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REEVALUATION OF THE GENUS PHYLLOPSORA WITH TAXONOMIC NOTES AND INTRODUCTION OF SQUAMACIDIA, GEN. NOV.

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SUMMARY

A new delimitation of Phyllopsora Müll. Arg. is presented based on study of all available type specimens of this genus and comparison with type material of related genera. Over 2000 general collections were examined, including abundant new material collected by the author and others in the neotropics. As a result of these studies, several taxa are excluded from Phyllopsora to allow for a more natural generic concept. This paper provides appropriate taxonomic and nomenclatural changes in Phyllopsora and introduces a new genus, Squamacidia, in anticipation of a forthcoming full monographic treatment of Phyllopsora.

INTRODUCTION

Müller-Argau (1894) first described the tribe Phyllopsorae in his systematic survey of New Zealand lichens, including it in his "Series II Thamno-Phylloblastae." He differentiated it by a loosely or moderately fixed squamulose thallus, "gonidia palmellaceae" and biatorine-lecideine apothecia. He included two genera in this tribe, distinguishing Phyllopsora by simple hyaline spores, and Psorella by transversely septate, hyaline spores. He assigned four species, one of which was regarded as doubtful, and one variety, to Phyllopsora. Zahlbruckner (1903-1908, 1926-1927) presented Müller-Argau's tribe as the family Phyllopsoraceae, including 41 species with numerous varieties in Phyllopsora and 14 species and one variety in Psorella, but he did not elaborate on Müller-Argau's original differentiation of these genera.

Currently, there are over 90 published names in Phyllopsora. The genus has not previously been monographed. Swinscow & Krog (1981) provided a detailed account of the eleven East African species, with notes on additional material they examined, including most of

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the type specimens. Phyllopsora was delimited by Swinscow & Krog (1981) and Hafellner (1984) by the following characters: 1) a squamulose thallus with an obvious prothallus, 2) an ascal apex composed of a hyaline hemispheric dome staining blue with iodine and surrounding a narrow, conical, lighter-staining masse axiale, 3) paraphyses with colorless unswollen apices, and 4) biatorine apothecia with a hypothecium composed of highly gelatinized hyphae. Swinscow & Krog (1981, 1985) briefly discussed the problem of distinguishing Phyllopsora from Bacidia De. Not. One of the main problems in understanding Phyllopsora is that in addition to Bacidia, several genera such as Biatora Th. Fr., Eschatogonia Trevisan, Psorella Müll. Arg. and Physcidia Tuck., include species that share many characters with Phyllopsora. In the past, these genera have been separated primarily by vegetative characters, but most of the taxa of these genera have not been critically examined since their original description.

Reexamination of type material and study of general collections of Phyllopsora and related genera (Brako, 1987) have provided information for the following generic delimitation of Phyllopsora and comparison with other genera.

TAXONOMIC SECTION

Phyllopsora Müll. Arg.
Bull. Herb. Boissier 2 (Appendix 1): 11. 1894.
Type species: Phyllopsora breviuscula (Nyl.) Müll. Arg. (This agrees with the lectotype designated by Clements & Shear, The Genera of Fungi, p. 319, 1931).

Thallus squamulose, small foliose, rarely appearing crustose. Squamules 0.1-1.0 mm wide. Upper surface glabrous to rough, fibrillose at the margin. Isidia common, sometimes dominating the thallus. Upper cortex 10-60 µm thick, consisting of anticlinally oriented, thin- to thick-walled hyphae with round to narrowly cylindrical lumina, commonly containing lichen substances. Photobiont in a continuous layer, green, unicellular, 5-15 µm diam., genus where known Pseudochlorella. Medulla usually poorly developed, of loosely woven and nonamyloid hyphae, frequently containing lichen substances. Lower cortex absent. Prothallus pale to dark red. Lichen substances: argopsin, atranorin, norargopsin, norvicanicin, pannarin, vicanicin, zeorin and numerous unknown compounds.

Apothecia to 1.5 mm diam., simple or aggregated, attached laminally to the squamules. Disc plane to convex, margin often slightly raised, tan to dark reddish-brown, epruinose. Exciple composed of radiating hyphae, tan to golden-brown or dark red, sometimes containing crystals. Hypothecium tan to golden-brown, or dark red, sometimes containing crystals, KOH- or KOH+ scarlet or purplish-red. Hymenium 20-60 µm tall, amyloid, epihymenium indistinct or a thin gelatinous layer with slight pigmentation, KOH-. Paraphyses cellular, straight, sparingly branched and anastomosing, apical cell slightly swollen, length to width ratio 6:1. Asci elongate-clavate, with a well developed tholus with a paler, conical masse axiale. Ascospores eight in the ascus, simple or uniseptate, colorless, ovoid, ellipsoid to fusiform, smooth-walled, without a halo, (4.5-) 5-20 x 2-5 µm.

Pycnidia spherical, immersed in the thallus to superficial, outer wall tan to reddish-brown, ostiole pale to brown pigmented. Conidiogenous cells enteroblastic, cylindrical to flask-shaped, arising directly from pycnidial wall cells or in groups of 2-3 at the tips of simple or branched condiophores that arise from the wall cells. Conidia rod-shaped, straight or bent, 7-15 x 0.5-1 µm (Fig. 1).

Phyllopsora is narrowly defined to include only species fitting all of the following diagnostic characteristics: thallus squamulose, small foliose, rarely crustose; lower surface not corticate, prothallus always present; apothecia biatorine, exciple and hypothecium of the same tissue type as the paraphyses; paraphyses highly gelatinized, length to width ratio 6:1; ascospores simple or once septate, ovoid to short-fusiform, less than 20 µm long, colorless, thin-walled.

Phyllopsora has a largely pantropical distribution, with a single species extending into northern Europe. Most species of Phyllopsora are corticolous. Some also grow on rocks or on bryophytes, but they are rarely found on leaves or dead wood. The altitudinal range of the genus is from sea level to

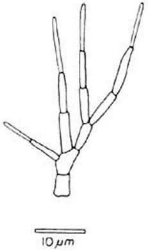


Fig. 1. Conidiogenous cells and conidia of the type found in Phyllopsora and Squamacidia (scale =10 µm).

3000 m; species of *Phyllopsora* are most common in humid, subtropical montane forests between 500 and 2000 m. In drier areas such as savannas, *Phyllopsora* is restricted to gallery forests.

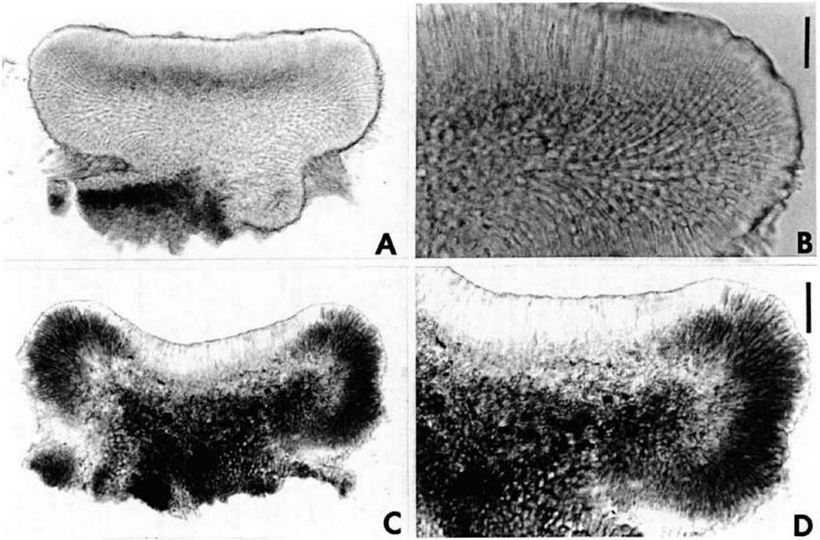
Phyllopsora is included in the lichen family Bacidiaceae based on its thallus form, its biatorine apothecia with radiate exciple, true paraphyses, and thick-walled asci with an amyloid hemispheric dome containing a narrow conical nonamyloid masse axiale. *Phyllopsora* may be separated from other genera by the combined characters of its ascal type, its apothecia composed of highly gelatinized hyphae with no clear distinction between the exciple and hypothecium, the same tissue type in the center and at the margin (Fig. 2A & B), and by its small, thin-walled, rarely septate ascospores.

Bacidia De Not., typified by *B. rosella* (Pers.) De Not., has an apothecial pattern with a cup-shaped exciple and distinct hypothecium and subhymenium of different tissue types. The ascospores are multiseptate and thick-walled. *Bacidia* as currently recognized is heterogeneous; it is a very large genus of several hundred species widespread in tropical and temperate areas, and is in great need of clarification.

Biatora Th. Fr., typified by *B. vernalis* (L.) Th. Fr., can be distinguished from *Phyllopsora* by its ascal type. It has the basic type found in the family with the addition of a darker-staining area around the masse axiale. *Biatora vernalis* has the same apothecial anatomy as *Phyllopsora* with larger, thicker-walled ascospores. Also, *B. vernalis* has a crustose thallus and appears to be primarily a temperate genus. *Biatora efflorescens* Nyl., an unusual sorediate species, also resembles *Phyllopsora* in apothecial anatomy and has argopsin, which may support a close relationship of *Biatora* and *Phyllopsora*.

Eschatogonia Trevisan, a genus comprising a few tropical species that have squamulose thalli, often grows together with *Phyllopsora*. It can be distinguished from *Phyllopsora* by its apothecial anatomy, with a distinct subhymenium, its chemistry including didymic acid and related substances, and by the presence of a lower cortex. The cortex has a distinct outer layer of uniformly arranged cells. The ascospores are slightly larger than those found in *Phyllopsora*, and are usually septate.

Fig. 2- A) *Phyllopsora parvifolia* (Pers.) Müll. Arg., Brazil, Campos do Jordão, *Kalb & Plöbst 23* (NY), section through ascocarp (scale =60 μm), B) close-up of the excipulum (scale =25 μm), C) *Squamacidia janeirensis* (Müll. Arg.) Brako, Brazil, Serra do Cachimbo, *Brako & Dibben 6917A* (INPA, NY, US), section through the ascocarp (scale =60 μm), D) close-up of the excipulum (scale =50 μm).


A
B
C
D

Psorella Müll. Arg., typified by *P. pannarioides* (Knight) Müll. Arg., is probably a synonym of *Bacidia*. *Psorella pannarioides* agrees with *Bacidia* in its apothecial anatomy and long, thick-walled ascospores. Following Swinscow & Krog (1981), two of the original 14 taxa included in *Psorella* by Zahlbruckner (1926-1927), *Psorella leptosperma* (Müll. Arg.) Zahlbr. and *P. spruceana* (Müll. Arg.) Zahlbr., are regarded as belonging to *Bacidia*, and *P. tryptophyllina* (Nyl.) Zahlbr. is regarded as possibly belonging to *Eschatogonia*. *Psorella delusa* (Nyl.) Zahlbr., *P. leucophyllina* (Nyl.) Zahlbr. and *P. psorina* (Nyl. ex Hue) Zahlbr. are not congeneric with *P. pannarioides*, nor with each other, but cannot be assigned to any currently recognized genera. Swinscow & Krog (1981) transferred four species of *Psorella* to *Phyllopsora*. Two of the species they transferred to *Phyllopsora*, *P. microphyllina* (Tuck. ex Nyl.) Swinscow & Krog and *P. pertexta* (Nyl.) Swinscow & Krog, together with *Psorella cognata* (Nyl.) Zahlbr., differ from *Phyllopsora* by possessing different tissue types in the exciple and hypothecium, thinner, less gelatinized paraphyses and long, septate, filiform ascospores. The apothecial anatomy and thinner-walled ascospores separate these species from *Bacidia rosella*. Before a new genus can be described for this group, more studies are needed on the anatomy of the ascus, as there appears to be much variation in the development of the tholus and masse axiale. Also, it is highly likely that additional taxa previously included in *Bacidia* will prove to be congeneric with this group. These species remain a subject of continuing study.

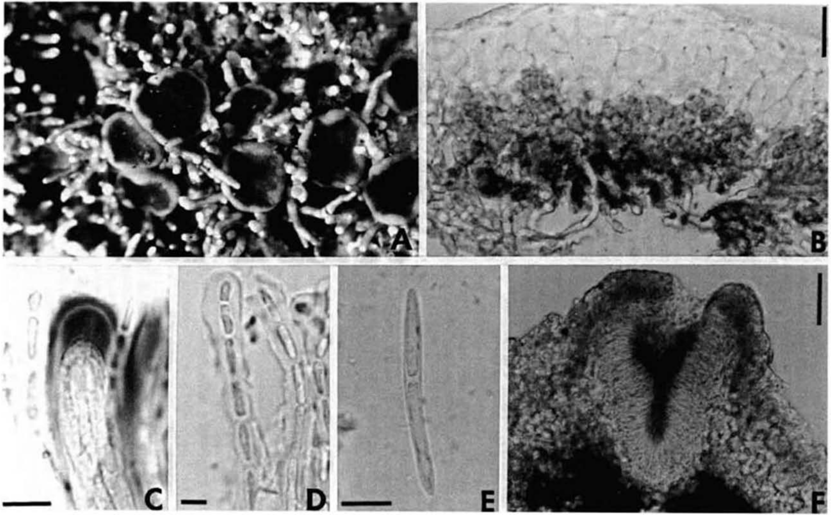
Swinscow & Krog (1981) also transferred *Psorella janeirensis* (Müll. Arg.) Zahlbr. to *Phyllopsora* based on study of the type specimen. After examination of additional material of this species, it is clear that it belongs with *Phyllopsora stenosperma* Zahlbr. and *Physcidia endococcinea* Zahlbr. in a new genus which is described below:

Squamacidia Brako, gen. nov.

