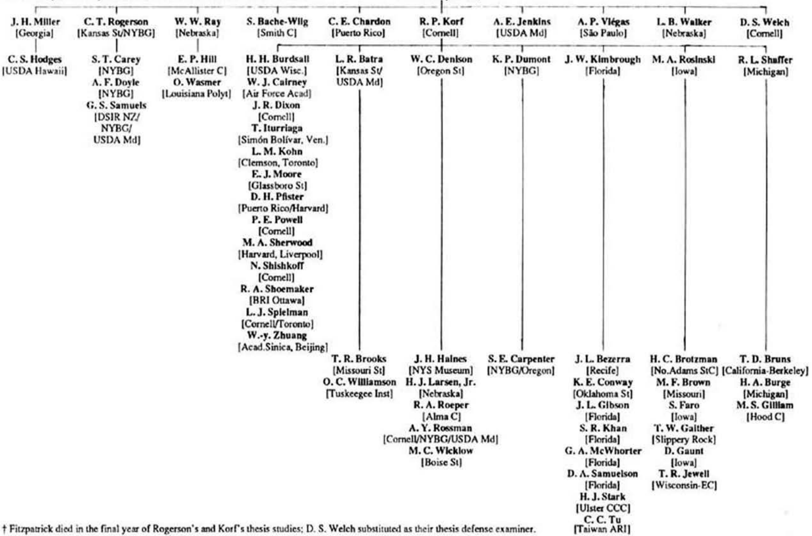


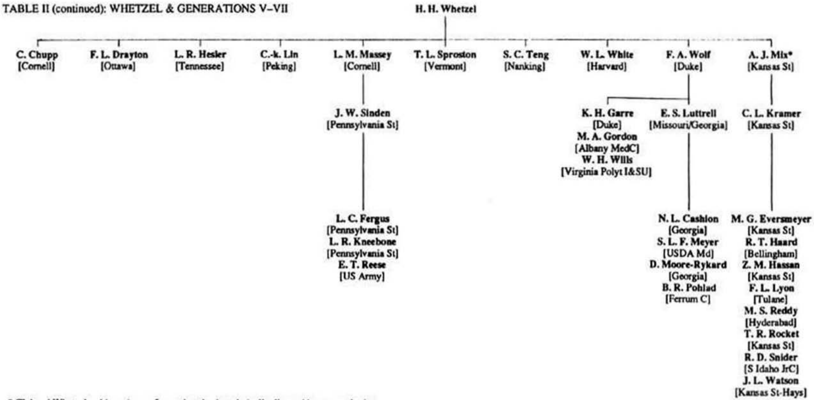
TABLE II (continued): FITZPATRICK & GENERATIONS V–VII



- **H. M. Fitzpatrick†**
  - **J. H. Miller** [Georgia]
    - **C. S. Hodges** [USDA Hawaii]
  - **C. T. Rogerson** [Kansas St/NYBG]
    - **S. T. Carey** [NYBG]
    - **A. F. Doyle** [NYBG]
    - **G. S. Samuels** [DSIR NZ/ NYBG/ USDA Md]
  - **W. W. Ray** [Nebraska]
    - **E. P. Hill** [McAllister C]
    - **O. Wasmer** [Louisiana Polyt]
  - **S. Bache-Wiig** [Smith C]
  - **C. E. Chardon** [Puerto Rico]
  - **R. P. Korf** [Cornell]
    - **H. H. Burdsall** [USDA Wisc.]
    - **W. J. Cairney** [Air Force Acad]
    - **J. R. Dixon** [Cornell]
    - **T. Iturriaga** [Simón Bolívar, Ven.]
    - **L. M. Kohn** [Clemson, Toronto]
    - **E. J. Moore** [Glassboro St]
    - **D. H. Pfister** [Puerto Rico/Harvard]
    - **P. E. Powell** [Cornell]
    - **M. A. Sherwood** [Harvard, Liverpool]
    - **N. Shishkoff** [Cornell]
    - **R. A. Shoemaker** [BRI Ottawa]
    - **L. J. Spielman** [Cornell/Toronto]
    - **W.-y. Zhuang** [Acad.Sinica, Beijing]
    - **L. R. Batra** [Kansas St/ USDA Md]
      - **T. R. Brooks** [Missouri St]
      - **O. C. Williamson** [Tuskeegee Inst]
    - **W. C. Denison** [Oregon St]
      - **J. H. Haines** [NYS Museum]
      - **H. J. Larsen, Jr.** [Nebraska]
      - **R. A. Roeper** [Alma C]
      - **A. Y. Rossman** [Cornell/NYBG/USDA Md]
      - **M. C. Wicklow** [Boise St]
    - **K. P. Dumont** [NYBG]
      - **S. E. Carpenter** [NYBG/Oregon]
    - **J. W. Kimbrough** [Florida]
      - **J. L. Bezerra** [Recife]
      - **K. E. Conway** [Oklahoma St]
      - **J. L. Gibson** [Florida]
      - **S. R. Khan** [Florida]
      - **G. A. McWhorter** [Florida]
      - **D. A. Samuelson** [Florida]
      - **H. J. Stark** [Ulster CCC]
      - **C. C. Tu** [Taiwan ARI]
    - **M. A. Rosinski** [Iowa]
      - **H. C. Brotzman** [No.Adams StC]
      - **M. F. Brown** [Missouri]
      - **S. Faro** [Iowa]
      - **T. W. Gaither** [Slippery Rock]
      - **D. Gaunt** [Iowa]
      - **T. R. Jewell** [Wisconsin-EC]
    - **R. L. Shaffer** [Michigan]
      - **T. D. Bruns** [California-Berkeley]
      - **H. A. Burge** [Michigan]
      - **M. S. Gilliam** [Hood C]
  - **A. E. Jenkins** [USDA Md]
  - **A. P. Viégas** [São Paulo]
  - **L. B. Walker** [Nebraska]
  - **D. S. Welch** [Cornell]

† Fitzpatrick died in the final year of Rogerson's and Korf's thesis studies; D. S. Welch substituted as their thesis defense examiner.

TABLE II (continued): WHETZEL & GENERATIONS V–VII



* Claimed Whetzel as his major professor, but thesis technically directed by a pomologist.

MYCOTAXON

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The Perfect Stage of *Pestalotiopsis* from China

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ABSTRACT: Three species of *Pestalosphaeria*, the perfect stage of *Pestalotiopsis*, from China are reported, of which two species are described as new, viz., *Pestalosphaeria accidenta* sp. nov. and *Pestalosphaeria jinggangensis* sp. nov. This is the first record of the genus of *Pestalosphaeria* Barr (1975) in China. A key to the known species of *Pestalosphaeria* is given.

KEY WORDS: *Pestalotiopsis*, *Pestalosphaeria*, China, perfect stage

During a survey of *Pestalotiopsis* fungi in China, 12 *Pestalotiopsis* specimens were collected from Jinggang Mountain, Jiangxi province, P. R. of China in Oct. 1987. Single spore isolates of *Pestalotiopsis* spp. were obtained from each of those 12 specimens. While they were maintained on PDA plate at room temperature for five to six months (from November to March or April next year), both perithecia and conidimata developed in culture in 5 isolates among them. After 12 days on PDA medium, all twenty single-ascospore isolates from each of the five isolates produced typical *Pestalotiopsis* conidia which were identical to those found on the leaves in nature. The ascospore and conidia isolates produced similar colonies on PDA medium. Based on morphological characters and the cultural evidence, these ascomycetes belong in the genus Pestalosphaeria, which was established by Barr in 1975 to accommodate the perfect stage of Pestalotiopsis. This is the first record of the genus of Pestalosphaeria Barr (1975) in China. Two isolates, which were from Fokienia hodginsii (Dunn.) Henry et Thomas and Liquidambar formosana Hance, were identified as Pestalosphaeria hansenii Shoemaker & Simpson; the other three isolates, which were from Rhododendron latoncheae Franch, Rhododendron sp. and Podocarpus nagi (Thunb.) Zoll. et Mor. ex Zoll., appear to be distinct from all the known Pestalosphaeria species, and have been described as two new species, viz., Pestalosphaeria accidenta sp. nov. and Pestalosphaeria jinggangensis sp. nov., based on their anamorph and teleomorph morphological characters.

1. Pestalosphaeria accidenta P. L. Zhu, Ge et T. Xu, sp. nov. (Fig. A-E)

ANAMORPH:
Pestalotiopsis baarnensis Stey., Bull. Jard. Bot. Etat Bruxelles 19:342-343, 1949.
=Pestalotia baarnensis (Stey.) Guba, Monograph of Monochaetia and Pestalotia, P.151-152, 1961.

Perithecia globosa vel depresse globosa, ad apicem collis papilliformibus praedita, 315.8-420.1 μm diam. Collum leniter erumpens, ostiolum circulare, usque ad 21.3-26.0 μm diametrum, paries 25.0-35.0 μm crassus. Asci unitunicati, clavati, breviter stipitati, octospori, 62.5-72.9 X 8.3-9.9μm. Paraphysibus parce septatis, hyalinis. Ascosporae monostrictae, ellipsodeae vel ovoideae, pallidae usque pallide brunneae, 2-septatae, rarissime 1-

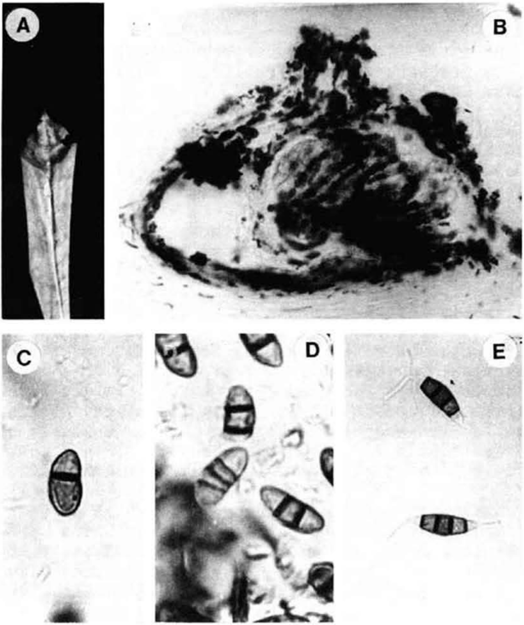

Fig.A-E: *Pestalosphaeria accidenta* sp. nov. from type.

A:Symptoms on leaves of *Rhododendron latoncheae* Franch. B:Vertical section of an ascoma,ca X 250. C, D: Mature ascospores with 1 to 3 septa, ca X 1000. E:Conidia of anamorph, ca X 1000.

vel 3-septatae, 13.0 -16.9(-18.2) X 4.8-6.8(-7.8) μm.

Habit in foliis Rhododendri latoncheae Franch, Jinggangshan, Jiangxi Provincia, Sinica, P. L. Zhu, 15 X 1987. (HSP87I-245 Typus).

Perithecia immersed in the matrix with a somewhat papillate neck, dark brown, globose to depressed, 315.8-420.1 μm diam. Apical ostiole erumpent, circular, up to 21.3-26.0 μm diam. Perithecia wall 25.0-35.0 μm thick. Asci unitunicate, clavate, with a short stalk, 8-spored, 62.5-72.9 X 8.3-8.9 μm. Paraphyses hyaline, sparsely septate. Ascospores uniseriate, ellipsoidal to ovate, pale to slightly brown, 2-septate, occasionally 1- or 3-septate, 13.0-16.9(-18.2) X 4.8-6.8(-7.8) μm. Its anamorph with conidia 5-celled, cylindric, straight or slightly curved, 20-27 X 6-7 μm; the upper two colored cells umber, the lower one light olivaceous, 14-17 μm; the apical hyaline cells long-conoid, bearing 2-3 appendages, occasionally 4, often branched, 13-25 μm long; pedicels straight or curved, 6-14 μm long.

On leaves of Rhododendron latoncheae Franch, Jinggang Mountain, Jiangxi Province, China. P. L. Zhu, Oct. 15, 1987. (HSP87I-245 Typus). On leaves of Rhododendron sp., Jinggang City, Jiangxi Province, China. P. L. Zhu, Oct. 16, 1987. (HSP87I-221). The type specimen of the new species is deposited in the Mycological Herbarium of the Dept. of Plant Protection, Zhejiang Agricultural University.

The brown lesions, starting from the top of the leaves, occasionally from the center, become gray brown eventually. There are just a few ascospores in the type specimem, and the type description was based on the fructifications on PDA plate.

The type species of the genus Pestalosphaeria, P. concentrica, was also recorded on Rhododendron, i.e., R. maximo L.(1), but its ascospores are longer, up to 13.5-20.0 X 7-10 μm, 3 celled, while the ascospores of P. accidenta are mostly three celled, occasionally 2 to 4 celled. They can also be distinguished by their different cultural characters. P. concentrica grows very slowly on PDA medium, colonies 2.5-3.5 cm in diameter in three weeks, while the P. accidenta has colonies up to 4.5 cm in diameter on PDA medium at 25 ℃ in 4 days.

Another species, Pestalosphaeria elaeidis (Booth & Robertson) Van der Aa = Leptosphaeria elaeidis Booth & Robertson, has an anamorph with conidia 27-34 X 6-7(-10) μm. and spathulate setae; the conidia of P. accidenta are not spathulate at the end of the setae. The teleomorphs of the above two species are quite similar, but the anamorphs differ markedly in conidia dimensions and their setulae features.

2.Pestalosphaeria jinggangensis P. L. Zhu, Ge et T. Xu, sp. nov. (Fig.F-J)

ANAMORPH:

Pestalotiopsis podocarpi (Dennis) X. A. Sun et Ge, Acta Agriculturae Universitatis Zhejingensis, 1990 Supplement(In press)

=Pestalotia podocarpi Dennis, Phytopathology 24:1026-1028, 1934, Fig. 1.

=Pestalotia funerea Desm. var. podocarpi Sacc., Monograph of Monochaetia and Pestalotia, P.133-134, Guba, 1961.

Perithecia fusce brunnea, depresse globosa, usque ad 210.5-294.7 μm diam, 189.5 alt, paries pseudoparenchymaticus, 18.2-23.4μm cr, ad apicem ostiolis circularibus praedita, usque ad

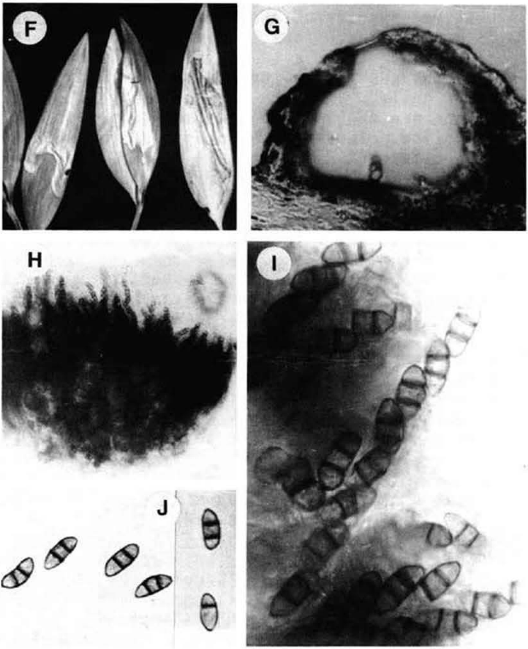

Fig.F-J:*Pestalosphaeria jinggangensis* sp. nov. from type.

F: Symptoms on leaves of *Podocarpus nagi* (Thunb.) Zoll. et Mor. ex Zoll. G: Vertical section of an ascoma, ca X 200. H: Asci, ca X 310. I: Asci and ascospores, ca X 1100. J: Ascospores with 1 to 2 septa, ca X 600.

21.3-26.0 μm diam. Asci unitruncati, clavati, octospori, 62.5-72.9 X 5.2-7.8 μm, paraphysibus simplicibus, parce septatis, hyalinis, interpositis. Ascosporae uniseriatae, cylindraceae vel ellipsoideae, pallide brunneae usque brunneae, plerumque 2-septatae, rarissime 1-septatae, in septo leniter contractae, 12.9-16.4 X 5.2-7.0 μm.

Habit in foliis Podocarpi nagi (Thunb.) Zoll. et Mor. ex Zoll., Jinggangshan, Jiangxi provincia, Sinica. P. L. Zhu, 16 X 1987, (HSP87I-223, Typus).

Perithecia formed in the matrix, then rises and finally becoming erumpent. They are black brown, globose depressed, with an ostiole, up to 210.5-294.7 μm diam, 189.5 μm high; perithecial wall 18.2-23.4 μm thick, composed of 10-15 layers of cells. The inner layers are thin-walled, and the outer ones thick-walled; ostiole circular, up to 21.3-26.0 μm diam. Asci unitunicate, clavate, 8-spored, 62.5-72.9 X 5.2-7.8 μm. Paraphyses simple, hyaline, sparsely septate. Ascospores uniseriate, cylindrical to ellipsoidal, umber to brown, mostly 2-septate, occasionally 1-septate, slightly constricted at the septa, 12.9-16.4 X 5.2-7.0 μm. Its anamorph with acervuli black, scattered under the epidermis, slightly erumpent. Conidia 5-celled, long-elliptical, tapering toward the extremities, slightly curved, 16.7-23.5 X 5.6-7.5 μm; the upper two colored cells yellow-brown, the lower one olivaceous; terminal cells hyaline, conic; appendages 2-4, acrogenous, acropleurogenous, 5.1-12.9 μm, occasionally up to 16 μm long; pedicels short, 2.6-7.8 μm.

On leaves of <u>Podocarpus nagi</u> (Thunb.) Zoll. et Mor. ex Zoll., Jianggang Mountain, Jiangxi province, China. P. L. Zhu, Oct. 16, 1987. (HSP87I-223. Typus). The type specimen is deposited in the Mycological Herbarium of the Dept. of Plant Protection, Zhejiang Agricultural University.

The lesions were situated on the wounds caused by insects, gray to light brown, with acervuli scattered under the epidermis. The single spore isolates of the *Pestalotiopsis* on the lesions formed perithecia of *Pestalosphaeria jinggangensis* on PDA medium after 5-6 months at room temperature.

Pestalosphaeria jinggangensis is similar to *Pestalosphaeria hansenii*, but the ascospores of *P. hansenii* are smaller, 13.0-14.5 X 4.5-6.0 µm, 2-septate, while those of *P. jinggangensis* are mostly 2-septate, occasionally 1-septate, and its corresponding anamorph has smaller conidia, 16.7-23.5 X 5.6-7.5 µm. They can be easily distinguished by their anamorphs, *P. hansenii* has conidia oblong elliptical, 21.5-27.5(-30) X 4.5-6.0 µm.

3. *Pestalosphaeria hansenii* Shoemaker & Simpson, Can. J. Bot. 59:986-991, 1982.

ANAMORPH:
Pestalotiopsis foedans (Sacc. & Ell.) Stey., Bull. Jard. Bot. Etat Bruxelles 19:329, 1949.
=*Pestalotia foedans* Sacc. & Ell., Syll. Fung. 3:792, 1884.

Ascomata immersed in the medium with an erumpent neck, globose to depressed globose, up to 200 µm in diam, 210-280 µm high, dark brown; wall 15-25 µm thick; ostiole circular, 24 µm in diameter. Asci unitunicate, cylindircal, apical apparatus with an amyloid annulus, octosporous, 71.0-78.5 X 7.7-9.0 µm. Ascospores uniseriate, two septate, occasionally three septate, pale brown to amber brown, wall smooth and slightly constricted at the septa, 13.0-14.5 X 4.8-6.0 μm. Its anamorph with acervuli densely gregarious, sooty at maturity, 200-425 X 170-340 μm. Conidia 5-celled, slender fusiform, tapering toward the base, erect, 19-24 X 5.5-7.0 μm, slightly constricted at the septa; the upper two colored cells amber, the lower most one olivaceous; apical hyaline cells conic, appendages 2-3, occasionally 4, 6-18 μm long; pedicels 4-9 μm.

On leaves of *Fokienia hodginsii* (Dunn.) Henry et Thomas, Jinggang Mountain, Jiangxi province, P. R. China. P. L. Zhu, Oct. 15, 1987. (HSP87I-243). On leaves of *Liquidambar formosana* Hance, Jinggang Mountain, Jiangxi province, P. R. China. P. L. Zhu, Oct. 15, 1987. (HSP87I-215).

This species was reported by Shoemaker et al. (1980) on *Pinus carribaea* Morelet var. *hondurensis* Barrett & Golfari.

Based on the type description of *P. hansenii* by Shoemaker et al. (1980), the anamorph of this species has conidia 5-celled, 21.5-27.5 X 4.8-6.0 μm, the three colored cells brown, sometimes with the center one slightly darker. The two specimens we obtained were identical to Shoemaker's description, and have been identified as *Pestalotiopsis foedans*. *Pestalotiopsis funerea* (Desm.) Stey., commonly recorded on pine, has broader conidia, 7.0 -9.5 μm wide, and with more apical appendages, usually 4 or 5.

Key to the known species of *Pestalosphaeria*

Based on the morphological features of both anamorph and teleomorph, a version of the key

(Nag Raj 1985) are given to the known species of *Pestalosphaeria* as follow:

1. Ascospores verruculose · · · · · · · · · · · 2
1. Ascospores smooth · · · · · · · · · · · · · · · 3

2. Ascospores 20-23 X 8.5-10 μm, versicoloured, central cells amber brown, end cells grayish brown · · · · · *Pestalosphaeria austroamericana*
2. Ascospores 10-17 X 6-8 μm, concolorous and pale brown to brown · · · *Pestalosphaeria varia*

3. Conidial appendages 2-3, with spathulate tip, 19-24 μm long. Conidia concolorous, olivaceous, brown. Ascospores 12-21 X 4.5-6.0 μm; · · · · · · · · · · *Pestalosphaeria elaeidis* ·
3. Conidial appendages without spathulate tip · · 4

4. Ascospores 12.5-15.5 μm long · · · · · · · · · 5
4. Ascospores 13.0-19.5 μm long · · · · · · · · · 6

5. Ascospores 2-septate, without wall ridges; conidia versicolorous, 21.5-27.5(-30) X 4.5 - 6 μm, appendages 2-4, filiform, 9-17 μm long · · · · · · · · · *Pestalosphaeria hansenii*
5. Ascospores mostly 2-septate, occasionally 1-septate; conidia concolorous, 16.7-23.5 X 5.6-7.3 μm, appendages 2-3, 6.3-13.3 μm long · · · · · · · *Pestalosphaeria jinggangensis*

6. Ascospores versicolorous, 7-10 μm wide, with conspicuous wall ridges; conidia 20-32 X 6-8 μm, apical appendages 2-4, 12-38 μm long · · · · · · · · · · · · *Pestalosphaeria concentrica*
6. Ascospores concolorous, 4.8-6.8 μm wide, without wall ridges; conidia 20.5-25.2 X 5.4-7.0 μm, apical appendages 2-4, 11.9-20.6 μm long · · · · · · · · *Pestalosphaeria accidenta*

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SCUTELLOSPORA IS SCUTELLOSPORA

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SUMMARY

Almeida's alteration of the genus name *Scutellospora* to *Scutellispora* is unacceptable. Recent papers published by Morton and Benny, and Morton, accepted the modification without critical comment. This acceptance was erroneous and should not be taken as lending credence to the change.

INTRODUCTION

The spelling of the genus *Scutellospora* Walker & Sanders was challenged on legalistic grounds in an article by Almeida (1990). The author stated that the correct spelling of the word should be *Scutellispora* because the compounding vowel should have been based in Latin rather than Greek.

In two important recent publications, Morton and Benny (1990) and Morton (1990) accept Almeida's recommendations without critical comment. This is particularly unfortunate in the former paper where the authors erected a new suborder and family, which include *Scutellospora*, and spelled the genus in the familial protologue with an -i- rather than an -o- as a compounding vowel. This acceptance was erroneous.

RULES OF NOMENCLATURE

The naming of taxa in the Fungal Kingdom is governed by the *International Code of Botanical Nomenclature* (the Code) (Greuter *et al.* 1988). This provides a set of rules (*Articles*) and accompanying guidance notes (*Recommendations*). The former are mandatory: in the words of the Code, "... names contrary to a rule cannot be maintained." The latter, however, deal with subsidiary points, and are merely for guidance. To quote the Code once more, "... names contrary to recommendations cannot ... be rejected ...".

The word 'name' applies to all taxa above and including genera. The name given to subgenus, species (and subspecies) is a special type of name, found only in combination with another, and is termed an *epithet* ("... a word, other than a generic name or a term indicative of rank, forming part of a combination") (Jeffrey 1977 [p. 59]). This distinction is important in the consideration of the rules and recommendations of the code.

SCUTELLOSPORA OR *SCUTELLISPORA*

Almeida's article discusses the roots of the name (a combination of Greek and Latin), and proposes, based on Recommendation 73G of Article 73.8 in the Code, that the connecting vowel between the components should be -i-, rather than -o- as in the generic protologue (Walker and Sanders 1986). The use of the vowel -i- was considered when the original article was written but it was rejected on the grounds of euphony. It was my view that *Scutellospora* had a more pleasing sound on pronunciation than *Scutellispora*, especially when used in conjunction with its related genera, *Acaulospora* Gerd. & Trappe and *Entrophospora* Ames & Schneider. This view is supported by Stearn (1973), who wrote, quoting Kretschmer (1899), "In late Latin ... owing to the influence of Greek, compounds were sometimes formed by -o- instead of -i- as a connecting vowel... [These] are not to be treated as orthographical errors, but accepted as examples of standard procedure ..."
[p. 287].

The Article (73.8), in the Code with its accompanying Recommendation (73G), to which Almeida refers applies only to epithets. To quote the Article, "The use of a compounding form contrary to Recommendation 73G in an adjectival epithet is treated as an error to be corrected." In justifying his change, Almeida assumes, erroneously, that this also applies to generic names. In addition, Article 20.1 of the Code states that the name of a genus "... may be taken from any source whatever, and may *even be composed in an absolutely arbitrary manner* [my emphasis]." The latter article is relevant to generic names, and applies in this instance. The former Article was misinterpreted by Almeida when he applied it to *Scutellospora*.

GIGASPORACEAE

The protologue of the family Gigasporaceae in Morton & Benny (1990) requires emendation to correct the errors resulting from Almeida's paper. The description of the family remains, for now, unaltered, but the genera it encompasses should read as follows:

Type genus: *Gigaspora* Gerd. & Trappe, 1974 (*Mycologia Memoir* **5**:25)

Other taxon: *Scutellospora* Walker & Sanders, 1974 (*Mycotaxon* **27**:179)

CONCLUSION

The original, validly published name of *Scutellospora* should be retained for that genus, and the change proposed by Almeida (1990) should be rejected. More attention should be paid to the distinction between rules and recommendations in the Code when suggesting the correction of names. Failure to do so in this instance has led to at least one major error of nomenclature in this important group of fungi, with consequent confusion in the minds of other workers.

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LACCARIA LONGIPES, A NEW NORTH AMERICAN SPECIES OF THE LACCARIA LACCATA COMPLEX

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Laccaria longipes is described from *Sphagnum* bogs in several upper midwestern states and Ontario, Canada. Specimens of this species have previously been included in *L. laccata* var. *moelleri*. Studies on phenetic similarities, intercollection pairing reactions, and analyses of restriction fragment length polymorphisms of mitochondrial and nuclear ribosomal DNA support recognition of two distinct taxa. The two taxa can be distinguished morphologically by the significantly smaller basidiospores reported for *L. longipes* in relation to those observed in *L. laccata* var. *moelleri*. *Laccaria longipes* has only been recorded from North America while *L. laccata* var. *moelleri* appears to be restricted to Europe.

Mueller and Vellinga (1986) and Mueller (1990) recognized several varieties of *Laccaria laccata* (Scop.: Fr.) Cooke including *L. laccata* var. *moelleri* Singer. This taxon was reported from several areas in Sweden and North America. *Laccaria laccata* var. *moelleri* occurs in *Sphagnum* bogs or, more rarely, among other mosses and is characterized by having moderately sized, striate pilei and very long stipes.

Data have since been obtained and analyzed from intercollection pairing studies, phenetic analyses (Mueller, unpublished), and analyses of restriction fragment length polymorphisms (RFLPs) of mitochondrial and nuclear ribosomal DNA (mtDNA and rDNA, respectively) (Gardes *et al.*, 1990a, b) on representatives of *L. laccata sensu lato*. A synthesis of these data indicate that North American specimens previously included in *L. laccata* var. *moelleri* should be treated as a separate species, *L. longipes sp. nov.* The European collections examined remain in *L. laccata* var. *moelleri*.

Color names within parentheses are from Kornerup and Wanscher (1978). The number of basidiospores measured and the number of collections examined for calculating mean size (= $\bar{x}$) and length/width ratio (= Q) are included in brackets with basidiospore size information to give some indication of reliability of these data (Bas, 1974). When available, data on basidiospores from additional collections were included in basidiospore size range data. Ranges of collection means ($\bar{x}$, Q) for basidiospore data rather than overall mean values for the taxon are provided to give a better indication of intraspecific variation. Basidiospore size data are always given without ornamentation with the hilar appendage in profile. Somatic culture mat data were obtained following the procedures outlined in Mueller (1984).

LACCARIA LONGIPES G. M. Mueller. *sp. nov.* FIG. 1.

> *Pileo 11-55(-78) mm lato, striato, subfibrilloso, aurantio-brunneo. Lamellis carnais. Stipite 67-138(-165) x 3-9 mm, substriato, pileo concolori; mycelio basali albo. Basidiis tetrasporis. Cheilocystidiis nullis. Basidiosporis plerumque 7-8.5 x 6-8 µm (sine ornamentatione), subglobosis vel late ellipsoideis, echinulatis; spinis 0.8-1.5 µm longis.*
>
> Type specimen. (HOLOTYPE): CANADA: Ontario, Nipissing District, Algonquin Provincial Park, Spruce Bog Trail, among *Sphagnum* under *Picea mariana*, *Larix laricina*, and *Alnus rugosa*, 18 September 1984, *G.M. Mueller 1929* (F 1091979) (F).

Pileus 11-55(-78) mm broad, convex to broadly convex often becoming plane to uplifted, often centrally depressed, slightly to moderately translucent striate, finely fibrillose, orange brown (6-B-5 to 6-D-7) fading to buff in age; margin incurved to decurved or plane, entire to undulate, becoming slightly eroded. **Lamellae** adnate, distant, moderately thick to thick, up to 10 mm broad, light flesh color (near 6-A-2). Stipe 67-138(-165) x 3-9 mm, equal with slightly swollen base or narrowly clavate, dry, slightly to moderately fibrillose striate, concolorous with pileus. **Basal mycelium** white. **Basidiospores in mass** white.

Pileipellis a cutis of radially arranged barrel-shaped hyphae with occasional, scattered small fascicles of 10-30 ± perpendicular hyphae; terminal cells 5-10 µm, morphologically undifferentiated to subclavate, hyaline. **Pileus trama** tightly interwoven, morphologically undifferentiated, hyaline to light yellowish brown. **Lamellar trama** of parallel to subparallel hyphae, mostly 3-19 µm diam, thin-walled, hyaline; cells long, barrel-shaped. **Subhymenium** morphologically undifferentiated. **Basidia** 28-44 x 7-10 µm, clavate, elongate, hyaline; sterigmata 4, up to 10 µm long. **Pleurocystidia** lacking. **Cheilocystidia** none seen. **Basidiospores** (excluding ornamentation) [158\7] 7-8.5(-9) x 6-7.8(-8.4) µm ($\bar{x}$ = 7.6-7.8 x 6.8-7.2 µm), Q = (1-)1.05-1.2(-1.3) (Q = 1.08-1.13), subglobose to broadly ellipsoid, occasionally globose or ellipsoid,

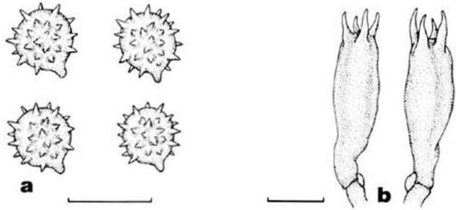

FIG. 1. *Laccaria longipes* (Holotype, *G. M. Mueller 1929*). **a**. Representative basidiospores. **b**. Representative basidia. Scale lines = 10 µm.

hyaline, inamyloid, not dextrinoid, acyanophilous, echinulate; echinulae (0.7-)1-1.5(-2) µm long, less than 1 µm wide at base. **Clamp connections** at nearly all septa.

SOMATIC CULTURE MAT MORPHOLOGY (n = 1; *G.M.M. 1929 I*): **PDA: Radius** at week 6 = 43 mm; **mat** felty, moderately thick to thick, tightly interwoven, submerged, not translucent, uniform texture near plug, forming dendritic thicker strands from midpoint to margin, tan to olive brown; **margin** up to 6 mm broad, subfelty to silky, abruptly thinner than mat, tan; **hyphae** 2.5-5 µm diam, morphologically undifferentiated. **MMN: Radius** at week 6 = 28 mm; **mat** felty, thick, tightly interwoven, submerged, uniform texture, dull white; **margin** up to 5 mm broad, very irregular, white; **hyphae** 2.5-8 µm diam, most morphologically undifferentiated, some irregularly swollen. **MEA: Radius** at week 6 = 42 mm; **mat** subfelty, thin, translucent, white; **margin** 2-3 mm broad, not well differentiated, white; **hyphae** 2.5-8 µm diam, most morphologically undifferentiated, occasionally irregularly swollen.

ETYMOLOGY: The epithet refers to the long stipe which is characteristic of this species.

HABITAT AND DISTRIBUTION: Among mosses, especially *Sphagnum*, usually under *Picea mariana* (Mill.) B. S. P. and other trees such as *Larix laricina* (Du Roi) K. Koch and *Alnus rugosa* (Du Roi) Spreng. Reported to date from southern Ontario, Canada, and Michigan, Wisconsin and Minnesota, U.S.A.

COLLECTIONS EXAMINED: **CANADA: Ontario:** Nipissing District, Algonquin Provincial Park, Spruce Bog Trail, among *Sphagnum* under *Picea mariana, Larix laricina* and *Alnus rugosa*, 18 September 1984, *G. M. Mueller 1925, 1926, 1927, 1928, 1929* (F 1091982, 1092174, 1092172, 1091081, 1091079, respectively); 24 September 1984, *G. M. Mueller 1943, R. Singer 5159* (F 1092173, 1059926, respectively). **U.S.A.: Michigan:** Iron Co., 16 km north of Iron River, among *Sphagnum* under *Larix laricina*, 3 September 1990, *J. J. Steinke s.n.* (F 1092175). **Minnesota:** Cook Co., Grand Marais, among *Sphagnum* under *Picea mariana* and *Populus sp.*, 29 August 1986, *R. L. Doudrick Grand Marais # 1* (F 1072215); **Wisconsin:** Ozaukee Co., UW-Milwaukee Field Station, Sapa Spruce bog, among *Sphagnum* under *Picea mariana* and *Larix laricina*, 5 October 1989, *A. D. Parker s.n.* (F 1091980).

OBSERVATIONS: *Laccaria longipes* can be distinguished from other members of the *L. laccata* complex by its relatively small, subglobose basidiospores, very long stipe, and restricted habitat. *Laccaria laccata* var. *moelleri* also occurs in bogs and has similar macromorphological features but differs in having larger basidiospores ($\bar{x}$ = 8-10 x 7.3-8.3 μm). *Laccaria galerinoides* Singer is another taxon which grows among *Sphagnum*. It appears to be restricted to southern Argentina and Chile and has only been reported from under *Nothofagus antarctica* (G. Forster) Derst. *Laccaria galerinoides* differs from the two Northern Hemisphere taxa by having smaller and darker colored basidiomata and more elongate basidiospores (Q = 1.34 for holotype).

Tested isolates of *L. longipes* were intersterile with all other tested isolates of the *L. laccata* complex including isolates of *L. laccata* var. *moelleri*. This is in contrast to the tested isolates of *L. laccata* var. *moelleri* which were intercompatible with some of the tested Swedish isolates of *L. laccata* [= intersterility group 4 of Fries and Mueller (1984) and biological species 3 of Gardes *et al.* (1990a, b)] (Mueller and Vellinga, 1986; Mueller, 1990). To date, tested Swedish isolates of *L. laccata sensu lato* have been intersterile with all of the tested North American isolates of the complex [*i.e.*, *L. laccata* var. *pallidifolia (Peck) Peck*, *L. montana* Singer, *L. ohiensis* (Mont.) Singer *sensu* Montagne *non* Singer and *L. striatula* (Peck) Peck] (Mueller, unpublished).

RFLPs of mtDNA and rDNA indicate that divergence has occurred between *L. longipes* and other taxa in the *L. laccata* complex (Gardes *et al.*, 1990a, b). Similarly, divergence was observed between the tested Swedish isolates (biological species 3 and 4) and the isolates representing the two tested North American biological species (1 and 2) (Gardes *et al.*, 1990a, b). However, data do not exist on the amount of DNA divergence between *L. laccata* var. *moelleri* and other members of biological species 3 since both isolates of that biological species tested by Gardes *et al.* (1990a, b) are referable to *L. laccata* var. *moelleri*. In the publications by Gardes *et al.* (1990a, b), North American *L. laccata* biological species 2 was cited as *L.*

laccata var. *moelleri* because we believed the North American and Swedish populations to be contaxic. The decision to treat the North American and Swedish populations as distinct taxa occurred only after a synthesis of the data on RFLPs with data on intercollection pairing reactions and phenetic similarities. For this same reason, I identified the representative material used in the paper of Doudrick and Anderson (1989), which were all intercompatible and collected in peatlands, as *L. laccata* var. *moelleri*. These collections are now treated as *L. longipes*.

Phylogenetic relationships between these two taxa have not yet been determined because of the paucity of usable morphological characters and problems in determining homologies with the data on RFLPs (Gardes *et al.*, 1990a, b; Mueller and Gardes, 1990). It is not clear, therefore, whether *L. longipes* and *L. laccata* var. *moelleri* are closely related or if their similar macromorphology is due to convergence resulting from their occurrence among *Sphagnum* and other mosses.

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NOTES ON HYPHOMYCETES. LXI. STILBELLA ECUADORENSIS, A NEW SYNNEMATOUS SPECIES BELONGING TO SECTION DIDYMOSTILBELLA, FROM BALSA

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ABSTRACT

A synnematous hyphomycete bearing white synnemata and orange conidial masses, occurring on cankers on bark of young balsa trees (*Ochroma pyramidalis* Urb.) in Ecuador, has been determined to be a hitherto undiscovered species. The name *Stilbella ecuadorensis* Morgan-Jones et McKemy and is established for it and it is described and illustrated. Classified in subgenus *Stilbella*, section *Didymostilbella*, it differs from other species in several respects, particularly in possessing much larger conidia.

INTRODUCTION

In February 1990, numerous small, whitish synnemata, bearing dull orange conidial masses, were observed near the center of necrotic cankers on the boles of young balsa trees, less than one-year-old, grown on the western slopes of the Andean foothills in Los Rios Province, Ecuador. The fungus was subsequently isolated from the bark of colonized trees and grown in pure culture for use in controlled inoculation experiments in the field. Twenty young canker-free balsa trees were selected for the study. Ten of the trees were inoculated by placing synnemata and hyphae of the fungus into a small slit cut through the bark and phloem tissues of each tree with a flame-sterilized scapel; ten control trees were treated the same way except that the fungus was not placed into the slits. After inoculation, each slit was covered for a three-week period with a thin plastic sheet held in place with tape. Inoculation sites were examined for canker development at the time the plastic sheets were removed and at three-week intervals thereafter for three months. Inoculations with cultures of the fungus failed to reproduce the disease and it is therefore considered to be saprotrophic rather than pathogenic (Kelley, unpublished). Based on our present knowledge,

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the cankers upon which the fungus was found are believed to have been of physiological origin.

Microscopic examination of the morphology of the fungus has revealed that it belongs in *Stilbella* Lindau, subgenus *Stilbella*, section *Didymostilbella* Siefert. Section *Didymostilbella* was established by Seifert (1985), in his comprehensive monograph of *Stilbella*, to accommodate species with pale colored synnemata bearing clavate or obovoid, aseptate or one-septate conidia. Three species, namely *S. fusca* (Sacc.) Siefert, *S. clavispora* Siefert and *S. stereicola* Siefert, were included in the section. The new species described herein is essentially similar to these species, especially *S. stereicola*, but differs in several respects, including having appreciably larger conidia.

TAXONOMIC PART

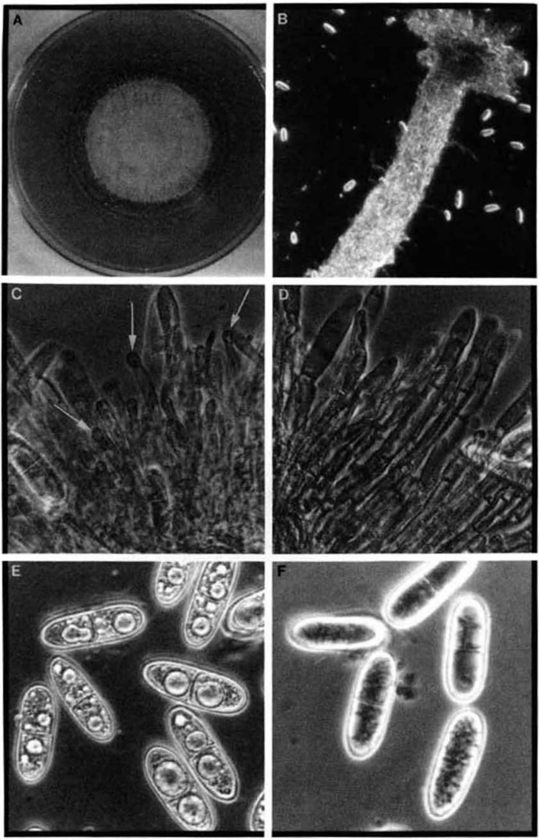
Stilbella ecuadorensis Morgan-Jones et McKemy, sp. nov. (Plate 1, Figure 1).

Mycelium immersum, ex hyphis hyalinis, ramosis, septatis, laevibus, 2-3 um crassis compositum. Coloniae in agaro decocto tuberorum lanosae, albae, zonatae, post 7 dies ad 25C 28 mm diametro. Synnemata dispersa vel gregaria, erecta, recta vel modice flexuosa, non ramosa, cylindrica ad modice clavata, capitata, usque ad 1,300 µm alta, 50 - 160 µm crassa; stipites minusve robusti, albi, modice pubescentes. Hyphae stipitis 2-3 µm crassae, laeviae, parallelae; hyphae marginales clavatae, 3-8 µm crassae, echinulatae ad verruculosae, parietibus modice crassis, ad apicem divergentiae. Conidiophora cylindrica, ex hyphis apicem versus ramosa, monochasialia. Cellae conidiogenae monophialidicae, in conidiophoris incorporatae, terminales vel laterales, determinatae, cylindricae vel leviter subulatae, 32-41 µm longae X 3.5-4 µm crassae. Conidia acropleurogena, enteroblastica, in capitulum mucosum producta, obovata, recta, laevia, hyalina, guttulata, 1-septata, ad basim plus minusve truncata, 27-41 X 10-11.5 µm. Conidiorum massa globosa, aurantiaca.

In corticis emortuis Ochromae pyramidalis, Los Rios Province, Ecuador, W.D. Kelley, February 1990, AUA, holotypus.

Mycelium mostly immersed in the substratum, composed of hyaline, branched, septate, smooth, 2-3 µm wide hyphae. Colonies on potato dextrose agar [Difco] rather slow-growing, variable in appearance, woolly, with aerial mycelium ranging from very sparse to relatively dense, white, or becoming Greyish Orange to Greyish Red, [6B4 to 7B4] (Kornerup and Wanscher, 1978), zonate, margin more of less even, attaining a diameter of 28 mm at 25C after 7 days, 23 mm at 20C, and 18 mm at 30C. With age, colonies becoming somewhat felted. Colonies with sparse aerial mycelium producing synnemata mush more abundantly than those which are dense and wooly. Reverse opaque white, often with pale, greyish-brown concentric rings. Colonies growing at 20C tending to

PLATE 1. *Stilbella ecuadorensis*. A, 14-day-old colony on V-8 juice agar grown at 25C, showing concentric rings of synnemata peripherally; B, synnema; C, conidiogenous cells (indicated by arrows); D, verruculose marginal hyphae; E, conidia (mounted in water); F, conidia (mounted in lactophenol), [B-F, phase contrast].


A
B
C
D
E
F

have denser aerial mycelium. Colonies on V-8 juice agar (Stevens, 1974) similar in appearance but, generally, with more abundant aerial mycelium, attaining a diameter of 46 mm at 25C after 7 days, 22 mm at 20C, and 21 mm at 30C. Synnemata in nature scattered or frequently gregarious, erect, straight or very slightly flexuous, unbranched, cylindrical or somewhat clavate, capitate, up to 1,300 µm in length, 50-160 µm wide; stipes fairly robust, white, sparsely pubescent with scattered marginal hairs diverging slightly from the main axis. Hyphae of stipe 2-3 µm wide, hyaline, cylindrical, smooth, more or less parallel, occasionally branched, with septa 16-38 µm apart; marginal hyphae clavate, 3-5 µm wide, up to 8 µm wide distally, densely echinulate to verruculose, with a slightly thickened wall, moderately divergent, especially toward the extreme apex of the synnemata. Marginal hyphae at the tip tending to be more inflated than those elsewhere and very slightly constricted at the septa. Synnemata in culture tending to be longer and more flexuous, up to 5 mm long in some instances, scattered or, more frequently, in dense concentric rings. Conidiophores cylindrical, branched towards the apices, monochasial. Conidiogenous cells monophialidic, integrated, terminal or lateral, determinate, cylindrical or slightly tapered toward the tip, 32-41 µm long, 3.5-4 µm wide, with a barely discernible, apical, periclinal thickening. Conidia acropleurogenous, enteroblastic, aggregated in a mucoid head, narrowly obovate to broadly clavate or broadly oblong with obtuse ends, straight, smooth, guttulate, 1-septate, with a narrow truncate base, 27-41 X 10-11.5 µm. Conidial mass more or less globose, Carrot Red to Reddish Golden [6B7 to 6C7] (Kornerup and Wanscher, 1978) in color.

On bark of *Ochroma pyramidalis* Urb.; South America.

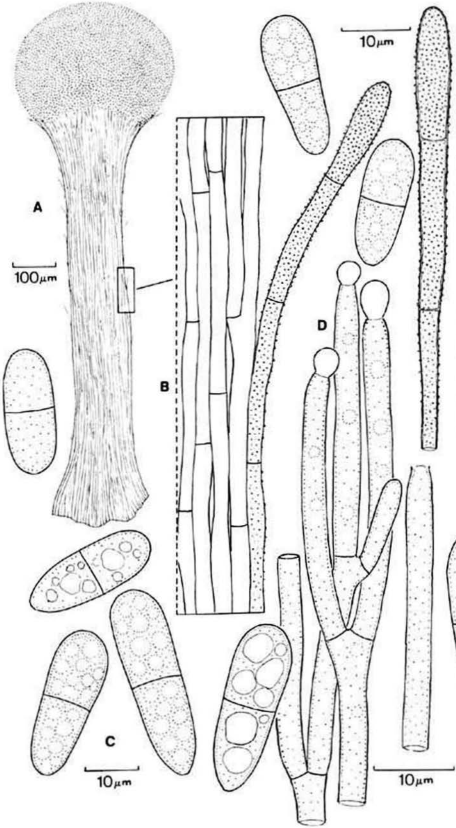
Collection examined: on necrotic cankers on dead bark of young *O. pyramidalis* trees, Los Rios Province [0 45' south latitude / 79 15' west longitude], Ecuador, W.D. Kelley, February, 1990, AUA, holotype. Isolates derived from this collection. Representative type isolate deposited at ATCC.

DISCUSSION

When first isolated, colonies of *S. ecuadorensis* form sparse aerial mycelium but produce synnemata abundantly in concentric rings. After transfer several times, colonies tend to become densely woolly and loose their capacity to form synnemata. Following maintenance in culture on agar for several months, synnemata are produced only sparsely or not at all. Isolates grown on V-8 juice agar retain capacity to produce synnemata longer than when grown on PDA.

Stilbella ecuadorensis, although having appreciably larger conidia than the other three species, fits well in section *Didymostilbella*. As indicated above, it broadly resembles *S. stereicola*. It has synnema with marginal hyphae that are similar in shape and ornamentation to those of that species. In conidium size and in having densely guttulate conidial cytoplasm, it resembles species of *Didymostilbe* Henn., but the conidia of species of that genus are quite different

FIGURE 1. *Stilbella ecuadorensis*. A, synnema; B, portion of synnema showing constituent hyphae, including one marginal hypha; C, conidia; D, conidiophores; E, marginal hyphae.


10µm
A
100µm
B
D
E
C
10µm
10µm

in being thick-walled and usually papillate at each end (Seifert, 1985). Moreover, the flaring, cupulate collarettes characteristic of conidiogenous cells of *Didymostilbe* are absent in *S. ecuadorensis*.

ACKNOWLEDGMENT

We thank Dr. J. Leland Crane, Illinois Natural History Survey, Champaign, for reviewing the manuscript.

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TAXONOMICAL STUDIES ON USTILAGINALES. VII.*

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ABSTRACT

NEW SPECIES proposed: Entyloma erodii Vánky (type on Erodium laciniatum). – Tilletia lepturi Sigriansky ex Vánky (type on Pholiurus pannonicus). – Ustilago prostrata Vánky & Oberwinkler (type on Polygonum prostratum).

NEW COMBINATIONS proposed: Sporisorium caledonicum (Patouillard) Vánky, based on Sorosporium caledonicum (on Heteropogon contortus). – Sporisorium contortum (Griffiths) Vánky, based on Sorosporium contortum (on Heteropogon contortus). – Sporisorium erythraeense (H. & P. Sydow) Vánky, based on Ustilago erythraeensis (on Hackelochloa granularis). – Sporisorium inconspicuum (Zundel) Vánky, based on Sphacelotheca inconspicua (on Mesosetum loliiforme). – Sporisorium lepturi (Thümen) Vánky, based on Ustilago carbo Tulasne var. lepturi (on Hemarthria altissima).

The following names are considered SYNONYMS: Urocystis hordei (Ciferri) Zundel (type on "Hordeum distichum" (= misidentified Secale cereale) is Urocystis occulta (Wallroth) Rabenhorst ex Fuckel. – Urocystis phlei (Lavrov) Ignataviciute (comb. illeg.) is Ur. phlei-alpini Terrier (type on Phleum alpinum). – Ustilago nagornyi Uljanishchev (type on Parapholis incurva) is Ustilago monermae R. Maire (type on Hainardia cylindrica). – Ustilago rottboelliae H. & P. Sydow & Butler (Type on Rottboellia compressa) is Sporisorium lepturi (Thümen) Vánky. – Ustilago urgineae R. Maire (type on Urginea maritima) is U. vaillantii L.-R. & C. Tulasne.

LECTOTYPE is selected for Sporisorium inconspicuum (Zundel) Vánky, for Ustilago nagornyi Uljanishchev (= U. monermae R. Maire), and for Ustilago urgineae R. Maire (= U. vaillantii L.-R. & C. Tulasne).

EXCLUDED SPECIES: Tuburcinia javanica Koorders on Hymenocallis sp.

In this paper, further results of my taxonomical investigations on smut fungi are presented.

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*Studies in Heterobasidiomycetes, part 86

Entyloma species on Geraniaceae.

Three Entyloma species were reported on different Geraniaceae: E. erodianum Sacc., E. atlanticum Mass., and E. geranii Kuzn. & Schwarzman.

Studying the type of E. erodianum Saccardo, 1915:33 (on Erodium moschatum (L.) Hér., Island of Malta, Addolorata, 9.III.1914, A. Caruano-Gatto, 388; PAD!), Vánky (1990:276) demonstrated that it is not a fungus but granules of an unidentified substance.

E. atlanticum Massenot, in Guyot, Malençon & Massenot, 1958:187 (as "atlantica"). Type on Geranium malviflorum Boiss. & Reuter, Morocco, Mts. Haut Atlas, near Asif Aït Iren, 1 km of Oukaïmeden refuge, 2500 m, 29.VI.1956, G. Malençon (Herb. Massenot!). It is characterised by the following:

Sori in leaves as slightly convex, yellowish-white to violet-tinted brown spots, 2–3 x 2–5 mm in diameter. Spores densely agglutinated, variable in form and size, rarely subglobose, usually angularly irregular, 10–17 x 13–22 µm, subhyaline to pale yellow; wall two-layered, inner layer thin (c. 0.5 µm), even, outer layer uneven, 0.5–3(–4) µm thick, smooth. Anamorph may be present. Known on Geranium malviflorum Boiss. & Reuter, G. transversale (Kar. & Kir.) Vved., and G. tuberosum L., Mediterranean Region to S.W. and C. Asia.

Entyloma geranii Kuznetzova & Schwarzman, in Schwarzman, 1960:276, was described from USSR, Kazakhstan, on different Geranium species (no type designated). The description of the sori is similar to that of E. atlanticum but the spores are supposed to be "globose, hyaline to brown, smooth, with a granular content, 3–13 µm in diameter; epispore 1–2 µm thick".

However, I conclude that E. geranii is a later synonym of E. atlanticum, based on my examination of a specimen labelled "type" as well as 3 out of 4 syntypes. Describing E. geranii, Kuznetzova & Schwarzman (in Schwarzman, 1960:276) neglected to compare their species to other Entyloma species on Geraniaceae. Spores from a specimen labelled "sp. nov. type" of E. geranii are, in variance with the original description, typical of E. atlanticum. In spite of its label, this specimen was not mentioned in the protologue. /The specimen is: "Entyloma geranii Kuznetzova & Schwarzman, sp. nov. Type", on Geranium transversale (Kar. & Kir.) Vved., USSR, Kazakhstan, Chilinskij raion, east spur of Zailijskij Alatau Mts, Syugatinskaya gorge, 6.V.1937, coll. Kubanskaya, det. S. Schwarzman; AA!/. Two further specimens, not mentioned in the protologue, of which I have seen only the labels, probably also contain spores of E. atlanticum. /One is on G. transversale (labelled as "Cotype") and the other is on G. tuberosum L., a plant often infected by E. atlanticum in C. and S.W. Asia/. The syntype I have not seen is on G. transversale, and it may well contain spores of E. atlanticum. The following three syntypes did not even contain Entyloma-type spores: 1) On Geranium albiflorum Ldb., Alma-Atinskaya obl., Mt. Zailijskij Alatau, Maloe Alma-Atinskoe gorge, 21.VI.1940, M. Kuznetzova (AA!), 2) On Geranium collinum Steph., Alma-Atinskaya obl., Mt. Zailijskij Alatau, Maloe Alma-Atinskoe gorge, at the Batarejka river, 30.VII.1978, S. Schwarzman (AA!), and 3) from Mynzhilki, 3000 m, 25.VIII.1947, M. Kuznetzova (AA!; on the label "10.VIII.1946"). Furthermore, the following specimen (not mentioned in the protologue) also lacks Entyloma-type spores: E. geranii on Geranium rectum Trautv., Alma-Atinskaya obl., Mt. Zailijskij Alatau, Bol'shoe Alma-Atinskoe gorge, 1.VII.1955, Ud'vichenko (AA!).

In the Herbarium of R. Maire, there is a further Entyloma, labelled as "Entyloma erodianum Sacc., on Erodium triangulare", which is different from both E. atlanticum, and also from the description of E. geranii (= E. atlanticum). It is described here as:

Entyloma erodii Vánky, sp. nov.
Typus in matrice *Erodium laciniatum* (Cav.) Willd. (= *E. triangulare* (Forsskål) Muschler), Tunisia, Sousse, 1927, Burollet (no. 94), Herb. Maire 8794 (MPU!).

Sori (Fig. 1) in foliis maculas rotundas parvas (0,3–2 mm) parum pustuliformes pallide brunneas formantes. Sporae (Fig. 2) globosae, ovoideae vel subpolygonaliter irregulares, 8–12 x 8–14 µm, subhyalinae usque flavobrunneae; pariete levi, sat frequenter aequali, 0,5–1 µm crasso, sed etiam inaequali: cum incrassationibus in angulis, episporio usque ad 2,5 µm crasso. Anamorpha ignota.

Entyloma erodii ab *E. atlantico* soris sporisque minoribus et pariete tenui sporarum distinctum.

Sori (Fig. 1) in leaves as small (0.3–2 mm), round, slightly pustular, light brown spots. Spores (Fig. 2) globose, ovoid or subpolygonally irregular, 8–12 x 8–14 µm, subhyaline to pale yellowish-brown; wall rather often even, 0.5–1 µm thick, but may be uneven with thickenings up to 2.5 µm at the angles, epispore smooth. Anamorph not seen.

Entyloma erodii differs from *E. atlanticum* in having smaller sori and smaller, thiner-walled spores.

Key to the *Entyloma* species on Geraniaceae.

Sori 2–5 mm long. Spores 13–22 µm long. Spore wall 1–4.5 µm thick. (On *Geranium* species) . . . . *E. atlanticum*

Sori 0.3–2 mm long. Spores 8–15 µm long. Spore wall 0.5–3 µm thick. (On *Erodium*) . . . . *E. erodii*

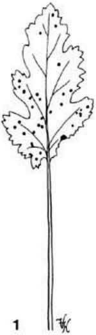
Entyloma on Araceae.

An interesting fungus on *Ambrosina bassii* L., was first reported by Bubák (1900:318) as *Cladochytrium pulposum* (Wallr.) A. Fischer. Bubák later (1903:255) restudied the original material and, influenced by P. Dietel, described it as *Entyloma dietelianum* Bubák, sp. nov. Ciferri (1924:59), without seeing a specimen, transferred *E. dietelianum* into the genus *Melanotaenium*. Ciferri based his decision on Bubák's original description of sori becoming black with age. However, when studied, the black sori proved to be produced by different saprophytic fungi. The description of this species is:

Entyloma dietelianum Bubák, 1903:255.
Melanotaenium? dietelianum (Bubák) Ciferri, 1924:59. – Type on *Ambrosina bassii* L., Italy, Island of Sardigna (Sardinia), Sinnai, Punto da Corsetta, 31.XII.1896, coll. Martelli (BPI 176989!).

The sori appear on the leaves as pustules, 0.5–1 mm in diameter, scattered or gregarious, reddish-brown, covered by the epidermis. Spores densely packed, variable in form and size, globose, ovoid or angular by mutual pressure, when young hyaline, later yellow to light yellowish-brown, 9–12(–14) x 10–16 (–19) µm; wall 1–3(–4) µm wide, two-layered, inner layer even (c. 1 µm), outer layer uneven, smooth. Anamorph not seen. This species is known only from the type collection.

In Madrid (MA 11672!) there is a specimen of "*Entyloma dietelianum*" on "Araceae cujusdam", collected in Morocco, containing spores of an *Entyloma* other than *E. dietelianum*. On examination, it proved to be *Entyloma ficariae* Fischer von Waldheim on *Ranunculus* sp. from *ficaria* group (host verified also by Prof. W. Sauer).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3


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Fig. 1. Sori of *Entyloma erodii* on a leaf of *Erodium laciniatum* (type).
Fig. 3. Sori of *Tilletia lepturi* in the ovaries of *Lepturus pannonicus* (type).
Fig. 5. Sori of *Ustilago prostrata* in the flowers of *Polygonum prostratum*.

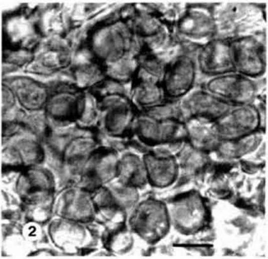
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Fig. 2. Spores of *Entyloma erodii* (type). (Bar = 10 µm).

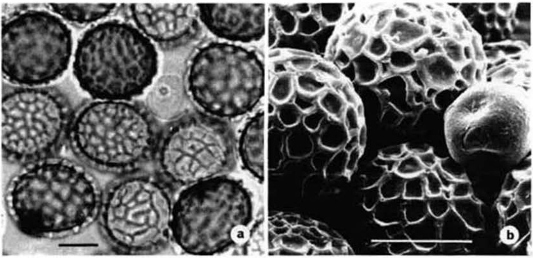

Fig. 4. Spores and sterile cells of Tilletia lepturi (type) in LM (a; Bar = 10 µm) and in SEM (b; Bar = 4 µm).

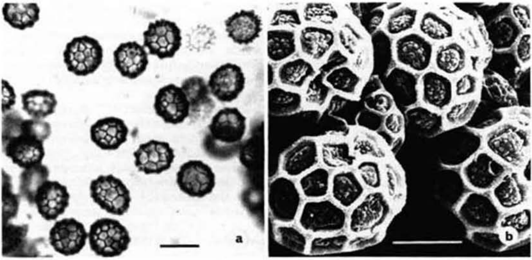

Fig. 6. Spores of Ustilago prostrata (type) in LM (a; Bar = 10 µm) and in SEM (b; Bar = 4 µm).

Professor J. Poelt kindly sent me smutted specimens of Hemarthria altissima (Poiret) Stapf & C.E. Hubbard (= Rottboellia altissima Poiret, = Manisuris altissima (Poiret) Hitschcock; det. H. Scholz), that he collected in Egypt, at Luxor. In connection with the identification of the fungus, I checked most of the floral smuts reported on Hainardia, Hemarthria, Lepturus, Manisuris, Monerma, Ophiurus, Parapholis, Pholiurus, and Rottboellia. Five species could be distinguished: 1) Tilletia lepturi Sigriansky, in Gutner (nomen nudum). 2) Ustilago monermae R. Maire, 3) Sporisorium lepturi, known as Ustilago lepturi (Thümen) P. Hennings, 4) Sporisorium ophiuri (P. Hennings) Vánky, and 5) Sporisorium erythraeense, known as Sphacelotheca erythraeensis (H. & P. Sydow) Clinton. Ustilago nagornyi Uljanishchev, turned out to be identical with U. monermae, and U. rottboelliae H. & P. Sydow & Butler identical with Sporisorium lepturi.

The main differentiating characters of these species are:

Sori in the ovaries. Spores reticulate, 21–25 µm long . . . . . . Tilletia lepturi
Sori in the spikelets. Spores verrucose, 12–17 µm long . . . Ustilago monermae
Sori in the whole inflorescence.
- Spores smooth to finely punctate, 6–10 µm long . . . . . Sporisorium lepturi
- Spores punctate to minutely echinulate, 9–14 µm long, sterile cells thick-walled . . . . Sporisorium ophiuri
- Spores echinulate, 9.5–12 µm long, sterile cells thin-walled . . . . Sporisorium erythraeense

Tilletia lepturi Sigriansky ex Vánky, sp. nov.

Tilletia lepturi Sigriansky, in Gutner, 1941:211 (nomen nudum). – Typus in matrice Lepturus pannonicus (Host) Kunth (= Pholiurus pannonicus (Host) Trin.), USSR, Obl. Voronezh, Raion Bobrov, pr. pag. Khrenovoye, 29.V.1914, M.P. Tomin (LEP!).

Sori (Fig. 3) in ovariis omnibus, evidentes, inter glumis sicut corpuscula atrobrunnea, ovoidea vel elongata, 2–3 mm longa, 1–1,5 mm lata apparentes, pericarpio induta; pericarpio rupto massa sporarum atrobrunnea, semi-agglutinata exposita. Sporae (Fig. 4) globosae, subglobosae usque ovoideae, 20–23(–24) x 21–25 µm, pallide flavobrunneae, pariete reticulatae cum maculis polygonalibus forma et magnitudine valde irregularibus, immo incompletis, diametris sporarum 5–10, muris 1,5–2 µm altis. Cellulae steriles globosae usque ovoideae, minores quam sporae (11–18 µm longae), hyalinae, pariete 1–2 µm crasso, leves.

Sori (Fig. 3) in all ovaries, evident, appearing between the glumes as dark brown, ovoid or elongate bodies, 2–3 mm long, 1–1.5 mm wide, covered by the pericarp which ruptures, exposing the semi-agglutinated, dark brown mass of spores. Spores (Fig. 4) globose, subglobose to ovoid, 20–23(–24) x 21–25 µm, light yellowish-brown; wall reticulate, meshes polygonal, very irregular in form and size, even incomplete, 5–10 meshes per spore diameter, muri 1.5–2 µm high. Sterile cells globose to ovoid, smaller than the spores (11–18 µm long), hyaline, wall 1–2 µm thick, smooth.

Ustilago monermae R. Maire, 1921:191.

Type on Monerma cylindrica (Willd.) Cosson & Durieu (= Hainardia cylindrica (Willd.) W. Greuter), Numidia (= Algeria), Constantine, Djebel-Ouach, 24.VI.1920, R. Maire (Herb. Maire 7160, MPU!).

Ustilago nagornyi Uljanishchev, 1950:82. – Lectotype on Lepturus incurvus (L.) Grossh. (= Parapholis incurva (L.) C.E. Hubbard; the exact host identity could not be checked on the fragment obtained from Prof. Uljanishchev), USSR, Azerbaydzhan (sel. here), Shirvan prov., delta of the Kura river at the Caspian sea, 11.V.1948, I. Shipanova (BAK!, LE!). The holotype (Azerbaydzhan, near Baku, 19.V.1928, V. Uljanishchev), as well as a further paratype were lost in Baku when a fire almost totally destroyed the herbarium ab. 25 years ago (Prof. Uljanishchev, pers. comm.). Only the above mentioned paratypes were saved and I propose the specimen in BAK as lectotype.

Sori in the rachis and spikelets, on the glumes restricted to the basal part, bullate, first covered by the epidermis which ruptures disclosing the black, semiagglutinated to powdery spore mass. Spores globose, subglobose to broadly ellipsoidal or rarely subpolygonally irregular, 10–14.5 x 12–17 µm, reddish-brown; wall 2–4 µm thick, two-layered, epispore rather uniformly, densely and distinctly verrucose. Germination: one to several germ tubes develop into four-celled basidia, each basidial cell producing an oblong basidiospore (Maire, 1921:192).

Sporisorium lepturi (Thümen) Vánky, comb. nov.

Basionym: Ustilago carbo Tulasne var. lepturi Thümen, in Fischer von Waldheim, Ann. Sci. Nat. Bot., Sér. 6, 4:200, 1877. – Ustilago lepturi (Thümen) P. Hennings, 1893:114. – Type on Lepturus incurvatus Trin. (= misidentified Hemarthria altissima (Poiret) Stapf & C.E. Hubbard), Egypt, near Damietta (= Dumyat), VII.1876, G. Schweinfurth. Isotypes in Thümen, Mycoth. univ. 1218 (as Ustilago carbo var. lepturi /"Leptura"/; HUV 3916!).

Ustilago rottboelliae H. & P. Sydow & Butler, 1907:486. – Sphacelotheca rottboelliae (H. & P. Sydow & Butler) Mundkur, 1939:111. – Type on Rottboellia compressa L. fil. (= Hemarthria compressa (L. fil.) R. Br.), India, Pusa, 28.VII.1907, E.J. Butler (723).

Cintractia densa McAlpine, 1910:168. – Sphacelotheca densa (McAlpine) Ciferri, 1928:32. – On Rottboellia compressa L., Australia (n.v.; No type designated; For this synonymy see Mundkur, 1939:111).

Sori comprising the whole inflorescence, cylindrical, 1.5–3 cm long, 1–2 mm wide, first covered by a grayish-brown fungal peridium which flakes away irregularly, disclosing the dark brown, powdery mass of spores, finally leaving behind a well-developed, central columella of host origin. In very young stage spores in irregular, many-spored groups, later single. Spores subglobose, ovoid to slightly irregular, 5.5–8 x 6–9(–10) µm, light olive-brown, wall thin (c. 0.5 µm), apparently smooth to very finely and sparsely punctate. Sterile cells in groups between the spores, irregular, larger than the spores, hyaline, smooth. Germination in MYP, at room temperature, in 2 days results in septate basidia bearing elongated basidiospores laterally and apically.

Sporisorium ophiuri (P. Hennings) Vánky, 1986:9.

Ustilago ophiuri P. Hennings, 1900:1. – Sphacelotheca ophiuri (P. Henn.) Ling, 1949:127. – Type on Ophiurus exaltatus (L. fil.) Kuntze (= Rottboellia conchinchinensis (Lour.) W.D. Clayton), Java, II.1884, O. Warburg (CONN).

Ustilago flagellata H. & P. Sydow, 1911:144. – Sphacelotheca flagellata (H. & P. Sydow) Zundel, 1938:301. – Type on Rottboellia exaltata L. fil. (= R. conchinchinensis (Lour.) W.D. Clayton), Philippines, Rizal Prov., Luzon, XII.1903, E.D. Merrill 7068 (CONN).

Sphacelotheca ophiuri-monostachydis Tai, in Ling, 1945:8. – Type on Ophiurus monostachys J.S. Presl (= Rottboellia conchinchinensis (Lour.) W.D. Clayton), China, Yunnan Prov., Wenshan, 11.VIII.1938, T.H. Wang & S.T. Chao. (For synonymy see Ling, 1949:127).

Sori along the rachis in the whole inflorescence, 8–30 cm long, first covered by a brown membrane which later flakes away revealing the dark brown mass of loose, many-spored spore balls and spores mixed with groups of sterile cells. Spores globose, subglobose, ovoid to slightly irregular, 8–12 x 9–14 µm, medium dark yellowish-brown, punctate to minutely echinulate. Sterile cells variable in shape and size, 10–18 µm long, usually with an oil droplet, singly, in pairs or usually in smaller or larger groups, collapsed in old specimens; wall smooth, thick.

Sporisorium erythraeense (H. & P. Sydow) Vánky, comb. nov.

Basionym: Ustilago erythraeensis H. & P. Sydow, Ann. Mycol. 9:144, 1911. – Sphacelotheca erythraeensis (H. & P. Sydow) Clinton, in Zundel, 1939:996. – Type on Manisuris granularis (L.) Swartz (= Hackelochloa granularis (L.) Kuntze), Africa, Erythrea, prov. Ghinda-Amasen, Dongollo, 13.III.1902, Pappi.

Sori comprising the whole inflorescence, partly hidden by the leaf sheaths, cylindrical, about 1 cm long, covered by a brownish fungal membrane which breaks away from the top exposing a semi-agglutinated to dusty, dark brown spore mass surrounding a well-developed, branched columella. Spores globose to subglobose, 9–11 x 9.5–12 µm, reddish-brown, minutely echinulate. Sterile cells about the size of the spores or slightly larger, in irregular groups scattered within the spore mass, hyaline to pale yellow, thin-walled, smooth, collapsed in old specimens.

Revising the Ustilaginales of Polygonaceae, we found the following new species on Polygonum prostratum:

Ustilago prostrata Vánky & Oberwinkler, sp. nov.

Typus in matrice Polygonum prostratum R. Br., Australia, Queensland, Nanango, IX.1947, leg. R.F. Langdon (HUV 14710!), isotypi in BRIP (15381) and BRIU (671). Paratypus in matrice Polygonum prostratum, Australia, New South Wales, 23 km S.E. Nimmitabel, pr. "Pipers Lookout", 36°36' S, 148°26' E, alt. c. 850 m, 4.II.1989, leg. G. Kirby (HUV 14867!, Herb. Kirby, The Flinders University of South Australia, Adelaide).

Sori (Fig. 5) in floribus tumefactis, deformatis, massa sporarum pulverea, atropurpurascenti-brunnea completis. Sporae (Fig. 6) globosae, subglobosae usque ovoideae, 9–11 x 9,5–12(–13,5) µm, tinctione violacea pallide brunneae, pariete 1,2–1,5 µm crasso, reticulato, maculis 3–5 per diametrum sporae; maculae plerumque pentagonales vel hexagonales, diametro (2–)2,5–4(–5,5) µm, forte etiam maculae incompletae presentes; muri inter maculas humiles (0,5–1 µm alti), in sectione mediana sporarum visu obtusae. Interstitia sub SEM convexa et irregulariter verrucosa.

Ustilago prostrata a speciebus similibus gen. Ustilago precipue per massam atram sporarum et spores humiliter reticulatas distincta.

Sori (Fig. 5) in swollen and deformed flowers contain a dark purplish-brown, powdery spore mass. Spores (Fig. 6) globose, subglobose to ovoid, 9–11 x 9.5–12(–13.5) µm, violet-tinted light brown; wall 1.2–1.5 µm thick, reticulate, 3–5 meshes per spore diameter, meshes mostly penta- or hexagonal, (2–)2.5–4(–5.5) µm in diameter, incomplete meshes may be present, muri low (0.5–1 µm), in median view with blunt edges. In SEM the convex interspaces are irregularly warty.

Ustilago prostrata differs from similar smuts in having lower reticulum on the spores and darker coloured spore masses.

NEW COMBINATIONS PROPOSED

Courtesy of Dr. R. Webster, I obtained some smutted spikelets of Mesosetum loliiforme (Gramineae) which turned out to be infected with one of the four known smuts on Mesosetum, "Sphacelotheca" inconspicua Zundel. The smut "Sphacelotheca" inconspicua has the characteristics of a Sporisorium and must be transferred to that genus. Species of Sphacelotheca are restricted to the Polygonaceae. The young spores of Sphacelotheca are catenulate, connected by disjunctors. The smuts on Gramineae possessing sori with peridium and columella, often sterile cells between the spores, and spores in spore balls, at least when they are young, belong to the genus Sporisorium.

Sporisorium inconspicuum (Zundel) Vánky, comb. nov.

Basionym: Sphacelotheca inconspicua Zundel, Mycologia 25:354, 1933. Lectotype (sel. here) on Mesosetum loliiforme (Hochst.) Chase (Gramineae), Brazil, Goyaz, near Goyaz City, 20-22.III.1930, A. Chase (Plants of Brazil No. 11464; BPI 177903). Syntype on Anoxopus marginatus (Trin.) Chase (Gramineae), Brazil, Goyaz, Rio Verde, 2.IV.1930, A. Chase (Plants of Brazil No. 1170/b; BPI).

Trying to identify a smut on Heteropogon contortus from Spain, labelled as Sorosporium contortum Griff., I checked the types of S. contortum and that of S. caledonicum Pat. and found that the specimen corresponded to the description of S. contortum but that the "type" of that species was unlike the description.

Sorosporium contortum was described by Griffiths (1904:83) as having smooth spores 5–8 µm in diameter. However, the spores of the "type", preserved in BPI (179674, 195119), are larger and finely punctate-echinulate, and identical with the type of the earlier described S. caledonicum. The reason for this discrepancy may lie in the fact that Griffith's original material was a mixture of two different fungi, as was the HUV duplicate (No. 9702) of S. contortum, distributed in Seymour & Earle, Econ. fgi., Suppl. C 114. This assumption seems to be supported by the fact that Clinton (1904:413), who presumably studied the "type", gave 9–13 µm for the length of the spores of S. contortum. Zundel (1953:57), referring to the discrepancy between the spore measurements in the original description and in Clinton's description, noted: "An examination of type material shows the original description to be correct." Consequently, it would be desirable to relocate the specimen on which Griffiths based his description and select that specimen as type.

The spores of the Spanish specimen measure 5–7 x 5.5–8 µm, and thus correspond with the description of S. contortum, but under high magnification the spore surface is very finely punctate, a fact which could not be observed in old microscopes. However, this species, together with S. caledonicum, belongs to the genus Sporisorium and the following new combinations are proposed:

Sporisorium contortum (Griffiths) Vánky, comb. nov.

Basionym: Sorosporium contortum Griffiths, Bull. Torrey Bot. Club 31:83, 1904. – Type on Andropogon contortus L. (= Heteropogon contortus (L.) Roemer & Schultes), USA, Arizona, Santa Rita Mts., 12.IX.1902, D. Griffiths; paratypes on Andropogon contortus, Arizona, Santa Rita Mts., 1.X.1902, D. Griffiths & Thornber; Arizona, Empire Ranch, 27.IX.1902, D. Griffiths & Thornber.

Sori comprise the whole upper internode and inflorescence, which are transformed into a 5–30 mm long, 0.6–1.5 mm wide, cylindrical, fusiform or contorted body, partly enclosed within the upper sheath and covered by a membrane composed of hyaline, cuboidal to somewhat elongated fungal cells. The membrane ruptures, becomes lacerated exposing the black, agglutinated, later semipowdery mass of spore balls. Spore balls subglobose, ovoid to slightly polyhedral, 50–62 x 50–80 µm, composed of numerous, rather loosely connected spores. Spores subglobose, ovoid, usually subpolyhedral, 5–7 x 5.5–8 µm, yellowish-brown; wall thin, rather sparsely and finely punctate.

Sporisorium caledonicum (Patouillard) Vánky, comb. nov.

Basionym: Sorosporium caledonicum Patouillard, Bull. Soc. Mycol. (France) 3:173, 1887. – Type on Heteropogon contortus (L.) Roemer & Schultes, Island of New Caledonia (South Pacific Ocean; PC!).

Sori comprise the whole inflorescence, partly hidden by the terminal leaf-sheath, cylindrical, several cm long, a few mm wide, covered by a pale brown peridium which ruptures irregularly to expose the black, granular-powdery mass of spore balls and several, long, filiform shreds ("columellae") of host tissue origin. Spore balls variable in form and size, globose, ovoid to elongated or irregular, 25–70 x 30–110(–130) µm, dark reddish-brown, opaque, composed of numerous (?25–?150 or more), rather firmly united spores. Spores subglobose, ellipsoidal or subpolygonal, 6.5–11 x 8–14 µm; outer spores dark reddish-brown, thick-walled (1–1.5 µm), rather densely and evidently punctate-echinulate, giving the spore profile a very finely serrulate aspect; inner spores paler, thin-walled (c. 0.5 µm), apparently smooth or very finely punctate. Peridium composed of longitudinally arranged, firmly united chains of elongated, hyaline fungal cells which have more or less lost their individuality.

SYNONYMS

Urocystis hordei (Cif.) Zundel = Urocystis occulta.

Ciferri (1931:13) described Tuburcinia hordei on "Hordeum distichum" from Italy, Avellino, summer 1892, coll. A.N. Berlese; isotypes distributed in Briosi & Cavara, Fgi. paras. 206 (as Urocystis occulta on Hordeum distichum). Zundel (1953:320) transferred the name into Urocystis and wrote that "it differs little if at all from Urocystis occulta (Wallroth) Rabenhorst and it is probable that the two species are not really distinct." Urocystis hordei was reported also from USSR (Gutner, 1941:283). A smut on a widely cultivated host, reported only twice, morphologically near or identical with U. occulta must be either very rare or, what is more probable, dubious. The error may originate with host misidentification. It is not rarely seen that one kind of smutted host plant is growing between apparently similar healthy plants. Indeed, I confirmed that the isotype in my herbarium (HUV 14761) is a smutted spike of Secale cereale, not Hordeum distichum, and its smut is Urocystis occulta (Wallroth) Rabenhorst ex Fuckel.

Urocystis on Phleum = Urocystis phlei-alpini.

Urocystis phlei (Lavrov) Ignataviciute, 1975:212 (comb. illeg.) is based on "Tuburcinia phlei Lavrov, Sist. zamet. Tomsk. univ. XI, 1 (1937) 2." However, Lavrov in that paper did not publish "Tuburcinia phlei". Neither was the name mentioned in a later paper of synthesis of Lavrov (1938). The next validly published name of Urocystis on Phleum is Urocystis phlei-alpini Terrier (1961:110). Type on Phleum alpinum L., Switzerland, Canton Valais, valley of Binn, "Lärcheltini", 3.VII.1960, E. Mayor & C. Terrier (NEU; isotype HUV 13538!).

Sori in leaves as long striae between the veins, first lead-coloured, covered by the epidermis which later ruptures disclosing the blackish-brown, semiagglutinated to granular-powdery mass of spore balls. Spore balls irregularly globose to ellipsoidal, 20–28 x 20–40 µm, composed of (0–)1–3(–4) spores and a completely, or nearly completely investing layer of sterile cells. Spores subglobose to elongate, usually slightly irregular, 10–14.5 x 12–18(–20) µm, yellowish- to light reddish-brown. Sterile cells irregular in form and size, 5–16 µm long, collapsed when dried, light yellow, wall thick proximal to the spores (1–1.5 µm), distally thin.

Urocystis on Phleum is morphologically close to, and sometimes reported as U. agropyri. This last species, however, has somewhat smaller spore balls and more regular, rounded spores. U. phlei-alpini ("U. phlei") is known on various Phleum species from Europe and North America.

Ustilago urgineae = Ustilago vaillantii.

Ustilago urgineae was described by R. Maire (1931:359) from the anthers of Urginea maritima (L.) Baker (syn. Urginea anthericoides (Poiret) Steinh.; Liliaceae) collected in Algeria, near Oran, and in Morocco, in Oudjda and Larache, November and December (No type designated). According to Maire, U. urgineae has larger spores than U. vaillantii, and unlike U. vaillantii, retards flowering. The study of one of the syntypes, selected here as lectotype: "Ustilago vaillantii Tul., Moroc, Larache, dunes, sur Urginea anthericoides, 10-12-1929, R. Maire, No. 9956" (MPU!) revealed no essential differences between U. urgineae and U. vaillantii (on Muscari and Scilla species). The differences in spore shape, size and ornamentation lies within the variability of this species. The type of germination of U. urgineae, given by Rayss (1946:24, fig. 2), is also similar to that of U. vaillantii on Scilla bifolia and Muscari comosum given by Schröter (in Cohn, 1877:358, Pl. 12, fig. 4), Paravicini (1917:68, Pl. 2, figs. 20–40), and Săvulescu (1957:684, fig. 204). Consequently, I consider U. urgineae R. Maire a synonym of U. vaillantii L.-R. & C. Tulasne (1847:90).

EXCLUDED SPECIES

Koorders (1907:196) described Tuburcinia javanica on cultivated Hymenocallis sp. (Amaryllidaceae) from Java, Prov. Kedu, in a garden in Akagelang, III.1905, S.H. Koorders (BPI 189131!). Ulbrich (1940:78-79) analysed Koorders' annotations and drawings as well as the type material in Berlin (B; destroyed in 1943), and concluded that it is not a smut fungus but probably a Stemphylium or a similar fungus. Zundel (1953:304) still listed it among the smut fungi of the world. Fortunately, there is a fragment of the type, preserved in Beltsville (BPI). The study of this sample, as well as Koorders's annotation (in Ulbrich, 1940:79) do not leave any doubts that this fungus is not a member of the Ustilaginales.

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ABBREVIATIONS

The abbreviations for herbaria follow Index Herbariorum (Stafleu, 1981).
HUV = Herb. Ustilag. Vánky, the author's private herbarium.

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A PRELIMINARY SYNOPSIS OF THE SPECIES OF CLADONIA IN CALIFORNIA AND ADJACENT OREGON

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SUMMARY

Continuing studies in the *Cladonia* flora of the western United States have yielded a number of new and hitherto unreported taxa, which are introduced in this paper. *Cladonia firma* is reported for the first time for North America. *Cladonia humilis* var. *bourgeanica* and *C.* cfr. *merochlorophaea* are reported as new to California. *Cladonia pulvinella*, an esorediate species with pillow-like granules on the podetia, containing both atranorin and bourgeanic acid in addition to fumarprotocetraric acid, is described as new. A diagnostic key and a synoptic key to the 32 known taxa of *Cladonia* in California and adjacent Oregon are provided.

INTRODUCTION

This paper is intended as a guide to the taxa of *Cladonia* (Ascomycotina:Lecanorales) occurring in California and adjacent Oregon. Thirty-two taxa are included in this treatment. The taxonomy in this paper is necessarily somewhat preliminary. Although I have collected the genus extensively in California and the western United States, there are still many Cladonias in that area whose taxonomic status is unresolved. Part of the study of a large group such as *Cladonia* includes problems presented by an old and intricate nomenclature and very broad, worldwide species concepts. Having studied the genus for several years in the field and in numerous herbaria, including several lengthy study visits with Professors Teuvo Ahti and John W. Thomson, there are still problems among the taxa presented here that are not sufficiently solved to present a submonographic work.

However, it is appropriate at this point to attempt a preliminary delimitation of the taxa of *Cladonia* Hill ex Browne in California and neighboring Oregon, with the rejoinder that future studies are likely to include changes in some of the concepts presented here.

The area under study in this paper encompasses the general geographical area referred to as the "California Floristic Province" (Raven and Axelrod 1978). Accounts of the climate, soils, and phytogeography of the region are presented in Raven and Axelrod as well as Munz (1958), Stebbins and Major (1965), Daubenmire (1969), and Kruckeberg (1969). In the present paper I draw a distinction between the California *Cladonia* flora and the coastal flora of the Oregon Dunes, ca 200 km north of the California-Oregon border. The latter represents the southern extension of a *Cladonia* flora characterized by many taxa that Thomson (1968) called boreal.

Although certain localities in California such as the stabilized sand dunes near Ft. Dick (Del Norte County) (Hammer 1989b) and the pygmy forest (Sonoma and Mendocino Counties) possess many species in common with the Oregon Dunes flora, they are nevertheless comparatively depauperate in species composition. For example, two subspecies of *C. gracilis* (L.) Willd. (subsp. *turbinata* (Ach.) Ahti and subsp. *vulnerata* Ahti (Ahti 1980), which are abundant in the Oregon Dunes, are missing from the California flora. Earlier reports of *C. gracilis* in California (cf. Tucker and Jordan 1979) are based on misidentifications or geographical error. *Cladonia ecmocyna* Leighton, *C. phyllophora* Hoffm., and *C. borealis* Stenroos (1989), which are abundant in coastal and inland localities from central Oregon northward, are also lacking in the California flora. Only one species in the closely related genus *Cladina*, *C. portentosa* subsp. *pacifica* (Ahti) Ahti (not treated in this paper) is found in California, whereas farther North and East, numerous taxa are present.

The frequency of occurrence of these and other boreal species increases northward and farther east, in the Olympic and Cascade Ranges of Washington and Oregon (Foster 1906; Howard 1937, 1950; Thomson 1969), and in localities in northern and eastern Idaho west of the Continental Divide (Anderegg 1977; McCune 1984; Schroeder et al. 1973). Most *Cladonia* taxa that occur in mountainous areas north of California are also absent from the area covered in this paper. Including them in this report would mislead readers who might expect their occurrence in the mountains of California. As discussed by Hale (1989) *Cladonia* and other terricolous lichens are conspicuously absent in the Sierra

Nevada, where most of the precipitation occurs as snow. The *Cladonia* flora of the Sierra Nevada is very depauperate, with only *C. chlorophaea* (Flörke *ex* Sommerf.) Sprengel and *C. fimbriata* (L.) Fr. occurring there.

All of the major subdivisions of the genus *Cladonia* are represented in California and adjacent Oregon, with the exception of sect. *Unciales* (Del.) Oxner *ex* Ahti. Numerous lineages within the included sections of the genus are represented, as discussed by Hammer and Ahti (1990). The *Cladonia* species in the area of study are mostly terricolous, but are found on a variety of other substrata as well. Many species are facultatively terricolous or corticolous. Others, such as *C. squamosa* (Scop.) Hoffm. and *C. ochrochlora* Flörke always occur on ecorticate, rotting wood. *Cladonia transcendens* (Vainio) Vainio, *C. macilenta* Hoffm., and *C. coniocraea* auct. grow at the base of trees. For terricolous species, open areas with more or less full exposure are best suited for Cladonias. In California and southern Oregon, trailsides and north-facing roadsides are among the most productive local habitats for the genus. Perennially damp rock faces where thin soil has developed between crevices are also good collecting sites. Other habitats of *Cladonia* are found where vascular plants are sparsely distributed such as on lateritic hardpan soils and stabilized sand dunes.

The genus *Cladonia* in California occurs in greatest abundance near the Pacific coast, with a notable inland extension on soils of the Ione Formation (Hammer 1989c). In the area included in this paper, the composition and abundance of *Cladonia* species is lower in inland and southern localities than in northern and more markedly oceanic localities (Hammer 1988). In certain marginal localities and on azonal soils, populations of *Cladonia* possess distinctive morphologies and chemistries (Hammer and Ahti 1990). In some cases, their status as possible endemics has not yet been decided, and they are being presented here according to the current broader taxonomic application. Specimens collected from these populations often vary considerably from their purported closest relatives elsewhere in the region. In a few cases such as *C. thiersii* (Hammer 1989a), *C. dimorpha*, and *C. prolifica* (Hammer and Ahti 1990), new species have been described from relatively narrowly circumscribed localities in California. *Cladonia pulvinella*, which is described in this paper, is considered sufficiently distinct to merit taxonomic status as well.

Especially problematic in the sense that they are possible endemics are the taxa referred to in this paper as

Cladonia cfr. *crispata*. Several populations in California possessing at least two distinct morphologies are known. They uniformly lack the characteristic phenolic component squamatic acid, and contain barbatic and/or thamnolic acids. Evans (1950) referred to a specimen from Pilarcitos Creek, San Mateo County, one of Herre's classic collecting localities, as *C. carassensis* Vainio. Although similar in chemistry (thamnolic acid), the California collections by Herre are morphologically distinct from *C. carassensis*, which is restricted to a few isolated localities in southeastern Brazil (Ahti pers. comm.). Another population, which is abundant in the pygmy forest of Mendocino and Sonoma Counties and on stabilized sand dunes farther north, possesses podetia with numerous gaping fissures. The podetia are conspicuously inflated, especially near the apothecium-bearing apices. This morphology is not restricted to the populations in Mendocino and Sonoma Counties. It is found in chemically similar populations northward to Vancouver Island, where it approaches *C. crispata* (Ach.) Flotow s. lat. (Ahti pers. comm.). I follow the current practice of Ahti in applying the name *C. crispata* to these morphologically and chemically distinct populations.

Cladonia firma Nyl.,which is widespread in Mediterranean Europe and Macaronesia, is locally abundant in San Luis Obispo County, California. This species, which is loosely classified in the "*C. verticillata* group" (Ahti pers. comm.) is characterized by poorly developed podetia borne on phyllopodia, and large, persistent primary squamules. Fumarprotocetraric acid and protocetraric acid are always present, and atranorin is found in most specimens. *Cladonia firma* is distinguished from *C. macrophyllodes* by its phyllopodia (elongated primary squamules that intergrade with podetia, and which are re-formed on scyphus margins, giving rise to further podetia), and the relatively smooth upper surface of the primary squamules. *Cladonia firma* in the region of study is only known from San Luis Obispo County, where it is found on stabilized sand dunes. For a discussion of similar Macaronesian-western North American lichen disjuncts see Kärnefelt (1980).

Cladonia cfr. *merochlorophaea* Asah. is added to the California flora in this paper. The characteristic compounds merochlorophaeic acid, 4-O-methylcryptochlorophaeic acid, and fumarprotocetraric acid were detected in two specimens from Humboldt County and Mendocino County. In specimens from the western United States, there are no soredia. The podetia are covered with abundant, tiny, imbricating squamules or with raised verruculae. Podetial bases of *C.* cfr. *merochlorophaea* become strongly blackened, even in young specimens. *Cladonia* cfr. *merochlorophaea* in the western states is distinct from *C. chlorophaea*, and its inclusion in the "*C. chlorophaea* group" on the basis of its general morphology may be taxonomically inappropriate. Ahti (pers. comm.) and Culberson (1986) suggest that its morphology is unlike European or Asian material of *C. merochlorophaea* s. str.

The introduction here of *C. humilis* (With.) Laundon var. *bourgeanica* Archer (Archer 1989) represents the first substantiated report of this taxon in California. Tucker and Jordan (1979) considered earlier reports of *C. humilis* var. *bourgeanica* (=*C. conista*) to be misidentifications of *C. chlorophaea*. In any case, the nomenclature of *C. humilis* was confused until Laundon's (1984) paper, and reports of this species in California were probably misidentifications.

The problem of the chemically-defined species, *C. asahinae* Thomson (1976), which occurs in my study area, remains unresolved. Hennings (1983) and Holien and Tønsberg (1985) discussed this problem, in which the holotype contained rangiformic and norrangiformic acids, instead of lichesterinic and protolichesterinic acids as described by Thomson. I am unable to discern morphological characters that distinguish the rangiformic-norrangiformic acid-containing *C. asahinae* from the lichesterinic-protolichesterinic acid-containing "unnamed" material, and I am therefore extremely reluctant to assign taxonomic status to the chemical variants as two distinct species. I have tested numerous podetia for these fatty acids, the majority of which, especially in central and southern California, contain lichesterinic and protolichesterinic acids.

Because of the difficulties encountered when keying *Cladonia*, it seems appropriate to offer an alternative to the diagnostic key in this paper. The many potential strengths of synoptic keys are outlined in Korf (1972), and users of this key are encouraged to consult Korf's paper. A synoptic key can be especially helpful in studying the genus *Cladonia*, where a single taxon may possess mixtures of character states, some of which may be contradictory or otherwise inappropriate or awkward for inclusion in a diagnostic key.

The synoptic key in this paper differs in some respects from that of Korf. For example, *C. cariosa* (Ach.) Sprengel (taxon 3) can give a P negative reaction if it lacks accessory fumarprotocetraric acid. Since *C. cariosa* usually possesses fumarprotocetraric acid in addition to atranorin, it is placed under part 1a (para-phenylinediamine reaction) in parentheses, and also appears in part 1c as "P" positive, which is the normal state on which it is found in western

North America. Like Korf, I have placed in parentheses character states under which more taxa are found. In addition, taxa are placed in parentheses when they are listed under the character state that occurs less frequently. When a taxon appears more than once under a single heading, its number is italicized to signify that the entry under which it is listed is not a decisive key character. For example, most of the entries listed under "primary squamules persistent or evanescent" would appear to possess both kinds of primary squamules. Why trouble readers with this character, when it is so unpredictable? By listing this character, I have attempted to call readers' attention to the primary squamules, and, in the few cases where the presence or absence of primary squamules is a decisive character (such as in *C. cervicornis* (Ach.) Flotow) it is hoped that this synoptic key entry will have been worth the extra trouble. Spot test reactions are standard procedure in *Cladonia* taxonomy. In both of the keys in this paper, I have also included salient characters regarding phenolics and fatty acids in *Cladonia*. Here, thin layer chromatography is required, and although I regret the trouble that this may cause certain collectors, I acknowledge that for some taxa, TLC is the most convenient means of identification (cf. Ahti 1966).

Finally, I have included comments on taxa that frequently entail difficulty in identification (see Table 1). The taxa in this group are all sorediate or appear sorediate, possess fumarprotocetraric acid (P+ brick red), and are always cup-forming to some extent (with cups closed). They have traditionally been treated as members of subsect. "*Thallostelides*," (Hammer and Ahti 1990). Informally, most of these taxa have been placed in the *C. chlorophaea*-*C. fimbriata* complex, a group in which convergent morphology and chemistry have probably obfuscated its members' polyphyly. I have added a list of these taxa (Table 1), hoping that a few words of comparison would offset readers' potential frustration. In any case, there will still be specimens for which there is no absolutely clear choice.

Weber (1963) pondered on the question of whether lichen species in isolated, azonal conditions such as the Chiricahua Mountains of southern Arizona might have developed endemic taxa, or whether they were best described as having relictual species. Ahti (pers. comm.) suggests that biogeographical trends in lichens are probably analogous to those of vascular plants. The genus *Cladonia* in California and the western United States present an enormous taxonomic and biogeographical challenge.

MATERIALS AND METHODS

Several thousand collections of *Cladonia* were examined from fresh material and herbarium specimens over a five year period. Specimens were studied for morphological and chemical characters. Chemical analyses were performed by routine chemical spot tests (White and James 1985) and thin layer chromatography (TLC). Solvent systems "A" and "B" were used (Culberson 1974; Culberson et al. 1981; White and James 1985). The specimens cited in this paper, unless otherwise designated immediately following the specimen number, are deposited at FH.

LIST OF INCLUDED TAXA

1. *Cladonia asahinae* Thomson
2. *Cladonia bellidiflora* (Ach.) Schaerer
3. *Cladonia cariosa* (Ach.) Sprengel
4. *Cladonia carneola* (Fries) Fries
5. *Cladonia cervicornis* (Ach.) Flotow subsp. *cervicornis*
6. *Cladonia cervicornis* subsp. *verticillata* (Hoffm.) Ahti
7. *Cladonia chlorophaea* (Flörke ex Sommerf.) Sprengel
8. *Cladonia coniocraea* auct.
9. *Cladonia cornuta* subsp. *groenlandica* (Dahl) Ahti
10. *Cladonia* cfr. *crispata* (Ach.) Flotow
11. *Cladonia dimorpha* Hammer
12. *Cladonia fimbriata* (L.) Fries
13. *Cladonia firma* Nyl.
14. *Cladonia furcata* (Huds.) Schrader
15. *Cladonia humilis* (With.) Laundon var. *bourgeanica* A.W. Archer
16. *Cladonia humilis* (With.) Laundon var. *humilis*
17. *Cladonia macilenta* Hoffm.
18. *Cladonia macrophyllodes* Nyl.
19. *Cladonia* cfr. *merochlorophaea* Asah.
20. *Cladonia multiformis* Merrill
21. *Cladonia ochrochlora* Flörke
22. *Cladonia prolifica* Ahti & Hammer
23. *Cladonia pulvinella* Hammer
24. *Cladonia pyxidata* (L.) Hoffm.
25. *Cladonia scabriuscula* (Delise in Duby) Nyl.
26. *Cladonia squamosa* (Scop.) Hoffm. var. *squamosa*
27. *Cladonia squamosa* var. *subsquamosa* (Nyl. ex Leighton) Vainio
28. *Cladonia subulata* (L.) Wigg.
29. *Cladonia thiersii* Hammer
30. *Cladonia transcendens* (Vainio) Vainio
31. *Cladonia umbricola* Tønsberg & Ahti
32. *Cladonia verruculosa* (Vainio) Ahti

DIAGNOSTIC KEY TO THE LICHEN GENUS *CLADONIA* IN CALIFORNIA

1. Podetia P-; no color change when P is applied........**2**

1. Podetia P+; yellow-orange, orange-red, red, or brick red..**7**

2. Podetia sorediate...................................**3**

2. Podetia esorediate..................................**4**

3. Podetia always cup-forming, never subulate; yellowish (usnic acid), sorediate, with bases sorediate or corticate, cups regular, often wide, (1-4 mm diam), proliferations from cup margins giving rise to further series of cups, pycnidia brown, regularly arranged on the dentate cup margins; apothecia light brown, never red; UV-..................................***C. carneola***

3. Podetia cup-forming or subulate; greenish, sorediate, with bases sorediate or indistinctly corticate, patchy cortex sometimes present above, soredia often enlarging and intergrading with podetial squamules, cups, when present, narrow, (1-2 mm diam), usually without marginal proliferations; apothecia red; UV+ (squamatic acid) ....***C. umbricola***

4. Podetia not cup-forming or, where cuplike structures are formed, their interiors opening distinctly and showing interior of hollow podetia below; apothecia and pycnidia, when present, on cup margins or irregularly occurring on the podetia...**5**

4. Podetia cup-forming, blunt, or subulate, interiors of cups closed, corticate; podetial cortex continuous or podetia with abundant squamules, podetia never appearing torn or shredded, podetia and primary squamules yellow (usnic acid); apothecia, when present, bright red; UV+ (squamatic acid).......................***C. bellidiflora***

5. Podetia cup-forming or blunt; if cup-forming, interiors of cups open exposing hollow interior of podetia; apothecia, when present,brown..........................**6**

5. Podetia never cup-forming, blunt, always appearing shredded, composed of numerous solid medullary strands, longitudinally arranged, with no part of podetia appearing cylindrical; bluish primary squamules usually persistent; podetia always tipped with brown apothecia..................................***C. cariosa***

6. Podetia abundantly squamulose, sometimes with very small squamules that resemble soredia to the naked eye; podetial surface beneath squamules ecorticate; openings punctiform or larger, usually quite regular (symmetrical); apothecia light to darker brown; UV+ (barbatic and squamatic acids) ....***C. squamosa*** var. ***squamosa***

6. Podetia variably squamulose or esquamulose, usually thinly corticate with broad verruculae and few squamules; squamules when present never resembling soredia to the naked eye; podetial surface beneath squamules usually corticate; openings usually large and gaping; apothecia usually dark brown; UV- (barbatic acid only) ....***C.*** cfr. ***crispata***

7. Podetia sorediate, at least in part, or with tiny, corticate squamules that resemble soredia...............**8**

7. Podetia with continuous cortex, or squamulose or with corticate, peltate squamules, but not sorediate........**26**

8. Podetia K+ bright yellow, color not dulling or fading, (indicating thamnolic acid); apothecia, when present, red...**9**

8. Podetia K+ bright yellow or dingy yellow, soon changing to dingy brown (indicating presence of atranorin if temporarily bright yellow), or K-, always with fumarprotocetraric acid; apothecia, when present, brown...**10**

9. Podetia never cup-forming, entirely sorediate or with considerable portions of the podetia thickly corticate, rarely almost entirely corticate with scattered erumpent, large clumps of soredia; thamnolic and barbatic acids....................................***C. macilenta***

9. Podetia cup-forming, (cups usually with corticate interiors), entirely sorediate or with irregular patches of cortex above base, soredia variable (40-200 µm), usually intergrading with isidioid structures; basal portions of podetia usually corticate; podetia sometimes luxuriantly covered with well developed, finely dissected squamules; usually growing at the bases of live *Sequoia sempervirens* or *Pseudotsuga menziesii* ;(thamnolic acid, sometimes with unknown fatty acids).....***C. transcendens***

10. Podetia subulate or cup-forming, but when cups present, their width is ca 10% or less of the height of the podetia...**11**

10. Podetia distinctly cup-forming, with cup width more than 10% of the height of the podetia......................**21**

11. Podetia distinctly corticate toward base..............**12**

11. Podetia indistinctly corticate or ecorticate toward base..**15**

12. Corticate portions of podetia distinctly longitudinally rugose; podetia always with brownish tinge; terricolous or on wood.............***C. cornuta*** subsp. ***groenlandica***

12. Corticate portions of podetia without distinct longitudinal striations; greenish or glaucescent green or bone white, rarely brownish..........................**13**

13. Podetia abundantly dichotomously branched; branches longitudinally fissured with soredia-like, corticate granules at tips......................***C. scabriuscula***

13. Podetia not as above..................................**14**

14. Podetia usually distinctly cup-forming; cup interiors corticate or sorediate; primary squamules entire-margined or slightly dissected, glaucescent green; large soredia (usually >80 µm) in soralia, sometimes erumpent in soralia and becoming effuse and occasionally corticate; soralia often helically arranged around upper portions of podetia; lower portions of the podetia usually thickly corticate, podetia and soredia glaucescent green or bone white.................................***C. ochrochlora***

14. Podetia subulate or rarely very narrowly cup-forming; if cups are formed, the interiors are too small to appear either corticate or sorediate with the naked eye; primary squamules conspicuously dissected, green; fine soredia (ca 40-80 µm), covering upper portions, usually not in soralia; when soralia present, they are distinct, not effuse and scattered, and not helically arranged around podetia; lower portion of podetia thinly corticate, often with scattered, thin verruculae...........***C. coniocraea***

15. Soredia of varying sizes on same podetium, sparse or abundant, often intergrading with podetial squamules; podetia cup-forming or subulate, sparingly laterally branched or unbranched, proliferations from cup margins or cup centers..**16**

15. Soredia of fairly uniform size (usually 40-80 µm); podetia cup-forming or subulate, unbranched; proliferations from cup margins only..................**19**

16. Podetia sparingly laterally branched or unbranched, podetia usually tall and slender (to 80 mm), pale or sometimes with brownish tinge; proliferations from center of cups or from cup margins, but always some podetia with central proliferations; soredia sparse or absent, large portions of podetia esorediate and ecorticate, usually with irregular verruculae toward base; terricolous, on stabilized sand dunes, roadsides, rock outcrops, and among sparse grasses....................***C. verruculosa***

16. Podetia unbranched; proliferations from cup margins only; soredia sparse or abundant; bases distinctly corticate or indistinctly corticate, or ecorticate....**17**

17. Podetia with distinctly corticate bases; cortex extending to base of cup, fine soredia on cup exteriors; podetia <1 cm tall...**25**

17. Podetia without distinctly corticate bases; soredia variable; podetia usually >1 cm tall..................**18**

18. Podetia greenish or brownish, sometimes with tinges of bronze or gray; bases blackening; proliferations from cup margins distinctly whitish in comparison to podetial color; soredia-like verruculae usually larger than 80 µm, usually replaced by abundant podetial squamules; merochlorophaeic acid with accessory 4-0-cryptochlorophaeic acid and fumarprotocetraric acid...........................***C.*** cfr. ***merochlorophaea***

18. Podetia usually greenish or white; podetial bases not blackening; soredia variable (40-80 µm, sometimes larger); some soredia present even in very old specimens; cups variable.......................................**19**

19. Cups of various widths, marginal proliferations, when present, blunt or subulate (not exceeding 2 mm), or giving rise to further series of cups; most podetia collected from one clump cup-forming; interiors of cups always closed; soredia in cup interiors often larger than podetial soredia.................................**20**

19. Cups narrow, rarely flaring; marginal proliferations always subulate, usually exceeding 2 mm (often much taller); interiors of cups sometimes perforated; most podetia collected from one clump with subulate apices or proliferations; soredia in cup interiors the same size as podetial soredia...........................***C. subulata***

20. Cups narrow to wide, often mixed in a given clump; cup margins irregularly dentate or with numerous blunt proliferations from cup margins; fumarprotocetraric acid only...***C. fimbriata***

20. Cups as above, but usually more or less uniform in a given clump; podetia very pale bluish-green (compare to color in lichesterinic acid-containing *Pycnothelia papillaria*); fumarprotocetraric acid and lichesterinic/protolichesterinic acid..........**unnamed**

21. Podetia usually greenish, brownish, or very pale bluish-green; entirely corticate or with irregular corticate patches, especially near base; cup interiors sorediate or with squamules;terricolous,corticolous,or musicolous...**22**

21. Podetia greenish or whitish; "soredia" actually loosely corticate squamules; cup interiors always bearing peltate or semi-erect squamules; terricolous; fumarprotocetraric acid, atranorin, and bourgeanic acid with accessory protocetraric acid........................***C. pulvinella***

22. Fumarprotocetraric acid only..........................**23**

22. Fumarprotocetraric acid and one or more fatty acids....**24**

23. Soredia irregular, coarse, mostly larger than 80 µm; cup margins not regularly dentate; cup interiors with soredia or peltate squamules....................***C. chlorophaea***

23. Soredia regular or irregular, usually not coarse, mostly smaller than 80 µm; cup margins dentate or digitate; cup interiors sorediate........................***C. fimbriata***

24. Podetia greenish; fumarprotocetraric acid plus rangiformic and/or norrangiformic acids......***C. asahinae***

24. Podetia very pale bluish-green (similar to color in lichesterinic acid-containing *Pyncnothelia papillaria*); fumarprotocetraric acid plus lichesterinic and/or protolicesterinic acids.........................**unnamed**

25. Podetia K+ bright yellow, fading to dingy yellow and finally to dingy brown; fumarprotocetraric acid and atranorin ....***C. humilis*** var. ***humilis***

25. Podetia K- or K+ dingy yellow changing to dingy brown fumarprotocetraric acid and bourgeanic acid
.........................***C. humilis*** var. ***bourgeanica***

26. Podetia P+ brick red; fumarprotocetraric acid..........**27**

26. Podetia P+ orange (not changing to red) or deep yellow; thamnolic acid.......................................**39**

27. Podetia or cup interiors with peltate squamules........**28**

27. Podetia with more or less continuous cortex; cup interiors without peltate squamules; if podetial squamules present, they are not peltate and closely resemble primary thallus..............................**30**

28. Cortex of podetia more or less continuous, sometimes scattered verruculose; apothecium-bearing proliferations never furcately branched....................***C. pyxidata***

28. Cortex of podetia cracked and discontinuous, often comprised of abundant peltate squamules................**29**

29. Apothecium-bearing proliferations from cup margins always branched and longitudinally fissured; or when bearing further series of cups, margins with regular, abundant, ± pointed pycnidia; fumarprotocetraric acid only ....***C. dimorpha***

29. Longitudinally-fissured proliferations not present; fumarprotocetraric acid with atranorin and bourgeanic acid..................................***C. pulvinella***

30. Podetia with distinct cups; cups with central proliferations.......................................**31**

30. Podetia with or without distinct cups; cuplike structures, where present, without central proliferations.......................................**35**

31. Podetia K+ bright yellow, changing to dingy yellow to dingy brown, or K+ dingy brown, or K-; one tier or no tiers of proliferations present; fumarprotocetraric acid with common accessory atranorin.......................**32**

31. Podetia K+ bright yellow, changing to dingy yellow to dingy brown, or K+ dingy brown, or K-; with more than one tier of proliferations; fumarprotocetraric acid with rare accessory atranorin.............................**34**

32. Primary squamules large (to 1 cm broad), never ligulate, with distinct raised whitish bumps on upper surface, ventral surface white or whitish, never blackening; podetia sparse and sometimes lacking; podetia, when present, usually with broad stipes and cups (3-4 mm broad)............................***C. macrophyllodes***

32. Primary squamules not as above........................**33**

33. Primary squamules to 8 mm long, ligulate, (strap-shaped), without raised bumps on upper surface, ventral surface blackening; podetia always present, usually with narrow stipes and cups (1-2 mm broad); Amador County. ....**C.** cfr. ***cervicornis***

33. Primary squamules to 1 cm long, usually not ligulate; podetia borne on phyllopodia, with further series of phyllopodia proliferating from cup margins; San Luis Obispo County................................***C. firma***

34. Primary squamules persistent; podetial squamules always present and sometimes abundant, especially around cups ....***C. cervicornis*** subsp. ***cervicornis***

34. Primary squamules not persistent; podetia usually with few if any squamules. ....***C. cervicornis*** subsp. ***verticillata***

35. Podetia never cup-forming, blunt, always appearing shredded, composed of numerous solid medullary strands, longitudinally arranged, with no part of podetia appearing cylindrical; bluish primary squamules usually persistent; podetia always tipped with brown apothecia....................................***C. cariosa***

35. Podetia and squamules not as above...................**36**

36. Podetia with or without distinct cups; cups, when present, usually oblique, with or without marginal proliferations; marginal proliferations never longitudinally fissured, and axils never open; cups, when present, closed......................***C. prolifica***

36. Podetia with or without distinct cups, always with proliferations or branches that are longitudinally fissured; axils open................................**37**

37. Podetia with distinct cuplike structures, usually with marginal proliferations that are longitudinally fissured; cup interiors with perforations..........***C. multiformis***

37. Podetia without cups; branches longitudinally fissured; axils open..**38**

38. Tips of branches with corticate granules ....***C. scabriuscula***

38. Tips of branches with continuous cortex......***C. furcata***

39. Podetia with narrow, open cups that expose hollow inner medullary layer...**40**

39. Podetia and cuplike structures usually somewhat swollen and deformed, especially near apices..................**41**

40. Podetia with few or no squamules; proliferations from margins of open cuplike structures always subulate; barbatic and thamnolic acids............**C.** cfr. ***crispata***

40. Podetia abundantly squamulose, sometimes with very small squamules that resemble soredia to the naked eye; podetial surface beneath squamules ecorticate; openings punctiform or larger, usually symmetrical; apothecia light to darker brown, upper surfaces of apothecia convex; barbatic and thamnolic acids present ....***C. squamosa*** var. ***subsquamosa***

41. Podetia bone white or brownish, to 80 mm; cuplike structures distinct, later becoming torn and obliquely oriented; cortex thin, verruculae thin and scattered; pycnidia regularly arranged around some cup margins; primary squamules evanescent; apices of podetia seldom closed...............................**C.** cfr. ***crispata***

41. Podetia greenish, often puffy, not exceeding 40 mm; cuplike structures indistinct, cortex thick; pycnidia never regularly arranged around margins; primary squamules persistent and partially buried beneath surface of substratum; apices of podetia sometimes closed ....***C. thiersii***

SYNOPTIC KEY TO THE GENUS *CLADONIA* IN CALIFORNIA AND ADJACENT OREGON

CHEMISTRY

1-1. *Spot test reactions*

- A. Para-phenylenediamine (P) spot test
    - 1. P negative: 2, (3), 4, (*10*), 26, 31
    - 2. P positive orange or deep yellow, not changing to red: *10*, 17, 27, 29, 30
    - 3. P positive red: 1, 3, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 28, 32
- B. Potassium hydroxide (K) spot test
    - 1. (K+ dingy yellow, changing to dingy brown or K negative)
    - 2. K positive bright yellow, unchanging: (*3*), (5), *10*, 17, 27, 29, 30

1-2. *Diagnostic phenolics*

- A. atranorin present: 3, (5), *13, 16, 18, 23*
- B. barbatic acid present: *10*, 17, *27*
- C. fumarprotocetraric acid present: 1, 3, *5*, 6, 7, 8, 9, 11, 12, *13*, 14, 15, *16*, 18, 19, 20, 21, 22, *23*, 24, 25, 28, 32
- D. merochlorophaeic acid present: 19
- E. squamatic acid present: *2*, 4, *26*, (*31*)
- F. thamnolic acid present: *10*, 27, 29, *30*
- G. usnic acid present: *2*, 4, *30*

1-3. *Diagnostic fatty acids*

- A. bourgeanic acid present: 16, 23
- B. lichesterinic acid present: 32
- C. norrangiformic and/or norrangiformic acids present: 1
- D. none present: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 18, 19, 20, 21, 22, 24, 26, 27, 28, 29, 30, 31, 32

PODETIAL CHARACTERS

2-1. *Podetial anatomy*

- A. Podetial morphology
  - 1. (comprised of more or less hollow tube)
  - 2. torn and shredded, comprised of numerous longitudinally-oriented, solid medullary strands: 3
- B. Podetial openings
  - 1. (axils and apices closed; no view of interior tube provided)
  - 2. regular openings at axils and/or apices, providing view of interior of podetial tube: 10, 14, 20, 25, 26, 27, 29
- C. Podetial swelling
  - 1. (podetia not swollen)
  - 2. podetia swollen, especially at apices and near cuplike structures: *10*, 29

2-2. *Podetial size*

- A. (Podetia at maturity > 1 cm tall)
- B. Podetia at maturity < 1 cm tall: (*1*), (*4*), (*7*), (*12*), *13*, 15, 16, (*17*), (*18*), (*23*), (*24*), *32*

2-3. *Scyphi (cups)*
A. (Podetia forming cups or cuplike structures)
B. Podetia not forming cups or cuplike structures: (*2*), 3, *8*, (*12*), 14, 17, (*21*), 25, *28*, (*31*), (*32*)

2-4. *Podetial branching*
A. Extent of branching at maturity
  1. (unbranched or sparingly branched)
  2. much-branched: *10, 11,* 14, 20, 25, 26, 27, (28), (32)
B. Location of branches or proliferations (if present)
  1. from cup margins: 1, 2, 4, (*5*), (*6*), 7, 8, 9, 10, 11, 12, 15, 16, 19, 20, *21*, 22, 23, 24, 26, 27, 28, *29*, 30, 31, 32, (*32*)
  2. from cup interiors: 5, 6, 13, 18, *33*
  3. laterally along podetia: 14, (*21*), 25, 29, *32*
C. Morphology of branches or proliferations
  1. (without distinct longitudinal fissures)
  2. with distinct longitudinal fissures: 11, 14, 20, 25

APOTHECIAL CHARACTERS

3-1. *Apothecial color*
A. Apothecia at maturity reddish-brown, chestnut-brown or dark brown: 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 32
B. Apothecia at maturity pale brown: 4
C. Apothecia at maturity red: 2, 17, 30, 31

3-2. *Apothecial surface*
A. (Convex)
B. Flat: *10*

CORTICAL FEATURES

4-1. *Soredia*

- A. Presence or absence of soredia or soredia-like structures (if soredia or soredia-like structures not present, skip B-E under this heading, and skip entries under 4-2).
  - 1. podetia sorediate at least in part: 1, 4, 7, 8, 9, 12, 15, 16, *17*, 19, 21, 28, 30, 31, *32*
  - 2. podetia esorediate without granules or verruculae that may appear as soredia: 2, 3, 5, 6, 10, 11, 13, 14, (*17*), 18, 23, 24, 26, 27, 29, (*32*) (see 3 below)
  - 3. podetia with granules or verruculae that may appear as soredia to the naked eye, but are not soredia: 2, 10, 11,14, 23, 24, 25, 26, 27
- B. Size of soredia only
  - 1. (soredia ca 40-80 µm)
  - 2. soredia larger than 80 mµ: 1, 7, (*12*), *17*, 19, (*21*), 30, (*31*), 32
- C. Presence or absence of soralia (if soredia present)
  - 1. (soredia not in soralia)
  - 2. soredia in soralia: (*8*), 9, (*17*), 21, (*30*)
- D. Condition of soralia (if present)
  - 1. (soralia with evenly distributed, small soredia)
  - 2. soralia with erumpent, large soredia: 17, (*21*), 30
- E. Soredia alone or intergrading with other cortical structures on podetia, such as squamules, isidioid structures, or verruculose agglomerations
  - 1. (soredia intergrading with other structures)
  - 2. soredia not intergrading with larger structures: (*12*), 15, 16, (*17*), *28*

4-2. *Podetial bases in sorediate taxa*

A. Cortication of bases

1. (bases corticate or verruculose, but not sorediate)
2. bases sorediate: 1, (*4*), *7*, *12*, (*17*), *19*, 28, *31*, 32

B. Presence or absence of distinct longitudinal ridges

1. (without distinct longitudinal ridges)
2. with distinct longitudinal ridges: 9

PRIMARY SQUAMULES

5-1. *Primary squamules perisitent* (present with well-developed podetia) *or evanescent* (absent with well-developed podetia)

A. (evanescent)

B. persistent: (*1*), (*2*), 3, (*4*), 5, (*7*), *8*, (*10*), (*12*), 13, (*17*), 18, *21*, (*22*), *23*, (*24*), 29, (*30*), *31*, (*32*)

5-2. *Shape of primary squamules*

A. entire-ligulate; 3, (*5*), (*13*), (*18*), 22, (*29*)

B. entire-rounded, with incisions less than 1/2 the length of squamule: 21

C. deeply incised (lobes at least 1/2 length of squamule): 1, 2, 4, *5*, 6, 7, 8, 9, 10, 11, 12, *13*, 14, 15, 16, 17, *18*, 19, 20, 23, 24, 26, 27, 28, *29*, 30, 31, 32, 5-3. *Color of primary squamules*

A. bluish: 3, *13*

B. yellowish: 4

C. greenish, olivaceous, or brown: 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, (*13*), 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32

SCYPHUS (CUP) INTERIORS

6-1. *Scyphus conformation*

A. open (with hollow interior of podetium visible from above): 10, 26, 27, 29

B. closed (not as above): 1, 2, 4, 5, 6, 7, *8*, 9, 11, 12, 13, 15, 16, 18, 19, 21, 22, 23, 24, *28*, 30, 31, 32, 33

C. closed, but with regular perforations: 20, (*28*)

D. podetia not cup-forming: 3, *8*, 14, 17, 25, *28*

6-2. *Scyphus surface* (in closed-scyphus taxa)

A. corticate: 2, 5, 6, (*9*), 10, 18, 20, *21*, 22, *30*

B. sorediate: 1, 4, 7, 8, *9*, 12, 15, 16, *19*, (*21*), 28, (*30*), 31, *32*

C. with peltate squamules: (*7*), 11, (12), (*19*), 23, 24, (*32*)

TABLE 1. Comparative notes on scyphus-forming, sorediate, (or sorediate-appearing) fumarprotocetraric acid-containing *Cladonia* species from California and adjacent Oregon.

1. **C. asahinae:** rangiformic/norrangiformic acids in TLC

7. **C. chlorophaea:** fumarprotocetraric acid only in TLC, highly variable, compare morphologically with taxa 1, 11, 12, 19, 23, 24, and 32.

8. **C. coniocraea:** podetia smoothly corticate at bases, soredia usually fine, primary squamules deeply dissected, many podetia subulate, compare with taxa 9 and 21.

9. **C. cornuta** subsp. **groenlandica:** bases corticate, longitudinally rugose, podetia brownish.

12. **C. dimorpha:** cortex cracked and appearing sorediate, but true soredia not present, apothecium-bearing proliferations always with longitudinal fissures (compare with *C. furcata*); non-apotheciate podetia with broad cups and usually with pycnidia regularly arranged along cup margin, compare with taxon 24.

13. **C. fimbriata:** quite variable, compare with taxa 7 and 28 in its extreme forms.

15. **C. humilis** var. **bourgeanica:** podetia <1 cm tall, bases corticate, bourgenic acid in TLC, compare with taxon 16.

16. **C. humilis** var. **humilis:** same morphology as taxon 15, atranorin in TLC

19. **C.** cfr. **merochlorophaea:** merochlorophaeic acid and 4-0 methylcryptochlorophaeic acid in TLC, podetia brownish, bases blackening, often covered with podetial squamules.

21. **C. ochrochlora:** compare with taxa 8 and 9, podetia smoothly corticate at base, soredia variable, often in soralia, primary squamules not deeply dissected, always some podetia cup-forming, cup interiors usually thickly corticate but sometimes sorediate.

23. **C. pulvinella:** sorediate-appearing, but not truly sorediate, bourgeanic acid and atranorin in TLC.

24. **C. pyxidata**: cortex variable but never sorediate, peltate squamules in cup interiors conspicuous, but taxa 1, 7, 11, 23, and 32 may share this character, especially in older podetia.

28. **C. subulata**: many podetia subulate, cup-forming podetia with subulate proliferations, soredia fine but may enlarge toward bases, and remaining fine in cup interiors.

32. **C. verruculosa**: soredia variable, fine to granular, podetia usually taller than others in this list, (to 80 mm), cups always narrow in comparison to podetia, bases appearing corticate but usually this "cortex" is verruculae that have agglomerated, proliferations from the center of cups (also from margins).

Cladonia pulvinella Hammer sp. nov. Holotype: USA, California, Marin County. Ridge Trail, Point Reyes National Seashore, ca 1 km from ocean. Collected on soil. Elev. ca 100 m. *Hammer* 2023 (Holotype FH; Isotype H); contains fumarprotocetraric acid, protocetraric acid, atranorin, and bourgeanic acid. (Fig. 1)

> *Thallus primarius squamulosus, persistens, usque 12 mm altus et 8 mm latus, subtus venosus, esorediatus. Podetia scyphifera, usque 2 cm alta, scyphi clausi, stratum exterius sorediis grandibus et schizidiis pulvinatis-peltatis, decorticatis, interius schizidiis peltatis. Atranorinam, acidum bourgeanicum, acidum fumarprotocetraricum, et acidum protocetraricum continentes.*

Primary thallus squamulose, persistent, 7-12 mm long, 3-8 mm wide, entire to irregulary crenate-lobate to shallow subdigitately lobate; upper surface glaucescent green to olivaceous, ventral surface white to ashy, darkening toward base, veins appearing toward base, subfibrillose, flattened to involute, wrapping around podetia in some and sometimes appearing cyathiform, esorediate or with granular soredia-like structures forming beneath margins.

Podetia from upper side of primary squamules, 3-10 (20) mm tall, unbranched, scyphus forming; cortex lacking from base, or with immediate basal area corticate, granulose, soft-appearing, pillow-like structures (80-200 µm in diam), appearing immediately above base, giving rise to small peltate squamules and isidioid structures, rarely enlarging

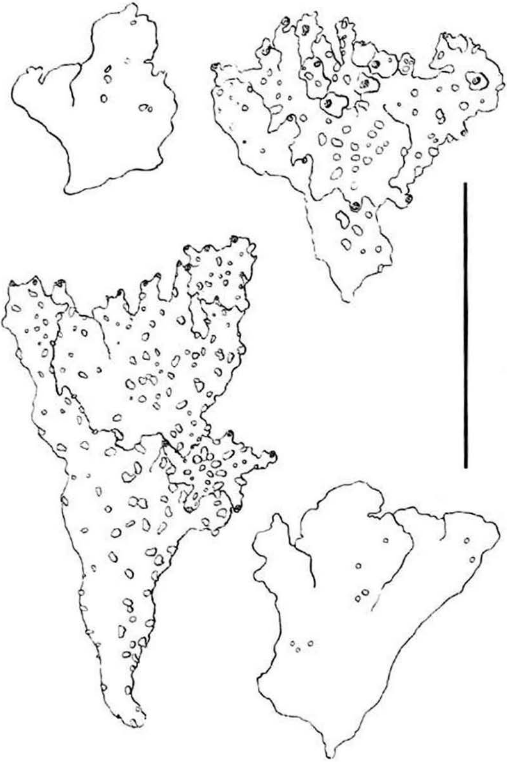

Fig. 1.*Cladonia pulvinella* sp. nov. Scale bar indicates 1 cm.

to form podetial squamules, exposed inner layer impellucid, white to brownish, surface barely fibrillose; scyphi 1-8 mm in diam., closed, shallow, frequently with punctiform opening in center of scyphus interior, abundantly covered with granulose soredia and peltate squamules, enlarging and deforming with age, margins producing numerous (5-23) digitate proliferations, apices of proliferations blunt or expanding to form scyphi, rarely giving rise to further proliferations.

Apothecia (immature in type, lacking in other specimens studied) numerous, borne singly along scyphus margins or at tips of proliferations, 120-200 µm in diam., dark reddish brown, asci and ascospores not observed. *Pycnidia* and *conidia* not observed.

Anatomy: Primary squamules 90-105 µm thick; cortex 23-30 µm thick, of closely agglutinated cells, 7-12 µm in diam.; algal layer 23-37 µm thick, medulla 35-65 µm thick, of loosely interwoven, irregularly arranged cells. Podetial wall 250-350 µm thick, cortex 30-50 µm thick, of tightly interwoven to agglutinated, subglobose cells, exterior medullary layer120-180 µm thick, of loosely interwoven hyphae, internal cartilaginous tissue 70-120 µm thick, hyphae densely interwoven.

Growing on thin soil.

Spot test reactions: K+ yellow, persistent, KC-, P+ orange, changing to red.
Chemical constituents: atranorin, bourgeanic acid, fumarprotocetraric acid, and protocetraric acid.
Specimens studied: CALIFORNIA. Amador Co.: *Hammer* 1281, 1316, *Hammer* 1332 (SFSU); Marin Co.: *Hammer* 2372 (FH); Stanislaus Co.: *Thiers* 33428 (SFSU).

Cladonia pulvinella was discussed in Hammer and Ahti (1990) as *C.* cfr. *humilis*. The cortical condition of *C. pulvinella* is interesting, in that podetia and scyphi are covered with large (to 200 µm), loosely corticate, pillow-like structures that appear at a glance as soredia. The regularly scyphus-forming, rather short podetia of *C. pulvinella* could cause confusion with the "*C. chlorophaea*" group, but close examination of specimens with both atranorin and bourgeanic acid should reveal no soredia, which are present in most other members of the group.

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CATALOG OF THE LICHENS OF UTAH

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SUMMARY

Four-hundred-and-twenty-five epithets of lichens have been reported for Utah. After correcting synonyms and misidentifications, 329 taxa remain: 85 genera, 318 species, and 11 varieties. This catalog is based on reports in 44 papers and includes introductory material on Utah's geology, climate and vegetation, and an overview of the Utah lichen flora.

DESCRIPTION OF THE STATE OF UTAH

The state of Utah encompasses some 219,990 km^2, and includes portions of the western Rocky Mountains, the northern Colorado Plateau, and the eastern Basin and Range Province. Boundaries of the state are roughly between 37 and 41 degrees north latitude and 108 and 114 degrees west longitude. Elevation ranges from 665 m in the Mojave Desert of southwest Utah to 4126 m in the Uinta Range of Utah's Rockies.

Geology and substrates. -- The Rocky Mountains in Utah are represented by the Wasatch Range in the north, the Uinta Mountains in the northeast, and a broad backbone of plateaus down the middle of the state. The Wasatch Range is a block-faulted escarpment extending about 300 km from southern Idaho to north-central Utah. The western slopes of the Wasatch are abrupt, while the eastern slopes are folded and more gradual. The range crests around 3100 m, with many peaks even higher. Lithology in the Wasatch includes Paleozoic marine deposits, Precambrian quartzite and some igneous intrusives. Pleistocene and Recent surficial deposits cover some of the exposed bedrock.

The Uinta Mountains in northeastern Utah are anticlinal in structure and consist of Precambrian quartzite in the core with younger sandstones, shales, and limestones on the flanks. Pleistocene glaciation in the Uintas is evidenced by moraines, cirques, and deep U-shaped valleys oriented perpendicular the anticlinal core. Twenty-six individual summits in the Uintas reach elevations greater than 3960 m, and King's Peak, Utah's maximum elevation, is also here, surrounded by extensive alpine meadows and felsenmeers.

Eight high plateaus, parallel and mostly north-south in orientation and ranging between 2500 and 3000 m in elevation, form the central backbone of the state. Continuing southward from the southern terminus of the Wasatch Range almost to the Utah-Arizona line, they form an uneven transition between the Basin and Range Province on the west and the Colorado Plateau on the east. Stratigraphy is relatively unbroken with the Colorado Plateau. Tertiary basaltic extrusions complicate the otherwise "layer-cake" regional stratigraphy.

Varicolored marine, lacustrine, and aeolian strata cover vast areas of the Colorado Plateau in eastern, southern, and central Utah. Differential weathering, erosion and redeposition have formed the mesas, deep canyons, pediments, massive linear cliffs, badlands, and other geomorphic features for which this portion of the state is noted. Igneous intrusives and volcanic extrusives of Tertiary age have created isolated mountain peaks within the plateau area.

Portions of the Basin and Range Province occupy most of western Utah. Structurally from east to west, this region alternates between mountain ranges and sediment-filled valleys. Both features are elongate, trending north to south. Predominant lithologies of the ranges include sandstone, limestone, and quartzite. Generally the ranges lack a distinct and dramatic peak and crest at an elevation of about 3000 m. The valley floors average 1300 m in elevation and are somewhat level or of moderate relief, consisting of detritus and alluvium eroded from adjacent ranges. Drainages in western Utah have no outlet to the sea; runoff flows into saline sinks and either evaporates soon after spring thaw or, as in the Great Salt Lake, fluctuates with the season. This region in Utah and Nevada is referred to as the Great Basin.

Climate. -- Occupying middle latitudes, Utah is affected by the seasonal oscillation of polar and tropical jet streams. The inland location of the state greatly modifies the influences of both. To the west the Sierra Nevada and Cascade Range remove most of the moisture from air masses moving towards Utah; to the east the

Rockies diminish the effect of the summer monsoon and shield the state from winter arctic extremes. As a result, Utah is the second driest of the fifty states, with sunny skies prevailing throughout most of the year.

Local climatic conditions vary with topography. Annual precipitation ranges from less than 12 cm across the Great Salt Lake Desert to over 150 cm at higher elevations in the Wasatch Range. Snowfall is moderately heavy in the mountains, especially in the north, and decreases with elevation and latitude. Temperature also varies with elevation and latitude. Mountains and elevated valleys experience cooler temperatures, while lower areas are warmer.

Plant communities. -- Alpine meadows in Utah occur mainly above 3355 m and are well developed and broadly continuous in the Wasatch and Uinta mountains. Alpine communities are common but restricted and somewhat patchy throughout the rest of the state.

Subalpine and montane coniferous forests are extensive in the Uinta, Wasatch, and La Sal ranges, and on the central plateaus. Coniferous forests are common throughout the rest of the state but restricted to the higher elevations of more isolated ranges. Forest composition differs from region to region, depending upon elevation, soil, and climatic patterns. In general, Engelmann spruce and lodgepole pine are the dominant conifers in the Uintas; Douglas fir in the Wasatch and Great Basin ranges and central plateaus; and ponderosa pine and white fir in the southern plateaus. Blue spruce favors high-elevation moist sites in the eastern half of the state. Limber pine and Great Basin bristlecone pine occur in isolated patches throughout the state, often in cold-air sites and on calcareous soils. The so-called pygmy forests of pinyon pine and Utah juniper occupy vast areas of Utah, usually on the lower slopes and foothills of mountains.

Deciduous forests are limited in Utah. Aspens grow at higher elevations, often in pure stands. Thickets of oak and maple scrub occur in restricted canyons or across extensive areas in the foothills.

The valleys of the Great Basin and the Colorado Plateau are dominated by cool desert shrubs. Sagebrush, winterfat and rabbitbrush communities characterize the alluvial valley floors in the Great Basin of western Utah. Chenopods are also abundant in the Great Basin, especially in saline soils. Shrub composition is more diverse in the Colorado Plateau of eastern Utah, where substrates are raw or colluvial and generally better drained. Isolated sand dune communities occur in both the Great Basin and the Colorado Plateau.

Floristic patterns in southwestern Utah (Washington County) sharply differ from those in the rest of the state. Joshua trees, various cacti, creosote, and other warm desert species grow in the lowest elevations, replaced by inland chaparral communities slightly higher. Much of this area presents a rich intermingling of floristic elements from the Mojave Desert, the Colorado Plateau, and the Great Basin.

Riparian communities, consisting of cottonwood, birch, alder, box elder, willows, reeds, sedges, rushes, and cattails, were more extensive throughout Utah before their destruction by large water projects on Utah's rivers. Reed, sedge, and cattail wetlands are located mostly in the valleys and sinks of the Wasatch Range and the Great Basin.

Utah is rich in microhabitats. Deep, narrow canyons frequently create cold air traps, supporting temperate biota at low, otherwise xeric elevations. Hanging gardens, a floristic feature of the Colorado Plateau, are isolated and often disjunct communities of ferns, orchids, sedges, and herbaceous dicots, clinging to seeps and wetwalls on protected sandstone cliffs in the deserts of the Colorado Plateau.

In summary Utah's plant communities reflect strong correlation between elevation and climate, but complex geology, mountainous relief, and microhabitat ecology complicate simple geographic delineations of floristic zones.

THE LICHEN FLORA OF UTAH

Alpine lichen communities are best developed in the high meadows, talus and felsenmeers of the Uinta Mountains. The most common alpine terricolous species are *Acarospora schleicheri, Arthonia glebosa, Catapyrenium cinereum, Cetraria ericetorum, C. tilesii, Coelocaulon aculeatum, Dactylina madreporiformis, Evernia divaricata, Lecanora epibryon, Leproloma vouauxii, Ochrolechia upsaliensis, Phaeorrhiza nimbosa*, and *Physconia muscigena*. Diversity of alpine terricolous species is less than that of adjacent intermountain states. *Cetraria cuculata, C. nivalis, Thamnolia subuliformis*, and other species prominent in alpine communities elsewhere in the Rocky Mountains are conspicuously absent from Utah.

Saxicolous alpine communities in Utah are similar to those of other western North American alpine regions. *Acarospora chlorophana, Dimelaena oreina, Lecanora argopholis, L. polytropa, L. rupicola, L. thomsonii, Lecidea atrobrunnea, L. tessellata, Lecidella* *stigmatea, Protoparmelia badia, Pseudephebe minuscula, Rhizoplaca chrysoleuca, R. melanophthalma, Rhizocarpon disporum, R. geographicum, Sporastatia testudinea, Tephromela armeniaca, Umbilicaria hyperborea, U. kraschennikovii, U. virginis,* and *Xanthoria elegans* are the most common saxicolous alpine species in Utah.

Lichen communities of subalpine and montane coniferous forests are also less diverse than those of similar habitats in adjacent western states. Crustose forms predominate over foliose forms, and fruticose forms are uncommon. Common corticolous species include *Buellia punctata, Lecanora hageni, L. varia, Megaspora verrucosa, Melanelia exasperata, M. subolivacea, Parmeliopsis ambigua, Rinodina pyrina, Xanthoria fallax,* and *X. polycarpa.* Rarely *Bryoria chalybeiformis, Bryoria fuscescens, Evernia divaricata,* and *Ramalina obtusata* are also collected from conifer bark. Species common in western North America but notably absent or rare in Utah include *Bryoria fremontii, B. pseudofuscescens, Flavoparmelia caperata, Hypogymnia imshaugii, H. physodes, Letharia columbiana, L. vulpina, Parmelia sulcata* and *Pseudevernia intensa.*

Quaking aspens in higher elevations host up to 10 different lichen species. The most common are *Caloplaca holocarpa, Candelariella deflexa, Lecanora hageni, Physcia adscendens,* and *Xanthoria fallax.* Lichens tend to occur on the main trunk of aspens and favor healed wounds and branch scars.

The most common terricolous species from subalpine and montane coniferous forests include *Cladonia cariosa, C. chlorophaea, C. pocillum, C. pyxidata, Mycobilimbia berengeriana, Peltigera aphthosa, P. canina, P. venosa,* and *Psoroma hypnorum.* Subalpine and montane saxicolous communities are best developed in open, sunny sites, and are characterized by *Acarospora fuscata, A. glaucocarpa, Aspicilia caesiocinerea, A. calcarea, A. cinerea, Candelariella rosulans, C. vitellina, Dermatocarpon miniatum, Dimelaena oreina, Lecanora argopholis, L. muralis, L. polytropa, Lecidea atrobrunnea, L. tessellata, Lecidella stigmatea, Rhizocarpon geographicum, R. disporum, Rhizoplaca chrysoleuca, R. melanophthalma, R. peltata, Umbilicaria virginis, U. torrefacta,* and *Xanthoria elegans.*

Scrub oak and maple communities in steep canyons and foothills support a fairly diverse lichen flora, including *Lecanora hageni, Phaeophyscia orbicularis, Physcia adscendens, P. dubia, P. stellaris, Physconia grisea, Xanthoria fallax,* and *X. polycarpa.*

The vegetation of lower slopes and foothills in Utah (and throughout the interior western United States) is characterized by juniper and pinyon pine. At some sites the twigs and lower trunks of these small trees are literally covered with 5-15 lichen species. Species most commonly collected from these substrates include *Caloplaca arizonica, Candelariella deflexa, Melanelia exasperata, M. subolivacea, Physconia grisea,* and *Xanthoria fallax*. In areas of southern Utah *Usnea hirta* may be found on the bark and dead twigs of pinyon pine. Ungrazed or lightly grazed soils in pinyon-juniper communities have well-developed cryptogamic crusts composed of the following species: *Agrestia hispida, Catapyrenium lachneum, Collema tenax, Endocarpon pusillum, Psora decipiens,* and *Xanthoparmelia chlorochroa*. Saxicolous lichens on small surficial rocks and pebbles in pinyon-juniper woodlands include *Acarospora fuscata, Aspicilia calcarea, A. desertorum, Lecidea tessellata,* and *Staurothele fuscocuprea*. Saxicolous lichens in bouldery areas of pinyon-juniper woodlands include *Acarospora americana, A. chlorophana, A. fuscata, A. strigata, Aspicilia alphoplaca, Collema polycarpon, Dermatocarpon miniatum, Dimelaena oreina, Lecanora argopholis, L. muralis, L. garovaglii, L. rupicola, Melanelia granulosa, M. sorediata, Neofuscelia loxodes, Rhizocarpon disporum,* and *Xanthoparmelia plittii.*

In Great Basin Desert shrublands, the older lower stems and younger dead branches of sagebrush are typically covered by *Candelariella deflexa, Xanthoria fallax* and *X. polycarpa*. Cryptogamic soil crusts occupy intershrub spaces. Although these soil crusts are predominantly composed of soil-binding cyanobacteria, the lichens *Catapyrenium lachneum, Collema tenax, Fulgensia bracteata,* and *Psora decipiens* are also common, especially at ungrazed sites. Lichen cover on the soil decreases with increasing soil salinity, *Catapyrenium lachneum* and *Collema tenax* having the highest salinity tolerance.

Sandstone cliffs of the Colorado Plateau support a rich microlichen flora, including *Acarospora fuscata, A. strigata, Aspicilia caesiocinerea, Buellia retrovertens, Caloplaca arenaria, C. decipiens, C. flavovirescens, C. fraudans, Candelariella rosulans, C. vitellina, Diploschistes actinostomus, Diplotomma alboatrum, Lecanora alphoplaca, L. crenulata, L. dispersa, Lecidea atrobrunnea, Psora russellii, Staurothele fuscocuprea,* and many others. Foliose lichens on sandstone include *Collema coccophorum, Dermatocarpon miniatum, Physcia sciastra, P. subtilis, Xanthoparmelia lineola* and *X. mexicana*.

Gypsiferous soils of the Colorado Plateau contain extraordinary lichen soil crusts. These soil communities cover large areas, are interrupted by few trees and shrubs, and approach 100% lichen cover with up to 35 species represented. The most common species in the gypsiferous crusts are *Acarospora nodulosa* var. *nodulosa, Buellia elegans, Catapyrenium lachneum, Collema tenax, Diploschistes scruposus, Fulgensia bracteata, Psora crenata, P. decipiens* and *Squamarina lentigera*.

In summary, Utah is rich in microlichens but poor in macrolichens. Paleoclimatic, abiotic, and biotic factors not fully understood at this time probably account for macrolichen impoverishment. Further sampling of mesic microhabitats might reveal other relict or recently dispersed macrolichen species of limited distribution. Continued investigation of the microlichen flora throughout Utah's substrate and habitat diversity will probably show that the total number of lichen taxa in Utah is comparable to that of other western states, even without an extensive macrolichen flora.

COLLECTORS OF UTAH LICHENS

In the past lichens have received only cursory attention from botanists and other collectors in Utah. Published references to Utah lichens are few compared to adjacent states. The scarcity of macrolichens in Utah may have discouraged floristic investigation. Major lichen collectors are listed below.

Anderson, David. C.
Anderson, Roger A.
Belnap, Jaynie
Brotherson, Jack D.
Fields, Rebecca D.
Flinders, Jerran T.
Flowers, Seville
Harper, Kimball T.
Johansen, Jeffrey R.
Magnusson, A. H.
Marsh, Janet
Nash, Thomas
Nebeker, Glen T.
Newberry, Clayton
Nielsen, H. S., Jr.
Pammel, Lewis H.
Pearson, Lorentz
Rushforth, Samuel R.
St. Clair, Larry L.
Shushan, Sam
Sigal, Lorene
Stutz, Howard C.
Thomson, John W., Jr.
Tuckerman, E.
Weber, William
Westgate, Kathleen
Wetmore, Clifford

LICHEN TYPES FROM UTAH

The following 13 taxa have their type locality in Utah.

ACAROSPORA ARENACEA Magnusson (UPS)
ACAROSPORA DESOLATA Magnusson (UPS)
ACAROSPORA FUSCESCENS Magnusson (UPS)
ACAROSPORA UTAHENSIS Magnusson (UPS)
BUELLIA LECANOROIDES Magnusson (UPS)
BUELLIA SAURINA W. Weber (COLO)
LECANORA FLOWERSIANA Magnusson (UPS)
LECANORA THALLOPHILA Magnusson (UPS)
LECANORA UTAHENSIS Magnusson (UPS)
RINODINA ATHALLINA Magnusson (UPS)
RINODINA CONSTRICTULA Magnusson (UPS)
SARCOGYNE OLIGOSPORA Magnusson (UPS)
STAUROTHELE SESSILIS Magnusson (UPS)

FORMAT OF THE UTAH LICHEN CATALOG

We have followed the nomenclature of Egan (1987, 1989, 1990) in the fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. All lichen references for the state of Utah are listed as they first appeared in the literature. Valid taxa are presented in upper case. Synonyms, invalid taxa and misidentifications are presented in italics, with current or valid designations preceded by equal signs. Citations are enclosed within parentheses, with each separate citation preceded by a dash. Where possible, substrate and geographical information are included.

CATALOG OF TAXA

ACAROSPORA Massal.

ACAROSPORA ARENACEA Magnusson (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Eastern Wayne County. Type locality.)

ACAROSPORA CERVINA (Pers. *in* Ach.) Massal. (--Flowers, S. 1954. p. 103. On dry rock. Antelope Island, Great Salt Lake, Davis County.) Synonym: *Lecanora cervina*

Acarospora cervina var. *eucarpa* Nyl. (--Flowers, S. 1954. p. 103. On dry rock. Antelope Island, Great Salt Lake, Davis County.) = SARCOGYNE CLAVUS (DC. *in* Lam. & DC.) Krempelh.

ACAROSPORA CERVINA Massal. var. GLAUCOCARPA (Wahlenb. *in* Ach.) Körber Synonym: *Acarospora glaucocarpa*

ACAROSPORA CHLOROPHANA (Wahlenb. *ex* Ach.) Massal. (--Flowers, S. 1954. p. 103. On dry rock. Antelope Island, Great Salt Lake, Davis County; Iron County. --Nash, T. H. 1974. p. 98. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonyms: *A. flava, Lecanora chlorophana*

ACAROSPORA DESOLATA Magnusson (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Eastern Wayne County. Type locality.)

Acarospora epilutescens Zahlbr. (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Carbon County.) = ACAROSPORA SCHLEICHERI (Ach.) Massal.

Acarospora flava (Bellardi) Ach. (--Fink, B. 1935. p. 285. On rock. Alpine elevations and lower.) = ACAROSPORA CHLOROPHANA (Wahlenb. *ex* Ach.) Massal.

ACAROSPORA FUSCATA (Nyl.) Arnold (--Flowers, S. 1954. p. 103. On dry rock. Salt Lake, Carbon, and Washington counties. --Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. On rock. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

ACAROSPORA FUSCESCENS Magnusson (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Eastern Wayne County. Type locality.)

Acarospora glaucocarpa (Wahlenb. *in* Ach.) Körber (--Magnusson, A. H. 1929. p. 237.) = ACAROSPORA CERVINA Massal. var. GLAUCOCARPA (Wahlenb. *in* Ach.) Körber

ACAROSPORA GLAUCOCARPA var. VERRUCOSA (Anzi) Magnusson (--Flowers, S. 1954. p. 103. On dry calcareous sandstone. Salt Lake County.)

ACAROSPORA NODULOSA (Dufour) Hue var. NODULOSA (--St. Clair, L. L. & R. B. Warrick. 1987. pp. 48-49. On gypsiferous soils. Near Zion National Park, Washington County.)

ACAROSPORA PELTASTICA Zahlbr. (--Flowers, S. 1954. p. 103. On dry rock. Carbon and Washington counties.)

ACAROSPORA SCHLEICHERI (Ach.) Massal. (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonyms: *A. epilutescens, Lecanora xanthophana*

ACAROSPORA SMARAGDULA (Wahlenb. *in* Ach.) Massal. (--Anderson, D. C. & S. R. Rushforth. 1976. p. 702. On rock. Desert Experimental Range, Millard County; Hurricane and Bloomington, Washington County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

ACAROSPORA STRIGATA (Nyl.) Jatta (--Flowers, S. 1954. p. 103. On dry rock. Eastern Wayne County. --Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 702. On rock. Desert Experimental Range, Millard County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

ACAROSPORA UTAHENSIS Magnusson (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Eastern Wayne County. Type locality.)

Acarospora xanthophana (Nyl.) Jatta (--Flowers, S. 1954. p. 103. Salt Lake and Washington counties.) = ACAROSPORA SCHLEICHERI (Ach.) Massal.

AGRESTIA Thomson

AGRESTIA HISPIDA (Mereschk.) Hale & Culb. (--Anderson, D. C. & S. R. Rushforth. 1976. p. 703. On soil. Desert Experimental Range, Millard County.) Possibly an environmental modification of ASPICILIA CALCAREA (L.) Mudd

ALECTORIA Ach.

Alectoria chalybeiformis (L.) Gray (--Nash, T. H. 1974. p. 98. On conifer bark. Navajo Mountain, San Juan County.) = BRYORIA CHALYBEIFORMIS (L.) Brodo & D. Hawksw.

Alectoria minuscula (Nyl. *ex* Arnold) Degel. (--Imshaug, H. A. 1957. p. 262. Summit of Leidy Peak and Marah Peak, Uintah County; Mt. Mellenthin, San Juan County. --Nash, T. H. 1974. p. 98. On sandstone. Navajo Mountain, San Juan County.) = PSEUDEPHEBE MINUSCULA (Nyl. *ex* Arnold) Brodo & D. Hawksw.

Alectoria pubescens (L.) Howe (--Imshaug, H. A., 1957. p. 261. Uinta Mountains.) = PSEUDEPHEBE PUBESCENS (L.) M. Choisy

ANAPTYCHIA Körber

ANAPTYCHIA NEOLEUCOMELAENA Kurokawa Synonym: *Heterodermia neoleucomelaena*

APATOPLACA Poelt & Hafellner

APATOPLACA OBLONGULA (Magnusson) Poelt & Hafellner Synonym: *Lecidea oblongula*

ASPICILIA Massal.

ASPICILIA ALPHOPLACA (Wahlenb. *in* Ach.) Poelt & Leuck. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonyms: *Lecanora thamnoplaca*, *L. alphoplaca*

ASPICILIA CAESIOCINEREA (Nyl. *ex* Malbr.) Arnold (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Lecanora caesiocinerea*

ASPICILIA CALCAREA (L.) Mudd (--Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Lecanora calcarea*

ASPICILIA CINEREA (L.) Körber (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Lecanora cinerea*

Aspicilia desertorum (Krempelh.) Mereschk. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Aspicilia gibbosa (Ach.) Körber Synonyms: *Lecanora gibbosa, L. gibbosula*

Aspicilia melanaspis (Ach.) Poelt & Leuck. Synonym: *Lecanora melanaspis*

BACIDIA de Not.
Bacidia inundata (Fr.) Körber (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

BELLEMEREA Hafellner & Roux
Bellemerea cinereorufescens (Ach.) Clauz. & Roux Synonyms: *Lecanora cinerea* var. *cinereorufescens, L. cinereorufescens*

BIATORA Fr.
Biatora decipiens (Ehrh.) Fr. (--Tuckerman, E. 1871. p. 413. On alkaline soil. Rabbit and Carrington islands, Great Salt Lake.) = Psora decipiens (Hedwig) Hoffm.

Biatora russellii Tuck. (--Tuckerman, E. 1871. p. 413. Stansbury Island, Great Salt Lake.) = Psora russellii (Tuck.) A. Schneider

BIATORELLA de Not.
Biatorella oligospora (Magnusson) Flowers (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Eastern Wayne County. Type locality.) = Sarcogyne oligospora Magnusson

Biatorella simplex (Davies) Branth & Rostrup (--Flowers, S. 1954. p. 103. On dry sandstone. Carbon County.) = Polysporina simplex (Davies) Vezda

Biatorella simplex var. *major* (Magnusson) Flowers (--Flowers, S. 1954. p. 103. On dry sandstone. Eastern Wayne County. Type locality.) = Polysporina simplex (Davies) Vezda

Biatorella simplex var. *pruinosa* (Ach.) Fink (--Flowers, S. 1954. p. 103. On dry sandstone. Carbon County.) = Sarcogyne regularis Körber

BRODOA Goward

BRODOA OROARCTICA (Krog) Goward Synonym: *Parmelia intestiniformis* (Vill.) Ach.

BRYORIA Brodo & D. Hawksw.

BRYORIA CHALYBEIFORMIS (L.) Brodo & D. Hawksw. Synonym: *Alectoria chalybeiformis* (L.) Gray

Bryoria vrangiana (Gyelnik) Brodo & D. Hawksw. (--Brodo, I. M. & D. L. Hawksworth. 1977. p. 98. Navajo Mountain, San Juan County.) A misidentification, probably of BRYORIA FUSCESCENS (Gyelnik) Brodo & D. Hawksw. (*fide* Brodo)

BUELLIA de Not.

Buellia alboatra (Hoffm.) Th. Fr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) = DIPLOTOMMA ALBOATRUM (Hoffm.) Flotow

BUELLIA DISCIFORMIS (Fr.) Mudd (--Nash, T. H. 1974. p. 98. On decaying wood. Navajo Mountain, San Juan County.) Synonym: *Buellia parasema*

BUELLIA ERUBESCENS Arnold Synonym: *Buellia zahlbruckneri*

BUELLIA LECANOROIDES Magnusson (--Flowers, S. 1954. p. 105. On dry exposed sandstone. Eastern Wayne County. Type locality.)

Buellia montagnei (Körber) Tuck. (--Tuckerman, E. 1871. p. 413. On rock. Antelope Island.) = RHIZOCARPON DISPORUM (Naeg. *ex* Hepp) Müll. Arg.

BUELLIA NOVOMEXICANA B. de Lesd. (--Nash, T. H. 1974. p. 98. On sandstone in fir forest. Navajo Mountain, San Juan County.)

BUELLIA PAPILLATA (Sommerf.) Tuck. (--Kleiner, E. F. & K. T. Harper. 1972. p. 302. Canyonlands National Park, San Juan County.)

Buellia parasema (Ach.) de Not. (--Flowers, S. 1954. p. 105. On bark of spruce in shady woods. Navajo Lake, Kane County.) = BUELLIA DISCIFORMIS (Fr.) Mudd

BUELLIA PUNCTATA (Hoffm.) Massal. (--Nash, T. H. 1974. p. 98. On *Juniperus, Abies lasiocarpa,* and dead wood. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

BUELLIA RETROVERTENS Tuck. (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

BUELLIA SAURINA W. Weber (--Weber, W. 1971. p.191. On loosely cemented aeolian sandstone. Blue Mountain Plateau, Dinosaur National Monument, Uintah County. Type locality.)

BUELLIA SPURIA (Schaerer) Anzi (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

BUELLIA TURGESCENS Tuck. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

BUELLIA VILIS Th. Fr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Buellia zahlbruckneri Steiner (--Nash, T. H. 1974. p. 98. On conifer bark. Navajo Mountain, San Juan County.) = BUELLIA ERUBESCENS Arnold

CALICIUM Pers.

Calicium populneum Brond. *ex* Duby (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.) = PHAEOCALICIUM POPULNEUM (Brond. *ex* Duby) A. Schmidt

CALOPLACA Th. Fr.

Caloplaca amabilis Zahlbr. (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County. Possible misidentification.) = CALOPLACA PELODELLA (Nyl.) Hasse

CALOPLACA APPROXIMATA (Lynge) Magnusson (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CALOPLACA ARENARIA (Pers.) Müll. Arg. (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CALOPLACA ARIZONICA Magnusson (--Nash, T. H. 1974. p. 98. On bark of *Juniperus osteosperma*. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On bark, mostly of *Quercus gambelii*. Zion National Park, Washington County.)

CALOPLACA ATROALBA (Tuck.) Zahlbr. (--Fink, B. 1935. p. 360. On rock. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CALOPLACA CERINA (Ehrh. *ex* Hedwig) Th. Fr. (--Nash, T. H. 1974. p. 98. On bark of *Juniperus, Mahonia,* and dead wood. Navajo Mountain, San Juan County; Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *Placodium cerinum* var. *biatorinum*

CALOPLACA CINNABARINA (Ach.) Zahlbr. (--Flowers, S. 1954. p. 105. On dry sandstone. Near St. George, Washington County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CALOPLACA CITRINA (Hoffm.) Th. Br. (--Flowers, S. 1954. p. 105. On dry sandstone. Near St. George, Washington County. --Nielsen, H. S., Jr. 1960. p. 46. On rock and cement. Near Springville, Utah County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 704. On soil. Canyonlands National Park, San Juan County.)

CALOPLACA DECIPIENS (Arnold) Blomb. & Forss. (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

Caloplaca elegans (Link) Th. Fr. (--Flowers, S. 1954. p. 105. On rock. Salt Lake, Toole, Carbon, Grand, Wayne, and Iron counties. --Nielsen, H. S., Jr. 1960. p. 45. On rock. Pole

Canyon, Utah County; Daniel's Canyon, Wasatch County; Alta, Salt Lake County.) = XANTHORIA ELEGANS (Link) Th. Fr.

CALOPLACA EPITHALLINA Lynge (--Nash, T. H. 1974. p. 98. On other lichens. Navajo Mountain, San Juan County.)

CALOPLACA FLAVOVIRESCENS (Wulfen) Dalla Torre & Saranth. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock, mostly sandstone. Zion National Park, Washington County.)

CALOPLACA FRAUDANS (Th. Fr.) H. Olivier (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County. --Rushforth, S. R. et al. 1982. p. 190. On rock, mostly sandstone. Zion National Park, Washington County.)

CALOPLACA HERBIDELLA (Hue) Magnusson (--Nash, T. H. 1974. On dead wood. Navajo Mountain, San Juan County. Possible misidentification.)

CALOPLACA HOLOCARPA (Hoffm.) Wade (--Nash, T. H. 1974. p. 98. On *Abies lasiocarpa*. Navajo Mountain, San Juan County.) Synonym: *Caloplaca pyracea*

CALOPLACA JUNGERMANNIAE (Vahl) Th. Fr. (--Nash, T. H. 1974. p. 98. On mosses. Navajo Mountain, San Juan County.)

Caloplaca lobulata (Flörke) Hellbom (--Flowers, S. 1954. p. 105. On dry limestone. Near Timpe, Toole County.) = XANTHORIA LOBULATA (Flörke) B. de Lesd.

CALOPLACA MODESTA (Zahlbr.) Fink (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

Caloplaca murorum (Hoffm.) Th. Fr. (--Flowers, S. 1954. p. 105. On dry sandstone. Near Price, Carbon County.) = CALOPLACA SAXICOLA (Hoffm.) Nordin

CALOPLACA PELODELLA (Nyl.) Hasse Synonym: *Caloplaca amabilis*

Caloplaca pyracea (Ach.) Th. Fr. (--Flowers, S. 1954. p. 105. On dry bleached logs. Near Greenwich, Piute County.) = CALOPLACA HOLOCARPA (Hoffm.) Wade

CALOPLACA SAXICOLA (Hoffm.) Nordin (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Caloplaca murorum*

CALOPLACA SIPEANA Magnusson (--Nash, T. H. 1974. p. 98. On sandstone. Navajo Mountain, San Juan County.)

CALOPLACA SQUAMOSA (B. de Lesd.) Zahlbr. (--Nash, T. H. 1974. p. 98. On sandstone. Kaiparowitz Plateau, Kane County.)

CALOPLACA SUBPYRACELLA (Nyl.) Zahlbr. (--Flowers, S. 1954. p. 105. On dry sandstone. Salt Lake County.)

CALOPLACA TIROLIENSIS Zahlbr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

CALOPLACA TRACHYPHYLLA (Tuck.) Zahlbr. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.)

CALOPLACA URCEOLATA B. de Lesd. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

CANDELARIA Massal.

CANDELARIA CONCOLOR (Dickson) B. Stein (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CANDELARIELLA Müll. Arg.

CANDELARIELLA ARCTICA (Körber) R. Sant. *in* Vezda Synonym: *C. crenulata*

CANDELARIELLA AURELLA (Hoffm.) Zahlbr. (--Nash, T. H. 1974. p. 99. On moss. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *C. cerinella*

Candelariella cerinella (Flörke) Zahlbr. (--Flowers, S. 1954. p. 104. On sandstone. Near St. George, Washington County.) = CANDELARIELLA AURELLA (Hoffm.) Zahlbr.

Candelariella crenulata (Wahlenb.) Zahlbr. (--Nielsen, H. S., Jr. 1960. p. 55. In crevices of weathering rock. Common throughout Wasatch Range.) = CANDELARIELLA ARCTICA (Körber) R. Sant. *in* Vezda

CANDELARIELLA DEFLEXA (Nyl.) Zahlbr. (--Nash, T. H. 1974. p. 99. On *Juniperus osteosperma, Quercus gambelii,* and *Mahonia* sp. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CANDELARIELLA ROSULANS (Müll. Arg.) Zahlbr. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

CANDELARIELLA VITELLINA (Hoffm.) Müll. Arg. (--Flowers, S. 1954. p. 104. On rock. Salt Lake, Carbon, and Washington counties. On dry rock. Near Greenwich, Piute County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Placodium vitellinum*

CANDELARIELLA VITELLINA var. ASSERICOLA Räsänen (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.)

CANDELARIELLA XANTHOSTIGMA (Ach.) Lettau (--Nash, T. H. 1974. p. 99. On dead wood. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CATAPYRENIUM Flotow

CATAPYRENIUM CINEREUM (Pers.) Körber Synonym: *Dermatocarpon cinereum*

CATAPYRENIUM COMPACTUM (Massal.) R. Sant. Synonym: *Dermatocarpon compactum*

CATAPYRENIUM LACHNEUM (Ach.) R. Sant. Synonyms: *Dermatocarpon hepaticum, D. lachneum*

CATAPYRENIUM PLUMBEUM (B. de Lesd.) Thomson Synonym: *Dermatocarpon plumbeum*

CATILLARIA Massal.

CATILLARIA KANSUENSIS Magnusson (--Anderson, R. A. 1967. p. 340. On calcareous rock. East of Salina, Sevier County; Split Mountain Gorge, Dinosaur National Monument, Uintah County.)

CETRARIA Ach.