A Phyllopsora ascosporis elongatis acerosis septatis, excipulo crasso pallido, granulas refractiles continenti, necnon acido lobarico et acido fumarprotocetrarico differt.

Type: *Squamacidia janeirensis* (Müll. Arg.) Brako. Figs. 1, 2C & D, 3A-F.

Fig. 3- *Squamacidia janeirensis* (Müll. Arg.) Brako, Brazil, Serra do Cachimbo, Brako & Dibben 6917A (INPA, NY, US). A) Thallus (12x), B) transverse section through the thallus (scale =20 μm), C) ascus tip (scale =10 μm), D) paraphyses (scale =5 μm), E) ascospore (scale =10 μm), F) section through pycnidium (scale =30 μm).


A
B
C
D
E
F

Thallus squamulose, squamules elongate and incised, 0.3-0.5 mm diam., convex. Upper surface glabrous, fibrillose at the margin. Isidia cylindrical. Upper cortex 20-60 µm thick, consisting of anticlinally oriented, thick-walled hyphae with narrowly cylindrical lumina, containing lichen substances. Photobiont in a continuous layer, green, unicellular, 10-15 µm diam. Medulla poorly developed, composed of loosely woven and nonamyloid hyphae, containing lichen substances. Lower cortex absent. Prothallus pale. Lichen substances: atranorin, fumarprotocetraric acid, lobaric acid, unknown rf. 6 and pigments.

Apothecia to 1.5 mm diam., simple or aggregated, attached laminally to the squamules. Disc plane to convex, tan to dark reddish-brown, margin generally raised, paler than the disc. Exciple cup-shaped, composed of hyphae with broad lumina at the margin, containing refractile granules, KOH-. Hypothecium tan, KOH-. Hymenium 80 µm tall, amyloid, epihymenium indistinct. Paraphyses cellular, straight, sparingly branched and anastomosing, apical cell slightly swollen, length to width ratio 10:1. Asci elongate-clavate, with a well developed tholus and lightened, narrow, conical masse axiale. Ascospores eight in the ascus, simple to 2-3 septate, colorless, acerose, smooth-walled, 24-40 x 2-2.5 µm.

Pycnidia spherical, immersed in the thallus to superficial, outer wall tan to reddish-brown, ostiole pale to brown pigmented. Conidiogenous cells enteroblastic, cylindrical to flask-shaped, arising directly from pycnidial wall cells, or in groups of 2-3 at the tips of short condiophores that arise from the wall cells. Conidia rod-shaped, straight, 9-15 x 0.5-1 µm.

This monotypic genus is distinguished by its squamulose thallus, obvious prothallus, characteristic apothecial anatomy, its long, acerose ascospores and distinctive chemistry.

Squamacidia has a pantropical distribution. All known specimens are corticolous. The altitudinal range of the genus is from 180-1400 m. _Squamacidia_ has been found both in shaded, humid rainforest habitats and in sun-exposed, dry savanna habitats.

Squamacidia janeirensis (Müll. Arg.) Brako, comb. nov.

Thalloidima janeirensis Müll. Arg., Hedwigia 31: 280. 1892. _Psorella janeirensis_ (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 4: 402. 1926. _Phyllopsora janeirensis_ (Müll. Arg.) Swinscow & Krog, Lichenologist 3: 242. 1981. Type: Brazil. Rio de Janeiro: _Portella s.n._ (holotype, BM, fumarprotocetraric acid, lobaric acid; isotype, G).

Phyllopsora stenospora Zahlbr., Repert. Spec. Nov. Regni Veg. 33: 44. 1933. Type: Taiwan. Mt. Arisan, Toroyen, _Asahina 170_ (holotype, W, lobaric acid; isotype, NY).

Thallus squamulose, squamules incised, 0.3-0.5 mm diam., complanate, adjoined and overlapping, adnate to ascending. Upper surface glabrous, fibrillose at the margin, Pd+ orange. Cortex 20-60 µm thick. Isidia cylindrical. Prothallus pale. Lichen substances: lobaric acid, and/or fumarprotocetraric acid, unknown rf. 6, UV+ orange, and pigments.

Apothecia common. Disc plane, orange-brown to brown. Margin raised, paler than the disc. Exciple tan, containing refractile granules, KOH-. Hypothecium tan, KOH-. Hymenium tan, 60 µm tall, epihymenium indistinct. Ascospores simple to 2-3 septate, acerose, 24-40 x 2-2.5 µm.

Conidiomata pycnidial. Conidia rod-shaped, straight, 9-15 x 0.5-1 µm.

Distribution: West Indies, South America, Taiwan and the Philippine Islands.

Of the 27 specimens of the type variety studied, nine were found to contain lobaric acid together with fumarprotocetraric acid and unknown rf. 6; eight have lobaric acid and fumarprotocetraric acid; four have lobaric acid alone; three have lobaric acid and unknown rf. 6; one has fumarprotocetraric acid and unknown rf. 6, and two have only fumarprotocetraric acid. This variation in chemistry does not appear to follow any distributional pattern, as different chemical varieties generally occur sympatrically.

Specimens examined: CUBA. [Oriente:] Monte Verde, Wright s.n. p.p, Lich. Cub. 179 (FH-TUCK 1919, BUF, G=2x, H-NYL 20535, L=2x, M=2x, UPS, W).

JAMAICA. 21 Mar 1905, Cummings 48 (FH=2x, NY); 1885, Hart s.n. (FH-TUCK 3018), Hart 32D (NY).

VENEZUELA. Bolivar: Parque Nacional Canaima, Gran Sabana, road from Aeropuerto Luepa to Kavanayen, 10 Apr 1985, Brako 8172 (NY).

FRENCH GUIANA. Saül, 2 km SW of the village, "sentier Limonade", 180-210 m, 22 Aug 1986, Montfoort & Ek 142 (U).

BRAZIL. Acre: Slopes of Serra da Moa, 19 Apr 1971, Prance et al. 12132 (INPA, NY). Amazonas: Platô da Serra do Aracá (Serra Norte), 1100 m, 14 Feb 1984, Cisneros et al. 30, 50 (INPA, NY); Reserva Biológia de Campina INPA-SUFRAMA on the Manaus-Caracarai road at point 45 km from intersection of the Manaus-Itacoatiara road, 6 Nov 1977, Dumont et al. 117 (INPA, NY); Reserva Experimental do INPA, Manaus-Caracarai km 61, 3 Aug 1973, Prance et al. 18717 p.p. (INPA, NY). Minas Gerais: Serra do Espinhaço, Serra do Caraça, 8 Jul 1978, Kalb & Plöbst 31 (Hb. Kalb), 1300 m, 12 Jul 1978, Kalb & Plöbst 34 (Hb. Kalb). Pará: Serra do Cachimbo, 774 km N of Cuiabá, ca. 400 m, 22 Apr 1983, Brako & Dibben 5531, 5556 (INPA, NY), 5605, 5612 (INPA); 763 km N of Cuiabá, ca. 400 m, 22 Apr 1983, Brako & Dibben 5887 (INPA, NY); Aeroporto Cachimbo, ca. 20 km N of the border with Mato

Grosso, ca. 430-480 m, 27 Apr 1983, Brako & Dibben 6171 (INPA, NY); 780 km N of Cuiabá, ca. 430-480 m, 29 Apr 1983, Brako & Dibben 6394 (INPA, NY); cataracts on the Rio Curuá, 877 km N of Cuiabá, ca. 350-500 m, 2 May 1983, Brako & Dibben 6621 (INPA, NY), 7 May 1983, Brako & Dibben 6917A (INPA, NY).

PHILIPPINE ISLANDS. North Luzon: Prov. Baguio, 1400 m, 10 Aug 1983, Kalb & Schrögl s.n. (Hb. Kalb).

Squamacidia janeirensis var. **endococcinea** (Zahlbr.) Brako, comb. et stat. nov.

Physcidia endococcinea Zahlbr., Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss., Kl. 83: 159. 1909. Type: Brazil. São Paulo: Itapecirica, near Barra Mansa, ca. 1000 m, 9 Jun 1901, Schiffner s.n. (holotype, W, fumarprotocetraric acid, lobaric acid).

Distribution: Panama, Venezuela and Brazil.

Variety endococcinea is distinguished by the straw-colored or scarlet-colored pigment in the medulla and frequent occurrence of atranorin. It is thus far known only from the neotropics.

Of the 13 specimens of this variety studied, three were found to contain atranorin together with fumarprotocetraric acid, lobaric acid and unknown rf. 6; two have atranorin, fumarprotocetraric acid and lobaric acid; two have fumarprotocetraric acid, lobaric acid and unknown rf. 6; one has fumarprotocetraric acid and lobaric acid; one has atranorin, lobaric acid and unknown rf. 6; two have atranorin and lobaric acid, and two have only lobaric acid. These chemical varieties do not appear to follow any distributional pattern.

Specimens examined: PANAMA. Panamá: Cerro Jefe, 900 m, 28 Nov 1985, Brako 8494 (NY).

VENEZUELA. Miranda: El Volcán, above Baruta, 1200-1400 m, 1 May 1986, Brako 8667 (NY).

BRAZIL. Amazonas: Along Igarapé Caititu off Rio Uatumá at Antônio Filinto, 18, 19 Aug 1979, Buck 2977, 2998 (INPA, NY); Reserva Biológica de Campina INPA-SUFRAMA, on the Manaus-Caracarai road at a point 45 km from the intersection of the Manaus-Itacoatiara road, 6 Nov 1977, Dumont BR-102 (INPA, NY); Rio Cuieras just below mouth of the Rio Brancinho, 27 Sep 1971, Prance et al. 14960 (INPA, NY). Pará: Serra do Cachimbo, 763 km N of Cuiabá, ca. 400 m, 22 Apr 1983, Brako & Dibben 5858 (INPA, NY), 24 Apr 1983, Brako & Dibben 5870 (INPA, NY); Aeroporto Cachimbo, ca. 20 km N of the border with Mato Grosso, ca. 430-480 m, 27 Apr 1983, Brako & Dibben 6185. Roraima: Along the Manaus-Boa Vista road at a point 350 km from the intersection of the Manaus-Itacoatiara road, 18 Nov 1977, Dumont et al. BR-599B, BR-600 (INPA, NY).

Squamacidia is included in the Bacidiaceae based on its thallus form, its biatorine apothecia, true paraphyses and bacidiacious ascal type. Squamacidia can be separated from Phyllopsora and other genera in the

Bacidiaceae by its thick apothecial margin (Fig. 2C & D), acerose ascospores (Fig. 2E) and distinct chemistry of fumarprotocetraric acid and/or lobaric acid. Apothecial anatomy is closest to that of Phyllopsora, but the texture of the center and the margin are different, and the hyphae of the exciple are expanded at the margin and covered with granules. The remaining taxa in Physcidia, P. squamulosa Tuck. and P. wrightii (Nyl.) Tuck., can be distinguished by their non-bacidiacious ascal type, lecanorine apothecia and chemistry of divaricatic acid and scrobiculin.

Key to Phyllopsora and associated genera

1a. Thallus with an upper and lower cortex comprised of a thin layer of cuboidal cells......... Eschatogonia

1b. Thallus lacking a lower cortex, upper cortex not as above.. 2

  2a. Apothecia lecanorine, thallus containing divaricatic acid and scrobiculin...... Physcidia

  2b. Apothecia biatorine, thallus lacking divaricatic acid.............................. 3

    3a. Apothecia with tissue types different in the center from the margin, spores over 20 µm long.................... 4

      4a. Spores thick-walled, multiseptate, thallus containing atranorin.... Bacidia

      4b. Spores thin-walled, simple to 2-3 septate, thallus containing fumarprotocetraric acid and/or lobaric acid....................... Squamacidia

    3b. Apothecia with the same tissue type throughout, spores less than 20 µm long... 5

      5a. Spores thick-walled, ascal tip with a darkened amyloid area around the masse axiale................... Biatora

      5b. Spores thin-walled, ascal tip lacking a darkened area around the masse axiale. .... Phyllopsora

In addition to reevaluating the generic concept of Phyllopsora, the species concept has also been reassessed. Most species had previously been distinguished by single differences of thalline characters, but the extent of environmental variability in these traits had never been critically evaluated. After field studies and examination of abundant new material, many character states were found to form a continuum and it became clear that certain taxa formerly considered species are more naturally considered as varieties, and certain taxa treated as varieties are actually distinct species. As a result of detailed study of the 51 species of *Phyllopsora* described from the neotropics (Brako, 1987), 25 names are reduced to synonymy and the following name changes are proposed:

Phyllopsora buettneri (Müll. Arg.) Zahlbr. var. **glauca** (B. de Lesd.) Brako, comb. nov.

Phyllopsora parvifolia (Pers.) Müll. Arg. var. *glauca* B. de Lesd., Rev. Bryol. Lichénol. 7: 60. 1934. Type: Cuba. [Oriente:] Loma del Gato, 1100 m, Jul 1931, *Hioram 9098* (lectotype, HAC, designated by Vězda, 1969 in hb., fragment NY; isosyntype: Cuba. Scala Victoria, 800 m, *Hioram 8909*, UPS).

Phyllopsora melanoglauca Zahlbr., Denkschr. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl. 83: 133. 1909. Type: Brazil. São Paulo: Near Iguape, 20-100 m, Aug 1901, *Schiffner s.n.* (holotype, W; isotype, BM).

Phyllopsora buettneri (Müll. Arg.) Zahlbr. var. **munda** (Malme) Brako, comb. et stat. nov.

Lecidea munda Malme, Ark. Bot. 28A(7): 49. 1936. *Phyllopsora munda* (Malme) Zahlbr., Cat. Lich. Univ. 10: 377. 1939. Type: Brazil. Rio Grande do Sul: Hamburgerberg, near São Leopoldo, 18 Oct 1892, *Malme s.n.*, Lich. Regnell. 617B (holotype, S).