Cetraria juniperina (L.) Ach. (--Fink, B. 1919. p. 298. On bark and dead wood.) = TUCKERMANNOPSIS JUNIPERINA (L.) Hale

CETRARIA TILESII Ach. (--Flowers, S. 1954. p. 104. On dry conglomerate. Emigration Canyon, Salt Lake County. --Imshaug, H. A. 1957. p. 250. Summit of Marsh Peak, Uintah County.)

CHRYSOTHRIX Mont.

CHRYSOTHRIX CHLORINA (Ach.) Laundon Synonym: *Lepraria chlorina*

CLADONIA Hill *ex* Browne, *nom. cons. prop.*

Cladonia alpicola (Flotow) Vainio (--Nielsen, H. S., Jr. 1960. p. 15. On solid and decomposing wood. Lodgepole Campground, Daniel's Canyon, Wasatch County.) = CLADONIA MACROPHYLLA (Schaerer) Stenh.

Cladonia balfourii Crombie (--Nash, T. H. 1974. p. 99. On dead wood. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Possible misidentification (Egan, 1987)

CLADONIA CARIOSA (Ach.) Sprengel (--Flowers, S. 1954. p. 102. On rotten wood and humus in shady woods. Navajo Lake, Kane County. --Nash, T. H. 1974. p. 99. On soil. Navajo Mountain, San Juan County.)

CLADONIA CENOTEA (Ach.) Schaerer (--Nash, T. H. 1974. p. 99. On soil. Navajo Mountain, San Juan County.)

CLADONIA CHLOROPHAEA (Flörke *ex* Sommerf.) Sprengel (--Nash, T. H. 1974. p. 99. On dead wood and soil. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park. Washington County.) Synonym: *Cladonia pyxidata* var. *chlorophaea*

CLADONIA CONIOCRAEA auct. (--Nielsen, H. S., Jr. 1960. p. 12. On soil and decaying wood. West of Strawberry Reservoir, Utah County. --Nash, T. H. 1974. p. 99. On dead wood and soil. Navajo Mountain, San Juan County.) Synonym: *C. fimbriata* var. *coniocraea*

Cladonia delicata auct. (--Nielsen, H. S., Jr. 1960. p. 15. On wood. West of Strawberry Reservoir, Utah County.) = CLADONIA PARASITICA (Hoffm.) Hoffm.

CLADONIA FIMBRIATA (L.) Fr. (--Tuckerman, E. 1871. p. 413. On shaded soil. Uinta Range. --Flowers, S. 1954. p. 102. On soil in shady woods. La Sal Range, Grand County. --Nielsen, H. S., Jr. 1960. p. 13. On rotten wood and humus. Broadhead Flats near the head of Provo River, Summit County. --Thomson, J. W., Jr. 1967. p. 110. On soil, decomposing logs, tree bases, and thin soil over rocks. --Egan, R. S. 1971. p. 103. --Nash, T. H. 1974. p. 99. On dead wood. Navajo Mountain, San Juan County. --Thomson, J. W., Jr. 1979. p. 133. On soil, rotten logs, earthen banks.)

Cladonia fimbriata var. *coniocraea* (Flörke) Vainio (--Flowers, S. 1954. p. 103. On rotten wood in shady woods. Navajo Lake, Kane County. --Nielsen, H. S., Jr. 1960. p. 13. On rotten wood and humus. Broadhead Flats near the head of Provo River, Summit County.) = CLADONIA CONIOCRAEA auct.

CLADONIA FIMBRIATA var. SIMPLEX (Weis.) Flotow (--Flowers, S. 1954. p. 103. On soil and humus in shady woods. Navajo Lake, Kane County.)

CLADONIA MACROPHYLLA (Schaerer) Stenh. Synonym: *Cladonia alpicola*

CLADONIA PARASITICA (Hoffm.) Hoffm. Synonym: *Cladonia delicata*

CLADONIA POCILLUM (Ach.) O. Rich Synonym: *Cladonia pyxidata* var. *pocillum*

CLADONIA PYXIDATA (L.) Hoffm. (--Tuckerman, E. 1871. p. 413. On shaded soil. Uinta Range. --Imshaug, H. A. 1957. p. 192, fig. 20. Uinta Range. --Nash, T. H. 1974. p. 99. On soil. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Cladonia pyxidata var. *chlorophaea* (Sprengel) Flörke (--Flowers, S. 1954. p. 103. On soil and rotten logs. Brighton, Salt Lake County. --Imshaug, H. A. 1957. pp. 227-228. Mt. Mellenthin, La Sal Range, San Juan County; Bald Mountain, Uinta Range.) = CLADONIA CHLOROPHAEA (Flörke *ex* Sommerf.) Sprengel

Cladonia pyxidata var. *pocillum* (Ach.) Flotow (--Flowers, S. 1954. p. 103. On soil and rotten logs. Mirror Lake, Uinta Range, Duchesne County.) = CLADONIA POCILLUM (Ach.) O. Rich

Cladonia pyxidata var. *symphycarpa* Fr. (--Tuckerman, E. 1871. p. 413. On shaded soil. Uinta Range.) = CLADONIA SYMPHYCARPA (Ach.) Fr.

CLADONIA SQUAMOSA (Scop.) Hoffm. (--Flowers, 1954. p. 103. On rotten logs and humus. Shingle Creek, Uinta Range, Summit County.)

CLADONIA SYMPHYCARPA (Ach.) Fr. (--Flowers, S. 1954. p. 103. On humus and soil. Mirror Lake, Uinta Range, Duchesne County.)

CLADONIA TURGIDA Ehrh. *ex* Hoffm. (--Flowers, S. 1954. p. 103. On soil and humus in shade. Mirror Lake, Uinta Range, Duchesne County.)

COELOCAULON Link

COELOCAULON ACULEATUM (Schreber) Link Synonym: *Cornicularia aculeata*

COLLEMA Wigg.

Collema auriculata Hoffm. (--Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County.) = COLLEMA AURIFORME (With.) Coppins & Laundon

COLLEMA AURIFORME (With.) Coppins & Laundon Synonyms: *C. auriculata*, *C. granosum*

COLLEMA COCCOPHORUM Tuck. (--Flowers, S. 1954. p. 101. On dry soil. Millard County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

COLLEMA CRISPUM (Huds.) Wigg. var. METZLERI (Arn.) Degel. (--Degelius, G. 1974. p. 78.)

COLLEMA CRISTATUM (L.) Weber *ex* Wigg. (--Degelius, G. 1974. p. 93. Split Mountain Gorge, Dinosaur National Park, Uintah County. -Thomson, J. W., Jr. 1984. p. 181. On old wood, soil, or calcareous rock.)

COLLEMA FURFURACEUM (Arnold) Du Rietz (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On bark. Zion National Park, Washington County.)

Collema furvum (Ach.) Ach. (--Flowers, S. 1954. p. 101. On dry sandstone. San Juan County.) = COLLEMA FUSCOVIRENS (With.) Laundon

COLLEMA FUSCOVIRENS (With.) Laundon Synonyms: *C. furvum, C. tuniforme*

Collema granosum auct. (--Flowers, S. 1954. p. 101. On dry sandstone. San Juan County.) = COLLEMA AURIFORME (With.) Coppins & Laundon

COLLEMA LIMOSUM (Ach.) Ach. (--Nielsen, H. S., Jr. 1960. p. 16. Scattered and solitary on rock, usually along streambanks. Diamond Fork Canyon and Hobble Creek Canyon, Utah County.)

COLLEMA POLYCARPON Hoffm. (--Flowers, S. 1954. p. 101. On dry soil. Millard County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

COLLEMA POLYCARPON Hoffm. var. POLYCARPON (Arn.) Degel. (--Degelius, G. 1974. p. 51.)

COLLEMA SUBFLACCIDUM Degel. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

COLLEMA TENAX (Schwartz) Ach. (--Kleiner, E. F. & K. T. Harper. 1972. p. 302. Canyonlands National Park, San Juan County. --Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County.)

COLLEMA TENAX (Schwartz) Ach. var. CERANOIDES (Borrer) Degel. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

Collema tuniforme (Ach.) Ach. (--Degelius, G. 1974. p. 94. On dry sandstone. Devil's Canyon, San Juan County; Split Mountain Gorge, Dinosaur National Monument, Uintah County. --Thomson, J. W., Jr. 1984. p. 190. On calcareous rock or rock with calcareous dust, preferably periodically wet or inundated.) = COLLEMA FUSCOVIRENS (With.) Laundon

COLLEMA UNDULATUM Laurer *ex* Flotow (--Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

COLLEMA UNDULATUM (Laurer *ex* Flotow) var. GRANULOSUM Degel. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

CORNICULARIA (Schreber) Hoffm.

Cornicularia aculeata (Schreber) Ach. (--Imshaug, H. A. 1957. p. 258. Summit of Marsh Peak, Uintah County.) = COELOCAULON ACULEATUM (Schreber) Link

CROCYNIA (Ach.) Massal.

Crocynia membranacea (Dicks.) Zahlbr. (--Nielsen, H. S., Jr. 1960. p. 57. On moss, soil, and rock in moist, protected sites. Hobble Creek Canyon, Mt. Timpanogos, Utah County.) = LEPROLOMA MEMBRANACEA (Dickson) Vainio

DACTYLINA Nyl.

DACTYLINA MADREPORIFORMIS (Ach.) Tuck. (--Imshaug, H. A. 1957. p. 256. Summits of Leidy and Marsh Peaks, Uintah County.)

DERMATOCARPON Eschw.

Dermatocarpon aquaticum (Weis.) Zahlbr. (--Flowers, S. 1954. p. 101. On dry rock. Tooele County. --Nielsen, H. S., Jr. 1960. p. 23. On dry rock and sandstone. Mt Timpanogos, Utah County.) = DERMATOCARPON LURIDUM (With.) Laundon

Dermatocarpon cinereum (Pers.) Körber (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County.) = CATAPYRENIUM CINEREUM (Pers.) Körber

Dermatocarpon compactum (Massal.) Lettau (--Anderson, D. C. & S. R. Rushforth. 1976. p. 705. On rock. Desert Experimental Range, Millard County.) = CATAPYRENIUM COMPACTUM (Massal.) R. Sant.

Dermatocarpon fluviatile (Weber) Th. Fr. (--Nash, T. H. 1974. p. 99. On wet sandstone. Kaiparowitz Plateau, Kane County.) = DERMATOCARPON LURIDUM (With.) Laundon

Dermatocarpon hepaticum (Ach.) Th. Fr. (--Flowers, S. 1954. p. 101. On soil. Wayne, Garfield, and San Juan counties. --Nielsen, H. S., Jr. 1960. p. 23. On soil. Diamond Fork Canyon, Utah County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 705. On soil. Common at Desert Experimental Range, Millard County; Hurricane, St. George, Washington County; Canyonlands National Park, San Juan County.) = CATAPYRENIUM LACHNEUM (Ach.) R. Sant.

Dermatocarpon lachneum (Ach.) A. L. Sm. (--Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 705. On gypsiferous soils. Canyonlands National Park, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On soil and rock. Zion National Park, Washington County.) = CATAPYRENIUM LACHNEUM (Ach.) R. Sant.

Dermatocarpon leptophyllum (Ach.) Vainio (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On sandstone cliffs. Zion National Park, Washington County.) = DERMATOCARPON MINIATUM (L.) Mann

DERMATOCARPON LURIDUM (With.) Laundon Synonyms: *D. aquaticum, D. fluviatile*

DERMATOCARPON MINIATUM (L.) Mann (--Flowers, S. 1954. p. 101. On dry rock. Salt Lake, Summit, Toole, Carbon, Grand, Wayne, Millard, San Juan, Kane, and Washington counties. --Imshaug, 1957. p. 211. Mt. Timpanogos, Utah County. --Nielsen, H. S., Jr. 1960. p. 22. On rock. Kolob Forest Camp, Hobble Creek Canyon, Rock Canyon and Mt. Timpanogos, Utah County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonyms: *D. leptophyllum, D. miniatum* var. *complicatum, Endocarpon miniatum*

Dermatocarpon miniatum var. *complicatum* (Lightf.) Th. Fr. (--Flowers, S. 1954. p. 101. On dry rock. Salt Lake, Toole, Duchesne, Carbon, Kane, and Millard counties.) = DERMATOCARPON MINIATUM (L.) Mann

DERMATOCARPON MOULINSII (Mont.) Zahlbr. Synonym: *D. moulinsii* var. *subpapillosum*

Dermatocarpon moulinsii (Mont.) Zahlbr. var. *subpapillosum* Fink (--Flowers, S. 1954. p. 101. On dry granite. Brighton, Salt Lake County.) = DERMATOCARPON MOULINSII (Mont.) Zahlbr.

Dermatocarpon plumbeum (B. de Lesd.) Zahlbr. (--Wetmore, C. M. 1967. p. 297. On calcareous rock.) = CATAPYRENIUM PLUMBEUM (B. de Lesd.) Thomson

DERMATOCARPON RETICULATUM Magnusson (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Open bouldery site. Navajo Sandstone, Zion National Park, Washington County.)

DIMELAENA Norman

DIMELAENA OREINA (Ach.) Norman (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

DIPLOSCHISTES Norman

DIPLOSCHISTES ACTINOSTOMUS (Pers.) Zahlbr. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

DIPLOSCHISTES DIACAPSIS (Ach.) Lumbsch (--Lumbsch, H. Th. 1989. p. 169.)

DIPLOSCHISTES SCRUPOSUS (Schreber) Norman (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 703. On soil. Bloomington and Hurricane, Washington County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Lumbsch, H. Th. 1989. p. 187.)

DIPLOTOMMA Flotow

DIPLOTOMMA ALBOATRUM (Hoffm.) Flotow Synonym: *Buellia alboatra*

ENDOCARPON Hedwig

Endocarpon miniatum (L.) Schaerer (--Tuckerman, E. 1871. p. 413. On rock. Uinta Range; Antelope Island.) = DERMATOCARPON MINIATUM (L.) Mann

ENDOCARPON PUSILLUM Hedwig (--Nash, T. H. 1974. p. 99. On soil and sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

EVERNIA Ach.

EVERNIA DIVARICATA (L.) Ach. (--Flowers, S. 1954. p. 104. On dead spruce branches. La Sal Range, Grand County; Pine Valley Range, Washington County. --Bird, C. D., 1974. p. 2428. Grand County. --Nash, T. H. 1974. p. 99. On *Abies lasiocarpa*, *Pseudotsuga menziesii*. Navajo Mountain, San Juan County.)

FLAVOPUNCTELIA (Krog) Hale

FLAVOPUNCTELIA SOREDICA (Nyl.) Hale Synonym: *Parmelia soredica*

FULGENSIA Massal. & de Not. *in* Massal.

FULGENSIA BRACTEATA (Hoffm.) Räsänen (--Kleiner, E. F. & K. T. Harper. 1972. p. 302. Canyonlands National Park, San Juan County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 704. On soil. Canyonlands National Park, San Juan County.) Synonym: *Placodium fulgens* var. *bracteatum*

FULGENSIA FULGENS (Swartz) Elenkin (--Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 704. Important component of gypsiferous soil crusts. Colorado Plateau.)

GONOHYMENIA Steiner

GONOHYMENIA CRIBELLIFERA (Nyl.) Henssen (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

HEPPIA

Heppia despreauxii (Mont.) Tuck. (--Flowers, S. 1954. p. 102. On dry soil. Millard County.) = HEPPIA LUTOSA (Ach.) Nyl.

Heppia guepinii (Delise) Nyl. (--Flowers, S. 1954. p. 102. On dry soil. Millard County.) = PELTULA EUPLOCA (Ach.) Poelt *ex* Pisút

HEPPIA LUTOSA (Ach.) Nyl. (--Wetmore, C. M. 1970. p. 178. San Rafael River, Emery County; Dolores River, Grand County; Colorado River at Rock Creek, Kane County; Split Mountain Gorge, Dinosaur National Monument, Uintah County. --Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *Heppia despreauxii*

HETERODERMIA Trevisan

Heterodermia neoleucomelaena (--Rushforth, S. R. et al. 1982. p. 191. On trees. Zion National Park, Washington County.) = ANAPTYCHIA NEOLEUCOMELAENA Kurokawa

HYPOGYMNIA (Nyl.) Nyl.

HYPOGYMNIA AUSTERODES (Nyl.) Räsänen Synonym: *Parmelia austerodes*

LECANIA Massal.

Lecania dimera (Nyl.) Th. Fr. (--Rushforth, S. R. et al. 1982. p. 190. Zion National Park, Washington County.) = LECANIA DUBITANS (Nyl.) A. L. Sm.

LECANIA DUBITANS (Nyl.) A. L. Sm. Synonym: *Lecania dimera*

LECANORA Ach. *in* Luyken
LECANORA ALLOPHANA Nyl. Synonym: *Lecanora subfusca*

Lecanora alphoplaca (Wahlenb. *in* Ach.) Ach. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) = ASPICILIA ALPHOPLACA (Wahlenb. *in* Ach.) Poelt & Leuck.

LECANORA ARGOPHOLIS (Ach.) Ach. Synonym: *L. frustulosa*

Lecanora badia (Hoffm.) Ach. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = PROTOPARMELIA BADIA (Hoffm.) Hafellner

Lecanora caesiocinerea Nyl. *ex* Malbr. (--Flowers, S. 1954. p. 103. On dry sandstone. San Juan County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = ASPICILIA CAESIOCINEREA (Nyl. *ex* Malbr.) Arnold

Lecanora calcarea (L.) Sommerf. (--Flowers, S. 1954. p. 103. On dry rock. Salt Lake and Carbon counties. --Nielsen, H. S., Jr. 1960. p. 29. On rock. Timp Haven, Utah County. --Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 703. On rock. Desert Experimental Range, Millard County; Hurricane, Washington County.) = ASPICILIA CALCAREA (L.) Mudd

LECANORA CARPINEA (L.) Vainio (--Nash, T. H. 1974. p. 99. On bark of *Abies lasiocarpa, Pseudotsuga menziesii.* Navajo Mountain, San Juan County.)

LECANORA CENISIA Ach. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Lecanora cervina (Pers.) Nyl. (--Tuckerman, E. 1871. p. 413. On rock. Antelope Island, Great Salt Lake.) = ACAROSPORA CERVINA (Pers. *in* Ach) Massal.

Lecanora cervina (Pers.) Nyl. var. *eucarpa* Malbr. (--Tuckerman, E. 1871. p. 413. On rock. Antelope Island, Great Salt Lake.) = SARCOGYNE CLAVUS (DC. *in* Lam. & DC.) Krempelh.

Lecanora chlarona (Ach.) Nyl. (--Nash, T. H. 1974. p. 99. On bark of *Abies lasiocarpa*. Navajo Mountain, San Juan County.) = L. PULICARIS (Pers.) Ach.

LECANORA CHLAROTERA Nyl. (--Nash, T. H. 1974. p. 99. On wood. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Lecanora chlorophana (Wahl.) Ach. (--Tuckerman, E. 1871. p. 413. On rock. Antelope Island, Great Salt Lake.) = ACAROSPORA CHLOROPHANA (Wahlenb. *ex* Ach.) Massal.

LECANORA CHRISTOI W. Weber. (--Weber, W. A. 1975. p. 206. On sandstone. Split Mountain Gorge, Dinosaur National Monument, Uintah County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Lecanora chrysoleuca (Sm.) Ach. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = RHIZOPLACA CHRYSOLEUCA (Sm.) Zopf

Lecanora cinerea (L.) Sommerf. (--Nielsen, H. S., Jr. 1960. p. 30. On rock. Hobble Creek Canyon, Utah County. --Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = ASPICILIA CINEREA (L.) Körber

Lecanora cinerea (L.) Sommerf. var. *cinereorufescens* Nyl. (--Tuckerman, E. 1871. p. 413. On rock. Antelope Island, Great Salt Lake, Davis County.) = BELLEMEREA CINEREORUFESCENS (Ach.) Clauz. & Roux

Lecanora cinereorufescens (Ach.) Hepp (--Fink, B. 1935. p. 298. On rock.) = BELLEMEREA CINEREORUFESCENS (Ach.) Clauz. & Roux

Lecanora coilocarpa (Ach.) Nyl. (--Flowers, S. 1954. p. 103. On dry exposed sandstone. San Juan County.) = LECANORA PULICARIS (Pers.) Ach.

LECANORA CRENULATA Hook. (--Flowers, S. 1954. p. 103. Parasitic on *Dermatocarpon miniatum*, the latter on dry sandstone cliffs. San Juan County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. p. 191. 1982. On rock. Zion National Park, Washington County.)

LECANORA DISPERSA (Pers.) Sommerf. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Rushforth, S. R. et al. p. 191. 1982. On rock. Zion National Park, Washington County.)

LECANORA FLOWERSIANA Magnusson (--Flowers, S. 1954. p. 103. On dry exposed sandstone. Eastern Wayne County. Type locality.)

Lecanora frustulosa (Dickson) Ach. (--Flowers, S. 1954. p. 103. On dry sandstone. Near Torrey, Wayne County. --Nielsen, H. S., Jr. 1960. p. 28. On rock. Mt. Timpanogos, Utah County; Little Cottonwood Canyon, Salt Lake County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = LECANORA ARGOPHOLIS (Ach.) Ach.

LECANORA GAROVAGLII (Körber) Zahlbr. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Lecanora gibbosa (Ach.) Nyl. (--Flowers, S. 1954. p. 103. On quartzite and granite. Big Cottonwood Canyon, Salt Lake County.) = ASPICILIA GIBBOSA (Ach.) Körber

Lecanora gibbosula Magnusson (--Nielsen, H. S., Jr. 1960. p. 30. On rock and small pebbles. Mt. Timpanogos, Utah County; Trial Lake, Uinta Range, Summit County.) = ASPICILIA GIBBOSA (Ach.) Körber

LECANORA HAGENI (Ach.) Ach. (--Flowers, S. 1954. p. 26. On *Populus angustifolia*. City Creek Canyon, Salt Lake County. --Nielsen, H. S., Jr. 1960. p. 26. On *Populus angustifolia*. Kelly's Grove, Hobble Creek Canyon, and Rotary Park, Utah County. --Nash, T.

H. 1974. p. 99. On dead wood and bark of *Juniperus osteosperma*. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On bark of mostly *Populus fremontii*. Zion National Park, Washington County.)

LECANORA HORIZA (Ach.) Lindsay Synonym: *Lecanora parisiensis*

LECANORA IMPUDENS Degel. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Lecanora lentigera (Weber) Ach. (--Flowers, S. 1954. p. 104. On soil. Colorado River above Moab, Grand County; near La Sal Junction, San Juan County.) = SQUAMARINA LENTIGERA (Weber) Poelt

LECANORA MARGINATA (Schaerer) Hertel & Rambold Synonyms: *Lecidea amylacea, L. elata, L. marginata*

Lecanora melanaspis (Ach.) Ach. (--Flowers, S. 1954. p. 104. On dry sandstone. Near Price, Carbon County; Devil's Canyon, San Juan County. --Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = ASPICILIA MELANASPIS (Ach.) Poelt & Leuck.

Lecanora melanophthalma (DC. *in* Lam. & DC.) Ramond (--Flowers, S. 1954. p. 104. On rock. Salt Lake, Iron, and Beaver counties. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = RHIZOPLACA MELANOPHTHALMA (DC. *in* Lam. & DC.) Leuck. & Poelt

LECANORA MURALIS (Schreber) Rabenh. (--Tuckerman, E. 1871. p. 412. On rock. Antelope Island, Great Salt Lake. --Flowers, S. 1954. p. 104. On rock. North Fork of Ogden River, Weber County; Emigration and Parley's canyons, Salt Lake County; Devil's Canyon, San Juan County; and near St. George, Washington County. --Nielsen, H. S., Jr. 1960. p. 28. On rock. Mt. Timpanogos, Utah County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. p. 191. 1982. On rock. Zion National Park, Washington County.)

LECANORA NOVOMEXICANA (B. de Lesd.) Zahlbr. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Lecanora parisiensis Nyl. (--Flowers, S. 1954. p. 104. On bark of *Pinus edulis*. Near Price, Carbon County.) = LECANORA HORIZA (Ach.) Lindsay

Lecanora peltata (Ramond) Steudel (--Flowers, S. 1954. p. 104. On rock. Near Big Cottonwood Canyon, Salt Lake County; near Price, Carbon County; Pahvant Butte, Millard County.) = RHIZOPLACA PELTATA (Ramond) Leuck. & Poelt

LECANORA PINIPERDA Körber (--Rushforth, S. R. et al. 1982. p. 190. Zion National Park, Washington County.)

LECANORA POLYTROPA (Hoffm.) Rabenh. (--Flowers, S. 1954. p. 104. On dry exposed sandstone. Eastern Wayne County. --Nielsen, H. S., Jr. 1960. p. 26. On rock. Mt. Timpanogos and Hobble Creek Canyon, Utah County. --Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Rushforth, S. R. et al. 1982. p. 190. On rock. Zion National Park, Washington County.)

LECANORA PRINGLEI (Tuck.) Lamb Synonym: *Lecidea brandegei*

LECANORA PULICARIS (Pers.) Ach. Synonyms: *L. chlarona, L. coilocarpa*

Lecanora rubina (Vill.) Ach. (--Tuckerman, E. 1871. p. 412. Uinta Range. --Flowers, S. 1954. p. 104. On rock. Emigration Canyon, Salt Lake County; Wayne and Carbon counties. --Nielsen, H. S., Jr. 1960. p. 27. On various rock substrates. Hobble Creek Canyon, Utah County.) = RHIZOPLACA CHRYSOLEUCA (Sm.) Zopf

Lecanora rubina var. *opaca* Ach. (--Tuckerman, E. 1871. p. 412. Antelope Island, Great Salt Lake.) = RHIZOPLACA MELANOPHTHALMA (DC. *in* Lam. & DC.) Leuck. & Poelt

LECANORA RUPICOLA (L.) Zahlbr. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. &

L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

LECANORA SALIGNA (Schrader) Zahlbr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

Lecanora subfusca (L.) Ach. (--Flowers, S. 1954. p. 104. On decorticated stems of *Artemisia tridentata*. Near Price, Carbon County.) = LECANORA ALLOPHANA Nyl.

Lecanora subfusca (L.) Ach. var. *sylvestris* Nyl. (--Tuckerman, E. 1871. p. 412. On cottonwood bark. Wasatch Range.) = LECANORA SYLVESTRIS (Nyl.) Zahlbr. Possible misidentification of a European taxon (*fide* Egan).

Lecanora subfusca var. *umbrina* Nyl. (--Tuckerman, E. 1871. p. 412. On rock. Antelope Island in Great Salt Lake, Davis County.) = LECANORA UMBRINA (Ach.) Massal.

LECANORA SYLVESTRIS (Nyl.) Zahlbr. Synonym: *Lecanora subfusca* var. *sylvestris*

LECANORA SYMMICTA (Ach.) Ach. (--Nash, T. H. 1974. p. 99. On bark of *Abies lasiocarpa*. Navajo Mountain, San Juan County.)

Lecanora symmicta var. *saepincola* (Ach.) Th. Fr. (--Flowers, S. 1954. p. 104. On old bleached lumber. Near Greenwich, Piute County.) = LECIDEA SYMMICTA (Ach.) Ach.

LECANORA THALLOPHILA Magnusson (--Magnusson, A, H. 1954. p. 196. On thallus of *Dermatocarpon miniatum*, on dry exposed sandstone. Devil's Canyon, San Juan County. Type locality.)

Lecanora thamnoplaca Tuck. (--Fink, B. 1935. p. 306. On rock. --Flowers, S. 1954. p. 104. On dry sandstone. Near Price, Carbon County.) = ASPICILIA ALPHOPLACA (Wahlenb. *in* Ach.) Poelt & Leuck.

LECANORA UMBRINA (Ach.) Massal. Synonym: *Lecanora subfusca* var. *umbrina*

LECANORA UTAHENSIS Magnusson (--Flowers, S. 1954. p. 104. On dry exposed sandstone. Eastern Wayne County. Type locality.)

LECANORA VALESIACA (Müll. Arg.) Stizenb. (--Ryan, B. 1990. p. 86. On rock. Grand County.)

LECANORA VARIA (Hoffm.) Ach. (--Nash, T. H. 1974. p. 99. On bark of *Pseudotsuga menziesii*. Navajo Mountain, San Juan County.)

Lecanora xanthophana Nyl. (--Tuckerman, E. 1871. p. 413.) = ACAROSPORA SCHLEICHERI (Ach.) Massal.

LECIDEA Ach.

Lecidea alaiensis Vainio (--Anderson, R. A. 1964. p. 59. On bones or calcareous rock, or on rocks near rodent latrines and bird nests. Split Mountain Gorge, Dinosaur National Monument, Uintah County.) = LECIDELLA ALAIENSIS (Vainio) Hertel

Lecidea amylacea Ach. (--Fink, B. 1935. p. 201. On rock.) = LECANORA MARGINATA (Schaerer) Hertel & Rambold

Lecidea armeniaca (DC.) Fr. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = TEPHROMELA ARMENIACA (DC.) Hertel & Rambold

LECIDEA ATROBRUNNEA (Ramond *in* Lam. & DC.) Schaerer (--Flowers, S. 1954. p. 102. On quartzite and granite in mountains. Salt Lake, Summit, Grand, Duchesne, San Juan, Garfield, and Wayne counties. --Nielsen, H. S., Jr. 1960. p. 52. On rock. Widely distributed in Wasatch Range. --Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.)

LECIDEA AURICULATA Th. Fr. (--Nielsen, H. S., Jr. 1960. p. 52. On rock, commonly in full sunlight. Mt. Timpanogos, Utah County.)

Lecidea auriculata f. *cinereoochracea* B. de Lesd. (--Flowers, S. 1954. p. 102. On sandstone. San Juan County.) = LECIDEA HASSEI Zahlbr.

Lecidea auriculata var. *paupera* Th. Fr. (--Flowers, S. 1954. p. 102. On sandstone. San Juan County.) = LECIDEA DIDUCENS Nyl.

Lecidea berengeriana (Massal.) Nyl. (--Flowers, S. 1954. p. 102. On damp humus in shady woods. Kane County. --Nash, T. H. 1974. p. 99. On moss and detritus. Navajo Mountain, San Juan County. --Nielsen, H. S., Jr. 1960. p. 50. On humic soil in moist and shaded sites. Common in Uinta Range.) = MYCOBILIMBIA BERENGERIANA (Massal.) Hafellner & V. Wirth *in* V. Wirth

Lecidea brandegei Tuck. (--Nielsen, H. S., Jr. 1960. p. 53. On rock in full sun. Mt. Timpanogos, Utah County.) = LECANORA PRINGLEI (Tuck.) Lamb

Lecidea crenata f. *dealbata* (Taylor) Zahlbr. (--Anderson, D. C. & S. R. Rushforth. 1976. p. 703. On soil. Hurricane and Bloomington, Washington County; Canyonlands National Park, San Juan County.) = PSORA CRENATA (Taylor) Reinke

Lecidea cyanea (Ach.) Röhl. (--Flowers, S. 1954. p. 102. On rock. Carbon, Millard, and San Juan counties.) = LECIDEA TESSELLATA Flörke

Lecidea decipiens (Hedwig) Ach. (--Nielsen, H. S., Jr. 1960. p. 50. In moss, soil, and rock crevices. Lower elevations throughout Wasatch Range. --Kleiner, E. F. & K. T. Harper. 1972. p. 302. Canyonlands National Park, San Juan County. --Nash, T. H. 1974. p. 99. On soil. Navajo Mountain, San Juan County. --Anderson, D. C. & S. R. Rushforth. 1976. p. 704. On soil. Desert Experimental Range, Millard County; Bloomington and Hurricane, Washington County; Canyonlands National Park, San Juan County.) = PSORA DECIPIENS (Hedwig) Hoffm.

LECIDEA DIDUCENS Nyl. Synonym: *L. auriculata* var. *paupera*

Lecidea elata Schaerer (--Flowers, S. 1954. p. 102. On dry sandstone. San Juan County.) = LECANORA MARGINATA (Schaerer) Hertel & Rambold

Lecidea enteroleuca auct. (--Nielsen, H. S., Jr. p. 53. On bark and old wood in shaded sites. Mt. Timpanogos, Kelly's Grove, Hobble Creek Canyon, Utah County.) Invalid taxon for various species of *Lecidella* sp. (Egan, R. S. 1987).

Lecidea globifera Ach. (--Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = PSORA GLOBIFERA (Ach.) Massal.

Lecidella glomerulosa (DC. *in* Lam. & DC.) Steudel (--Nash, T. H. 1974. p. 99. On bark of *Abies concolor, Abies lasiocarpa, Pinus strobiformis, Populus tremuloides, Pseudotsuga menziesii.* Navajo Mountain, San Juan County.) = LECIDELLA EUPHOREA (Flörke) Hertel

Lecidea goniophila auct. (--Fink, B. 1919. p. 303. West Fork Lake.) = LECIDELLA ANOMALOIDES (Massal.) Hertel & Kilias

LECIDEA HASSEI Zahlbr. Synonym: *L. auriculata* f. *cinereoochracea*

LECIDEA HYPOCRITA Massal. (--Thomson, J. W., Jr. 1979. p. 69. On sun-exposed calcareous rock.)

LECIDEA LAPICIDA (Ach.) Ach. (--Flowers, S. 1954. p. 102. On dry sandstone. San Juan County.)

LECIDEA LITHOPHILA (Ach.) Ach. (--Flowers, S. 1954. p. 102. On dry sandstone. Carbon County.)

Lecidea luridella Tuck. (--Nielsen, H. S., Jr. 1960. p. 49. On moss and soil. Pole Canyon, Utah County.) = PSORA LURIDELLA (Tuck.) Fink

Lecidea marginata Schaerer (--Thomson, J. W., Jr. 1979. p. 81. On calcareous rock.) = LECANORA MARGINATA (Schaerer) Hertel & Rambold

Lecidea morio Fr. (--Fink, B. 1919. p. 303. On rock.) = SPORASTATIA TESTUDINEA (Ach.) Massal.

Lecidea oblongula Magnusson (--Flowers, S. 1954. p. 102. On dry sandstone. Eastern Wayne County. Type locality.) = APATOPLACA OBLONGULA (Magnusson) Poelt & Hafellner

Lecidea parasema Ach. (--Flowers, S. 1954. p. 102. On rock. Salt Lake and Carbon counties.) = LECIDELLA EUPHOREA (Flörke) Hertel

LECIDEA PAUPERCULA Th. Fr. (--Flowers, S. 1954. p. 102. On dry sandstone. San Juan County. --Thomson, J. W., Jr. 1979. p. 73. On acid rock, granites, and sandstones.)

Lecidea rubiformis (Ach.) Wahlenb. (--Kleiner, E. F. & K. T. Harper. 1972. p. 302. Canyonlands National Park, San Juan County.) = PSORA RUBIFORMIS (Ach.) Hook.

Lecidea russellii Tuck. (--Nash, T. H. 1974. p. 99. On soil. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = PSORA RUSSELLII (Tuck.) A. Schneider

Lecidea stigmatea Ach. (--Anderson, R. A. 1964. p. 56. On lower montane to alpine bark, wood, siliceous and sometimes calcareous rock. --Egan, R. S. 1971. p. 161.) = LECIDELLA STIGMATEA (Ach.) Hertel & Leuck.

LECIDEA SYMMICTA (Ach.) Ach. Synonym: *Lecanora symmicta* var. *saepincola*

LECIDEA TESSELLATA Flörke (--Nielsen, H. S., Jr. 1960. p. 51. On predominantly limestone rock. Daniel's Canyon, Wasatch County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *L. cyanea*

Lecidea tuckermanii nomen nudum (--Anderson, R. A. 1964. p. 143. On moss, soil, and calcareous or subcalcareous rock. Near Blanding, San Juan County; Beckwith Pass, Toole County; Virgin River near St. George, Washington County.) = PSORA TUCKERMANII R. Anderson *ex* Timdal

LECIDEA UMBONATA (Hepp) Mudd (--Thomson, J. W., Jr. 1979. p. 76. On calcareous rock.)

Lecidea vesicularis (Hoffm.) Ach. (--Tuckerman, E. 1871. p. 413. On soil. Near Salt Lake City.) = TONINIA CAERULEONIGRICANS (Lightf.) Th. Fr.

LECIDEA VIOLASCENS Magnusson (--Nielsen, H. S., Jr. 1960. p. 53. Sandstone and limestone, in full sun. Daniel's Canyon, Wasatch County.)

LECIDELLA Körber

LECIDELLA ALAIENSIS (Vainio) Hertel Synonym: *Lecidea alaiensis*

LECIDELLA ANOMALOIDES (Massal.) Hertel & Kilias Synonym: *Lecidea goniophila*

LECIDELLA CARPATHICA Körber (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

LECIDELLA EUPHOREA (Flörke) Hertel Synonyms: *Lecidea glomerulosa, L. parasema, Lecidella glomerulosa*

Lecidella glomerulosa (DC. *in* Lam. & DC.) M. Choisy (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = LECIDELLA EUPHOREA (Flörke) Hertel

LECIDELLA STIGMATEA (Ach.) Hertel & Leuck. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *Lecidea stigmatea*

LEPRARIA Ach.

Lepraria chlorina (Ach.) Ach. *in* Sm. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = CHRYSOTHRIX CHLORINA (Ach.) Laundon

Lepraria membranacea auct. (--Nash, T. H. 1974. p. 99. On soil and sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = LEPROLOMA MEMBRANACEA (Dickson) Vainio

LEPROCAULON Nyl. *ex* Lamy

LEPROCAULON GRACILESCENS (Nyl.) Lamb & Ward (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

LEPROLOMA Nyl. *ex* Crombie

LEPROLOMA MEMBRANACEA (Dickson) Vainio Synonyms: *Crocynia membranacea, Lepraria membranacea*

LEPTOCHIDIUM M. Choisy
LEPTOCHIDIUM ALBOCILIATUM (Desmaz.) M. Choisy Synonym: *Polychidium albociliatum*

LEPTOGIUM (Ach.) Gray
LEPTOGIUM ARSENEI Sierk (--Sierk, H. A. 1964. p. 298. San Juan County.)

LEPTOGIUM CALIFORNICUM Tuck. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

LEPTOGIUM CHLOROMELUM (Swartz *ex* Ach.) Nyl. (--Flowers, S. 1954. p. 101. On shaded basalt. Wayne County.)

LEPTOGIUM CYANESCENS (Rabenh.) Körber (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

LEPTOGIUM ERECTUM Sierk (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

LEPTOGIUM GELATINOSUM (With.) Laundon Synonym: *Leptogium sinuatum*

LEPTOGIUM LICHENOIDES (L.) Zahlbr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

LEPTOGIUM PLICATILE (Ach.) Leighton (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. Possible misidentification.)

LEPTOGIUM SATURNINUM (Dickson) Nyl. (--Sierk, H. A. 1964. p. 270. Oowah Lake, La Sal Range, Grand County.)

Leptogium sinuatum (Huds.) Massal. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = LEPTOGIUM GELATINOSUM (With.) Laundon

LICHENOTHELIA D. Hawksw.
LICHENOTHELIA SCOPULARIA (Nyl.) D. Hawksw. Synonym: *Microthelia aterrima*

MEGASPORA (Clauz. & Roux) Hafellner & V. Wirth

MEGASPORA VERRUCOSA (Ach.) Hafellner & V. Wirth Synonym: *Pachyospora mutabilis*

MELANELIA Essl.

MELANELIA EXASPERATA (de Not) Essl. Synonyms: *Parmelia aspidota, P. olivacea* var. *aspidota*

MELANELIA GRANULOSA (Lynge) Essl. Synonym: *Parmelia disjuncta*

MELANELIA INCOLORATA (Parr.) Essl. Synonym: *Parmelia elegantula*

MELANELIA INFUMATA (Nyl.) Essl. Synonym: *Parmelia infumata*

MELANELIA MULTISPORA (Schneider) Essl. Synonym: *Parmelia multispora*

MELANELIA OLIVACEA (L.) Essl. Synonym: *Parmelia olivacea*

MELANELIA SOREDIATA (Ach.) Goward & Ahti Synonym: *Parmelia sorediata*

MELANELIA SUBARGENTIFERA (Nyl.) Essl. Synonym: *Parmelia subargentifera*

MELANELIA SUBOLIVACEA (Nyl. *in* Hasse) Essl. Synonym: *Parmelia subolivacea*

MELANELIA SUBSTYGIA (Räsänen) Essl. Synonyms: *Parmelia saximontana, P. substygia*

MICROTHELIA Körber

Microthelia aterrima (Krempelh. *ex* Anzi) Zahlbr. (--Flowers, S. 1954. p. 101. On quartzite. Salt Lake County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County.) = LICHENOTHELIA SCOPULARIA (Nyl.) D. Hawksw.

MYCOBILIMBIA Rehm. *in* Rabenh.

MYCOBILIMBIA BERENGERIANA (Massal.) Hafellner & V. Wirth *in* V. Wirth Synonym: *Lecidea berengeriana*

MYCOCALICIUM Vainio *in* Reinke

MYCOCALICIUM SUBTILE (Pers.) Szat. (--Nash, T. H. 1974. p. 99. On dead *Abies*. Navajo Mountain, San Juan County. --Tibell, L. 1975. p. 57. Mostly on conifer wood.)

NEOFUSCELIA Essl.

NEOFUSCELIA LOXODES (Nyl.) Essl. Synonyms: *Parmelia isidiotyla, P. loxodes*

NEOFUSCELIA PUSTULOSA (Essl.) Essl. Synonym: *Parmelia pustulosa*

NEOFUSCELIA SUBHOSSEANA (Essl.) Essl. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

OMPHALODISCUS Schol.

Omphalodiscus krascheninnikovii (Savicz) Schol. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = UMBILICARIA KRASCHENINNIKOVII (Savicz) Zahlbr.

Omphalodiscus virginis (Schaerer) Schol. (--Llano, G. A. 1950. p. 95. Lamotte Peak between Bear River and Middle Fork Black's Fork, Uinta Range, Summit County; Farmington Canyon, Wasatch Range, Salt Lake County. --Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = UMBILICARIA VIRGINIS Schaerer

PACHYOSPORA Massal.

Pachyospora mutabilis (Ach.) Massal. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = MEGASPORA VERRUCOSA (Ach.) Hafellner & V. Wirth

PANNARIA Delise *in* Bory

Pannaria hypnorum (Vahl) Körber (--Tuckerman, E. 1871. p. 412. On soil. Uinta Range.) = PSOROMA HYPNORUM (Vahl) Gray

PANNARIA LEUCOPHAEA (Vahl) P. Jørg. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PANNARIA PEZIZOIDES (G. Weber) Trevisan (--Nash, T. H. 1974. p. 99. On detritus. Navajo Mountain, San Juan County.)

PARMELIA Ach.

Parmelia aspidota (Ach.) Poetsch (--Flowers, S. 1954. p. 104. On bark of *Pinus edulis*. Near Price, Carbon County.) = MELANELIA EXASPERATA (de Not.) Essl.

Parmelia austerodes Nyl. (--Imshaug, H. A. 1957. p. 243. Mt. Mellenthin, San Juan County.) = HYPOGYMNIA AUSTERODES (Nyl.) Räsänen

Parmelia chlorochroa Tuck. (--Flowers, S. 1954. p. 104. On soil. Summit, Piute, and Millard counties. --Anderson, D. C. & S. R. Rushforth. 1976. p. 704. On soil. Desert Experimental Range, Millard County.) = XANTHOPARMELIA CHLOROCHLOA (Tuck.) Hale

Parmelia conspersa (Ehrh. *ex* Ach.) Ach. (--Tuckerman, E. 1871. p. 412. Uinta Range. --Flowers, S. 1954. p. 104. On rock. Common in Wayne, Grand, Piute, Garfield, Millard, and Washington counties. --Nielsen, H. S., Jr. 1960. p. 40. On dry rock. Daniel's Canyon, Wasatch County.) = XANTHOPARMELIA CONSPERSA (Ehrh. *ex* Ach.) Hale

Parmelia cumberlandia (Gyelnik) Hale (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = XANTHOPARMELIA CUMBERLANDIA (Gyelnik) Hale

Parmelia dierythra Hale (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County.) = XANTHOPARMELIA DIERYTHRA (Hale) Hale

Parmelia disjuncta Erichs. (--Imshaug, H. A. 1957. p. 247. Mt. Mellenthin, San Juan County.) = MELANELIA GRANULOSA (Lynge) Essl.

Parmelia elegantula (Zahlbr.) Szat. (--Nash, T. H. 1974. p. 99. On bark of *Juniperus osteosperma*, *Pseudotsuga menziesii*. Navajo Mountain, San Juan County. --Esslinger, T. L. 1977. p. 177, fig. 49.) = MELANELIA INCOLORATA (Parr.) Essl.

Parmelia infumata Nyl. (--Nash, T. H. 1974. p. 99. On sandstone. Navajo Mountain, San Juan County.) = MELANELIA INFUMATA (Nyl.) Essl.

Parmelia intestiniformis (Vill.) Ach. (--Imshaug, H. A. 1957. p. 244. Marsh Peak, Uintah County; Mt. Mellenthin, San Juan County.) = BRODOA OROARCTICA (Krog) Goward

Parmelia isidiotyla Nyl. (--Anderson, R. A. 1962. p. 254.) = NEOFUSCELIA LOXODES (Nyl.) Essl.

Parmelia lineola Berry (--Berry, E. C. 1941. p. 78. Full sun to partial shade. North of Blanding, San Juan County. --Flowers, S. 1954. p. 104. On humus over rock. Mirror Lake, Uinta Range, Duchesne County. --Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = XANTHOPARMELIA LINEOLA (Berry) Hale

Parmelia loxodes Nyl. (--Esslinger, T. L. 1977. p. 173, fig.13. On rock or occasionally on moss over rock; rarely on wood or bark.) = NEOFUSCELIA LOXODES (Nyl.) Essl.

Parmelia mexicana Gyelnik (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = XANTHOPARMELIA MEXICANA (Gyelnik) Hale

Parmelia multispora A. Schneider (--Fink, B. 1935. p. 333. On trees and shrubs.) = MELANELIA MULTISPORA (Schneider) Essl.

Parmelia novomexicana Gyelnik (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = XANTHOPARMELIA NOVOMEXICANA (Gyelnik) Hale

Parmelia olivacea (L.) Ach. (--Tuckerman, E. 1871. p. 412. On bark of *Cercocarpus*. Wasatch Range. --Flowers, S. 1954. p. 104. Near Price, Carbon County; Zion National Park, Washington County. --Nielsen, H. S., Jr. 1960. p. 40. On shaded bark of *Acer grandidentatum*, *Quercus gambelii*. Common in Pole Canyon, Utah County.) = MELANELIA OLIVACEA (L.) Essl.

Parmelia olivacea var. *aspidota* Ach. (--Nielsen, H. S., Jr. 1960. p. 41. On bark. Kelly's Grove, Hobble Creek Canyon, Utah County.) = MELANELIA EXASPERATA (de Not.) Essl.

Parmelia plittii Gyelnik *ex* D. Dietr. (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = XANTHOPARMELIA PLITTII (Gyelnik *ex* D. Dietr.) Hale

Parmelia pustulosa Essl. (--Esslinger, T. L. 1977. p. 139. On rock. Dinosaur National Monument, Uintah County.) = NEOFUSCELIA PUSTULOSA (Essl.) Essl.

Parmelia saximontana R. Anderson & W. Weber (--Anderson, R. A. & W. Weber. 1962. p. 238. Split Mountain Gorge, Dinosaur National Monument, Uintah County.) = MELANELIA SUBSTYGIA (Räsänen) Essl.

Parmelia sorediata (Ach.) Th. Fr. (--Flowers, S. 1954. p. 104. On dry sandstone. Devil's Canyon, San Juan County.) = MELANELIA SOREDIATA (Ach.) Goward & Ahti

Parmelia soredica Nyl. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = FLAVOPUNCTELIA SOREDICA (Nyl.) Hale

Parmelia stenophylla (Ach.) Du Rietz (--Imshaug, H. A. 1957. p. 248. Mt. Mellenthin, San Juan County; Murdock Mountain, Duchesne County; Bald Mt, border of Summit and Duchesne counties; Leidy Peak and Marsh Peak, Uintah County; Mt. Baldy, border of Salt Lake and Utah counties.) = XANTHOPARMELIA COLORADOENSIS (Gyelnik) Hale

Parmelia subargentifera Nyl. (--Esslinger, T. L. 1977. p. 174, fig. 26. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = MELANELIA SUBARGENTIFERA (Nyl.) Essl.

Parmelia subolivacea Nyl. *in* Hasse (--Ahti, T. 1966. p. 36. On spruce. Navajo Lake, Kane County; Fish Lake, Sevier County; Wasatch Range. --Nash, T. H. 1974. pp. 99-100. On bark of *Abies lasiocarpa, Acer grandidentatum, Picea engelmannii, Pinus strobiformis. Pseudotsuga menziesii.* Navajo Mountain, San Juan County. --Esslinger, T. L. 1977. p. 177, fig. 22. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On bark. Zion National Park, Washington County.) = MELANELIA SUBOLIVACEA (Nyl. *in* Hasse) Essl.

Parmelia substygia Räsänen (--Nash, T. H. 1974. p. 100. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = MELANELIA SUBSTYGIA (Räsänen) Essl.

PARMELIOPSIS (Stizenb.) Nyl.

PARMELIOPSIS AMBIGUA (Wulfen *in* Jacq.) Nyl. (--Nash, T. H. 1974. p. 100. On *Abies lasiocarpa, Pseudotsuga menziesii.* Navajo Mountain, San Juan County.)

PELTIGERA Willd.

PELTIGERA APHTHOSA (L.) Willd. (--Tuckerman, E. 1871. p. 412. Uinta Range. --Thomson, J. W., Jr. 1950. p. 7. Uinta Range. --Flowers, S. 1954. p. 102. On damp soil in woods. Uinta Range, Summit and Duchesne counties; Boulder Mountain, Kane County. --Nielsen, H. S., Jr. 1960. p. 19. On soil, humus, and rotten logs. Broadhead Flats, near head of Provo River, Summit County.)

Peltigera aphthosa (L.) Willd. var. *variolosa* (Massal.) Thomson (--Thomson, J. W., Jr. 1950. p. 11. Dyer Mountain, Uinta Range.) = PELTIGERA LEUCOPHLEBIA (Nyl.) Gyelnik

PELTIGERA CANINA (L.) Willd. (--Tuckerman, E. 1871. p. 412. Uinta Range. --Flowers, S. 1954. p. 102. On soil, usually in woods. Summit, Duchesne, Salt Lake, Toole, Utah, Grand, Millard, and Wayne counties. --Imshaug, H. A. 1957. pp. 217-218. Mt. Mellenthin, San Juan County; Murdock Mountain, Duchesne County; Leidy Peak, Uintah County; Mt. Baldy, border of Salt Lake and Utah counties; Mt Timpanogos, Utah County. --Nielsen, H. S., Jr. 1960. p. 20. On soil, humus, and rotten logs. Mt Timpanogos, Utah County; Lodgepole Campground, Wasatch County. --Nash, T. H. 1974. p. 100. On soil. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Peltigera canina (L.) Willd. var. *rufescens* (Weis) Mudd (--Thomson, J. W., Jr. 1950. p. 54. Beaver Creek, Summit County; City Creek Canyon, Alta, Big Cotton Canyon opposite Clayton Creek, and Brighton, Salt Lake County; La Sal Creek, San Juan County.) = PELTIGERA RUFESCENS (Weis) Humb.

Peltigera canina var. *ulorrhiza* (Flörke) Schaerer (--Thomson, J. W., Jr. 1950. p. 46. Gold Basin, La Sal Range, San Juan County.) = PELTIGERA RUFESCENS (Weis.) Humb.

PELTIGERA COLLINA (Ach.) Schrader. Synonym: *Peltigera scutata*

PELTIGERA DIDACTYLA (With.) Laundon Synonym: *Peltigera spuria*

PELTIGERA LEUCOPHLEBIA (Nyl.) Gyelnik Synonym: *Peltigera aphthosa* var. *variolosa*

PELTIGERA MALACEA (Ach.) Funck (--Nash, T. H. 1974. p. 100. On soil. Navajo Mountain, San Juan County.)

PELTIGERA POLYDACTYLA (Necker) Hoffm. (--Nash, T. H. 1974. p. 100. On soil. Navajo Mountain, San Juan County.)

PELTIGERA PONOJENSIS Gyelnik (Brodo, I. M. et al. 1987. p. 105.)

PELTIGERA RUFESCENS (Weis) Humb. (--Tuckerman, E. 1871. p. 412. On soil. --Flowers, S. 1954. p. 102. On rotten logs in mountains. Salt Lake County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonyms: *Peltigera canina* var. *rufescens*, *P. canina* var. *ulorrhiza*

Peltigera scutata (Dickson) Duby (--Thomson, J. W., Jr. 1950. p. 20. City Creek Canyon. Salt Lake County.) = PELTIGERA COLLINA (Ach.) Schrader

Peltigera spuria (Ach.) DC. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = PELTIGERA DIDACTYLA (With.) Laundon

PELTIGERA VENOSA (L.) Hoffm. (--Flowers, S. 1954. p. 102. On shaded damp soil. Wasatch Plateau; Sanpete County. --Nielsen, H. S., Jr. 1960. p. 20. On soil and mossy soil. Mt. Timpanogos, Utah County; Broadhead Flats near head of Provo River, Summit County.)

PELTULA Nyl.

PELTULA BOLANDERI (Tuck.) Wetm. (--Wetmore, C. M. 1970. p. 181. East of Santa Clara, Washington County.)

PELTULA EUPLOCA (Ach.) Poelt *ex* Pisút (--Wetmore, C. M. 1970. p. 181. East of Santa Clara, Washington County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *Heppia guepinii*

PELTULA OBSCURANS (Nyl.) Gyelnik var. DESERTICOLA (Zahlbr.) Wetm. (--Wetmore, C. M. 1970. p. 191. South of Price, Grand County; east of Green River, Emery County.)

PHAEOCALICIUM A. Schmidt

PHAEOCALICIUM POPULNEUM (Brond. *ex* Duby) A. Schmidt Synonym: *Calicium populneum*

PHAEOPHYSCIA Moberg

PHAEOPHYSCIA CERNOHORSKYI (Nádv.) Essl. Synonym: *Physcia orbicularis* f. *albociliata* (B. de Lesd.) Thomson

PHAEOPHYSCIA CILIATA (Hoffm.) Moberg (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonyms: *Physcia ciliata, P. obscura*

PHAEOPHYSCIA CONSTIPATA (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHAEOPHYSCIA ENDOCOCCINEA (Körber) Moberg Synonym: *Physcia endococcinea*

PHAEOPHYSCIA ENDOCOCCINODES (Poelt) Essl. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHAEOPHYSCIA HISPIDULA (Ach.) Essl. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHAEOPHYSCIA ORBICULARIS (Necker) Moberg (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *Physcia orbicularis*

PHAEOPHYSCIA SCIASTRA (Ach.) Moberg (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) Synonym: *Physcia sciastra*

PHYSCIA (Schreber) Michaux

PHYSCIA ADSCENDENS (Fr.) H. Olivier (--Nielsen, H. S., Jr. 1960. p. 36. On bark of usually *Acer grandidentatum, Populus angustifolia*. Timp Haven, Utah County. --Nash, T. H. 1974. p. 100. On bark of *Populus tremuloides*. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHYSCIA AIPOLIA (Ehrh. *ex* Humb.) Fürnr. (--Nash, T. H. 1974. p. 100. On bark of *Pseudotsuga menziesii*. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHYSCIA BIZIANA (Massal.) Zahlbr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHYSCIA CAESIA (Hoffm.) Fürnr. (--Flowers, S. 1954. p. 105. On moss, damp soil, or bark. Salt Lake County. --Nash, T. H. 1974. p. 100. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHYSCIA CALLOSA Nyl. (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.)

Physcia ciliata (Hoffm.) Du Rietz (--Nielsen, H. S., Jr. 1960. p. 35. Kelly's Grove, Hobble Creek Canyon, Utah County. --Thomson, J. W., Jr. 1963. p. 113. --Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.) = PHAEOPHYSCIA CILIATA (Hoffm.) Moberg

PHYSCIA CLEMENTEI (Sm. *in* Sm. & Sow.) Lynge Synonym: *Physcia clementiana* (Ach.) Kickx.

Physcia clementiana (Ach.) Kickx. (--Flowers, S. 1954. p. 105. On shale. Big Cottonwood Canyon, Salt Lake County.) = PHYSCIA CLEMENTEI (Sm. *in* Sm. & Sow.) Lynge

PHYSCIA DUBIA (Hoffm.) Lettau (--Thomson, J. W., Jr. 1963. p. 94. Usually on rock, occasionally on weathered boards and bones. Emigration Canyon, Salt Lake County. --Nash, T. H. 1974. p. 100. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p.

49. Zion National Park, Washington County.) Synonyms: *P. intermedia*, *P. tertiuscula*

Physcia endococcinea (Körber) Th. Fr. (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.) = PHAEOPHYSCIA ENDOCOCCINEA (Körber) Moberg

Physcia intermedia Vainio (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.) = PHYSCIA DUBIA (Hoffm.) Lettau

PHYSCIA MILLEGRANA Degel. (--Nielsen, H. S., Jr. 1957. On rock, soil, moss, and bark. Salt Lake County.)

Physcia muscigena (Ach.) Nyl. (--Imshaug, H. A. 1957. p. 268. Leidy Peak, Uintah County; border of Summit and Duchesne counties; Mt. Baldy, border of Salt Lake and Utah counties. --Nielsen, H. S., Jr. 1960. p. 37. On moss. Hobble Creek Canyon, Utah County.) = PHYSCONIA MUSCIGNEA (Ach.) Poelt

Physcia muscigena f. *isidiata* (Lynge) Thomson (--Thomson, J. W., Jr. 1963. p. 144. Bald Mt, Uinta Range.) = PHYSCONIA MUSCIGENA (Ach.) Poelt

Physcia obscura (Ehrh.) Nyl. (--Tuckerman, E. 1871. p. 412. On bark. Wasatch Range.) = PHAEOPHYSCIA CILIATA (Hoffm.) Moberg

Physcia orbicularis (Necker) Poetsch. (--Nielsen, H. S., Jr. 1960. p. 36. On moss, rock, and trees, usually in shaded sites. Kelly's Grove, Hobble Creek Canyon, Utah County. --Rushforth, S. R. et al. 1982. p. 191. On trees, usually *Acer grandidentatum*. Zion National Park, Washington County.) = PHAEOPHYSCIA ORBICULARIS (Necker) Moberg

Physcia orbicularis f. *albociliata* (B. de Lesd.) Thomson. (--Nash, T. H. 1974. p. 100. On sandstone and *Juniperus osteosperma*. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) = PHAEOPHYSCIA CERNOHORSKYI (Nádv.) Essl.

PHYSCIA PHAEA (Tuck.) Thomson. (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Physcia pulverulenta auct. non (Schreber) Fürnr. (--Flowers, S. 1954. p. 105. On moss, rock, and bark. Kane and Washington counties.) = PHYSCONIA DISTORTA (With.) Laundon

Physcia pulverulenta var. *argyphaea* (Ach.) Nyl. (--Flowers, S. 1954. p. 105. On bark of *Acer interior*. Zion Canyon, Washington County.) = PHYSCONIA MUSCIGENA (Ach.) Poelt

Physcia pulverulenta (Schreb.) Hampe f. *coralloidea* Suza (--Thomson, J. W., Jr. 1963. p. 136. Zion National Park, Washington County.) = PHYSCONIA DISTORTA (With.) Laundon

Physcia sciastra (Ach.) Du Rietz (--Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) = PHAEOPHYSCIA SCIASTRA (Ach.) Moberg

PHYSCIA STELLARIS (L.) Nyl. (--Tuckerman, E. 1871. p. 412. On rock. Antelope Island, Great Salt Lake. --Flowers, S. 1954. p. 105. On soil, rock, and bark. Salt Lake and Washington counties. --Nielsen, H. S., Jr. 1960. p. 38. On bark of various trees, especially *Acer grandidentatum*. Provo Canyon, Utah County. --Nash, T. H. 1974. p. 100. On *Juniperus osteosperma, Pinus strobiformis*. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On trees. Zion National Park, Washington County.)

PHYSCIA SUBTILIS Degel. (--Rushforth, S. R. et al. 1982. p. 190. On rock. Zion National Park, Washington County.)

PHYSCIA TENELLA (Scop.) DC. *in* Lam. & DC. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

Physcia tertiuscula (Ach.) Lynge (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.) = PHYSCIA DUBIA (Hoffm.) Lettau

PHYSCIA TRIBACIA (Ach.) Nyl. (--Flowers, S. 1954. p. 105. On moss, soil, rock, and bark. Salt Lake and Washington counties.)

PHYSCONIA Poelt

PHYSCONIA DETERSA (Nyl.) Poelt (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PHYSCONIA DISTORTA (With.) Laundon Synonyms: *Physcia pulverulenta* f *coralloidea, Physconia grisea* var. *isidiigera, P. pulverulacea, P. pulverulenta*

PHYSCONIA GRISEA (Lam.) Poelt (--Nash, T. H. 1974. p. 100. On moss. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.)

Physconia grisea (Lam.) Poelt f. *isidiigera* (Zahlbr.) Thomson (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = PHYSCONIA DISTORTA (With.) Laundon

PHYSCONIA MUSCIGENA (Ach.) Poelt (--Nash, T. H. 1974. p. 100. On soil and sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonyms: *Physcia muscigena, P, muscigena* f. *isidiata, P. pulverulenta* var. *argyphaea*

Physconia pulverulacea Moberg *in* Gunnerb. & Moberg (--Rushforth, S. R. et al. 1982. p. 191. On bark. Zion National Park, Washington County.) = PHYSCONIA DISTORTA (With.) Laundon

Physconia pulverulenta (Schreber) Hampe (--Rushforth, S. R. et al. 1982. p. 191. On trees. Zion National Park, Washington County.) = PHYSCONIA DISTORTA (With.) Laundon

PLACODIUM Ach.

Placodium cerinum (Hedw.) Naeg. *apud* Hepp var. *biatorinum* Nyl. (--Tuckerman, E. 1871. p. 412. On bark of *Populus*, Wasatch Range.) = CALOPLACA CERINA (Ehrh. *ex* Hedwig) Th. Fr.

Placodium elegans (Link) DC. (--Tuckerman, E. 1871. p. 412. On rocks. Uinta Range; Antelope Island.) = XANTHORIA ELEGANS (Link) Th. Fr.

Placodium fulgens var. *bracteatum* Duby (--Tuckerman, E. 1871. On soil. Carrington Island, Great Salt Lake.) = FULGENSIA BRACTEATA (Hoffm.) Räsänen

Placodium vitellinum (Ehrh.) Naeg. & Hepp (--Tuckerman, E. 1871. p. 412. On rocks. Uinta Range.) = CANDELARIELLA VITELLINA (Hoffm.) Müll. Arg.

PLACYNTHIUM (Ach.) Gray

PLACYNTHIUM NIGRUM (Huds.) Gray (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PLACYNTHIUM NIGRUM (Huds.) Gray var. NIGRUM Henssen (--Henssen, A. 1963. p. 1697. Split Mountain Gorge, Dinosaur National Monument, Uintah County.)

POLYBLASTIA Massal.

POLYBLASTIA BRYOPHILA Lönnr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

POLYCHIDIUM (Ach.) Gray

Polychidium albociliatum (Desmaz.) Zahlbr. (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.) = LEPTOCHIDIUM ALBOCILIATUM (Desmaz.) M. Choisy

POLYSPORINA Vezda

POLYSPORINA SIMPLEX (Davies) Vezda Synonyms: *Biatorella simplex, B. simplex* var. *major, Sarcogyne simplex*

PROTOBLASTENIA (Zahlbr.) Steiner

PROTOBLASTENIA RUPESTRIS (Scop.) Steiner (--Nash, T. H. & L. L. Sigal. 1981. p. 49. Zion National Park, Washington County.)

PROTOPARMELIA M. Choisy

PROTOPARMELIA BADIA (Hoffm.) Hafellner Synonym: *Lecanora badia*

PSEUDEPHEBE M. Choisy

PSEUDEPHEBE MINUSCULA (Nyl. *ex* Arnold) Brodo & D. Hawksw. Synonym: *Alectoria minuscula*

PSEUDEPHEBE PUBESCENS (L.) M. Choisy Synonym: *Alectoria pubescens*

PSORA Hoffm.

PSORA CEREBRIFORMIS W. Weber (--Timdal, E. 1986. p. 259. On soil.)

PSORA CRENATA (Taylor) Reinke (--Flowers, S. 1954. p. 102. Common in dry desert soil. Toole, Millard, Carbon, San Juan, and Washington counties. --Timdal, E. 1896. p. 260.) Synonyms: *Lecidea crenata* f. *dealbata, Psora crenata* f. *dealbata*

Psora crenata f. *dealbata* (Tuck.) Zahlbr. (--Flowers, S. 1954. p. 102. In dry desert soils. Common in Toole, Millard, Carbon, San Juan, and Washington counties.) = PSORA CRENATA (Taylor) Reinke

PSORA DECIPIENS (Hedwig) Hoffm. (--Flowers, S. 1954. p. 102. In soil and rock crevices. Common in deserts and mountains of Summit, Salt Lake, Toole, Carbon, Millard, Wayne, Beaver, Garfield, and San Juan counties. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Timdal, E. 1986. p. 261. On soil.) Synonyms: *Biatora decipiens, Lecidea decipiens*

PSORA GLOBIFERA (Ach.) Massal. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Timdal, E. 1986. p. 262. On soil.) Synonym: *Lecidea globifera*

PSORA HIMALAYANA (Church. Bab.) Timdal (--Timdal, E. 1986. p. 264. On soil.)

PSORA LURIDELLA (Tuck.) Fink (--Flowers, S. 1954. p. 102. In dry soil and rock crevices. Salt Lake and Garfield counties. --Timdal, E. 1986. p. 265. On soil.) Synonym: *Lecidea luridella*

PSORA MONTANA Timdal (--Timdal, E. 1986. p. 266. On soil.)

PSORA NIPPONICA (Zahlbr.) G. Schneider (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Timdal, E. 1986. p. 267. On soil.)

PSORA RUBIFORMIS (Ach.) Hook. Synonym: *Lecidea rubiformis*

PSORA RUSSELLII (Tuck.) A. Schneider (--Flowers, S. 1954. p. 102. In soil and rock crevices. Salt Lake, Carbon, and Wayne counties.

--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock or soil over rock. Zion National Park, Washington County.) Synonyms: *Biatora russellii, Lecidea russellii*

PSORA TUCKERMANII R. Anderson *ex* Timdal (--Timdal, E. 1986. p. 274. On soil.)

PSOROMA Ach. *in* Michaux

PSOROMA HYPNORUM (Vahl) Gray (--Flowers, S. 1954. p. 102. On moss in damp soil. Uinta Range, Summit County.) Synonym: *Pannaria hypnorum*

PSOROTICHIA Massal.

PSOROTICHIA SCHAERERI (Massal.) Arnold (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

PYRENOPSIS Nyl.

PYRENOPSIS POLYCOCCA (Nyl.) Tuck. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

RAMALINA Ach.

RAMALINA OBTUSATA (Arnold) Bitter (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

RHIZOCARPON Ramond *ex* DC.

RHIZOCARPON BADIOATRUM (Flörke *ex* Sprengel) Th. Fr. (--Nielsen, H. S., Jr. 1960. p. 62. On rock in full sunlight. Hobble Creek Canyon, Utah County.)

RHIZOCARPON DISPORUM (Naeg. *ex* Hepp) Müll. Arg. (--Flowers, S. 1954. p. 102. p. 63. On dry quartzite and granite. Summit, Salt Lake, and Grand counties. --Nielsen, H. S., Jr. 1960. p. 63. Indifferent to sunlight intensity, on rock. Hobble Creek Canyon, Utah County. --Nash, T. H. 1974. p. 100. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Buellia montagnei*

RHIZOCARPON GEOGRAPHICUM (L.) DC. (--Flowers, S. 1954. p. 102. On dry quartzite, basalt, and granite. Salt Lake, Utah, Grand and Kane counties. --Nielsen, H. S., Jr. 1960. p. 63. On rock in full sunlight. Alta, Salt Lake County; Daniel's Canyon, Wasatch County; Uinta Range. --Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

RHIZOCARPON RIPARIUM Räsänen (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

RHIZOPLACA

RHIZOPLACA CHRYSOLEUCA (Sm.) Zopf (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County) Synonyms: *Lecanora chrysoleuca, L. rubina*

RHIZOPLACA MELANOPHTHALMA (DC. *in* Lam. & DC.) Leuck. & Poelt (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) Synonyms: *Lecanora melanophthalma, L. rubina* var. *opaca*

RHIZOPLACA PELTATA (Ramond) Leuck. & Poelt Synonym: *Lecanora peltata*

RINODINA (Ach.) Gray

RINODINA ATHALLINA Magnusson (--Flowers, S. p. 105. On dry exposed sandstone. Eastern Wayne County. Type locality.)

RINODINA CONSTRICTULA Magnusson (--Flowers, S. 1954. p. 105. On dry exposed sandstone. Eastern Wayne County. Type locality.)

RINODINA EXIGUA (Ach.) Gray (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

RINODINA HALLII Tuck. (--Nash, T. H. 1974. p. 100. On wood. Navajo Mountain, San Juan County.)

RINODINA LAEVIGATA (Ach.) Malme (--Nash, T. H. 1974. p. 100. On *Acer grandidentatum*. Navajo Mountain, San Juan County.)

RINODINA MNIARAEA (Ach.) Körber (--Nash, T. H. 1974. p. 100. On soil. Navajo Mountain, San Juan County.)

RINODINA PYRINA (Ach.) Arnold (--Rushforth, S. R. et al. 1982. p. 191. On trees. Zion National Park, Washington County.)

Rinodina sophodes (Ach.) Massal. (--Tuckerman, E. 1871. p. 413. On bark of *Populus*. Wasatch Range. --Flowers, S. 1954. p. 105. On dead stems of *Sarcobatus vermiculatus*. Carbon County.) Possible misidentification (Hale & Culberson, 1970)

RINODINA TEPHRASPIS (Tuck.) Herre (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

Rinodina violascens Magnusson (--Anderson, R. A. 1962. p. 257. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. = RINODINA ZWACKHIANA (Krempelh.) Körber

RINODINA ZWACKHIANA (Krempelh.) Körber Synonym: *Rinodina violascens*

SARCOGYNE Flotow

SARCOGYNE CLAVUS (DC. *in* Lam. & DC.) Krempelh. Synonyms: *Acarospora cervina* var. *eucarpa*, *Lecanora cervina* var. *eucarpa*

SARCOGYNE OLIGOSPORA Magnusson (--Magnusson, A. H. 1952. On dry, exposed sandstone. Ekker's Ranch, 1830 m elevation, Wayne County. Type locality.) Synonym: *Biatorella oligospora*

SARCOGYNE REGULARIS Körber Synonym: *Biatorella simplex* var. *pruinosa* (Ach.) Fink

Sarcogyne simplex (Davies) Nyl. (--Nash, T. H. 1974. p. 100. On sandstone. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) = POLYSPORINA SIMPLEX (Davies) Vezda

SOLENOSPORA Massal.

SOLENOSPORA CANDICANS (Dickson) Steiner (--Flowers, S. 1954. p. 104. On dry limestone. Emigration Canyon, Salt Lake County.)

SOLORINA Ach.

SOLORINA SPONGIOSA (Ach.) Anzi (--Flowers, S. 1954. p. 102. On damp soil. Brighton, Salt Lake County.)

SPORASTATIA Massal.

SPORASTATIA TESTUDINEA (Ach.) Massal. (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.) Synonym: *Lecidea morio* Fr.

SQUAMARINA Poelt

SQUAMARINA LENTIGERA (Weber) Poelt Synonym: *Lecanora lentigera*

STAUROTHELE Norman

Staurothele clopima (Wahlenb.) Th. Fr. (--Nielsen, H. S., Jr. 1960. p. 58. On mostly limestone rock in full sunlight. Mt. Timpanogos, Utah County. --Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) = STAUROTHELE FUSCOCUPREA (Nyl.) Zsch.

STAUROTHELE FUSCOCUPREA (Nyl.) Zsch. Synonym: *Staurothele clopima*

STAUROTHELE SESSILIS Magnusson (--Magnusson, A. H. 1952. pp. 31-32. On rock. Ekker's Ranch, Wayne County. Type locality.)

STRANGOSPORA Massal.

STRANGOSPORA OCHROPHORA (Nyl.) R. Anderson *in* Carmer (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

TELOSCHISTES Norman

Teloschistes candelarius (L.) Th. Fr. (--Flowers, S. 1954. p. 105. On moss and bark. Salt Lake County.) = XANTHORIA CANDELARIA (L.) Th. Fr.

TELOSCHISTES CONTORTUPLICATUS (Ach.) Clauz. & Rondon *ex* Vezda (--Anderson, R. A. 1976. p. 1.)

Teloschistes fallax (Hepp) Arnold (--Flowers, S. 1954. p. 105. On bark of *Populus angustifolia*. Emigration Canyon, Salt Lake County.) = XANTHORIA FALLAX (Hepp *in* Arnold) Arnold

Teloschistes parietinus (L.) Norman (--Flowers, S. 1954. p. 105. On bark of *Pinus edulis*. San Juan County.) = XANTHORIA PARIETINA (L.) Th. Fr.

Teloschistes parietinus var. *lychneus* F. Wils. (--Tuckerman, E. 1871. p. 412. Wasatch Range.) = XANTHORIA CANDELARIA (L.) Th. Fr.

Teloschistes parietinus var. *polycarpus* Müll. Arg. (--Tuckerman, E. 1871. p. 412. On bark of *Quercus*. Wasatch Range.) = XANTHORIA POLYCARPA (Hoffm.) Rieber

Teloschistes polycarpus (Hoffm.) Tuck. (--Fink, B. 1919. p. 307. --Flowers, S. 1954. p. 105. On bark. Salt Lake County.) = XANTHORIA POLYCARPA (Hoffm.) Rieber

TEPHROMELA A. Choisy

TEPHROMELA ARMENIACA (DC.) Hertel & Rambold Synonym: *Lecidea armeniaca*

THELIDIUM Massal.

Thelidium sp. (--Nielsen, H. S., Jr. 1960. p. 60. On rock in full sunlight. Aspen Grove, Utah County.) Misidentification = STAUROTHELE FUSCOCUPREA (Nyl.) Zsch.

TONINIA Massal.

TONINIA CAERULEONIGRICANS (Lightf.) Th. Fr. (--Flowers, S. 1954. p. 102. On dry soil. Carbon, Wayne, San Juan, and Washington counties. --Nash, T. H. 1974. p. 100. On soil. Kaiparowitz Plateau, Kane County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Lecidea vesicularis*

TONINIA CANDIDA (Weber) Th. Fr. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

TONINIA MASSATA (Tuck.) Herre (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

TONINIA TRISTIS (Th. Fr.) Th. Fr. (--Anderson, R. A. 1962. p. 259. On calcareous and siliceous rock. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

TUCKERMANNOPSIS Gyelnik

TUCKERMANNOPSIS JUNIPERINA (L.) Hale Synonym: *Cetraria juniperina*

UMBILICARIA Hoffm.

Umbilicaria cylindrica (L.) Delise *ex* Duby (--Llano, G. A. 1950. p. 122. Lamotte Peak, Uintah County. --Nielsen, H. S., Jr. 1960. p. 33. On rock. Mt. Timpanogos, Utah County.) A misidentification of U. VIRGINIS Schaerer (Imshaug 1957).

UMBILICARIA HYPERBOREA (Ach.) Hoffm. (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.)

UMBILICARIA KRASCHENINNIKOVII (Savicz) Zahlbr. (--Imshaug, H. A. 1957. p. 238. Mt. Mellenthin, San Juan County.) Synonym: *Omphalodiscus krascheninnikovii*

UMBILICARIA PHAEA Tuck. (--Llano, G. A. 1950. p. 149. Salt Lake Basin, Wasatch Range, and Farmington Canyon near Salt Lake City, Salt Lake County. --Nielsen, H. S., Jr. 1960. p. 33. On rock. Daniel's Canyon, Wasatch County; Rock Canyon, Utah County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

UMBILICARIA VIRGINIS Schaerer (--Imshaug, H. A. 1957. pp. 239-240. Leidy Peak, Marsh Peak, and Bald Mountain, Summit County; Mt Baldy, border of Utah and Salt Lake counties; Mt Mellenthin, San Juan County.) Synonym: *Omphalodiscus virginis*

USNEA Dill. *ex* Adans.

USNEA GLABRATA (Ach.) Vainio Synonym: *Usnea sorediifera* (Arnold) Lynge

USNEA LAPPONICA Vainio Synonym: *Usnea sorediifera* Motyka

Usnea sorediifera (Arnold) Lynge (--Nash, T. H. 1974. p. 100. On bark of *Abies concolor, Abies lasiocarpa, Pinus strobiformis.* Navajo Mountain, San Juan County.) = USNEA GLABRATA (Ach.) Vainio

Usnea sorediifera Motyka (--Flowers, S. 1954. p. 104. On bark of large spruce trees. Navajo Lake, Kane County.) = USNEA LAPPONICA Vainio

USNEA SUBFLORIDANA Stirton (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

VERRUCARIA Schrader

VERRUCARIA FUSCELLA (Turn.) Winch (--Nielsen, H. S., Jr. 1960. p. 59. On rock. Mt. Timpanogos, Utah County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

VERRUCARIA HYDRELA Ach. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

VERRUCARIA MARGACEA (Wahlenb. *in* Ach.) Wahlenb. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

VERRUCARIA MURALIS Ach. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

VERRUCARIA VIRIDULA (Schrader) Ach. (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.)

XANTHOPARMELIA (Vainio) Hale

XANTHOPARMELIA CHLOROCHLOA (Tuck.) Hale Synonym: *Parmelia chlorochroa*

XANTHOPARMELIA COLORADOENSIS (Gyelnik) Hale Synonyms: *Parmelia stenophylla, Xanthoparmelia taractica*

XANTHOPARMELIA CONSPERSA (Ehrh. *ex* Ach.) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) Synonym: *Parmelia conspersa*

XANTHOPARMELIA CUMBERLANDIA (Gyelnik) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) Synonym: *Parmelia cumberlandia*

XANTHOPARMELIA DIERYTHRA (Hale) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) Synonym: *Parmelia dierythra*

XANTHOPARMELIA LINEOLA (Berry) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. -- Rushforth, S. R. et al. 1982. p. 191. On rock, mostly sandstone. Zion National Park, Washington County.) Synonym: *Parmelia lineola*

XANTHOPARMELIA MEXICANA (Gyelnik) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. -- Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Parmelia mexicana*

XANTHOPARMELIA NOVOMEXICANA (Gyelnik) Hale (--Nash, T. H. 1974. p. 99. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County.) Synonym: *Parmelia novomexicana*

XANTHOPARMELIA PLITTII (Gyelnik *ex* D. Dietr.) Hale Synonym: *Parmelia plittii*

XANTHOPARMELIA SUBDECIPIENS (Vainio) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.)

Xanthoparmelia taractica (Krempelh.) Hale (--Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. Possible misidentification.) = XANTHOPARMELIA COLORADOENSIS (Gyelnik) Hale

XANTHORIA (Fr.) Th. Fr.

XANTHORIA CANDELARIA (L.) Th. Fr. (--Nielsen, H. S., Jr. 1960. p. 44. On bark of *Acer grandidentatum, Quercus gambelii, Cercocarpus* sp. Hobble Creek Canyon, Utah County.) Synonyms: *Teloschistes candelarius, T. parietinus* var. *lychneus*

XANTHORIA ELEGANS (Link) Th. Fr. (--Nash, T. H. 1974. p. 100. On sandstone. Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) Synonyms: *Caloplaca elegans, Placodium elegans*

XANTHORIA FALLAX (Hepp *in* Arnold) Arnold (--Nielsen, H. S., Jr. 1960. p. 43. On rocks and trees. Hobble Creek Canyon, Utah County. --Nash, T. H. 1974. p. 100. On bark of *Juniperus osteosperma, Pinus edulis, Mahonia.* Kaiparowitz Plateau, Kane County; Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County. --Rushforth, S. R. et al. 1982. p. 191. On rock. Zion National Park, Washington County.) Synonym: *Teloschistes fallax*

XANTHORIA LOBULATA (Flörke) B. de Lesd. Synonym: *Caloplaca lobulata*

XANTHORIA PARIETINA (L.) Th. Fr. Synonym: *Teloschistes parietinus*

XANTHORIA POLYCARPA (Hoffm.) Rieber (--Nash, T. H. 1974. p. 100. On bark of *Abies lasiocarpa, Pinus strobiformis, Populus tremuloides.* Navajo Mountain, San Juan County. --Nash, T. H. & L. L. Sigal. 1981. p. 50. Zion National Park, Washington County.) Synonyms: *Teloschistes parietinus* var. *polycarpus, T. polycarpus*

XANTHORIA SOREDIATA (Vainio) Poelt (--Nash, T. H. 1974. p. 100. On sandstone. Navajo Mountain, San Juan County.)

XYLOGRAPHA (Fr.) Fr.

XYLOGRAPHA ABIETINA (Pers.) Zahlbr. (--Nash, T. H. 1974. p. 100. On bark of *Abies lasiocarpa.* Navajo Mountain, San Juan County.)

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A NEW SPECIES IN THE LICHEN GENUS ALMBORNIA (PARMELIACEAE, ASCOMYCOTINA)

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ABSTRACT

A new species of *Almbornia* (Parmeliaceae, Lichenized Ascomycotina), *Almbornia azaniensis* Brusse, is described and illustrated. It's chemistry and affinities is discussed.

NEW SPECIES

Almbornia azaniensis Brusse, *sp. nov.*

Thallus foliosus vel subfruticosus, saxicola, usque ad 4 cm diametro, laxe adnatus. *Lobi* lineares, usque ad 1 mm lati, applanati sed ad extremum subteretes, 50−330 μm crassi. *Thallus superne* atrobrunneus, vel atrofuscus, nitidus, laevis vel in partes senescentes foveolatus vel rugosus, isidiis sorediisque destitutus, epicortice poroso. *Cortex superior* 6−13 μm crassus, paraplectenchymatus. *Stratum gonidiale* 15−65 μm crassum, algis *Trebouxiis*, 5.5−17.0 μm diametris. *Medulla* hyalina, chondroidea, 40−270 μm crassa. *Cortex inferior* circa 6 μm crassus. *Thallus inferne* pallide brunneus vel brunneus, parce hapteratus. *Haptera* simplicia, 50−220 μm crassa. *Apothecia* sat numerosa, Parmelioidea, adnata, usque ad 3 mm diametris. *Medulla* laxa, alba. *Thecium* cum crystallis lanceolatis (oxalas calcii) anticlinate penetratum. *Hypothecium* hyalinum, 20−35 μm crassum, J -. *Subhymenium* hyalinum, 5−10 μm crassum, J + pallide caeruleum. *Hymenium* hyalinum, 55−65 μm crassum, J + caeruleum. *Asci* clavati, tholis J + caeruleis (figura 1). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 8.0−9.5 × 4.5−5.5 μm. *Pycnidia* hyalina, globosa, 100−115 μm profunda, 90−155 μm lata. *Pycnidiosporae* hyalinae, rectae, aciculares, 5−8 × 0.8 μm. *Thallus* acidum lichesterinicum solum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE—**3319** (Worcester): Summit of Waboomberg near Ceres. On Table Mountain Sandstone on NW slope. Alt. 1850 m (**-AD**). *F. Brusse 5385b*, 16.iii.1988 (**PRE**, holo-; **BM**, **LD**, iso-). Figura 2.

Thallus foliose to subfruticose, saxicolous, up to 4 cm diam., loosely adnate. *Lobes* linear, up to 1 mm wide, flattened but ultimately subterete (especially when wet), 50–330 μm thick. *Upper surface* dark brown to dark grey-brown, glossy, smooth to pitted or rugose in older parts, neither isidiate nor sorediate; epicortex pored. *Upper cortex* 6–13 μm thick, paraplectenchymatous. *Algal layer* 15–65 μm thick; algae *Trebouxia*, 5.5–17.0 μm diam. *Medulla* hyaline, chondroid, 40–270 μm thick. *Lower cortex* about 6 μm thick. *Under surface* pale brown to brown, sparsely hapterate. *Hold fasts* simple, 50–200 μm thick. *Apothecia* moderately abundant, Parmelioid, adnate, up to 3 mm across. *Medulla* lax, white. *Thecium* penetrated by anticlinal lanceolate crystals of calcium oxalate. *Hypothecium* hyaline, 20–35 μm thick, J -. *Subhymenium* hyaline, 5–10 μm thick, J + pale blue. *Hymenium* hyaline, 55–65 μm thick. *Asci* clavate, eight-spored; tholus J + blue (figure 1). *Ascospores* hyaline, simple, ellipsoid, 8.0–9.5 × 4.5–5.5 μm (only a few poorly developed ones seen). *Pycnidia* hyaline, globose, 100–115 μm deep, 90–155 μm wide. *Pycnidiospores* hyaline, straight needles, 5–8 × 0.8 μm. Chemistry: lichesterinic acid present in the algal layer.

This is the second species of *Almbornia* to be described. The new species is closely related to *A. cafferensis* Essl., but is clearly distinguished from that species by the presence of lichesterinic acid in the algal layer instead of norstictic acid (Esslinger 1981). Consequently, *A. azaniensis* is negative to the lichenological spot reagents K and P, whereas *A. cafferensis* gives positive reactions with these two tests.

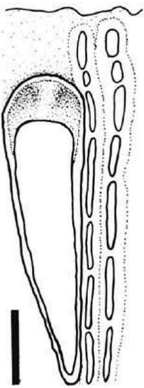

FIGURE 1.—*Almbornia azaniensis* Brusse, ascus and paraphyses. *F. Brusse 5385b*, holotype. Bar = 10 μm.

Although not originally known (Esslinger 1981), the apothecia of *A. cafferensis* were subsequently found, and shown to be typically Parmeliaceous (Esslinger 1986). The type material of *A. azaniensis* is quite abundantly apotheciate, and is very similar. Interestingly, the thecium of *A. azaniensis* contains calcium oxalate stakes in it, a condition also found in the unrelated *Parmelia lucrosa* Brusse (1991). These stakes probably act as a grazing deterrent for mycophagous mites, which seem to be fond of thecial tissue. This feature was not observed in *A. cafferensis* by Esslinger (1986).

The main branches of *A. azaniensis* reach 1 mm wide and are clearly flattened, whereas those of *A. cafferensis* only reach 0.4 mm wide and are subterete. Although the medulla in this genus appears quite distinctive because of its completely chondroid nature, there are some brown *Parmeliae* with a partially chondroid medulla, especially towards the lower cortex (e.g. *P. adamantea* Brusse). These brown *Parmeliae* seem otherwise unrelated to *Almbornia*, which has a more paraplectenchymatous structure to the upper cortex.

The chondroid medulla causes the lichen to swell up more than is usual when wetted (clearly visible when placing a dry lobe section in water).

FIGURE 2.—*Almbornia azaniensis* Brusse, habit. *F. Brusse 5385b*, holotype. Scale in mm.

At present, this new species is known only from the type locality, the summit of Waboomberg near Ceres.

ACKNOWLEDGEMENTS

My thanks are extended to Dr J.A. Elix for kindly reviewing this manuscript. I am also grateful to Mrs A.J. Romanowski for the photograph, and to Mrs J. Mulvenna for typing and Mrs S.S. Brink for type-setting this manuscript.

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MYCOTAXON

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KIMBROPEZIA AND PFISTERA, TWO NEW GENERA WITH BIZARRE ASCUS APICES (PEZIZALES)

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ABSTRACT

Two new genera of operculate discomycetes (Pezizales) are described from the Canary Islands. *Kimbropezia campestris*, gen. et sp. nov., is assigned to the Pezizaceae, differing from the genus *Peziza* in having a cyanophilic and congo-red-staining lens-shaped disk within the J+ ascus operculum, (new term: *opercular lens*). The species is saprophytic, occurring on soil amongst grasses and weeds on Tenerife. *Pfistera pyrophila*, gen. et sp. nov., is at best distantly related to *Geopyxis*, and is tentatively assigned to the Geopyxideae of the Otideaceae. It has J– asci with a fairly rigid wall which suddenly becomes exceptionally thin and flexible over the apical dome, in some ways recalling the asci of *Ascozonus*. The species is a firesite inhabitant, on burnt soil, and was collected on La Palma.

KEYWORDS: *Kimbropezia campestris*, *Pfistera pyrophila*, Pezizales, Pezizaceae, Otideaceae, Geopyxideae, *Peziza*, *Ascozonus*, *Geopyxis*, *Aparaphysaria*.

Two new genera of Pezizales are described here from the Canary Islands. Both, in the field, could be taken for species of the genus *Peziza* L. : Fr., but each displays features of the ascus apex unknown in any other member of the order.

KIMBROPEZIA

The species we describe below as representing a new genus, *Kimbropezia*, clearly belongs to the Pezizaceae, and must stand close

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to the genus *Peziza*. Like that genus it has asci in which the apical region blues intensely in iodine solutions (*e.g.*, Melzer's Reagent) (FIG. 2b). The fairly large, discoid apothecia range in size from 0.8–3.5 cm diam, with a light brown to brown disc and a whitish receptacle, and with an enrolled margin. In section the apothecial excipulum (FIG. 1b) is clearly 4-layered, much as in such species as *Peziza cerea* Bull. : Fr., *P. micropus* Pers. : Fr., and *P. varia* (Hedw. : Fr.) Fr. that are similarly (though somewhat lighter) colored and also have smooth or nearly smooth (under the light microscope) ascospores (Svrček, 1970; Donadini, 1981). A distinct middle layer of more or less parallel hyphae is seen in all these fungi between two layers of large, globose cells (FIG. 1b). The ascospores of the new genus are rather loosely arranged in the ascus (FIG. 1e), smooth, and eguttulate (FIG. 1c).

The asci display several strange features. The asci appear unusually brittle, and are attached in a very even zone to the subhymenium. The base of each ascus is rather abruptly narrowed and often twisted (FIG. 1f), somewhat reminiscent of the ascus base in some members of the Sarcoscyphineae. At the base of the hymenium are many young asci, the apices (and sides) of which stain deeply blue in Melzer's Reagent. But certainly what is most peculiar is the presence of a lens-shaped structure that is strongly blue in lactic acid cotton blue (*i.e.*, cyanophilic) *within* the operculum (FIGS. 1a, 2a). Such a structure, for which we coin the term *opercular lens*, has not been reported before in operculate discomycetes. It can be seen in asci of various ages, and in discharged asci the opercular lens is visible in the open operculum. It stains slightly grey in Waterman's blue-black ink mounts, and, as Professor James W. Kimbrough has pointed out to us, also stains (pink) in congo red when material is first mounted in aqueous KOH, then mounted in aqueous congo red, and remounted in aqueous KOH. The opercular lens neither takes phloxine dye, nor reacts with aqueous cresyl blue or with Melzer's Reagent. The fungus was collected in two separate gatherings in the fields adjacent to a popular tourist stop in Tenerife, within a hundred meters of the bus stop at the Drago Tree, Icod de los Vinos, by the senior author and

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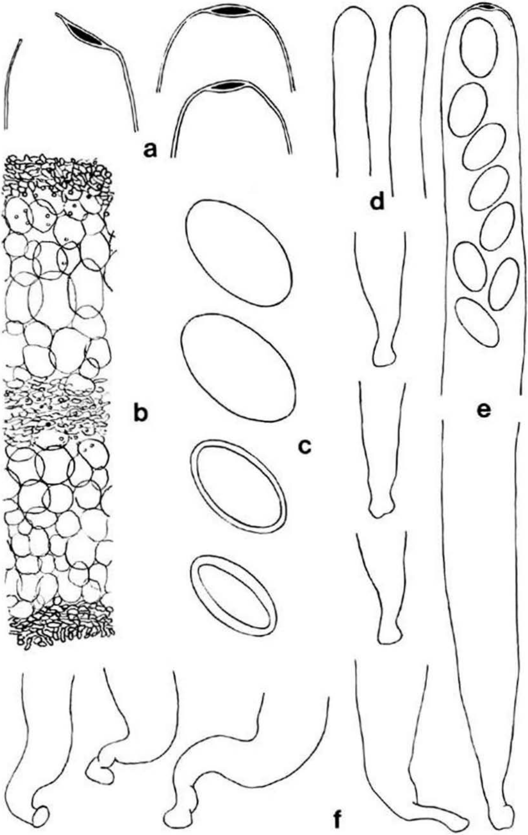
FIG. 1. **Kimbropezia campestris. a,** ascus apices stained in lactic acid cotton blue showing opercular lens. **b,** section through apothecium showing subhymenium at top and 4-layered excipulum. **c,** four ascospores, 2 basal younger and thicker-walled. **d,** paraphysis apices. **e,** ascus showing ascospore arrangement. **f,** seven ascus bases. (All from holotype, CUP-MM 2762, except lower left 3 ascus bases from CUP-MM 2761, **b** x100, **e** x500, all others x1000.)


a
b
c
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members of the British Mycological Society foray to the Canary Islands in 1990.

Kimbropezia campestris Korf & W.-y. Zhuang, *gen. et sp. nov.*
(FIGS. 1, 2)

Ab Peziza *structura cyanophilica lentiformi intra parietem operculi asci inclusa differens.*

APOTHECIA discoid, sessile, margin slightly to strongly enrolled, 0.8–3.5 cm diam when fresh. DISC light brown to brown (Methuen 7E6 to 7D5) when fresh. RECEPTACLE whitish, surface noted to be pustulate or not when fresh. EXCIPULUM 4–layered: outermost layer <56 µm thick, of textura intricata, with very short hyphae 4.5–8.0 µm wide extending towards the outside; second layer ca 300 µm thick, of textura angularis to textura globulosa, cells nearly isodiametric, 19–75 µm diam; third layer 35–120 µm thick, of textura intricata with hyphae 6.0–15 µm wide; fourth (innermost) layer 140–440 µm thick, thin at the margin and thicker toward the base, of large-celled textura angularis to textura globulosa, cells thin-walled, isodiametric to ellipsoid, 35–95 µm diam, up to 117 × 84 µm if elliptic. SUBHYMENIUM 35–55 µm thick, of textura intricata with hyphae mostly 5–10 µm wide. CYANOPHILIC RINGS of thickened wall material formed at septa commonly throughout the subhymenium and the adjacent excipular layer. HYMENIUM ca 380–410 µm thick. ASCI 8-spored, 345–430 × 24–37 µm, subcylindrical in upper and middle portions, abruptly drawn down into a short, narrow, often twisted base, walls thin and rigid, breaking easily, apically J+ in Melzer's Reagent (FIG. 2b), with an apical lens-shaped disc (opercular lens) within the operculum, the lens staining strongly blue in lactic acid cotton blue mounts (FIGS. 1a, 2a), staining pink in KOH-congo red mounts, and slightly grey in Waterman's blue-black ink mounts, but not reacting to Melzer's Reagent, cresyl blue, or phloxine dyes. ASCOSPORES 22.0–26.4 × 12.4–14.6 µm, ellipsoid, thick-walled, biseriately arranged, and with strongly dextrinoid contents when young (FIG. 2b), thin-walled, uniseriate, eguttulate, and forming de Bary bubbles at maturity. PARAPHYSES subcylindrical, ca 6.5–8.5 µm wide, with exceptionally thin walls, septa not seen.

HOLOTYPE: On soil amongst grasses and weeds, at Drago Tree, Icod de los Vinos, Tenerife, Canary Islands, elev. 250 ft., leg. E. Beltrán, R. P. Korf, J. T. Palmer, et al., 20. i. 1990, CUP-MM 2762. (Isotype: L.)

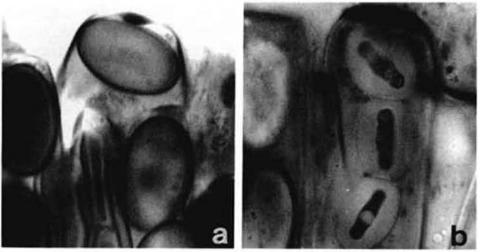

FIG. 2. **Kimbropezia campestris, a,** ascus apex in cotton blue lactic acid showing opercular lens and cyanophilic ascospore walls. **b,** young asci in Melzer's Reagent, showing intense blueing of ascus apex with opercular lens unstained, and thick-walled young ascospores with dextrinoid cytoplasm with one or more guttules, both from paratype, x1000.

PARATYPE: Same data as the holotype, CUP-MM 2761 (Isoparatype: TFC).

ETYMOLOGY: *Kimbro-*, to honor James W. Kimbrough, University of Florida, long-time student of the Pezizales and of ascus structure, plus *pezia*, from the Greek root *pezis*, and its Latin counterpart, to indicate relationship to the genus *Peziza; campestris*, of the fields, from its ecology.

PFISTERA

On a burn site on La Palma the senior author and his colleagues collected two discomycetes together as a mixed collection, one being *Peziza azorica* Dennis, the other a previously undescribed fungus we designate as the type of a new genus, *Pfistera*. Exactly where to place the new genus in the classification is, as yet, open to question. On the basis of its J– asci we exclude it from the Pezizaceae (but see our notes below). Its pigmentation and ascospores lacking guttules suggest that it is best accommodated somewhere in the tribe Geopyxideae (Otideaceae, subf. Otidioideae). Our field notes are poor, but the dried material allows for easy recognition of this most peculiar fungus. The apothecia are discoid to distinctly cupulate, sessile, with a dark brown to blackish disc when dry and a somewhat lighter receptacle, and are 0.8–1.2 cm in diam when dry, thus large for the Geopyxideae. The apothecial structure is unique, and more complex than in *Geopyxis* (Pers. : Fr.) Sacc. or *Pyropyxis* Egger, two other genera currently assigned to the Geopyxideae which we have compared closely (see our notes below in regard to *Aparaphysaria* Speg.).

The excipulum may be considered to be 3-layered, or 4-layered, depending on how one wishes to interpret the outermost fungal material. The questionable layer consists of somewhat disorganized cells, some perhaps without cell walls, that appear to have sloughed off the more typical outer ectal excipular layer. The outer ectal layer is composed of a firm textura angularis with strongly cyanophilic cell walls (an unusual feature), the cells mostly devoid of contents. The very outermost cells of this layer are often broken, and appear to have given rise (by wall breakdown?) to the sloughed-off tissues mentioned earlier (FIG. 3a). There is a sharp division between the cyanophilic ectal excipular layer and the next layer inward, of the medullary excipulum, which consists of textura intricata. Between this layer and the dense subhymenium occurs the third layer, composed of both hyphae in a looser textura intricata and of very large, very thin-walled, nearly spherical cells (FIG. 3b).

It is the asci that display the truly unusual character of the new fungus. They are J– in Melzer's Reagent, whether pre-treated in KOH or not, and are strongly dextrinoid in youth. The ascus wall is relatively rigid and uniformly thick up the sides of the ascus until close to the apex, where the wall suddenly becomes exceptionally thin and forms a broadly arched dome sharply delimited from the side walls of the ascus (FIGS. 3c, 4c). In some asci the dome collapses down within the apex to give a depressed apex, sometimes taking on the outline of the uppermost ascospore in the ascus. The rupture of the ascus apex apparently varies. The dome may have a vertical or irregular slit, faintly recalling that in the probably unrelated genus *Ascozonus* (Renny) Hansen (Ascobolaceae), or the dome may tear along most of the circular junction where the wall thins abruptly, perhaps thus functioning as a huge operculum. The ascospores also show a variety of rather strange features. Some of the spores develop a de Bary bubble at maturity, a few appear to have scattered cyanophilic markings while others are completely smooth, with overmature spores becoming wrinkled and distorted (FIG. 3d, 4a). The thin perispore of mature (not overmature) spores refracts light peculiarly, appearing distinctly blue under the microscope.

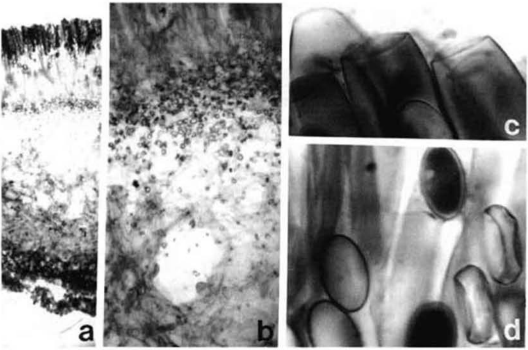

FIG. 3. **Pfistera pyrophila, a,** section through apothecium, showing hymenium, subhymenium, layer of large cells mixed with textura intricata, layer of textura intricata, cyanophilic ectal excipular layer, and outermost, sloughing layer, x66. **b,** base of hymenium, subhymenium showing cyanophilic rings, and upper portion of medullary tissue showing large cells (one so large as to appear an empty space), x250. **c,** ascus apices, showing thin-walled dome, x1000. **d,** ascospores within asci, mature spores with non-staining contents and cyanophilic perispore, young spores with densely cyanophilic contents, overmature spores wrinkled and folded, x1000; all from holotype.

Pfistera pyrophila Korf & W.-y. Zhuang, *gen. et sp. nov.* (FIGS. 3, 4)

Ab Pezizalibus aliis (praeter Ascozonus) *asci tholo apicale gaudentibus pariete valde tenui munito, ab* Ascozono *habitu non coprophilo et apotheciis multo magis grandioribus et complexe fabricatis differens.*

APOTHECIA discoid to cupulate, sessile, 0.8-1.2 cm diam when dry. DISC dark brown to blackish brown when dry. RECEPTACLE slightly lighter than disc when dry, somewhat pustulate. ECTAL EXCIPULUM 140–165 µm thick, of textura angularis, cells 15–47 µm diam, walls strongly cyanophilic, contents apparently missing, the outermost cells often broken and apparently giving rise to more or

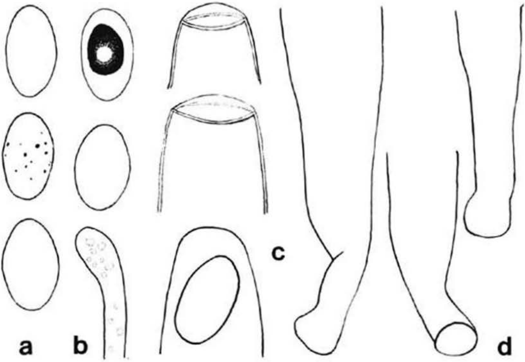

FIG. 4. **Pfistera pyrophila. a,** ascospores. **b,** paraphysis apex. **c,** ascus apices. **d,** ascus bases. (All from holotype, CUP-MM 854, x1000.)

less amorphous hyphae or cells without obvious walls that comprise an outer, scurfy, sloughed-off, covering layer. MEDULLARY EXCIPULUM two-layered, that closest to the ectal excipulum 75–103 µm thick, of textura intricata, hyphae mostly 4.5–11.5 µm wide, the upper layer ca 56 µm thick near the margin, 180–220 µm thick at the flanks, thickest at the base, consisting of a mixture of hyphae 6.0–14.5 µm wide forming a loose textura intricata and of ovoid to globose cells 28–93 µm in diam, with exceptionally thin walls so as to appear as "empty spaces" unless one observes the delicate cell wall in face view. SUBHYMENIUM 30–60 µm thick, of a dense textura intricata, hyphae mostly 3-6 µm diam. CYANOPHILIC RINGS at septal thickenings evident throughout the subhymenium, with a few also scattered in the medullary excipulum. HYMENIUM ca 260–270 µm thick. ASCI 8-spored, arising from distinct croziers, 235–271 × 18.3–22.0 µm, J– in Melzer's Reagent with or without KOH pretreatment, with a very thin, arched apical dome at maturity that may split vertically, horizontally or irregularly, epiplasm dextrinoid in youth. ASCOSPORES 17.6–20.5 × 10.2–12.0 µm, uniseriate, ellipsoid, smooth, rarely with a few cyanophilic warts, more or less wrinkled when overmature, perispore blue (spherical aberration?) under the microscope in water mounts, contents highly refractive when mature, eguttulate, sometimes forming deBary bubbles, strongly dextrinoid in youth in Melzer's Reagent. PARAPHYSES difficult to find in some mature apothecia, 5.0–6.8 µm wide at apex and ca. 3.7 µm wide below, with few septa.

HOLOTYPE: On a burn site, near mine entrance at km. mark 13, road between Buenavista and El Paso, La Palma, Canary Islands, leg. R.. P. Korf, W. C. Denison, L. M. Kohn, & M. A. Sherwood, 18. i. 1976, CUP-MM 854 (Isotypes: L, TFC, OSC).

ETYMOLOGY: *Pfistera*, to honor Donald H. Pfister, Harvard University, premier American student of *Peziza; pyrophila* for fire-loving, from its ecology.

Notes: We should point out here that at one point we seriously considered assigning this new genus to the Pezizaceae, despite the lack of any blueing reaction to iodine, in part propelled to such a disposition by the multi-layered excipulum of the new fungus (albeit unlike any typical member of the Pezizaceae), in part by wondering if loss of a blue reaction might have some relationship to the unusual, thin dome of the asci. Further, we remembered Svrček's (1970) comments on a specimen of otherwise typical *Peziza varia* in which he had been unable to find any trace of a blueing reaction. Dr. Svrček has kindly sent us a fragment of that collection, now on deposit as CUP 61972. His notes indicate that some collapsed asci are J+, "Asci plerumque *inamyloidei*, sed in hymenio nonnullie asci collapsis leniter amyloidei ...," and we find a distinct, blue apical ring in many asci, so that clearly this is very different from the situation in *Pfistera*.

Another serious problem for us is the ecologically different genus *Aparaphysaria* Spegazzini (1922), which should occur on moist soil and among mosses. The genus was founded on *A. doelloi* Speg., collected in 1921 in Tierra del Fuego, and described and illustrated with clearly apically truncate, operculate asci 250-350 × 16–18 µm, and smooth, ellipsoid, eguttulate ascospores 20 × 12 µm. It was characterized by a complete lack of paraphyses, and was first assigned to the Geopyxideae by Korf (1972). When the senior author wrote many years ago to examine the type specimen of this species while preparing that paper, Prof. Irma Gamundí, Instituto de Botânica "Spegazzini," advised us that there was no material in La Plata of *A. doelloi* (she indicated that also in Gamundí, 1975). She did, however, send us the type packet of *Geopyxis aparaphysata* Speg. (1899), collected in 1896, also in Tierra del Fuego, described with asci

280–300 × 8–12 µm, "cylindracei apice rotundato-subtruncati." As indicated by the specific epithet, this too lacked paraphyses, but it was described with smaller ascospores, 14–16 × 7–8 µm. The type packet of this species is completely empty, as also indicated by Gamundí (1975); she reports that Spegazzini annotated a manuscript synonymizing the two species, despite the differences he reported in spore measurements. The fungus has apparently never been collected again, and Gamundí did not propose a new combination in *Aparaphysaria* for the older epithet, even though she, as do we, apparently accepted the genus. The truncate, clearly operculate asci seem to rule out a synonymy between *Aparaphysaria* and *Pfistera*, but we do point out that at maturity it is difficult to find very many paraphyses in some apothecia in our material. There is no description whatsoever of the apothecial structure in either of Spegazzini's descriptions. We also note Gamundí's (1975) quotation from a Spegazzini manuscript, in which material of this species preserved in formalin was reported to give a ferrugineus color in asci and ascospores when mounted in tincture of iodine. This could be a similar reaction to the strongly dextrinoid asci and ascospores of *Pfistera*. We admit to being tempted to try to "save" Spegazzini's generic name by neotypifying *A. doelloi* with our Macaronesian material, but have decided that would be very rash indeed, considering the differences in the descriptions, the ecology, the geographical distance involved, and lack of any information on the apothecial microanatomy of Spegazzini's fungus. *Aparaphysaria* remains an intriguing enigma about which very little is known. New collections are obviously needed before its position in the classification can be judged. The very few details we do have concerning it point to some possible connection to *Pfistera*.

ACKNOWLEDGEMENTS

We wish to thank Professor James W. Kimbrough, University of Florida, for his confirming observations and comments on *Kimbropezia* and Professor Donald H. Pfister, Harvard University, for his helpful observations and comments on *Pfistera*. Neither was aware that we planned to dedicate the new genera to them. We thank Dr. J. van Brummelen, Rijksherbarium, Leiden, who served as presubmission reviewer, and Emeritus Professor William J. Dress, Bailey Hortorium, Cornell University, who provided our Latin diagnoses. Collecting trips were supported by a US National Science Foundation grant to the senior author for the study of the Discomycete Flora of Macaronesia and by the Anna E. Jenkins bequest to Cornell University. The bequest also has provided the funds for the junior author's postdoctoral associateship.

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MYCOTAXON

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AMANITA MORRISII—HISTORY, TAXONOMY, AND DISTRIBUTION

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Summary

Amanita morrisii Peck was originally described in 1910, but has been a poorly understood species for decades. Location of three watercolor illustrations of this species (in NYS[1] and PM) painted by its original collector, George E. Morris, and a re-examination of the holotype and isotypes (NCU, NYS, CUP-A, PM) and newly located topotypes (FH, PM) provide opportunity for a modern description.

Amanita morrisii Peck. 1910. *Bull. N. Y. St. Mus.* 139: 42, pl. W, figs. 1-4.
≡*Venenarius morrisii* (Pk.) Murrill. 1913. *Mycologia* 5(2): 75.
≡*Amplariella morrisii* (Pk.) Gilbert nom. inval. 1940-41. *Amanitaceae*: 78. [No citation of basionym.]
non *Amanita morrisii* sens. A. H. Smith in Gilbert. 1940-41. *ibid.*: tab. 50.

Belonging to section *Validae*, *Amanita morrisii* is a medium to large mushroom with a dark brown pileus that fades slightly with age; the pallid stipe has an ellipsoid to subglobose bulb and may have a few irregular, submembranous patches of universal veil near the top of the bulb. The stipe also has a peculiar, short, membranous annulus that is pinkish below and white and striate on the upper surface. The spores have an average Q per specimen of (1.28-) 1.30 - 1.39 (-1.42).

PILEUS: 45 - 95 (-114) mm diam, dark grayish brown to blackish brown becoming paler with age, subcampanulate becoming broadly convex, viscid when moist; margin nonstriate, nonappendiculate; pileipellis separable; context white, rather thick at stipe; universal veil absent or as irregular submembranous pallid patches. LAMELLAE: white, drying 5B5-7[2] to 6B5 to 6B8 to 6C4 to 6D8 to 5YR 5-6/8[3] to 10YR 6/8, thin,

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[1]
CUP-A - G. F. Atkinson Herbarium, separately accessioned in CUP, the Plant Pathology Herbarium, Cornell University, Ithaca, New York, U.S.A.
FH - Farlow Reference Library and Herbarium, Harvard University, Cambridge, Massachusetts, U.S.A.
NCU - Herbarium, Department of Botany, University of North Carolina, Chapel Hill, U.S.A.
NY - Herbarium of The New York Botanical Garden, Bronx, U.S.A.
NYS - Herbarium of the New York State Museum, Albany, U.S.A.
PM - Herbarium, Peabody Museum of Salem, Massachusetts, U.S.A.

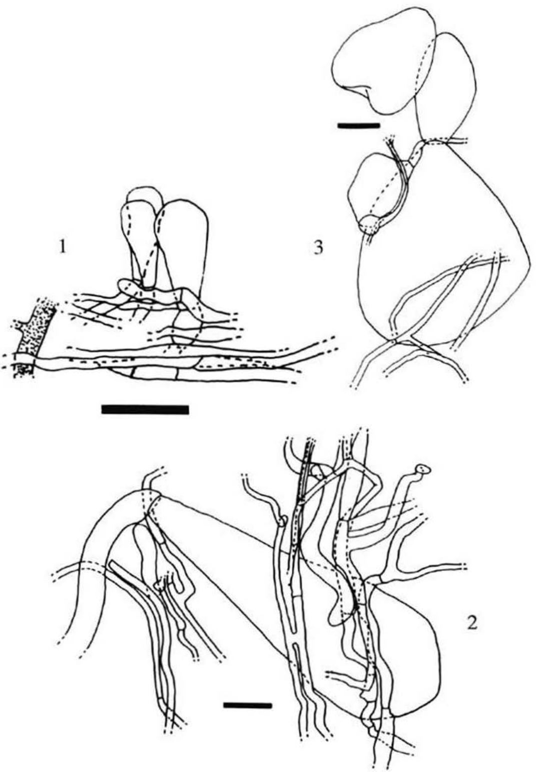
[2] Color codes of this form are from Kornerup & Wanscher (1978).

[3] Color codes of this form are from Munsell Color (1975).

close, narrow, narrowly adnate, sometimes with a decurrent line on the stipe; lamellulae probably attenuate. STIPE: to 153 × 10± - 15 ± mm, white, sometimes grayish above annulus, cylindric or slightly narrowing upward, slightly floccose or fibrillose on the surface; context probably whitish or pallid, solid or stuffed; partial veil white and striate above, pink below, called "double" by Peck, superior, but low enough on stipe that its margin is at first made to flare upward due to the tension created by the expanding pileus; bulb clavate to subglobose, to 38 × 34 mm; universal veil in whitish to pallid grayish patches on lower stipe or upper part of the bulb, easily left in the soil or lost.

PILEIPELLIS: 30 - 75 μm thick, gelatinizing at surface, with orange brown intracellular pigment in exsiccata (in KOH); branching undifferentiated filamentous hyphae subradially arranged, interwoven, 2.0 - 6.0 μm diam; oleiferous hyphae present 1.5 - 4.0 μm diam. PILEUS CONTEXT: branching undifferentiated filamentous hyphae 1.2 - 10.0 μm diam; inflated cells ellipsoid to ovoid (to 81 × 51 μm) to clavate (to 110 × 38 μm), terminal, thin-walled; branching oleiferous hyphae present, 1.0 - 3.8 μm diam. LAMELLA TRAMA: bilateral, at times somewhat obscurely, at 1000× appearing in many sections to be a single uniform "central stratum" reaching from subhymenium to subhymenium; when diverging structures are visible, the angle of divergence is around 30°±; interwoven branching undifferentiated filamentous hyphae dominating, 1.2 - 8.8 μm; inflated cells clavate, to 90 × 25 μm, thin-walled, not uncommon but hidden in the tight mesh of filamentous hyphae; branching oleiferous hyphae rather common, 1.2 - 9.7 μm diam, often to be found in the region immediately below the subhymenium or even in the subhymenial region. SUBHYMENIUM: somewhat obscure and shallow; basidia arising directly from short sometimes slightly inflated hyphal segments that make a sharp, at times right-angle, turn toward the hymenium from a short distance away where hyphae run roughly parallel to the hymenial surface; basidia may also arise from rather small inflated cells that arise singly on hyphae diverging only slightly from being parallel to the hymenial surface; such inflated cells form a sparsely populated single layer. BASIDIA: 24 - 32 × 7.8 - 12.0 μm, 4-sterigmate, thin-walled; clamps not observed. UNIVERSAL VEIL: On pileus: none found. On stipe base: branching tangled undifferentiated filamentous hyphae plentiful, 2.0 - 12.0 μm diam; plentiful inflated cells, ellipsoid to pyriform to subglobose to broadly clavate to clavate, thin-walled, terminal, to 99 × 79 μm; branching oleiferous hyphae present, 1.8 - 4.2 μm diam. STIPE CONTEXT: acrophysalidic; branching undifferentiated filamentous hyphae, 1.8 - 8.0 μm diam; acrophysalides plentiful, to 302 × 57 μm; oleiferous hyphae present, 1.2 - 14.8 μm diam. PARTIAL VEIL: frequently branching undifferentiated filamentous hyphae dominating, 1.2 - 11.2 μm diam, with the narrowest branching somewhat less frequently and more often radially arranged, overall with the appearance of directionless tangle; inflated cells terminal on hyphae of largest diam, scattered, sometimes clustered, thin-walled, barely inflated to elongate to clavate to ellipsoid, to 143 × 50 μm; oleiferous hyphae present, branching, 1.5 - 4.2 μm diam. All tissues hyaline to pale yellowish in KOH unless otherwise stated.

BASIDIOSPORES: [485 measured from 24 specimens] (6.0-) 7.2 - 9.5 (-11.5) × (4.2-) 5.5 - 7.0 (-8.2) μm, (average length per specimen = (7.4-) 7.7 - 8.9 (-9.0) μm; average length overall = 8.4 μm; average width per specimen = (5.5-) 5.6 - 6.5 (-6.6) μm; average width overall = 6.2 μm; Q = (1.11-) 1.20 - 1.51 (-1.64); average Q per specimen = (1.28-) 1.30 - 1.39 (-1.42); average Q overall = 1.35), amyloid, hyaline, thin-walled, smooth, broadly ellipsoid to ellipsoid, sometimes swollen at one end,



Figs. 1-3 *Amanita morrisii*. 1. Portion of hymenium and subhymenium (ix.1911 Blackford s.n. (FH)). 2. Structure in partial veil (holotype). 3. Structure in universal veil (holotype). The bars in Figs. 1-3 represent 20 µm. Refractive content of hyphae is indicated by stippling.

adaxially flattened; apiculus sublateral, cylindric; contents guttulate; white in deposit.

Distribution and habitat: Single to subgregarious in black vegetable mold among mosses—a swampy area, in September and October. Known only from eastern Massachusetts.

Collections examined: **UNITED STATES:** MASSACHUSETTS - Essex County, Lynn, Lynn Woods, 1.x.1927 Mrs. S. C. Pierce s.n. (NY); Middlesex Co., Natick, 11-13.ix.1909 G. E. Morris s.n. (isotype, PM with watercolor no. 33), 13.ix-1.x.1909 G. E. Morris s.n. (holotype, NYS; three separate portions at CUP-A & one at NCU), 1.x.1909 G. E. Morris s.n. (isotype, CUP-A "part of type, pale form"), 13.x.1909 G. E. Morris s.n. (PM), 23.ix.1910 G. E. Morris s.n. (PM, watercolor no. 34 without voucher), ix.1911 Mrs. Eliza B. Blackford s.n. (FH).

DISCUSSION

The sparseness of inflated cells in the subhymenium and the presence of undifferentiated and oleiferous hyphae in the subhymenial region and running roughly parallel to the hymenial surface is unusual in section *Validae*. Taxa in this section frequently display a cellular subhymenium. On the other hand, the subhymenial structure found in *A. morrisii* is not altogether unknown. I have observed subhymenia containing plentiful hyphae running parallel to the central stratum and giving rise to basidia directly or with only a single, small, inflated, intermediary cell in species distributed through four sections of the genus *Amanita*: Examples include *A. crenulata* Peck in section *Amanita*, *A. peckiana* Kauffman in Peck in section *Amidella*, *A. magnivelaris* Peck in section *Phalloideae*, and *A. morrisii*. Detailed examination of both the lamella trama and the subhymenium appears to be very valuable for future systematic work in *Amanita*.

In addition to the anatomy of the lamellae and the size and shape of the spores, the colored underside of the annulus and the very dark pileus of young specimens becoming paler with age should clearly distinguish *A. morrisii*.

Dr. John H. Haines (NYS) was extremely helpful in locating the list of Morris' watercolors (Morse, 1918) and relevant correspondence from Morris to Peck. For example, while Peck did not publish dimensions of *A. morrisii* in the protologue, one can get information by measuring Morris' spore prints (PM) and from Morris' letter to Peck dated 1 October 1909—the only reference to size of *A. morrisii* I have found. This correspondence also indicates that Peck originally intended to call the mushroom "*A. bicolor*" because of the stark difference between the dark pileus and the pallid colors of the rest of the basidiocarp (letter of Peck to Morris of 14 September 1909 in FH), but changed the name to honor the collector—over Morris' objections. Apparently Morris had already announced to his colleagues in the Boston Mycological Club the first-proposed name.

While I have found only one collection made anywhere other than in Natick (the type locality), Morris makes reference to a collection made in Needham, Massachusetts by a Miss Hibbard; this collection apparently made its way to W. G. Farlow to the consternation of Morris who would appear to have been very protective of Peck's priority in naming of fungi and as the preferred mycological guru of the age (letter of Morris to Peck, 4 October 1909 in NYS). I am unable to locate the Hibbard collection in FH.

Excellent watercolors of *A. morrisii* by George E. Morris are located in NYS and PM. From Morris' letter of 28 November 1909 (NYS), we discover that the painting in NYS (marked 1-1032 in the upper right hand corner) is not drawn from fresh material. In the cited letter, Morris expresses surprise that Peck thought he had already asked for such a painting; Morris promises to send the painting as soon as his busy teaching schedule allows. He was a secondary school art teacher. In the extensive Morris collection at PM, the *A. morrisii* paintings are numbers 33 and 34. For number 33, a voucher collection has been identified in PM. It is noteworthy that the underside of the annulus in the paintings drawn from fresh material is distinctly pink while in the painting at NYS there is a faint brownish tone added making a pale orangish beige that Peck called "buff" in the protologue. Mrs. E. B. Blackford also painted *A. morrisii* (Blackford watercolors numbers 26 and 27 in FH); she was the lesser of the two painters as a botanic illustrator; but her colors are in good agreement with Morris' including the pink tinge on the annulus which, however, she sometimes shows on the top margin and sometimes on the bottom.

In letters to Peck dated 4 October and 14 November 1909 (NYS), Morris mentions planning to send and having sent fragments of *A. morrisii* to William W. Ford for Ford's studies of poisons in mushrooms. The results of injecting extracts of *A. morrisii* in animal subjects led Ford to conclude that the species was poisonous (Ford, 1911; Ford & Clark, 1914). The analytical techniques of the time were such that Ford could determine that there was an hemolytic agent that was destroyed by heating to 60° - 65° C. His experiments with guinea pigs and rabbits indicated that there was also a heat stabile, deadly poison present that deteriorated in potency over a period of eight to nine months. It must be taken into account that Ford admits his animals sometimes died for reasons other than injections of mushroom extracts. To my knowledge, there have been no subsequent studies of the possibility of poisons in *A. morrisii.*

The Morris collection dated 11-13.ix.1909 (PM) and the holotype (NYS) are both mixed collections. One of the basidiocarps in each collection is not conspecific with the remainder. Possibly these two (globose-spored) specimens represent *A. brunnescens* Atkinson. The possibility of confusion with the rather common *A. brunnescens* should be minimal today because its nearly globose spores and distinctive, cleft bulb are widely described in field guides and are easily recognized.

The collections of C. H. Kauffman and A. H. Smith which are briefly described by Gilbert (1940-41) have very different coloring from that of *A. morrisii*—bright yellow or chrome universal veil (CHK) and smoky ochraceous [pileus?] (AHS). I did not locate a collection that might be the voucher for the photograph supplied to Gilbert by Smith (Gilbert, 1940-41: tab. 50); the distribution of universal veil in rings on the lower stipe as seen in that picture was present on the Lynn Woods collection here accepted as *A. morrisii.*

ACKNOWLEDGMENTS

I wish to express my gratitude to the following persons who made it possible for this article to be completed: Drs. Jean Boise and Donald H. Pfister and Mr. Gennaro J. Cacavio, all of FH, provided me telephone consultation, information about collections by mail, and access to collections and a working space during my visit to the Farlow. Dr. John H. Haines (NY) allowed me access to the Peck herbarium, supported me with searches through the Peck correspondence, and was the rediscoverer of the Morse listing of Morris watercolors. Drs. Roy E. Halling and Barbara Thiers hosted me at NY; and Dr. Halling allowed me the use of his laboratory for the examination of specimens. Dr. David T. Jenkins, Department of Biology, University of Alabama at Birmingham, once again provided his generous support by reviewing the article. Ms. Mary A. King, Roosevelt, New Jersey, assisted me in note-taking at PM and assisted in final preparation of figures and text for publication. Dr. Richard P. Korf and Ms. Susan C. Gruff, Department of Plant Pathology, Cornell University, Ithaca, New York, supplied information concerning collections in CUP-A and arranged for loans of the material. Dr. J. R. Massey, Mr. William Burk, and Ms. Mary Felton generously supported my visit to NCU. Mr. Rob Moir hosted me at PM and has been extremely supportive of making the Morris watercolors and herbarium accessible to study. Dr. Joseph L. Peterson, Plant Pathology Department, Cook College, Rutgers University, New Brunswick, New Jersey, assisted me once again with obtaining loans of important specimens.

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MYCOTAXON

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A PRELIMINARY DISCOMYCETE FLORA OF MACARONESIA: PART 13, MORCHELLACEAE, HELVELLACEAE [1]

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and
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"All the world is queer save thee and me,
and even thou art a little queer."
Robert Owen
ON SEVERING BUSINESS RELATIONS WITH HIS PARTNER (1828)

Order PEZIZALES
Suborder PEZIZINEAE
Family MORCHELLACEAE Reichenbach 1834 (ut 'Morchellini')

One known Macaronesian genus

MORCHELLA Dillenius ex Pers. : Fr. 1797

Notes: Our species concept in this genus is very broad, based on experimental studies such as those of Groves and Hoare (1953). The narrow species concepts adopted by Boudier in the late 19th and early 20th centuries, and continued by, e.g., Jacquetant (1984), seem wholly unrealistic.

Key to the known Macaronesian species

1 Spores large, 20.5–29.4 x 12.4–17.6 µm .... **1. M. dubia**
1' Spores smaller 2

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[1] The parts of this flora will appear in irregular order. Reprints of individual parts will not be available for distribution.

[2] Professor of Mycology

[3] Anna E. Jenkins Postdoctoral Associate

2(1') Ribs remaining pale, without a decided ridge separating pileus from stalk . . . . **3. M. esculenta**

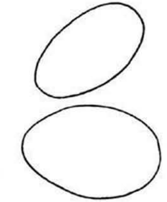
2'(1') Ribs brownish black, with a decided ridge separating pileus from stalk . . . . **2. M. elata**

1. **Morchella dubia** Montagne *in* Barker-Webb and Berthelot, Hist. Nat. des Isles Canaries 3(2): 79. 1840.

RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
*Montagne (1840), †Cool (1924), ††Cool (1925), **Beltrán & Wildpret (1975, as M. *conica*), †††Beltrán (1980).

HOLOTYPE DATA:
In sylvâ Azona García, Tenerife (FI, Herb. Webbianum).



M. dubia, ascospores, CUP-MM 2525, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. CUP-MM 2533 (FI).
Tenerife. † †† ††† CUP-MM **2523 (TFC), *2525 (FI, holotype).

SUBSTRATUM:
Soil.

Notes: This is clearly a *Morchella*, but the type specimen and the other specimen in Montagne's collections at Firenze are not in good condition. The ascospores are quite large, but these specimens may merely represent overmature M. *esculenta* (L.) Pers. : Fr.

2. **Morchella elata** Fries : Fr., Syst. mycol. 2: 8. 1822.

= *Morchella costata* (Vent.) Pers., Syn. meth. fung., p. 20. 1801.

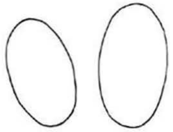
RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984), Jacquetant (1984).

PREVIOUS MACARONESIAN RECORDS:
†Wildpret et al. (1969), ††Wildpret et al. (1972), †††Beltrán (1980), *Calonge (1974).

TYPE LOCALITY:
Sweden.

KNOWN MACARONESIAN DISTRIBUTION

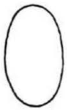
CANARY ISLANDS:
La Palms. † †† (preserved in formalin, accidentally destroyed) †††
Tenerife. †† CUP-MM *2543 (MA)



M. elata, ascospores, CUP-MM 2543, x1000.

3. **Morchella esculenta** (L.) Pers. : Fr., Syn. meth. fung., p. 618. 1801.

= *Morchella conica* Pers., Traité champ. comest., p. 256. 1818.



M. esculenta, ascospore, CUP-MM 2517, x1000.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984), Jacquetant (1984).

PREVIOUS MACARONESIAN RECORDS:
*Montagne (1840), †Cool (1925), ††Cool (1926), ††††Wildpret et al. (1969), **Beltrán & Wildpret (1975), †††Beltrán (1980), †††† Bañares & Beltrán (1982).

TYPE LOCALITY:
Sweden.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. ††† †††† CUP-MM **2514 (TFC, immature).
Gran Canaria. † †† ††† ††††CUP-MM *2524 (FI, watercolor drawing only).
Tenerife. ††† CUP-MM **2517 (TFC), **2513 (TFC, immature).

SUBSTRATUM:
Soil.

Family HELVELLACEAE Fries : Fr. 1823 (ut 'Elvellacei')

KEY TO THE KNOWN MACARONESIAN GENERA

1 Ascospores with a single, large guttule .... **Helvella**
1' Ascospores biguttulate or with more than two guttules 2
  2(1') Ascospores biguttulate, without pointed appendages; ascocarps stalked, with cerebriform or mitrate caps .... **Gyromitra**
  2'(1') Ascospores with a pointed apiculus at each end; ascocarps sessile, with rhizoids on outer surface .... **Rhizina**

GYROMITRA Fries 1849 (nomen conservandum)

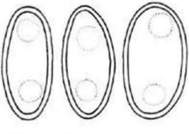
= *Physomitra* Boudier 1885.

Key to the known Macaronesian species

1 Pileus cerebriform, elastic; ascospores ellipsoid, mostly 22.7–24.2 x 10.2–12.4 µm .... **1. G. esculenta**
1' Pileus irregularly saddle-shaped, fragile; ascospores narrowly ellipsoid, mostly 20.5–23.5 x 7.0–8.8 µm .... **2. G. infula**

1. Gyromitra esculenta (Pers. : Fr.) Fries, Summa veg. scand., pars post., p. 346. 1849.

≡ *Physomitra esculenta* (Pers. : Fr.) Boud., Icon. mycol., Liste prélim., p. [2]. 1904.



G. esculenta, ascospores, CUP-MM 1152, x1000.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
*Wildpret & Beltrán (1974), †Beltrán (1980).

TYPE LOCALITY:
Europe.

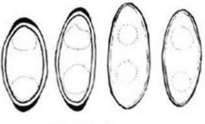
KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. † CUP-MM 1152 (O), *2505 (TFC).

SUBSTRATUM:
Soil.

2. **Gyromitra infula** (Schaeff. : Fr.) Quélet, Enchir. fung., p. 272. 1886.

≡ *Physomitra infula* (Schaeff. : Fr.) Boud., Icon. mycol., Liste prélim., p. [2]. 1904.



G. infula, ascospores, CUP-MM 1228, x1000.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
*Beltrán & Wildpret (1975), †Beltrán (1980), ††Gonzales & Beltrán (1980).

TYPE LOCALITY:
Germany.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
La Palma. † †† CUP-MM *2518 (TFC).
Tenerife. † CUP-MM 312 (TFC, OSC), 1228 (TFC), 2504 (TFC).

SUBSTRATA:
On duff, on soil under *Pinus canariensis*.

HELVELLA L. : Fr. 1763

= *Paxina* Kuntze 1891.

Key to the known Macaronesian species

1 Apothecia short-stipitate, flat to folded, 0.5–2 cm broad, hymenium and receptacle black, but often paler toward base . . . 1. **H. helvellula**

1' Apothecia larger or distinctly stalked 2

  2(1') Stipe long, distinctly fluted; pileus saddle-shaped. 2. **H. lacunosa**

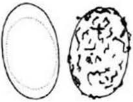
  2'(1') Stipe short, apothecium cupulate with a crenate margin, mostly (2–) 4-7 (-10) cm diam . . . . 3. **H. leucomelaena**

1. **Helvella helvellula** (Dur. & Mont. in Dur.) Dissing, Rev. Mycol. (Paris) **31:** 204. 1966.

RECENT TAXONOMIC TREATMENT:
Dissing (1966).

PREVIOUS MACARONESIAN RECORDS:
*Bañares et al. (1986). **Bañares (1988).

TYPE LOCALITY:
Algeria.



H. helvellula, ascospores, CUP-MM 1417, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. CUP-MM 2676 (TFC).
Gran Canaria. CUP-MM * ** 2609 (TFC).
Hierro. CUP-MM 1403 (TFC), 1412 (TFC, OSC, C), 1417 (TFC, OSC, C), 1422, 1426, 1469.
Tenerife. CUP-MM 1153 (O).

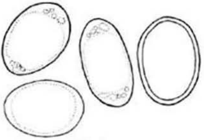
SUBSTRATA:
On soil, on bare soil, on mossy soil, among mosses.

2. **Helvella lacunosa** Afz. : Fr., Kongl. Vetensk. Akad. Nya Handl. **4:** 303. 1783.

= ? *Helvella phlebophora* Pat. & Doass. *in* Pat., Tab. anal. fung. **5:** 208. 1886.

RECENT TAXONOMIC TREATMENTS:
Dissing (1966), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
†Cool (1924). ††Cool (1925). †††Beltrán (1980). ††††Bañares et al. (1986); †††††Gonzales & Beltrán (1987); ††††††Bañares (1988). †††††††Beltrán et al. (1990).



H. lacunosa, right ascospore CUP-MM 752, others CUP-MM 1142, x1000.

TYPE LOCALITY:
Sweden.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS
Gran Canaria. †††† ††††††
Hierro. †††††††
La Palma. CUP-MM 752 (TFC, OSC), 1156 (O).
Tenerife. † †† ††† †††† CUP-MM 1142 (O), 2731 (TFC), 2746, 2749 (TFC).

SUBSTRATA:
On soil, on burnt ground.

Notes: One of our collections from Tenerife (CUP-MM 2746) may well represent *H. phlebophora* according to Dr. Henry Dissing, if indeed that taxon can be distinguished from *H. lacunosa*.

3. **Helvella leucomelaena** (Pers.) Nannf. *in* Lundell & Nannf., Fungi exs. praes. Upsal., fasc. **19-20:** 21. 1941.

≡ *Paxina leucomelaena* (Pers.) O. Kuntze (ut 'leucomelas'), Rev. gen. pl. **2:** 864. 1891.

H. leucomelaena, ascospore, CUP-MM 2610, x1000.

RECENT TAXONOMIC TREATMENTS:
Dissing (1966), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
*Bañares et al. (1986), **Bañares (1988), †Beltrán et al. (1990).

TYPE LOCALITY:
Europe.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gran Canaria. CUP-MM * **2610 (TFC)
Hierro. †

Notes: The earlier reports from Gran Canaria are based on Korf's identification of CUP-MM 2610.

RHIZINA Fries : Fr. 1815

One known Macaronesian species

1. **Rhizina undulata** Fries : Fr., Obs. myc. **1**: 161. 1815.

≡ *Rhizina inflata* (Schaeff.) Karst., Acta Soc. Fauna Fl. Fenn. 2(6): 112. 1885.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORD:
*Dybhavn (1990).

TYPE LOCALITY:
Germany (Schaeffer's type locality for *Elvela inflata*, which Fries renamed).

R. undulata, ascospore, CUP-MM 1572, x 1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 1572 (TFC, OSC), *2777 (O).

SUBSTRATA:
On duff, on the ground in pine forest.

MYCOTAXON

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A REVISION OF THE LICHENS BRYONORA CASTANEA AND B. CURVESCENS

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SUMMARY

On the basis of morphology, spore size and chemistry, the lichen species *Bryonora castanea* (Hepp) Poelt and *B. curvescens* (Mudd) Poelt are here treated as four species: *B. castanea*, *B. curvescens*, *B. pruinosa* (Th. Fr.) Holt.-Hartw. comb. nov., and *B. septentrionalis* Holt.-Hartw. sp. nov.

INTRODUCTION

The genus *Bryonora* Poelt (Poelt 1983) originally included six species. Three of them were transferred from *Lecanora*: *B. castanea* (Hepp) Poelt, *B. curvescens* (Mudd) Poelt, and *B. rhypariza* (Nyl.) Poelt. *Bryonora corallina* Poelt, *B. stipitata* Poelt and *B. yeti* Poelt were described as new, and are still known only from their type localities; *B. corallina* from the Alps, the two others from the Himalayas. Poelt & Mayrhofer (1988) later described *B. reducta* Poelt & Mayrh. and *B. selenospora* Poelt & Mayrh., both known only from their type localities in the Himalayas. These two species are according to Poelt & Mayrhofer (1988) cyanotrophic, i.e. lichens living in close relationship with cyanobacteria.

The thallus in *B. corallina* and *B. stipitata* is stipitate and coralloid, in *B. rhypariza* subsquamulose, in the other species more or less poorly developed.

In connection with a revision of the genus for a coming Norwegian crustose lichen flora, it became apparent that *B. castanea* and *B. curvescens* were heterogeneous. The aim of this paper is to analyse the morphological and chemical variation within these species in the northern hemisphere.

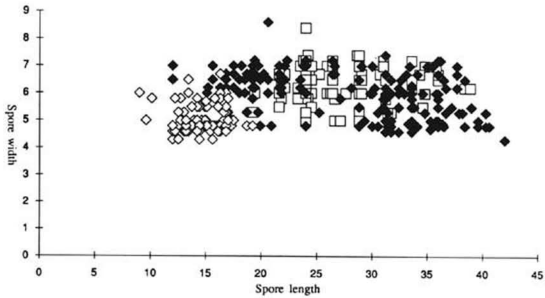

Fig. 1. Ascospore length vs width vs chemotype of 40 specimens traditionally referred to as *Bryonora castanea* and *B. curvescens*. Usnic acid (◇), norstictic acid (◆), isousnic acid (□).

MATERIAL AND METHODS

This study is based on all relevant material of *Bryonora* in the institutional herbaria BG, C, GZU, H, M, O, S, TRH, TROM, and UPS, and includes approximately 390 specimens. Type material of *Biatora castanea* Hepp (WU) and *Lecanora castanea* v. *pruinosa* Th. Fr. (UPS) were also studied.

The descriptions refer to dry material, unless otherwise stated. Dissecting microscope (magnifications 6x–32x) and a light microscope (100x–1000x) were used for morphological and anatomical studies. Anatomical studies of the apothecia were made on sections cut by free-hand or freezing microtome. Spores were studied in squash preparations mounted in H_2O. 400 spores were measured, i.e. ten spores from each of ten specimens of the usnic acid chemotype, the isousnic acid chemotype, and from the two morphotypes of the norstictic acid chemotype traditionally referred to as *B. castanea* and *B. curvescens*.

Under the description of the species, the spore measurements are given as $(L_{min}–)\ L–1.5*\sigma_{n-1}–\mathit{L}–L+1.5*\sigma_{n-1}\ (–L_{max})$ x $(W_{min}–)\ W–1.5*\sigma_{n-1}–\mathit{W}–W+1.5*\sigma_{n-1}$; where L and W are arithmetic means of length and width and $\sigma_{n-1}$is the standard deviation. The numbers are rounded to the nearest 0.5 µm. The chemical tests referred to are: K (10 % KOH), N (10 % HNO_3), and KI (a modified Lugol's solution (water being replaced by lactic acid), after pretreatment in K).

131 specimens were subjected to chemical analyses by thin layer chromatography according to the standard techniques described by Culberson & Kristinsson (1970) and Culberson (1972), modified by Menlove (1974).

RESULTS

Among the specimens subjected to TLC, 42 contained norstictic acid, 44 isousnic acid, and 45 usnic acid.

To make an objective analysis of the variation in spore size, 400 spores were measured from 40 specimens of known chemotype. The relationship between spore length vs width vs chemotype is shown in Fig 1. The norstictic acid chemotype is represented by two point swarms. The isousnic acid chemotype is represented by a wide swarm overlapping both of the two norstictic acid swarms. The usnic acid chemotype is represented by a well delimited point swarm partly overlapping one of the norstictic acid swarms.

The results of the morphological analyses are given in the descriptions below.

General description of the species

Thallus poorly developed. Apothecia 0.5–4.5 mm diam., constricted below and attached by a narrow point, often crowded; lower side with a well developed cortex, 50–120 µm high, composed of anticlinally oriented, anastomosing, branched, thick-walled hyphae; algal layer 50–120 µm high, of unicellular green algae; individual cells up to 13 µm diam.; medulla KI– or KI+ faintly violet. Proper exciple poorly developed and not clearly separated from the apothecial cortex; cortex KI– or KI+ faintly violet. Subhymenial layers colorless, formed by long-celled, thick-walled, intricately branched, irregularly oriented hyphae. Hymenium colorless. Epithecium yellowish brown, K–, N–. Paraphyses strongly conglutinated, straight, unbranched, sometimes anastomosing, with a slightly thickened apical cell containing a yellowish brown cell wall pigment in the upper part. Ascus clavate, with a well developed, KI+ blue tholus containing a deeper amyloid tube. Spores 8 per ascus, colorless, ellipsoid to cylindrical, usually simple, sometimes becoming 1– to 3-septate when long trapped in the ascus, 9–42 x 4–9 µm. Pycnidia not seen.

Key to the species

1. Margin of apothecia usually darker than the disk; spores usually less than 16 µm long; apothecia containing usnic acid . . . . 3. *B. pruinosa*
1. Margin of apothecia paler or concolorous with the disk; spores usually more than 16 µm long; apothecia containing isousnic acid or norstictic acid . . 2
2. Apothecia containing isousnic acid; apothecial disk often distinctly pruinose; apothecial cortex lacking crystals arranged in anticlinal rows . . . . 4. *B. septentrionalis*
2. Apothecia containing norstictic acid; apothecial disk without pruina or sometimes slightly pruinose; apothecial cortex containing crystals arranged in anticlinal rows 3
3. Spores usually less than 24 µm long; growing on various mosses and on plant debris . . . . 1. *B. castanea*
3. Spores usually more than 24 µm long, growing exclusively on *Andreaea* and *Grimmia* . . . . 2. *B. curvescens*

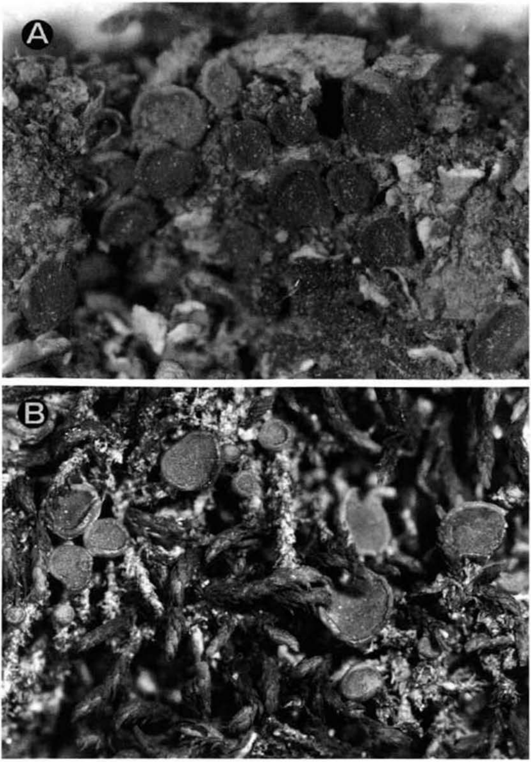

Fig. 2. A, *Bryonora castanea* (Greenland, Blåfjell, 16 Jun 1871, T.M. Fries, S), x 9. B, *B. curvescens* (J.J. Havaas, Lich. Exs. Norv. No 4, H), x 9.

1. **Bryonora castanea** (Hepp) Poelt

Illustration: Fig. 2A.

Nova Hedwigia 38: 86 (1983). – *Biatora castanea* Hepp, Flechten eur. No 270 (1857). – Type: Hepp, Flechten eur. No 270, häufig auf Polstern abgefallener Lerchen-Nadeln, auf Granitfelsen, in Gesellschaft von *L. insignis* v. *muscorum* und *Psora turfacea* α, bei St Moris. H. (WU, lectotype!).

Thallus indistinct or forming a thin, greyish white to dark brown, granular crust on the substrate. Apothecia 0.5–1.5 (–2.0) mm in diam.; disk usually epruinose, concave to flat, medium brown, with a concolorous or paler margin; cortex containing crystals arranged in anticlinal rows (polarized light !), K+ red, KI–; medulla K–, KI–. Epithecium yellowish brown, K–, N–. Spores ellipsoid to oblong ellipsoid, simple, sometimes 1-septate, (12–) 14.5–*20*–25.5 (–31) x (4.5–) 5.5–*6.5*–7.5 (–8.5) µm.

Chemistry: Norstictic acid.

Ecology: Growing on mosses and plant debris in arctic and alpine regions.

Distribution: See Fig. 4A.

Bryonora castanea is recognized by its medium sized spores, usually epruinose disk, and by containing norstictic acid.

*Selected specimens: **Austria***, Tirol, Ötztaler Alpen, Gneisboden des Kahlen abhang, ober dem Plenderlesee, Küthai in Tirol, Aug 1874 F. Arnold (M). *Bjørnøya*, Mt. Misery, 25 Jul 1868 T.M. Fries (O). *Iceland*, Central Highlands, S of Hofsjökull Glacier, ?Mulaver, H. Kristinsson 24861 (H, UPS). *Italy*, Lombardia, prov. Sondriensis, Anzi, Lich. rar. Lang. exs. No 177 (O, S, UPS). *Norway*, Finnmark, Vadsø, Wadsøe, 13 Aug 1857 T.M. Fries (O, UPS); Oppland, Lom, Jotunheimen, beim See unter den E-Abbrüchen des Berges Skauthö E ober Spiterstulen, 26 Aug 1984 J. Hafellner & A. Ochsenhofer (GZU). *Novaya Zemlya*, Strømsnes bugt i Mashigin, 8 Aug 1921 B. Lynge (O). *Romania*, Retyezat, in Transsylvania, Lojka (H). *Svalbard*, Van Mijen Bay, Blåhuken, 16 Aug 1926 B. Lynge (O). *Sweden*, Jämtland, Storlien, Skurdalshöjden, G.O. Malme, Lich. suec. exs. No 957 (C, H, O, UPS). *Switzerland*, Graubünden, Pontresina, 10 Sep 1863 J.F. Laurer (H). *U.S.S.R.*, Jenisejsk, Dudinka, M. Brenner 741b (S). *Canada*, Rocky Mountains, 30 Jun 1897 ?J.Macoun (C). *Greenland*, Godhavn, Engelskmandens Havn, Mar 1950 P. Gelting (C). *Nepal*, Khumbu Himal, Felsige Hänge nördlich Khumzung, 10 Sep 1962 J. Poelt (M).

2. **Bryonora curvescens** (Mudd) Poelt

Illustration: Fig. 2B.

Nova Hedwigia 38: 93 (1983). – *Pannaria curvescens* Mudd, Manual Brit. Lich.: 125 (1861). – Type: Scotland, Tayside, Ben Lawers, Jones (BM, holotype (not seen); H, UPS, ?isotypes!).

Thallus forming a thin, greyish to dark brown, granular crust on species of *Andreaea* and *Grimmia*. Apothecia 0.8–1.9 (–4.5) mm diam.; disk often faintly pruinose, dark brown to blackish brown, concave to flat, margin usually prominent, glossy, concolorous or paler than the disk: cortex containing crystals arranged in anticlinal rows (polarized light!), K+ red, KI–; medulla K–, KI–. Epithecium yellowish brown, K–, N–. Spores subcylindrical with obtuse to pointed ends, often curved, simple, sometimes becoming up to 4-septate when long trapped in ascus, (25–) 29–*34*–39 (–42) x (4–) 4.5–*5.5*–7 (–7.5) µm.

Chemistry: Norstictic acid.

Ecology: The species always grows on *Andreaea* and *Grimmia*, and occurs in screes and on rock walls in the arctic and alpine regions.

Distribution: See Fig. 4B.

Bryonora curvescens is recognized by its dark brown to black apothecia with a usually prominent and glossy margin, the long spores and the occurrence of norstictic acid. The species is always growing on species of *Andreaea* or *Grimmia*.

Selected specimens: *Austria*, Tirol, Ötztaler Alpen, W oberhalb des Riffelsees, 23 Aug 1961 J. Poelt & M. Steiner (M). *Finland*, Lapponia enontekiensis, Porojärvet, Ridni, A. Henssen 821 (M). *France*, Korsika, Vizzanova Monte d'Or, K. Kalb 4051 (GZU). *Norway*, Finnmark, Hammerfest, 10 Jul 1906 J.J. Havaas (BG); Hordaland, Granvin, Nesheimshorgen, J.J. Havaas, Lich. exs. norv. No 4 (C, H, O); Møre og Romsdal, Alterhøa i Romsdalen, Jul 1904 J.J. Havaas (BG); Nord-Trøndelag, Grane, Mellingsfjeld, 21 Jun 1939 S. Ahlner (S); Oppland, Lom, near Bøvertun, Holtan-Hartwig 4602 (O); Sogn og Fjordane, Tarvalseggen på Statlandet, 5 Aug 1904 J.J. Havaas (BG); Sør-Trøndelag, Oppdal, Høgsnyta, 1863 T.M. Fries (C, H, UPS); Troms, Storfjord, in jugo inter Kilpisjävri – Lyngen, 1867 J.P. Norrlin (H). *Portugal*, Beira-Alta, Serra da Estrêla, Snrª do Desterro, C. Tavares 1335 (UPS). *Scotland*, Tayside, Ben Lawers, 1860 Jones (H, UPS). *Spain*, Avila, Parameras de Avila, bei Mengamuoz, 10 Sep 1980 J. Hafellner (H, M). *Svalbard*, Kobb Bay, 1868 T.M. Fries (S). *Sweden*, Härjedalen, Funnäsdalsberget, 1867 P.J. Hellbom (H, M, UPS); Jämtland, Anjeskutan, 7 Jul 1914 A.H. Magnusson (UPS); Lule Lappmark, Nammats, 1871 P.J. Hellbom (M, UPS); Lycksele Lappmark, Tärna, Rivovardo, A.H. Magnusson 7925 (UPS); Torne Lappmark, Abisko, Njutum, 14 Jul 1919 A.H. Magnusson 3135 a (UPS). *Greenland*, Narssaq, Kangerdluarssuk east of Lilleelv, V. Alstrup 80434 (C). *Nepal*, Khumbu Himal, Felsige Hänge südlich Khumzung, 10 Sep 1962 J. Poelt (M).

3. **Bryonora pruinosa** (Th. Fr.) Holt.-Hartw., **comb. nov.**

Illustration: Fig. 3A.

Lecanora castanea var. *pruinosa* Th. Fr., Lichenes arctoi: 195 (1860). – Type: Norway, Finnmark, Varanger, Aldjok, 2 July 1857 T.M. Fries (UPS, holotype!).

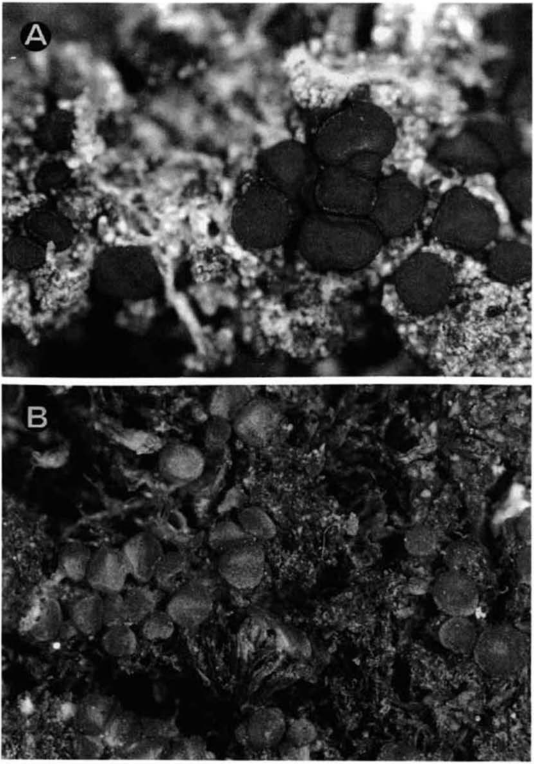

Fig. 3. A, *Bryonora pruinosa* (Norway, J. Holtan-Hartwig 4659, O), x 16. B, *B. septentrionalis* (holotype, O), x 9.

Thallus indistinct or forming a thin, whitish, granular crust on the substrate. Apothecia 0.5–2.0 (–3.0) mm in diam.; disk sometimes pruinose, more or less flat, pale yellowish brown to brown, usually with a narrow, blackish brown margin, with age sometimes slightly convex with down-turned margins; cortex lacking internal crystals (polarized light!), KI+ faintly violet; medulla KI+ faintly violet. Epithecium yellowish brown K–, N–. Spores shortly ellipsoid, simple, sometimes 1-septate, (9–) 11.5–*14.5*–17.5 (–19) x (4–) 4–*5*–5.5 (–6.5) µm.

Chemistry: Usnic acid.

Ecology: Growing on lichens and plant debris. In arctic and alpine regions, often in dry sites.

Distribution: See Fig. 4C.

Bryonora pruinosa is recognized by its delicate, peltate apothecia, the narrow apothecial margin which is often darker than the disk, the small spores, and the occurrence of usnic acid.

Selected specimens: *Austria*, Tirol, Landeck, Obladis, Schönjöchl, A.H. Magnusson 10986 (UPS). *Finland*, Lapponia enontekiensis, Enontekiö, Ounastunturi, J.P. Norrlin 718 (H); Ostrobottnia borealis, Ylitornio, Alkula, 1867 J.P. Norrlin (H). *Norway*, Buskerud, Budalsstølen, Jul 1915 B. Lynge (O); Finnmark (holotype, UPS); Hordaland, Ulvik, Finse, Foten av Kirkesdørnuten, 29 Aug 1916 B. Lynge (O); Møre og Romsdal, Gruvedalen i Sundalen, 1902 J.J. Havaas (BG); Oppland, Dombås, Fogstuen, 28 Jul 1863 T.M. Fries (H, S, UPS); Sør-Trøndelag, Røros, Skårhammerdal, A.H. Magnusson 3638 (C, S, UPS); Troms, Thomasjordaasen pr. Tromsø, J.M. Norman (O). *Sweden*, Härjedalen, Funnäsdalen, 1878 P.J. Hellbom (UPS); Lule Lappmark, Nammats, 1871 P.J. & E.V.M. Hellbom (C, O, S, UPS); Lycksele Lappmark, Tärna, Umfors, Brakotjåkko, A.H. Magnusson 8477 (S, UPS); Norrbotten, Muodoslompolo, N Parkalompolo, 20 Aug 1963 O. Lönnqvist (S); Torne Lappmark, Karesuando, in monte Puolama (Linakeo), Lång, Krypt. exs. Vindob. No 2171 (C, H, O, S). *Switzerland*, Graubünden, Rosegthal bei Pontresina, Aug 1856 J.F. Laurer (S). *Canada*, Rocky Mountains, 6 Jul 1885 J. Macoun. *Greenland*, Sdr Isortoq, Qaersutsiaup qulâ, V. Alstrup 77077 (C).

4. **Bryonora septentrionalis** Holt.-Hartw., **sp. nov.**

Illustration: Fig. 3B.

Thallus indistinctus vel tenuissimus. Apothecia 0.5–1.1 (–2.0) mm diam.; discus vulgo pruinosus; margo concolor vel pallidior. Sporae 20–33 x 5–7 µm. Apothecia acidum isousnicum continentes.

Type: Norway, Nordland, Røst, Quirini Sandøy, 4 Aug 1925, B. Lynge (O, holotype).

Thallus indistinct or forming a thin, whitish granular crust on the substrate. Apothecia 0.5–1.1 (–2.0) mm i diam., when old often crowded and irregular; disk usually pruinose, pale reddish brown to medium reddish brown; with a concolorous or paler margin; later often weakly convex and bumpy, with somewhat down-turned margin; cortex without internal crystals (polarized light!), K–, KI+ faintly violet; medulla K–, KI+ faintly violet. Epithecium yellowish brown, K–, N–. Spores ellipsoid to cylindrical, sometimes curved, simple, or sometimes up to 2-septate, (19–) 20–*26.5*–33 (–39) x (5–) 5–*6*–7 (–8.5) µm.

Chemistry: Isousnic acid.

Ecology: Growing on mosses, in arctic and alpine regions.

Distribution: See fig. 4D.

Bryonora septentrionalis is recognized by its long spores, the occurrence of isousnic acid, and by the often densely pruinose and slightly convex apothecial disks.

Selected specimens: *Finland*, Lapponia enontekiensis, Enontekis, Kilpisjärvi, 1867 J.P. Norrlin (UPS). *Norway*, Nordland, Røst, Quirini sandøy, 4 Aug 1925 B. Lynge (O); Sør-Trøndelag, Oppdal, toppen av N. Knutshø, 27 Jul 1916 B. Lynge (O). *Svalbard*, Carls Forland, 15 Aug 1868 T.M. Fries (O, S). *Sweden*, Jämtland, Åreskutan, 1868 Almquist (S); Lule Lappmark, Jokkmokk par., Kvikkjokk, 9 May 1944 P. Gelting (C); Torne Lappmark, Jukkasjärvi, Nuolja, A.H. Magnusson 5529 (UPS). *Novaya Zemlya*, Admirality Peninsula, 21 Aug 1921 B. Lynge (O). *U.S.S.R.*, Insula Tajmyr, "Portus Actiniæ", 14 Aug 1878 E. Almquist (S). *Canada*, Northwest Territories, Baffin Island, Clyde Fiord, May 1950 M.E. Hale (H, S). *Greenland*, Egedesminde, Arfersiorfik Fjord, Kuanit, P. Gelting 16399a (C).

DISCUSSION

The four species are apparently closely related, but may, with some experience, be distinguished morphologically. Although overlapping, each species have a high degree of internal continuity in spore size, and the results of spore analyses fit well with a classification into four species based on morphology.

The KI reaction in the cortex and medulla of *B. pruinosa* and *B. septentrionalis* may sometimes be very faint and is not a good diagnostic character.

All four species occur above or north of the timberline, and have quite similar distribution areas. *Bryonora septentrionalis* has the most northern distribution area, apparently lacking in the Alps and in the southern parts of Greenland. *Bryonora pruinosa* is apparently lacking in Svalbard, and occurs at somewhat lower altitudes than the other three species. I have seen rather few collections of *Bryonora* from the Alps, however, and can not definitely state that *B. septentrionalis* is missing there.

The four species grow on plant debris or dying mosses and lichens. *Bryonora curvescens* is always growing on *Andreaea* and *Grimmia*, whereas *B. pruinosa* often is growing on dying lichens. The other two are apparently less specific in choice of substrate.

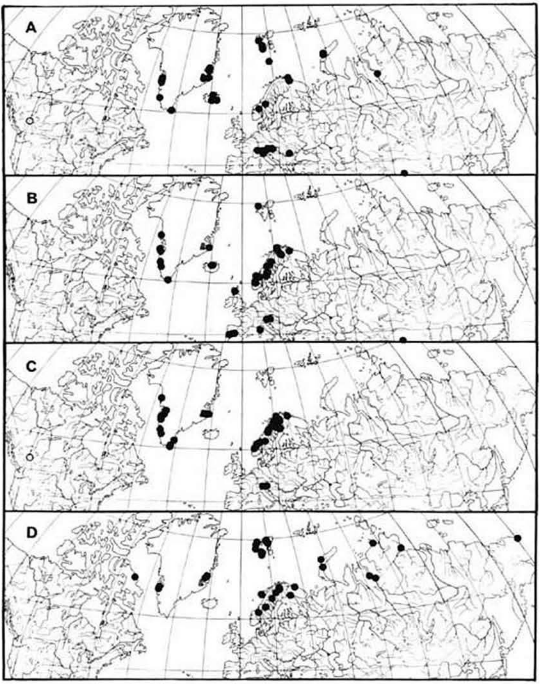

Fig. 4. Distribution of *Bryonora castanea* (A), *B. curvescens* (B), *B. pruinosa* (C), and *B. septentrionalis* (D), based on material examined. Open circles indicate records lacking accurate locality data.

ACKNOWLEDGEMENTS

I am grateful to Prof. R. Santesson, Uppsala and Mr E. Timdal, Oslo for comments on the manuscript. Thanks are also due to the curators of BG, C, GZU, H, M, O, S, TRH, TROM, UPS, and WU for loan of material.

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MYCOTAXON

Volume XL, pp. 307-318 January-March 1991

A PRELIMINARY DISCOMYCETE FLORA OF MACARONESIA: PART 12, PYRONEMATINEAE, AND PEZIZINEAE, ASCOBOLACEAE[1]

RICHARD P. KORF[2]
and
WEN-YING ZHUANG[3]

Plant Pathology Herbarium, Cornell University, Ithaca, New York 14853, USA

> "A professor can never better distinguish himself in his work than by encouraging a clever pupil, for the true discoverers are among them, as comets amongst the stars."
> Carl Linnaeus
> quoted by Benjamin Daydon Jackson, Chapt. 9, LINNAEUS

Order PEZIZALES
Suborder PYRONEMATINEAE
Family PYRONEMATACEAE Corda 1842 (ut 'Pyronemeae') emend. Kimbrough 1989

KEY TO THE KNOWN MACARONESIAN GENERA

1 Coprophilous; ascospores with de Bary bubbles .... **Coprotus**
1´ Pyrophilous; ascospores without de Bary bubbles .... **Pyronema**

COPROTUS Korf & Kimbr. *in* Kimbr. & Korf 1967

= ? *Leporina* Velen. 1947.