Lecidea schizophylloides Malme, Ark. Bot. 28A(7): 45. 1936. *Phyllopsora schizophylloides* (Malme) G. Schneider, Biblioth. Lich. 13: 178. 1979. Type: Brazil. Rio Grande do Sul: Silveira Martins, 7 Mar 1893, *Malme s.n.*, Lich. Regnell. 1251B (holotype, S).

Phyllopsora canoumbrina (Vainio) Brako, comb. nov.

Lecidea canoumbrina Vainio, Proc. Amer. Acad. Arts 58: 135. 1923. Type: Trinidad. Maraval Valley, Jan-Apr 1913, *R. Thaxter 19* (holotype, FH).

Lecidea parvifolia Pers. f. *subgranulosa* Tuck., Proc. Amer. Acad. Arts 6: 273. 1866. *Biatora parvifolia* (Pers.) Mont. var. *subgranulosa* (Tuck.) Tuck., Syn. N. Amer. Lich. 2: 8. 1888. *Psora parvifolia* (Pers.) Massal. var. *subgranulosa* (Tuck.) Müll. Arg., J. Linn. Soc., Bot. 29: 219. 1893. *Phyllopsora parvifolia* (Pers.) Müll. Arg. var. *subgranulosa* (Tuck.) Müll. Arg., Bot. Jahrb. Syst. 20: 264. 1894. Type: Cuba. [Oriente:] Monte Verde, 6 Apr, *Wright s.n.*, Lich. Cub. 185 (lectotype here designated, FH-TUCK 2923, piece marked "w"; isolectotypes, BM, BUF, G=3x, L=2x, L-6889, M, UPS, US).

Phyllopsora corallina (Eschw.) Müll. Arg. var. **glaucella** (Vainio) Brako, comb. nov.
Lecidea breviuscula (Nyl.) Müll. Arg. var. glaucella Vainio, Dansk Bot. Arkiv 4(11): 21. 1926. Phyllopsora breviuscula (Nyl.) Müll. Arg. var. glaucella (Vainio) Zahlbr., Cat. Lich. Univ. 10: 426. 1939 "fo. glaucina". Type: Mexico. Veracruz: Mirador, Liebmann s.n., Pl. Mex. 7381a (holotype, TUR-VAIN 34026).

Phyllopsora corallina (Eschw.) Müll. Arg. var. **ochroxantha** (Nyl.) Brako, comb. et stat. nov.
Lecidea ochroxantha Nyl., Ann. Sci. Nat. Bot., sér. 4, 11: 223. 1859. Phyllopsora ochroxantha (Nyl.) Zahlbr., Cat. Lich. Univ. 10: 377. 1939. Type: Bolivia. Camplolicans, [1847,] Weddell s.n. (lectotype designated by Swinscow & Krog, 1981, H-NYL 20489; isolectotypes H, PC).

Lecidea subvirescens Nyl., Ann. Sci. Nat. Bot., sér. 5, 7: 321. 1867. Phyllopsora subvirescens (Nyl.) G. Schneider, Biblioth. Lich. 13: 179. 1979. Type: Venezuela. Río Negro, 1200 m, 1863, Lindig s.n. (holotype, H-NYL 20492).

Lecidea ernstiana Müll. Arg., Flora 60: 473. 1877. Psora ernstiana (Müll. Arg.) Müll. Arg., Flora 70: 320. 1887. Phyllopsora ernstiana (Müll. Arg.) Müll. Arg., Bot. Jahrb. Syst. 20: 265. 1894. Type: Venezuela. Distrito Federal: Caracas, Ernst 90 (holotype, G).

Psora polydactyla Müll. Arg., Flora 70: 320. 1887. Phyllopsora polydactyla (Müll. Arg.) Zahlbr., Cat. Lich. Univ. 4: 400. 1926. Type: Brazil. São Paulo: Apiahy (Apiaí), Apr 1882, Puiggari 2156 (holotype, G).

Lecidea spinulosa Vainio, Acta Soc. Fauna Fl. Fenn. 2: 46. 1890. Phyllopsora spinulosa (Vainio) Zahlbr., Cat. Lich. Univ. 4: 401. 1926. Type: Brazil. Minas Gerais: Sitio, 1885, Vainio s.n., Lich. Bras. Exs. 993 (holotype, TUR-VAIN 22627; isotypes, BM=2x, M, TUR-VAIN 22626, ZT).

Lecidea glabriuscula Nyl., Sert. lich. trop. 40. 1891. Phyllopsora glabriuscula (Nyl.) Swinscow & Krog, Lichenologist 13: 241. 1981. Type: Cuba. Wright s.n., Lich. Cub. ser. 2, 105 (holotype, H-NYL 20534).

Phyllopsora cinerella Zahlbr. in H. Magn. & Zahlbr., Ark. Bot. 3IA(6): 18. 1944. Type: U.S.A. Hawaii: Kauai, near Robinson's summerhouse, 1000 m, Feb 1910, Faurie 308 (lectotype here designated, PC; syntypes, Faurie 307, UPS, Maui, 350 m, Faurie 539, n.v.).

Phyllopsora cinerella Zahlbr. f. virescens Zahlbr. in H. Magn. & Zahlbr., Ark. Bot. 31A(6): 19. 1944. Type: U.S.A. Hawaii: Oahu, near Honolulu, 400 m, Faurie 413 (lectotype here designated, PC; isolectotype, BM).

Phyllopsora martinii Swinscow & Krog, Lichenologist 3: 232. 1981. Type: Kenya. Coast Prov.: Kwale District, Shimba Hills, Kivumoni Forest, 350 m, 1972, Krog & Swinscow K 42/3 (holotype BM; isotypes, BM, O, UPS).

Phyllopsora corallina (Eschw.) Müll. Arg. var. **phaeobyssina** (Vainio) Brako, comb. nov.

Lecidea breviuscula Nyl. var. phaeobyssina Vainio, Ann. Acad. Sci. Fenn., ser. A, 6(7): 127. 1915. Phyllopsora breviuscula (Nyl.) Müll. Arg. var. phaeobyssina (Vainio) Zahlbr., Cat. Lich. Univ. 4: 396. 1926. Type: Guadeloupe. Houelmont, [1897,] Duss 481 (holotype, TUR-VAIN 22602; isotype, NY).

Phyllopsora corallina (Eschw.) Müll. Arg. var. **santensis** (Tuck.) Brako, comb. et stat. nov.

Lecidea santensis Tuck., Amer. J. Sci. Arts, ser. 2, 25: 428. 1858. Phyllopsora santensis (Tuck.) Swinscow & Krog, Lichenologist 13: 236. 1981. Type: U.S.A. South Carolina: [Berkeley Co.,] Santee Canal, 1849, Ravenel 182 (holotype, FH-TUCK 2822).

Phyllopsora albicans Müll. Arg., Bull. Soc. Roy. Bot. Belgique 32: 132. 1893. Type: Costa Rica. Cartago: Terraba (Turrialba), 1893, Tonduz s.n. (holotype, G; isotypes, US=2x, as Pittier & Durand, Pl. Costar. Exs. 5474).

Lecidea porphyromelaena Vainio, Ann. Acad. Sci. Fenn., ser. A, 15(6): 113. 1921. Phyllopsora porphyromelaena (Vainio) Zahlbr., Cat. Lich. Univ. 4: 401. 1926. Type: Philippines. Luzon: Bataan Prov., Mount Marivales, Dec 1908, Merrill s.n., Bur. Sci. 6273 (lectotype designated by Swinscow & Krog, 1981, TUR-VAIN 22619; syntype, Bur. Sci. 6256, TUR-VAIN 22620; isosyntypes, BM, US).

Lecidea miradorensis Vainio, Dansk Bot. Ark. 4(11): 22. 1926. Phyllopsora miradorensis (Vainio) G. Schneider, Biblioth. Lich. 13: 177. 1979. Type: Mexico. [Veracruz:] Mirador, 18 Mar 1842, Liebmann s.n., Pl. Mex. 7373 (lectotype designated by Swinscow & Krog, 1981, TUR-VAIN 34034; isolectotype, FH; syntype, Liebmann s.n., Pl. Mex. 7372A, TUR-VAIN 34035).

Phyllopsora formosana Zahlbr., Repert. Spec. Nov. Regni Veg. 33: 43. 1933. Type: Taiwan. Raisha, 5 Jan 1925, Asahina s.n. (holotype, W).

Lecidea corallina Eschw. f. saxicola Malme, Ark. Bot. 28A(7): 47. 1936. Type: Brazil. Mato Grosso:

Santo Antônio near Cuiabá, Morrinho, 24 Apr 1894, Malme s.n., Lich. Regnell. 2607B (holotype, S).

Phyllopsora minor Brako, nom. nov.
Lecidea corallina Eschw. var. schizophylloides Vainio, J. Bot. 34: 106. 1896. Phyllopsora corallina (Eschw.) Müll. Arg. var. schizophylloides (Vainio) Zahlbr., Cat. Lich. Univ. 4: 397. 1926 (non Phyllopsora schizophylloides (Malme) Schneider =Phyllopsora buettneri (Müll. Arg.) Zahlbr. var. munda (Malme) Brako). Type: St. Vincent. Richmond Peak, 1000-2000 m, Elliott 261 (lectotype designated by Swinscow & Krog, 1981, TUR-VAIN 22612A; isolectotype, BM).

Phyllopsora parvifolia (Pers.) Müll. Arg. var. **breviuscula** (Nyl.) Brako, comb. et stat. nov.
Phyllopsora breviuscula (Nyl.) Müll. Arg., Bull. Herb. Boissier 2(Appendix 1): 45. 1894. Lecidea breviuscula Nyl., Ann. Sci. Nat. Bot., sér. 4, 19: 339. 1863. Lecidea parvifolia* breviuscula (Nyl.) Nyl., Ann. Sci. Nat. Bot., sér. 5, 7: 321. 1867. Psora breviuscula (Nyl.) Müll. Arg., Flora 65: 483. 1882. Type: Cuba. [Oriente:] Monte Verde, Wright s.n. (holotype, H-NYL 20557; isotypes as Lich. Cub. 181, B, BM, G=3x, L=2x, UPS).
Phyllopsora brachyspora Müll. Arg., Bot. Jahrb. Syst. 20: 264. 1894. Type: Tanzania. "Hochwald ob Kwa Mstufa in Usambara, D.O. Afr.", 1894, Holst 9181 p.p. (holotype, G; isotypes, BM, M, W).

Phyllopsora subcrustacea (Malme) Brako, comb. et stat. nov.
Lecidea corallina Eschw. var. subcrustacea Malme, Ark. Bot. 28A(7): 47. 1936. Phyllopsora corallina (Eschw.) Müll. Arg. var. subcrustacea (Malme) Zahlbr., Cat. Lich. Univ. 10: 377. 1939. Type: Paraguay. Asunción, 18 Aug 1893, Malme s.n., Lich. Regnell. 1612B (holotype, S; isotype, UPS).

The following taxa, previously assigned to Phyllopsora, do not belong to the genus as currently delimited and are placed in other genera (indicated in boldface):

Lecidea aleuroides Stirton, J. Linn. Bot. 14: 469. 1875. Phyllopsora aleuroides (Stirton) Müll. Arg., Bull. Herb. Boissier 2(Appendix 1): 45. 1894. Type. New Zealand. Near Wellington, Buchanan s.n. (lectotype designated by Galloway 1983, GLAM; isolectotypes, BM, WELT).
=**Psoromidium aleuroides** (Stirton) D. Galloway

Lecidea congregans Zahlbr., Akad. Wiss. Wien, Math-Naturwiss. Kl., Denkschr. 104: 305. 1941. Phyllopsora congregans (Zahlbr.) D. Galloway, New Zealand J. Bot. 21: 196. 1983. Type: New Zealand. Otago, Mt. Cargill near Dunedin, 400 m, May 1935, J.S. Thomson A96 (lectotype, W3424).
=**Trapeliopsis congregans** (Zahlbr.) Brako, comb. nov.

Lecidea coroniformis Krempelh., Verh. Zool.-Bot. Ges. Wien 18: 327. 1868. Phyllopsora coroniformis (Krempelh.) Zahlbr. in Engler & Prantl, Nat. Pflanzenfam. 1(1*): 139. 1905. Biatora coroniformis (Krempelh.) Jatta, Flora Ital. Cryptog., 3: 520. 1911. Type: USA. Texas, Ex. hb. Endichler (holotype, M).
=**Psora crenata** (Tayl.) Reinke

Phyllopsora cryptocarpa Riddle, Mycologia 15: 80. 1923. Type: Cuba. Isle of Pines: San Juan, 15 Mar 1916, Britton et al. 15588 (holotype, FH; isotype FH, NY).
=**Fellhanera cryptocarpa** (Riddle) Brako, comb. nov.

Phyllopsora leprosa W. Riedl, Österr. Bot. Z. 121: 145. 1973. Type: Surinam. 1827, Weigel s.n. (holotype, W).
=**Crocynia gossypina** (Sw.) Massal.

Phyllopsora melanocarpa Müll. Arg., Hedwigia 34: 28. 1895. Type: Australia. Victoria, Wilson 150 (holotype, G; isotype W).
=**Neophyllis pachyphylla** (Müll. Arg.) G. Schneider

Phyllopsora subcorallina Zahlbr., Ann. Mycol. 33: 43. 1935. Type: U.S.A. Florida: Sanford, Mar 1928, Rapp 70 (lectotype here designated, W; syntype, Rapp 69, FH).
=**Catinaria subcorallina** (Zahlbr.) Brako

Phyllopsora subfilamentosa Zahlbr., Ann. Mycol. 33: 44. 1935. Type: U.S.A. Florida: Sanford, Rapp 62 (holotype, W).
=**Fuscidea subfilamentosa** (Zahlbr.) Brako

Psoromidium wellingtonii Stirton, Proc. Phil. Soc. Glasgow 10: 304. 1877. Phyllopsora wellingtonii (Stirton) Müll. Arg., Bull. Herb. Boissier 2(Appendix 1): 45. 1894. Type: New Zealand. Near Wellington, J. Buchanan s.n. (lectotype designated by D. Galloway, 1983, BM).
=**Psoromidium aleuroides** (Stirton) D. Galloway

The following taxa are also excluded from Phyllopsora, but do not belong to any currently recognized genera and are here listed alphabetically by their basionyms:

Biatora pyrrhomelaena Tuck., Amer. J. Sci. Arts, ser. 2, 28: 205. 1859. Phyllopsora pyrrhomelaena (Tuck.) Swinscow & Krog, Lichenologist 13: 244. 1981. Type: Cuba. [Oriente:] Monte Verde Woods, 7 Apr, Wright s.n., Lich. Cub. 178 (holotype, FH; isotypes, BM, BUF, L=2x, UPS, US=2x).
This species belongs in an undescribed genus in the Bacidiaceae. It differs from Phyllopsora by its apothecial anatomy and pigmentation.

Lecidea curatellae Malme, Ark. Bot. 28A(7): 42. 1936. Phyllopsora curatellae (Malme) G. Schneider, Biblioth. Lich. 13: 175. 1979. Type: Brazil. Mato Grosso: Cuiabá, 27 Nov 1893, Malme s.n., Lich. Regnell. 2038 (lectotype designated by Swinscow & Krog, 1981, S; isolectotype, UPS).
This species belongs to an undescribed genus in the Lecanoraceae based on its ascal type, dark hypothecium and small ascospores.

Lecidea leucophyllina Nyl., Ann. Sci. Nat. Bot., sér. 4, 19: 347. 1863. Thalloidima leucophyllinum (Nyl.) Müll. Arg., Rev. Mycol. 10: 60. 1888. Biatora leucophyllina (Nyl.) Tuck., Synop. N. Amer. Lich. 2: 40. 1888. Psorella leucophyllina (Nyl.) Zahlbr., Cat. Lich. Univ. 4: 402. 1926. Type: Cuba. Wright s.n. (holotype, H-NYL 17345C,E; isotypes as Lich. Cub. 213, BM=2x, BUF, FH-TUCK 3018, FH, G=3x, L=2x, UPS).
This species belongs to an undescribed genus in the Bacidiaceae based on its ascal type, its sorediate thallus containing sekikaic acid, its apothecia with refractile granules, and its long septate, thin-walled ascospores.

Lecidea stylophora Malme, Ark. Bot. 28A(7): 40. 1936. Phyllopsora stylophora (Malme) G. Schneider, Biblioth. Lich. 13: 179. 1979. Type: Brazil. Mato Grosso: Serra da Chapada, Burutí, 27 Jun 1894, Malme s.n. (holotype, S; isotypes, G, H, US).
This species belongs in the Lecanoraceae based on the ascal type characteristic of the family and simple, hyaline, broad ascospores.

Lecidea thaleriza Stirton, Trans. Glasgow Soc. Field Nat. 5: 217. 1877. Phyllopsora thaleriza (Stirton) G. Schneider, Biblioth. Lich. 13: 180. 1979. Type: South Africa. Somerset East, Boschberg, 1874, McOwan s.n. (holotype, BM; not found in GLAM).

Psora compaginata Müll. Arg., Rev. Mycol. 10: 60. 1888. Phyllopsora compaginata (Müll. Arg.) G. Schneider, Biblioth. Lich. 13: 175. 1979. Type: Paraguay. Cerro San Thomas, Jun 1881, Balansa 4134 (holotype, G, isotypes, M, W; possible isotype, H-NYL 4132).

This species belongs to an undescribed genus in the Bacidiaceae. It differs from Phyllopsora by its pseudoparenchymatous hypothecium, its crustose thallus and its algal type which does not agree well with Pseudochlorella.

Phyllopsora longispora Swinscow & Krog, Nord. J. Bot. 5:493. 1985. Type: Kenya. Western Prov.: Kakamega District, Kakamega Forest, 1700 m, 20 Jan 1970, Santesson 21698A (holotype, UPS).

This species belongs to an undescribed genus in the the Bacidiaceae. It has a squamulose thallus like Phyllopsora, an apothecial anatomy like Bacidia rosella and long filiform thin-walled ascospores. It is only known from the type collection.

Full synonymy and additional nomenclatural changes in Phyllopsora will be included in forthcoming publications.

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FOUR NEW SPECIES OF PARMELIA (LICHENES) FROM SOUTHERN AFRICA, WITH FURTHER NOTES, NEW COMBINATIONS AND NEW LICHEN RECORDS

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ABSTRACT

Four new species of *Parmelia* (Parmeliaceae, lichenized Ascomycotina) are described from southern Africa. They are: *Parmelia dwaasbergensis* Brusse, *P. inops* Brusse, *P. lyrigera* Brusse, and *P. sitiens* Brusse. Two new combinations are made: *Parmelia evernica* (Hale) Brusse and *P. rubropustulata* (Hale) Brusse. Two lichens are recorded for the first time from southern Africa and notes on seven *Parmelia* species are given.

PARMELIA DWAASBERGENSIS Brusse, *sp. nov.* Fig. 2

Thallus foliosus, saxicola, ad 5 cm diametro, laxe adnatus, 85 - 175 µm crassus. *Lobi* elongati, imbricati, 0,5 - 3,0 mm lati. *Thallus superne* cinereus, nitidus, isidiis sorediisque destitutus. *Cortex superior* 13 - 15 µm crassus. *Stratum gonidiale* 15 - 45 µm crassum, algis *Trebouxiis*, 6,5 - 16,5 µm diametris. *Medulla* alba, 45 - 95 µm crassa. *Cortex inferior* 8 - 11 µm crassus. *Thallus inferne* piceus, sat rhizinatus. *Rhizinae* simplices, 40 - 100 µm crassae. *Apothecia et pycnidia* non visa. *Thallus* atranorinum, acidum hyposticticum, acidum hyposalazinicum et acidum hypoconsticticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE - 3323 (Willowmore): 7 km S of road junction near Misgunst Farm, farm Krommekloof, E side of Dwaasberg hill. Table Mountain Sandstone outcrop on SW slope, on SW face. Alt. 1060 m (-CB). *F. Brusse 5211*, 8. iii. 1988 (PRE, holo-; BM, COLO, LD, iso-).

Figura 2.

Thallus foliose, saxicolous, to 5 cm across, loosely adnate, 85 - 175 µm thick. *Lobes* elongate, imbricate, 0,5 - 3,0 mm broad. *Upper surface* grey, glossy, without isidia or soredia. *Upper cortex* 13 - 15 µm thick. *Algal layer* 15 - 45 µm thick, algae *Trebouxia*, 6,5 - 16,5 µm diam. *Medulla* white, 45 - 95 µm thick. *Lower cortex* 8 - 11 µm thick. *Lower surface* black, moderately rhizinate. *Rhizines* simple, 40 - 100 µm thick. *Apothecia and pycnidia* not seen. *Chemistry:* atranorin, hypostictic, hyposalazinic, and hypoconstictic acids present.

This new species is probably most closely related to the Australian, *Paraparmelia brownliei* Elix & Johnston (1988) with a chestnut brown lower surface. *Parmelia dwaasbergensis* is black below, and is more loosely adnate and broader lobed than *P. brownliei*. In addition, *P. brownliei* contains hypostictic acid as the only major medullary constituent, hypoconstictic acid being found in minor quantities, and hyposalazinic acid being present only in trace amounts. *Parmelia dwaasbergensis*, on the other hand, contains these substances in more or less equal concentrations (i.e. all three substances are present in major amounts).

Parmelia dwaasbergensis is also related to the following species to be described new, *Parmelia inops*, but is also more loosely adnate and broader-lobed than the latter.

Other *Paraparmelia*'s containing hypostictic acid are isidiate.

The habit of this lichen resembles loose forms of *Parmelia vanderbylii* Zahlbr. (sometimes referred to as a distinct species, *P. prolata* Hale). This loose habit is also frequently found in *P. tortula* Kurok., which this new lichen may also resemble.

At present this new species is known only from the type locality, the east side of a hill called Dwaasberg, northeast of Uniondale.

PARMELIA INOPS Brusse, *sp. nov.* Fig. 3

Thallus minute foliosus, saxicola, ad 3,5 cm diametro. *Lobi* elongati vel sublineares, 0,2 - 1,0 mm lati, 65 - 160 µm crassi. *Thallus superne* cinereus, nitidus, isidiis srorediisque destitutus. *Cortex superior* 9 - 16 µm crassus. *Stratum gonidiale* 15 - 30 µm crassum, algis *Trebouxiis*, 5,5 - 17 µm diametris. *Medulla* alba, 30 - 110 µm crassa. *Cortex inferior* 7 - 12 µm crassus. *Thallus inferne* piceus, sat rhizinatus. *Rhizinae* simplices, 35 - 55 µm crassae. *Apothecia* adnata, ad 1,5 mm diametris. *Hypothecium* hyalinum, 13 - 35 µm crassum. *Subhymenium* hyalinum, 9 - 12 µm crassum, J+ pallide caeruleum. *Hymenium* hyalinum, 45 - 50 µm altum, J+ caeruleum. *Asci* clavati, tholis J+ caeruleis (figura 1). *Ascosporae* octonae, hyalinae, simplices, ellipsoideae, 7,5 - 12,0 X 4,5 - 7,0 µm. *Pycnidia* non visa. *Thallus* atranorinum, acidum hyposticticum, acidum hyposalazinicum et acidum hypoconsticticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE - 3323 (Willowmore): 7 km S of road junction at Misgunst Farm, farm Krommekloof, E side of Dwaasberg hill. Near S base of Table Mountain Sandstone outcrop, on SW slope. Alt. 1060 m (-CB). *F. Brusse 5212*, 8. iii. 1988 (PRE, holo-; BM, COLO, LD, iso-). Figura 3.

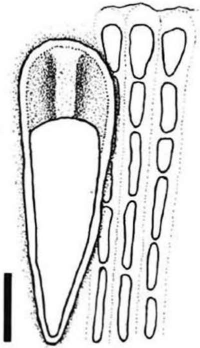


FIGURE 1. *Parmelia inops* Brusse, ascus and paraphyses. *F. Brusse 5212*, holotype. Bar = 10 µm.

Thallus minutely foliose, saxicolous, to 3,5 cm across. *Lobes* elongate to sublinear, 0,2 - 1,0 mm broad, 65 - 160 µm thick. *Upper surface* grey, glossy, without isidia or soredia. *Upper cortex* 9 - 16 µm thick. *Algal layer* 15 - 30 µm thick, algae *Trebouxia*, 5,5 - 17 µm diam. *Medulla* white, 30 - 110 µm thick. *Lower cortex* 7 - 12 µm thick. *Under surface* black, moderately rhizinate. *Rhizines* simple, 35 - 55 µm thick. *Apothecia* adnate, to 1,5 mm across. *Hypothecium* hyaline, 13 - 35 µm thick. *Subhymenium* hyaline, 9 - 12 µm thick, J+ pale blue. *Hymenium* hyaline, 45 - 50 µm high, J+ blue. *Asci* clavate, eight-spored, tholus J+ blue (figure 1). *Ascospores* hyaline, simple, ellipsoid, 7,5 - 12,0 X 4,5 - 7,0 µm. *Pycnidia* not seen. *Chemistry:* atranorin, hypostictic, hyposalazinic and hypoconstictic acids present.

This new species is probably most closely related to the Australian, *Paraparmelia brownliei* Elix & Johnston (1988), with a chestnut brown lower surface. *Parmelia inops* is black below, and is tighter and more narrow lobed than *P. brownliei*. *Paraparmelia brownliei* contains hypostictic acid as the only major medullary substance, hypoconstictic acid being found as a minor constituent, and only traces of hyposalazinic acid are present. In contrast, *P. inops* contains these substances in approximately equal concentrations (i.e. all three substances are present in major amounts).

Parmelia inops is also related to the previous new species from the same locality, *P. dwaasbergensis*, but is tighter and more narrow-lobed than the latter.

This new species resembles the more common, *P. xanthomelanoides* (Elix & Nash) Brusse (1988b), but contains the hypostictic acid series instead of the stictic acid series.

Paraparmelia subtropica Elix & Johnston (1986) may be close to the hypothetical isidiate counterpart of this species, but the lobes are elongate, not sublinear as in *P. inops*, and contains norstictic acid as the major constituent, with only traces of hypostictic and hyposalazinic acids.

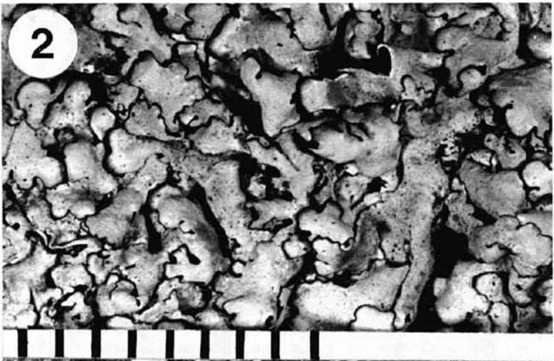
At present this new species is known only from the type collection, from just east of Dwaasberg hill, north-east of Uniondale.