Notes: The possibility exists that *Leporina multispora* Velen., the monotype of the generic name *Leporina*, may be based on a mixture of *Coprotus sexdecimsporus* (Cr. & Cr.) Kimbr. *in* Kimbr. & Korf and some member of the Ascobolaceae, but if so the generic name

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[1] The parts of this flora will appear in irregular order. Reprints of individual parts will not be available for distribution.

[2] Professor of Mycology

[3] Anna E. Jenkins Postdoctoral Associate

Leporina should be typified by the Ascobolaceous element so that this name does not imperil *Coprotus;* the other alternative is to propose *Coprotus* for conservation..

Key to the known Macaronesian species

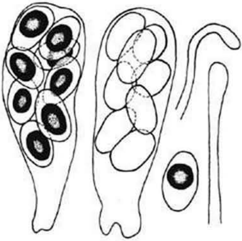
1	Asci 16–spored	2
1′	Asci 8–spored	3
2(1)	Spores 8.0–8.4 x 4.0–4.4 µm	**3. C. duplus**
2′(1)	Spores 8.8–11.0 x 6.2–8.0 µm	**7. C. sexdecimsporus**
3(1′)	Spores shorter than 10 µm	4
3′(1′)	Spores longer than 10 µm	5
4(3)	Spores 6.6-8.0 x 2.9–3.7 µm	**4. C.** cfr. **glaucellus**
4′(3)	Spores 8.0–9.5 x 5.1–7.3 µm	**6. C. luteus**
5(3′)	Asci ± cylindrical, spores mostly uniseriate	**2. C. disculus**
5′(3′)	Asci clavate to broadly clavate, ascospores biseriate	6
6(5′)	Paraphyses curved to uncinate	**1. C. breviascus**
6′(5′)	Paraphyses clavate enlarged	**5. C. granuliformis**

1. **Coprotus breviascus** (Velen.) Kimbr., Luck-Allen, & Cain, Canad. J. Bot. **50:** 961. 1972.

RECENT TAXONOMIC TREATMENT:
Kimbrough et al. (1972).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Mnichovice, Czechoslovakia.



C. breviascus, ascus with spores showing de Bary bubbles, curved paraphysis apex, CUP-MM 2005; ascus with spores, one spore with de Bary bubble, clavate paraphysis apex, CUP-MM 2134; all x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Flores. CUP-MM 2134 (TFC, OSC).
Terceira. CUP-MM 2005.
MADEIRA.
Madeira. CUP-MM 2584 (UPS)
CANARY ISLANDS.
Tenerife. CUP-MM 2585 (UPS), 2588 (UPS), 2772 (UPS).

SUBSTRATA:
On cow dung, goat dung, sheep dung.

2. **Coprotus disculus** Kimbr., Luck-Allen, & Cain, Canad. J. Bot. 50: 962. 1972.

RECENT TAXONOMIC TREATMENT:
Kimbrough at al. (1972).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Bergen Swamp, near Rochester, NY, USA.

C. disculus, paraphysis apex, spores, CUP-MM 2065, x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Terceira. CUP-MM 2065 (TFC, OSC).

SUBSTRATUM:
On cow dung.

3. **Coprotus duplus** Kimbr., Luck-Allen, & Cain, Canad. J. Bot. 50: 963. 1972.

RECENT TAXONOMIC TREATMENT:
Kimbrough et al. (1972).

PREVIOUS MACARONESIAN RECORDS:
None.

C. duplus, spores, CUP-MM 2594, x1000.

TYPE LOCALITY:
Dorset, Ontario, Canada.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2594 (UPS).

SUBSTRATUM:
On goat dung.

Notes: The 16-spored asci with much narrower and somewhat shorter ascospores than in *C. sexdecimsporus* are diagnostic.

4. **Coprotus** cfr. **glaucellus** (Rehm) Kimbr. *in* Kimbr. & Korf, Amer. J. Bot. **54:** 22. 1967.

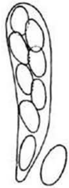
RECENT TAXONOMIC TREATMENT:
Kimbrough et al. (1972).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Bavarian Alps.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM 1411*b*.



C. cfr. **glaucellus,** ascus, spore, CUP-MM 1411*b*, x1000.

SUBSTRATUM:
On dung.

Notes: The specimen is poor, and the spores seem rather small for this species. No operculum was seen. This could possibly be an 8-spored *Thelebolus*.

5. **Coprotus granuliformis** (Cr. & Cr.) Kimbr. *in* Kimbr. & Korf, Amer. J. Bot. **54:** 22. 1967.

RECENT TAXONOMIC TREATMENTS:
Kimbrough et al. (1972), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Finistère, France.

C. granuliformis, spores, paraphysis apex, CUP-MM 2004, x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Terceira. CUP-MM 2004 (TFC).

SUBSTRATUM:
On cow dung.

6. **Coprotus luteus** Kimbr., Luck-Allen, & Cain, Canad. J. Bot. **50:** 966. 1972.

RECENT TAXONOMIC TREATMENT:
Kimbrough et al. (1972).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Canandaigua, NY, USA.

C. luteus, spores, CUP-MM 1123, x1000.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 1123 (O).

SUBSTRATUM:
On dung.

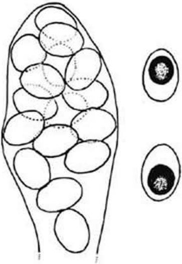
7. **Coprotus sexdecimsporus** (Cr. & Cr.) Kimbr. *in* Kimbr. & Korf, Amer. J. Bot. **50:** 22. 1967.

RECENT TAXONOMIC TREATMENTS:
Kimbrough et al. (1972), Dennis (1978).

PREVIOUS MACARONESIAN RECORD:
†Dennis et al. (1977).

TYPE LOCALITY:
Finistère, France.

KNOWN MACARONESIAN DISTRIBUTION
AZORES.
Terceira. †
CANARY ISLANDS.
Tenerife. CUP-MM 2582 (UPS), 2587 (UPS).



C. sexdecimsporus, apical portion of ascus, 2 ascospores with de Bary bubbles, CUP-MM 2582, x1000.

SUBSTRATA:
On ass dung, cow dung, goat dung.

PYRONEMA Carus 1835

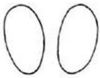
One known Macaronesian species

1. **Pyronema omphalodes** (Bull. : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 319. 1870.

RECENT TAXONOMIC TREATMENT:
Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY
France.



P. omphalodes, ascospores, CUP-MM 2389, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2389 (TFC).
CANARY ISLANDS.
La Palma. CUP-MM 853 (TFC, OSC).

SUBSTRATA:
On a burn site, on recently burned wood and soil in a fireplace.

Family ASCOBOLACEAE Boudier *ex* Saccardo 1884
(ut 'Ascoboleae')

KEY TO THE KNOWN MACARONESIAN GENERA

1 Spores hyaline at maturity .... **Thecotheus**
1′ Spores purple-brown at maturity 2
  2(1′) Spores firmly united as a group and discharged as a single projectile .... **Saccobolus**
  2′(1′) Spores free from one another, discharged individually. **Ascobolus**

ASCOBOLUS Persoon *in* Gmelin : Fr. 1792

Key to the known Macaronesian species

1 Pyrophilous; ascospores with isolated warts .... **1. A. carbonarius**
1′ Coprophilous; spores with longitudinal lines or a network of lines ... 2

2(1´) Spores 43-56 x 30-37 µm, spore surface with a network of lines . . . . **3. A. immersus**
2´(1´) Spores much smaller, spore surface with longitudinal lines 3
3(2´) Spores 24.9–29.4 x 11.0–14.6 µm . . . . **2. A. furfuraceus**
3´(2´) Spores 15.4–19.0 x 8.8–9.5 µm . . . . **4. A. lignatilis**

1. **Ascobolus carbonarius** Karst., Fungi fenn. exs. #463. 1866.

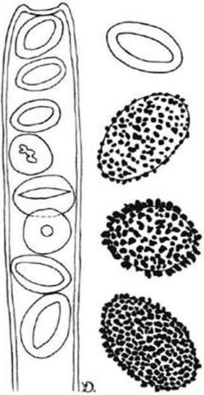
RECENT TAXONOMIC TREATMENTS:
Brummelen (1967), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
†Bañares et al. (1968), ††Bañares (1988), †††Dennis (1990).

TYPE LOCALITY:
Mustiala, Finland.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS. †††
Gran Canaria. † ††
La Palma. CUP-MM 913 (TFC, OSC).

SUBSTRATUM:
Firesites.



A. carbonarius, young ascus with immature spores, one young and 3 mature spores, CUP-MM 913, x1000.

2. **Ascobolus furfuraceus** Pers. : Fr., Neues Mag. Bot. 1: 115. 1794.

RECENT TAXONOMIC TREATMENTS:
Olive (1954), Brummelen (1967), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Germany.

A. furfuraceus, spore, CUP-MM 2001, x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

Flores. CUP-MM 2108 (TFC, OSC), 2135 (TFC, OSC), 2159.
Terceira. CUP-MM 2001 (TFC), 2063.

CANARY ISLANDS.

Tenerife. CUP-MM 2568 (UPS).

SUBSTRATUM:
On cow dung.

Notes: We follow Olive (1954) in distinguishing this from *A. stercorarius* (Bull.) Schroet., though van Brummelen (1967) synonymized them.

3. Ascobolus immersus Pers. : Fr., Neues Mag. Bot. **1:** 115. 1794.

RECENT TAXONOMIC TREATMENTS:
Brummelen (1967), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

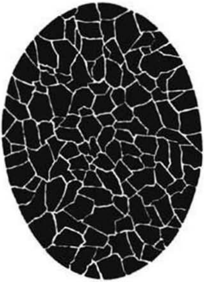
TYPE LOCALITY:
Germany.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Tenerife. CUP-MM 2561 (UPS), 2562 (UPS), 2569 (UPS).

SUBSTRATA:
On cow dung, sheep dung.



A. immersus, ascospore, CUP-MM 2561, x1000.

4. Ascobolus lignatilis Alb. & Schw. : Fr., Consp. fung. lusat., p. 347. 1805.

RECENT TAXONOMIC TREATMENT:
Brummelen (1967).

PREVIOUS MACARONESIAN RECORDS:
None.

A. lignatilis, spore, CUP-MM 2558, x1000.

TYPE LOCALITY:
Poland.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2558 (UPS).

SUBSTRATUM:
On goat dung.

SACCOBOLUS Boudier 1869

Key to the known Macaronesian species

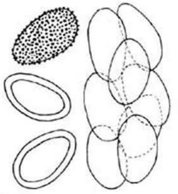
1 Spores with angular warts ca 0.8–1.1 µm in diam ..... **2. S. obscurus**
1´ Spores punctate or more delicately marked with tiny warts 2
  2(1´) Spore surface punctate, spores arranged in four rows of two spores .... **3. S. truncatus**
  2´(1´) Spore surface finely warted, spores initially arranged in two rows of three spores and one row of two spores 3
3(2´) Spores 11.0–15.4 x 5.1–8.5 µm, surface granulate . . . **1. S. depauperatus**
3´(2´) Spores 14.0-16.8 x 7.3–8.5 µm, surface with interconnecting warts. **4. S. versicolor**

1. **Saccobolus depauperatus** (Berk. & Br.) Hansen, Vidensk. Meddel. Dansk Naturhist. Foren. Kjøbenhavn **1876:** 293. 1877.

RECENT TAXONOMIC TREATMENTS:
Brummelen (1967), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

LECTOTYPE LOCALITY:
Hanham, Great Britain.



S. depauperatus, mature and 2 young spores, spore arrangement, CUP-MM 1120, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2567, 2591 (UPS).
CANARY ISLANDS.
Tenerife. CUP-MM 1120 (O), 2560 (UPS), 2564 (UPS), 2570 (UPS), 2571 (UPS), 2574 (UPS), 2576 (UPS), 2590 (UPS), 2593 (UPS).

SUBSTRATA:
On dung of rabbit, donkey, goat, and sheep.

2. **Saccobolus obscurus** (Cooke) Phill., Man. Brit. Discomyc. p. 295. 1887.

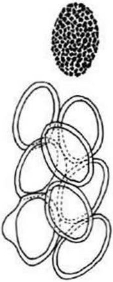
RECENT TAXONOMIC TREATMENTS:
Brummelen (1967), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Ferden, England.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2592 (UPS).

SUBSTRATUM:
On rabbit dung.



S. obscurus, mature spore, spore arrangement, CUP-MM 2592, x1000.

3. **Saccobolus truncatus** Velen., Monogr. Discomyc. Bohem. **1:** 370. 1934.

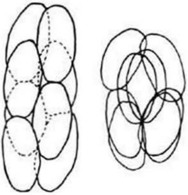
RECENT TAXONOMIC TREATMENT:
Brummelen (1967).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Mnichovice, Czechoslovakia.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2565 (UPS), 2578 (UPS), 2579 (UPS).

SUBSTRATA:
On goat, sheep, and cow dung.



S. truncatus, arrangements of spores, CUP-MM 2565, x1000.

4. **Saccobolus versicolor** (Karst.) Karst., Acta Soc. Fauna Fl. Fenn. 2(6): 123. 1885.

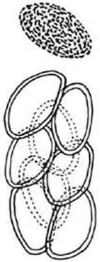
RECENT TAXONOMIC TREATMENT:
Brummelen (1967).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Mustiala, Finland.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2583 (UPS), 2586 (UPS).

SUBSTRATA:
On rabbit dung, on cow dung.



S. versicolor, mature spore, spore arrangement, CUP-MM 2583, x1000.

THECOTHEUS Boudier 1869

Key to the known Macaronesian species

1 Asci 8-spored, ascospores minutely warted, with apiculi. **1. T. holmskjoldii**

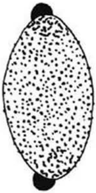
1′ Asci 32-spored, ascospores smooth .... **2. T. pelletieri**

1. **Thecotheus holmskjoldii** (Hansen) Eckblad, Nytt Mag. Bot. **15**: 25. 1968.

RECENT TAXONOMIC TREATMENTS:
Eckblad (1968), Dennis (1978).

PREVIOUS MACARONESIAN RECORDS:
None.

SYNTYPE LOCALITIES:
Nestved and Copenhagen, Denmark.



T. holmskjoldii, spore, CUP-MM 2770, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM 2566 (UPS), 2770 (UPS).

SUBSTRATUM:

On goat dung.

Notes: Kimbrough (1969) synonymized this with *T. cinereus* (Cr. & Cr.) Chenantais, but most authors keep these separate, as do we.

2. Thecotheus pelletieri (Cr. & Cr.) Boudier, Ann. Sci. Nat., Bot., sér. 5, **10:** 236. 1869.

RECENT TAXONOMIC TREATMENTS:

Kimbrough (1969), Dennis (1978).

PREVIOUS MACARONESIAN RECORD:

†Dennis et al. (1977).

TYPE LOCALITY:

Brest, Finistère, France.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

Terceira. †

SUBSTRATUM:

On ass dung.

Notes: We were unable to examine Dennis's collection from the Azores, but have no reason to doubt his identification.

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WHAT ARE NAMES IN CURRENT USE?

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At the International Botanical Congress in Berlin 1988 the possibilities of indexing recognized "names in current use", with the possibility of granting them a protected or sanctioned status, were vividly discussed (Greuter *et al.*, 1989). The laudable intention of stabilizing nomenclature was only confronted with a widespread aversion against any kind of censorship that might be exerted, dictating what names should be used.

Those who advocate sanctioning of names in current use (Hawksworth & Greuter, 1989; Hawksworth, 1990a) claim that the only purpose of the action is to get rid of the danger of old and forgotten names being dug up; the principle of priority of both generic and specific names would not be violated, except for cases of old and long forgotten names.

Some recent developments, nevertheless, serve as a warning. The best examples can be taken from some well-studied genera, such as *Fusarium* and *Penicillium*.

For *Fusarium*, Nelson *et al.* (1983) tried to introduce a rule, that 1935, the year of Wollenweber & Reinking's most influential monograph, should become a starting point for *Fusarium* nomenclature. This suggestion has not been followed by other *Fusarium* experts, and several new combinations with old, but well typified names, have been introduced since (Nirenberg, 1990).

In *Penicillium* most epithets date from this century and cannot be considered long forgotten. In some recent studies contradictory conclusions have been drawn: Pitt (1979), Seifert & Samson (1985), Frisvad *et al.* (1990) have done their best to establish priority among the names used in this genus, basing them on type material wherever possible. On the other hand, Bridge *et al.* (1989), anticipating a forthcoming rule of sanctioning, preferred the names used by Raper & Thom (1949), such as *P. claviforme* for *P. vulpinum*, *P. granulatum* for *P. glandicola*. For the older names of these species either herbarium specimens or living cultures are available which document their identity beyond doubt. There is no reason to reject the older names as being of doubtful application. Moreover, they have already been taken up by a majority of the experts in the genus (Samson & Pitt, 1990).

In other groups of fungi, knowledge is far less advanced and a selection of "names in current use" would be bound to be much more arbitrary by drawing a temporal line somewhere. It is thus inevitable that any specialist who happens to prepare the list will impose his views about what is in current use to the mycological community.

The proposal that, pending a new ruling on nomenclatorial stability, no name changes should be enacted (Hawksworth, 1990b), would prevent taxonomic progress which is expressed in the use of the appropriate names. It can and must not be applied before the relevant changes have been incorporated in ICBN.

Once "names in current use" are granted a protected status, the question arises: what is the status of old names not covered by the index? Do they still compete in nomenclature when comparable organisms are found or are new names admissible? If the former choice is adopted, and this is obviously the only meaningful alternative, a protection of names in current use will hardly relieve mycologists from the tedious duty of carefully scrutinizing the literature and a thorough nomenclatorial analysis. The other alternative would be to index all newly coined names and automatically grant them a protected status. This can hardly be the intention of sound taxonomy.

Conclusion

Indexing of available names is a good thing. It is possible and feasible by means of computers. Any published authoritative lists, particularly in association with thorough revisions, will be widely used; they will strongly contribute to the stabilization of names in any case.

The additional protection of names in current use will be acceptable to many taxonomists only if a very wide array of typified names is included in the indexes so that a choice on taxonomic grounds can be made at any time. A rejection of old names only makes sense when confined to poorly described species ostensibly lacking holotype or other authentic material.

Thus the suspicion of imposing a censorship can be alleviated only if as many typified names as possible are included in the index, with the deliberate exclusion of names of uncertain application. But the explicit incorporation of these names in a computerized data base with appropriate indications of their status would greatly increase the value of the project.

Alternatively, it seems that the goal of nomenclatural stability is better served by a mechanism in ICBN that prevents neotypification of taxa in those cases where name changes would ensue.

Acknowledgement: Drs. R. P. Korf and Th. W. Kuyper kindly suggested improvements of the text.

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THE CLASSIFICATION AND PHYTOPATHOLOGY OF *CYLINDROCLADIUM* SPECIES

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ABSTRACT

A review of the genus *Cylindrocladium* Morgan (syn. *Candelospora* Hawley, *Tetracytum* Vanderwalle, *Acontiopsis* Negru, *Cylindrocladiella* Boesewinkel) is made, exactly forty years after Boedijn & Reitsma (1950) published their notes on the genus, which then consisted of seven species. A key for the identification of 26 species of *Cylindrocladium*, now accepted, is presented, and it emphasizes conidial and vesicle morphology as important criteria in their delimitation. Vesicle morphology, claimed by some workers as unreliable in *Cylindrocladium* taxonomy, is stable and reliable when fresh cultures are studied. Mycological studies with old cultures of *Cylindrocladium* could lead to wrong and misleading conclusions especially as regards vesicle morphology and its value as a taxonomic criterion. Ten species of *Calonectria* possessing a *Cylindrocladium* anamorph are recognized. Phytopathological notes are given for *C. scoparium*, *C. theae*, *C. crotalariae*, *C. floridanum*, *C. quinqueseptatum*, *C. pteridis*, *C. clavatum*, *C. camelliae*, *C. brasiliense*, *C. colhounii* and *C. spathiphylli*.

INTRODUCTION

Exactly forty years ago, Boedijn & Reitsma (1950) in their review of the genus *Cylindrocladium* Morgan, recognized seven species: *C. scoparium* Morgan, *C. parvum* Anderson, *C. citri* (Fawcett & Klotz) Boedijn & Reitsma, *C. ilicicola* (Hawley) Boedijn & Reitsma, *C. macrosporum* Sherb., *C. curvatum* Boedijn & Reitsma and *C. quinqueseptatum* Boedijn & Reitsma. Subsequently, Peerally (1974a-j) described ten pathogenic species. The genus now has a significant literature and some thirty-six species have been cited in this literature, some of which have been incompletely described while some others are mere synonyms. *Cylindrocladium* diseases have been reported world-wide on a variety of economic plants. Many of them grow optimally under very humid conditions, and disease progress on aerial parts is checked once humid conditions cease. All *Cylindrocladium* species, with the exception of *C. penicilloides*, have been shown to possess one or more sterile appendages on the conidiophores. In the case of *C. penicilloides*, Tubaki (1958) has clearly pointed out the absence of a sterile appendage. The teleomorphs have been described for ten species and they all belong to *Calonectria*. *Cylindrocladium* was erected by Morgan (1892) for a white mould or "Mucedineae" as the only genus in Saccardo's Didymosporeae possessing cylindric spores. The original description was as follows:

Cylindrocladium Morgan. Sterile hyphae creeping, branched; fertile hyphae erect, forked of trichotomously branched, the sporophores in pairs or threes at the extremities of the branchlets and cymosely arranged; spores solitary, cylindric, 1-septate, hyaline.

The type species, *C. scoparium*, found growing on an old pod of *Gleditsia triacanthos*, was noted to possess septate conidia 40-50 µm in length and about 4 µm wide. In the original description Morgan (1892) did not refer to the presence of a sterile appendage but examination of the type material by E.K. Sobers (personal communication) and the author has clearly revealed the occurrence of sterile appendages ending in an oval to ellipsoid vesicle. Various authors have, since Morgan's original publication, described fungi under various generic names when they should in fact have been attributed to *Cylindrocladium*.

Diplocladium cylindrosporum Ellis & Everh. was noted by its authors (Ellis & Everhart, 1900) to have dichotomously branched conidiophores bearing at the tips cylindrical, hyaline, obtuse, 1-septate conidia, 40-50 x 4-5 µm with a sterile appendage swollen at the tip. The fungus - obviously a *Cylindrocladium* species - was found to be similar to *C. scoparium* by Boedijn & Reitsma (1950).

Hawley (in Rea & Hawley, 1912) introduced the new genus *Candelospora* for a fungus from the leaves of *Ilicis aquifolium* characterized by penicillate branching and conidia produced singly at the tips of branchlets. The name recalled the observation that when free from mucus the conidia stood "side by side like some candles". The occurrence of appendage and vesicle was not referred to by Hawley but Boedijn & Reitsma (1950), who examined Hawley's type material, found it to be a *Cylindrocladium*, and made the combination *C. ilicicola* (Hawley) Boedijn & Reitsma.

A new generic name *Tetracytum* was introduced by Vanderwalle (1945) for a leaf pathogen of *Laurus nobilis*. He recognized the similarity of his *Tetracytum* with Morgan's *Cylindrocladium*, but justified the introduction of a new genus by the 3-septate conidia of the type species *T. lauri*. Like Morgan, Vanderwalle made no reference to the occurrence of a sterile appendage and vesicle.

Negru (1961) employed the new generic name *Acontiopsis* for what is again clearly a *Cylindrocladium*. Negru placed particular emphasis on the occurrence of a vertical sterile appendage bearing a swelling at the top, "like a hammer". The type material of the new genus, *A. crataegi* Negru, isolated from fruits and leaves of *Crataegus monogyna*, was described as possessing hyaline, non-septate conidia, 14-18 x 2-3 µm.

More recently Boesewinkel (1982) argued for the separation of the small-conidial *Cylindrocladium* species into a new genus *Cylindrocladiella*. Since there is a very wide range of conidial morphology in *Cylindrocladium* (Fig. 8), the fragmentation of the genus into separate genera on the basis of conidial size is clearly not warranted in view of the similarity in all other characters, and therefore the genus *Cylindrocladiella* is reduced to synonymy with *Cylindrocladium*.

Significant new information on *Cylindrocladium* species (Bell & Sobers, 1966; Sobers & Seymour, 1967; Morrison & French, 1969; Peerally, 1974a-j) has led to a better understanding of the genus as a whole and it is therefore opportune to redescribe it.

CYLINDROCLADIUM Morgan, Bot. Gaz. 17: 191, 1892.

= *Candelospora* Hawley, in Rea & Hawley, Proc. R. Irish Acad. 31: 11, 1912.
= *Tetracytum* Vanderwalle, Parasitica 5: 5, 1945.
= *Acontiopsis* Negru, Communicarile Aca. Repub. Pop. Rom. 7: 839, 1961.
= *Cylindrocladiella* Boesewinkel, Can. J. Bot. 60: 2288, 1982.

Type Species: *C. scoparium* Morgan (holotype)

Conidiophores (Fig. 1-4) dichotomously or trichotomously branched, the main stipe arising from aerial or procumbent mycelium or from masses of pseudoparenchymatous cells. Primary conidiophore branches arising laterally from the stipe, sometimes giving rise to secondary, tertiary or quaternary branches usually aseptate or occasionally septate. Conidiogenous cells, arising on the ultimate conidiophore branches, enteroblastic, cylindrical, hyaline, non-septate. Small-conidial species sometimes producing subverticillate conidiophores (Fig. 2) with slender phialides much longer than those on the usual conidiophores.

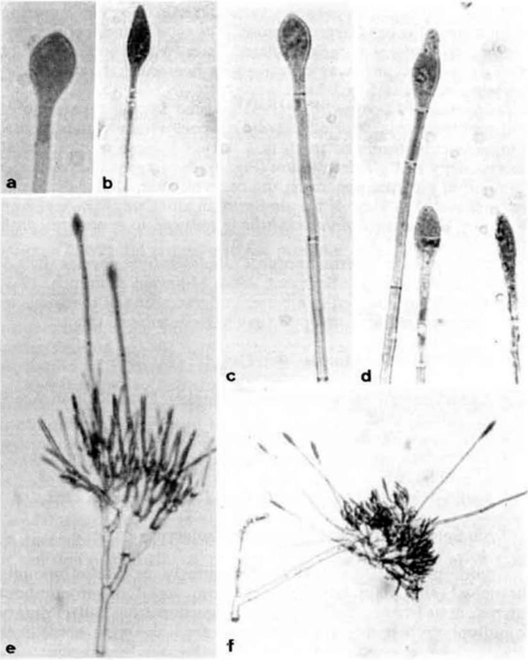
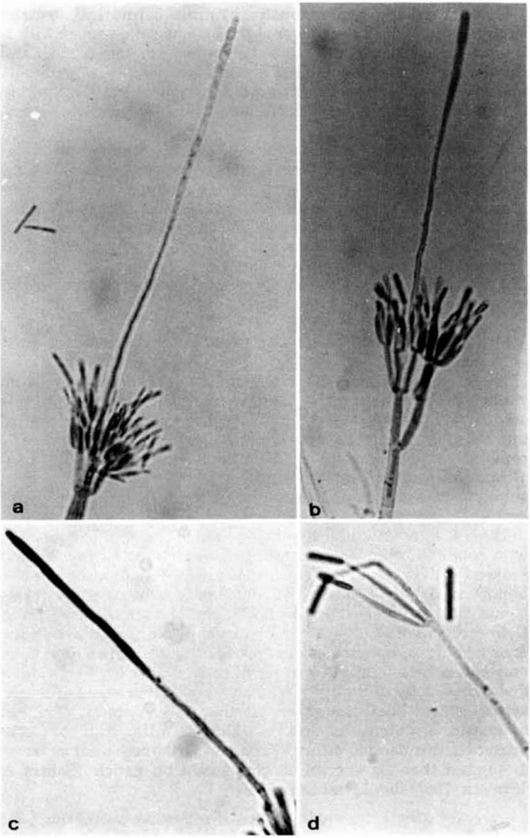


Fig. 1. *Cylindrocladium scoparium*, a-d: vesicles; e-f: conidiophores

Fig. 2. *Cylindrocladium infestans*, a-c: conidiopho res with sterile appendage; d: subverticillate conidiophore. (see next page)


a
b
c
d

Conidia arising acrogenously, hyaline, cylindrical, usually straight, often slightly narrower at the base, usually septate with 1-7 septa, or rarely aseptate. In some species aseptate conidia and conidia with a varying number of septa occuring together with a majority of the conidia with septation typical for the species. Dumb-bell or club-shaped conidia occasionally present in some species (Fig. 7).

A slender vertical sterile appendage as a prolongation of the main stipe and bearing, towards the apex, a swollen vesicle, characteristically shaped for each species produced by all but one species; vesicle shape varying within a narrow range of related shapes or occasionally "abnormal" in some species. Lateral sterile appendages present in some species (e.g. *C. scoparium* and *C. floridanum*), arising from the conidiophore branches (Fig. 1). Chlamydospores present in all species. Microsclerotia reported for most species (Fig. 5).

MORPHOLOGY OF VECICLES AND CONIDIA

These are illustrated diagramatically in Fig. 6 & 7, based on studies of fresh cultures or of type material. According to this scheme vesicle shape and conidial morphology have been classified into various groups. Each *Cylindrocladium* species has a specific combination of vesicle and conidial morphology shown in Fig. 6 & 7 although, for the small conidial fungi, the occurrence of subverticillate conidiophores may constitute a further criterion for species delineation.

There is now no doubt that vesicle shape, taken in conjunction with conidial morphology, constitutes an important consideration for species delineation in *Cylindrocladium*. Failure to recognize this important fact has caused some confusion in the taxonomy of this genus. Thus Hunter & Barnett (1978) studied some 16 species of *Cylindrocladium* comprising 58 isolates in culture to determine their trophic, morphological and sporulation responses to various nutrients and to light. As a result of their studies they concluded that morphology of the apical vesicle was variable even within the same isolate. They therefore felt that this characteristic was untenable for delineating species which according to them was a matter of considerable difficulty. Hunter & Barnett went as far as to suggest that the species concept based on vesicle (Sobers & Seymour, 1967) should be discarded.

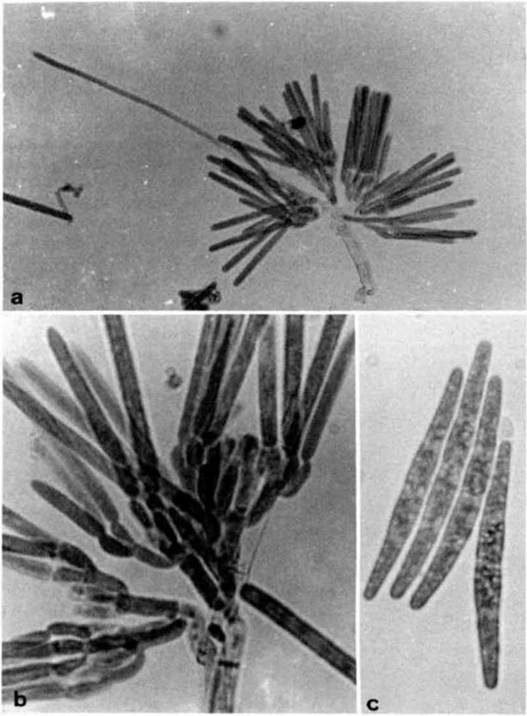
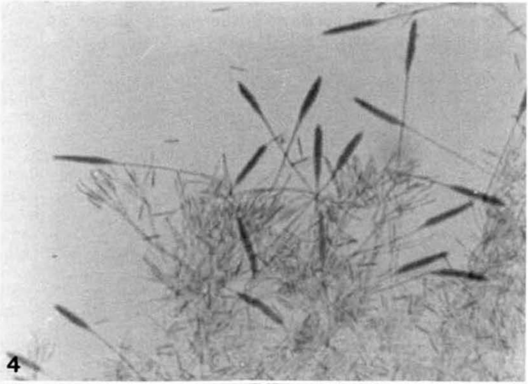


Fig. 3. *Calonectria colhounii*, a-b: conidiophores; c: ascospores.



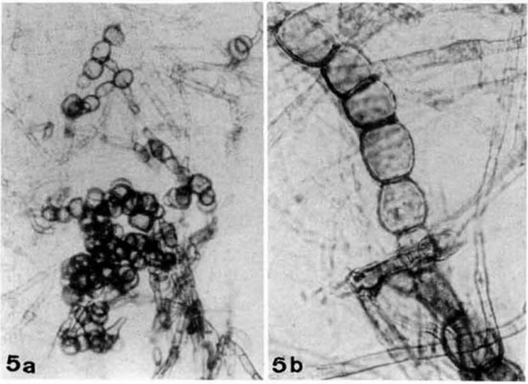


Fig. 4. *Cylindrocladium camelliae*, conidiophores with vesicles.
Fig. 5. *Cylindrocladium floridanum*, a: microsclerotia; b: chlamydospores.

As a result of my examination of over a hundred cultures of *Cylindrocladium* from various sources [E.K. Sobers (USA), W. Gerlach (Germany), T. Terashita (Japan), M.B. Figueiredo (Brazil), CAB International Mycological Institute (IMI, U.K.), Centraalbureau voor Schimmelcultures (CBS, The Netherlands), American Type Culture Collection (ATCC, USA)] as well as a large number of my own isolates, I have concluded that old cultures of *Cylindrocladium* often produce abnormal conidia and vesicles and should not be utilized in systematic and physiological studies, unless they have been, if possible, rejunevated. During my studies on *Cylindrocladium*, most species have been compared *in vitro* and *in vivo*; and it is only when the morphological characteristics agree under these two cultural conditions that a culture is considered acceptable. All freshly obtained isolates from infected plant tissues produce good cultures while most old isolates, repeatedly subcultured, obtained from culture collections rarely do.

Dr. T. Terashita from the Government Forest Station, Kyoto, Japan, who sent me cultures of *C. penicilloides*, *C. hederae* and *C. scoparium* in 1971 remarked that these "have changed" and looked "very different from initial isolation by long successive subcultures". I believe that several of the isolates used by Hunter & Barnett (1978) were of this nature, so explaining their views on vesicle morphology.

Boedijn & Reitsma (1950), in their useful review of the genus, devised a simple key for the delineation of *Cylindrocladium* species based entirely on conidial morphology, but it is apparent that they were rather confused with respect to vesicle shape. Thus they described *C. scoparium* and *C. ilicicola* to have club-shaped and globose vesicles respectively. However, in the same figure, they illustrated *C. ilicicola* as having a globose vesicle and yet in another drawing grouped *C. ilicicola* and *C. scoparium*, together as possessing a club-shaped vesicle. Following the publication of Boedijn & Reitsma, *C. ilicicola* has been consistently described as having globose vesicles (Bell & Sobers, 1966; Sobers & Seymour, 1967). Critical examination of part of the holotype material (IMI 76542) of *C. ilicicola* (Peerally, 1974e) revealed that species in fact to possess typically clavate to club-shaped and umbonate vesicle 5-11 µm wide.

The vesicle has been the subject of significant misunderstanding and misinterpretation ever since Morgan (1892) neglected to include this in his drawing and description, a character which, strangely enough, stands out conspicuously in most

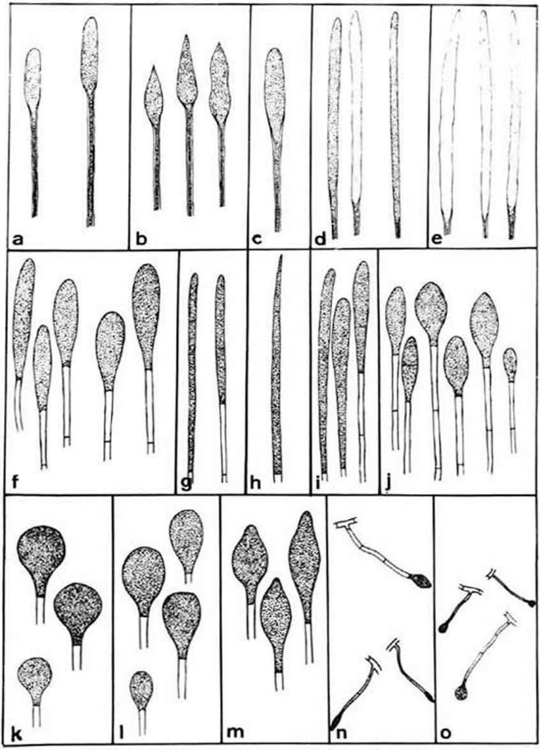


Fig. 6: Vesicle morphology in *Cylindrocladium*, a-e: small-conidial species, a: club-shaped, b: hastate to lanceolate, c: clavate, d: narrowly clavate, e: clavate to lanceolate, f: clavate to club-shaped, g: narrowly clavate, h: avesiculate, i: clavate, j: oval to ellipsoidal, k: globose, l: subglobose, m: umbonate, n: lateral appendage (*C. scoparium*), o: lateral appendage (*C. floridanum*).

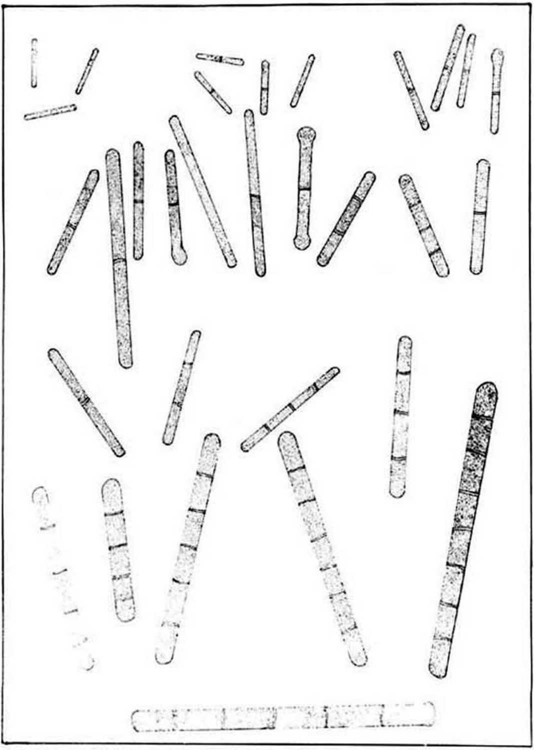


Fig. 7: Conidial morphology in *Cylindrocladium*.

Cylindrocladium cultures. The importance of vesicle morphology in delineating *Cylindrocladium* species has been correctly emphasized by Bell & Sobers (1966), Sobers & Seymour (1967), Morrison & French (1969) and Peerally (1974a-j). However the delineation of *Cylindrocladium* species should be based, as far as possible, on both conidial and vesicle morphology.

TAXONMIC AND NOMENCLATURAL NOTES

In the genus *Cylindrocladium* some 36 species have been proposed. Of these, six are not valid, while five others, in fact, represent new records, rather than new species. In this publication 25 species are recognized.

C. curvatum Boedijn & Reitsma (Boedijn & Reitsma, 1950) seems to be a good *Cylindrocladium* species, although Boedijn & Reitsma could not maintain their isolate neither collect the species again, nor we could do. The species description is accompagnied by an illustration, showing the exact shape of the vesicle, that can be considered as iconotype, upto the time it is collected again and neotypified. *C. curvatum* is close to *C. floridanum* of which it differs by its narrower vesicles (5-7 µm) and curved conidia.

In addition to not conforming to nomenclatural rules for the validation of names,*C. lanceolatum* Peerally (Peerally, 1972b) and *C. hastatum* Sob. & Alf. (Sobers & Alfieri, 1972) are synonyms of *C. camelliae* Venkataram. and Venkata Ram (Venkataramani & Venkata Ram, 1961). All three of them were reported as pathogens of *Camellia sinensis*. *C. peruvianum* Bat., Bez. & Herrera (Batista *et al.*, 1965) is also synonymous with *C. camelliae*, a conclusion reached after I examined the original ex-type of *C. peruvianum* (IMI 170223). These two species are similar in cultural appearance, and in the morphology of conidia, vesicle and chlamydospores.

On the basis of their conidiophore type *C. courartariae* Ram & Ram (Ram & Ram, 1972), *C. simplex* Meyer and *C. simplex* var. *microchlamydosporum* Meyer (Meyer, 1959) do not belong to *Cylindrocladium* but to *Gliocephalotrichum*.

C. ellipticum Alf., Seymour & Sob. (Alfieri *et al.*, 1970) has essentially the same morphological characters as *C. candelabrum* Viegas (Viegas, 1946), a species which has remained practically unknown since its original publication. It is therefore reduced to synonymy with *C. candelabrum*.

El-Gholl *et al.* (1986) have recently named a new *Cylindrocladium* species, *C. spathulatum* El-Gholl, Kimb., Barn., Alf. & Schoult. This species, which has 1-3-septate conidia, 39-86 x 4-6 µm wide, is clearly similar to C. *ilicicola* (Hawley) Boedijn & Reitsma which I have redescribed (Peerally, 1974e) from an examination of part of its type material (IMI 176542). The illustrations presented (Peerally, 1974e) clearly show the occurrence of a spathulate vesicle as well. There can be no doubt that the inability of El-Gholl *et al.* to correctly identify their isolate as C. *ilicicola* could be attributed to the inaccurate vesicle description, repeatedly published in the literature (Bell & Sobers, 1966; Sobers & Seymour, 1967; Sobers, 1969), claiming C. *ilicicola* to possess globose vesicles. C. *spathulatum* is therefore reduced to synonymy with C. *ilicicola*.

After examining part of the original type material of C. *scoparium* var. *brasiliensis* Batista & Ciferri (IMI 43688), I established (Peerally, 1974g) the new combination C. *brasiliense* (Batista & Ciferri) Peerally (as *braziliensis*). Conidia and vesicles are significantly smaller in C. *brasiliense* as compared to C. *scoparium*.

Sobers (1968) clearly demonstrated that C. *macrosporum* Sherb. (Sherbakoff, 1928) should be reduced to synonymy with C. *pteridis* Wolf (Wolf, 1926).

Subsequently C. *macrosporum* var. *hederae* Arn. was proposed by Arnaud (1952) without Latin diagnosis but with an accurate illustration of the fungus and with *Tetracytum lauri* Vanderwalle and *Candelospora citri* Fawcett & Klotz as, said explicitely, putative synomyms. He also mentioned the association of the fungus with the teleomorphic new species *Calonectria hederae* Arnaud, a name proposed without providing a validating Latin diagnosis. Boedijn & Reitsma (1950) have transfered *Candelospora citri* to *Cylindrocladium* and redescribed it. Booth & Murray (1960), when redescribing and validating *Calonectria hederae* , confirmed the rejection of the synonymy of *Cylindrocladium citri* with C. *macrosporum* var. *hederae*, but did not validate the later name. Peerally (1974f) recognizing also in the later a distinct species of *Cylindrocladium* transfered it to the rank of species as C. *hederae* (Arnaud) Peerally but invalidly. Considering *Tetracytum lauri* Vanderwalle a doubtful *Cylindrocladium* species, unaccurately described and apparently without sterile appendage, we propose the validation of Arnaud's species as a new species.

***Cylindrocladium hederae* Arnaud ex Peerally, spec. nov. anam.**

= *Cylindrocladium hederae* (Arnaud) Peerally in CMI Descriptions of pathogenic fungi and Bacteria, 43:426, 1974 (nomen invalidum)
= *Cylindrocladium macrosporum* var. *hederae* Arnaud, Bull. Soc. Mycol. Fr. 68:205, 1952 (nomen invalidum)
Holomorph: *Calonectria hederae* Booth & Muray, Trans. Br. myc. Soc. 43:70, 1960.

Conidiophora erecta, hyalina, 350-400 µm longa, ad basim 6-8 µm, ad apicem 3 µm lata, superne in vesiculam apicalem ovatam aut clavatam 30-40 x 6-14 µm inflata, ad 50-70 µm altitudinem penicillum lateralem saepius singularem ferentia. Ramus primarius non septatus vel uniseptatus, 12-22 µm ; rami secondarii non septati, 9.6-16.4 µm; rami tertii 8.6-11.4 µm, 2-4 phialides 12-16.4 x 5-6 µm ferentes. Conidia cylindrica, utrinque rotundata, hyalina, 1-5-septata, plerumque 3-septata, (44)51-83(102) x 6-9 µm. Habitat in foliis repentis*Hederae helicis*. Lectotypus a G. Arnaud in Horto Versailles, Francia, 17 decembro 1948, collectus et in figuris 2413 & 2416 delineatus, in LCP herbario, Paris (IMI 39232 ex typo). Other collections: (2) dead leaves of creeping *Hedera helix*, Parc of Versailles, France, 29 june 1948, G. Arnaud, in LCP; (3) leaves of creeping *Hedera helix*, Parc of Versailles, France, together with "*Calonectria hederae* n.sp.", 8 july 1948, G. Arnaud, in LCP; (4) leaf of *Hedera helix*, Surrey, England, 1958, Booth & Murray, in IMI 75300 type material of *Calonectria hederae*.

C. hederae is distinguished by having 1-5 septate conidia, mostly (95%) 3-septate, some 4 and 5-septate (2.5%), and a sterile appendage terminating in a clavate to oval vesicle. *C. pteridis* differs from *C. hederae* in producing a small-conidial form also and by its mostly 1-septate conidia.

Cylindrocarpon gracile Bugnicourt, and *Cylindrocarpon reteaudii* Bugnicourt (originally *reteaudi*) have been renamed *Cylindrocladium gracile* (Bugnicourt) Boesew. and *C. reteaudii* (Bugnicourt) Boesew. (Boesewinkel, 1982b). The new species *C. brassicae* described by Panwar & Bohra (1974) is essentially similar to *C. gracile*. It is therefore reduced to synonymy with *C. gracile*.

Acontiopsis crataegi was described by Negru (1961) as a fungus with penicillately branched conidiophores, conidia aseptate, hyaline, 14-18 x 2-3 µm and sterile appendage terminating in a club-shaped vesicle 3-5 µm large. This fungus is clearly a

Cylindrocladium. The combination *Cylindrocladium crataegi* (Negru) Peerally is therefore proposed.

Cylindrocladium crataegi **(Negru) Peerally comb. nov.**
= *Acontiopsis crataegi* Negru, Comunicarile Acad. Repub. Pop. Rom. 11 (7): 839-842, 1961.

The new genus *Cylindrocladiella* introduced by Boesewinkel (1982a) to accommodate the small-conidial species of *Cylindrocladium* led the author to propose the combinations *Cylindrocladiella novae-zelandiae*, *C. camelliae*, *C. peruviana* and *C. parva* and the new species *Cylindrocladiella infestans*. Of these *C. infestans* being not previously assigned to *Cylindrocladium*, the new combination *Cylindrocladium infestans* (Boesew.) Peerally is therefore proposed.

Cylindrocladium infestans **(Boesew.) Peerally comb. nov.**
= *Cylindrocladiella infestans* Boesew., Can. J. Bot. 60: 2288-2294, 1982.

The following 26 *Cylindrocladium* species are recognized in this publication:

C. avesiculatum **Gill, Alf. & Sob.,** (Gill *et al.*, 1971)
C. brasiliense **(Batista & Ciferri) Peerally,** (Peerally, 1974g)
  = *C. scoparium* var. *brasiliensis* , (Batista, 1951)
C. camelliae **Venkataram. & Venkata Ram,** (Venkataramani & Venkata Ram, 1961; Peerally, 1974h)
  = *C. peruvianum* Bat., Bez. & Herrera, (Batista *et al.*, 1965)
  = *C. hastatum* Sob. & Alf., (Sobers & Alfieri, 1972)
  = *C. lanceolatum* Peerally, (Peerally, 1972b)
C. candelabrum **Viegas,** (Viegas, 1946)
  = *C. ellipticum* Alf., Seymour & Sob., (Alfieri *et al.*, 1970)
C. citri **(Fawcett & Klotz) Boedijn & Reitsma,** (Fawcett & Klotz, 1937; Boedijn & Reitsma, 1950)
C. clavatum **Hodges & May,** (Hodges & May, 1972; Peerally, 1974b)
C. colhounii **Peerally,** (Peerally, 1973; 1974j, k)
C. crataegi **(Negru) Peerally comb. nov.** (Negru, 1961)
C. crotalariae **(Loos) Bell & Sob.,** (Bell & Sobers, 1966; Peerally, 1974i)
C. curvatum **Boedijn & Reitsma,** (Boedijn & Reitsma, 1950)

C. floridanum **Sob. & Seymour,** (Sobers & Seymour, 1967; Peerally, 1974a)
C. gracile **(Bugnicourt) Boesew.,** (Boesewinkel, 1982b)
= *C. brassicae* Panwar & Bohra, (Panwar & Bohra, 1974)
C. hederae **Arnaud ex Peerally n. sp.**
= *C. hederae* (Arnaud) Peerally (nom. inv.), (Peerally, 1974f)
= *C. macrosporum* var. *hederae* Arnaud (nom. inv.), (Arnaud, 1952)
C. heptaseptatum **Sob., Alf. & Knauss.,** (Sobers *et al.*, 1975)
C. ilicicola **(Hawley) Boedijn & Reitsma,** (Boedijn & Reitsma, 1950; Peerally, 1974e)
= *C. spathulatum* El-Gholl, Kimb., Barn., Alf. & Schoult., (El-Gholl *et al.*, 1986)
C. infestans **(Boesew.) Peerally comb. nov.,**(Boesewinkel, 1982a)
C. leucothoeae **El-Gholl, Leahy & Schubert,** (El-Gholl *et al.*, 1989)
C. novae-zelandiae **Boesew.,** (Boesewinkel, 1981)
C. parvum **Anderson,** (Anderson, 1919; Boedijn & Reitsma, 1950)
C. penicilloides **(Tubaki) Tubaki,** (Tubaki, 1958)
C. pteridis **Wolf,** (Wolf, 1926; Sobers, 1968)
= *C. macrosporum* Sherb., (Sherbakoff, 1928)
C. quinqueseptatum **Boedijn & Reitsma,** (Boedijn & Reitsma, 1950; Peerally, 1974c)
C. reteaudii **(Bugnicourt) Boesew.,** (Boesewinkel, 1982b)
C. scoparium **Morgan,** (Morgan, 1892; Sobers & Seymour, 1967; Morrison & French, 1969)
C. spathiphylli **Shoult., El-Gholl & Alf.,** (Schoulties *et al.*, 1982)
C. theae **(Petch) Subram.,** (Subramanian, 1971; Peerally, 1974d)
= *C. theae* (Petch) Alf. & Sob., (Alfieri *et al.*, 1972)

The teleomorph

The original association of a teleomorph to a *Cylindrocladium* anamorph was effected by Boedijn & Reitsma (1950), who established *Calonectria ilicicola* Boedijn & Reitsma as the sexual state of *Cylindrocladium ilicicola*. Bugnicourt (1939) described *Cylindrocarpon reteaudii* Bugnicourt as the conidial state of *Neonectria reteaudii* Bugn., subsequently renamed *Calonectria reteaudii* (Bugnicourt) Booth (Booth, 1966). Recently Boesewinkel (1982b) made the new combination *Cylindrocladium reteaudii* (Bugnicourt) Boesew. Several other species, all belonging to *Calonectria* de Not., have been shown to have a *Cylindrocladium* anamorph.

The genus *Calonectria* has been given a new interpretation by Rossman (1979a, b; 1983). She attributed to it nectrioid species with a *Cylindrocladium* anamorph, irrespective of ascospore septation. This interpretation is significantly different from that of Saccardo (1883), who limited *Calonectria* to nectrioid species with more than 1-septate ascospores and *Nectria* to those species with 1-septate ascospores, a view upheld by Boesewinkel (1982b). Rossman (1983) recognized only five species of *Calonectria*: *C. pyrochroa* (Desmazières) Saccardo, *C. ophiospora* Rossman, *C. camelliae* Shipton, *C. colhounii* Peerally and *C. kyotensis* Terashita. However, as pointed out by Boesewinkel (1982b), the type species of *Calonectria*, *C. daldiniana* de Not., is not known to produce a *Cylindrocladium* anamorph while of *C. ophiospora* no anamorph is known yet. Of the five species of *Calonectria* recognized by Rossman (1983) only three species, *C. kyotensis*, *C. camelliae* and *C. colhounii*, therefore, produce a *Cylindrocladium* anamorph. It is interesting to note that Rossman, who herself did not undertake systematic comparative morphological studies with *Cylindrocladium* species, appeared to have relied significantly on the work of Hunter & Barnett (1978) referred to earlier in this paper, and she accepted their view that vesicle morphology in *Cylindrocladium* should not be used as a diagnostic character. As a result Rossman inevitably lumped together distinctly different species of *Calonectria*. Thus she arbitrarily made *Cylindrocladium ilicicola* the anamorph of *Calonectria pyrochroa* and *Cylindrocladium scoparium* synonymous with *C. floridanum*. She went as far as to make *Calonectria crotalariae* (Loos) Bell & Sobers, *C. theae* Loos, *C. quinqueseptata* Figueiredo & Namekata and *C. hederae* Booth & Murray synonymous with *C. pyrochroa*. Rossman (1979a, b; 1983) also repeatedly emphasized that *C. daldiniana* de Not. was also a synonym of *C. pyrochroa*, an observation that needs to be re-examined.

It is felt that Rossman's interpretation of *Calonectria* confronts a conceptual problem. The classification of an ascomycetous species must take into account the description of both teleomorph and anamorph as far as possible. It should also be recognized that the sexual states of fungi generally possess a narrower range of morphological criteria compared to their anamorphs, and Rossman's conception of *Calonectria*, by focussing all taxonomic consideration solely on the characters of the sexual state, made her merge together several distinct species which, superficially on the basis of the teleomorphs, appear to have some resemblance, but whose anamorphs are distinctly different.

Calonectria uniseptata and *C. floridana* have been shown to be synonymous with *C. kyotensis* (Peerally, 1972a; Sobers 1972). *Calonectria crotalariae*, *C. theae*, *C. hederae* and *C. quinqueseptata* have been clearly shown to be different (Peerally, 1974c, d, f & i). *Cylindrocladium scoparium* and *C. floridanum* are different not only morphologically but in their phytopathology (Sobers & Seymour, 1967). The attribution of *C. scoparium* as the anamorph of *Calonectria uniseptata* Gerlach in Index of Fungi is incorrect since the later is synonymous with *Calonectria kyotensis* whose anamorph is *Cylindrocladium floridanum* (Peerally, 1972a; Sbers, 1972).

Boesewinkel (1982a) demonstrated that *Calonectria camelliae* Shipton was the teleomorph not of *Cylindrocladium camelliae*, as Shipton (1971; 1979) believed, but of *C. infestans*. Shipton overlooked vesicle morphology in his work and was unable, therefore, to realize the correct identity of his anamorph. However, when Boesewinkel (1982a) decided to introduce the new genus *Cylindrocladiella* to accommodate the small-conidial species of *Cylindrocladium*, he felt it appropriate to transfer *Calonectria camelliae* to *Nectria* on the basis of its 1-septate ascospores, the cylindrical asci and the small cells on the outer perithecial wall. Boesewinkel (1982b) considered that *Calonectria* species should have, on the other hand, clavate asci, ascospores with more than one septum, and rough large cells on the outer perithecial wall.

There are some difficulties in accepting Boesewinkel's point of view. First one cannot help feeling that the cylindrical shape of the asci in *Calonectria camelliae* is due to the 1-seriate arrangement of the ascospores and not to any genetical explanation. Second other species of *Calonectria*, such as *C. kyotensis*, accepted by Boesewinkel as valid, have 1-septate ascospores. Ascospore septation is generally viewed as a minor taxonomic criterion. As regards the outer cells of the perithecial wall in *Calonectria*, these have been described as globose to angular cells extended into scales (Rossman, 1983). It does not appear reasonable to segregate *Nectria camelliae* from *Calonectria* on the basis of such cells, especially as Rossman (1983) has shown in *Calonectria camelliae* the occurrence of a few loose globose cells on the outer perithecial wall. The transfer of *Calonectria camelliae* to *Nectria* (Boesewinkel, 1982a) is therefore not accepted and *Calonectria* *camelliae* is here considered to be the correct epithet for this species.

Calonectria spathulata, described by El-Gholl *et al.* (1986), is similar to *C. ilicicola* Boedijn & Reitsma and it is therefore reduced to synonymy with *C. ilicicola*.

Calonectria scoparia Ribeiro & Matsuoka in Ribeiro being not validly published, we validate the species, providing here an amended Latin diagnosis from Ribeiro (1978):

Calonectria scoparia Ribeiro & Matsuoka ex Peerally spec. nov.
= *Calonectria scoparia* Ribeiro & Matsuoka in Ribeiro, M.S. Thesis, Vicosa, 1978, *nomen invalidum* (ICBN Art. 29).

Perithecia sparsa ad gregaria, subgolbosa, rufo-brunnea, 362-527 x 301-452 µm, ostiolata. Asci hyalini, clavati, tenue pariete, stipite proceres, apice aculeati indiscretique, 103-178 x 13-25.7 µm. Ascosporae hyalinae, falcatae, uniseptatae, septo mediocriter constricto, 27-65 x 4-7.8 µm. Holotypus in herbario Federalis Universitatis Vicosae n. 2875.

All the sexual states of *Cylindrocladium* belong to *Calonectria*. A teleomorph has not, however, been shown to occur for several species of *Cylindrocladium* and this is possibly due to the occurrence of heterothallism (Sobers, 1973; Shipton, 1979). The sexual states are easily produced in some species (Bell & Sobers, 1966; Peerally, 1972a, b). In others they are produced with difficulty (Ribeiro, 1978; Shipton, 1979).

The following ten teleomorphs of *Cylindrocladium* are recognized:

***Calonectria camelliae* Shipton,** (Shipton, 1979; Rossman, 1983)
= *Nectria camelliae* (Shipton) Boesew.
Anamorph: *Cylindrocladium infestans* (Boesew.) Peerally

***Calonectria colhounii* Peerally,** (Peerally, 1973, 1974j, k; Rossman, 1983)
Anamorph: *Cylindrocladium colhounii* Peerally

***Calonectria crotalariae* (Loos) Bell & Sob.,** (Loos, 1949; Bell & Sobers, 1966; Peerally, 1974d)
Anamorph: *Cylindrocladium crotalariae* (Loos) Bell & Sob.

***Calonectria hederae* Arnaud ex Booth & Murray,** (Booth & Murray, 1960; Peerally, 1974f)

Table 1. Distinguishing characters of *Calonectria* species possessing a *Cylindrocladium* anamorph.

Calonectria & anamorph	Distinguishing characters
C. camelliae *Cyl. infestans*	Perithecia scarlet, 200-350 µm high, 150-290 µm wide; asci 8-spored; ascospores 1-septate, rarely 2-, 7-11 x 3-4 µm; conidiophore with vertical sterile appendage; vesicle narrowly clavate, 4-5 µm wide; conidia 15-21 x 2-3 µm.
C. scoparia *Cyl. scoparium*	Perithecia reddish brown, 360-530 µm high, 310-450 µm wide; asci 8-spored; ascospores 1-septate, 27-65 x 4-8 µm; conidiophore with vertical sterile appendage; lateral appendages present in most isolates; vesicle oval to ellipsoidal and umbonate 3-17 µm wide; conidia 1-septate, 33-59 x 3-4 µm.
C. kyotensis *Cyl. floridanum*	Perithecia scarlet, 240-490 µm high, 170-440 µm wide; asci 8-spored; ascospores 1-septate 29-42 x 6-8 µm. Conidiophore with vertical and lateral sterile appendage; vesicle globose to subglobose 8-18 µm diam.; conidia 1-septate, 36-57 x 3-6 µm.
C. ilicicola *Cyl. ilicicola*	Perithecia orange 400-500 µm high, 320-370 µm wide; asci 8-spored; ascospores 1-septate, becoming 3-5, usually 3-septate when extruded; conidiophore with vertical sterile appendage; vesicle clavate to club-shaped, and umbonate, 5-11 µm wide; conidia 1-3-septate, mostly 3-septate, 37-68 x 4-5 µm.
C. colhounii *Cyl. colhounii*	Perithecia yellow, 250-460 µm high, 310-520 µm wide; asci 4-spored; ascospores 3-septate, 34-84 x 4-8 µm; conidiophore with vertical sterile appendage; vesicle narrowly clavate, 2-5 µm wide; conidia 3-septate, 38-84 x 3-6 µm.

C. reteaudii *Cyl. reteaudii*	Perithecia 410 x 280 µm; asci 8-spored; ascospores 1-3-septate, 56-60 x 5-8 µm; conidiophore with vertical sterile appendage; vesicle clavate to subglobose 5-7 µm wide; conidia 5-6-septate, 80-110 x 6-7 µm.
C. theae *Cyl. theae*	Perithecia orange red, becoming reddish brown, 220-450 µm high, 220-420 µm wide; asci 8-spored, ascospores 3-septate, 51-77 x 5-9 µm; conidiophore with vertical sterile appendage; vesicle narrowly clavate 3-5 µm wide, conidia 1-3-septate, usually 3-septate, 63-103 x 5-7 µm.
C. crotalariae *Cyl. crotalariae*	Perithecia orange to red, 300-480 µm high, 280-450 µm wide; asci 8-spored; ascospores 1-3-septate, 31-62 x 6-8 µm; conidiophore with vertical sterile appendage; vesicle globose 6-13 µm diam.; conidia 1-3-septate, mostly 3-septate, 60-105 x 5-7 µm.
C. hederae *Cyl. hederae*	Perithecia yellowish red to red, 300-370 µm high, 200-300 µm wide; asci 8-spored; ascospores 3-septate, 34-69 x 5-7 µm; conidiophores with vertical sterile appendage; vesicle clavate to club-shaped, 6-14 µm wide; conidia 1-5-septate, mainly 3-septate, 44-102 x 4-9 µm.
C. quinqueseptata *Cyl. quinqueseptatum*	Perithecia orange to chestnut, 360-580 µm high, 300-440 µm wide, asci 8-spored; ascospores 1-6-septate, mostly 3-septate, 30-80 x 4-7 µm; conidiophore with vertical sterile appendage; vesicle narrowly clavate, 2-3 µm wide; conidia 1-6-septate, mostly 5-septate, 60-120 x 5-8 µm.

Anamorph: *Cylindrocladium hederae* (Arnaud) Peerally

***Calonectria ilicicola* Boedijn & Reitsma,** (Boedijn & Reitsma, 1950)

= *Calonectria spathulata* El-Gholl, Kimb., Barn., Alf. & Schoult., (El-Gholl *et al.*, 1986)

Anamorph: *Cylindrocladium ilicicola* (Hawley) Boedijn & Reitsma

***Calonectria kyotensis* Terashita,** (Terashita, 1968; Peerally 1974a)

= *Calonectria uniseptata* Gerlach, (Gerlach, 1968)

= *Calonectria floridana* Sob., (Sobers, 1969)

Anamorph: *Cylindrocladium floridanum* Sob. & Seymour

***Calonectria quinqueseptata* Figueiredo & Namekata,** (Figueiredo & Namekata, 1967; Peerally, 1974c)

Anamorph: *Cylindrocladium quinqueseptatum* Boedijn & Reitsma

***Calonectria reteaudii* (Bugnicourt) Booth,** (Bugnicourt, 1939; Booth, 1966)

Anamorph: *Cylindrocladium reteaudii* (Bugnicourt) Boesew.

***Calonectria scoparia* Ribeiro & Matsuoka ex Peerally**

= *Calonectria scoparia* Ribeiro & Matsuoka in Ribeiro, (Ribeiro, 1978), *nomen invalidum*

Anamorph: *Cylindrocladium scoparium* Morgan

***Calonectria theae* Loos,** (Loos, 1949; Peerally, 1974d)

Anamorph: *Cylindrocladium theae* (Petch) Subram., (Loos, 1949; Subramanian, 1971; Alfieri & Sobers, 1972)

CLASSIFICATION OF CYLINDROCLADIUM

The taxonomic criteria used here are the sterile appendage, vesicle shape and size, conidial morphology and, for the small-conidial species, subverticillate conidiophore

Key to species of *Cylindrocladium*

1\. Sterile appendage present .... 2.
1\. Sterile appendage absent,
    conidia 3-septate, 33-62 x 4-6 µm .... *C. penicilloides*
2\. Conidia less than 23 µm long .... 3.
2\. Conidia more than 23 µm long.. 7.
3\. Conidia 1-septate .... 4.
3\. Conidia aseptate, 14-18 x 2-3 µm,
    vesicle club-shaped, 3-5 µm wide...................... *C. crataegi*
4\. Subverticillate conidiophores present................................ 5.
4\. Subverticillate conidiophores absent .... 6.
5\. Vesicle club-shaped, hastate to lanceolate,
    3-7 µm wide, conidia 10-16 x 2 µm .... *C. camelliae*
5\. Vesicle narrowly clavate, 4-5 µm wide,
    conidia 15-21 x 2-3 µm.................................... *C. infestans*
6\. Vesicle conspicuous, clavate to club-shaped,
    4-5 µm wide, conidia 15-21 x 2-3 µm................. *C. parvum*
6\. Vesicle inconspicuous, clavate or lanceolate,
    tapering, 4-7 µm wide,
    conidia 8-15 x 2-4 µm......................... *C. novae-zelandiae*
7\. Conidia generally 1-septate, occasionally
    aseptate or up to 3-septate .... 8.
7\. Conidia generally 3- or more septate................................17.
8\. Conidia 1-septate, 24-38 x 2-3 µm, vesicle
    oval to ellipsoidal and umbonate,
    3-6 µm wide... *C. brasiliense*
8\. Conidia over 24-38 x 2-3 µm .... 9.
9\. Conidia 1-septate 26-44 x 3-4 µm,
    vesicle narrowly clavate 4-5 µm wide................. *C. gracile*
9\. Conidia over 26-44 µm long...10.
10\. Conidia within the range 33-60 µm long ....11.
10\. Conidia over 33-60 µm long ....14.
11\. Vesicle globose to subglobose, ...12.
11\. Vesicle clavate, or oval to ellipsoidal and umbonate ....13.
12\. Vesicle 5-7 µm diam., conidia curved, 1-septate,

conidia 40-46 x 3-4 µm .... *C. curvatum*

12. Vesicle 8-18 µm diam., conidia straigth, 1 septate, conidia 36-57 x 3-6 µm................................ *C floridanum*

13. Vesicle narrowly clavate, 2-5 µm wide, conidia 1-septate 36-60 x 3-5 µm .... *C. clavatum*

13. Vesicle oval to ellipsoidal, and umbonate 3-17 µm wide, conidia 1-septate 33-59 x 3-4 µm .... *C. scoparium*

14. Sterile appendage vesiculate ....15.

14. Appendage avesiculate, rarely narrowly clavate, conidia 1-septate 51-78 x 4-5 µm .... *C. avesiculatum*

15. Vesicle clavate or oval to ellipsoidal................................16.

15. Vesicle globose 9-15 µm diam., conidia 1-septate 45-101 x 5-7 µm............... *C. spathiphylli*

16. Vesicle clavate 5-10 µm wide, conidia of two types: large form mostly 1-septate 61-118 x 5 µm, small form 1-septate 23-48 x 4-5 µm.................. *C. pteridis*

16. Vesicle oval to ellipsoidal 7-11 µm wide, conidia 1-septate 40-88 x 4-6 µm .... *C. candelabrum*

17. Conidia mostly 3-septate..18.

17. Conidia mostly more than 3-septate...............................24.

18. Vesicle 2-5 µm wide..18.

18. Vesicle more than 2-5 µm wide..19.

19. Conidia 1-3-septate, mostly 3-septate 38-84 x 3-6 µm, vesicle narrowly clavate 2-5 µm wide... *C. colhounii*

19. Conidia 1-3-septate, mostly 3-septate 63-103 x 5-7 µm, vesicle narrowly clavate 2-5 µm wide... *C. theae*

20. Vesicle clavate to club-shaped 6-14 µm wide, conidia 1-5-septate, mostly 3-septate 44-102 x 4-9 µm .... *C. hederae*

20. Vesicle globose or oval to ellipsoidal and umbonate or clavate to club-shaped and umbonate.......21.

21. Vesicle globose 6-13 µm diam., conidia 1-3-septate, mostly 3-septate 60-105 x 5-7 µm................. *C. crotalariae*

21. Vesicle oval to ellipsoidal and umbonate or clavate to club-shaped and umbonate ....22.

22. Vesicle clavate to club-shaped and umbonate 5-11 µm wide, conidia 1-3-septate, mostly 3-septate, 37-68 x 4-5 µm .... *C. ilicicola*

22. Vesicle oval to ellipsoidal and umbonate.........................23.

23. Conidia 1-3-septate, mostly 3-septate, 43-48 x 4-5 µm,
    vesicle 11-13 µm wide.. *C. citri*
23. Conidia 1-6-septate, mostly 3-septate, 62-102 x 4-6 µm,
    vesicle 6-12 µm wide................................*C. leucothoeae*
24. Vesicle clavate..25.
24. Vesicle clavate to subglobose 5-7 µm wide,
    conidia 5-6-septate 80-110 x 6-7 µm .... *C. reteaudii*
25. Conidia generally 5-septate 60-120 x 5-8 µm,
    vesicle narrowly clavate
    2-3 µm wide.......................................*C. quinqueseptatum*
25. Conidia generally 7-septate 80-132 x 6.5-9.5 µm,
    vesicle clavate 4-7 µm wide...................*C. heptaseptatum*

PHYTOPATHOLOGICAL NOTES

Ever since *Cylindrocladium scoparium* was found growing on an old pod of *Gleditsia triacanthos* by Morgan (1892), this species and *C. crotalariae*, *C. theae*, *C. clavatum*, *C. quinqueseptatum*, *C. floridanum* and *C. pteridis* have been described to cause serious losses to economic crops. Although most other species of *Cylindrocladium*, especially *C. hederae*, *C. citri*, *C. infestans*, *C. novae-zelandiae*, *C. heptaseptatum* and *C. avesiculatum* are, in fact, minor pathogens, certain others like *C. camelliae*, *C. brasiliense*, *C. spathiphylli* and *C. colhounii* have been sometimes recorded to cause significant damage to economic plants.

A review of the literature indicates that phytopathological studies of *Cylindrocladium* have essentially focussed on the identification of the pathogens, pathogenicity tests, the role of microsclerotia in disease aetiology, chemical control and, in some instances, screening of cultivars for host resistance. There have been some attempts to investigate the existence of special forms or physiological races but these studies have met with some difficulties. Thus Rowe & Beute (1975), in an investigation of virulence variability of *C. crotalariae* isolates, found that all isolates tested, regardless of geographical origins, produced the same pattern of disease development on six groundnut cultivars. They, therefore, concluded that there was no evidence of detectable physiological specialization in this species.

Nearly all virulent species of *Cylindrocladium* appear to be able to infect a range of hosts from different families of seed plants. An interesting observation is the frequent references to the existence of a disease complex involving mainly two or more species of *Cylindrocladium*.

Thus *C. floridanum* and *C. camelliae* were reported to be associated with a decline of tea bushes (Peerally, 1972b) while *C. clavatum*, *C. floridanum* and *Cylindrocarpon tenue* were observed to be associated in a root rot complex of tea (Peerally, 1974b). Wilson *et al.* (1979) have reported mixed infection of *C. quinqueseptatum* and *Colletotrichum capsici* causing leaf blight of clove in South India. It has also been estimated in Kerala, India, that 60-100 % mortality rates of seedlings of *Eucalyptus grandis* and *E. tereticornis* were due to a disease complex which included *Cylindrocladium quinqueseptatum*, *C. clavatum* and *C. ilicicola* (Anon., 1982). This observation was confirmed by Mohanan & Sharma (1986) who found several species of *Cylindrocladium* associated with *Eucalyptus* spp., causing a complex of damping off, stem canker, and leaf and shoot blight in nurseries in Kerala.

Cylindrocladium scoparium

C. scoparium causes disease world-wide on various hosts but has been particularly reported on *Eucalyptus* and *Rhododendron* (azaleas).

In Mauritius it was observed to cause severe damage in an eucalyptus nursery, and the pathogen isolated characteristically had several lateral sterile appendages (Fig. 1). Seedling of eucalyptus is also affected by this pathogen (Barnard, 1980). In Brazil it was described as the main eucalyptus disease in the State of Minas Gerais (Ferreira, 1985).

Its occurrence on eucalyptus has also been observed in New South Wales (Keirie, 1981). In Florida (Barnard, 1984) it was reported to cause extensive damage to *E. grandis* and *E. robusta* seedlings by inducing girdling cankers on the lower stem. Infection started on the leaves and progressed through the petioles to the stems. Disease was enhanced by ambient nursery conditions, especially very humid conditions caused by overhead irrigation, as well as high temperature and reduced aeration. Trials indicated that Benomyl could control infection. In India, *Cylindrocladium scoparium* was found associated with *C. clavatum* in a leaf blight and stem canker of *E. tereticornis* seedlings and blight of trees (Rattan & Dhanda, 1985). Seed treatments with Bavistin, Argoll-3, Captan, Thiram and Panoram at 10 mg/g seed were effective against the seedling blight when the treated seeds were sown in inoculated soil. Recently Alfenas *et al.* (1988) have found that constant use of Benomyl to control *Cylindrocladium scoparium* in eucalyptus nurseries has led to the development of strains tolerant of the fungicide up to 1000 p.p.m. Excellent control was obtained with Thiram at 2000 p.p.m. and it was suggested (Alfenas *et al.*, 1988) that fungicides with different biochemical modes of action be used in rotation to avoid the build up of strains.

The occurrence of *C. scoparium* on azaleas (*Rhododendron* spp.) has been reported by Timonin & Self (1955), Horst & Hoitink (1968) and Alfieri *et al.* (1972).

According to Timonin & Self (1955) *Cylindrocladium scoparium* caused extensive losses of azaleas and other ornamentals in propagation houses. Losses of cuttings of azaleas varied from 10 to 100 %. The symptoms on azaleas were of two types, blight and wilt. In blight infected leaves turned brown to black depending on the cultivar. The petiole bases softened, and the leaves usually dropped in 3 to 4 days. The bark of infected stem also turned brown. In wilt symptoms, the leaves wilted and dropped without any visible leaf spots or stem cankers. The bark and wood were discoloured and water soaked and vascular discolouration sometimes was visible up to the cutting tip. The disease was found to be particularly serious under conditions of high humidity. Timonin & Self (1955) also showed that *C. scoparium* was pathogenic to *Magnolia soulangeana*, *Hydrangea* sp., *Ilex rotundifolia*, *Pyracantha* sp., *Callistemon rigidus* and *Poinsettia* sp. The efficacy of chemical control against *Cylindrocladium scoparium* on azaleas was studied by Prest (1988) and Prest & Poppe (1988). Prest (1988) showed Prochloraz to be the most effective of several fungicides in controlling the pathogen, either when used as a dip or as a drench; the dip treatment caused some phytotoxicity not observed after drenching. None of the fungicides used, however, were effective under high infection pressure (Prest & Poppe, 1988). The need to take hygienic measures in taking azalea cuttings such as use of clean pots and substrate was emphasized by Stegmann & Bohmer (1989) for preventing or limiting infection by *C. scoparium*. Jamart & Kamoen (1986) also reported almost complete control of *C. scoparium* on azalea (*Rhododendron simsii*) with Prochloraz.

C. scoparium has also been reported to cause leaf spotting and stem cankering of seedlings of *Acacia baileyena* and *A. pycnantha* (Bertus, 1976); root rot of sweetgum (*Liquidambar styraciflua*) in natural stands in Georgia, resulting in tree mortality (Cordell & Rowan, 1975); leaf and stem rot of miniature roses in Germany

(Brielmaier & Dalchow, 1986); leaf spots and severe wilt causing losses of 20 % of a cocoa crop in Sao Paulo (Feitosa *et al.*, 1986) and leaf spot and blight on *Acacia longifolia* in South Africa (Hagemann & Rose, 1988). According to Hagemann & Rose (1988) their studies suggested that *Cylindrocladium scoparium* might have some potential as a biological control agent for *A. longifolia*, an invader species in South Africa.

Cylindrocladium theae

Petch (1921) from Sri Lanka reported severe cases of disease outbreaks due to *C. theae* which, he observed, spread from acacias to tea. The disease caused severe defoliation and the tea leaves became black and rotten. With the return of fine weather after the rains the disease was arrested. Similarly, Gadd (1927) noted that *C. theae* was the most severe tea disease in Ceylon. He found that spores of *C. theae*, rarely seen on tea, were produced in abundance on *Eucalyptus* spp. and on *Albizzia lopantha* and tea was infected from these sources.

Cylindrocladium theae was also reported to cause a severe tea disease from India (Venkata Ram, 1962). Various workers (Petch, 1921, 1922; Gadd, 1927; Webster, 1954 and Loos, 1951) have reported that disease incidence on tea was enhanced by wet conditions and was checked with the cessation of rain. Similar reports have been made by Hiremath & Anahosur (1976) for a common root rot disease of *Medicago sativa* caused *Cylindrocladium theae* and by Mohanan & Sharma (1986) for a disease complex of *Eucalyptus* involving several species of *Cylindrocladium* including *C. theae.*

Cylindrocladium crotalariae

C. crotalariae was initially described to infect both tea and crotalaria (Loos, 1949). That this pathogen could cause a severe peg rot and root necrosis of *Arachis hypogaea* was first shown by Bell & Sobers (1966). Symptoms included chlorosis, wilting and necrosis. This disease, which was called *Cylindrocladium* black rot (CBR) became progressively more prevalent in Virginia, USA, between 1970-1973 reaching epidemic proportions in 1973 (Garren & Coffelt, 1976). By 1973 *C. crotalariae* was regarded as a major pathogen of both groundnut and soybean in Japan (Misonou, 1973).

CBR is generally regarded as very destructive. The widespread occurrence of CBR on groundnut in Virginia was attributed to closely related cultivars being planted thus providing a narrow germplasm base. Sung (1983) has described this disease as one of the most serious on soybean in Korea.

When they compared pathogenicity of *C. crotalariae* with *C. floridanum* and *C. scoparium* on groundnut, soybean, barley, oat, rye and wheat, Sobers & Littrell (1974) concluded that *C. crotalariae* was the most virulent. Black & Beute (1984) compared 145 *C. crotalariae* isolates from 6 groundnut genotypes using test resistant and susceptible cultivars. Overall nut rot mean was recorded to be highest for isolates from resistant and lowest for those from susceptible cultivars.

Seed transmission in the spread of *C. crotalariae* has been shown to be possible (Porter & Mozingo, 1986). The pathogen was isolated from undamaged seeds at low frequency. However isolation was prevented by seed treatment for 2 weeks with dichloran + captan.

Disease development is slowed when soil temperatures exceed 25°C and stops if temperatures exceed 35°C (Sidebottom & Beute, 1989). Remote sensing has been employed in monitoring disease development by CBR with aerial, false-colour photography (Percy *et al.*, 1989). The use of this technique was described as a mean of rapidly, accurately, and economically mapping the extent and severity of this disease over large areas (Powell *et al.*, 1976).

Control of CBR has been attempted by using soil fumigants (Phipps, 1982, 1985) and resistant cultivars (Coffelt *et al.*, 1980; Coffelt, 1983).

Cylindrocladium floridanum

C. floridanum was first reported to be associated with a decline of peach trees in Florida (Sobers & Seymour, 1967), and to cause wilting, root rot and death of peach seedlings in greenhouse experiments. In their studies Sobers & Seymour established the pathogenicity of *C. floridanum* to leaves of *Callistemon citrinus*, *C. rigidus*, *Eucalyptus camadulensis*, *E. robusta* and *E. rudis*, *E. saligna*, *E. tereticornis*, and to four cultivars of *Rhododendron obtusum*.

Boesewinkel (1974) isolated this species from rotting and dying seedlings of *Pinus* spp. and *Liriodendron tulipifera* in New Zealand. Myren *et al.* (1975) from Ontario found *Cylindrocladium floridanum* on dead roots of *Picea mariana*, and from seedlings of

Picea glauca, Pinus resinosa and *Pinus banksiana* showing root rot symptoms.