PARMELIA LYRIGERA Brusse, *sp. nov.* Fig. 4

Thallus crustosus et effiguratus, saxicola, ad 3 cm diametro. *Lobi* elongati, 0,2 - 0,7 mm lati, 65 - 100 µm crassi. *Thallus superne* flavo-viridis, subnitidus vel grosse pruinosus, isidiatus. *Isidia* 0,05 - 0,1 mm crassa. *Cortex superior* 15 - 20 µm crassus. *Stratum gonidiale* 20 - 35 µm crassum, algis *Trebouxiis*, 5 - 18,5 µm diametris. *Medulla* alba, 20 - 40 µm crassa. *Cortex inferior* 10 - 13 µm crassus. *Thallus inferne* piceus. *Rhizinae* non bene evolutae. *Apothecia* non visa. *Pycnidia* hyalina, globosa, 110 - 150 µm profunda, 90 - 110 µm lata. *Pycnidiosporae* hyalinae, aciculares, 6 - 9 X 0,8 µm. *Thallus* acidum usnicum, acidum hyposticticum, acidum hyposalazinicum et acidum hypoconsticticum continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE - 2630 (Carolina): 7 km from Amsterdam to Nerston, farm Tweepoort, hill slope with SW aspect. On basic rocks of the Ususwhana complex. Alt. 1440 m (-DA). *F. Brusse 5564*, 13. v. 1988 (PRE, holo-; BM, COLO, iso-). Figura 4.

Thallus effigurate-crustose, saxicolous, to 3 cm across. *Lobes* elongate, 0,2 - 0,7 mm broad, 65 - 100 µm thick. *Upper surface* yellow-green, subnitid to coarse-pruinose, isidiate. *Isidia* 0,05 - 0,1 mm thick. *Upper cortex* 15 - 20 µm thick. *Algal layer* 20 - 35 µm thick, algae *Trebouxia*, 5 - 18,5 µm diam. *Medulla* white, 20 - 40 µm thick. *Lower cortex* 10 - 13 µm thick. *Lower surface* black. *Rhizines* not well developed. *Apothecia* not seen. *Pycnidia* hyaline, glob-



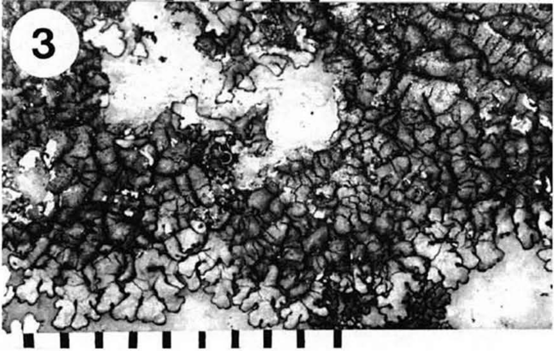


FIGURE 2. - *Parmelia dwaasbergensis* Brusse, habit. *F. Brusse 5211*, holotype. Scale in mm.

FIGURE 3. - *Parmelia inops* Brusse, habit. *F. Brusse 5212*, holotype. Scale in mm.

ose, 110 - 150 µm deep, 90 - 110 µm wide. *Pycnidiospores* hyaline needles, 6 - 9 X 0,8 µm. *Chemistry:* usnic acid in the cortex, hypostictic, hyposalazinic and hypoconstictic acids in the medulla.

This is a unique new species, probably belonging to the *Parmelia adhaerens* Nyl. group. This is the first species of this group known to be isidiate. Like *P. adhaerens*, *P. lyrigera* contains hypostictic acid in the medulla, but lacks the stictic acid of *P. adhaerens*, and contains hyposalazinic acid instead.

Without close inspection, this new lichen resembles the widespread (in the eastern half of the country) *P. adligans* Brusse (1988b), which this lichen was at first presumed to be. However, *P. adligans* contains atranorin as well as usnic acid in the upper cortex, contains only the stictic acid complex in the medulla, and most of all lacks isidia.

Parmelia tantillum Brusse (syn. *Xanthoparmelia inconspicua* Hale, 1987) is not really the non-isidiate progenitor of this species, for although small, it is genuinely foliose, has a glossy upper surface, and small, true rhizines below.

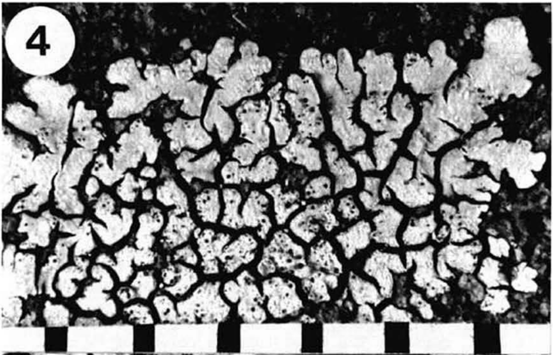
The rock type from which this new lichen was collected is restricted to small areas of the south-eastern Transvaal and adjacent Swaziland, and is a fine grained, dark grey, basic igneous rock, belonging to the Ususwhana complex. However, it would be surprising if this species were restricted to this rock type.

At present, this new species is known only from the type locality, in the hills just east of Amsterdam, in the south-eastern Transvaal.

PARMELIA SITIENS Brusse, *sp. nov.* Fig. 5

Thallus minute foliosus, saxicola, ad 2 cm diametro, arcte adnatus. *Lobi* elongati, truncati, 0,2 - 1,0 mm lati, 95 - 200 µm crassi. *Thallus superne* cinereus, nitidus, emaculatus, isidiis sorediisque destitutus. *Cortex superior* 13 - 16 µm crassus. *Stratum gonidiale* 20 - 45 µm crassum, algis *Trebouxiis*, 4 - 18 µm diametris. *Medulla* alba, 45 - 120 µm crassa. *Cortex inferior* 10 - 14 µm crassus. *Thallus inferne* piceus, sat rhizinatus. *Rhizinae* simplices, 45 - 140 µm crassae. *Apothecia et pycnidia* non visa. *Thallus* atranorinum, acidum salazinicum et materiam ignotam continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE - 3319 (Worcester): W side of Franschhoek Pass, overlooking the town of Franschhoek, above hairpin bend and just below summit of Pass.



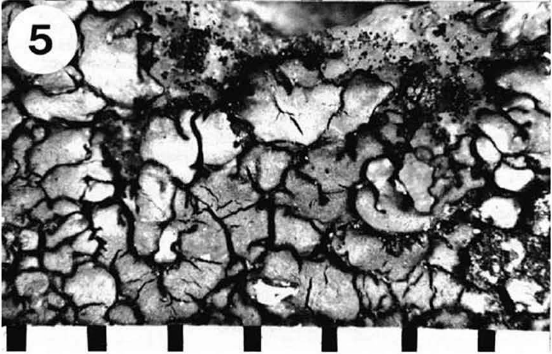


FIGURE 4. - *Parmelia lyrigera* Brusse, habit. *F. Brusse 5564*, holotype. Scale in mm.

FIGURE 5. - *Parmelia sitiens* Brusse, habit. *F. Brusse 5437*, holotype. Scale in mm.

Large Table Mountain Sandstone outcrop on steep W slope. On sloped N face at base of outcrop. Alt. 730 m (-CC). *F. Brusse 5437*, 20. iii. 1988 (PRE, holo-; BM, iso-). Figura 5.

Thallus minutely foliose, saxicolous, to 2 cm across, tightly adnate. *Lobes* elongate, truncate, 0,2 - 1,0 mm broad, 95 - 200 µm thick. *Upper surface* grey, glossy, emaculate, non-isidiate and non-sorediate. *Upper cortex* 13 - 16 µm thick. *Algal layer* 20 - 45 µm thick, algae *Trebouxia*, 4 - 18 µm diam. *Medulla* white, 45 - 120 µm thick. *Lower cortex* 10 - 14 µm thick. *Lower surface* black, moderately rhizinate. *Rhizines* simple, 45 - 140 µm thick. *Apothecia and pycnidia* not seen. *Chemistry:* atranorin, salazinic acid and the "chalybaeizans unknown" present.

Parmelia sitiens is the second *Paraparmelia* known to contain salazinic acid and the "chalybaeizans unknown" in the medulla, the first being the common *P. condyloides* Kurok. (Hale 1972, 1976). *P. sitiens* is a much smaller lichen than *P. condyloides*, and also has a black rather than a pale lower surface. The under surface colour of *P. condyloides* is quite variable, and can become sooty black in some places on certain specimens. Judicious selection of such material, can produce specimens that look homogeneously black below, but further collections at the locality of origin will reveal the variation again. Nevertheless, the normal colour for the under surface of *P. condyloides* is pale brown.

Parmelia pudens Brusse (1986) is another small *Paraparmelia* with a black lower surface which contains salazinic acid, but this lichen lacks the "chalybaeizans unknown" and has smaller discrete sublinear to linear lobes. *P. sitiens* has broader, truncate, elongate lobes that are contiguous, not discrete.

At present, this new species is known only from the type locality, just east of the town of Franschhoek, in the south-western Cape Province.

NEW COMBINATIONS

Brusse (1988b, 1989) has made new combinations in *Parmelia* for lichens previously assigned to *Paraparmelia* and *Xanthoparmelia*, by other authors, notably Hale and Elix, for reasons explained by Brusse (1988a). A proposal, 291A (McNeill 1986), which would have rendered all lectotypifications proposed before 1935 void, has not been passed by the Berlin International Botanical Congress (Greuter & McNeill 1987, McNeill 1987). This leaves the first typification of *Parmelia* as *Parmelia conspersa* Ach. (Clements & Shear 1931), and the arguments presented by Brusse (1988a) unchanged.

The following new combinations in *Parmelia* are proposed:

Parmelia evernica (Hale) Brusse, *comb. nov.*
Basionym: *Xanthoparmelia evernica* Hale, *Mycotaxon* 27: 577, 1986.

Parmelia rubropustulata (Hale) Brusse, *comb. nov.*
Basionym: *Xanthoparmelia rubropustulata* Hale, *Mycotaxon* 29: 264, 1987.

NEW LICHEN RECORDS

Parmelia (Parmotrema) araucariarum Zahlbr.

SWAZILAND - 2631 (Mbabane): Mbabane district. 10 km from Ezulweni to Commissie Nek, near nJinjane Kraal. Kloof forest patch on SE slope, near mountain summit. On vertical face of granite boulder, in complete shade. Alt. 990m (-AC). *F. Brusse 4304*, 25. xii. 1985 (BM, LD, PRE, US).

This material is not quite identical to the holotype (W), but one of the pigments is the same as in both pieces of the holotype. A series of aliphatic acids are present in the above material in high concentrations, some of which seem the same as in the holotype (as judged by TLC in three solvent systems). This difference is probably chemosyndromic, and is probably not taxonomically significant.

Porpidia (Poeltiaria) turgescens (Koerb.) Brusse

SOUTH AFRICA, CAPE PROVINCE - 3226 (Fort Beaufort): Katberg Pass between Fort Beaufort and Queenstown. Main Katberg Forest, steep SW slope of Branderskop, at Rest Spot. On SW face of Beaufort mudstone boulder near stream, in deep forest shade. Alt. 1100 m (-BC). *F. Brusse 5143*, 3. iii. 1988 (BM, COLO, LD, PRE).

This material is unusual in that it lacks confluentic and 2'-O-methylperlatolic acids. In fact, no substances were detected by TLC. However, there seems to be no significant morphological differences between this material and the available descriptions of *P. turgescens* (Hertel 1984), although I have not examined any authentic material.

NOTES ON SOME PARMELIACEAE

Parmelia astricta Brusse, *Bothalia* 15: 315, 1984.
Synonyms: *Paraparmelia astricta* (Brusse) Elix & Jen Johnston, *Mycotaxon* 27: 279, 1986.
Paraparmelia olivetorica Nash & Elix, *Mycotaxon* 29: 468, 1987.

Dr Elix has kindly sent me a fragment of *Parmotrema demethylmicrophyllinicum* Elix as an authentic source of 4-O-demethylmicrophyllinic acid. This was run on TLC plates together with alectoronic acid and an acetone extract of *Parmelia astricta*, and although running close together on all three plates, 4-O-demethylmicrophyllinic acid has a pale pinkish colour, whereas alectoronic acid is completely colourless. This indicated that *P. astricta* does not contain alectoronic acid as originally stated, but 4-O-demethylmicrophyllinic acid. This renders *Paraparmelia olivetorica* Nash & Elix, a synonym of *Parmelia astricta* Brusse.

Parmelia astricta is a common lichen in the southern and south-western Cape Province, and the following are additional localities for this species, over and above Bain's Kloof and those cited by Brusse (1988b):

SOUTH AFRICA, CAPE PROVINCE - 3318 (Cape Town): Cape Town, south side of summit of Table Mountain. On vertical SW face of Table Mountain Sandstone outcrop on SW slope. Alt. 1040 m (-CD). *F. Brusse 5415*, 18. iii. 1988 (BM, PRE). 3319 (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On low Table Mountain Sandstone outcrop in rock shade, on N slope. Alt. 1620 m (-DC). *F. Brusse 5464*, 21. iii. 1988 (BM, PRE). 3320 (Montagu): 7 km S of winery at Barrydale, Tradouw Pass, on Table Mountain Sandstone cliffs with overall S aspect, but on sloped portion with W aspect. Alt. 300 m (-DC). *F. Brusse 5343*, 14. iii. 1988 (BM, PRE). 3419 (Caledon): Summit of Galgeberg near Greyton (but accessed via McGregor), farm Galge Berg. On S face of Table Mountain Sandstone cliff on steep S slope. Alt. 1410 m (-BA). *F. Brusse 5488*, 22. iii. 1988 (BM, COLO, LD, PRE).

Parmelia burmeisteri Elix, *Austral. J. Bot.* 24: 664, 1976.
Synonym: *Xanthoparmelia burmeisteri* (Elix) Egan, *Bryologist* 85: 129, 1982.

An interesting extension of the southern African range of this species, *c.f.* Brusse (1988b), is provided by the following specimen:

SOUTH AFRICA, CAPE PROVINCE - 3219 (Wuppertal): 5 km NW of Wupperthal. Small hill just N of Kouberg settlement. On

TMS on S to W slopes. Alt. 900 m (-AC). *F. Brusse 3197*, 4. v. 1981 (PRE).

Parmelia fausta Brusse, *Mycotaxon* 27: 185, 1986.

The range of this lichen, which was previously only known from the summit of Swartberg Pass near the Cango Caves and Oudtshoorn (the type locality), has been significantly increased by the following specimens:

SOUTH AFRICA, CAPE PROVINCE - 3318 (Cape Town): Cape Town, south side of summit of Table Mountain, SSW slope overlooking Hely-Hutchinson Reservoir. On S side of Table Mountain Sandstone outcrop. Alt. 950 m (-CD). *F. Brusse 5423*, 19. iii. 1988 (BM, PRE, UPS). 3319 (Worcester): Hawequa's Mountains, east of Paarl, near TV tower. On NW Table Mountain Sandstone cliffs on almost vertical slope. Alt. 1070 m (-CA). *F. Brusse 5405*, 17. iii. 1988 (BM, LD, PRE). Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. On Table Mountain Sandstone outcrop in rock shade on N slope. Alt. 1620 m (-DC). *F. Brusse 5464b*, 21. iii. 1988 (BM, PRE).

Parmelia mongaensis Elix, *Austral. J. Bot.* 29: 22, 1981.
Synonyms: *Paraparmelia mongaensis* (Elix) Elix & Jen Johnston, *Mycotaxon* 27: 280, 1986.
Parmelia insignis Brusse, *Mycotaxon* 27: 186, 1986.

Since the last note on *Parmelia insignis* (Brusse 1988b) I have been able to examine an Australian specimen of *P. mongaensis*, through the generosity of Dr J. A. Elix (Canberra). Although ascospores were again not found, despite the presence of small apothecia, the general appearances of the lichens and the chemistries are identical, so that I have no hesitation in synonomizing *P. insignis* with *P. mongaensis*. The "insig-1" of the original publication is stenosporonic acid and the "insig-2" is colensoic acid. Divaronic acid also occurs in this species in minor quantities as well as one or two substances in the physodic acid series, but these latter substances often occur only as traces.

The synonym *Parmelia insignis* Brusse is, in fact, the first record of *P. mongaensis* Elix from southern Africa (and the African continent), and not the specimen reported to have been collected from Magoeba's Kloof, cited by Nash and Elix (1987).

The southern African range of this lichen has been extended almost to Cape Town by the following specimens:

SOUTH AFRICA, CAPE PROVINCE - 3319 (Worcester): Hawequa's Mountains, east of Paarl. Hugenootskop. On low Table Mountain Sandstone pavedment, on fairly gentle E slope. Lines the mouths of rock pockets here. Alt. 1070 m (-CA). *F. Brusse 5411*, 17. iii. 1988 (BM, COLO, PRE). 3324 (Steytlerville): Suuranysberg Range. 7,5 km from the Krom River bridge at Assegaaibos near Kareedouw to the Upper Kouga River Basin area. On S face at base of Table Mountain Sandstone outcrop on steep W slope. Alt. 600 m (-CD). *F. Brusse 5190*, 7. iii. 1988 (BM, COLO, LD, PRE, UC, UPS).

Parmelia nimbicola Brusse, *Mycotaxon* 27: 238, 1986.

This rare lichen has now been found further west in the Langeberg at Garcia's Pass near Riversdale. It was origially only known from the very eastern end of the Langeberg Range (actually the very western end of the succeeding mountain range, the Outeniqua Mountains) at Robinson's Pass.

SOUTH AFRICA, CAPE PROVINCE - 3321 (Ladismith): 17 km N of Riverdale, Garcia's Pass. SW slopes of Kareekop, Langeberg Range. On Table Mountain Sandstone outcrops on steep S slope. Alt. 500 m (-CC). *F. Brusse 5338*, 14. iii. 1988 (BM, PRE).

Parmelia princeps Brusse, *Bothalia* 17: 27, 1987.

The type locality of this lichen was thoroughly examined for more material, in an effort to clarify the status of this name, since the type material is rather scanty and mixed with *Parmelia squamariata* Nyl. or a very similar species. However, I was unable to find a brown *Parmelia* with a chemistry identical to the original material, but did find material containing "squamatic acid". This determination is erroneous, but the uppermost substance (which fluoresces white under longwave ultra-violet light) on plate B, seems identical to one of the substances in *Parmelia thamnolica* (Hale) Brusse, which does contain squamatic acid. Three other substances are present, but do not correspond on TLC plates to any of the other substances in *P. thamnolica* or to thamnolic and decarboxythamnolic acids. The new material of *P. princeps* has lobes with scabrous upper surfaces up to 1 mm broad and apothecia up to 1,5 mm broad. The lichen appears to be related to *P. trachythallina* Essl.

Besides the type locality at Witelskloof near Clanwilliam, this lichen has also been found at Nuwekloof near Tulbagh:

SOUTH AFRICA, CAPE PROVINCE - 3218 (Clanwilliam): 8 km W of Olyvenboskraal, Witelskloof. Farm Groot Alexanders Hoek, near Klein Alexandershoek farm house. On slightly sloping top of large Table Mountain Sandstone boulder outcrop, just W of Koperfonteinkloof stream. Alt. 500 m (-BD). *F. Brusse 5538*, 25. iii. 1988 (BM, LD, PRE). 3319 (Worcester): 7 km W of Tulbagh, Nuwekloof in the Obiqua Mountains. On SE side of Table Mountain Sandstone rock, on steep SW slope. Alt. 140 m (-AC). *F. Brusse 5499a*, 22. iii. 1988 (PRE).

Parmelia sigillata Brusse, *Mycotaxon* 31: 537, 1988.

The chemistry of this lichen was inadvertantly omitted from the original publication and the final sentence of the Latin description should read: *Thallus* acidum usnicum, acidum evernicum et acidum lecanoricum continens. (Instead of being omitted). Similarly the final sentence of the English description that follows should read: *Chemistry:* usnic acid in the cortex, evernic and lecanoric acids in the medulla. (Instead of being omitted).

ACKNOWLEDGEMENTS

My thanks are extended to Dr J. A. Elix for reviewing this paper. The directors and curators of the following herbaria are thanked for the loan of valuable type and other material: BM, FH, G, GLAM, H, LD, TNS, TRH, TUR, VER, W, and ZT. Mrs A. J. Romanowski prepared the photographs and Mrs M van der Merwe typed this manuscript with my gratitude.

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GANODERMA MICROSPORUM, A NEW SPECIES ON WEEPING WILLOW IN TAIWAN

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SUMMARY

This report discribes a rare fungus found on the dead trunk of a weeping willow (Salix babylonica Linn.) in Taipei. The fungus can be assigned to the genus Ganoderma, but differs from other common species in color and shape, and in the small size of the basidiospores. Monokaryons from isolates of the fungus were cultured and mated with monokaryons from other species in Taiwan, but none of the matings yielded fruiting bodies. Because the fungus differs substantially from other known species, it is described as new.

INTRODUCTION

The genus Ganoderma was established by Karsten (1881) with G. lucidum (W.Curt.:Fr) Karst. as the only species. Murrill in his published synopses (1902, 1908) considered primary taxonomic characters to be host specificity, geographical distribution, and macromorphology of the fruiting body which included context color, the shape of the margin of the pileus, and whether the fruiting body was stipitate or sessile. Haddow(1931) and Steyaert(1972-80) based their taxonomy on basidiospore characteristics and morphology of cutis hyphal elements of the fruiting body.

The first recording of Ganoderma species in Taiwan was by Sawada(1931, 1942), in which 6 species were included. Chang and Chen(1984) recorded a new species Ganoderma formosanum (host: Liquidambar formosana).

In 1983 a fruiting body was found in Taipei on the dead trunk of Salix babylonica Linn. The purpose of this paper is to prove that this is a new species. The research used the above mentioned taxonomic characters to establish this.

Ganoderma microsporum Hseu, sp. nov.

Basidioma annuum, sessilis et dimidiatum vel plerumque stipitatum, flabelliformis vel conchatum, pleuropum, pileis sejunctis interdum crescentibus, suberosis vel ligneis, usque ad 6 cm diametro et 2-2.5 cm crasso. Pilei pagina radialiter rugosa, concentrice undulata, niger, gradatim argillacea vel isabellina marginem versus; specimina juniores cremea vel eburnea, matura nigricantia et splendide laccata. Margo sterilis, obtusus, undulatus vel rectus. Stipes brevis, crassus, niger, laccatus, cylindricus, 0.5-2 X 1-1.5 cm, basi crassior aliquantus. Pagina porifera brunnea, strato tubifero usque ad 1.2 cm crasso. Pori in speciminibus juvenibus parvi, circulares, cremei, in maturis flavi neapolitani vel bubalini, 160-210 um diametro, 4-6 in omnibus millimetris, dissepimenti (40)65-165 um. Contextus 0.2-1.2 cm crassus bubalinus vel subroseus in parte superiore, in zona super tubis cinnamomeus vel brunneus. Dermis e cellulis crassis, aureis, claviformibus composita; hae cellulae ex extremitatibus hypharum skeletalium enata, 5-10 X 87.5-100 um, luminibus angustatis extremitatibus obtusis, in hymenio dispositae, strato crasso laccato obtecto. Systema hypharum trimiticum. Hyphae generatoriae hyalinae 1-2.5 um diametro, parce ramosae; parietibus tenuibus, septis non nisi in fibulis; in marginem pilei abundantes, in contextu et in dissepimentis aliquot. Hyphae skeletalia non septatae, 1-3 diametro, crassitunicatae, contextus et dissepimentorum partem majorem faciens. Hyphae colligantes quam hyphae skeletalia tenuior, crassitunicatae, non septatae, copiose ramosae, 0.3-1 um diametro. Basidia breviter clavata vel subglobosa, 7-11 X 11-19 um, sporis quatuor. Basidiosporae ovoideae vel subsphaeriacae, pariete bistrato cyanophilo; perisporium hyalinum tenue, endosporium aureum, crassum, echinulatum; basidiosporae maturae 4.5-5 X 6-8 um.

Fruitbody: annual, sessile, dimidiate, or more frequently, stiptitate to flabelliform to conchate, pleuropus with isolated pilei which are sometimes concrescent, corky to woody, up to 6 cm diam and 2.0-2.5 cm thick.

Pileus: surface radially rugose, which concentric, slightly raised sulcations making it appear undulated, aniline black or raisin black, gradually becoming clay color or isabelline towards the margin; young specimens cream or ivory-yellow color, this gradation in color not seen in mature specimens, the color tending to become homogeneous aniline black or raisin black and brilliantly laccate. Margin sterile, blunt, undulate or even.

Stem: Horizontal, short and thick, aniline black or raisin black, laccate, cylindric, 0.5-2.0 cm long, 1-1.5 cm thick, somewhat thicker at the base.

Context: 0.2-1.2 cm thick, cartridge buff or pale pinkish is the upper part, cinnamon buff or sayal brown in the zone above the tubes. Dermis composed of thick, golden-walled claviform elements originating from the end of skeletal hyphae, with narrow limina and blunt ends, 5-10 X 87.5-100 um, arranged in a palisade-like hymenium, covered with a thick layer of lacquer-like substance.

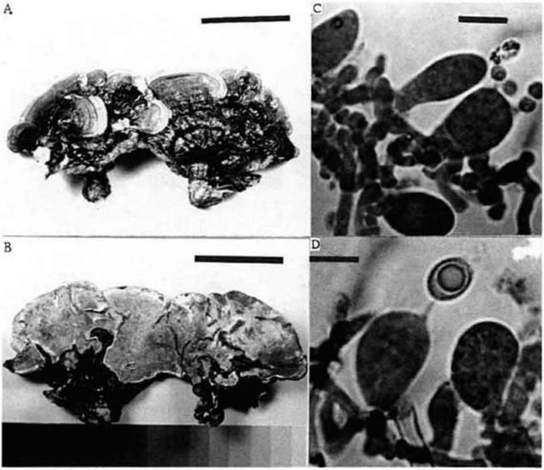

Figure 1. *Ganoderma microsporum* (TAI9021, holotype).
A-B. Basidiocarps of *Ganoderma microsporum*.
The bar in each figure = 4 cm.
C-D. Brightfield microscopy of basidia of *Ganoderma microsporum*. The bar in each figure = 5 um.

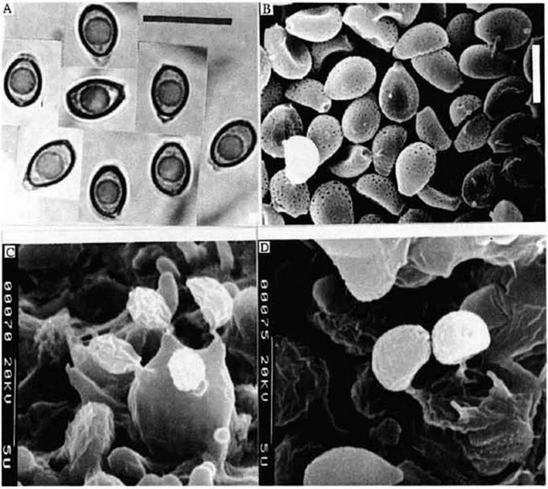

Figure 2. Ganoderma microsporum (TAI9021, holotype).
A. Brightfield microscopy of basidiospores.
   The bar in figure = 10 um.
B. Scanning electron microscopy of basidiospores.
   The bar in figure = 5 um.
C-D. Scanning electron microscopy of basidia and basidiospores.