The occurrence of *Cylindrocladium floridanum* on tea has been reported by Peerally (1972a, b; 1974a, k) from Mauritius. In Mauritius the disease was found both in nurseries and in the fields. In rooted cuttings infection occurred mainly through the lower cut end of the stem, and progressed upwards rapidly until the petiole and finally the leaf blade were penetrated while the axillary bud was quickly invaded and killed. The stems of these cuttings were observed to turn dark brown to black, the leaves rapidly lost their green colour, turned pale brown to dark brown and dropped off readily. In less than ten days after planting infected cuttings succumbed. Humidity level of the soil and of the atmosphere within the nursery was the most critical environmental factor affecting this disease, high humidity level dramatically favouring disease development. On the other hand a decline of tea bushes associated with *C. floridanum* was also reported in Mauritius as alarming (Peerally, 1972b). Diseased plants in an advanced stage of infection stood out by their unproductive moribund appearance and had a serious root rot and when the infected roots were maintained in a humid chamber they rapidly developed numerous scarlet perithecia of *Calonectria kyotensis*. Some measure of disease control was achieved by drenching attacked plants with Dithane M-45; drenching with Benlate and Captan followed by adding fertilizers (NPK) and earthing up resulted in definite improvement of the diseased plants (Peerally, 1972b). Philip (1980) from India reported a disease of tea seedlings also due to *C. floridanum*.

The *Cylindrocladium* described by Wormald (1944) as causing a shoot wilt of plum and cherry in the United Kingdom was identified as *C. floridanum* (Peerally, 1972c, unpublished). *C. floridanum* has also been reported to cause a disease of conifer seedlings (Morrison & French, 1969) and of *Acacia dealbata* (Terashita, 1968).

Cylindrocladium quinqueseptatum

This species was initially described from Indonesia where it was reported as a dangerous pathogen of clove by Reitsma & Sloof (1951). These authors demonstrated the rapid spread of the disease in a humid environment, whereas in a dry atmosphere, the activity of the fungus was suddenly checked and the disease subsequently spread very slowly within the host plant. They also observed that on infected plants exposed to humid conditions sporulation occurred within four days. However when such plants were not exposed to humid conditions further sporulation was checked and disease progress by conidia became impossible.

C. quinqueseptatum was observed for the first time in Brazil by Figueiredo & Namekata (1967) on *Eucalyptus tereticornis, Anona squamosa* and clove. In Malaysia it was reported by cause leaf spots of rubber in a nursery (Rao, 1971).

There are several reports of the occurrence of this species in India. Thus according to Wilson *et al.* (1979) *C. quinqueseptatum* in mixed infection with *Colletotrichum capsici* caused a leaf spot of clove and seedling death in Kerala. Sarma & Nambiar (1978) observed it on leaves of mature clove trees as well, although disease was more severe on clove seedlings. They also observed that the pathogen could infect *Eugenia jambolana, Pimenta dioica, Eucalyptus grandis, E. maculata* and *E. globulus*. Sharma & Mohanan (1982) reported *Cylindrocladium quinqueseptatum* as a major pathogen in Kerala in nurseries and plantations of eucalyptus.

Fungicidal control of this pathogen has been attempted by Anahosur *et al.* (1977) who concluded from their tests, that baristin, Thiram and hexaferb were very effective in inhibiting this species.

Cylindrocladium pteridis

C. pteridis has been consistently recorded as a serious leaf pathogen. Originally shown to cause brown leaf spot of leather leaf fern (Wolf, 1926), it was subsequently recorded to be responsible for a leaf spot disease of *Washingtonia robusta*. In 1973 Ivory reported a seedling blight of *Pinus* spp. caused by *C. pteridis* in West Malaysia. A similar disease was also described from Brazil by Hodges *et al.* (1975).

Sobers (1968) found that isolates of *Cylindrocladium pteridis* were pathogenic to leaves, roots and stems of several species of eucalyptus and to various ferns and palms. *C. pteridis* also causes a severe leaf spot of coconut palm (Silva & Sousa, 1981). According to Almeida & Bolkan (1981) *C. pteridis* was pathogenic to eucalyptus, groundnut and potato in greenhouse tests. In laboratory tests Bedendo & Krügner (1987) observed mycelial growth of *C. pteridis* on potato dextrose agar to be completely inhibited by Benomyl at 10 p.p.m. but only 60 % by Chlorothalonil at 10 p.p.m. On the other hand, conidial germination was completely inhibited by Chlorothalonil at 10 p.p.m. and by Benomyl at 100 p.p.m.

Cylindrocladium clavatum

This species was first reported by Hodges & May (1972) to cause a root disease of *Araucaria*, pine and eucalyptus in Brazil. The pathogen was found on diseased roots of dying 10 to 15-year-old trees of *Araucaria angustifolia*, and the roots of such trees were pitch-soaked and copiously exuded resin, causing large quantities of soil to stick to the roots (Hodges & May, 1972). *Cylindrocladium clavatum* was reported to be associated in a root rot complex of tea in Mauritius (Peerally, 1974c). However this species has frequently been described as a serious pathogen. Thus it has been reported (Anon, 1982) that 60 to 100 % mortality rates of seedlings of *Eucalyptus grandis* and *E. tereticornis* were due to a disease complex including *Cylindrocladium clavatum*. Lopes & Reifschneider (1982) found *C. clavatum* to cause a foot rot of field grown peas in Brazil, leading to yellowing, wilting and death. A new disease of cassava causing tissue rot, root necrosis, wilt and death was described by Almeida *et al.* (1982). This species, consistently isolated from dying seedlings of lucerne (Ooka & Uchida, 1982), has been shown to attack potato tuber as well (Bolkan *et al.*, 1981). More recently Rattan & Dhanda (1985) have described *C. clavatum* as causing leaf blight and stem canker of *Eucalyptus tereticornis* seedlings and blight of trees, in addition to seed rot, seedling blight and seedling wilt.

Cylindrocladium camelliae

Originally reported to attack tea roots in India (Venkataramani, 1952; Venkataramani & Venkata Ram, 1961) a similar disease was reported from Mauritius (Peerally, 1972b). Rahman *et al.* (1982) found this species to cause wilting and death of 8-year-old plants of nutmeg in India. Seedling blight of *Eucalyptus grandis* and *E. tereticornis* due to *Cylindrocladium camelliae* was shown to be one of the most prevalent nursery diseases in Kerala, India (Sharma *et al.*, 1984). Almeida & Bolkan (1981) found that several isolates of *C. camelliae* tested under glasshouse conditions were pathogenic to groundnut, eucalyptus and potato.

Cylindrocladium brasiliense

C. brasiliense was first reported to produce damping-off in seed beds and dieback of adult trees of eucalyptus in Brazil (Batista, 1951).

Subsequently Cruz & Figueiredo (1960) found this species to be an important pathogen of eucalyptus in Sao Paulo, causing intense damping-off, lesions or even galls on the crown of young plants.

Cylindrocladium colhounii

C. colhounii was first described (Peerally, 1973; 1974j; 1974k) from Mauritius as a minor but common pathogen of tea, *Eucalyptus robusta* and *Callistemon lanceolatus*, causing leaf spots. In pathogenicity tests it proved to be very virulent to groundnut, cultivar "Cabri", on which conidia and perithecia were readily produced. Examination of materials in the Herbarium at CAB IMI (Peerally, 1974j) revealed that *C. colhounii* also occurred in India (IMI 126589) on *Wisteria chinensis*, and in Australia on dead leaves in forests (IMI 58313; IMI 158326). Interestingly enough the only other reports, subsequently made, of the occurrence of *Cylindrocladium colhounii* have so far been from India, Australia and the U.S.A. Nair & Jayasree (1986) from India reported this species on seedlings of *Eucalyptus* spp. Hutton & Sanewski (1989) have recently described considerable damage to leaves and fruits of *Annona squamosa* caused by *Cylindrocladium colhounii* in Australia. The fungus was found to be pathogenic to fruits, leaves, stems and roots. Control strategies included minimization of rain splash dispersal by pruning low branches, mulching under trees and grassing inter-tree areas (Hutton & Sanewski, 1989). Rossman (1983) reported its occurrence in the U.S.A., on fallen leaves of *Eucalyptus* sp. and *Liriodendron tulipifera*, on fallen cones of *Pinus strobus* and on senescent leaves of *Heuchera americana*.

Cylindrocladium spathiphylli

Schoulties & El-Gholl (1980, 1981) have described serious economic losses from a *Cylindrocladium* sp., causing root and foliar disease of various species of *Spathiphyllum*. The pathogen was subsequently identified as a new species, *Cylindrocladium spathiphylli* (Schoulties *et al.*, 1982). Chase (1986) reported that addition of an ammonium fertilizer to a Benomyl drench significantly improved control of *C. spathiphylli* on *Spathiphyllum* sp. Two new compounds, Prochloraz and Triflumizole, were as effective or more so than Benomyl at equivalent rates. Chase (1987) found that, of several fungicides evaluated for the control of *C. spathiphylli*, the best were Triflumizole or Prochloraz. Chase & Poole (1987) observed that plants of *Spathiphyllum* sp. grown with little or no added dolomite had more severe disease levels than plants grown in the high levels of dolomite in the potting medium. The effect was attributed to pH changes in the medium. A root and petiole rot of *Spathiphyllum* sp. caused by *Cylindrocladium spathiphylli* in Queensland has recently been reported (Forsberg, 1988).

Microsclerotia, inoculum potential and disease incidence

Ecological and epidemiological studies of *Cylindrocladium* diseases have focussed essentially on the soil-borne species, especially *C. crotalariae*. Microsclerotia, which are abundantly produced, not surprisingly, have been noted to play a significant role in the phytopathology of *Cylindrocladium*.

In an early attempt to measure inoculum potential under nursery conditions Menge & French (1976a) determined the percentage of soil samples in a total of 100 1g samples that produced sign of *C. floridanum* disease on alfalfa seedlings. They thus found the inoculum potential of *C. floridanum* to range from 8 to 100 % in the four soils tested, and this was correlated with percentage of diseased black spruce seedlings found in the same soils. Menge & French (1976a) also confirmed previous reports that *C. floridanum* could survive long periods under a variety of soil conditions and even to withstand chemical control measure.

Direct observation of the saprophytic activities of the fungus in the soil was also attempted by Menge & French (1976b). They found that microsclerotia of *C. floridanum* could germinate more frequently in soils treated with grass and maize cob amendments. From their studies they concluded that *C floridanum* had the characteristics of a competitive saprophyte.

Hwang & Ko (1975) developed a technique for the selective isolation and quantitative determination of *C. crotalariae* from soil. The fungus produced brownish colonies and microsclerotia on an acidified medium containing 2 % dextrose, 0.02 % peptone and 2 % agar. After establishing the reliability of their technique with artificially inoculated soil, they were able to show that the population of *C. crotalariae* in the vicinity of diseased pawpaw seedlings in five naturally infected soil samples ranged from 350 to 3000 propagules per gram of dried soil.

Krigsvold & Griffin (1975) also developed a procedure to quantitatively isolate microsclerotia of *C. crotalariae* from naturally infected peanut and soybean soils. Their procedure consisted of sieving soil through 150 and 44 µm sieves, treatment for 30 secs. with 0.25 % NaOCl and plating on a selective medium containing sucrose, peptone, streptomycin, chlortetracycline, oxgall, pentachloronitrobenzene and thiabendazole as main components. They found naturally infected soil to contain 1 to 103 microsclerotia per gram soil.

According to Hwang & Ko (1976) microsclerotia were the most infective propagules of *Cylindrocladium* on pawpaw. The infection potential of conidia and ascospores were about the same. However the ability of these three propagule types to colonize dead pawpaw stems did not differ significantly. Their survival studies also indicated that the population of conidia, ascospores and microsclerotia, decreased 87, 46 and 20 %, respectively after 8 months incubation in soil. Only microsclerotia remained viable after 8 months when colonized pawpaw tissues containing all three propagule types were incubated in soil. Hwang & Ko (1976) also observed that microsclerotia, but no conidia or ascospores, were recovered from soils in which pawpaw seedlings were killed by *C. crotalariae* 3 years previously in an abandoned field.

The effects of temperature and water potential on the survival of microsclerotia of *C. crotalariae* have also been investigated. Thus Phipps & Beute (1979) noticed that soil freezing, due to subnormal temperatures, brought a decline in the number of microsclerotia of *C. crotalariae*. Graham & Griffin (1988) confirmed in laboratory trials that chilling and saturation of soil with water was highly detrimental to microsclerotia germinability, similar in effects to soil freezing. They also observed that high soil temperatures, in the range of 30-40°C, greatly decreased microsclerotial germination. The effects of high temperatures were much greater at low water potentials than at high potentials.

In studying microsclerotial germination of *C. crotalariae* in the rhizosphere of susceptible and resistant plants, Krigsvold *et al.* (1982) observed that germination was significantly higher in the rhizosphere of the susceptible versus the resistant cultivars.

Cultivation equipment and drainage water could spread *Cylindrocladium* black rot disease (Krigsvold *et al.*, 1977). They found that of 59 soil samples from groundnut cultivation equipment used in fields with histories of CBR, 52 contained microsclerotia of *C. crotalariae*.

The investigation of groundnut resistance to CBR using soil artificially inoculated with microsclerotia has been attempted. Thus Phipps & Beute (1977) found two groundnut cultivars to have some resistance when grown in artificially infected soil having densities of *C. crotalariae* microsclerotia as high as 1000/g soil, when other cultivars became severely diseased at inoculum level of 0.5 microsclerotia/g soil. After Rowe *et al.* (1974) found that soil control of CBR could be achieved by using wide spectrum biocides such as sodium azide, Hanounik *et al.* (1977) concluded from their trials that the proper combination of cultivar choice and sodium azide treatment could be important in controlling CBR.

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CYLINDROCLADIUM HAWKSWORTHII SP. NOV. PATHOGENIC ON WATER-LILIES IN MAURITIUS

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ABSTRACT

Cylindrocladium hawksworthii sp. nov. causes, usually in association with *Cylindrocladium quinqueseptatum*, a common foliage disease on *Nelumbo nucifera* and *Nymphaea lotus* in Mauritius. In infection trials it was also pathogenic to leaves of *Thea sinensis*, *Eucalyptus robusta* and *E. tereticornis*. The pathogen is described as a new *Cylindrocladium* species characterized by curved 1-septate conidia, 36-62 x 3-5 µm, and clavate to club-shaped and ellipsoidal vesicles, 25-110 x 5-9 µm.

Running Title: *Cylindrocladium hawksworthii* sp. nov.

Keywords: *Cylindrocladium hawksworthii*, water-lilies, *Nelumbo nucifera*, *Nymphaea lotus*.

INTRODUCTION

Two species of water-lilies, *Nelumbo nucifera* Gaertn. and *Nymphaea lotus* L. are affected by a foliage disease at Pamplemousses Garden in Mauritius. This is a matter of some concern since these water-lilies are a focus of tourist attraction. As the disease had not been previously studied or reported in Mauritius and elsewhere, an investigation was initiated to elucidate its nature, and it was soon realized that it was a disease complex in association with *Cylindrocladium quinqueseptatum* Boedijn & Reitsma together with what was clearly a hitherto undescribed species. The purpose of this paper is to report and describe this new species. The disease complex will be the subject of a separate publication.

Cylindrocladium species appear to be fairly common in Mauritius, and are particularly prevalent on tea and eucalyptus in the central super-humid zone of the island. *C. scoparium* Morgan causes a severe nursery disease of *Eucalyptus* (Peerally, 1990) while

Cylindrocladium quinqueseptatum Boedijn & Reitsma is commonly encountered on both tea and *Eucalyptus* (Peerally, 1974a). A decline of tea bushes was found to be associated with a disease complex involving *Cylindrocladium floridanum* Sob. & Seymour, *C. clavatum* Hodges & May and *C. camelliae* Venkatara. & Venkata Ram (Peerally, 1972b). A severe rot of tea cuttings was attributed to *C. floridanum* (Peerally, 1972a) while *C. colhounii* was first reported as a common foliage parasite of tea in Mauritius (Peerally, 1973, 1974b).

In a recent review of the genus *Cylindrocladium* (Peerally, 1990) twenty-six species are recognized. Species delimitation is mainly based on both conidial and vesicle morphology shown to be reliable taxonomic criteria when fresh cultures are studied in vivo and in vitro (Peerally, 1990).

MATERIALS AND METHODS

The *Cylindrocladium* species studied in this work was isolated from diseased leaves of *Nelumbo nucifera* and *Nymphaea lotus* collected from two fresh-water ponds at Pamplemousses Garden. Cultures on potato dextrose agar were initially obtained from leaf surfaces sterilized in sodium hypochlorite solution (1-2% available chlorine). Morphological studies were carried out with materials obtained in vivo from leaves of the host plants (Fig. 1, 2) and, in vitro, on potato dextrose agar, corn-meal agar and tap-water.

Pathogenicity tests were effected on the natural hosts *Nelumbo nucifera* and *Nymphaea lotus*, as well as on *Thea sinensis* L., *Eucalyptus robusta* J.E. Sm. and *E. tereticornis* J.E. Sm., which are known to be susceptible to *Cylindrocladium* species (Petch, 1923; Bell & Sobers, 1966; Figueiredo & Namekata, 1967; Sobers, 1972 & Peerally, 1974a). Artificially and naturally infected excised leaves were maintained in a moist box to induce profuse sporulation. Agar cultures were maintained at 25°C.

RESULTS

THE DISEASE

Symptoms on the two natural host species show some differences. Necrotic spots on *Nelumbo nucifera* are initially greyish, becoming dark brown to black. Mycelium and conidiophores of the pathogen are quite easily seen when the upper

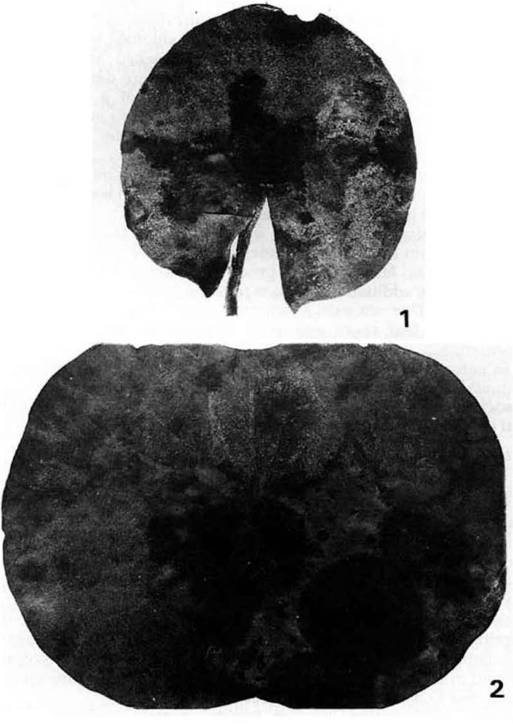


Fig. 1-2. Leaf of *Nymphaea lotus* (1) and of *Nelumbo nucifera* (2) showing mixed conidial masses of *C. quinqueseptatum* and *C. hawksworthii* n. sp..

surface of naturally infected leaves are examined under a stereoscopic microscope. The first indication of disease on *Nymphaea lotus* is the appearance of minute chlorotic specks. Such spots enlarge and become brown water-soaked areas which coalesce until the whole leaf, in severe attacks, turn dark brown to black, resulting in a wet rot. The presence of a fungus on *Nymphaea lotus* and *Nelumbo nucifera* becomes more evident after incubating diseased leaves in a moist atmosphere for some days, when profuse sporulation occurs (Fig. 1, 2).

Fortunately the disease caused by the pathogen on the water-lilies does not usually kill the host plants but infected leaves become unsightly and have to be periodically removed.

The *Cylindrocladium* under investigation was successfully reisolated from artificially inoculated leaves of *Nelumbo nucifera* and *Nymphaea lotus*, so that proof of pathogenicity has been established. In addition in infection tests the fungus was pathogenic to leaves of *Thea sinensis*, *Eucalyptus robusta* and *E. tereticornis*, dark brown leaf spots appearing within two days following inoculation.

In nature the pathogen occurs on leaves of *Nymphaea lotus* and *Nelumbo nucifera*, but not on petioles and stems, usually in association with *Cylindrocladium quinqueseptatum* (Fig. 1, 2), but leaf spots due to the latter are frequently more numerous.

THE PATHOGEN

Colonies on potato dextrose agar are a dark reddish-brown with irregular margin and tan aerial mycelium. Reddish-brown microsclerotia and thick-walled chlamydospores are produced in abundance as in most *Cylindrocladium* species. Cultures on corn-meal agar are of a light reddish-brown colour with sparse aerial mycelium. No coloration is produced on tap-water agar. Sporulation is usually poor on all three agar media but it is induced significantly when fully grown colonies on potato dextrose agar are damaged by cutting off fragments of agar. The rate of mycelial growth in artificial media is fairly good, giving colony diameters of 6 cm after 7 days growth on all three media.

Conidiophores (Fig. 3) erect, hyaline, septate, dichotomously branched, 250-500 µm long, inclusive of sterile appendage. Stipe conspicuous, septate with only a small proportion in agar cultures extended into the sterile appendage; sterile appendage 160-280 µm long, bearing a clavate to club-shaped and ellipsoidal vesicle, 25-

110 x 5-9 µm (Fig. 3-6, 7-9), primary conidiophore branches aseptate or 1-septate, 12-80 µm long; secondary branches aseptate or septate, 12-45 µm long; tertiary branches usually aseptate, 8-30 µm long; quaternary branches usually aseptate, 7-35 µm long; phialides solitary or in groups of 2 to 3 or sometimes arising directly from the stipe, hyaline, aseptate, 7-13 µm long; conidia hyaline, curved, rarely straight or sigmoid, (Fig. 3-5, 10), 1-septate, 36-62 µm x 3-5 µm.

The morphological features of the conidiophores, sterile appendage, vesicles and conidia are comparable in vivo (Fig. 3-6) and in vitro (Fig. 7-10), cultures on potato dextrose, corn-meal and tap-water agar producing curved conidia and normal vesicles. The occurrence of quaternary conidiophore branches was observed in vivo only.

DISCUSSION

The species of *Cylindrocladium* described in this paper is a pathogen on *Nelumbo nucifera* and *Nymphaea lotus* under natural conditions. Pathogenicity tests show that it has a wider potential host range, being also pathogenic to leaves of tea, *Eucalyptus teriticornis* and *E. robusta*. The differences in symptoms on *N. nucifera* and *N. lotus* are reminiscent of those caused by *Cylindrocladium colhounii* which produces a dry rot on tea leaves while on groundnut leaves it induces a wet rot (Peerally, 1973).

Although sporulation on potato dextrose, corn meal and tap-water agar is sparse, when infected host leaves are incubated profuse conidiophore formation occurs giving a striking talc-like appearance to the conidial masses.

Peerally (1990), in a comprehensive review of the genus *Cylindrocladium*, recognized 26 species one of which, *C. curvatum*, normally has curved conidia only.

As Sobers (1968) has clearly shown, *C. pteridis* Wolf (syn. *C. macrosporum* Sherbakoff) produces two conidial forms on the infected hosts: a large-spored form which has 1-septate straight conidia 61-118 x 5-7 µm, and a small-spored form with curved, 1-septate conidia 23-47 x 3-5 µm. However the small-spored form is rarely produced on conventional agar media and only in the presence of the large-spored form in old cultures. According to Sobers (1968) single spore transfers of the small and large forms on PDA yielded only colonies of the large form of *C. pteridis*. Mycelial transfers of the large form to water agar give rise to the large form

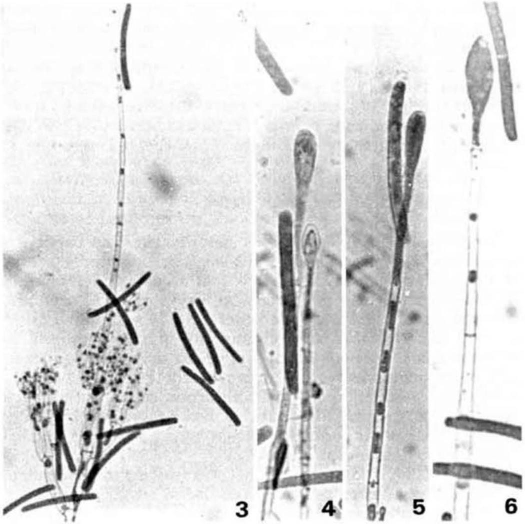
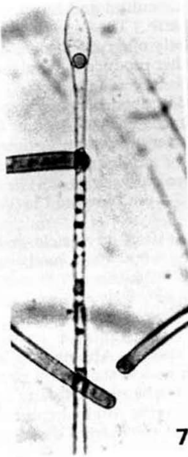


Fig. 3. Conidiophore and conidia of *C. hawksworthii* n. sp. in vivo.
Fig. 4-6. Sterile appendage and vesicle of the same in vivo.
Fig. 7-9. Sterile appendage and vesicle of *C. hawksworthii* n. sp. in vitro. Fig. 10. Conidia of the same in vitro. (next page)



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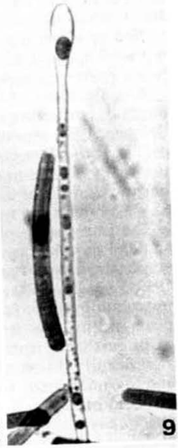

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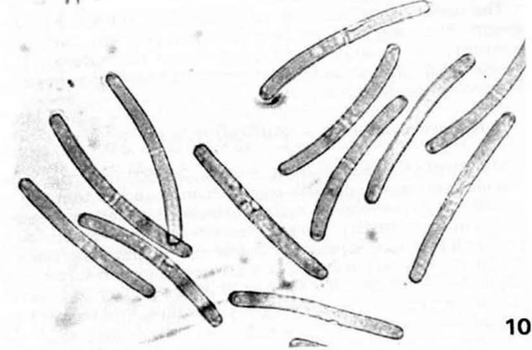

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immediately surrounding the transferred inoculum and the small form throughout the rest of the plate. The species of *Cylindrocladium* reported here produces only one type of conidia whose shape and size are comparable whether produced in vivo on living hosts or on culture media.

A comparison of the *Cylindrocladium* described here with the original description of *C. curvatum* Boedijn & Reitsma (Boedijn & Reitsma, 1950) shows the two to be clearly very different. Vesicles of *C. curvatum* are globose to subglobose, 6-7 x 5 µm as compared to usually clavate to club-shaped and ellipsoidal vesicles, 25-110 x 5-9 µm. Conidia of *C. curvatum* are 40-46 x 3-4 µm compared to 36-62 x 3-5 µm for the water-lily isolate.

The importance of basing species delineation on vesicle and conidial morphology in the taxonomy of *Cylindrocladium* has been emphasized by various workers (Sobers, 1969; Morrison & French, 1969; Peerally, 1974a, 1990). On the strength of vesicle and conidial morphology the species described in this paper is clearly outstanding by its normally curved conidia, and easily distinguishable from all other published species. Although it is significantly different from *C. curvatum* in vesicle shape and size and in conidial size, the latter is not regarded to be a valid species in not conforming to nomenclatural rules, since the original culture was totally lost by its authors at the time of its publication (Boedijn & Reitsma, 1950) and never seen again.

The name *Cylindrocladium hawksworthii* is proposed for the species occurring on *Nymphaea lotus* and *Nelumbo nucifera* in Mauritius, in honour of the contribution of Professor D.L. Hawksworth, Director of CAB International Mycological Institute, to mycology worldwide.

Cylindrocladium hawksworthii Peerally, n. sp.

Conidiophores erect, hyaline, septate, 250-500 µm long. Stipe conspicuous septate; primary conidiophore branches 1-septate or aseptate 12-80 µm long; secondary branches 1-septate or aseptate 12-45 µm long; tertiary branches usually aseptate 8-30 µm long; quaternary branches usually aseptate 7-35 µm long; sterile appendage 160-280 µm long, bearing a clavate to club-shaped and ellipsoidal vesicle 25-110 x 5-9 µm; phialides solitary or in small groups, sometimes arising directly from the stipe, hyaline, aseptate, 7-13 µm long; conidia, hyaline,cylindrical, curved, 1-septate, 36-62 x 3-5 µm. In leaves of *Nelumbo nucifera* Gaertn. (holotype in

Herbarium MUCL 30866) and *Nymphaea lotus* L. (paratype in Herbarium MUCL 30865), Pamplemousses Garden, Mauritius. Living ex-type culture MUCL 30866.

Cylindrocladium hawksworthii Peerally, sp. nov.

Conidiophora erecta, hyalina, septata, 250-500 µm longa, stipite manifeste septato, primis ramis 1-septatis vel non septatis, 12-80 µm longis, secondis ramis 1-septatis vel non septatis, 12-45 µm longis, tertiis ramis saepe non septatis, 8-30 µm longis, quaternis ramis, saepe non septatis, 7-35 µm longis, sterile appendice, 160-280 µm longo, clavato vel ellipsoideo, 25-110 x 5-9 µm vesiculo terminato. Phialides solitariae vel paucae aggregatae, ad ramos vel demum ad stipem, hyalinae, non septatae, 7-13 µm longae. Conidia, hyalina, cylindrica, curvata, 1-septata, 36-62 x 3-5 µm. In foliis *Nelumbis nuciferae* Gaertn. (holotypus in herbario MUCL 30866) and *Nymphaeae lotus* L. (paratypus in herbario MUCL 30865), Pamplemousses Horto Botanico, in Mauritio. Viva cultura MUCL 30866 e typo.

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EIGHT NEW SPECIES IN THE LICHEN GENUS PARMELIA (PARMELIACEAE, ASCOMYCOTINA) FROM SOUTHERN AFRICA WITH NOTES ON SOUTHERN AFRICAN LICHENS

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ABSTRACT

Eight new species in the lichen genus *Parmelia* (Parmeliaceae, Ascomycotina) are described from Southern Africa. They are: *Parmelia abraxas* Brusse, *P. adamantea* Brusse, *P. assimilis* Brusse, *P. lucrosa* Brusse, *P. musculina* Brusse, *P. oreophila* Brusse, *P. parilis* Brusse and *P. putida* Brusse. Four new combinations are made: *Gonolecania fumosonigricans* (Müll. Arg.) Brusse, *Parmelia brevilobata* (Hale) Brusse, *P. esterhuyseniae* (Hale) Brusse and *P. tsekensis* (Hale) Brusse. Fifteen new lichen records for southern Africa are noted and several miscellaneous notes and corrections are presented.

NEW SPECIES

Parmelia abraxas Brusse, *sp. nov.* Fig. 4.

Thallus parvofoliosus, saxicola, usque ad 4 cm diametro, sat adnatus. *Lobi* sublineares vel lineares, 0.1 – 0.7 mm lati, 50 – 110 µm crassi, plani vel leviter concavi, fragiles; margines pseudociliati, rhizinis marginalibus atris, longis. *Thallus superne* viridis, nitidus, isidiis sorediisque destitutus, nigromarginatus; epicortice poroso. *Cortex superior* 8 – 15 µm crassus. *Stratum gonidiale* 15 – 30 µm crassum, algis *Trebouxiis*, 3 – 18 µm diametris. *Medulla* alba, 10 – 65 µm crassa. *Cortex inferior* circa 10 µm crassus. *Thallus inferne* piceus, parce rhizinatus, sed copiose pseudociliatus. *Rhizinae* simplices, 20 – 70 µm crassae. *Apothecia* et *pycnidia* non visa. *Thallus* acidum usnicum et acidum diffractaicum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On Table Mountain Sandstone cliffs on steep S slope. Alt. 1640 m (-**DC**). *F. Brusse 5461*, 21. iii. 1988 (**PRE**, holo-; **BM**, iso-). Figura 4.

This paper is dedicated in memory of Dr. Mason E. Hale Jnr. (†) in recognition of his substantial contribution to lichenology, in particular to the chemotaxonomy of the Parmeliaceae.

Thallus small foliose, saxicolous, up to 4 cm across. *Lobes* sublinear to linear, 0.1 – 0.7 mm wide, 50 – 110 μm thick, flat or slightly concave, brittle; margins pseudociliate, marginal rhizines black, long. *Upper surface* green, glossy, neither isidiate nor sorediate, black lined; epicortex pored. *Upper cortex* 8 – 15 μm thick. *Algal layer* 15 – 30 μm thick; algae *Trebouxia*, 3 – 18 μm diam. *Medulla* white, 10 – 65 μm thick. *Lower cortex* about 10 μm thick. *Lower surface* black, sparsely rhizinate, but abundantly pseudociliate. *Rhizines* simple, 20 – 70 μm thick. *Apothecia* and *pycnidia* not seen. *Chemistry*: Usnic acid in the upper cortex, and diffractaic acid in the medulla (traces of barbatic, 4-O-demethylbarbatic and 4-O-demethyldiffractaic acids are also present).

This is another peculiar new species, which is attached to the substrate only by rhizines. The rhizines are very abundant and longer on the margins and are here termed pseudocilia, but still serve to attach the lichen to the substrate and so are not true cilia. The lichen gives the impression of a centipede or a dual-in-line electronic device. The central parts do not become subareolate, and the whole lichen is easy to remove cleanly from the substrate with watch-maker's forceps, although the lobes are rather brittle. There are no other lichens comparable to *P. abraxas*, but *P. heterodoxa* Hale (1971) is a similar small lichen with easily detached lobes. *P. heterodoxa*, however, does not have pseudocilia and contains olivetoric acid.

So far, this new species is known only from the type locality, Jona's Kop in the Riviersonderend Mountains near Villiersdorp.

Parmelia adamantea Brusse, *sp. nov.* Fig. 5.

Thallus foliosus, saxicola, sat adnatus, usque ad 4 cm diametro. *Lobi* sublineares, 0.3 – 1.2 mm lati, 150 – 480 μm crassi, leviter convexi, coriacei. *Thallus superne* brunneus, nitidus, isidiis sorediisque destitutus, dilute maculatus, epicortice poroso. *Cortex superior* circa 20 μm crassus. *Stratum gonidiale* 15 – 70 μm crassum, algis *Trebouxiis*, 4.5 – 20 μm diametris. *Medulla* albida, 70 – 390 μm crassa. *Cortex inferior* 10 – 15 μm crassus. *Thallus inferne* pallide brunneus vel brunneus, non rhizinatus. *Apothecia* non visa. *Pycnidia* hyalina, globosa, circa 100 μm diametris. *Pycnidiosporae* hyalinae, aciculares, rectae, 4 – 6.5 × 0.8 μm. *Thallus* acidum hyposticticum, acidum sticticum et acidum hypoconsticticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE — **3319** (Worcester): Summit of Waboomberg near Ceres. On Table Mountain Sandstone on S slope. Alt. 1850 m (**-AD**). *F.Brusse 5387b*, 16. iii. 1988 (**PRE**, holo-; **BM**, iso-). Figura 5.

Thallus foliose, saxicolous, moderately adnate, up to 4 cm across. *Lobes* sublinear, 0.3 – 1.2 mm wide, 150 – 480 μm thick, lightly convex, leathery. *Upper surface* brown, glossy, not isidiate and not sorediate, faintly maculate; epicortex pored. *Upper cortex* about 20 μm thick. *Algal layer* 15 – 70 μm thick; algae *Trebouxia*, 4.5 – 20 μm diam. *Medulla* whitish, 70 – 390 μm thick. *Lower cortex* 10 – 15 μm thick. *Lower surface* pale brown to brown, not rhizinate. *Apothecia* not seen. *Pycnidia* hyaline, globose, about 100 μm diam. *Pycnidiospores* hyaline, straight needles, 4 – 6.5 × 0.8 μm. *Chemistry*: Hypostictic, stictic and hypoconstictic acids present.

The upper surface of this new species is HNO_3 + blue-green and therefore might be considered to be a *Neofuscelia*. However, the upper cortex is anticlinally prosoplectenchymatous and cannot be considered a true member of this group. Morphologically this species is similar to both *P. dregeana* Hampe ex Nyl. and *P. tentaculina* Essl., but differs from both of these in the unusual combination of lichen substances. Accordingly, *P. dregeana* contains norstictic acid and *P. tentaculina* Essl. contains hypostictic, hyposalazinic, and hypoconstictic acids but lacks more highly oxidized depsidones, whereas *P. adamantea* contains hypostictic and hypoconstictic acids together with stictic acid.

Parmelia adamantea also differs morphologically from these two species, in that it lacks rhizines. The lobes are very strongly attached to the sandstone surface by lobe edges and loboid holdfasts, but are not closely appressed (figure 5), the points of attachment being rather sparse. However, the rhizines of *P. dregeana* and *P. tentaculina* are rather coarse, and Esslinger (1977) described the rhizines of *P. dregeana* as hapterate.

The lower part of the medulla is partially and irregularly infarcated by the lower cortex in this new species. That is, the hyphae in the lower part of the medulla are denser, with the tissue here being subchondroid and approaching the chondroid lower cortex in texture. The lobes are very tough and leathery as a result of this.

At present, this new species is known only from the type collection from the summit of Waboomberg near Ceres.

Parmelia assimilis Brusse, *sp. nov.* Fig. 6.

Thallus foliosus, saxicola, laxe adnatus, usque ad 6 cm diametro. *Lobi* lineares, 0.2 – 1.0 mm lati, 100 – 290 µm crassi, constricti. *Thallus superne* viridis, nitidus, isidiis sorediisque destitutus, nigromarginatus, epicortice poroso. *Cortex superior* 13 – 25 µm crassus. *Stratum gonidiale* 20 – 70 µm crassum, algis *Trebouxiis*, 4.5 – 18.5 µm diametris. *Medulla* alba, 45 – 205 µm crassa. *Cortex inferior* 10 – 15 µm crassus. *Thallus inferne* pallide brunneus, sat rhizinatus. *Rhizinae* simplices, 70 – 220 µm crassae. *Apothecia* non visa. *Pycnidia* hyalina, globosa, circa 200 µm diametris. *Pycnidiosporae* hyalinae, rectae, aciculares, 5 – 7.5 × 0.8 µm. *Thallus* acidum usnicum, acidum protoconstipaticum et acidum constipaticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On S facing Table Mountain Sandstone cliffs. Alt. 1640 m (-**DC**). *F. Brusse 5473*, 21. iii. 1988 (**PRE**, holo-; **ANUC**, **BM**, **COLO**, **LD**, iso-). Figura 6.

Thallus foliose, saxicolous, loosely adnate, up to 6 cm across. *Lobes* linear, 0.2 – 1.0 mm wide, 100 – 290 µm thick, constricted. *Upper surface* green, glossy, neither isidiate nor sorediate, black margined; epicortex pored. *Upper cortex* 13 – 25 µm thick. *Algal layer* 20 – 70 µm thick, algae *Trebouxia*, 4.5 – 18.5 µm diam. *Medulla* white, 45 – 205 µm thick. *Lower cortex* 10 – 15 µm thick. *Lower surface* pale brown, moderately rhizinate. *Rhizines* simple, 70 – 220 µm thick. *Apothecia* not seen. *Pycnidia* hyaline, globose, about 200 µm diam. *Pycnidiospores* hyaline, straight needles, 5 – 7.5 × 0.8 µm. *Chemistry*: Usnic acid in the cortex, protoconstipatic and constipatic acids in the medulla.

This new species is probably most closely related to *Parmelia subdecipiens* Vain. ex Lynge, but the lobes are much narrower and are often constricted.

Superficially it resembles the common *Parmelia constrictans* Nyl., but the lower side is pale, instead of black, and the medulla is negative to all spot tests, whereas that of *P. constrictans* is K + red. *P. almbornii* Hale (1971) is similar, but lacks constrictions and contains fumarprotocetraric acid.

At present, this new species is known only from the type locality, the summit of Jona's Kop in the Riviersonderend Mountains nearest Villiersdorp.

Parmelia lucrosa Brusse, *sp. nov.* Fig. 7.

Thallus parvofoliosus, saxicola, arcte adnatus, usque ad 4 cm diametro. *Lobi* elongati, 0.2 – 1.0 mm lati, 50 – 160 μm crassi. *Thallus superne* flavo-viridis, nitidus, isidiis sorediisque destitutus, epicortice poroso. *Cortex superior* 9 – 15 μm crassus. *Stratum gonidiale* 15 – 50 μm crassum, algis *Trebouxiis*, 6 – 20 μm diametris. *Medulla* alba, 10 – 100 μm crassa. *Cortex inferior* 8 – 10 μm crassus. *Thallus inferne* pallide brunneus, sat rhizinatus. *Rhizinae* parvae, non bene evolutae, 20 – 50 μm crassae. *Apothecia* adnata, sat numerosa, usque ad 1 mm diametris. *Thecium* cum crystallis lanceolatis (oxalas calcii), 40 – 130 μm seorsum dispositis, anticlinate penetratum. *Hypothecium* hyalinum, 10 – 20 μm crassum, J -. *Subhymenium* hyalinum, 10 – 20 μm crassum, J + pallide caeruleum. *Hymenium* hyalinum, 45 – 55 μm crassum, J + caeruleum. *Asci* clavati, tholis J + caeruleis (figura 1). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 7.5 – 11.0 × 4.5 – 7.0 μm. *Pycnidia* globosa, hyalina, circa 100 μm diametris. *Pycnidiosporae* hyalinae, rectae, aciculares, 5 – 7 × 0.8 μm. *Thallus* acidum usnicum, acidum evernicum, et acidum lecanoricum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE — **3320** (Montagu): 7 km SW of Montagu. Kogman's Kloof. Langeberg. On S faces of large Table Mountain Sandstone outcrop on steep W slope. Alt. 200 m (-CC). *F. Brusse 3700*, 12. v. 1981 (**PRE**, holo-; **COLO**, iso-). Figura 7.

Thallus small foliose, saxicolous, tightly adnate, up to 4 cm across. *Lobes* elongate, 0.2 – 1.0 mm wide, 50 – 160 μm thick. *Upper surface* yellow-green, glossy, not isidiate and not sorediate; epicortex pored. *Upper cortex* 9 – 15 μm thick. *Algal layer* 15 – 50 μm thick, algae *Trebouxia*, 6 – 20 μm diam. *Medulla* white, 10 – 100 μm thick. *Lower cortex* 8 – 10 μm thick. *Lower surface* pale brown, moderately rhizinate. *Rhizines* small, not well developed, 20 – 50 μm thick. *Apothecia* adnate, moderately numerous, up to 1 mm across. *Thecium* penetrated by vertical lanceolate calcium oxalate crystals spaced 40 – 130 μm apart. *Hypothecium* hyaline, 10 – 20 μm thick, J -. *Subhymenium* hyaline, 10 – 20 μm thick, J + pale blue. *Hymenium* hyaline, 45 – 55 μm thick, J + blue. *Asci* clavate, eight-spored; tholus J + blue (figure 1). *Ascospores* hyaline, unilocular, ellipsoid, 7.5 – 11.0 × 4.5 – 7.0 μm. *Pycnidia* globose, hyaline, about 100 μm diam. *Pycnidiospores* hyaline, straight needles, 5 – 7 × 0.8 μm. *Chemistry:* Usnic acid in the cortex, evernic and lecanoric acids in the medulla.

The regularly spaced, lanceolate, calcium oxalate crystals in the thecium of mature apothecia, set this lichen apart from other Xanthoparmeliae. The lanceolate calcium oxalate crystals, seem to start in the algal layer below the hypothecium, and penetrate all three layers of the thecium, the hypothecium, the subhymenium and the hymenium. The hard vertical stakes of calcium oxalate in the thecium, probably serve as a feeding deterrent for mycophagous grazers. Mites are known to feed on the hymenium of lichens, and the presence of these calcium oxalate stakes would probably deter feeding on the hymenium and underlaying layers, by causing excessive wear on the mouth parts of such mites. Despite the selective advantage this characteristic must give this lichen, it is not common and is collected only rarely. These calcium oxalate stakes have not been observed in any other *Parmelia*.

Otherwise this lichen approaches *P. scitula* Brusse (1984) with a similar habit, and containing lecanoric acid (without evernic acid) in the medulla. *P. lucrosa* contains both lecanoric and evernic acids in the medulla. Needless to say, *P. scitula* does not have lanceolate calcium oxalate stakes in the thecium.

Parmelia spissa Brusse (1988a) is also similar to *P. lucrosa*, but lacks lanceolate calcium oxalate stakes in the thecium, and the upper surface is coarse-pruinose to matt, not glossy like that of *P. lucrosa*. The pycnidiospores of *P. lucrosa* are only 5 – 7 μm long, whereas those of *P. spissa* are 7.5 – 11.5 μm long. The chemistries of these two species are identical.

Thus far, this new species is known only from the type locality at Kogman's Kloof near Montagu.

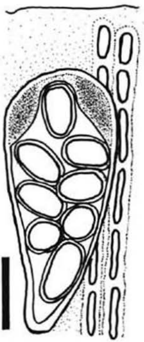

FIGURE 1. – **Parmelia lucrosa** Brusse, ascus and paraphyses. F. Brusse 3700, holotype. Bar = 10 μm.

Parmelia musculina Brusse, *sp. nov.* Fig. 8.

Thallus foliosus, saxicola, laxe adnatus, usque ad 6 cm diametro. *Lobi* lineares, 0.2 – 1.2 mm lati, 140 – 250 μm crassi. *Thallus superne* viridis, nitidus, isidiis sorediisque destitutus, epicortice poroso. *Cortex superior* 15 – 20 μm crassus. *Stratum gonidiale* 20 – 45 μm crassum, algis *Trebouxiis*, 5.5 – 19 μm diametris. *Medulla* alba, 80 – 170 μm crassa. *Cortex inferior* 8 – 20 μm crassus. *Thallus inferne* piceus, sparse rhizinatus. *Rhizinae* circa 100 μm crassa. *Apothecia* non visa. *Pycnidia* numerosa, globosa, hyalina, circa 100 μm diametris. *Pycnidiosporae* hyalinae, rectae, aciculares, 4.5 – 6.5 × 0.8 μm. *Thallus* acidum usnicum, acidum hyposticticum et acidum sticticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Waboomberg near Ceres. On Table Mountain Sandstone on S slope. Alt. 1850 m (**-AD**). *F. Brusse 5382*, 16. iii. 1988 (**PRE**, holo-; **ANUC**, **B**, **BM**, **COLO**, **LD**, **S**, **UPS**, **US**, iso-). Figura 8.

Thallus foliose, saxicolous, loosely adnate, up to 6 cm across. *Lobes* linear, 0.2 – 1.2 mm wide, 140 – 250 μm thick. *Upper surface* green, glossy, neither isidiate nor sorediate; epicortex pored. *Upper cortex* 15 – 20 μm thick. *Algal layer* 20 – 45 μm thick, algae *Trebouxia*, 5.5 – 19 μm diam. *Medulla* white, 80 – 170 μm thick. *Lower cortex* 8 – 20 μm thick. *Lower surface* black, sparsely rhizinate. *Rhizines* about 100 μm thick. *Apothecia* not seen. *Pycnidia* numerous, globose, hyaline, about 100 μm diam. *Pycnidiospores* hyaline, straight needles, 4.5 – 6.5 × 0.8 μm. *Chemistry:* Usnic acid in the cortex, hypostictic and stictic acids in the medulla (traces of hyposalazinic, hypoconstictic and constictic acids also present.)

This new species resembles *Parmelia suberadicata* des Abb., except it contains significant quantities of both stictic and hypostictic acids in the medulla, whereas *P. suberadicata* contains only stictic acid. The lobes of *P. musculina* also tend to be slightly convex, whereas those of *P. suberadicata* tend to be flat.

At present, this new species is known only from the type collection from Waboomberg near Ceres.

Parmelia oreophila Brusse, *sp. nov.* Fig. 9, 10.

Thallus foliosus, saxicola, laxe adnatus, usque ad 5 cm diametro. *Lobi* lineares, 0.2 – 2.0 mm lati, 95 – 230 μm crassi. *Thallus superne* flavo-viridis, subnitidus, isidiis sorediisque destitutus, epicortice poroso. *Cortex superior* 18 – 30 μm crassus, passim rubrotinctus. *Stratum gonidiale* 35 – 60 μm crassum, algis *Trebouxiis*, 4.5 – 13.5 μm diametris. *Medulla* alba, 10 – 140 μm crassa. *Cortex inferior* 5 – 12 μm crassus. *Thallus inferne* pallide brunneus, sparse rhizinatus. *Rhizinae* simplices, 50 – 80 μm crassae. *Apothecia* adnata, usque ad 2 mm diametris, sat numerosa. *Hymenium* non visum. *Pycnidia* non visa. *Thallus* acidum usnicum, acidum protoconstipaticum, et acidum constipaticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE — **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On Table Mountain Sandstone rocks on N slope. Alt. 1630 m (-DC). *F. Brusse 5452*, 21. iii. 1988 (**PRE**, holo-; **BM**, **LD**, iso-). Figurae 9, 10.

Thallus foliose, saxicolous, loosely adnate, up to 5 cm across. *Lobes* linear, 0.2 – 2.0 mm wide, 95 – 230 μm thick. *Upper surface* yellow-green, subnited, neither isidiate nor sorediate; epicortex pored, but absent in central parts. *Upper cortex* 18 – 30 μm thick, tinged red in places. *Algal layer* 35 – 60 μm thick, algae *Trebouxia*, 4.5 – 13.5 μm diam. *Medulla* white, 10 – 140 μm thick. *Lower cortex* 5 – 12 μm thick. *Lower surface* pale brown, sparsely rhizinate. *Rhizines* simple, 50 – 80 μm thick. *Apothecia* adnate, up to 2 mm across, moderately numerous. *Hymenium* not seen (all damaged by mite grazing). *Pycnidia* not seen. *Chemistry:* Usnic acid in the cortex, protoconstipatic and constipatic acids in the medulla.

This peculiar looking *Parmelia* has an upper cortex which is red tinged in places. The upper surface is also strange, with the margins appearing more translucent than the interior (figure 9). Indeed, the translucent margins are pored epicorticate, whereas the more opaque interior lacks an epicortex (figure 10). This is a consequence of the epicortex sloughing-off in the central parts, but remaining attached at the margins (figure 10). The epicortex of *P. assimilis* Brusse, a closely related species from the same locality, shows none of these peculiar features. Further, *P. oreophila* does not have constricted lobes like *P. assimilis*. Although these two species were collected at the same locality, *P. oreophila* occurs on the north slope, whereas *P. assimilis* occurs on steep south facing cliffs. For these reasons these two species are upheld as distinct.

Apothecia are present on the holotype (figure 9), but all lack any hymenium, and most of them have the white medulla exposed. This is presumed to be caused by mites, which often show a preference for thecial tissue. It is interesting that apothecia could not be found on *P. assimilis*, even though the type material is more ample than that of *P. oreophila*. The reverse is true for the pycnidia – none being found on *P. oreophila*, but being present in moderate numbers on *P. assimilis*. However, these observations are probably not significant.

At present, this new species is known only from the type locality, the summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp.

Parmelia parilis Brusse, *sp. nov.* Fig. 11.

Thallus foliosus, saxicola, usque ad 8 cm diametro, sat adnatus. *Lobi* elongati, 1 – 3 mm lati, 80 – 350 µm crassi. *Thallus superne* brunneus, nitidus, isidiis sorediisque destitutus, epicortice poroso. *Cortex superior* paraplectenchymatus, 10 – 20 µm crassus. *Stratum gonidiale* 15 – 60 µm crassum, algis *Trebouxiis*, 5 – 23 µm diametris. *Medulla* marronina vel violacea, 20 – 260 µm crassa. *Cortex inferior* 8 – 10 µm crassus. *Thallus inferne* pallide brunneus, copiose rhizinatus. *Rhizinae* simplices, 30 -100 µm crassae. *Apothecia* adnata, sat numerosa vel numerosa, usque ad 6 mm diametris. *Hypothecium* hyalinum, 15 – 40 µm crassum, J -. *Subhymenium* hyalinum, 5 – 10 µm crassum, J + pallide caeruleum. *Hymenium* hyalinum, 45 – 55 µm crassum J + caeruleum. *Asci* clavati, tholis J + caeruleis (figura 2). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 8 – 11 × 4.5 – 6.5 µm. *Pycnidia* non visa. *Thallus* acidum protocetraricum, et quatuor pigmenta anthraquinona ignota (ut in *Parmelia endomiltode* Nyl.) continens.

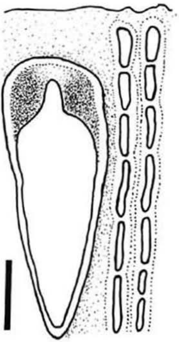

FIGURE 2. – **Parmelia parilis** Brusse, ascus and paraphyses. F. Brusse 5375, holotype.

TYPUS: SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Waboomberg near Ceres. On Table Mountain Sandstone on NE slope. Alt. 1850 m (-**AD**). *F. Brusse 5375*, 16. iii. 1988 (**PRE**, holo-; **ANUC**, **BM**, **COLO**, **LD**, iso-). Figura 11.

Thallus foliose, saxicolous, up to 8 cm across, moderately adnate. *Lobes* elongate, 1 – 3 mm broad, 80 – 350 µm thick. *Upper surface* brown, glossy, neither isidiate nor sorediate; epicortex pored. *Upper cortex* paraplectenchymatous, 10 – 20 µm thick. *Algal layer* 15 – 60 µm thick, algae *Trebouxia*, 5 – 23 µm diam. *Medulla* maroon to violet, 20 – 260 µm thick. *Lower cortex* 8 – 10 µm thick. *Lower surface* pale brown, copiously rhizinate. *Rhizines* simple, 30 – 100 µm thick. *Apothecia* adnate, moderately numerous to numerous, up to 6 mm across. *Hypothecium* hyaline, 15 – 40 µm thick, J -. *Subhymenium* hyaline, 5 – 10 µm thick, J + pale blue. *Hymenium* hyaline, 45 – 55 µm thick, J + blue. *Asci* clavate, eight-spored; tholus J + blue (figure 2). *Ascospores* hyaline, simple, ellipsoid, 8 – 11 × 4.5 – 6.5 µm. *Pycnidia* not seen. *Chemistry:* protocetraric acid and four unknown anthraquinone pigments (as in *Parmelia endomiltodes* Nyl.)

This new species is very similar to *Parmelia vernicosa* Brusse (1984) but contains protocetraric acid in addition to unknown anthraquinones (as found in *Parmelia endomiltodes* Nyl.), whereas *P. vernicosa* contains no substances in addition to these "*endomiltodes*" anthraquinones. *P. parilis* is even more closely related to the grey *Parmelia violacea* Kurok., than *P. vernicosa* is, because it contains protocetraric acid, a depsidone metabolite closely related to the succinoprotocetraric and fumarprotocetraric acids found in *P. violacea* (Hale 1976).

Thus far, this new species is known only from the type locality, Waboomberg near Ceres.

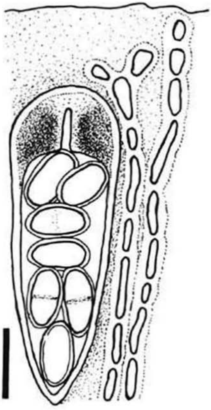

FIGURE 3. – **Parmelia putida** Brusse, ascus and paraphyses. F. Brusse 5440, holotype. Bar = 10 μm.

Parmelia putida Brusse, *sp. nov.* Fig. 12.

Thallus parvofoliosus, saxicola, sat adnatus, usque ad 3 cm diametro. *Lobi* sublineares, 0.2 – 0.8 mm lati, 75 – 185 μm crassi, axillis obtusis. *Thallus superne* brunneus, nitidus, isidiis sorediisque destitutus, epicortice poroso. *Cortex superior* paraplectenchymatus, 10 – 20 μm crassus. *Stratum gonidiale* 20 – 55 μm crassum, algis *Trebouxiis*, 4.5 – 17 μm diametris. *Medulla* alba, 20 – 115 μm crassa. *Cortex inferior* 8 – 15 μm crassus. *Thallus inferne* piceus, parce rhinatus. *Rhizinae* simplices, 70 – 110 μm crassae. *Apothecia* adnata, sparsa, usque ad 2.5 mm diametris. *Hypothecium* hyalinum, 30 – 60 μm crassum, J -. *Subhymenium* hyalinum, 5 – 20 μm crassum, J + pallide caeruleum. *Hymenium* hyalinum, 60 – 70 μm crassum, J + caeruleum. *Asci* clavati, tholis J + caeruleis (figura 3). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 9 – 12.5 × 5 – 7 μm. *Pycnidia* globosa, hyalina, circa 100 μm diametris. *Pycnidiosporae* hyalinae, aciculares, rectae, 5 – 8 × 0.8 μm. *Thallus* acidum isousnicum, acidum sticticum et acidum consticticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On Table Mountain Sandstone rocks on N slope. Alt. 1630 m (-**DC**). *F. Brusse 5440*, 20. iii. 1988 (**PRE**, holo-; **BM**, **LD**, iso-). Figura 12.

Thallus small foliose, saxicolous, adnate, up to 3 cm across. *Lobes* sublinear, 0.2 – 0.8 mm broad, 75 – 185 μm thick, axils obtuse. *Upper surface* brown, glossy, neither isidiate nor sorediate; epicortex pored. *Upper cortex* paraplectenchymatous, 10 – 20 μm thick. *Algal layer* 20 – 55 μm thick, algae *Trebouxia*, 4.5 – 17 μm diam. *Medulla* white, 20 – 115 μm thick. *Lower cortex* 8 – 15 μm thick. *Lower surface* black, sparsely rhizinate. *Rhizines* simple, 70 – 110 μm thick. *Apothecia* adnate, sparse, up to 2.5 mm diam. *Hypothecium* hyaline, 30 – 60 μm thick, J -. *Subhymenium* hyaline, 5 – 20 μm thick, J + pale blue. *Hymenium* hyaline, 60 – 70 μm thick, J + blue. *Asci* clavate, eight-spored; tholus J + blue (figure 3). *Ascospores* hyaline, simple, ellipsoid, 9 – 12.5 × 5 – 7 μm. *Pycnidia* globose, hyaline, about 100 μm diam. *Pycnidiospores* hyaline, straight needles, 5 – 8 × 0.8 μm. *Chemistry:* Isousnic, stictic and constictic acids present.

This is a peculiar new *Parmelia* species, because it contains isousnic acid. The upper cortex is also clearly paraplectenchymatous (checked by means of scanning electron microscopy of lobe sections), and is also brown in colour, which turns to green with concentrated nitric acid. This paraplectenchymatous structure of the upper cortex is quite common in the genus *Neofuscelia* proposed by Esslinger (1978), but some species placed here by him have an anticlinal prosoplectenchymatous structure.

This new lichen resembles a browned specimen of *P. interrupta* Stiz., which also has a paraplectenchymatous upper cortex, but the latter is very tightly adnate and contains cortical usnic acid. The obtuse lobe axils (figure 12) of *Parmelia putida*, are quite characteristic, and have not been seen in *P. interrupta*. *Parmelia xanthomelaena* Müll. Arg. resembles this species more closely, but also lacks obtuse lobe axils and has usnic acid in the upper cortex.

Thus far, this new species is known only from the type locality, the summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp.

NEW COMBINATIONS IN PARMELIA

Eriksson & Hawksworth (1989) argued that the lichen names listed as conserved in Appendix III A ("*Nomina generica conservanda et rejicienda*") in the International Code of Botanical Nomenclature (Greuter 1988), can only be considered as having been endorsed as the list has appeared unchallenged since 1956. However, close examination of the code reveals that there is no clause, that allows endorsement by such a procedure. The names were presumably neglected after the Paris Congress (Ahlner 1954), probably due to the lack of lobbyists for the lichen names at subsequent Congresses. This has resulted in the failure to get the names from the Special Committee stage, into the General Committee and then finally submitted to a vote by a general assembly of an International Botanical Congress.

If it is generally felt that such a change would result in even further destabilization, then it would be advisable to recommend *P. saxatilis* (L) Ach. as type to a future Congress (as was done by the Special Committee for Lichenes at Paris). However, there is no indication that the names have proceeded further than a Special Committee to date (Brusse 1988a).

There are good reasons for rejecting the type selected by Fink (1910), that is *P. elacista*. The reason being that Acharius (1810) himself implicitly excluded this species as type, by excluding it from *Parmelia* and placing it in synonomy with *Lecanora coarctata* (= *Discocera* A.L. Sm. & Ramsb.). No such objections exist for *P. conspersa*, the species selected by Clements & Shear (1931).

As the nomenclatural and taxonomic ambiguities still persist, the following new combinations in *Parmelia* are proposed:

Parmelia brevilobata (Hale) Brusse, *comb. nov.*
Basionym: *Xanthoparmelia brevilobata* Hale, Mycotaxon **29**: 253. 1987.

This lichen was originally thought to be a synonym of *Parmelia saniensis* (Hale) Brusse, as the "bumps" on *P. saniensis* were considered to be regrowth from damaged points or as a response to the presence of a parasitic fungus. However, *P. saniensis* has been recollected at Mont-aux-Sources in Natal, and the globose structures on the surface are now considered natural features, and can be considered dactyls. These dactyls never become pustulate, but do become cracked on the surface. *P. brevilobata* has the identical chemistry, but lacks dactyls, and is therefore considered a good species. As mentioned in the original description, *P. brevilobata* is closest to *P. subcrustacea* Gyeln. from Australia, but differs in containing a minor amount of an additional substance, possibly lividic acid. It is difficult to say what this substance is, because it is obscured on TLC plates run in solvents A and C by the hypostictic, hyposalazinic and hypoconstictic acids and the skyrin present. Nevertheless this same metabolite also occurs in minor amounts in *P. saniensis*.

Xanthoparmelia naudesnekia Hale is morphologically similar but contains stenosporonic and colensoic acids instead of the substance tentatively called lividic acid.

Parmelia esterhuyseniae (Hale) Brusse, *comb. nov.*
Basionym: *Xanthoparmelia esterhuyseniae* Hale, Mycotaxon **27**: 577. 1986.
Synonym: *Xanthoparmelia simulans* Hale, Mycotaxon **27**: 597. 1986. (non *Parmelia simulans* Hale, Phytologia **22**: 32. 1971)

This species is the stictic acid counterpart of *Parmelia constrictans* Nyl., which contains salazinic acid. I have found the differences between *P. constrictans* and *P. eradicata* unworkable, as there is a continuous gradient of lobe widths between these two species. Consequently, the placement of some specimens in one or other species becomes somewhat arbitrary. *P. esterhuyseniae* displays exactly the same tendencies. These species are so alike, that they have previously been regarded as chemical strains of *P. constrictans*.

Parmelia tsekensis (Hale) Brusse, *comb. nov.*
Basionym: *Xanthoparmelia tsekensis* Hale, Mycotaxon **34**: 562. 1989.

This species has been re-collected at Mont-aux-Sources in Qwaqwa.

SOUTH AFRICA. QWAQWA – **2828** (Bethlehem): 35 km S of Phuthaditjhaba. Up Tugela Valley from Western Buttress towards Mont-aux-Sources peak, past Crow's Nest hill. On solitary basalt boulder in vlei area on W side of Tugela River, on gentle N slope. Alt. 3050 m (**-DD**). *F. Brusse 5754*, 26. v. 1990 (**ANUC, B, BM, COLO, LD, PRE, UPS**).

NEW RECORDS, NOTES & CORRECTIONS

Bacidia apiahica (Müll. Arg.) Zahlbr.
SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature

Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5669* (on *Acridocarpus natalitius* Juss. leaves; **PRE**), *5681* (on *Asplenium prionitis* Kunze leaves; **PRE**) & *5702* (on *Buxus natalensis* (Oliv.) Hutch. leaves; **BM**, **PRE**), 10. i. 1990.

Chroodiscus mirificus (Krempelh.) R. Sant.

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5701* (on *Buxus natalensis* (Oliv.) Hutch. leaves; **BM, PRE**), 10. i. 1990.

Dimerella epiphylla (Müll. Arg.) Malme

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5656* (on leaves of *Cassipourea gummiflua* Tul.; **PRE**), *5677* (on the peculiar peltate coppice leaves of *Heywoodia lucens* Sim; **PRE**) & *5704* (on leaves of *Buxus natalensis* (Oliv.) Hutch.; **BM, PRE**). 10. i. 1990.

Fellhanera fuscatula (Müll. Arg.) Vezda

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5652* (on leaves of *Teclea natalensis* (Sond.) Engl.; **PRE**), & *5668* (on leaves of *Cassipourea gummiflua* Tul.; **BM, COLO, LD, PRE, UPS**), 10. i. 1990.

Gonolecania fumosonigricans (Müll. Arg.) Brusse, *comb. nov.*

Basionym: *Patellaria fumoso-nigricans* Müll. Arg., Lichenes Epiphylli Novi p. 7. 1890.

In the original publication of *Byssolecania* Vainio (1921) two binomials are validated under the genus name *Byssolecania*, which lacks an autonomous description. The genus name *Byssolecania* Vain. is therefore not validated in terms of article 42 of the code, even though both binomials refer to one and the same species, *Gonolecania fumosonigricans* (Müll. Arg.) Brusse (Santesson 1952).

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5651* (on leaves of *Teclea natalensis* (Sond.) Engl.; **PRE**), *5657* (on leaves of *Cassipourea gummiflua* Tul.; **PRE**), *5679* (on the peculiar peltate coppice leaves of *Heywoodia lucens* Sim; **BM, COLO, LD, PRE**), *5689* (on leaves of the fern *Asplenium prionitis* Kunze; **BM, PRE**) & *5703* (on leaves of *Buxus natalensis* (Oliv.) Hutch.; **BM, PRE**), 10. i. 1990.

Gyalectidium filicinum Müll. Arg.

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. About 0.5 km from campsite on road to mPume gate. In understorey vegetation of coastal forest, near road clearing. Alt. 40 m (**-BD**). *F. Brusse 5636*, 9. i. 1990 (on leaves of *Acridocarpus natalitius* Juss.; **BM, PRE**). Dwesa Nature Reserve. 4

km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5664* (on leaves of *Cassipourea gummiflua* Tul.; **BM, PRE**), *5690* (on leaves of *Asplenium prionitis* Kunze; **LD, PRE**), *5700* (on leaves of *Suregada procera* (Prain) Croizat; **BM, PRE**) & *5707* (on leaves of *Buxus natalensis* (Oliv.) Hutch.; **BM, PRE**), 10. i. 1990.

Lecanora gangaleoides Nyl.

A recent re-examination of the chemistry of the specimen cited as this species by Brusse (1988c), has revealed that it contains copious amounts of 2'-O-methylperlatolic acid and not gangaleoidin as previously thought. It also differs morphologically from true *Lecanora gangaleoides*, and the record is hereby deleted. The true identity of this specimen is unknown to me.

Parmelia festiva Brusse (1989b)

The description of this species is based on a misinterpretation of the situation on the type material. The species was originally thought to be granular sorediate with rhizocarpic acid in the cortex and soralia. This has unfortunately proven to be erroneous, as the rhizocarpic acid is restricted to the "soralia" only. In fact, the "soralia" are not really soralia as originally thought, but a second lichen species growing over the surface of the type material. This lichen could be *Arthrorhaphis citrinella* (Ach.) Poelt and thus rhizocarpic acid is still unknown from the genus *Parmelia*.

The fate of this name depends on the interpretation of the name *Xanthoparmelia olivetorica* Hale by Hale in his forthcoming monograph of *Xanthoparmelia*.

Parmelia leiophylla Kurok.

This lichen contains 4-O-demethylmicrophyllinic acid as the C + red substance resembling alectoronic acid on TLC plates (Knox 1982, Krog & Swinscow 1979, Swinscow & Krog 1988).

Parmelia minuta Essl.

This new record extends the range of this species considerably, as it has previously only been found in New Zealand (Esslinger 1977).

SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Hawequa's Mountains, east of Paarl. Hugenootskop. On low Table Mountain Sandstone pavement, on fairly gentle E slope. Alt. 1070 m (**-CA**). *F. Brusse 5404*, 17. iii. 1988 (**PRE**).

Parmelia mougeotii Schaer. ex Dietr.

Brusse (1989a) expressed doubt about the presence of this species in southern Africa, but it has now been collected on the summit of Waboomberg, an interesting locality where the brown Parmeliae dominate.

Parmelia stuhlmannii Dodge

SOUTH AFRICA, TRANSVAAL – **2430** (Pilgrim's Rest): 1.5 km from the Motse River bridge to Burgersfort, on the main Pietersburg - Burgersfort road. Farm Croydon 120 KT at border with Forest Hill 117 KT (now Lebowa), near Mecklenburg. On norite exposures on rocky E slope of hill. Alt. 790 m (**-AC**). *F. Brusse 5626*, 3. viii. 1989 (**ANUC, BM, COLO, LD, PRE**).

Porina phyllogena Müll. Arg.

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5706* (on leaves of *Buxus natalensis* (Oliv.) Hutch.; **BM, COLO, LD, PRE**), 10. i. 1990.

Porina trichothelioides R. Sant.

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. About 0.5 km from campsite on road to mPume gate. In understorey vegetation of coastal forest. Alt. 40 m (**-BD**). *F. Brusse 5635* (on leaves of *Encephalartos villosus* Lem.; **ANUC, B, BM, COLO, LD, NDA, PRE, S, UPS**), 9. i. 1990.

Rhizocarpon superficiale (Schaer.) Vain.

SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Waboomberg near Ceres. On Table Mountain Sandstone on NW slope. Alt. 1850 m (**-AD**). *F. Brusse 5376*, 16. iii. 1988 (**B, BM, COLO, LD, NDA, PRE, UPS**).

Schizodiscus afroalpinus Brusse

Young thalli of this lichen growing directly in seepage and with continuous rimose thalli, were found to have ascospores with very large halos, clearly visible by negative staining in dilute indian ink. The type material, however, has ascospores with only thin, indistinct halos. I cannot detect any other difference between these two lichens, and so the former specimens are also presumed to be *Schizodiscus afroalpinus*. *Schizodiscus afroalpinus* is therefore a species with halonate ascospores, contrary to what was originally thought (Brusse 1988b, Rambold 1989). The hypothecium of this species is J + blue, particularly in the lower parts, but the cortex and medulla are J -. The habit of this lichen so strikingly resembles that of many species of *Amygdalaria* Norm. (Brodo & Hertel 1987, Inoue 1984), that it could be considered a non-cephalodiate species of this genus. Nevertheless, the hypothecium is only stramineous in *Schizodiscus*, not dark brown as in *Amygdalaria* (Inoue 1984), in addition to the absence of cephalodia, and the considerably smaller ascospores.

Sphaerophorus globosus (Huds.) Vain

SOUTH AFRICA, CAPE PROVINCE – **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On steep S Table Mountain Sandstone cliffs. Alt. 1630 m (**-DC**). *F. Brusse 5468*, 21. iii. 1988 (to be distributed in Almborn, Lichenes Africani).

Sporopodium xantholeucum (Müll. Arg.) Zahlbr.

SOUTH AFRICA, TRANSKEI – **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 – 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (**-BD**). *F. Brusse 5713* (on leaves of *Buxus natalensis* (Oliv.) Hutch.; **BM, PRE**), 10. i. 1990.

Toninia toniniana (Massal.) Zahlbr.

SOUTH AFRICA, CAPE PROVINCE – **2621** (Khuis): Van Zijlsrust - Middelputs, on the Malopo River. On calcrete rock with N aspect. Habitat - *Acacia* open low woodland (**-DB**). *F. Venter 12,907a*, 31. iii. 1988 (**BM, PRE**). I would like to thank Angela Niebel-Lohmann for suggesting the identity of this lichen.

Trapeliopsis granulosa (Hoffm.) H.T. Lumbsch

SOUTH AFRICA, CAPE PROVINCE — **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On soil and detritus on ledges on steep S Table Mountain Sandstone cliffs. Alt. 1630 m (-**DC**). *F. Brusse 5446*, 20. iii. 1988 (**LD**, **PRE**). The material in **LD** is mostly sorediate, whereas the material in **PRE** is fertile, with practically no soralia.

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FIGURE 4. — *Parmelia abraxas* Brusse, habit. *F. Brusse 5461*, holotype. Scale in mm.

FIGURE 5. — *Parmelia adamantea* Brusse, habit. *F. Brusse 5387b*, holotype. Scale in mm.

FIGURE 6. — *Parmelia assimilis* Brusse, habit. *F. Brusse 5473*, holotype. Scale in mm.

FIGURE 7. — *Parmelia lucrosa* Brusse, habit. *F. Brusse 3700*, holotype. Scale in mm.


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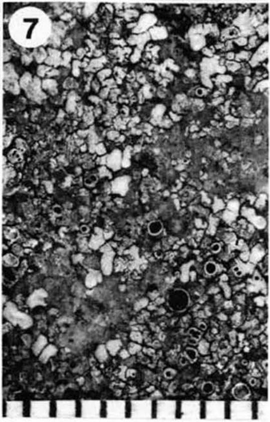
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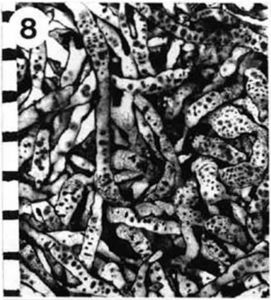
FIGURE 8. – *Parmelia musculina* Brusse, habit. *F. Brusse 5382*, holotype. Scale in mm.

FIGURE 9. – *Parmelia oreophila* Brusse, habit. *F. Brusse 5452*, holotype. Scale in mm.

FIGURE 10. – *Parmelia oreophila* Brusse, scanning electron micrograph of upper surface showing sloughed-off epicortex in central parts. *F. Brusse 5452*, holotype. Bar = 0.22 mm.

FIGURE 11. – *Parmelia parilis* Brusse, habit. *F. Brusse 5375*, holotype. Scale in mm.

FIGURE 12. – *Parmelia putida* Brusse, habit. *F. Brusse 5440*, holotype. Scale in mm.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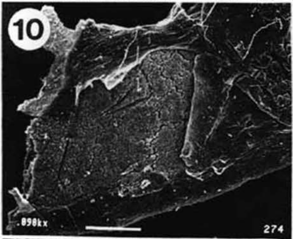
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MYCOTAXON

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A PRELIMINARY DISCOMYCETE FLORA OF MACARONESIA: PART 14, PEZIZACEAE[1]

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> "A hundred little things make likenesses
> In brethren born, and show the father's blood."
> Euripides [tr. Sir Gilbert Murray]
> ELECTRA, Line 642

Order PEZIZALES
Suborder PEZIZINEAE
Family PEZIZACEAE Dumortier 1829

KEY TO THE KNOWN MACARONESIAN GENERA

1 Apothecia broadly attached; excipulum giving rise to hyphoid hairs in a gelatinous matrix; asci diffusely blue in iodine ...... **Pachyella**

1′ Apothecia not broadly attached; excipulum not giving rise to hairs in a gel matrix; asci in iodine diffusely blue or blueing only at the apex 2

- 2(1′) Apothecia hemispheric to subglobose, with a brain-like surface; asci diffusely blue in iodine; ascospores not violently discharged .... **Ruhlandiella**
- 2′(1′) Apothecia discoid, lenticular, convex, or cupulate; ascospores violently discharged 3

3(2′) Apothecia mostly 1–2 mm diam, rarely 3–4 mm diam, lenticular to convex; entire ascus wall diffusely blue in iodine ...... **Iodophanus**

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[1] The parts of this flora will appear in irregular order. Reprints of individual parts will not be available for distribution.

[2] Professor of Mycology

[3] Anna E. Jenkins Postdoctoral Associate

3′(2′) Apothecia much larger, discoid to cupulate; asci with a distinct apical ring blueing in iodine, or with the apical portion much deeper blue than the lower portion 4
  4(3′) Ascus with a cyanophilic opercular lens within the operculum . . . . **Kimbropezia**
  4′(3′) Ascus operculum lacking an opercular lens . . . . **Peziza**

IODOPHANUS Korf *in* Kimbrough & Korf 1967

Key to the known Macaronesian species

1 Spores 15.0–19.8 x 8.3–11 (–12.4) µm, markings <0.5 µm diam. **1. I. carneus**
1′ Spores 16.8–22.4 x 9.5–13.2 µm, markings ≥0.5 µm diam, larger towards the poles . . . . **2. I. testaceus**

Notes: We confidently assign this genus now to the Pezizaceae on the bases of J. W. Kimbrough's studies of the asci and the production of an *Oedocephalum* anamorph in some species, as in some species of *Peziza*.

1. **Iodophanus carneus** (Pers. : Fr.) Korf *in* Kimbr. & Korf, Amer. J. Bot. **54:** 19. 1967.

RECENT TAXONOMIC TREATMENTS:
Kimbrough et al. (1969), Dennis (1978), Thind & Kaushal (1978), Breitenbach & Kränzlin (1984).

I. carneus, ascospore, CUP-MM 2589, x1000.

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Europe.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2589 (UPS), 2597 (UPS).

SUBSTRATUM:
On rabbit dung.

Notes: The ascospores of CUP-MM 2597 are a bit short, and approach those of *I. kimbroughii* Thind & Kaushal (1978) but are somewhat longer and wider than described for that species. The excipular structure also does not match their species.

2. **Iodophanus testaceus** (Moug. in Fr. : Fr.) Korf in Kimbr. & Korf, Amer. J. Bot. **54:** 19. 1967.

RECENT TAXONOMIC TREATMENT:
Kimbrough et al. (1969).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
France.

I. testaceus, ascospore, CUP-MM 2696, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM 2575 (UPS), 2580 (UPS), 2696 (TFC).

SUBSTRATA:
On wet, well-decayed wood, on goat dung, on fowl dung.

Notes: This species is not normally on dung, but CUP-MM 2575 and 2580 are certainly this species and not *I. carneus*, despite the substrate being dung.

KIMBROPEZIA Korf & Zhuang 1991

One known Macaronesian species

1. **Kimbropezia campestris** Korf & Zhuang, Mycotaxon **40:** 272. 1991.

RECENT TAXONOMIC TREATMENT:
Korf & Zhuang (1991).

PREVIOUS MACARONESIAN RECORDS:
*Korf & Zhuang (1991).

TYPE LOCALITY:
Icod de los Vinos, Tenerife, Canary Islands.

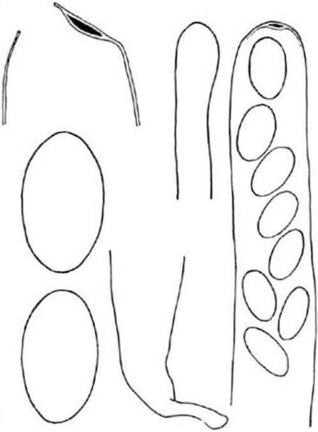
KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Tenerife. CUP-MM •2761 (TFC, paratype), •2672 (holotype).

SUBSTRATUM:

On soil amongst grasses and weeds.



K. campestris, acus apex mounted in lactic acid cotton blue showing opercular lens, paraphysis apex, ascospores, ascus base, all x1000; upper portion of an ascus with young ascospores, x500; all CUP-MM 2762 (holotype).

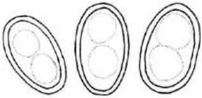
PACHYELLA Boudier 1907

One known Macaronesian species

1. **Pachyella babingtonii** (Berk. & Br.) Boudier, Hist. classific. discomyc. Europe, p. 51. 1907.

RECENT TAXONOMIC TREATMENTS:

Pfister (1973), Dennis (1978), Breitenbach & Kränzlin (1984).



P. babingtonii, 2 left ascospores CUP-MM 1274, right ascospore CUP-MM 549, all x1000.

PREVIOUS MACARONESIAN RECORDS:

None.

TYPE LOCALITY:

Lancashire, England.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

São Miguel. CUP-MM 1864.
Terceira. CUP-MM 1909.

MADEIRA.

Madeira. CUP-MM 2418.

CANARY ISLANDS.

Tenerife. CUP-MM 549 (TFC), 1274 (TFC, OSC), 1275, 1276, 2556 (UPS, young, poor).

SUBSTRATA:

On wet and very wet wood, twigs, mossy wood, and on stem of *Hedychium gardnerianum* (Zingiberaceae).

PEZIZA [Dill.] Linnaeus : Fr. 1753

= *Plicaria* Fuckel 1870
= *Aleuria* (Fr.) Gillet 1879 (non *Aleuria* Fuckel 1870)
= *Galactinia* (Cooke) Boudier 1885

Notes: We include in this genus the spherical-spored species now often placed instead in *Plicaria*, since at least some spherical-spored species produce a *Chromelosporium* anamorph, as do many species of *Peziza* with ovoid ascospores.