Pore surface: verona brown or chestnut brown, with the tube layer up to 1.2 cm deep. Pores small, circular, cream colored in young specimens, and naples yellow or colonial buff in mature ones, 160-210 um diam, dissepiments (40)65-165 um, 4-6 per mm.

Basidia: short clavate to subglobose, 4-spored, 7-11 X 11-19 um.

Basidiospores: ovoid to subspherical, with two-layered cyanophilous wall; perisporium hyaline, thin; endosporium golden-yellow, thick; endosporic echinula numerous, slender; mature sproes 4.5-5.0 X 6-8 um.

Hyphal system: trimitic. Generative hyphae clamped, thin-walled hyaline, with septa restricted to clamps, sparingly branched, 1-2.5 um diam; abundant at the margin of the plieus but also present in the context and dissepiments. Skeletal hyphae aseptate, thick-walled, 1-3 um in diam, forming the bulk of the context and dissepiments. Binding hyphae thinner than the skeletals, thick-walled, aseptate, abundantly branched, 0.3-1 um in diam.

Habitat: On dead trunk of Salix babylonica Linn.

Specimens examined: Taipei, 21 August 1983. TAI 9021, Holotype.

ACKNOWLEDGMENTS

The authors would like to thank Professor Roger D. Goos for critical review of the manuscript and Dr. F.A. Uecker for providing the Latin description and useful suggestions.

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中文摘要

許氏小孢子靈芝（ *Ganoderma microsporum* Hseu, sp. nov. ）爲在台北地區所發現的新種眞菌。此種的特徵在於其擔孢子較一般靈芝屬的擔孢子爲小，僅 4.5 － 5.0 × 6 － 8 μm，而子實體形態與菌蓋顏色也與其他種類不同，且其寄主爲垂柳（ *Salix babylonica* Linn. ）。並由單孢系菌株間的交配試驗結果顯示與台灣其他種類的靈芝皆具不親和性反應。故作者以新種命名之。

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A NEW LICHEN GENUS, PSILOPARMELIA HALE (ASCOMYCOTINA: PARMELIACEAE)

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Abstract: A new lichen genus *Psiloparmelia* is proposed. It is based on *Parmelia distincta* Nyl. (*Psiloparmelia distincta* (Nyl.) Hale, comb. nov.) from the high Andes Mountains. A second species, *P. arhizinosa* Hale, sp. nov., has been discovered in Lesotho. The genus is characterized by a velvety lower surface without rhizines, a negative test for lichenin, and a high concentration of usnic acid and atranorin in the cortex.

Introduction

When I proposed the genus *Xanthoparmelia* (Hale, 1974), I included in it five well-known arctic species, *P. aleuritica* Nyl., *P. centrifuga* (L.) Ach., *P. incurva* (Pers.) Ach., *P. separata* Th. Fr., and *P. subcentrifuga* Oxner. Later (Hale, 1986a), I realized that these species formed a heterogeneous element and erected the new genus *Arctoparmelia* to accommodate them. The main characters used to delimit *Arctoparmelia* were constant presence of alectoronic acid in the medulla (only one of 406 species of *Xanthoparmelia* contains alectoronic acid as the main medullary component), high concentrations of atranorin and usnic acid in the cortex (usnic lacking only in *A. aleuritica*), a strong iodine test for lichenin, a negative test with Melzer's reagent, and a peculiar ivory-white to purplish black velvety lower surface. *Xanthoparmelia* rarely has atranorin and then only as traces, is positive for both lichenin and Melzer's reagent (unpublished data, Ralph Common), and has a smooth, shiny lower surface.

I had also placed *Parmelia distincta* Nyl. (Hale, 1974) in *Xanthoparmelia*. Although this well-known species is superficially very similar to *Arctoparmelia* in lobe configuration, cortical chemistry, and presence of a velvety lower surface, I had hesitated to put it in that genus for several reasons. It occurs at very high elevations in the Andes Mountains of South America, not in the arctic, and is therefore completely allopatric. While it has a velvety lower surface (Fig. 1), rhizines are totally lacking (as noted by Nylander in the original description). One of the major metabolites, fumarprotocetraric acid, is biogenetically unrelated to alectoronic acid and occurs in the cortex, not the medulla. Most significantly, it has a negative iodine test for lichenin (Ralph Common, unpublished data). While a negative lichenin test would suggest a relationship with *Pseudoparmelia* Lynge, my recent delimitation of this genus (Hale, 1986b) would exclude *P. distincta* on the basis of chemical and lower surface characteristics. *Pseudoparmelia* has a smooth rhizinate lower surface and an unknown yellowish medullary pigment.

I recently collected another species closely related to *X. distincta* in Lesotho, adding to my conviction that the two of them are distinct from both *Arctoparmelia* and *Xanthoparmelia*. With our better knowledge of generic limits in the Parmeliaceae, I believe that these erhizinate species should be recognized as a new genus, *Psiloparmelia*. The differences between these genera are summarized in the chart below:

	Xanthoparmelia	*Arctoparmelia*	*Psiloparmelia*
Cortical Substances	Usnic acid atranorin (±trace)	Usnic acid* atranorin**	Usnic acid atranorin** and fumarprotocetraric acid (±)
Lichenin	Positive	Positive	Negative
Melzer's Reagent	Positive	Negative	Negative
Lower Surface	Smooth, shiny	Velvety	Velvety
Rhizines	Present***	Present	Lacking
Geography	Cosmopolitan	Arctic	Southern Hemisphere

*Lacking in *A. aleuritica*
**Present in high concentration
***Lacking in 6 of 406 species

Psiloparmelia, gen. nov.

Parmelia sect. *Xanthoparmelia* subsect. *Endocoerulea* Gyel. Type species of subsection: *Parmelia bouly de lesdainii* [*"lesdaini"*] Gyel. 1931:282.

Thallus foliaceus, adnatus, saxicola, lobis sublinearibus, superne epicorticatus, pruinosus, subtus minute papillatus, erhizinosus. Pycnidia immersa, conidiis bifusiformibus. Apothecia substipitata, sporis incoloribus, simplicibus.

Type species: *Parmelia distincta* Nyl.

Psiloparmelia distincta (Nyl.) Hale, comb. nov.

Parmelia distincta Nyl., 1861:374. Type collection: Prov. Yungas, Bolivia, *Weddell* s.n. (H-Nyl, Nyl. Herb. No. 34819, lectotype).

Parmelia subcongruens Müll. Arg., 1889:64. Type collection: Argentina, *Lorentz & Hieronymus* s.n. (M, lectotype; G, W, isolectotypes).

Parmelia flavobrunnea Müll. Arg., 1891:379. Type collection: Azangaro, Peru, *Lechler* 1766 (BM, lectotype; G, isolectotype).

Parmelia bouly de lesdainii Gyel., 1931:281. Type collection: Hacienda d'Angasmurca, 160 km from Trujillo, Libertad, Peru, *Standaert* s.n.(BP, lectotype).

Parmelia subcongruens var. *bouly de lesdainii* (Gyel.) Gyel., 1935:21.

Parmelia distincta f. *bouly de lesdainii* (Gyel.) Gyel., 1938:26.

Parmelia distincta f. *subcongruens* (Müll. Arg.) Gyel., 1938:26.

Xanthoparmelia distincta (Nyl.) Hale, 1974:487.

Xanthoparmelia flavobrunnea (Müll. Arg.) Hale, 1974:487.

Thallus (Fig. 3) adnate to loosely adnate, leathery, 5–10 cm in diameter, light yellowish green; lobes subirregular to sublinear, irregularly branched, 0.8–3 mm wide, imbricate; upper surface dull, emaculate, becoming coarsely white pruinose with age, transversely cracked and rugulose at the center, isidia and soredia lacking; medulla white or darkening somewhat, dense and waxy in texture; lower surface plane, dull, velvety, yellowish grey at the margins but turning jet black toward the center, rhizines lacking. Pycnidia immersed, commonly produced; conidia bifusiform, 0.5 × 5–6 μm. Apothecia adnate to substipitate, 2–5 mm in diameter; spores subspherical to elliptical, 6–9 × 10–12 μm.

Chemistry: Usnic acid, atranorin, and fumarprotocetraric acid (minor) in the cortex (P+ red), protoconstipatic acid (major), constipatic acid, protocetraric acid (±trace), and ursolic acid (trace) (annotations by J. A. Elix in H-Nyl for the lectotype specimen).

Additional representative specimens examined. ECUADOR. Prov. El Altar: *Meyer* 383 (W). Prov. Chimborazo: 10 km W of San Juan, *King* 74-40, 74-67 (US). Prov. Cotopaxi: Parque Nacional Cotopaxi, *Harris* 17386 (NY). Prov. Tungurahua: Riobamba, *Iltis* E-488 (US). PERU. Prov. Recuay: Huaraz, *Armstrong* 168, 172 (PH); Colltu, *Gomez* 542 (US). Dept. Puno: Chucuito, *Thomasson* s.n.

(UPS). Dept. Junin: Tarma, *Killip & Smith* 21874 (F). Aequipa, *Stafford* s.n. (BM). Chaira, *Wood* s.n. (US). Rio Blanco, *Bryan* 93, 136 (F). BOLIVIA. Bolivia, Andes, *Mandon* s.n. (H-Nyl, Nyl. Herb. No. 34818, 34820, isosyntypes of *P. distincta*). Prov. Larecaja: Challana, *Mandon* 1760 (W). Prov. Manco: Puna, *Feuerer* 15522 (HBG). Prov. Murillo: Zongotal, *Feuerer* s.n. (HBG, US).Lake Titicaca, Capacabana, *Suarez* 7 (US). ARGENTINA. Prov. Catamarca: Las Rosas, *Lamb* 5765 (FH, US).

Nylander's herbarium contains three collections from Bolivia. Gyel. (1938:25) apparently saw only one of these (no. 34819) and designated it as the type of *P. distincta*. I see no reason not to follow his lectotypification. Gyel. (1931) also used *P. bouly de lesdainii* as the type for his *Parmelia* sect. *Xanthoparmelia* subsect. *Endocoerulea* Gyel. The description of the subsection, "medulla thalli coerulea," seems to be based on the waxy, sometimes darkening medulla in some specimens. He later (1935) amended the subsection to read "erhizinosus."

This is perhaps the most commonly collected foliose lichen at high elevation in the Andes Mountains from Ecuador south to Bolivia and into northern Argentina. The chemistry is unusual in that fumarprotocetraric acid appears to be confined to the cortex, which reacts P+ orange, the medulla reacting P−. However, about half of the specimens tested react P− in the cortex and contain only the fatty acids. The types of *Parmelia distincta* (nos. 34819 and 34820) and *P. subcongruens* react P+ red; the third syntype of *P. distincta* (no. 34818) and the type of *P. flavobrunnea* are P−. I have not rechecked the P test for *P. bouly de lesdainii*.

Psiloparmelia arhizinosa Hale, sp. nov.

Thallus adnatus, saxicola, 3−7 cm latus, albo-flavicans, lobis subirregularibus, 0.8−2 mm latis, subimbricatis, superne continuus, emaculatus, albopruinosus, cortice epicorticato, aetate rugulosus, pustulato-sorediatus, soraliis capitatis, ad 1 mm diametro, sorediis crassis, subtus planus, pallide griseo-brunneus, erhizinosus. Pycnidia atque apothecia desunt.

Thallus (Fig. 4) tightly adnate to adnate on rock, 3−7 cm broad, pale whitish yellow-green; lobes subirregular, 0.8−2 mm wide, irregularly dichotomously branched, subimbricate; upper surface continuous, dull, emaculate, faintly to strongly white pruinose, rugulose with age, sparsely to moderately grossly pustulate, the pustules erupting into coarsely sorediate masses up to 1 mm in diameter; medulla white; lower surface plane, finely felty-velvety, dull, brown to dull mineral gray at the center, pale to ivory-colored at the tips, rhizines lacking. Pycnidia and apothecia lacking.

Chemistry: Atranorin and usnic acid in the cortex, protoconstipatic acid and constipatic acid in the medulla.

Type: Dolerite ledges 16.6 km NW of Sani Pass at the west side of Kotisephola Pass (on road to Moteng Pass), elev. 3100 m, Lesotho, Grid 2929 AC, *M. E. Hale* 81411, 5 May 1988 (US, holotype; LD, PRE, isotypes).

Additional specimens examined. Lesotho: Same locality as the holotype, *Hale* 81434 (US); 56.1 km NW of Mapholaneng (ca 26 km N of Letsengla-Terai), on Moteng Pass road, *Hale* 81438, 81439, 81440 (US)

This unusual species occurs in high elevation alpine habitats (3000−3300 m) in Lesotho, usually on the sheltered lower sides of dolerite ledges which receive little if any direct rainfall. It has a peculiar grayish velvety lower surface (Fig. 2) (*P. distincta* is black) without rhizines, a rugose, pruinose surface, and coarse soralia (*P. distincta* is esorediate). It contains high concentrations of atranorin in the cortex along with usnic acid, just as in *P. distincta* and *Arctoparmelia* species in general. Finally, it has the same negative lichenin test as *P. distincta* (Ralph Common, personal communication) and the same fatty acid chemistry but without fumarprotocetraric acid.