Key to the known Macaronesian species

1 Spores with marked walls (under light microscopy) 2
1′ Spores smooth-walled (under light microscope) 8
2(1) Spore walls with isolated, low warts 3
2′(1) Spore walls with obvious warts, crests, or a reticulum 4
3(2) Spores eguttulate in youth, 13.2–18.3 (–19.0) x 7.3–9.5 (–11.7) µm. **2. P. arvernensis**
3′(2) Spores biguttulate in youth, 11–12.5 (–15) x 6–8 µm. **7. P. domiciliana**
4(2′) Spore markings isolated warts 5
4′(2′) Spore markings crests or a reticulum 7
5(4) Spores with denser markings at the poles, sometimes forming pads at the ends, (16.1–) 18.3–21.3 x (6.6–) 8–10.2 µm ... **12. P. phyllogena**
5′(4) Spores without thickened pads or denser markings at the poles ... 6
6(5′) Spores multiguttulate, 11.0–15.4 (–16.1) x 6.6–8.8 µm. **10. P. labessiana**
6′(5′) Spores biguttulate, 10–13 x 6–7 µm ...... **13. P. praetervisa**
7(4′) Spores with a complete or partially incomplete reticulum, 15.6–17.5 x 8.8–9.8 µm .... **4. P. badia**

7′(4′) Spores with crests, (16.8–) 17.6–19.0 (–20.5) x 9.5–11.7 µm. **15. P. subumbrina**

8(1′) Spores long fusoid, 23–27.1 x 7.3–8.8 µm ...... **9. P. gerardii**

8′(1′) Spores spherical or ellipsoid 9

9(8′) Spores spherical, with a few guttules, forming de Bary bubbles. **8. P. endocarpoides**

9′(8′) Spores ellipsoid, eguttulate, de Bary bubbles rare 10

10(9′) Spores mostly longer than 20 µm 11

10′(9′) Spores mostly shorter than 20 µm 13

11(10) Spores 24.2–26.7 x (9.5–) 12.4–16.1 µm .... **6. P. crassipes**

11′(10) Spores 20–24 µm long 12

12(11′) Spores 19.8–22.7 x 12.4–13.9 µm; apothecia very dark brown, on soil and litter .... **14. P. sepiatra**

12′(11′) Spores 20–24 x 11–14 µm; apothecia beige, on dung or heavily fertilized soil .... **16. P. vesiculosa**

13(10′) Spores thick-walled when young, loosening perispore usually obvious, prominent de Bary bubbles formed .... **3. P. azorica**

13′(10′) Spores without a loosening perispore, without de Bary bubbles . . . 14

14(13′) Spores 17.6–19.8 (–21.3) x 9.5–11.7 µm ....**1. P. ampliata**

14′(13′) Spores less than 17 µm long (marked under EM) 15

15(14′) Disc pale to bright ochre-yellow; on disturbed soil, in gardens, on burlap, etc. .... **5. P. cerea**

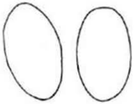
15′(14′) Disc ochre-brown to chestnut-brown; on rotting wood, especially on fallen tree trunks ....**11. P. micropus**

1. **Peziza ampliata** Pers. : Fr., Icon. descr. fung. 1: 31. 1798.

RECENT TAXONOMIC TREATMENTS:
Svrček (1970), Dennis (1978), Donadini (1981).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Europe.



P. ampliata, ascospores, CUP-MM 2506, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gomera. CUP-MM 1170 (O).
Tenerife. CUP-MM 1231, 2506 (TFC).

SUBSTRATA:
On soil, on soil under *Eucalyptus*, on burnt soil.

Notes: The lack of hyphal hairs and of a hyphal middle-layer in the apothecium agrees with Svrček's (1970) concept.

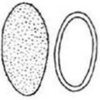
2. **Peziza arvernensis** Boudier, Bull. Soc. Bot. France **26:** lxxvi. 1879.

= *Peziza sylvestris* (Boud.) Sacc. & Traverso, Syll. Fung. **20:** 317. 1911.

RECENT TAXONOMIC TREATMENTS:
Svrček (1970), Dennis (1978), Donadini (1981), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

SYNTYPE LOCALITIES:
Aurillac and Vic-sur-Cère, France.



P. arvernensis, ascospores, one in optical section, CUP-MM 1164, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 1517 (TFC, OSC), 1549.
CANARY ISLANDS.
Gomera. CUP-MM 1164 (O), 2641 (TFC).

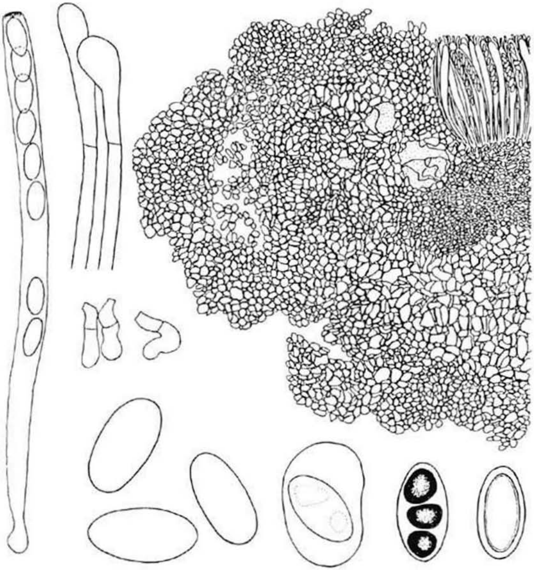
SUBSTRATA:
On soil, on duff, on sand and remnants of a cement bag, on old cardboard.

Notes: This is a widespread and easily recognized species characterized by its delicately marked ascospores and large apothecia. It often may also occur on rotting tree trunks. The collection on cardboard (CUP-MM 1549) differs in having somewhat wider ascospores that collapse and become wrinkled and infolded at maturity, and may represent instead another species unknown to us.

3. **Peziza azorica** Dennis *in* Dennis, Reid, & Spooner, Kew Bull. **32:** 109. 1977.

RECENT TAXONOMIC TREATMENT:
Dennis et al. (1977).

PREVIOUS MACARONESIAN RECORD:
*Dennis et al. (1977).



P. azorica, ascus with apex staining blue in Melzer's Reagent, x400, paraphysis apices, x1000, CUP-MM 866; excipular hairs, x1000, apothecial anatomy, x100, CUP-MM 1941; left 3 ascospores, CUP-MM 1669, right 3 ascospores, one showing de Bary bubbles, 2 showing loose perispore and free-floating endospore, CUP-MM 2751, x1000.

TYPE LOCALITY:

S. of Mata de Junta Geral, Terceira, Azores.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

Terceira. CUP-MM *1669 (K, holotype), 1941 (TFC, K, OSC, to be issued in Korf & Gruff, Discomycetes Exsiccati, topotype).

CANARY ISLANDS.

Gomera. CUP-MM 1173 (O), 1372 (TFC), 2649.
La Palma. CUP-MM 815, 866, 875 (TFC, OSC), 2783.
Tenerife. CUP-MM 2709 (TFC), 2714 (TFC), 2751 (TFC).

SUBSTRATA:

On soil, on bare soil, on rocks and wood fragments in a gravel slide, on dung of ? donkey, on mule dung, on a firesite.

Notes: This differs critically from *P. cerea* sensu Svrček (1970) in larger ascospores, but like that species has hyphoid excipular hairs and a hyphal mediostratum. The apothecial colors are also more sombre than in *P. cerea*. The presence of de Bary bubbles in mature ascospores is also rare in the genus but in particular the separating perispore makes this species most unusual. There are deeply staining cyanophilic rings at septal thickenings throughout the tissues.

4. **Peziza badia** Pers. : Fr., Observ. mycol. **2:** 78. 1800 [1799].

RECENT TAXONOMIC TREATMENTS:

Dennis (1978), Donadini (1981), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORD:

*Dybhavn (1990).

TYPE LOCALITY:

Europe.

P. badia, ascospore, CUP-MM 2781, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM *2781 (O).

Notes: The reports of this species from Gran Canaria by Montagne (1840) [repeated by Cool (1924, 1925) and by Beltrán (1980)] are the result of a misidentification, for Montagne's material proved to be *Sarcoscypha macaronesica* Baral & Korf in Baral (see part 11 of this flora, CUP-MM 2527).

5. **Peziza cerea** Bull. : Fr., Herb. France, pl. 44. 1780-81.

RECENT TAXONOMIC TREATMENTS:

Svrček (1970), Dennis (1978), Donadini (1981).

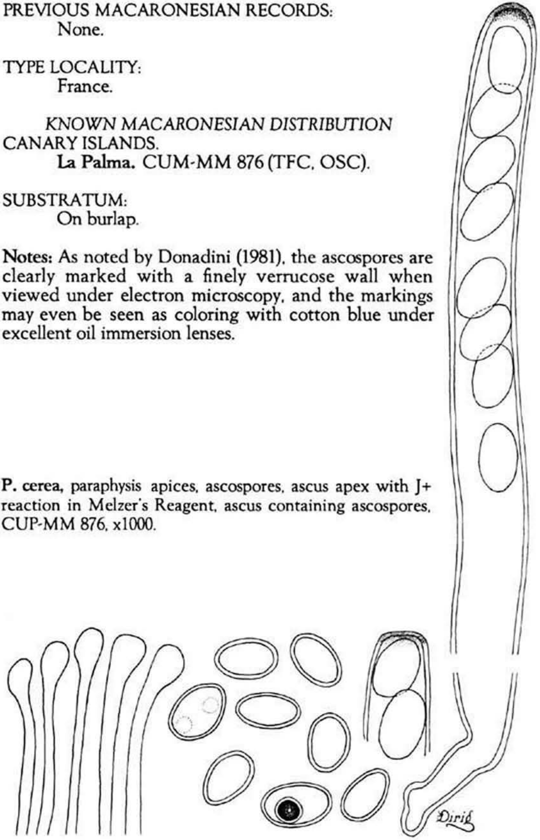
PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
France.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
La Palma. CUM-MM 876 (TFC, OSC).

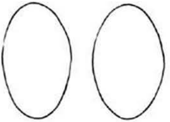
SUBSTRATUM:
On burlap.

Notes: As noted by Donadini (1981), the ascospores are clearly marked with a finely verrucose wall when viewed under electron microscopy, and the markings may even be seen as coloring with cotton blue under excellent oil immersion lenses.



P. cerea, paraphysis apices, ascospores, ascus apex with J+ reaction in Melzer's Reagent, ascus containing ascospores, CUP-MM 876, x1000.

6. **Peziza crassipes** Quélet, Compte Rend. Assoc. franç. Av. Sci. (La Rochelle 1882) **11**: 405. 1883.



P. crassipes, ascospores, CUP-MM 2774, x1000.

RECENT TAXONOMIC TREATMENTS:
Svrček (1970), Donadini (1981).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Jura, France.

KNOWN MACARONESIAN DISTRIBUTION

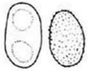
CANARY ISLANDS.
Tenerife. CUP-MM 2774.

SUBSTRATUM:
On soil.

Notes: Ascospores in our collection are larger than those described by Svrček (1970) or Donadini (1981), 24.2–26.7 x (9.5–) 12.4–13.9 (–16.1) µm, and the asci may be appreciably broader than they report.

7. **Peziza domiciliana** Cooke, Gard. Chron. **41**: 793. 1877.

= *Peziza adae* Sadler in Cooke, Trans. Bot. Soc. Edinburgh **13**: 45. 1877 (later).



P. domiciliana, ascospores, CUP-MM 1675, x1000.

RECENT TAXONOMIC TREATMENTS:
Moser (1961), Donadini (1981),
Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORD:
•Dennis et al. (1977).

TYPE LOCALITY:
Edinburgh, Scotland.

KNOWN MACARONESIAN DISTRIBUTION

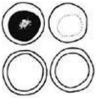
AZORES.
Terceira. CUP-MM •1675 (K).

SUBSTRATUM:
On bare soil.

8. **Peziza endocarpoides** Berk. *in* J. D. Hook., Fl. Nov.-Zel. **2**(7): 199. 1855.

= *Plicaria endocarpoides* (Berk. *in* J. D. Hook.) Rifai, Verh. Kon. Ned. Akad. Wetensch., Afd. Natuurk., Tweede Sect., **57**(3): 255. 1968.

= *Plicaria leiocarpa* Curr.) Boud., Icon. Mycol., Liste prélim., p. [3]. 1904.



P. endocarpoides, ascospores, two top CUP-MM 1399, two bottom CUP-MM 1137, x1000.

RECENT TAXONOMIC TREATMENTS:
Rifai (1968), Dennis (1978), Donadini (1981).

PREVIOUS MACARONESIAN RECORD:
*Korf & Gruff (1978).

TYPE LOCALITY:
Mission Station, New Zealand.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM *1516 (TFC, OSC, also issued in Korf & Gruff, Discomycetes Exsiccati #69), 1573 (TFC, OSC).

CANARY ISLANDS.
Hierro. CUP-MM 1399.
La Palma. CUP-MM 1159 (O).
Tenerife. CUP-MM 1137 (O).

SUBSTRATA:
On burnt ground, on soil, on soil under needles.

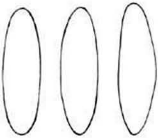
9. **Peziza gerardii** Cooke, Mycographia **1:** 26. 1875.

= *Peziza ionella* Quél., Bull. Soc. Bot. France **24:** 328. 1877.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Pfister (1978).
Donadini (1981).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
United States.



P. gerardii, ascospores, CUP-MM 2711, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Tenerife. CUP-MM 2711.

SUBSTRATUM:

On soil.

Notes: We follow Pfister (1978) and Donadini (1981) in synonymizing *P. ionella.*

10. **Peziza labessiana** (Boud.) Sacc. & Traverso, Syll. Fung. **20:** 315. 1911.

RECENT TAXONOMIC TREATMENTS:

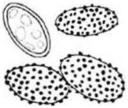
Moser (1961), Donadini (1981).

PREVIOUS MACARONESIAN RECORDS:

None.

TYPE LOCALITY:

Angers, France.



P. labessiana, ascospores in surface view and optical section, CUP-MM 1075, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Gran Canaria. CUP-MM 1075.

SUBSTRATUM:

On soil with liverworts.

11. **Peziza micropus** Pers. : Fr., Icon. descr. fung. **2:** 30. 1800.

= *Peziza repanda* Pers., Icon. pict. sp. fung. **4:** 49. 1808 (non *P. repanda* Wahl. : Fr.).

RECENT TAXONOMIC TREATMENTS:

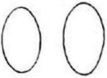
Svrček (1970), Dennis (1978), Donadini (1981), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:

†Wildpret et al. (1969), *Wildpret et al. (1972), ††Beltrán (1980), †††Rodríguez et al. (1988), [all as *P. repanda*]; **Dybhavn (1990, as *P. varia*].

TYPE LOCALITY:

Europe.



P. micropus, ascospores, CUP-MM 2598, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM **2782 (O).

CANARY ISLANDS.

Lanzarote. †††
La Palma. CUP-MM *2598 (TFC).
Tenerife. † ††

SUBSTRATA:

On soil, on humus of pines.

Notes: The literature citations from Macaronesia are suspect. Dybhavn's (1990) report as *P. varia* Hedw. : Fr. is based on a specimen lacking the characteristic moniliform paraphyses and pigmented middle layer of that species, and we accommodate it here. Donadini (1981) reports the spores smooth under light microscopy, but finely verrucose under electron microscopy.

12. **Peziza phyllogena** Cooke, Mycographia **1:** 148. 1877.

= *Aleuria olivacea* Boud., Bull. Soc. Mycol. France 13: 14. 1897.
≡ *Peziza badioconfusa* Korf, Mycologia **46:** 838. 1955.

RECENT TAXONOMIC TREATMENTS:

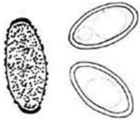
Ginns (1980), Donadini (1981), Pfister (1987).

PREVIOUS MACARONESIAN RECORDS:

*Bañares et al (1986), **Bañares (1988).

TYPE LOCALITY:

North or South Carolina, USA.



P. phyllogena, mature ascospore, CUP-MM 2552, young ascospores, CUP-MM 1141, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Gran Canaria. CUP-MM * **2603 (= CUP-MM 2552) (TFC).
Tenerife. CUP-MM 1141 (O).

SUBSTRATA:

On soil among leaves of *Cystis*, among mosses, on burnt ground.

Notes: Pfister (1987) has pointed out that Cooke's name should be adopted now for this taxon. Earlier reports used Korf's species name.

13. Peziza praetervisa Bres., Malpighia 11: 266. 1897.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Donadini (1981).

PREVIOUS MACARONESIAN RECORD:
†Rodríguez et al. (1988).

TYPE LOCALITY:
Mollia di Valsesia, Italy.

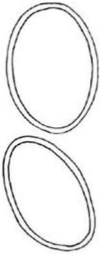
REPORTED MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. †

SUBSTRATUM:
Pyrophilous, with *Anthracobia melaloma*.

Notes: We have not seen this material, and the species has been regularly confused. The description by Rodríguez et al. (1988) could well apply to this taxon.

14. Peziza sepiatra Cooke, Grevillea 3: 119. 1875.



P. sepiatra, ascospores, CUP-MM 2404, x1000.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Donadini (1981),
Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORD:
•Dennis et al. (1977).

SYNTYPE LOCALITIES:
Epping and Shrewsbury, England.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.
Terceira. CUP-MM •1670 (K, immature).
MADEIRA.
Madeira. CUP-MM 2404 (TFC).

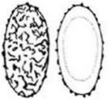
SUBSTRATA:
On bare soil under *Pittosporum undulatum*, on well-rotted litter.

15. **Peziza subumbrina** Boudier *in* Cooke, Mycographia 1: 229. 1879.

RECENT TAXONOMIC TREATMENTS:
Le Gal (1941), Moser (1963), Donadini (1981).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
France.



P. subumbrina, ascospores in face view and optical section. CUP-MM 1216, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM 1402 (TFC, OSC), 1407.
Tenerife. CUP-MM 1216 (TFC, OSC), 1218, 1220 (TFC), 1233, 2712 (TFC), 2716.

SUBSTRATA:
On soil, on mossy soil.

Notes: This species has not been reported recently by other authors. The broken flesh may be greenish, and the disc and receptacle may have olivaceous tints as noted in the field.

16. **Peziza vesiculosa** Bull. : Fr., Herb. France **10:** pl. 457, f. 1. 1790.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Donadini (1981), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
•Montagne (1840), †Torrend (1912), ••Cool (1925), •••Beltrán (1980).

TYPE LOCALITY:
France.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. †
CANARY ISLANDS.
Gran Canaria. CUP-MM • •• •••2526 (FI).

SUBSTRATA:
On soil, on dung.

Notes: We have been unable to locate the collection reported by Torrend from Madeira. All other records refer to Montagne's early report of the Webb and Berthelot collection. The cited specimen from the herbarium at Firenze has only a pencil sketch showing apothecia, and what is illustrated could be small specimens of *P. vesiculosa*. Another possibility is that the fungus was *P. azorica*, which occurs both on soil and dung. We have never collected typical *P. vesiculosa* in Macaronesia, and resident mycologists have also not found it, though it is a cosmopolitan species and should be expected.

RUHLANDIELLA Hennings 1903

One known Macaronesian species

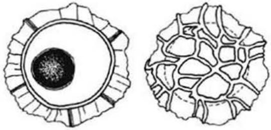
1. **Ruhlandiella berolinensis** Henn., Hedwigia **42:** (24). 1903.

= *Sphaerosoma hespericum* (Setchell) Seaver, North Am. Cup-fungi (Operc.), p. 51. 1928.

RECENT TAXONOMIC TREATMENT:
Dissing & Korf (1980).

PREVIOUS MACARONESIAN RECORDS:
*Dissing & Korf (1980),
**Korf & Gruff (1981).

TYPE LOCALITY:
Berlin, Germany.



R. berolinensis, ascospores in optical section showing de Bary bubble and in face view, CUP-MM 1230, x1000.

NEOTYPE LOCALITY:
Burn site along road in *Eucalyptus* grove at km. mark 14, Bosque de la Esperanza, Tenerife, Canary Islands.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM * **1230 (TFC, OSC, C, also issued in Korf & Gruff, Discomycetes Exsiccati #84) (neotype).

SUBSTRATUM:
On soil, associated with *Eucalyptus* at a burn site.

MYCOTAXON

Volume XL, pp. 413-433 January-March 1991

A PRELIMINARY DISCOMYCETE FLORA OF MACARONESIA: PART 15, TERFEZIACEAE, AND OTIDEACEAE, OTIDEOIDEAE[1]

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and
WEN-YING ZHUANG[3]

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> "Whoso would be a man must be a non-conformist."
> Ralph Waldo Emerson
> SELF RELIANCE

Order PEZIZALES
Suborder PEZIZINEAE
Family TERFEZIACEAE Fischer 1897

One known Macaronesian genus

TERFEZIA (Tul. & Tul.) Tul. & Tul. 1851

Notes: We key out here three taxa under this generic name, but are deeply troubled by species concepts in this genus. In our material the spore markings in any one collection vary from smooth in the youngest spores delimited to roughened in the mature spores. The strongly spinulose mature spores of material we identify as *Terfezia olbiensis* never go through stages in development of spore markings that resemble those of the species we call *T. pinoyi* (with a regular, low, dense reticulum), nor those of the species we call *T.* sp. 2732 (with crests and irregular warts). The seminal work by Mattirolo

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[1] The parts of this flora will appear in irregular order. Reprints of individual parts will not be available for distribution.

[2] Professor of Mycology

[3] Anna E. Jenkins Postdoctoral Associate

(1922) on this family has shown immense variation in the spore sculpturing in the related *Delastria rosea* Tul. (even within a single ascus!), and within a single ascocarp of *T. claveryi* Chatin. These studies led Mattirolo to reduce drastically the number of species recognized by Chatin (1892) in his treatment of *Terfezia*. Mattirolo's key to species was reproduced in a more accessible German translation by Fischer (1938) in the second edition of Engler und Prantl's *Die Natürlichen Pflanzenfamilien*.

Key to the known Macaronesian species

1 Ascospores spinose, 12.7–14.6 µm in diam .... **1. T. olbiensis**
1´ Ascospores otherwise marked 2
  2(1´) Ascospores reticulate, 16.1–17.2 µm in diam .... **2. T. pinoyi**
  2´(1´) Ascospores with irregular, short crests and warts, not forming a reticulum, 11.7–12.4 µm in diam .... **3. T. sp. 2732**

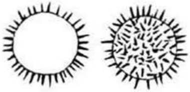
1. Terfezia olbiensis (Tul. & Tul.) Tul. & Tul., Fungi Hypogaei, p. 176. 1851.

= ? *Terfezia leptoderma* (Tul. & Tul.) Tul. & Tul., Ann. Sci. Nat., sér. 3, **3**: 350. 1845.

RECENT TAXONOMIC TREATMENTS:
Mattirolo (1922), Fischer (1938), Fogel (1980).

PREVIOUS MACARONESIAN RECORD:
·Fogel (1980).

SYNTYPE LOCALITIES:
Isle de Porquerolles (France),
Sardinia (Italy).



T. olbiensis, ascospores
CUP-MM 1133, x1000.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Hierro. CUP-MM ·1434 (OSC), ·1440 (TFC, OSC).
Tenerife. CUP-MM ·330 (TFC, OSC), ·1133 (O), ·1325 (TFC, OSC).

SUBSTRATA:
Under *Pinus* sp., under *Pinus canariensis*.

2. **Terfezia pinoyi** Maire, Ann. Mycol. 4: 332. 1906.

RECENT TAXONOMIC TREATMENTS
Mattirolo (1922), Fischer (1938), Rodríguez et al. (1988).

PREVIOUS MACARONESIAN RECORD:
•Rodríguez et al. (1988).

TYPE LOCALITY:
Sidi-Khalifa, Algeria.

T. pinoyi, ascospore, CUP-MM 2614, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Lanzarote. CUP-MM •2614 (TFC).

SUBSTRATUM:
Mycorrhizal on roots of *Helianthemum canariense.*

Notes: The report by Rodríguez et al. (1988) is based upon Korf's identification.

3. **Terfezia sp. 2732.**

RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
None.

T. sp. 2732, ascospore, CUP-MM 2732, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM 2732 (IMI).

SUBSTRATUM:
In soil.

Notes: ASCOCARPS hypogeous, subspherical, when dry outer surface brown, ca 1 cm diam. ASCI 8-spored, scattered, spherical or subspherical to ovoid. ASCOSPORES spherical, hyaline, uniguttulate, thick-walled in youth, 11.4-12.4 µm in diam, strongly marked with irregular warts or short crests which may interconnect, markings ca. 0.7 µm high. A portion of the collection, taken by Mr. Peter

Roberts near Lomo Pelado, above La Esperanza, 3300-3500 ft elev., Tenerife, 17. i. 1990, was shared with Korf when collecting together on the recent British Mycological Society foray, the remainder being deposited in the International Mycological Institute herbarium.

Family OTIDEACEAE Eckblad 1968

KEY TO THE SUBFAMILIES

1 Carotenoid pigments usually lacking, or if present apothecia not clothed with hairs or setae .... **Otideoideae**

1´ Carotenoid pigments usually prominent in paraphyses so that the hymenium is brightly colored .... **Scutellinioideae**

Subfamily OTIDEOIDEAE Korf 1972

KEY TO THE KNOWN MACARONESIAN GENERA

1 Apothecia with a sterile, elevated marginal rim .... **Fimaria**

1´ Sterile, elevated marginal rim on apothecium absent 2

  2(1´) Pigmented hairs or setae present at margin or on receptacle surface 3

  2´(1´) Setae absent, but short, hyaline hairs rarely present 7

3(2) Ascospores guttulate 4

3´(2) Ascospores eguttulate 6

  4(3) Hairs flexuous, cylindrical; apothecia partially or wholly immersed in the ground; spores smooth .... **Geopora**

  4´(3) Hairs usually stiff, tapering to apex; spores smooth or rough ... 5

5(4´) Apothecia deep-cupulate at maturity; spores biguttulate, with discrete, rounded warts .... **Humaria**

5´(4´) Apothecia discoid at maturity; spores 1–2-guttulate, smooth or variously marked .... **Trichophaea**

  6(3´) Apothecia broadly sessile, partially sunken in substrate; hairs marginal only, anamorph an *Ascorhizoctonia* .... **Tricharina**

  6´(3´) Apothecia centrally attached; hairs at margin and on receptacle surface; anamorph a *Complexipes* .... **Wilcoxina**

7(2´) Apothecia cupulate, with deep violet pigmentation in both spores and apothecial tissues .... **Smardaea**

7´(2´) Violet pigmentation lacking in spores and tissues 8

  8(7´) Apothecia cupulate; asci with an exceptionally thin dome; spores smooth or marked, non-guttulate; paraphyses neither hooked nor apically deformed .... **Pfistera**

  8´(7´) Apothecia cupulate or ear-shaped; asci typically operculate; spores smooth, biguttulate; paraphyses hooked or deformed ... 9

9(8′) Apothecia deep-cupulate; nuclei of ascospores and paraphyses staining in acetocarmine and cotton blue dyes .... **Tarzetta**
9′(8′) Apothecia ear-shaped, or cupulate and split down one side; nuclei in spores and paraphyses not reacting to acetocarmine or cotton blue dyes .... **Otidea**

FIMARIA Velen. 1934

Key to the known Macaronesian species

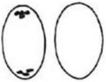
1 Ascospores ellipsoid .... **1. F. theioleuca**
1′ Ascospores spherical .... **2. F. trochospora**

1. **Fimaria theioleuca** (Roll.) Brumm., Persoonia **2:** 329. 1969.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Paris, France.



F. theioleuca, spores
CUP-MM 2393, x1000.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.
Madeira. CUP-MM 2393.

SUBSTRATUM:
On dung of goat or sheep, associated with a *Lasiobolus.*

2. **Fimaria trochospora** Jeng & Krug, Canad. J. Bot. **55:** 2996. 1978 ('1977').

RECENT TAXONOMIC TREATMENTS:
Jeng & Krug (1978), Calonge (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Rio Aguas Caliente, Venezuela.

F. trochospora,
paraphysis apex, spore,
CUP-MM 2563, x1000.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Tenerife. CUP-MM 2563 (UPS), 2596 (UPS).

SUBSTRATUM:
On rabbit dung.

Notes: Jeng and Cain (1978) reported the paraphyses up to 9 µm broad at the apices, but their illustration shows much narrower paraphyses, which we calculate as about 4.4 µm. In our material the paraphyses are up to 5.0 µm broad at the apices.

GEOPORA Harkness 1885 emend. Burdsall 1968

Key to the known Macaronesian taxa

1 Apothecia spherical to subspherical, hypogeous to emergent; hairs brown; spores 20.0–25.7 x 13.9–18.1 µm ... **G. clausa** subsp. **clausa** 2
1´ Apothecia cupulate, partially immersed in the soil; hairs subhyaline to pale brown; spores 14.6–21.3 x 8.8–11.0 µm .... **3. G. sp. 1112**
  2(1) Spores broadly ellipsoid to ovoid, 20.0-25.7 x 15.0–18.1 µm. **1. G. clausa** f. **clausa**
  2´(1) Spores ellipsoid, 21.5–24.9 x 13.9–15.1 µm. **2. G. clausa** f. **ellipsospora**

1. Geopora clausa (Tul.) Burdsall, Mycologia **60:** 507. 1968 subsp. **clausa** forma **clausa**

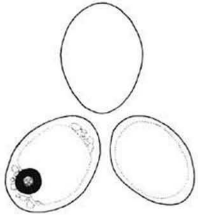
RECENT TAXONOMIC TREATMENTS:
Burdsall (1968), Fogel (1980).

PREVIOUS MACARONESIAN RECORDS:
*Fogel (1980).

TYPE LOCALITY:
Bordeaux, France.

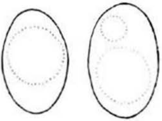
KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS:
Gomera. CUP-MM *1160 (O).

SUBSTRATUM:
Under *Pinus canariensis.*



G. clausa f. **clausa**, spores, CUP-MM 1160, x1000.

2. **Geopora clausa** subsp. **clausa** f. **ellipsospora** Burdsall, Mycologia 60: 511. 1968.



G. clausa f. **ellipsospora,** spores, CUP-MM 1433, x1000.

RECENT TAXONOMIC TREATMENTS:
Burdsall (1968), Fogel (1980).

PREVIOUS MACARONESIAN RECORD:
*Fogel (1980).

TYPE LOCALITY:
St. Fiel, Portugal.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM *1432 (OSC), *1433 (TFC, OSC).

SUBSTRATUM:
Hypogeous and emergent under *Pinus* sp.

3. **Geopora sp. 1112**

RECENT TAXONOMIC TREATMENTS:
None.

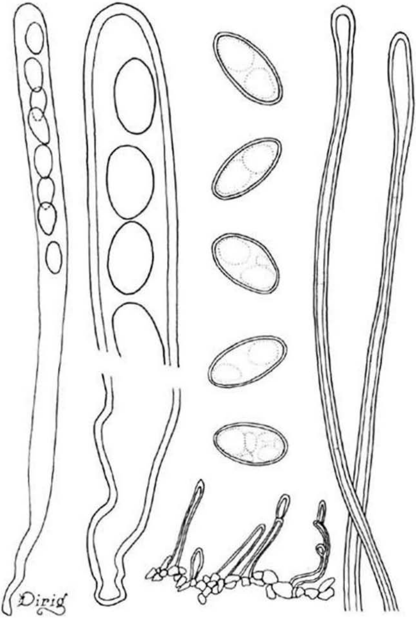
PREVIOUS MACARONESIAN RECORDS:
None.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM 1112 (O).

SUBSTRATUM:
On the ground.

Notes: APOTHECIA cupulate, immersed, 8–12 mm diam when dry, disc brownish when dry, receptacle obviously woolly, minutely pustulate. HAIRS subcylindrical, hyaline to pale brown, mostly short, rounded at the apex, branching or not, 22–60 (–100) µm x 4.4–6.6 µm, septa rare. ECTAL EXCIPULUM of textura angularis, 110–150 µm thick, cells hyaline to subhyaline, thin-walled, isodiametric to elongate. MEDULLARY EXCIPULUM of textura intricata, ca 200–210 µm thick. HYMENIUM 300–310 µm thick. ASCI 8-spored, subcylindrical, J– in Melzer's Reagent, (294–) 309–367 x 11–19 µm. ASCOSPORES 14.6–21.3 x 8.8–11.0 µm. PARAPHYSES filiform, ca 3.0 µm wide, not exceeding the asci, thick-walled, septa thin.



Geopora sp. 1112, ascus, apex and case of ascus, ascospores, paraphyses, hairs from near apothecial base, CUP-MM 1112; complete ascus and hairs x500, all others x1000.

We admit to being exceptionally puzzled by this fungus, which appears not to be fully mature judging by the cyanophilic ascospore contents. It differs from typical *Geopora* in the color of the hairs, but does not seem referable to *Leucoscypha* either, since it lacks carminophilic nuclei in the ascospores. Rather than describe it as a new taxon, we merely call attention to it here in case it is rediscovered in a more mature state.

HUMARIA Fuckel 1870

One known Macaronesian species

1. **Humaria hemisphaerica** (Wigg. : Fr.) Fuckel, Jahresb. Nassauischen Vereins Naturk. **23-24**: 322. 1870.

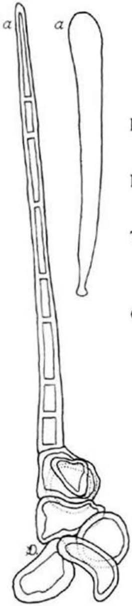
≡ *Mycolachnea hemisphaerica* (Wigg. : Fr.) Maire, Publ. Inst. Bot. 3(4): 24. 1937.

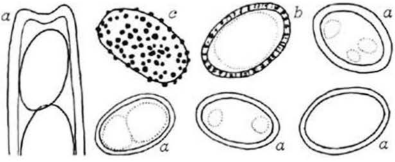
RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
†Wildpret et al. (1969, ††Beltrán (1980).

TYPE LOCALITY:
Germany.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Hierro. CUP-MM 1460 (TFC), 1461.
La Palma. CUP-MM 763, 791, 857 (TFC, OSC).
Tenerife. † ††





H. hemisphaerica, hair and ectal excipular cells, young ascus, ascus apex, spores; *a* from CUP-MM 791, *b* from CUP-MM 857, *c* from CUP-MM 1461; hair and young ascus x500, others x 1000.

Notes: "A brown species, perhaps undescribed," was reported by Trelease (1897) as "*Humaria* sp.," but his use of the generic name was surely for a non-setose species of *Humaria* (Fr.) Boud. 1885, a later homonym of Fuckel's genus. We have been unable to trace Trelease's specimen, and have no idea what it could have been.

OTIDEA (Persoon) Bonorden 1851

Key to the known Macaronesian species

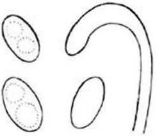
1 Ascospores 16–18 x 7–8 mm; apothecia dark brown .. **3. O. cochleata**
1′ Ascospores smaller 2
  2(1′) Ascospores 11.7–14.9 x 5.4–7.3 µm; apothecia dark brown, cupulate but split down one side; medullary hyphal segments with pigmented "fingerprint" depositions .... **2. O. bufonia**
  2′(1′) Ascospores 9.5–11.7 x 5.9–7.0 µm; apothecia pale brown, slightly ear-shaped; pigmented "fingerprint" depositions on segments of medullary hyphae lacking .... **1. O. alutacea**

1. **Otidea alutacea** (Pers. : Fr.) Massee, Brit. fung.-fl. 4: 446. 1895.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Europe.



O. alutacea, spores, paraphysis apex, CUP-MM 2710, x1000.

KNOWN MACARONESIAN DISTRIBUTION

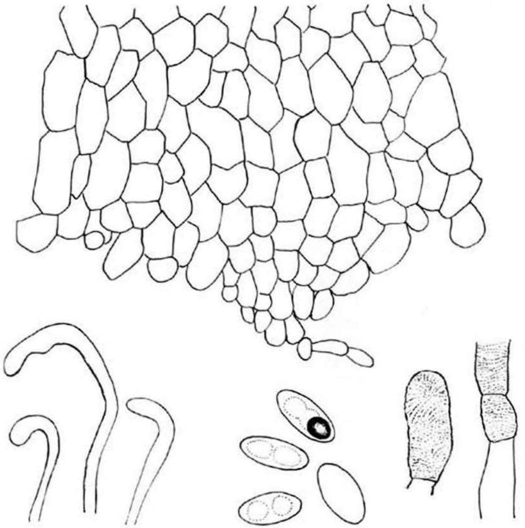
CANARY ISLANDS.
Tenerife. CUP-MM 2710.

SUBSTRATUM:
On soil

Notes: The ascospores are shorter than typical, approaching those of *Otidea alutacea* var. *microspora* Kanouse (1950).

2. **Otidea bufonia** (Pers. : Fr.) Boudiier, Hist. classific. discomyc. Europe, p. 52. 1907.

RECENT TAXONOMIC TREATMENT:
Dennis (1978).



O. bufonia, ectal excipular structure, paraphysis apices, ascospores, segments of medullary hyphae with pigmented "fingerprint" depositions, CUP-MM 2663, all x1000 except ectal excipulum, x500.

PREVIOUS MACARONESIAN RECORDS:
†Bañares et al. (1986), ††Bañares & Beltrán (1987), †††Bañares (1988).

TYPE LOCALITY:
Europe.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.

Gomera. CUP-MM 2645 (TFC), 2663 (TFC).

Gran Canaria. † ††

Hierro. CUP-MM 1454, 1465 (TFC, OSC).

Tenerife. ††

SUBSTRATA:

On soil, on duff.

Notes: Our studies of this widespread European species have shown us a feature hitherto unreported in *Otidea* species, or in any other member of the Pezizales so far as we are aware. We have checked a number of European collections identified as O. *bufonia* by J. A. Nannfeldt against our material (identified by Harmaja) and find in all, though in varying degree, the presence of dark brown amorphous depositions on medullary hyphae, particularly on hyphae near the margin. The depositions range in size from 9–47 x 4.5–20 mm (PLATE I, a), and often appear to flow about the hypha, imparting a "fingerprint"-like appearance (PLATE I, b, c). The apothecia are frequently clustered closely together (PLATE I, d), and can be mistaken easily for a species of *Peziza*, but of course lack the J+ ascus apex reaction of that genus.

3. **Otidea cochleata** (L. : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 329. 1870.

RECENT TAXONOMIC TREATMENTS:

Nannfeldt (1966), Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:

†Drouet (1866), ††Trelease (1897).

TYPE LOCALITY:

Sweden.

KNOWN MACARONESIAN DISTRIBUTION

AZORES:

São Miguel. † ††

PLATE I. **O. bufonia, a,** medullary hyphae near margin, showing brown pigmented segments, x250; **b, c,** pigmented segments showing flowing nature of the deposition and "fingerprint"-like feature, x2000; **d,** apothecia x 1/2; **a-c,** CUP-MM 2645, **d,** CUP-MM 1465; photographs by Korf.


a
b
c
d

SUBSTRATUM:
On soil.

Notes: Drouet's report of this species was copied by Trelease. We cannot determine which species of *Otidea* this may have been, no voucher specimen being found. *Otidea platyspora* Nannfeldt (1966) has large spores, and his concept of *O. cochleata* is the smaller-spored species illustrated by Boudier in the *Icones Mycologicae* pl. 330 as *O. umbrina* (Pers. : Fr.) Bres. Dennis (1978) and Breitenbach & Kränzlin (1984) both use *O. cochleata* for the larger-spored concept.

PFISTERA Korf & W.-y. Zhuang 1991

One known Macaronesian species

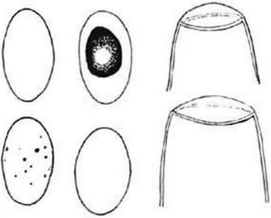
1. **Pfistera pyrophila** Korf & W.-y. Zhuang, Mycotaxon **40:** 275. 1991.

RECENT TAXONOMIC TREATMENT:
Korf & Zhuang (1991).

PREVIOUS MACARONESIAN RECORD:
*Korf & Zhuang (1991).

TYPE LOCALITY:
La Palma, Canary Islands.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
La Palma. CUP-MM *854 (Holotype) (TFC, OSC, Isotypes).



P. pyrophila, spores, ascus apices showing "dome," CUP-MM 854, x1000.

SUBSTRATUM:
On a burn site.

Notes: This strange fungus was described in detail by Korf & Zhuang (1991), who assigned it to the tribe Geopyxidae Korf. It is much larger and has a more complex apothecial structure than *Geopyxis* (Pers.) Sacc., a genus not yet known from Macaronesia [the report of *G. carbonaria* (Alb. & Schw. : Fr.) from Madeira is based on a misidentification; see Part 16, sub *Anthracobia macrocystis* (Cooke) Boud.].

SMARDAEA Svrček 1969

One known Macaronesian species

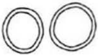
1. **Smardaea planchonis** (Dun. *ex* Boudier) Korf & W.-y. Zhuang, **comb. nov.**

≡ *Plicaria planchonis* Dun. *ex* Boud., Bull. Soc. Mycol. France **3:** 92. 1887.
≡ *Pulparia planchonis* (Dun. *ex* Boud.) Korf, Pfister, & Rogers *in* Korf, Phytologia **21:** 206. 1971.
≡ *Greletia planchonis* (Dun. *ex* Boud.) Donadini, Bull. Soc. Mycol. France **95:** 184. 1979.
= *Marcelleina atroviolacea* [Delile *ex* de Seynes] Brumm., Persoonia, Suppl. **1:** 233. 1967.

RECENT TAXONOMIC TREATMENTS:
Rifai (1968), Donadini (1979).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Nice, France.



S. planchonis, spores, CUP-MM 1475, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM 1475 (TFC).

SUBSTRATUM:
On soil

Notes: We find no way to distinguish *Smardaea* from *Greletia* Donadini. In both all the tissues and ascospores have violet to dark violet pigments. If *Marcelleina* Brumm., Korf & Rifai *in* Brumm. is merged, a new combination under that generic name would be required, but for now we follow Donadini (1979) in recognizing two genera. What he called *Pulparia* Karst. we now accept as *Marcelleina*, and his *Greletia* becomes *Smardaea*.

TARZETTA (Cooke) Lambotte 1887

= *Pustularia* Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 328. 1870, emend. Boud. 1885, non *Pustularia* Bonord. 1851.
≡ *Pustulina* Eckblad, Nytt Mag. Bot. **15:** 84. 1968.

Key to the known Macaronesian species

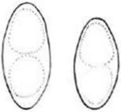
1 Paraphyses clavate, not deformed apically .... **1. T. catinus**
1´ Paraphyses strongly knobbed and deformed apically ... **2. T. spurcata**

1. Tarzetta catinus (Holmsk. : Fr.) Korf & Rogers *in* Korf, Phytologia **21:** 206. 1971.

≡ *Pustularia catinus* (Holmsk. : Fr.) Fuckel, Jahrb. Nassauischen Vereins Naturk. **23-24:** 328. 1870.
≡ *Pustulina catinus* (Holmsk. : Fr.) Eckbl., Nytt Mag. Bot. **15:** 84. 1968.

RECENT TAXONOMIC TREATMENTS:
Dennis (1978), Breitenbach & Kränzlin (1984).

PREVIOUS MACARONESIAN RECORDS:
*Montagne (1840), †Cool (1924), ††Cool (1925), †††Beltrán (1980), ††††Gonzales & Beltrán (1987).



T. catinus, spores, CUP-MM 2553, x1000.

TYPE LOCALITY:
Denmark.

KNOWN MACARONESIAN DISTRIBUTION

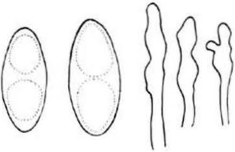
CANARY ISLANDS.
Gran Canaria. † †† ††† CUP-MM *2528 (FI, drawing only).
Tenerife. †††† CUP-MM 2553 (UPS).

SUBSTRATA:
On the ground, on moist soil.

2. Tarzetta spurcata (Pers.) Harmaja, Karstenia **14:** 119. 1974.

RECENT TAXONOMIC TREATMENT:
Harmaja (1976).

PREVIOUS MACARONESIAN RECORDS:
*Bañares et al. (1986),
**Bañares (1988).



T. spurcata, spores, paraphysis apices, CUP-MM 2606, x1000.

NEOTYPE LOCALITY:
Europe.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Gran Canaria. CUP-MM • ••2606 (TFC).
Tenerife. CUP-MM 2723 (TFC).

SUBSTRATUM:
On soil.

Notes: This species differs from *T. catinus* not only in the deformed paraphysis apices, but by having a far more hairy ectal excipulum. The two previous records from Macaronesia are based on Korf's identifications.

TRICHARINA Eckblad 1968

One known Macaronesian species

1. **Tricharina pallidisetosa** (Cash) Thind & Kaushal, Indian J Mycol. Plant Pathol. **9:** 228. 1979.

RECENT TAXONOMIC TREATMENTS:
Thind & Kaushal (1979), Yang & Korf (1985).

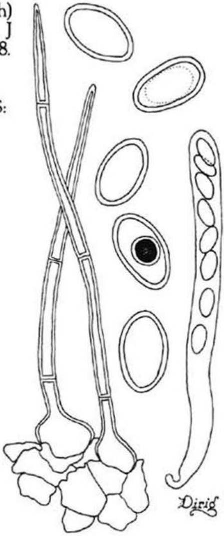
PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Punjab, India.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Tenerife. CUP-MM 440 (TFC, OSC).

SUBSTRATUM:
On rocks and soil.



T. pallidisetosa, hairs and lower ectal excipular cells, x500; spores, x1000; ascus. x500; CUP-MM 440.

Notes: The hairs at the margin arise in fascicles, and not from swollen cells, while those lower down on the receptacle arise from bulbous, more or less globose cells 14–34 µm broad, not described by Cash in the original description, nor by Yang & Korf (1985), but such cells are present as well in the type specimen which we have reexamined. This appears to be the second known collection of this species.

TRICHOPHAEA Boudier 1885

Key to the known Macaronesian species

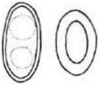
1 Spores broadly ellipsoid, usually 16.8–21.3 x 12.4–16.1 µm, smooth-walled .... **3. T. woolhopeia**
1´ Spores ellipsoid, narrower, smooth-walled or verrucose 2
  2(1´) Spores smooth-walled, 14.6–16.8 x 8.8–9.5 µm .... **1. T. boudieri**
  2´(1´) Spores with irregularly sized warts, 16.8–22.0 (–23.5) x 8.8–11.7 µm .... **2. T. variornata**

1. **Trichophaea boudieri** Grelet, Bull. Soc. Mycol. France 33: 95. 1917.

RECENT TAXONOMIC TREATMENT:
Kanouse (1958).

PREVIOUS MACARONESIAN RECORDS:
None.

TYPE LOCALITY:
Savigné, France.



T. boudieri, mature spore, thick-walled young spore, CUP-MM 1467, x1000.

KNOWN MACARONESIAN DISTRIBUTION
CANARY ISLANDS.
Hierro. CUP-MM 1467.

SUBSTRATUM:
On a twig.

Notes: The long, thin hairs appear diagnostic, and the deeply cupulate apothecia recall *Humaria*, to which genus this species may belong. Our material is not completely mature, and we measure the ascospores only 14.6–16.8 x 8.0–9.5 µm, while Grelet described them as 18–21 x 12–13 µm. When Kanouse (1958) redescribed this species from American collections a full line of text giving ascospore size was inadvertently dropped in her printed description.

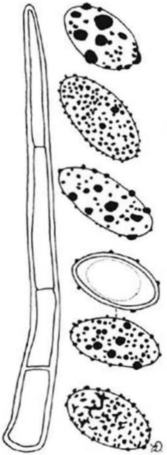
2. **Trichophaea variornata** Korf & W.-y. Zhuang, **sp. nov.**

RECENT TAXONOMIC TREATMENTS:
None.

PREVIOUS MACARONESIAN RECORDS:
None.

Ab Trichophaea gregaria *f.* gregaria *verruculis ascosporarum grandioribus, ab* T. pseudogregaria *verruculis ascosporarum minoribus differens.*

APOTHECIA discoid, sessile, up to 3.5 mm diam when dry. HYMENIUM dirty orange to brown and RECEPTACLE brown when dry. HAIRS not thick-walled, light brown to subhyaline, paler towards the end, tapering to the apex, septate, one or two basal septa thick, remainder thin, distributed more at the margin than towards the base, 35–243 x 7.5–11.2 µm. ECTAL EXCIPULUM of textura globulosa to textura angularis, 55–145 µm thick, thinner at margin than at base, surface pustulate, cells isodiametric, 9.5–35 µm diam, walls thin, subhyaline to light brown. MEDULLARY EXCIPULUM of textura intricata, 75–115 µm thick, hyphal walls hyaline, hyphae 3.0–6.5 µm wide. ASCI 8-spored, subcylindrical, J– in Melzer's Reagent, 196–243 x 11.7–14.6 µm. ASCOSPORES uniseriate, subfusoid, uniguttulate, markings quite variable, many spores with fairly large warts intermixed with smaller warts, markings completely disappearing after treatment with aqueous KOH as in *T. paludosa* and *T. pseudogregaria*, 16.8–22.0 (–23.5) x 8.8–11.7 µm. PARAPHYSES subcylindrical, septate, 3.7–4.0 µm wide, sometimes slightly wider at the apex.



T. variornata, hair, spores, all CUP-MM 1505 except bottom spore, CUP-MM 1529, all x1000.

HOLOTYPE:
Madeira, on soil, 1 km above Vinhaticos, toward Encumeada, leg. R. P. Korf, R. Fogel, G. L. Hennebert, & L. M. Kohn, 15. i. 1977, CUP-MM 1529.

KNOWN MACARONESIAN DISTRIBUTION

MADEIRA.

Madeira. CUP-MM 1505 (paratype), 1529 (holotype).

SUBSTRATA:

On soil, and on duff (mostly needles of *Pseudotsuga*).

Notes: Though this is clearly a member of the *T. gregaria*-*T. pseudogregaria* complex, the variable shapes and sizes of the spore markings seem highly diagnostic.

3. **Trichophaea woolhopeia** (Cooke & Phill. *in* Cooke) Arnauld, Bull. Soc. Mycol. France **9**: 112. 1893.

= ? *Trichophaea albospadicea* (Grev.) Boud., Hist. classific. discomyc. Europe, p. 61. 1907.
= *Trichophaea bullata* Kanouse, Mycologia **50**: 131. 1958.

RECENT TAXONOMIC TREATMENTS:

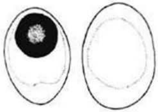
None.

PREVIOUS MACARONESIAN RECORDS:

None.

TYPE LOCALITY:

Downton, England.



T. woolhopeia, spores, CUP-MM 765, x1000.

KNOWN MACARONESIAN DISTRIBUTION

AZORES.

Terceira. CUP-MM 2057.

MADEIRA.

Madeira. CUP-MM 1522.

CANARY ISLANDS

Hierro. CUP-MM 1457, 1464 (TFC).
La Palma. CUP-MM 765, 768 (TFC), 794, 795, 893.
Tenerife. CUP-MM 1189 (TFC).

SUBSTRATA:

On soil, on duff, among mosses.

Notes: This "species complex" (Pfister, 1982) needs restudy of Greville's type specimen of *Peziza albospadicea*. Most authors agree that Kanouse's *T. bullata* does not differ from *T. woolhopeia*.

WILCOXINA Yang & Korf 1985

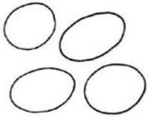
One known Macaronesian species

1. **Wilcoxina rehmii** Yang & Korf, Mycotaxon **24:** 517. 1985.

RECENT TAXONOMIC TREATMENT:
Yang & Korf (1985).

PREVIOUS MACARONESIAN RECORD:
*Yang & Korf (1985).

TYPE LOCALITY:
Berlin, Germany.



W. rehmii, spores,
CUP-MM 1421, x1000.

KNOWN MACARONESIAN DISTRIBUTION

CANARY ISLANDS.
Hierro. CUP-MM *1421 (TFC, OSC) (Isotypes).

SUBSTRATUM:
On soil under pine.

MYCOTAXON

Volume XL, pp. 435-439 January-March 1991

RINODINA BOLEANA[*] spec. nova, A NEW LICHEN SPECIES FROM NORTH-EASTERN SPAIN

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ABSTRACT: A new species of the genus *Rinodina*, with *Pachysporaria*-type ascospores, *Rinodina boleana*, is described. It is known only from some localities of SE Catalonia (NE Spain) at low and middle altitudes, growing on the bark of trees and shrubs. A complete description, iconography, ecology and chorology are presented. The characters of the new species are compared with other closely related taxa.

Rinodina boleana GIRALT & H. MAYRH. spec. nova

Thallus crustaceous, effusus, griseus ad griseo-fuscus, subtiliter granulosus. *Apothecia* lecanorina, sessilia, (0,1)0,25-0,35(0,4) mm in diametro, dispersa vel raro conferta. Disci plani vel subconvexi, nigrobrunnei. Hymenia (45)50-60(70) µm alta. Epihymenia brunnea. Paraphyses simplices, 1,5-1,8 µm crassae, apicibus 3-6 µm crassis. Asci clavati (30)35-45(50) x (8)10-15 µm, 8-spori, typo *Lecanorae*. Sporae ellipsoideae, rectae vel curvulae, 1-septatae, typo *Pachysporaria*, toro vix evoluto, (10)11-13(16) x (4,5)5,8-6,5(7,5) µm. Pycnidia non visa.

TYPE: *Spain*: Catalonia, Querol, (Alt Camp), Esblada, UTM 31TCF7190, 650m, on *Rosmarinus officinalis*, 21.II.1988, *M.GIRALT, A.GÓMEZ-BOLEA & P.NAVARRO* (BCC-Lich. 4427 - holotype; GZU, Hb. Sheard & Hb. Giralt - isotypes).

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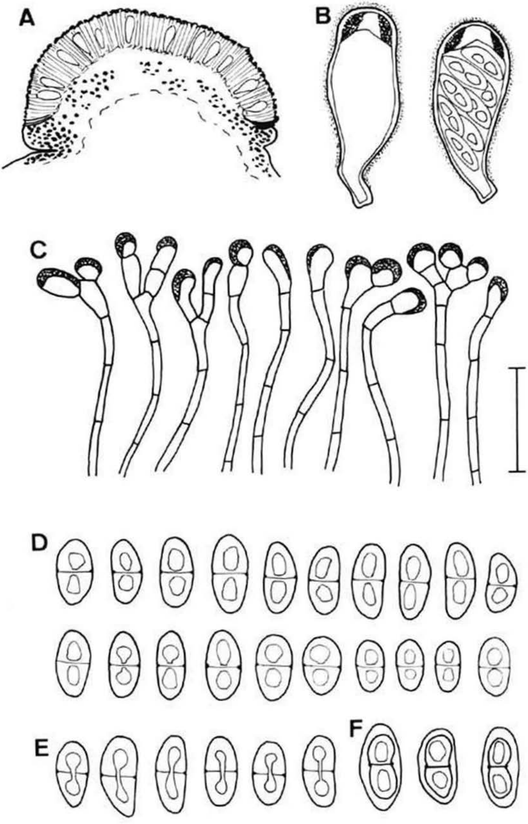
[*] dedicated to Dr.A.GÓMEZ-BOLEA


A
B
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F

Figure 2. Ascospores of *Rinodina boleana* (holotype), scale = 10 µm.

Thallus corticolous, crustaceous, discontinuous, thin to very thin to evanescent, minutely granulose, greenish grey or usually greyish brown, without perceptible prothallus. Photobiont trebouxioid, cells (10)15-22 µm diam. *Apothecia* lecanorine (Fig. 1A), sessile, frequent, scattered or sometimes contiguous, to (0,1)0,25-0,35(0,4) mm in diameter. Disc plane to subconvex, dark brown, rarely becoming black. Thalline margin concolorous with thallus, thin, entire, persistent, rarely completely excluded at maturity. Excipulum thallinum 30-50(60) µm wide. Cortex 5-10(15) µm thick, cellular, with cells more or less distinctly isodiametric, colourless, to (3)4-7(8) µm diam. Excipulum proprium very narrow, colourless, to 5(10) µm laterally, expanding to 10(20) µm above. Hymenium (45)50-60(70) µm tall. Epihymenium dark brown, without epipsamma. Hypothecium to (30)40-50(60) µm thick, colourless to very pale brownish. Paraphyses (Fig. 1C), 1,5-1,8 µm wide, lax, simple, apices 3-6 µm wide. Asci (Fig. 1B), clavate (30)35-45(50) x (8)10-15 µm, of *Lecanora*-type (HONEGGER 1978). Spores (Fig. 1D-F, Fig. 2), ellipsoid, straight or curved, of *Pachysporaria*-type (MAYRHOFER 1982), torus usually poorly developed, (10)11-13(16) x (4,5)5,8-6,5(7,5) µm. *Conidiomata* not seen. *Chemistry:* Thallus K-, C-, P- and I-. Excipulum I-.

Figure 1. *Rinodina boleana* (holotype, BCC-Lich. 4427). A, section of apothecium, scale = 150 µm; B, Asci in I; C, Paraphyses in KOH; D, Ascospores in water; E, Ascospores in KOH; F, Overmature ascospores in KOH, scale = 20 µm.

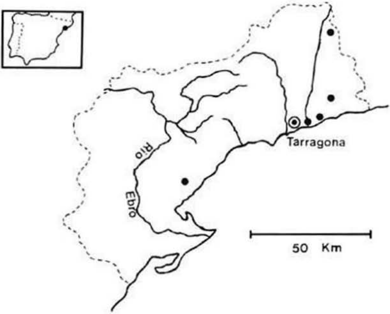

Figure 3. Distribution of *Rinodina boleana* in Tarragona (Spain, Catalonia).

OBSERVATIONS: *Rinodina boleana* is characterized by its thin to evanescent thallus, small apothecia and very small spores with thick uniform walls and irregularly rounded lumina (*Pachysporaria*-type). Other corticolous European species of the genus with similar *Pachysporaria*-type spores (excluding sorediate or isidiate taxa) include *R. confinis* and *R. roboris*. *R. boleana* can be separated easily from these taxa by its smaller spores (25-35 x 12-17 µm in *R. confinis* according to MAGNUSSON 1947, and 14,5-21,5 x 7,5-12 µm in *R. roboris* according to SHEARD 1967). The latter is furthermore distinguished by its chemistry (K+yellow). It is also noteworthy that the five known specimens of the new species are more or less infected by a hyphomycete, which may have some influence on the colour of the thallus.

HABITAT and DISTRIBUTION: *Rinodina boleana* shows a scattered distribution throughout SE Catalonia (Fig. 3). It is found in localities with a typical mediterranean climate, ranging from the coast to inland, and from low to middle altitudes. It occurs in parkland, wayside situations and in open maquis or woodlands (degraded stages of *Quercus ilex* forests). The new species grows most frequently on the eutrophicated upper surface of young and exposed branches of evergreen trees and shrubs, e.g. *Ceratonia siliqua*, *Erica arborea*, *Olea europaea* v. *sylvestris*, *Quercus ilex* and *Rosmarinus officinalis*. It has been found on deciduous trees (*Ficus carica*) only once. It grows on either rough or smooth bark. *Rinodina boleana* is thus predominantly thermophilous, photophilous, nitrophilous and mesophilous-xerophilous.

The new species occurs in communities belonging to the *Xanthorion parietinae*, associated with *Bacidia naegelii*, *Caloplaca holocarpa* s.l., *Catillaria nigroclavata*, *Hyperphyscia adglutinata*, *Physcia adscendens* and *Xanthoria parietina*. It may also be associated with species referable to the *Lecanorion subfuscae*, such as *Lecanora* sp.pl., *Caloplaca pollinii* and *Lecidella elaeochroma*.

ADDITIONAL SPECIMENS EXAMINED: *Spain*: Catalonia: Tarragona, Altafulla (Tarragonès), Mas d'en Casido, UTM 31TCF6156, 25m, on *Quercus ilex* and *Erica arborea*, 3.VI.1987, *M.GIRALT* 739, 752 (Hb. Giralt). - Torredembarra (Tarragonès), Cal Pantxo, UTM 31TCF6556, on *Ficus carica*, 25.X.1986, *M.GIRALT* 476 (Hb. Giralt). - Bonastre (Alt Camp), Cal Lluiset, UTM 31TCF6865, 200m, on *Ceratonia siliqua*, 6.I.1984, *M.GIRALT* 233 (Hb. Giralt). - Tivissa (Ribera d'Ebre), Barranc Franqués, UTM 31TCF1136, 150m, on *Olea europaea* v. *sylvestris*, 1.VI.1988, *M.GIRALT 1210*, *A.GÓMEZ-BOLEA & P.NAVARRO* (Hb. Giralt).

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MYCOTAXON

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BOOK REVIEWS

by

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ASCOMYCETES, an APS slide collection, by G.J. WEIDEMANN, in 4° folder, 1988. APS Press, The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, MN 55121, USA. ISBN 0 89054-091-8. US$71.00.

The Ascomycetes are the largest group of living fungi, comprised of more than 25,000 known species. The one feature that distinguishes the Ascomycetes from all other fungi is the ascus. The promotion issue received for review contains 28 slides disposed in a slide binder, together with double page explanatory text. The slides, contributed by different mycologists, are referred by number to the text where they are explained in a didactic sequence. The first slide in diazo line-drawing of an ascocarp and asci is reproduced from Kendrick's The Fifth Kingdom. Slides 2-6 demonstrate unitunicate and bitunicate asci, with excellent slides showing the operculate ascus (by B. Kendrick) and bitunicate asci (by F.W. Spiegel) under the microscope. The next group of 9 slides illustrates the ascocarp morphology. Four examples of common plant pathogenic ascomycetes are presented in 12 slides to illustrate the major ascocarp type. There are *Taphrina deformans*, un unidentified powdery mildew, presumably an *Uncinula* species, *Monilinia fructicola* and *Venturia inaequalis*. The slides are photographs of fruit bodies in natural condition, macrophotographs of ascocarps or anamorphs on plant organs, stained or unstained sections through ascomata in plant or fungal stromatic tissue or just a diazo line-drawing. The complete collection shall undoubtedly make a very good tool for teaching mycology.

ILLUSTRATED GENERA OF ASCOMYCETES, by Richard T. HANLIN, viii+236 p., ill., 15 x 23 cm, spiral binding, 1990. APS Press, The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, MN 55121, USA. ISBN 0 89054-107-8. US$34.00.

This is a compendium of the generic descriptions of 100 common Ascomycetes, 65 of them plant pathogenic, each description facing a plate of lines drawings illustrating the gross habit and the section of the ascocarp and of ascus and ascospore of one species. The genera are grouped according to the Saccardoan classification of spore types (pigmentation, septation and shape) with no regard to modern taxonomy. The descriptions are concise, followed by the indication of the anamorph(s), the habitat, the representative species, short comments (on 130 related additional genera) and literature. Line-drawing plates are somewhat diagrammatic. Seven plates of photographs illustrate some 30 genera. This book is not intended for the ascomycete specialist, but for students of mycology and plant pathology, as a guide to the genus in the identification of their collections. For that reason, the dichotomous key of 12 pages allows the student to enter this major group of fungi. After the genus has been identified, he is guided to an abundant literature for checking the species.

FLORE MYCOLOGIQUE D'EUROPE; 1. LES HYGROPHORES, Hygrophoraceae Lotsy, by Marcel BON, 99 p., ill., 6 col. pl., 16 x 22.5 cm, 1990. Documents Mycologiques, Mémoire hors série 1. Ed. Association d'Ecologie et de Mycologie, Marcel Bon, F-80230 St Valéry-sur-Somme, France. ISSN 0291-8420

This monograph is written in a concise but didactic style introducing the reader to the exact observation of the criteria by an introduction of 23 pages. Four genera are revised: *Hygrophorus* (77 taxa), *Hygrocybe* (87 taxa), *Cuphophyllus* (27 taxa) and *Neohygrophorus* (1 taxon). Spores and epicutis hyphae of each species are illustrated. 57 species are provided with water colour illustrations. After the taxonomic part, some pages summarize the author's view on the phylogenetic position of the family. *Cuphophyllus* is at the base, originating from the Cantharellaceae and giving rise to *Hygrocybe* (*Pseudohygrocybe* dividing in *Hygrocybe* and *Gliophorus*, and *Neohygrocybe* as lateral branch), and *Hygrophorus* (dividing in *Hygrophorus-Limacium* and *Neocamarophyllus*). The branches *Hygrocybe* and *Hygrophorus-Limacium* would be terminal, *Cuphophyllus* appears related to the Tricholomataceae and the Marasmiaceae, and perhaps the Russulaceae, while *Neocamarophyllus* might be related to the Gomphidiaceae.

GEASTRACEAE (BASIDIOMYCOTINA), Morphology, Ecology and Systematics with special Emphasis on the North European Species, by Stellan SUNHEDE, Synopsis Fungorum Vol. 1, 534 p., 232 ill., 3 col. pl., 16 x 23 cm, cloth hardcover, 1990. Fungiflora A/S, Box 95, Blindern, 0314 Oslo 3, Norway. ISBN 82-90724-05-5

The eight genera of Geastraceae, *Geastrum, Geasteropsis, Myriostoma, Pyrenogaster, Radiigera, Terrostella, Trichaster* and the new one *Phialastrum*, are described with their type species. Twenty four species of *Geastrum*, one species of *Myriostoma* and one of *Trichaster* collected in Northern Europe (mainly Denmark, Sweden, Norway and Finland) are described on the basis of more than 28000 specimens. Each species is extensively analyzed on 10 to 26 pages. That includes the macro- and micromorphology abundantly illustrated (1-4 line-drawing plates, 1-3 photographic plates including SEM photographs of spores, eventually a graphic distribution of the variable characters), a taxonomic discussion based on the type material study and the variation observed on the field, and a detailed ecological and distribution study of the species. This account is ended by some good color pictures of fruit-bodies. It would be difficult to say in a few lines the years of methodic collecting and laboratory work that are condensed in those 534 pages. The very large number of observations is beautifully synthesized with care and precision. The excellent illustration and the associated ecological study make the book very attractive.

CONTRIBUTION TOWARD A MYCOBIOTA OF INDONESIA: Hypocreales, Synnematous Hyphomycetes, Aphyllophorales, Phragmobasidiomycetes and Myxomycetes, by Gary J. SAMUELS, Y. DOI, C.T. ROGERSON, K.A. SEIFERT, L. RYVARDEN, B. LOWY & M.L. FARR.. Memoirs of the New York Botanical Garden, W.R. BUCK ed., vol. 59, 180 p., 42 fig., 17.5 x 25.5 cm, paperback, 1990. Bioscience 31. The New York Botanical Garden, Bronx, New York 10458, USA. ISBN 0-89327-354-6. US$ 39.30 or 40.65 abroad.

Five hundred specimens collected in six weeks yielded over 200 taxa of which 20 are described here as new. They include 34 Aphyllophorales, 7 Heterobasidiomycetes, 73 Hypocreales, 46 Xylariaceae (not included in this paper), 56 Hyphomycetes and 7 Myxomycetes. In the Hypocreales Samuels, Doi and Rogerson describe and illustrate species in *Nectria, Calonectria, Giberella, Nectriopsis, Hypomyces, Ophinectria, Pseudohypocrea* and *Sphaerostilbella*. Seifert classifies the Hyphomycetes in 36 genera of which *Cornutostilbe* is new. His contribution ends with a revision of a large number of synnematous Hyphomycetes described previously from Indonesia by Penzig, Saccardo and other authors. Twenty eight genera of Aphyllophorales, mostly Polyporaceae, are represented, of which Ryvarden describes one new species.

THE LICHENICOLOUS FUNGI OF GREENLAND, by Vagn ALSTRUP & David HAWKSWORTH, 90 p., 45 fig., 6 col. pl., 19 x 26.5 cm, paperback, 1990. Bioscience 31. Ed. Nyt Nordisk Forlag Arnold Busck A/S, Koebmagergade 49, DK-1150 Copenhagen K, Denmark. ISBN 87-17-0967-4. DKK 192.-

124 lichen-inhabiting fungi are reported from Greenland, 72 for the first time, based on 350 collections of lichens made over 17 years. They represent 2/3 of the actual flora of lichenicolous fungi known from Greenland. Three new genera, *Deichmannia* (Hyphomycetes), *Geltingia* and *Kalaalia* (Ascomycetes), and 24 new species are described. A key is provided, as are illustrations of new and rare species, extensive references to the literature and lists of the species by the host lichens.

SETAS (HONGOS) GUIA ILUSTRADA by Francisco DE DIEGO CALONGE 462 p., 252 col. pl., 15 x 22 cm, hardcover, 1990. Ediciones Mundi-Prensa, Castello 37, E-28001 Madrid. ISBN 84-7114-281-3.

This second edition Spanish field guide for students of mycology includes a larger number of species, 48 Discomycetes, 109 Agaricales, 44 Aphyllophorales and 26 Hymenogastrales. All species are illustrated by a color photographs. Latin names are given with authors and synonyms, besides the common names. Descriptions include macroscopic and microscopic features. Useful observations are added to emphasize differences among very close species. This guide is of quality and will prove useful.

LA MERULE, SCIENCE TECHNIQUE ET DROIT, by G.L. HENNEBERT, Ph. BOULENGER & Fr. BALON, 198 p., 5 figs., 55 col. ph., 16 x 24 cm, 1990. Editions Artel, Chaussée de Gand 14, B-1080 Brussels or G.L.Hennebert, 3 Pl. Croix du Sud, B-1348 Louvain-la-Neuve, Belgium. BEF 750. ISBN 2-87085-210-X

Three complementary aspects, scientific, technical and juridical, of the troublesome house fungus, *Serpula lacrimans*, the cause of the true dry rot of fabric wood and the deterioration of masonry, are treated by each of the authors respectively. A large scientific literature, an everyday experience of the technical problems and a full juridiction documentation support an easily read text. The mycological description deals with morphology, in comparison to other dry rot fungi, like *Serpula himantioides*, *Leucogyrophana pulverulenta* or *Coniophora puteana*, with growth conditions and nutrition of the fungus, its growth rate and its water and nutrient translocation in dry conditions, its extension and age, its detection and its identification. Building damage is described together with the causes, the conditions of occurrence, the prevention and the control. Dry rot decay is also a social problem often dealt with by courts as a hidden defect in cases of sale or of rent and rejected by insurance companies as water damage. The book demonstrates the right of such claims.

MUCL LIST OF CULTURES 1989. FUNGI-YEASTS, by G.L. HENNEBERT and Coll., xxii + 360 p., 21 x 29 cm, paperback, 1989. Mycothèque de l'Université Catholique de Louvain, B-1348 Louvain-la-Neuve, Science Policy Office of Belgium, 8, Rue de la Science, 1040 Bruxelles. FB600.-

This is the first edition of the catalogue of the fungi and yeasts kept in pure culture in the MUCL collection. It includes almost 5000 strains, most of Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. The data includes a nomenclator, the strain origin, status, history, optimal growth conditions, state of preservation and some properties like enzyme production, industrial applications, assays, etc. The living collection consists of 19000 strains derived from half the 30000 specimens kept in MUCL mycological herbarium.

MUCL, together with IHEM collection of fungi related to man (6000 strains, Brussels) and LMG collection of bacteria (8000 strains, Ghent), together make up the Belgian Coordinated Culture Collections (BCCM), a consortium coordinated by the Sciences Policy Office of Belgium. The three catalogues are available on request, free of charge. All data in the collections are in databases according to the general dataformat agreed upon by the Microbial Information Network Europe (MINE).

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LISTS OF NAMES IN CURRENT USE: A NEW INITIATIVE TO ADDRESS A CONTINUING PROBLEM

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Abstract: Instability of names is a major criticism levelled at taxonomists. It irritates its users and contributes to the lack of support for the subject. The current provisions of the Code do not provide the stability required. Changes resulting from advances in science and a greater understanding of relationships and functional characteristics are to be welcomed, but those arising from nomenclatural rules must be minimized. Prompted by the International Union of Biological Sciences (IUBS), the General Committee of the International Association for Plant Taxonomy (IAPT) established a Special Committee on *Lists of Names in Current Use.* Lists are being prepared for **all** groups covered by the International Code of Botanical Nomenclature, for which special protected status will be sought at subsequent International Botanical Congresses. The International Commission on Zoological Nomenclature (ICZN) decided to follow the same course in 1990. Generic names are the first target, and procedures for vetting and developing those draft *Lists* are described. This initiative, especially as it is extended to the species level, will alleviate the nomenclatural "noise" in the system which arises from the recognition of earlier synonyms, and uncatalogued or newly typified names. It will also give mycologists more time to study fungi by reducing the time necessary to thoroughly examine the application and status of long-forgotten names. These proposals have massive international support, and while they are under active discussion, taxonomists are advised **not** to change well-established names simply on the basis of priority of publication or ammended typifications.

INTRODUCTION

"Name changes continue to irritate" was a recent headline in *Nature* (Crisp & Fogg 1988). This is nothing new, indeed Gilmour (1961: 27) viewed the need to improve stability in names as one of the key "birth-pangs" of botany. In reviewing the prospects for systematics 25 years later, nomenclatural stability has been identified as one of the major consumer requirements not being fulfilled by the discipline (Hawksworth & Bisby 1988: 17). Burdsall (1990: 4) independently stressed this need in mycology, and the dangers for the future of the subject if current practices do not become more sensitive to user needs. He noted the reduction of full-time systematic posts in three leading US mycological centres from 13 to 6 in recent years. In the UK, this apparent disregard for the taxonomist was sharply focussed by the announcement in April 1990 of the loss of 100 scientific posts in the Natural History Museum in London (Hamer *et al.* 1990).

Taxonomy has many practical products of crucial importance throughout biology and natural history. The current renewed interest in biodiversity, the environment, and biotechnological applications, should have led to the subject being on the ascendent. The demand can be seen from the stocks of field guides in bookstores and training courses on offer. The reality to be faced in the realism of the 1990s is that taxonomists are not fulfilling customer needs, to the extent that headlines such as "Stop Taxonomists" appear (Barnett 1989). If the retail aspect of the subject is not met (Bisby 1984), the corollary is that the funding will not be forthcoming to produce unwanted goods (Hawksworth & Bisby 1988). All pertinent problems cannot be addressed immediately or simultaneously, but international effort is gratifyingly now starting to be addressed to the ubiquitously acknowledged need to reduce unnecessary name changes.

This contribution focusses on one of these initiatives, the production of *Lists of Names in Current Use*, being conducted under the auspices of the International Union of Biological Sciences (IUBS) and the International Association for Plant Taxonomy (IAPT).

STABILITY UNDER THE BERLIN CODE

The International Code of Botanical Nomenclature (ICBN) has been revised at International Botanical Congresses (IBC's) since 1867 (De Candolle 1867), most recently at the XIII IBC held in Berlin in 1987

(Greuter *et al.* 1988). In 1987 there were 349 proposals to alter the Code itself (Greuter & McNeill 1987); fortunately for stability, most were not approved. The Preamble to the Code makes it clear that its objective is nomenclatural stability (Greuter *et al.* 1988: 1). The reality that this aim is not being achieved to the degree demanded by the consumers of its products across biology as a whole has to be confronted and addressed.

Disillusionment and lack of confidence is increasingly leading to various groups ignoring the Code. Specialists in yeasts continue to cite only living cultures as types and lean towards the International Code of Nomenclature of Bacteria; the International Organization for Succulent Plants (IOSP) has produced a list of generic names to be used (Hunt & Taylor 1986), and is now preparing a list at species level; the International Seed Testing Association (ISTA) has had standard lists for many years; a completely alternative reference system for all fossil groups has been proposed (Hughes 1989); the International Legume Database and Information Service (ILDIS) is preparing consensus lists for all legumes (Bisby 1986); etc.

Molecular biologists and geneticists are especially uncompromising in genera such as *Aspergillus* (Bennett 1985); at a British Mycological Society symposium on the "Molecular Biology of Fungi" held in Nottingham in April 1990, *no* contributor used the nomenclaturally correct names of several repeatedly cited species, such as *Aspergillus nidulans*, *A. niger*, and *Penicillium chrysogenum*. The extent of name changes in some of these genera is remarkable, 47% of those in *Penicillium* have changed over 30 years (Hawksworth 1990).

All name changes are not due to nomenclature. Those that relate to an increased knowledge of relationships are to be welcomed when based on firm evidence. Names then have a greater predictive value with regard to the properties of the included individuals or taxa. Taxonomists are, regrettably, not always sufficiently careful or user-aware. Irresponsible and incorrect names changes are a major element of instability. This aspect is starting to be addressed in consensus systems such as ILDIS (Bisby 1986), *Systema Ascomycetum* (Eriksson & Hawksworth 1986), and also by the International Commission on the Taxonomy of Fungi, ICTF (Cannon 1986). The question of conserving *taxonomy* is a quite separate issue *not* being addressed by the *Lists* initiative. It cannot be stressed too strongly that proposals to introduce regulatory systems for taxonomy form no part of this proposal, and none are expected to be made at the next IBC in 1993.

The cumulative effect of nomenclatural and taxonomic changes can be substantial. In the case of fungi recorded from Slapton in South Devon, 168 name changes (11%) occurred in 1495 species over 1972/6-90 (Hawksworth,D L unpublished); at that rate around 80% would be altered over 100 years causing major problems for the rapid comparison of lists to assess changes in species present. Indeed, this is already a serious problem in conservation, floristic, and information fields of which taxonomists need to be aware.

The *Lists* proposals are targeted to overcoming the main cause of nomenclatural changes, those arising from the application of the rule of priority of publication. The principle of priority was thought to be a way of ensuring stability, but it fails because previously uncatalogued or unconsidered names continue to come to light. To give some mycological examples, overlooked works by Dumortier (1822) and Paulet (1791) have resulted in several conservation proposals in recent years, and in the case of the badly catalogued names of fungi growing on lichens about 30 epithets published in the last century have come to light only since 1986 (e.g. Alstrup & Hawksworth 1990). Also, as old names are examined and typified they can disrupt names stable for in some cases two century's, as in Laundon's (1984) resurrection of 16 epithets introduced by Withering (1776); even Withering did not employ these himself a few years later (Withering 1787-92). In some genera disturbingly large numbers of epithets lurk which are contenders for resurrection; 175 exist in *Penicillium* alone (Pitt 1980). The ficticious Professor N J McGinty who discovered new taxa on steps in libraries (Lloyd 1913, Fitzpatrick 1927) is all too often a reality.

Current procedures to conserve names under the Code are too cumbersome and lengthy to satisfactorily solve the priority question on their own. Separate proposals have to be: (1) published in *Taxon*, a journal not seen by most users of scientific names; (2) discussed and voted on by one of a series of group-orientated Committees [the Committee for Fungi and Lichens for fungi]; (3) reviewed by the General Committee; (4) included in Committee Reports published in *Taxon*; and (5) passed for ratification to the next IBC. To be approved by the group-orientated committees, a two-thirds majority vote of all Committee members is needed. With this requirement and six-year intervals between Congresses, final decisions can take up to 12 years. Further, taxonomists are under no obligation to either make conservation proposals, or to use the more familiar name while proposals are still under consideration. An all too common pattern is for an older name to be taken up by one author, the transfers published or usages changed, and then for another more user-orientated taxonomist frustrated by what he sees as an undesirable change then making a formal proposal not to adopt that already published change. While a proposal is under consideration, the competing names are both used for some years compounding confusion while the conservation mechanism takes its course, and taking years to be lost from the system should they chance to be used in textbooks, manuals and checklists. Examples of this in mycology resolved by conservation are: *Debaryomyces* vs. *Debaryozyma*, *Guignardia* vs. *Discochora*, Physciaceae vs. Pyxinaceae, *Xylaria* vs. *Xylosphaera*. The Committees also (of necessity ?) comprise leading nomenclaturalists rather than users, and have daunting numbers of names to consider. In the fungi, 131 names have been formally proposed for conservation or rejection since 1981; a massive total when compared to the 159 treated in the current Code (Greuter *et al.* 1988).

Since 1981 it has been possible to protect species names of major economic importance through the conservation procedures, but when the Committee for Spermatophyta rejected a proposal to protect the name of the tomato, faith in the efficacy of that system plummeted; fortunately the General Committee overuled that Committe's view. I trust that the Committee for Fungi and Lichens will be more consumer-friendly when it considers its first species names; some in *Aspergillus* and *Penicillium* are now being proposed (Frisvad *et al.* 1990). At least in mycology, we are fortunate that the "sanctioning" procedure wisely adopted by the IBC at Sydney in 1981 has limited the extent of proposals required at the species as well as the generic level to a considerable degree.

In summary, the present system is cumbersome, lengthy, retroactive, causes confusion while in train (and ripples after), can be disregarded when proposing changes, and does not safeguard any names not on the conserved list from published changes. Significantly, with the demands on the world's dwindling corps of morphotaxonomists in the 1990s, the debates also result in an unacceptable level of man-hours of the world's leading systematists being spent non-productively. As noted by Cowan (1970: 145), when bacteriologists were arguing over the introduction of their Approved Lists, such expert time is better devoted to improving our knowledge of the organisms themselves and of their relationships and properties.

The potential threats to names in use are huge. In the case of the fungi, around 250K validly published names exist for the approximately 64K species currently recognized (Hawksworth & Greuter 1989a).

STABILITY THROUGH LISTS OF NAMES IN CURRENT USE

Background

The IUBS has been voicing the concern of many user groups over the need to improve nomenclatural stability for many years, and particularly at its XXI General Assembley in Ottawa in 1982. As as a result, sessions on this topic were held during the Third International Congress for Systematic and Evolutionary Biology (ICSEB III) held at Brighton in 1985 (Ride & Younes 1986). Later that year the IUBS General Assembly in Budapest supported resolutions passed in Brighton which were taken up by a group established by the General Committee for Plant Nomenclature in January 1986. This made proposals regarding the registration of newly published names (Greuter 1986); interestingly these echoed those argued for by the mycologists Ainsworth & Ciferri (1955: 4) thirty years previously. At the XIV IBC in Berlin in 1987, these were extensively discussed, and the proposals were referred to two subcommittees for further discussion (Greuter *et al.* 1989). It was recognized at that Congress, and at other international meetings later in 1987, that a package dealing with current as well as newly published names was required. An *ad hoc* meeting was sponsored by IUBS at Kew in April 1988 to investigate possibilities further. The conclusions of that key meeting were that the production of *Lists of Names in Current Use* for all groups covered by the Code was now feasible, and that if these were given specially protected status they would be a major contribution to nomenclatural stability (Hawksworth 1988, Hawksworth & Greuter 1989a). The General Committee on Botanical Nomenclature then formally established a Special Committee on *Lists of Names in Current Use* in March 1989, charged with reporting to the XV IBC in 1993. A report of work in 1988-89 was issued by Hawksworth & Greuter (1989b), and the subcommittee charged with *List* production met in Gran Canaria in November 1989 and at Kew in June 1990. The following sections report the provisional conclusions from those meetings, without prejudice to the final proposals to be made, drafts of which are still undergoing discussion within the Committees.

Production of the Lists

The initial objective of the project is to produce a list of the around 36 500 generic names in current use. This is being achieved through a close collaboration with the IAPT *Index Nominum Genericorum* (ING) database. Output from this has been made available on disc to institutions and organizations who have accepted responsibility for co-ordinating the names to be included for different groups: Algae (Professor P C Silva and Dr R L Moe, University of California, Berkeley), Bryophytes (Dr M Crosby, Missouri Botanical Garden; assisted by Dr R Grolle, Halle), Fossil Plants (International Organization for Paleobotany, Plant Fossil Record project), Fungi (Dr P M Kirk, International Mycological Institute) and Vascular Plants (Dr R K Brummitt, Royal Botanic Gardens, Kew).

Drafts prepared on a group basis are undergoing review in several stages: (1) in 1989/90 by sending copies to selected organizations and individuals; (2) by exposure at appropriate international congresses; (3) in 1991/92 drafts divided into groups (to family in some cases) will be available on request and free of charge by application to the IAPT office in Berlin [announcements and further details will appear in general and specialist taxonomic journals in the next months]; (4) collated ammended lists will be published in *Regnum Vegetabile* early in 1993; (5) further additions or deletions can be considered at the IBC that year.

Each entry will include the generic name, place of publication, type fields for ING (edited or corrected where necessary), an indication of the groups and(or) period to which the name belong.

Criteria for Inclusion

"Names in Current Use" (NCUs) are defined as legitimate names adopted in the most recent revision of the group, recent floras, or ones that would be used if a particular taxon was referred to. The criteria are viewed as flexible and pragmatic, and must cater for alternative taxonomies in accordance with the Code, provided that such taxonomies are currently employed. That means in mycology that "segregates" in use in broad genera such as *Hygrophorus*, *Lachnum*, *Lepiota* and *Parmelia* would all be included. The *Lists* will be "splitters lists" rather than "lumpers lists".

It is planned to exclude from the *Lists* names that are forgotten or unused because they are universally considered as synonyms, illegitimate names (homonyms, superfluous names) unless sufficiently in use to justify conservation (a separate proposal then being required), ones which cannot be typified or the type interpreted, or names that have been used in different senses and become misleading.

Names published up to 31 December 1990 only are to be included in the generic NCU list to be published in 1993. Three years is regarded as too short a time for a name to be regarded as in general use.

Status of Names on the List

It is envisaged that protection will be sought for names on the *List* against any unlisted names and homonyms. It is also anticipated that the spelling (orthography) would be protected, as would the place of valid publication cited. In the case of competing listed names arising from alternative taxonomies, priority of publication would apply as at present, subject to the current conservation procedures which necessarily would remain in force.

Names on the *List* will probably be termed "Protected Names" as they are not identical to either "Sanctioned", or "Conserved" names. Conserved names would take precedence over "Protected" names, but "Protected" names would take priority over "Sanctioned" names. However, validly published legitimate names not on the *List* but otherwise in accordance with the Code would remain available for use provided they did not compete nomenclaturally with any listed name. Unlisted names would *not* be devalidated as is the case with the "Approved List" for Bacteria. Taxonomists would be free to use any unlisted name without republishing it as is necessary in bacteriology, provided that no listed name was threatened.

Opinions on the status of the types to be listed vary and it is anticipated that will be referred for decision to the 1993 IBC. Listed types need not inevitably have to have the specially protected status of the names themselves.

Updating and Approving the Lists

Currently it is envisaged that updated *Lists* would be presented for approval at all subsequent IBC's. Any included names that did *not* for any reason gain IBC endorsement could be listed separately in the edition of the ICBN produced after that Congress.

With this method of operation, it is important to stress that the procedure is not dependent on the introduction of any system of Registration for newly published names and (or) publications.

Species Names

Species-level *Lists* are the most important to consumers. Trials to produce such *Lists* for selected groups are underway, including all mosses, legumes, and fungi.

In the case of the fungi, a "Species Fungorum" project is being developed from IMI; about 31 500 accepted species names, i.e., just over 50% of the total recognized in the world (Hawksworth *et al.* 1983), together with places of publication, are now available in a machine-readable form. Subject to funding, all 64 000 are planned to be keyed by 1993. It is not, however, anticipated at this stage that any species-level *List* will have been sufficiently vetted internationally to be formally submitted for adoption in 1993.

Proposals to modify the Code now being considered, would require a single new Article 15, that could cover species level names as well as genera and families.

Opening up the Debate

In view of the international concern over the stability of names, a wide-ranging and open debate is essential. This must involve user-groups, in addition to taxonomists and nomenclaturalists. To this end presentations and symposia on this matter have been made at various meetings including the X Congress of European Mycologists (Tallinn, 1989), the International Bryological Congress (St Louis, 1989), Fourth International Congress of Systematic and Evolutionary Biology (Maryland, 1990), Fourth International Mycological Congress (Regensburg, 1990), Designs for a Global Plant Species Information System (Delphi, 1990), and

International Congress of Palaeobotany (Frankfurt, 1990). In addition notices and reports have appeared in a variety of newsletters and journals, and IUBS has solicited comments from its constituent national committees and also scientific members.

The most important debate will, however, be at an international symposium under the title "Improving the Stability of Names: Needs and Options", sponsored by IUBS, IAPT, and the Systematics Association, and to be held in the UK in February 1991. The presentations, discussions, and committee reports will then be published as an issue of *Regnum Vegetabile* later that year. The arguements presented in that volume will then be available for debate by the scientific community at large prior to the decisions that have to be taken at the 1993 IBC.

DISCUSSION

Support for the philosophy of the IUBS/IAPT *Lists of Names in Current Use* (NCU) approach has been received from a gratifying variety of organizations, including financial assistance from several. Where adverse comments have been made, such as those of Bremer *et al.* (1990), they have almost always been based on a failure of the authors to study what is proposed. The *Lists* will in no way inhibit taxonomic research, but rather enable taxonomists to reduce the time they have to devote to unproductive nomenclatural investigations. Consensus taxonomy *Lists* are *not* envisaged, although they are campaigned for by some user groups, and alternative taxonomies in use will be catered for. Further, 250 years of scientific literature will *not* be bulldozed away; names not listed will not be devalidated and so remain available for use. With revisions at each International Botanical Congress, older names that come into use again can be added (and others falling out of current use removed).

It is important to stress again that the NCU approach is not dependent on that of "Registration" of newly published names. That issue is being addressed by a separate Special Committee established by the 1987 Berlin IBC; the main objective of the Committee on Registration is to overcome problems of defining effective publication in the era of desk-top publishing and "grey" literature. It is, however, hoped to include a report on the principle conclusions of the Committee on Registration in the record of the 1991 symposium (see above). Together these initiatives will lead to a much-improved system of Botanical Nomenclature in the years ahead.

Current indications, especially from broad discussions which took place at ICSEB IV in June 1990, leave little doubt that the NCU proposals will be accepted in 1993 for family and generic names, with some uncertainty over species names. Indeed, it has been noticeable that, as the proposals have been debated and aspects clarified, much of the initial and largely emotive reaction has evaporated. The General Assembly of ICSEB IV went so far aas to pass a Resolution urging the IBC ".. to devise and implement such changes to the International Code of Botanical Nomenclature as may be necessary to bring the lists of names compiled by its working groups into effective use".

The discussions within the botanical community have been closely monitored by zoologists. The International Commission on Zoological Nomenclature (ICZN) has participated in relevant committee meeetings since 1986. At the meeting of the ICZN held during ICSEB IV at the University of Maryland in July 1990, the Commission decided that it would follow the NCU route and proceed (in collaboration where appropriate with BIOSIS, producers of the *Zoological Record*) to prepare and adopt lists of names in zoological nomenclature at all taxonomic levels.

With this background, I wish to urge mycologists currently contemplating changing names merely on the basis of priority of publication not to do so. At this watershed in biological, and not only botanical, nomenclature, it would be more appropriate to state that they are adopting that practice as it is anticipated that by the 1999 IBC species *Lists* will receive Protected status. Indeed, I am personally now deliberately not taking up species as well as generic names that will receive protection through the NCU process (Purvis *et al.* 1991). To do otherwise is in my view irresponsible at this point in the history of nomenclature.

Carl Linnaeus was bold in his introduction of bionomial nomenclature, which led to the devalidation of the polymonials of the past. The NCU proposals are not as drastic, and the nomenclatural community should not shirk its responsibilities to improve its systems and practices in the light of current concerns. Linnaeus was a pragmatist, and for taxonomists to fail to be so in the 1990s is to loose the resources to operate; to risk becoming increasingly endangered if not extinct. We must strive to ensure that "The Disappearance" of taxonomists of which Isely (1972) dreamed does not further approach reality through the neglect of user needs by this generation of systematists.

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SHALL WE ABANDON THE PRINCIPLE OF PRIORITY (AND OTHER NOMENCLATURAL CAVEATS) FOR THE SAKE OF EXPEDIENCY?

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ABSTRACT

The proposed preparation of "Lists of names in current use" is applauded, but providing names on such lists with a "protected status" under the International Code of Botanical Nomenclature is considered most unwise. Existing mechanisms under the Code to avoid disadvantageous name changes caused by application of the principle of priority are adequate to take care of the problem through conservation and rejection of names. The perception that name changes are due in any large degree to application of the principle of priority appears to be false; a selection of name changes of common fungi that have occurred over the past 40 years shows the vast majority to have been caused instead by improvements in our taxonomy, which necessarily resulted in name changes to reflect that new information and those new rearrangements of taxa. In this age of computerization of information it will be easy to provide updated lists of names that mirror current taxonomies without destroying the principle of priority of publication, a principle basic to most sciences.

I first became aware of the proposal to give special (protected) nomenclatural status to names on proposed "Lists of Names in Current Use" in a publication by Professor Hawksworth (1988) in which it was stated that it might well be time to avoid the disadvantageous changes in names that come about by—and I quote—*the application of the rules of priority and other nomenclatural caveats*.

This statement was, for me, something like the matador's cape before the bull. I was, quite honestly, deeply disturbed by the statement from one of our eminent nomenclaturalists and one of the most vocal members of the International Association of Plant Taxonomy's (IAPT)

Committee on Fungi and Lichens that made no distinction between what are *principles* of the International Code of Botanical Nomenclature[1] and what are *rules*. Our Code has long been divided into a set of six *Principles* and some 76 *Rules* and *Recommendations*. Let me briefly restate the six Principles for you. (Greuter et al., 1988):

Principle I

Botanical nomenclature is independent of zoological nomenclature. The Code applies equally to names of taxonomic groups treated as plants whether or not these groups were originally so treated (see Pre[amble] 7).

Principle II

The application of names of taxonomic groups is determined by means of nomenclatural types.

Principle III

The nomenclature of a taxonomic group is based upon priority of publication.

Principle IV

Each taxonomic group with a particular circumscription, position, and rank can bear only one correct name, the earliest that is in accordance with the Rules, except in specified cases.

Principle V

Scientific names of taxonomic groups are treated as Latin regardless of their derivation.

Principle VI

The Rules of nomenclature are retroactive unless expressly limited.

It is, of course, Principle III that is the primary target of Professor Hawksworth and others, a principle that is generally recognized throughout all science.[2] We still argue today as to which scientist

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[1] It is clear that not all is well with our Code. We tinker with it regularly, sometimes to the dismay of many users, but always with good intentions in mind. A wholesale revision of the Code, as suggested by Parkinson (1990) for example, seems an unlikely outcome, though surely many of his proposals deserve a far more receptive hearing than they have received at recent International Botanical Congresses.

[2] An engaging treatment of the principle of priority, mostly from a zoological point of view, is presented by Gould (1990), in which are detailed the efforts of the Strickland Committee of the British Association for the Advancement of Science and their 1842 strict construction on absolute priority, through later developments, to the final question of *Brontosaurus* vs. *Apatosaurus*.

was the first to develop calculus, for example, with British and German contenders. Closer to home, in mycology, we have the controversy as to whether penicillin was first discovered by Sir Arthur Flemming, who is usually credited with that discovery, or by a Canadian whose work has largely been forgotten.

Why should botanists (inclusive of mycologists!) be called upon to relinquish priority of publication as one of the principles on which their nomenclature is founded? Professor Hawksworth's (1991) eloquent presentation of the arguments are before you. It is clear he has a sincere desire to reduce the perceived bad image that botanists have who change names—to the dismay of the non-botanical "users" of those names, foresters, pharmaceutical and industrial workers, phytopathologists, and others.

The proposal to prepare lists of names in current use is, in itself, a laudable one, for given such lists I foresee that finally we will find some stability arising from that use, particularly in author citations of our names, a problem that for me is perhaps more plaguing than are name changes necessitated by application of the Rules of nomenclature.

The *danger* of the proposal is the giving of "special priority status" (protection) to names appearing on such lists.

Restriction on priority is already well-established in our Code. Many of the Rules specifically limit priority—a glance at the various dates only after which particular Articles take effect, such as starting point date, requirements for a Latin description/diagnosis, requirements for designation of a type, etc.—are all limitations on the principle of priority. The major limitation, of course, is in Articles 14 and 69, which provide for lists of conserved and rejected names proposed "to avoid disadvantageous changes in the nomenclature of families, genera, and species entailed by the strict application of the rules, and especially of the principle of priority... ."

If we accept Professor Hawksworth's proposal, which he and his colleagues have labelled as the most significant change in nomenclature since Linnaeus, we must believe that our processes of conservation and rejection of names has failed.

I do not believe that this is true. Each such proposal made by a scientist or group of scientists is carefully examined by a committee of the IAPT, argued at length, and a decision reached, which then takes effect after ratification at the next International Botanical Congress.

What are the other "nomenclatural caveats" that Professor Hawksworth and his colleagues would have us abandon? He has referred (Hawksworth, 1991) to headlines such as "Stop Taxonomists," which only emphasizes the utter incapacity of non-botanical "users" of names to understand what scientific advancement is all about. If the cry were for "Stop Nomenclaturalists," we would better understand the problem. Indeed, what are "names in current use": he cites in that article that no contributor to a recent British Mycological Society symposium on the molecular biology of fungi used the nomenclaturally correct names for several repeatedly cited species of *Aspergillus* and *Penicillium* (see also Gams, 1991). But surely those were "names in current use!" He has pointed out that the "cumulative effect of nomenclatural and taxonomic changes can be substantial," but correctly sees that only the nomenclatural changes can be addressed without destroying science. And his summary conclusion is that "current procedures to conserve names under the Code are too cumbersome and lengthy to satisfactorily solve the priority question on their own." He further urges "mycologists currently contemplating changing names merely on the basis of priority of publication not to do so." As Secretary of the IAPT's Committee on Fungi and Lichens I must voice my strong dissent from those conclusions.

Let me take this opportunity to discuss the effect of *authority* on the development of mycological science. I shall use but two examples, both of which I spell out in some detail to my students, both under the broad rubric of "The Dead Hand of Authority on Scientific Advancement."

By far the worst case is the amazing, important, and essential 26-volume *Sylloge Fungorum* (Saccardo, 1882-1966). Brought together in one place were descriptions of "all" taxa described for fungi, in a generally similar format, with many references to the primary and secondary literature on each taxon. Those volumes had, of necessity, a taxonomic framework which, by today's standards, was necessarily rigid. Genera were frequently distinguished one from another on spore shape or septation when we now know such separations in many cases do not reflect phylogenetic differences. But the "dead hand" of Saccardo exerted (and still exerts!) an immense gravity, a millstone about our necks for the development of a taxonomy that mirrors biology. It represents a classic case of "names in current use," and getting rid of those Saccardoan names and educating our colleagues on modern taxonomy remains, for many of us, a tiresome burden. Had Saccardo's names been given "Protected Status" such as Professor Hawksworth envisions for his "Lists of names in current use," mycological taxonomy would have been even further stifled.

For my second example I choose the eminently scholarly and useful books by M. B. Ellis (1971, 1976), *Dematiaceous Hyphomycetes* and *More Dematiaceous Hyphomycetes*. These have had a profound impact on the development of work on hyphomycetes. But in turn his particular conservative taxonomic position on the grass-inhabiting plant pathogens once referred to *Helminthosporium* has led to a failure on the part of plant pathologists (particularly in Britain and its former colonies) to recognize the very real differences among these fungi, and to stifle information that could apply to disease control techniques. Ellis clearly followed the lead of Hughes (1958) in restricting the use of *Helminthosporium* to primarily wood-inhabiting species (but also at least one plant pathogen, the causal agent of "silver scurf" disease of potatoes). For the grass-inhabiting species Ellis adopted only one split genus, *Drechslera*, despite the availability of two additional generic names for species differing only slightly in their anamorphoses, *Bipolaris* and *Exserohilum*. What is critical biologically is that each of these three anamorphic genera can confidently be connected to a very different teleomorphic genus: *Drechslera* sensu stricto connects to *Pyrenophora*, *Bipolaris* to *Cochliobolus*, and *Exserohilum* to *Setosphaeria*. Whatever one can say biologically about, for example, *Bipolaris-Cochliobolus* cannot be said about either *Drechslera-Pyrenophora* or *Exserohilum-Setosphaeria*, and Ellis's "dead hand" of conservative taxonomy to this day holds back that essential information.

My next step in the analysis of the proposal for "Lists of names in current use" was to ask myself what fungi that I normally introduce my students to on field trips have had name changes during my teaching career, fully aware that in the 40-year period I have had to learn new names for many "old friends" in the woods. For this purpose I consulted the recent compendium, *Fungi on Plants and Plant Products in the United States* (Farr, et al., 1989). In examining only the entries under the generic names "A" through "C" I came up with the following changes, for each of which I addressed the question of "why the name change?" The name or names I had previously used I have marked in each instance with an asterisk (*).

Acanthophyscium weirii (Burt) Parmasto
Aleurodiscus weirii Burt

Why the name change? This is a purely taxonomic decision, and inclusion on a "List of names in current use" would not have prevented the need for a name change.

Antrodiella semisupina (B. & C.) Ryvarden
**Polyporus semisupinus* B. & C.
**Tyromyces semisupinus* (B. & C.) Murrill
Flaviporus semisupinus (B. & C.) Ginns

Why the name changes? These were all purely taxonomic decisions, and inclusion on a "List of names in current use" would not have prevented the need for changes.

Apiosporina morbosa (Schw. : Fr.) Arx
**Plowrightia morbosa* (Schw. : Fr.) Sacc.
**Dibotryon morbosum* (Schw. : Fr.) Theiss. & Syd.

What I had learned as *Plowrightia* I had to relearn as *Dibotryon*, and after decades of teaching that name I had to change again to *Apiosporina*. Why? Not because of nomenclatural caveats or the principle of priority, but because we learned that this fungus does not belong in either of those genera, but instead in *Apiosporina*, new and important taxonomic information. No inclusion on a "List of names in current use" could have prevented my having to make those changes in my use of names.

***Armillaria mellea** (Vahl. : Fr.) Kummer
**Armillariella mellea* (Vahl. : Fr.) Karsten
↓
Armillaria spp. (including *A. mellea*)

Why the name changes? One was based on typification of *Armillaria*, now no longer accepted, a taxonomic and nomenclatural matter. But today I must advise my students that what we once thought to be one, variable species is a complex of at least six biological species (in North America), some of which are distinguishable in the field, others requiring the microscope for correct identification. No inclusion on a "List of names in current use" could have prevented any of these changes.

***Ascocalyx abietina** (Lagerb.) Schläpfer
**Scleroderris abietina* (Lagerb.) Gremmen
**Gremmeniella abietina* (Lagerb.) Morelet
Lagerbergia abietina (Lagerb.) Reid *in* Dennis

[*Brunchorstia pinea* (Karst.) Höhn., anam.]

Again the name changes are questions of taxonomy, not nomenclature. Whether, in fact, I should be using *Ascocalyx* or

Gremmeniella appears an unresolved taxonomic question, and surely *both* would need to be on any "List of names in current use." But inclusion of any or all on such a list would not have saved the confusion that exists as to the correct name for the "Scleroderris canker" organism.

*__Bipolaris__ spp., *__Drechslera__ spp., *__Exserohilum__ spp.
↑ ↑ ↑
*__Helminthosporium__ spp.
↓
*__Pseudospiropes__ spp.

There are too many species to list here. I admit to having one plant pathology colleague who stated flatly to me that he would "never stop calling the grass pathogens *Helminthosporium*" (luckily not the attitude of most of my colleagues). And I have had to learn that the anamorphs of a discomycete genus with which I have worked, *Strossmayeria*, are to be called *Pseudospiropes*, not *Helminthosporium*. Once again, "Lists of names in current use" would have played no rôle in avoiding any of these scores of name changes.

Blumeriella jaapii (Rehm) Arx
Pseudopeziza jaapii Rehm
*_Coccomyces hiemalis_ Higgins
*_Higginsia hiemalis_ (Higgins) Nannf.
*_Coccomyces lutescens_ Higgins
*_Higginsia lutescens_ (Higgins) Nannf.
Coccomyces prunophorae Higgins

[*Phleospora padi* (Lib.) Arx, synanam.]
[*Microgloeum pruni* Petr. in Syd. & Petr., synanam.]

Here is a case where the names plant pathologists were commonly using was clearly wrong taxonomically, and after a period I convinced phytopathologists in my department to switch to *Higginsia*, only later to discover that that name was unavailable (a later homonym). I wonder how many have now adopted *Blumeriella*, or realize that von Arx synonymized three species described by Higgins. Once again, none of these changes would have been saved by adding names to a "List of names in current use."

$$\begin{tikzcd}
\textit{Ceratostoma} \arrow[r] & {}^{*}\textit{Ceratostomella} \arrow[d] \arrow[dr] & \\
& \textit{Linostoma} \arrow[d] & {}^{*}\textbf{\textit{Ceratocystis}} \\
& {}^{*}\textbf{\textit{Ophiostoma}} & {}^{*}\textit{Endoconidiophora} \arrow[u]
\end{tikzcd}$$

What teacher of an advanced mycology course hasn't had a heyday with this taxonomic tangle! The Dutch-elm disease fungus and the oak wilt fungus are surely discussed in most such courses. Tracing the taxonomic history from *Ceratostomella* (even in the 1940's I learned that *Ceratostoma* was "old hat" taxonomy) through *Linostoma* and then *Ophiostoma*, through the submersion of *Ophiostoma* into *Ceratocystis* and to the abandonment of *Endoconidiophora*, to the final reinstatement of *Ophiostoma*—how better to teach a student what taxonomic inquiry is all about, and what kinds of information a binomial can carry with it! But would inclusion of any of these names on a "List of names in current use" have changed anything? Not at all.

Chondrostereum purpureum (Pers. : Fr.) Pouzar
Stereum purpureum Pers. : Fr.

Another taxonomic change, not nomenclatural, for which our "Lists" would have no impact.

Cryphonectria parasitica (Murrill) Barr
Endothia parasitica (Murrill) Anders. & Anders.

The change in name for the Chestnut-blight disease organism is purely taxonomic, not nomenclatural. Need I say more?

Cyclaneusma niveum (Pers. : Fr.) DiCosmo & al.
Naemacyclus niveus (Pers. : Fr.) Sacc.

Taxonomy, not nomenclature, again at play. "Lists" are again useless.

Cyphellopsis anomala (Pers. : Fr.) Donk
Cyphella anomala (Pers. : Fr.) Pat.
Merismodes anomalus (Pers. : Fr.) Singer
Henningsomyces anomalus (Pers. : Fr.) Kuntze
Solenia anomala (Pers. : Fr.) Fuckel

I had had to learn that this characteristic *Solenia* ought to be called *Henningsomyces*, only now to discover that I must relearn it as a species of *Cyphellopsis*. Would inclusion on a "List of names in current use" have saved me these changes? Not at all.

Having run my way through the A's, B's, and C's of the book (Farr, et al., 1989) it suddenly occurred to me that I hadn't encountered the omnipresent fungus I have confidently been calling *Coriolus versicolor* this past decade or so. A quick check proved to me that I was far from "current use," for it is now hiding in *Trametes*:

> ***Trametes versicolor*** (L. : Fr.) Pilát
>
> **Polyporus versicolor* (L. : Fr.) Fr.
>
> *Polystictus versicolor* (L. : Fr.) Fr.
>
> **Coriolus versicolor* (L. : Fr.) Quél.

And once again, the change from *Polyporus* to *Coriolus* and now to *Trametes* mirrors our knowledge of taxonomic relatedness, and has no bearing on any "nomenclatural caveat."

All this analysis leads me to one incontrovertible conclusion: the names of fungi *do change*, but for the *best* of reasons: new taxonomic information that allows a better arrangement of fungi and a reflection of that arrangement in the name applied to the taxon. It may be purely fortuitous that the name changes I have had to endure (from A through C, at least) have not been for nomenclatural reasons. That *none* of the changes could have been prevented had there been "Lists of names in current use" in force and given protected status, was a surprise to me. It directly attacks the focus of Hawksworth's proposal, since it does not support the contention that name changes are in any great frequency caused by "nomenclatural caveats." And if there are some that are indeed brought about by application of the principle of priority, I am loathe to give up a *principle* that scientists in many disciplines hold sacred.[3]

To my mind one of the most compelling reasons to avoid the protected status for names on the "Lists" is that this *is* "the age of computerization." Part of the excuse for the attack on the principle of priority by Hawksworth and colleagues is that now so much information is computerized that it is necessary to make names uniform. Not at all, I contend, for it is the very versatility of the computer that can come to our aid. If names on "Lists of names in current use" need

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[3] Hawksworth (1991) did go so far as to allow that "All name changes are not due to nomenclature." The crass, commercial analogies he used, referring to taxonomists providing "customers" with "products," and the "retail" nature of their "goods," seem singularly out-of-place in science

to change, fine and dandy: a simple global substitution in the database allows the "new" taxonomy (or even the new nomenclature!) to be instantly updated. There is no need to destroy a basic principle, priority, and certainly no need to bring about "the most significant change in nomenclature since Linnaeus." Hawksworth (1991) tells us that there is "little doubt" that these "proposals will be accepted in 1993 for family and generic names, with some uncertainty over species names." I, for one, hope we will come to our senses before then and will recognize that what is not broken scarcely needs mending. Moreover, suggesting the use of a sledge-hammer (*i.e.*, destroying the principle of priority) is advocating the wrong tool to address a mis-perceived problem.

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THE DESIRABILITY OF GRANTING A PRIVILEGED TYPIFICATION STATUS TO SANCTIONED NAMES

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Abstract

The peculiar status of Fries's Systema mycologicum and Elenchus Fungorum has only seldom been noted. The Introduction to this work makes clear that the Systema mycologicum is not only a taxonomic conspectus of the fungi, but also an application of a systematic philosophy based on German romantic natural philosophy. I demonstrate that this speculative philosophy lies at the basis of some taxonomic decisions. As Fries tried to revert to a more empirically based taxonomy, starting with the General Index of the Systema mycologicum, it seems a retrograde step to sanction his earliest taxonomic decisions. I conclude that the privileged typification status for sanctioned names is not desirable. As abolition of this special typification status will hardly affect agaric nomenclature, this nomenclatural anomaly is also unnecessary.

Nomenclature of fungi is governed by a special set of rules, called the sanctioning system. Under these rules names that have been published in the basic books (the sanctioning works) have a special nomenclatural status, as these names are treated as if they are conserved. This system clearly contributes to nomenclatural stability, and that is very important. Such names also have a special typification status, which is indicated in Art. 7.20 (Greuter & al. 1988):

"Typification of names adopted in one of the works specified in Art. 13.1(d), and thereby sanctioned, may be effected in the light of anything associated with the name in that work".

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Simply stated this rule means that not the protologue (the validating description) is decisive, but that the sanctioning description can serve as a guideline for typification. The article was introduced to further promote stability, but it is not yet clear whether it effectively serves this goal. A number of problems are associated with it, as is clear from discussions within the Committee on Fungi and Lichens.

In this paper I would like to treat the question whether such a privileged typification status for sanctioned names is desirable. I will only discuss the application of Art. 7.20 with respect to the nomenclature of the Agaricales, not because I am an agaricologist, but because Fries's main interest was with the Agaricales. Fries's sanctioning books (Systema mycologicum and Elenchus Fungorum) were published in a period of twelve years (1821-1832) and in this period Fries radically changed his systematic philosophy. This change had a substantial impact on the taxonomy of the Agaricales.

An extensive study of Fries's philosophy has been published by Eriksson (1962). Unfortunately, this work is hardly known among mycologists, although an English summary was published in Eriksson (1966). This book treats the ideas of Fries about classification of the higher taxa (above the genus level). In this review I will also direct attention to the taxonomy of the individual species.

Fries (1821: v) began the Ratio Operis of the Systema mycologicum by noting that twenty years had elapsed since the publication of Persoon (1801). In those twenty years three problems had become manifest:

1. The lack of systematic principles and a sound theoretical basis has led to an unsatisfactory classification.

2. A large number of new species had been described, without critically checking whether they really represented new species (Fries 1830: 689).

3. An equally large number of already known species had been redescribed and renamed, resulting in nomenclatural confusion. Fries (1830: 690) said that new names are merely drips in that famous sea of oblivion that is formed by the already aborted names of the agarics. This renaming was mainly a consequence of essentialist thinking, which implied that the specific epithet had to

express the essential character of the species. Because of this essentialism the present rules on typification of superfluous names create several problems. It is therefore a useful addition to the ICBN that sanctioned names are exempted from automatic typification (Art. 7.13).

These problems are still vehemently debated by modern taxonomists. Fries (1821: ix) also said that the Natural System is the ultimate aim of botany. Such a natural system must not be understood in evolutionary terms, as Fries firmly believed in the constancy of all species. Fries interpreted a natural system according to the principles of the German romantic natural philosophers ("Naturphilosophie") like Schelling and Oken, i.e. the representation of nature as spiritual unity of constantly moving, opposing forces, in which every element represents the whole, as a microcosmos reflecting the macrocosmos.

The distinction between natural and artificial systems was already emphasised by Linnaeus (Larson 1971; Mayr 1982). In the present-day terminology, natural is equated with empirical, inductive and a posteriori, whereas artificial implies the same as logical, deductive-transcendental, and a priori. However, at that time the German natural philosophers used the term natural for their transcendental method of logical division, in which plants were classified according to their real affinity, i.e. the Platonic ideas.

In order to arrive at the Natural System (= Systema Naturae) Fries needed a natural method. Such a natural method had to be absolutely logical, because the eternal and immutable laws of logic are the most profound laws of nature, and no human invention (Fries 1825: 16). The romantic philosophy also implied that the human powers of reason enabled knowledge of nature, and that the microcosm-macrocosm relationship led to knowledge of the whole by studying one single part of nature. Methods were for that reason both logical and empirical.

Fries's metaphysical system of fungi, which was partly built on the principles laid down by Oken, Link, and Nees von Esenbeck can be described as follows:

1. Everything is built on four principles (Fries 1821: xxiv-xxv): nisus reproductivus, air, heat, and light. The foundation

of this system radically changed between 1821 and 1825 (Eriksson 1962). In 1821 it was strictly based on deductive principles and the four original elements, whereas in 1825 it was based on the polarity of forces and the relationship of analogy and affinity (Fries 1825: 20). Numerical systems like quinarianism and septenarianism, with their cabbalistic overtones, were characteristic of the natural philosophers (Rehbock 1983; Jahn & al. 1985). Both MacLeay (1823) and Lindley (1826) did much to spread Fries's ideas among British naturalists.

2. Different proportions of these principles explain all differences between the Fungi.

3. There are therefore four classes of Fungi (Coniomycetes, Hyphomycetes, Gasteromycetes, Hymenomycetes; Fries 1821: xxx), each class containing four orders (= families), each family containing four main genera. In a later classification, Fries (1825: 48-50) continued to recognise four classes (cohorts), although different ones, viz. Hymenomycetes, Pyrenomycetes, Gasteromycetes, Coniomycetes, each still containing four orders (families).

4. There are four kinds of genera (Fries 1821: xiii), viz. genus originarium (= main genus, which is always very rich in species), genus intermedium, genus subordinans, genus aberrans.

5. In each group there are a centre and radii that border on other groups of equal rank (Fries 1821: xi-xiii; 1825: 5-6).

6. Taxa within a group are connected by affinitas; taxa between groups are connected by analogia (Fries 1821: xv-xvi; 1825: 6). Fries did not provide strict criteria for the recognition of both types that survive in the modern concepts of homology and analogy.

However, Fries soon came to the conclusion that nature did not always conform to the laws of logic. He tried to free himself from his dogmatism and adapted an empiricist view. This change of view gradually took place between 1825 and 1830. The Systema Orbis vegetabilis (Fries 1825) shows both vestiges of deductive-transcendental thinking and the germs of an empiricist philosophy. Fries always was silent as to this caesura, just as he remained reticent in his autobiography of his romanticism; in fact he gave a completely distorted view (Fries 1857).

When Fries (1832) wrote the Index generalis to the Systema mycologicum, his conversion was complete. Empiricism has since that time been the dominant theme in Fries's mycological work. Empiricism had a basis in vitalist thinking, because nature with a vis vitalis was in principle unknowable (even with the help of logic!). Hence humble observation instead of reason could lead to the unveiling of some of nature's mysteries. A consequence of Fries's vitalism was his interest in living fungi and his lack of interest in exsiccates (Fries 1825: 24).

It seems therefore a straightforward conclusion that there is a discontinuity within the sanctioning books, but a continuity afterwards. That the Index generalis (which was intended to be more than a mere index) is a discontinuity within the structure of the Systema, is clear from Fries's statement that an Index (being even worse than an artificial system) was the opposite to a Systema naturale (Fries 1825: 7).

It has been suggested by Demoulin (1985) to use only the Index generalis to decide about sanctioning, and there is much logic in it. French mycologists (Kühner & Romagnesi 1953: xiii) decided to use Fries (1838) as starting point for agaric nomenclature, but such a decision is contrary to the rules.

I will indicate how Fries's philosophy influenced his taxonomy. The first part of the listing of the genus Agaricus (Table 1) clearly shows the regular structure of the Systema mycologicum. The order in which the tribus are listed might seem queer, as Fries started with higher developed tribus (at least in contemporary phylogenetic classifications). Interestingly, part of this classification has survived as an attempt towards a phylogenetic classification (Singer 1936; Parmasto 1986). This downward classification merited the term Systema philosophicum or Systema naturale (Fries 1825: 16), in contradistinction to an upward classification that was called the Systema mathematicum (Fries 1825: 10). Fries started with white-spored agarics, as the colour white is, according to Goethe's theory of colour, the most perfect colour.

There are only a limited number of spore print colours possible, and Fries must have felt at unease with species with yellow spore prints. He admitted yellow spore prints in Russula, where he had 3 species with that character (Fries 1821: 54), but not in Clitocybe (Fries 1821: 78). He was silent on spore print colour in Agaricus centunculus, but it was described as subochraceous later on (Fries 1838: 193). However, being silent on this point seemed a better strategy than to admit another exception.

Table 1. Logical structure of the Systema mycologicum, Vol. 1. Indicated are the numbers of species per infratribal group and the total number of species within a (sub)tribus of *Agaricus*.

I.	Amanita		3 + 3 + 3 + 3 = 12
II.	Lepiota		3 + 3 + 3 + 3 = 12
III.	Armillaria		3 + 3 + 3 + 3 = 12
IV.	Limacium		3 + 3 + 3 + 3 = 12
V.	Tricholoma	1.	3 + 3 + 3 + 3 = 12
		2.	3 + 3 + 3 + 3 = 12
		3.	3 + 3 + 3 + 3 = 12
		4.	3 + 3 + 3 + 3 = 12
VI.	Russula		4 + 4 + 4 + 1 = 13
VII.	Galorrheus	1.	3 + 3 + 3 = 9
		2.	3 + 3 + 3 + 3 = 12
		3.	4 + 4 + 4 = 12
		4.	3 + 3 + 3 = 9

Fries also needed species, for which his concepts of analogy and affinity could be exemplified. Fries (1821: 91) described *A. suaveolens* as a species with affinity to *A. odorus*, but admitted that his description of *A. suaveolens* clearly deviated from that of the original author Schumacher. *Agaricus villosus* Bull. was originally described as having reddish lamellae (and hence a pink spore print). Fries changed the name, saying that too many species could bear the epithet villosus, described ochraceous lamellae and a brown spore print, and mentioned that it was analogous with *A. hispidulus* (Fries 1821: 238), two species that are now considered as indeed closely related.

There are of course exceptions to these regular numbers of 3s and 4s. In tribus *Russula* one species, *A. adustus*, was left, and his wording "species heteroclita" makes clear that it is not a true member of this tribus. Fries (1821: 61) noted that on account of its characters it could belong to tribus *Clitocybe* but that on account of its habit it is optimally classified in tribus *Russula*. Fries (1830: 696-698) also considered the colour of the pileus as a character without systematic value. When he revised his species concept in Russula (Fries 1838) the number of species increased from 13 to 42 in 17 years, with a proportionally larger increase of the number of species with yellow spore prints.

Other exceptions may be found in tribus Clitocybe (Table 2).

Table 2. Taxonomic structure of tribus Clitocybe. The tribus consists of 9 subtribus, arranged in 3 groups of 3 subtribus.

1. Dasyphylli		
- Omphalarii	2 + 4 + 3 + 3	= 12
- Genuini	3 + 3 + 3 + 3	= 12
- Collybarii	4 + 4 + 6 + 4	= 18
- Heterocliti	4 + 4	= 8
2. Camarophylli		= 4
3. Hygrocybi	3 + 3 + 3 + 3	= 12
4. Oesypii	3 + 3 + 3 + 3	= 12
5. Calodontes	3 + 3	= 6
6. Thrausti	3 + 5 + 1	= 9
7. Rhizopodes		= 2
8. Chondropodes	5 + 5 + 5	= 15
9. Scortei	4 + 4	= 8

The third species, A. flaccidus, was described as intermediate between A. gilvus (nr. 2) and A. gibbus (nr. 4), and could in fact be easily transferred to the first infratribal taxon. The anomalous position of A. suaveolens (nr. 33, in Collybarii) has already been mentioned. The next group, Heterocliti, is extremely heterogeneous, as already admitted by Fries (1821: 97), and could not easily be fitted in his scheme. Within subtribus Oesypii the regular structure is restored, but A. pachyphyllus Fr. 1815 is listed among the species inquirendae. It was, however, accepted in the Index generalis and all subsequent works. Its peculiar position seems clear now: Fries simply had no place for it in his logical system!

Another way to create a regular structure is the use of double listings, as exemplified by A. stipitarius (nr. 21a) and A. foetidus (nr. 21b in Fries 1821: 138). The same trick was used with A. tuber-regium and A. sajor-caju (Fries 1821: 174-175) and with A. reniformis and A. acerosus (Fries 1821: 191). This trick has already been noted but not explained by Petersen (1983). Acceptance of species in footnotes, e.g. A. racemosus and A. aueri (Fries 1821: 134) is a further method to preserve the logical structure.

And finally, there is the psychological trick in tribus Inoloma (Fries 1821: 217-226). This is a most unusual way to arrive at 24 species in a regular way. It should be borne in mind, however, that none of the first 13 species could be transferred to the second group (Table 3).

Table 3. Taxonomic structure in tribus Inoloma.

1. Inoloma genuina	2. Inoloma phlegmacioidea
1. A. violaceus	13. A. variecolor
2. A. violaceocinereus	14. A. centrifugus
3. A. traganus	15. A. subtortus
4. A. argentatus	16. A. infractus
5. A. alboviolaceus	17. A. scaurus
6. A. camphoratus	18. A. rufoolivaceus
7. A. mallachius	19. A. callochrous
8. A. saturninus	20. A. decoloratus
9. A. conopus	21.
10. A. pholideus	22. A. glaucopus
11. A. spilomeus	23. A. varius
A. anomalus	
12. A. bulliardii	24. A. turbinatus

Of course not all groups consist of regular numbers of 3s and 4s. Almost certainly Fries had observed that nature was not conforming to his scheme, but it took some time before he had freed himself completely from his speculative thinking. However, when he had achieved this, the need for revision of his earlier taxonomic concepts, and the need for more extensive descriptions were clear. This subsequent work (Fries 1838) was remarkably successful: it is one of the best mycological books! But Fries succeeded in concealing his radical break (Fries 1857). And from an analysis of the taxonomy itself, it is admittedly difficult to see this discontinuity.

This is a paradoxical situation. Even if Fries in his sanctioning book was dogmatic, he succeeded surprisingly well in laying the foundations for a taxonomy that is still for a large part (more than 50%) considered natural. Obviously Fries was a very keen observer and his choice for spore colour as a classificatory principle was good. Maybe the principle was not derived from any theory, but theory is only used in the context of justification (cf Larson 1971). But a little bit of stretching and bending of diagnoses (as shown above) must have been helpful as well. But would it be worthwhile to declare these tricks as holy, as our sanctioning system allows us? Would we do more respect to Fries as an empirical mycologist if we used the validating protologue, instead of the sanctioning description, which was sometimes written with a special purpose? Donk (1957) already answered these questions: "Accepting an error like a misinterpretation as correct creates an anomalous situation from which there is no way out except by crooked exit".

Such an act (abolition of Art. 7.20) would not destabilise nomenclature. I will show so in another paper (Kuyper, in prep.). Fries has done a remarkably good job in interpreting old diagnoses. We hardly could do better, except in a limited number of cases. Just because Fries had set out to drastically reduce the number of species, he always had a large number of synonyms available for most taxa, and he therefore could have chosen the one that created the least difficulties. We are therefore confronted with a second paradox: just because of his philosphy (a strong reduction of the number of species to make order in nomenclature and taxonomy) he effectively laid the foundation for a stable nomenclature of the fungi. We must honour Fries for this merit, not for the faults that are associated with it.

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ART. 59 AND THE PROBLEM WITH PLEOANAMORPHIC FUNGI

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Any beginner in mycology, including myself, has faced the paradoxical "logic," perhaps better said "the ill logic," of the International Code of Botanical Nomenclature.

On one hand, the Code emphasizes principles as primordial, such as "one species, one name" and "if several names for one taxon, only one has priority." On the other hand it disobeys its own principles, in accepting the coexistence of several priorable names for the same fungus when pleomorphic, then at specifying that not all pleomorphic fungi are tolerated to have several names but only the so-called "pleomorphic" Ascomycetes and Basidiomycetes, and not the other pleomorphic fungi, Zygomycetes or Mastigomycetes, nor other similarly pleomorphic organisms, algae or higher plants, and finally at not strictly limiting multiplication of tolerated names for pleomorphic taxa.

It is as well a heritage from the past that several names are given to different parts of the same fungus. But instead of prohibiting the practice, the Code strangely tolerated it and recently confirmed its tolerance.

I said tolerance, but let us honestly remind ourselves that it is tolerance and nothing more. Therefore we ought to consider that situation abnormal and temporary and think about how to make it normal and prepare ourselves to do so.

The last 20 years.

In 1970, at the Kananaskis conference convened by W.B. Kendrick, I (Hennebert, 1971) defined **pleomorphy** in the fungi in the sense of the ICBN, and about the exact meaning of the term

"imperfect state" in the ICBN: does it cover the imperfect phase or one single imperfect state when several could be distinguished. I also demonstrated the existence in practice of four systems of nomenclature for such pleomorphic fungi, that I called the **botanical system** (the one applied, e.g., in Zygomycetes or by Thom and Raper in the Ascomycetes in rejection then of the accepted custom of having anamorph and teleomorph separately named), the **anatomical system** (the one applied in Ascomycetes and Basidiomycetes in respect to Art. 59 and by some mycologists naming separate synanamorphs in the Deuteromycetes), the **botanico-anatomical system** (the one applied for pleoanamorphic genera in the Deuteromycetes, e.g., by Wollenweber in *Fusarium*, the epithets of which cover all synanamorphs) and the **cross-reference system** (applied by S. J. Hughes and some other mycologists using a monoanamorphic generic name to refer a state to another fully named synanamorph).

At IMC2, in Tampa, USA, in 1977, a decision was taken by mycologists to continue obedience to Art. 59 of the Code. A botanical system that would apply to the Ascomycetes and the Basidiomycetes, like that of Thom and Raper, giving priority to the name *Penicillium* for the perfect fungus, was rejected. A dual anatomical nomenclature was maintained in those groups, the names of sexual states being of botanical value, serving as the name of the fungus.

Also in 1977, Hennebert and Weresub (1977) introduced new terms to replace the expressions "perfect state" and "imperfect state," seeking objectivity and unambiguity. Objectivity: we wanted to avoid the implication of the state of knowledge of the life cycle: is the imperfect state an incompletely known life cycle, the perfect state being a completely known life cycle, an incomplete life cycle (actually lacking the sexual reproduction) or just the asexual part of the life cycle? Unambiguity: is the perfect state the sexual reproduction only or the fungus in its complete life cycle?

We coined the term **anamorph** for any morphologically distinct state of asexual reproduction or propagation, the term **teleomorph** for the sexual organ of reproduction of the fungus and the term **holomorph** to cover the whole fungus in all its potentialities, known or unknown, whether the fungus is actually (I do not say is known as) both sexual and asexual or asexual forever, having lost its sexual reproduction. The term holomorph is therefore the concept of a living being which ought to be named by one name in its fullness. The terms were inspired by the existing term "**anamorphosis**" coined previously by Donk (1960) to indicate the asexual condition of a fungus.

Those new terms were immediately adopted by the mycologists worldwide.

But some new expressions or deviations soon appeared.

Hughes (1979), convinced that genera and species in the Deuteromycetes must be based on one form of conidiogenesis only and therefore must be monoanamorphic, introduced the term "**synanamorph**" to designate the distinct anamorphs that may exist in the same fungus. Such synanamorphs might have received a name already or ought to be named.

Consequently, the term "**pleoanamorphy**" was introduced by Carmichael (1979) to designate that pleomorphic condition of a fungus that develops two or more anamorphs (or synanamorphs).

More recently the term "**anamorphic holomorph**" appeared to designate a fungus lacking sexual reproduction or known only in its anamorphic condition.

Indeed the Deuteromycotina include two kinds of named fungi, the anamorphs of Asco- and Basidiomycetes and the "anamorphic fungi," the teleomorph thereof lacking or at least unknown. They are either monoanamorphic and recognized by a single name or pleoanamorphic, exhibiting two or more synanamorphs, either all synanamorphs covered by a single name or each of them named separately.

Calling anamorphic fungi "anamorphic holomorphs" leads to a deviation of the concept holomorph. The holomorph is the living being in all its potentialities, known and unknown. It is therefore a *contradictio in terminis* to juxtapose the words holomorph and anamorphic. It presumes that the fungus has lost sexual reproduction forever. But it is impossible nowadays to assert that a fungus has lost forever the production of sexual spores and therefore to limit the holomorph to an anamorph. Furthermore, accepting anamorphic fungi as anamorphic holomorphs immediately requires that the anamorphic names given to such holomorphs are priorable over any other names, even when the teleomorph is discovered.

In the meantime an International Committee on Art. 59 was set up by the IMA Secretariat for Nomenclature and chaired by Luella Weresub. It finalized a proposal for the emendation of Art. 59 and relative articles of the ICBN, in order to make a clear borderline between the two nomenclatures, one of the anamorphs and the other of the holomorphs in the Ascomycetes and Basidiomycetes. The emendation of Art. 59 was adopted by the Session of Nomenclature at the Sidney Botanical Congress in 1981 and integrated in the ICBN (1983). The continuation of a dual system of nomenclature was confirmed.

In 1984, at the Third International Mycological Congress (IMC 3) in Tokyo, in a symposium convened by J. Sugiyama (1987), I made anew an analysis of the situation, restricting myself to the nomenclature of the pleoanamorphic fungi and of the synanamorphs in Ascomycetes and Basidiomycetes (Hennebert, 1987).

At first, I emphasized the distinction I had already made at Kananaskis in 1971 between the imperfect phase of a fungus and its perfect phase. The imperfect phase I was speaking of had been properly named by Donk "**anamorphosis.**" I therefore designated the perfect phase of the fungus "**teleomorphosis.**"

The telemorphosis consists of a single teleomorph, sexual reproduction characterizing the Linnean species in agreement with Linné's principle expressed in his Philosophia Botanica. At the opposite the anamorphosis of a fungus can be represented by either one or several morphologically distinguishable anamorphs, according to taxonomic opinion, like having different kinds of conidiophores and conidia or other asexual propagules.

In the second place, I stressed the distinction to be made between the **anamorphosis** of a fungus and its constitutive **anamorphs** (synanamorphs) as essential to the understanding of the problem lying in the nomenclature of pleoanamorphic fungi.

Third, I distinguished, for the sake of clarity, **two levels of pleomorphy** in the fungi in question (Fig. 1). The **first** level of pleomorphy is the duality teleomorphosis - anamorphosis, meaning the coexistence of a teleomorph and anamorph(s) in the same fungus. That pleomorphy is the pleomorphy dealt with in the ICBN, where Art. 59 marks the borderline between the nomenclature of holomorphs and that of anamorphs. The **second** level of pleomorphy is the diversity of anamorphs in the anamorphosis. That pleomorphy has been called pleoanamorphy (Carmichael, 1979). The ICBN does not deal with it. Thus pleoanamorphy remains a matter of nomenclatural conflicts.

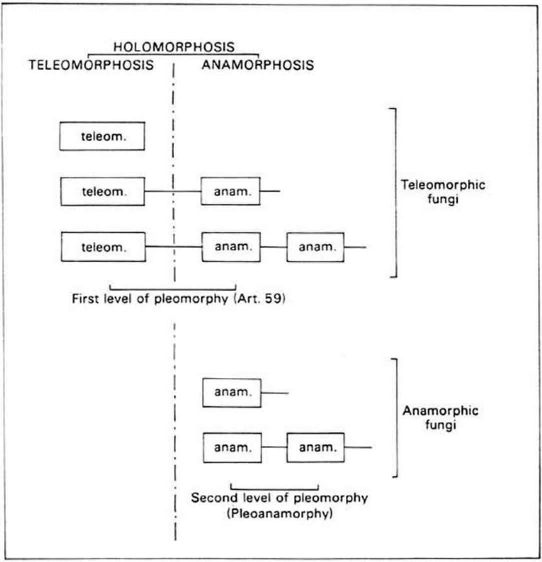

Fig. 1. Pleomorphy in the fungi (Hennebert, 1987)

What is the problem?

The question standing unanswered is: **whether the anamorphosis as such or each of the synanamorphs thereof deserves a name.** In other words, the question is: should we name the anamorphic portion (the anamorphic phase) of the fungus as an entity, a specific taxon, or should we dissect that portion into cut-off synanamorphs and name each of them separately as distinct, specific taxa?

The ICBN Code does not deal with pleoanamorphy. It does not answer the question. The ICBN Code leaves freedom to the taxonomists to answer the question. Why?

The matter is indeed a taxonomic matter. It is a matter of deciding which concept of specific and generic taxa we agree upon for the anamorphic fungi.

The ICBN has nothing to do with taxonomic matters. The ICBN rules the nomenclature of holomorphs. Anamorphic fungi and anamorphs or organs of holomorphs have been banished from botanical nomenclature. The Code tolerates our treating the anamorphic fungi **as if they were holomorphs**, but for the time being, in expectation of the discovery of their teleomorph, and in a segregated nomenclature which ought to disappear. In other words, the Code leaves those incompletely known species with an odd, provisional, anamorphic name in the purgatory, waiting for the time they will be clean of that odd name, receive a proper teleomorphic name and enter paradise as "holy morphs." Also, as a consequence of the adoption of a dual nomenclature, the Code tolerates that such odd names remain in use for the anamorphic portions of properly named holomorphs.

The matter of naming anamorphic fungi or their synanamorphs is taxonomical, not nomenclatural, but has of course nomenclatural consequences.

The conflicts result from the disagreement of taxonomists on the concept of the anamorphic taxa, genus and species. The disagreement is not about the circumscription of the taxon, I mean, not about where to delimit a group of individuals. The conflict is about **what is the individual in anamorphic taxonomy**. It is about whether one has to keep the asexually reproducing mycelium undivided as an individual or to cut it, and where to cut it, dividing it into several pieces as distinct individuals.

In 1984, I reemphasized the four possible systems of nomenclature previously detected in use in the Deuteromycetes, and have shown that they result from two different taxonomic concepts of the species and the genus, one botanical, the other anatomical.

To represent the four systems, I choose a pleoanamorphic fungus represented by an anamorphosis in which three synanamorphs can be distinguished (Fig. 2)

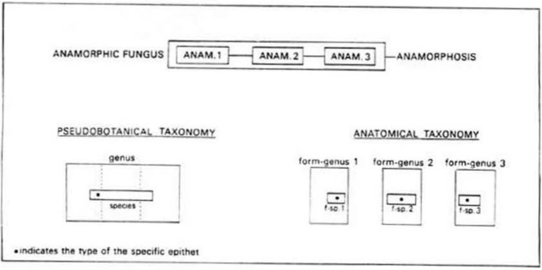

Fig. 2. The two taxonomic treatments of the pleoanamorphic fungi

To the question "what is the individual?" there are two answers: either the individual is the fungus representing one species or the individual is a part (an organ) dissected from the fungus to be classified, like each of the other parts as other individuals, in distinct species.

In the first option, **taxonomy** is **botanical-like** (pseudobotanical, Hennebert, 1984). The species accommodates the anamorphic fungus as it is with all its anamorphic facets. It is classified in a single genus of botanical-like concept. A *Fusarium* species with macroconidia, microconidia and chlamydospores bears only one name, as if it is an holomorphic species.

In the other option, **taxonomy** is **anatomical**: each part of the fungus will make a distinct taxon, a distinct form-species, classifiable in distinct, appropriate form-genera. A *Fusarium* species with macroconidia, microconidia and chlamydospores would have three names, a binomial in *Fusarium*, one in *Pseudofusarium*, *Fusisporum*, or another *Acremonium*-like form-genus, and yet another in a *Sepedonium*-like form-genus.

The difference between the two taxonomies lies in the concept of the taxa species and genus.

In a botanical-like taxonomy, the specific taxon encompasses the anamorphic fungus. All the anamorphs are just organs or characters of the individual that are included in the taxonomic description. Only one name is given. The type of the species is any element that characterizes the fungus. The species and the genus concepts are potentially or actually pleoanamorphic.

In an anatomical taxonomy, the fungus, cut in several pieces (synanamorphs), needs several species and several genera to be accommodated and named. There will be several names based on several types, names that are totally segregated and cannot be synonymized, the organic link between morphs being ignored. The species and the genus concepts are monoanamorphic.

These two taxonomies are concurrently applied to the anamorphic fungi, and lead to conflicting nomenclatures (Gams and Nirenberg, 1989).

In practice, as it is the right of the taxonomist to decide which characters of the anamorphosis characterise the anamorphic taxon he wants to describe, he will necessarily express his own concept of anamorphic taxa. If he includes the diverse so-called anamorphs as mere additional characters to describe the fungus, his species and genus concepts will be botanical-like and pleoanamorphic. The fungus shall have one name. On the other hand, if he prefers genera being monoanamorphic, characterized by a single conidiogenesis, by a single type of conidium or a single type of propagule, the species he wants to define shall be monoanamorphic and he will dissect the fungus into morphs or organs and name them separately.

The cases illustrating the alternatives are numerous. That of *Fusarium* has been extensively treated by Gams and Nirenberg (1989). As sole examples of the opposite taxonomic behaviours to illustrate this paper, I propose the decisions that Nathalie Buffin and I have been taking successively and experimentally.

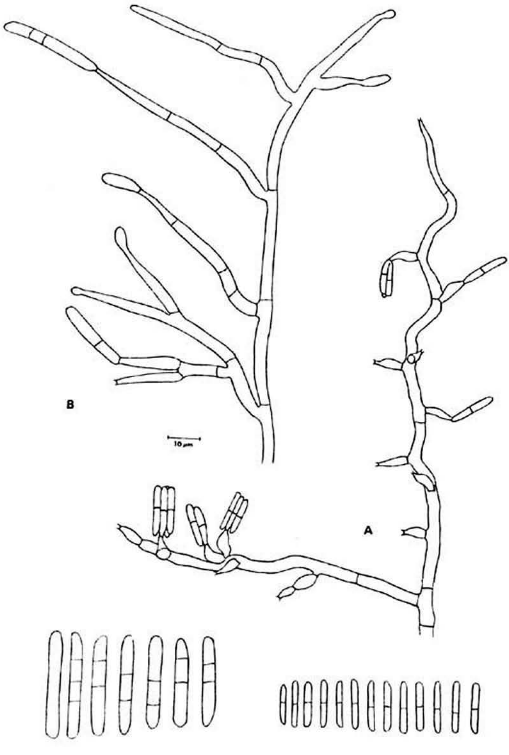

Fig. 3. *Cylindrodendrum album* Bonorden (A), *Cylindrocarpon hydrophilum* Buffin & Hennebert (B).

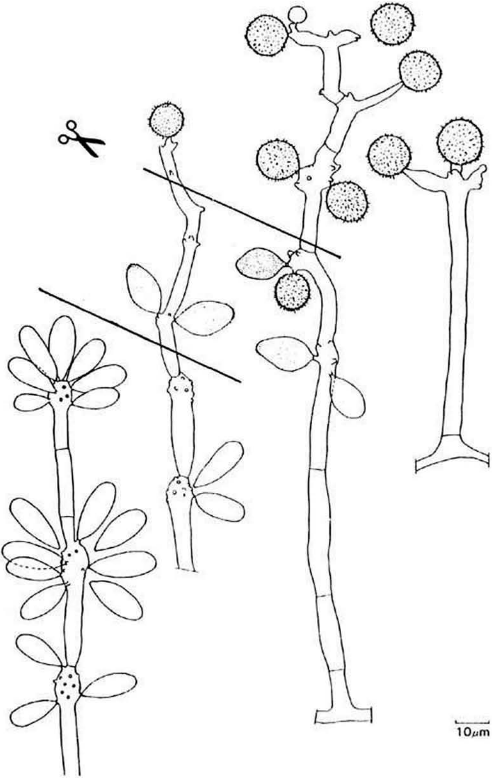

Fig. 4. *Basifimbria spinosa* Buffin & Hennebert.

In order to draw to completion the logic of the anatomical taxonomy and nomenclature of anamorphic fungi, we added a second name to the existing name of an anamorphic fungus showing two distinguishable conidiomata (Fig. 3). *Cylindrodendrum album* Bonorden produces in nature and on very poor media compact, dendroid, phialidic conidiomata, with short phialides and small, simple to 1-septate, cylindric conidia. But on richer media the same produces sparsely branched, elongate conidiomata with wider hyphae, long phialides and large, up to 3-septate, cylindrical conidia, which we named *Cylindrocarpon hydrophilum*. Both forms develop in culture, one or another form predominating according to the nutrient supply. *Cylindrodendrum album* has been neotypified by a dried culture A of the isolate MUCL 28016 and *Cylindrocarpon hydrophilum* typified by another dried culture B (on a different medium) of the same isolate, thus demonstrating that the two described taxa are parts of the same fungus.

By that procedure, we recognized the fungus was pleoanamorphic with two synanamorphs and applied an anatomical taxonomy and an anatomical nomenclature resulting in two names. But from the botanical point of view, what shall be the name of the fungus according to the ICBN principle "one fungus, one name?" Further, should the two names having the same fungal isolate in dried culture as type not be synonymized, the later being superfluous and illegitimate? Obviously, from that point of view, the name of the anamorphic fungus is the oldest one, *Cylindrodendrum album* Bonorden, which covers all anamorphic potentialities of the fungus, and *Cylindrocarpon hydrophilum* is illegitimate.

Later a still more troublesome case came up (Fig. 4). A new species of *Basifimbria* was isolated from dried horse dung, and it produced on fresh culture medium *Arthrobotrys*-like conidiophores with elliptical smooth conidia. Progressively, while the medium was drying out and being exhausted, it evolved to continuous sympodula bearing conidia becoming round and ornamented as are typical of *Basifimbria*. Another isolate from fresh horse dung that had been recorded as *Arthrobotrys* sp. also proved to produce the *Basifimbria* type of conidiophore while the culture medium dries out. As the two extreme types of conidiation together with intermediate stages were formed on the same conidiophore in the same culture dish, we were reluctant to cut the conidiophores with scissors into parts as distinct anamorphs and to name the parts separately. We gave the fungus the single name, *Basifimbria spinosa*.

Doing so, we considered the whole anamorphosis instead of parts of it as delimiting the taxon, and named it by a single name as if we were dealing with an holomorph in a botanical taxonomy and nomenclature, according to the principle "one fungus, one name."

It would have been foolish to proceed otherwise. We consider now that it was so to create a second and superfluous name for a circumstantial variation of *Cylindrodendrum album*.

Which taxonomy should be used for anamorphic fungi and the anamorphoses of Ascomycetes and Basidiomycetes?

It is clear from the examples given above and their nomenclatural treatment by us, that my answer to the question is a botanical-like taxonomy for the anamorphic fungi, obediently governed by Art. 59.

I therefore recommend that taxonomists adopt a pleoanamorphic concept of taxa - and consequently of types - for the anamorphic fungi (Deuteromycetes), resulting in **one binomial name** for each fungus in its **entire anamorphosis**.

The fundamental aim of naming living beings is indeed to make possible recognition, inventory and classification, by giving each of them one single name and not a multiplicity of names.

The concept of a botanical-like anamorphic taxonomy implies at first that we **reject the idea of dissecting the anamorphosis** into synanamorphs as the basic elements of taxonomy, in other words that we refuse to classify and name separately the asexual reproductive or propagative organs of the fungus, but classify and name the anamorphic fungus itself.

That means that our **species concept** in the taxonomy of the anamorphic fungi is **pleoanamorphic**, each possible so-called anamorph or synanamorph providing additional characters for the species description. The species concept shall include, e.g., phialides with macroconidia and microconidia, aleurioconidia (terminal chlamydospores) and intercalary chlamydospores, as in *Fusarium* spp., phialides, annelides, sympodulae and yeast-like blastospores and chlamydospores, as in *Rhinocladiella* spp. (Schol-Schwarz, 1968), blastoconidia, phialoconidia (spermatia), appressoria, and sclerotia, as in *Botrytis* spp., phialidic pycnioconidia and aleurioconidia or catenate blastoconidia, as in *Phoma* spp. (Boerema et al., 1965).

The **nomenclatural type** of such a species obeys strictly Art. 7.2 of the ICBN. The species is characterized by a number of forms and its correct name (the oldest valid and legitimate epithet) is typified by any of them that allows species recognition. When several epithets are separately typified by different forms of the species, the type of the correct epithet does not necessarily represent the form that is the most characteristic of the genus.

That pleoanamorphic species concept implies that the **generic concept** is also **pleoanamorphic**. Such a genus is based on a type species possibly characterized by a number of forms and the name of which is typified by any of them that allow recognition. The genus accommodates other species for their *in globo* morphological and biological similarity and not by the presence of a strictly similar morph in their respective type specimens. Such a type specimen may indeed contain one or another morph and not necessarily all that characterize the genus.

Would that botanical-like taxonomy of the anamorphic fungi be acceptable under the ICBN Art. 59?

Mason already, in 1937, made the point that there is no reason to give the same fungus species up to three, four or five names, and used the cross reference denotation, already used by the Tulasnes, in order to limit the multiplication of anamorphic names.

Mason and after him, Vuillemin, Hughes, and others, emphasized the distinct conidiogenetic processes as a basis for the distinction of anamorphs and their classification in monoanamorphic genera in the Deuteromycetes.

But more investigations, particularly by Cole and Samson (1979), Stalpers (1987), de Hoog (1987), and others, have brought together sufficient evidence showing that the different conidiogeneses are not clearcut categories, one often evolving into another in the same fungus according to external, nutritional, or aging conditions. It is well known also that grouped or fasciculate conidiophores can be reduced to single ones, that so-called micro and macroconidia of the same fungus may show intermediate sizes and shapes and similarly for many other characters. As a result, most of the Saccardoan categories in the Deuteromycetes have disappeared. Hughes's (1953) eight conidiogenous categories have become so numerous now that they form almost a *continuum*. More connections are found between Coelomycetes and Hyphomycetes (Minter, 1987), and soon those categories themselves may become obsolete.

Because of these facts, the anatomical concept of "anamorph" and "synanamorph" must be questioned. Is the anatomical distinction of anamorphs in the same mycelium as taxonomic entities really always possible? Certainly not. "Whole organisms are easy to delimit, but organs are interconnected and interdependent. It is much easier to recognize an entire organism, in all its variations, that to decide where a particular organ in an organism starts or ends" (Jong & Birmingham, 1990).

Is the distinction of synanamorphs needed in botanical-like taxonomy of anamorphic fungi? Not as taxonomic entities. The recognition, when possible, of distinct morphological and functional structures exhibiting useful taxonomic characters is of course necessary for an adequate description of the fungus. These structures and their characteristics are properly denoted by descriptive terms, like those coined by Mason, Vuillemin, Hughes, Ellis, and others. These descriptive terms help fullfill the needs of taxonomic description of the anamorphic plasticity. Dissecting those structures from each other and giving each of them a Latin binomial according to the ICBN is absolutely not needed in a botanical taxonomy where the fungus itself receives a name.

Furthermore, the unity of the fungal organism is evident when chemotaxonomic characters are considered. Specific physiological and enzymatic tests, the cell wall reaction to Diazonium Blue B, the electrophoretic profile of proteins, the isoenzyme profile, the DNA base composition (G-C contents), the DNA reassociation, the RNA sequencing are many ways to characterize the whole fungus and demonstrate its unity as an individual and its taxonomic indivisibility. Connections of discrete anamorphs and teleomorphs have been assumed by those taxonomic means, even without having been able to obtain sexual reproduction of the anamorph (Phaff, 1989; Vancanneyt et al., 1990). In the same ways, morphologically segregated anamorphs of a fungus will appear taxonomicaly identical and their names synonyms.

In regard to the ICBN, I questioned, in 1971, what interpretation to give to the expression "imperfect state" then used by the Code. Is it the imperfect phase or a defined state thereof? Today, the same question stands in other terms: should "the anamorph" of the ICBN be understood as "the anamorphosis" or "one of the synanamorphs"? The Code as we already said does not answer the question and does not intend to do so. Both interpretations are possible. When we realize in an anamorphic fungus the diversity and the plasticity of conidiogenesis and other propagule development as expressions of the same genome, we can easily conceive the anamorphosis as a unique anamorph, like the teleomorphosis as a unique teleomorph. Consequently the use of the term anamorph in the Articles 7, 13, 34 and 59 of the ICBN can be applied to a botanical-like taxonomy of the anamorphic fungi without further ruling or emendation.

No longer need the anamorphosis have more than one name to be fully designated. All its existing names should be synonymized under the names of broadly conceived genera.

All that has been said of the anamorphic fungi remains true for the anamorphs of named Ascomycetes and Basidiomycetes. The anamorphosis of the latter may, by virtue of Art. 59, be tolerated to keep one Latin binomial in the frame of a botanical-like taxonomy of anamorphic fungi. Furthermore, we must be aware that the names given and maintained for anamorphs of sexual Ascomycetes and Basidiomycetes are simply superfluous and should disappear, the holomorphic fungus, its anamorphosis included, already being properly named and its name to be of common use.

Conclusion

The morphological diversity, the ontogenetic plasticity of forms and the unity of the chemotaxonomical characters expressed by the unique gene pool in the same fungus demonstrates clearly enough the artificial nature of anatomical, monoanamorphic categories as taxa and the need for a more synthetic concept of the species to approach a more natural taxonomy.

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P.S. From the time of Linné, it has been generally accepted that the sexual reproduction of the species is unique. It has therefore been implied that the fungal teleomorphosis is represented by a single teleomorph, i.e. "the morph characterized by the production of asci/ascospores, basidia/basidiospores, teliospores, or other basidium-bearing organs" (ICBN, Art. 59, 1988). Even when the organ (morph) producing basidia can have distinct morphology, like the unicellular and the bicellular single-pored smooth teliospores of *Gymnosporangium gauemannii* ssp. *albertense* (Hitatsuka, Mycologia 65: 440, 1987), or the natural basidiocarp and the in vitro fertile structure produced by *Trametes versicolor*, they should not be considered "synteleomorphs" if the resulting meiospores are similar morphologically and functionally. And if because of natural diversity, morphologically distinct meiospores should be produced by different organs in the same fungus and synteleomorphs might be considered and distinguished, the term teleomorph in ICBN Art. 59 should remain interpreted as a unique teleomorphosis.

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DIFFICULTIES IN LICHEN NOMENCLATURE

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SUMMARY

The remaining nomenclatural problems in lichens are related to their "double nature." It is shown that Art. 13d, tying the lichen names to the fungal elements, is necessary and is worded in such a way that taxa recognized only on photobiont differences are validly published.

The exception for lichens in Art. 59 is also necessary as long as definition of morphs is tied to production of reproductive organs. It has, however, caused some difficulties, forcing on us some generic names given to and used for sterile lichen thalli. This can be taken care of by conservation procedures. The number of known non-lichenized anamorphs originating from lichens are, however, increasing, and is a more serious problem. It is also necessary to allow separate names for different phototypes of lichens. This is best done under Art. 11.1.

INTRODUCTION

Nomenclaturally, non-lichenized fungi have generally been regarded as more difficult than lichens. In fact lichenologists were worried when it was proposed that lichen names should be treated in the same way as in other fungi, but it was accepted since Hawksworth (1986) showed that few name changes would result from this proposal.

We still, however, have some nomenclatural problems caused by the so-called double nature of lichens, discovered by Schwendener (1868). This discovery initiated a heated debate, which lasted about 50 years (Lorch, 1988). Today everybody accepts that a lichen consists of at least one myco- and one photo-(phyco-)biont, and that lichenization is just another life strategy for fungi. There remain, however, two problems in the Code of Botanical Nomenclature related to this fact, which will be discussed below. I do not pretend to solve them fully here, but hope this will stimulate further discussions and finally solutions.

ARTICLE 13b

This reads: "For nomenclatural purposes names given to lichens shall be considered as applying to their fungal component." This is necessary since one name cannot cover two different organisms (fungus and alga/cyanobacterium) (Principle IV). In my opinion this is a very elegant solution to a difficult problem, and definitely superior to the procedure suggested by Ciferri and Tomaselli (1954) where the mycobiont had to be renamed by adding *-myces* to the lichen generic name.

However, recently Fröberg (1989: 41) has claimed that the generic name *Ionaspis* Th. Fr. is invalid because of this article, since Fries (1871: 273) only distinguished it from *Aspicilia* on the gonidia (= algae). If this is a correct interpretation many names, also on the species level, are threatened since they were described in a similar way, and the Code would have to be changed to avoid many name changes.

I believe, however, that this is unnecessary since Fröberg's statement in my opinion is incorrect. When Fries described *Ionaspis*, he regarded the difference in gonidia to be a valid distinguishing character. The Code can and shall not be a judge of taxonomic characters, outlawing some of them, and it has not done so in this case. The wording of Art. 13d clearly reflects this: "shall be considered"—we are for *purely formalistic* reasons tying the name to the fungus, irrespective of how the lichen was described with a name given to a thallus containing at least two different organisms.[1]

ARTICLE 59

This is a much more complex problem originating from the fact that this article excepts lichens from being allowed valid names for both anamorphs and teleomorphs—this in contrast to other ascomycetous and basidiomycetous fungi. This is a necessary exception since many lichens are described on sterile thalli, later often redescribed on fertile material.

It is important to be aware of and to accept that there is a general basic difference between non-lichenized fungi and lichens. The former has mycelia hidden in the soil, in wood, or in its host, producing annually more or less short-lived, visible fruitbodies (with some notable exceptions, as the Aphyllophorales). The hyphae of the

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[1] The audience at Regensburg had no objections to this view, and the author will accordingly not propose a changed text to this article.

fungal partner in lichens are found in visible, perennial thalli which from a certain age produce fruitbodies more or less continuously (for exceptions on short-lived lichens, see Poelt and Vězda, 1990).

Anamorphs of lichens have rarely been recorded. However, a few lichenized ones are known (see Hawksworth and Poelt, 1990), but they may not necessarily originate from lichens. On the other hand there is an increasing number of documented, known non-lichenized anamorphs which have lichens as teleomorphs (Tibell, 1990).

A phenomenon more similar to the situation in non-lichenized fungi is the so-called species pairs among lichens with vegetatively reproducing (isidiate/sorediate) counterparts of fertile species (see Tehler, 1982). There is at the moment a debate on how to interpret this taxonomically basic situation: the problem being that it is often difficult to prove that isidiate/sorediate morphotypes *only* are vegetatively reproducing clones of their fertile counterparts. But *if* this is the case, we have a situation with a teleomorph—the fertile species with an independent side-cycle reproducing vegetatively, rather similar to that found in non-lichenized fungi. In this case they are, however, morphologically much more similar, ± identical in all but the reproductive organs, though distinguishable and often with differences in distribution and ecology.

The only real parallel in lichens to that found in non-lichenized fungi are phototypes, where totally different-looking organisms represent the same fungal species. The difference is caused by differences in algal partner, often green/blue-green. A well-known example is that of *Sticta filix* (Sw.) Nyl., a foliose green lichen with cyphellae on the lower surface, and *Dendriscocaulon dendroides* (Nyl.) H. Magn., a fruiticose lichen with a blue-green photobiont, cylindrical branches, and no cyphellae. It was only after combined thalli were found that their relationship was understood (James and Henssen, 1976). There are still *Dendriscocaulon* species where the green phototype is not known, and may not exist. New examples of this ecologically important phenomenon are still being discovered in several genera. We are therefore facing a number of problems in connection with Art. 59 because of the special nature of lichens. Already when the article was reconstructed I had correspondence with Luella Weresub over some of these aspects. Luella, as the clever lawyer she was, finally thought it best to leave the lichens out as an exception. This is a fully acceptable way for a law-maker in this situation, but we now known much more about lichen biology and some of the exceptions are becoming so important that we cannot just neglect them.

A reexamination of the present situation leads to the following conclusions:

(1) The difficulties concerning lichen names given and used for sterile thalli—where one would prefer to use the names of the teleomorphs—are few, and seem possible to handle by conservation procedures, as in the case of *Botrydina* and *Phytoconis/Omphalina* (Jørgensen and Ryman, 1989).

(2) It might be desirable to accept different names for fertile/isidiate-sorediate counterparts when and if they are regarded as part of the same species. The taxonomic situation is, however, rather unsettled at the moment, and no change seems immediately necessary.

(3) The most serious difficulty and challenge to the present text is the discovery of several anamorphic non-lichenized fungi being linked with lichenized species. If common and widespread anamorphic fungi belong in this group, we are in trouble, although conservation might be a possibility for anamorph names of taxa of economic importance—though Art. 14 would have to be emended to cover such cases.

(4) We should allow different phototypes of the same mycobiont different names, for the same reason we do this for anamorphs/teleomorphs. These growth forms (morphs) of the same species are morphologically, ecologically, and often geographically so distinct that they have become known under different names.

It is also a troublesome Code and communication system—and that is what nomenclature is about—if one is forced to write (think of tables!): "the blue-green phototype of *Sticta canariensis*" instead of "*Sticta dufourii*." This change can be accomplished in a fairly simple way by adding a sentence or a separate point in the article.[2]

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[2] During the discussion at Regensburg, both Dr. V. Demoulin and Dr. W. Greuter strongly recommended that this should be done in Art. 11.1 instead of Art. 59—a recommendation the author is in agreement with.

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This index contains the names of genera, infrageneric taxa, species, and infraspecific taxa. New names are in **boldface,** as are the page numbers on which such new taxa are proposed.

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ERRATA, VOLUME TWENTY-FIVE

Page	528	line	45	for	*macrocladium*	read	*macrocladum*
	534		46	for	*macrocladium*	read	*macrocladum*

ERRATA, VOLUME TWENTY-SEVEN

Page	344	line	10	for	**cerrusatus**	read	**cerussatus**

ERRATA, VOLUME TWENTY-EIGHT

Page	170	line	16	for	Libertiana	read	Libartania
	277		34	for	*anthirrhini*	read	*antirrhini*

ERRATA, VOLUME TWENTY-NINE

Page	444	line	40	*for*	Macentia	*read*	Macentina

ERRATA, VOLUME THIRTY-TWO

Page 149 between lines 8 and 9 insert:
Holotype: O. West 248 (K), S. Africa, Estcourt distr., 1200 m,
02.1937, on Hyparrhenia quarrei Robyns. Isotype in NPPI.

	234		42	for	*albii-cepae*	read	*allii-cepae*

ERRATA, VOLUME THIRTY-THREE

Page	267	line	24	for	**cerrusatus**	read	**cerussatus**
	303		14	for	**cerrussata**	read	**cerussata**
	305		22	for read	**Ceriporisopsis cerrusata** **Ceriporiopsis cerussata**		
	306		1	for	**cerrusata**	read	**cerussata**

ERRATA, VOLUME THIRTY-FOUR

Page	579	line	6	for	*Kirschteiniothelia*	read	*Kirschsteiniothelia*
			13	for	*Kirschteiniella*	read	*Kirschsteiniella*
	587		39	for	*densisimmum*	read	*densissimum*
	623		9	for	*karstensii*	read	*karstenii*
	629		20	for	*karstensii*	read	*karstenii*
	630		7	for	***karstensii***	read	***karstenii***

ERRATA, VOLUME THIRTY-FIVE

Page	421	line	55	*for*	Hypocoenomyce	*read*	Hypocenomyce
			56	*for*	Hypocoenomyce	*read*	Hypocenomyce

ERRATA, VOLUME THIRTY-EIGHT

Page	48	line	11	for	***karstensii***	read	***karstenii***
	99		50	for	fasiculatum	read	fasciculatum
	475		50	*for*	dense irregulariter subreticulato		
				read	sublaevi		

ERRATA, VOLUME THIRTY-NINE

Page	66	line	31	for	*Sawadaea*	read	*Sawadaia*
	70		30	for	*phaseolorum*	read	*phaseolarum*
	103		19	for	*Pteridosperma*	read	*Pteridiosperma*
	109		43	for	*Shiraea*	read	*Shiraia*
	246		32	for	*mopa*	read	*mompa*
			39	for	*Kriegera*	read	*Kriegeria*
	247		21	for	*mopa*	read	*mompa*
	320		34	for	venezuelianus	read	venezuelanus

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