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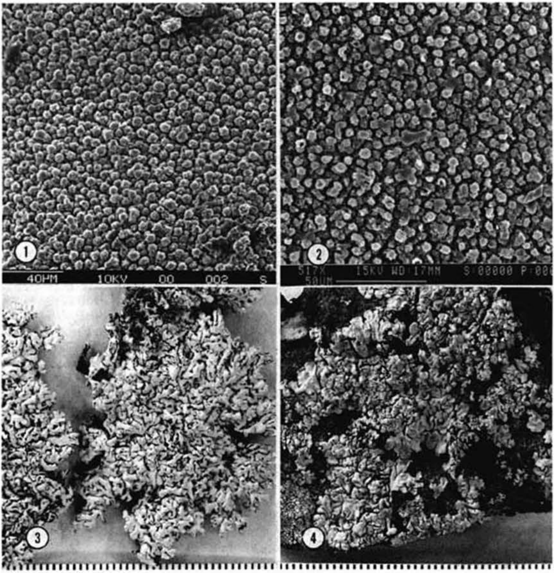

Figures 1 – 4. Species of *Psiloparmelia*: 1, lower surface of *P. distincta* (SEM) (*King* 74-40); 2, lower surface of *P. arhizinosa* (SEM) (*Hale* 81440); specimen of *P. distincta* (*Killip & Smith* 21874) (scale in mm); 4, holotype specimen of *P. arhizinosa* (*Hale* 81411) (scale in mm).

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QUELQUES RUSSULES A LAMPROCYSTIDES

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INTRODUCTION

Suite à la découverte d'une nouvelle *Russula* à lamprocystides, dont la description est présentée ici, les caractères microscopiques de *R. guayarensis* Singer sont décrits et illustrés en détail. Cette espèce bolivienne représente à elle seule la sous-section *Guayarenses* Singer que Singer range parmi les *Pelliculariae* Heim ex Singer et qu'il définie (1983 : 205) par les cystides hyméniales à paroi épaisse et par la structure du type 'virescens' du revêtement piléique reposant sur un subpellis gélifié.

Les exsiccata ont été traités par une solution aqueuse (ca. 20%) de KOH pour faciliter la dissociation et le regonflement des tissus, dont l'étude s'est effectuée à partir de préparations semi-permanentes dans le rouge Congo ammonical additionné de 10% de glycérine. Dans les descriptions qui suivent, les dimensions sporales, basées sur vingt spores, donnent la longueur et la largeur moyennes, accompagnées de leur écart type (standard deviation): suit encore, entre parenthèses, le rapport moyen de la longueur sur la largeur.

Nous donnons d'abord les descriptions des deux espèces et, ensuite, la présence de lamprocystides dans le genre *Russula* sera discutée.

RUSSULA GUAYARENSIS Singer, Beih. Nova Hedw. 7 : 205-206 (1983).

Caractères microscopiques - Fig. 1-3.

Spores subglobuleuses à brièvement ellipsoïdes, 7,63 ± 1,47 x 7,02 ± 1,08 µm (Q = 1,09), ornées de crêtes hautes et de quelques longues épines aiguës, fortement ou partiellement amyloïdes, parfois reliées par de brefs tractus, plus souvent cristulées-caténulées, formant un réseau quasiment complet; plage non à faiblement amyloïde, verruqueuse au bord. **Basides** (42-)45-55 x 12-14(-16) µm, légèrement clavées, tétrasporiques, à contenu finement granulé; stérigmates aigus; basidioles clavulées. **Cystides** assez abondantes sur les faces, (50)-65-75 x 8-13(-16) µm, subfusiformes, clavulées, souvent mucronées de façon peu apparente parce que vite flétries, à contenu peu abondant, pailleté-granuleux, réfringent; très abondantes près de l'arête, (40-)45-55(-60) x (6-)7-8(-9) µm, à paroi remarquablement épaissie (lamprocystides), parfois à paroi plus mince et alors plus petites, mais plus larges (35-45 x 9-13 µm), à contenu granulé-réfringent, concentré au sommet. **Revêtement piléique** formé d'hyphes entremêlées, peu gélifiées, droites ou sinueuses, 2-5 µm de large, obtuses, optiquement vides, surmontées d'un trichoderm discontinu, à poils de 3 à 6 articles globuleux-ellipsoïdes, 10-20(-30) µm de diam., contenant quelques granules réfringents; l'article apical le plus souvent obtus, lagéniforme ou longuement appendiculé. Pileocystides abondantes; les unes naissant entre les poils, (17-)20-35 x (5-)6-8(-9) µm, clavées, parfois même pédicellées, subfusiformes, obtuses ou mucronées, parfois à paroi un peu épaissie, à contenu pailleté-réfringent ou localement granuleux; les autres naissant dans le subpellis et alors beaucoup plus grandes, 33-70(-125) x 6-8 µm, subcylindracées à clavulées. Hyphes oléifères peu rares. **Revêtement du stipe** composé d'hyphes grêles, 2-4 µm de diam., peu gélifiées et densément entremêlées, émettant, en haut du stipe, un suprapellis discontinu, le plus souvent composé de poils réunis en touffes; vers la base du stipe à revêtement continu, très dense; les poils formés d'articles de 6-13 µm de large; le terminal assez versiforme, le plus souvent ampulacé, lagéniforme ou lancéolé, obtus ou mucroné au sommet. Vers la base du stipe tous les articles - mais surtout le terminal - sont moins volumineux que dans le haut et plus souvent subulés ou effilés en bec grêle au sommet. Caulocystides abondantes en haut du stipe, de dimensions très variables, (14-)25-50(-75) x 6-8(-13) µm, devenant très abondantes vers la base du stipe, (25-)30-40(-45) x 6-8 µm, cylindracées, clavées à fusiformes, parfois un peu rétrécies vers le sommet, à contenu pailleté-réfringent; cystides du subpellis un peu plus longues, mais moins frappantes que dans le chapeau.

Bolivia : Beni, Vaca diez, Guayaramerin, mars 1956, Singer B1761 (F holotypus).

RUSSULA LAMPROCYSTIDIATA sp. nov.

Pileus fragilissimus, 30-40 mm diam., planus, sed leviter depressus in centro; margo regularis, paulum in-

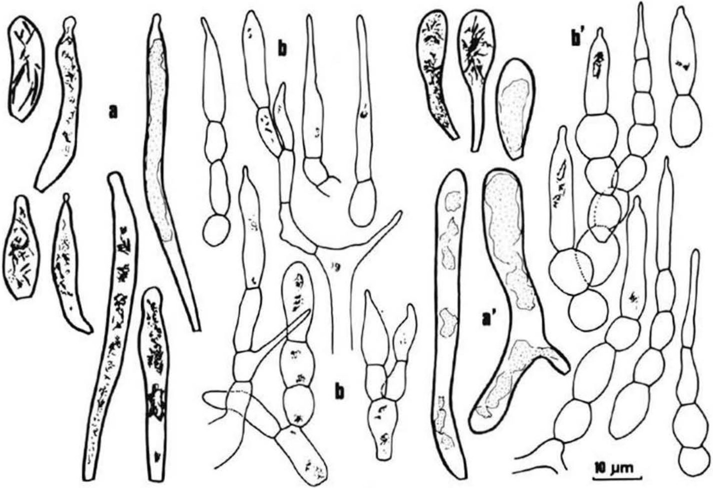

Fig. 1 : *R. guayarensis*, éléments du revêtement piléique. a-a' : dermatocystides montrant la paroi légèrement épaissie et le contenu granuleux-pailleté, au centre (a') et vers la marge (a) du chapeau; b-b' : poils contenant souvent une granulation d'origine probablement pigmentaire, au centre (b') et vers la marge (b) du chapeau.

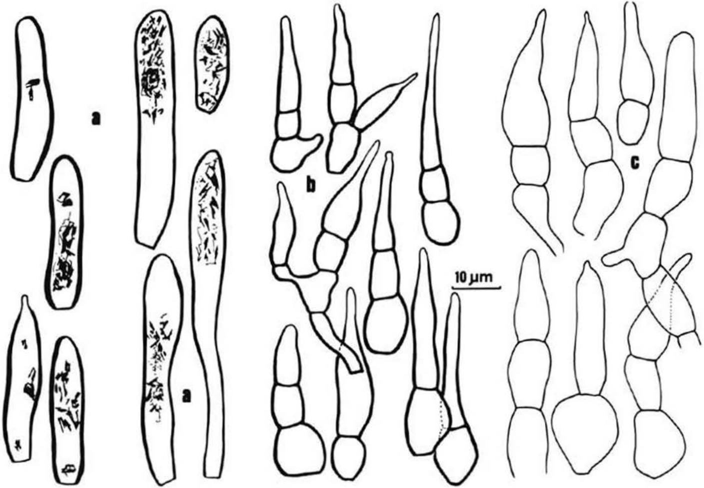

Fig. 2 : *R. guayarensis*, éléments du revêtement du stipe. a : caulocystides; b-c : poils du revêtement à paroi légèrement épaissie, près de la base (b) et au sommet (c) du stipe.

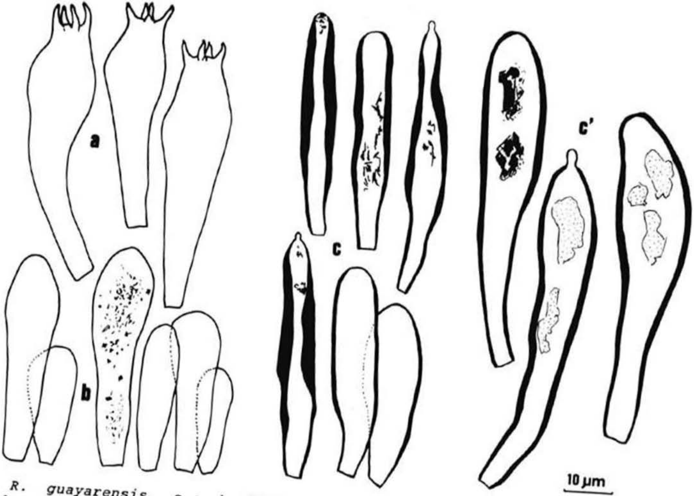

Fig. 3 : *R. guayarensis*, a : basides; b : basidioles, avec indication du contenu parfois granuleux dans une entr'elles; c–c' : cystides montrant la paroi parfois très fortement épaissie près de l'arête (c) et sur la faces (c') des lamelles; remarquez le contenu granuleux, peu abondant.

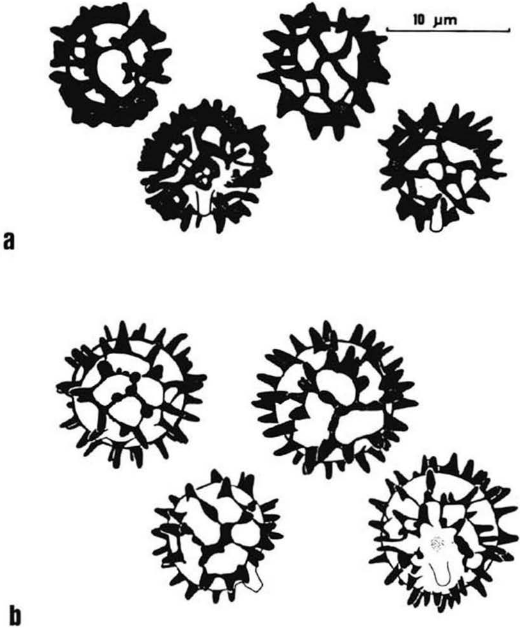

Fig. 4 : Ornementation sporale, observée dans le réactif de Melzer; a : *R. guayarensis*, b : *R. lamprocystidiata*.

curvatus, subtiliter striatus; pileipellis secernens, marginem versus in areolis magnis crassis mollibus saturate griseis plus minusve concentrice modo dispositis rumpens; pileipellis inter areolis pallidior, griseobrunnea, saturate brunnea in centro. **Stipes** longus, gracilis, 70-80 x 6-8 mm, cylindricus, glabrus, sordide albidus, leviter flavescens. **Lamellae** adnatae, breviter subdecurrentes, 3-4 mm latae, angustae, confertae (11/cm); acies concolor, integra. **Caro** spongiosa, alba, grisescens per actione vermorum, inodora, mitis. **Sporae** in cumulo colore ignoto, probaliter pallidae.

Sporae subglobosae, 10,39 ±1,32 x 9,76 ±1,19 µm (Q = 1,06), spinis longis, usque ad 2,5 µm altis, dense reticulatis per trabeculis subtilibus, hic illic catenulatis; macula suprahilaris inamyloidea. **Basidia** (35-)40-47 x 13-18 µm, subclavata, tetraspora, intus contentu granulosa repleta; sterigmata 4-6 x 2-3 µm. **Cystidia** sparsa in lateribus, 60-90 x (7-)13-18 µm, voluminosa, subfusiformia, obtusa vel mucronata, tenuitunicata; in acie numerosa, 40-53(-65) x 7-13(-20) µm, fusiformia, lageniformia, torulosa, plerumque indistincte capitata, pariete irregulariter sed plerumque fortiter incrassata azureo cresylico haud metachromatica praedita, hic illic autem tenuitunicata. **Pileipellis** ex hyphis gracilibus gelatinosis, 2-4 µm diam. efformata; pili suprapellis cellulis 30-70 x 6-15 µm, lageniformibus sinuosis obclavatis ampullaceis, ex cellula globosa basale haerentibus compositi. Pileocystidia modice numerosa, 35-55 x 5-8 µm, lageniformia, subulata vel subfusiformia, obtusa, intus contentu granulosa refringente repleta, pariete tenuiter incrassata praedita.

Zaïre : Forestier central : Binga, épars sur le sol de la forêt sèche, févr. 1933, Goossens-Fontana 966 (BR holotypus).

OBSERVATIONS

(1) : La description macroscopique de *R. lamprocystidiata* est basée sur les notes et l'aquarelle de Mme Goossens-Fontana. L'espèce sera illustrée en détail dans une révision des Russules tropicales africaines, à paraître bientôt dans la "Flore Illustrée des champignons d'Afrique centrale" du Jardin botanique national de Belgique.

(2) : *R. lamprocystidiata* ressemble *R. guayarensis* tout d'abord par la possession d'abondantes lamprocystides sur l'arête des lamelles (unique jusqu'alors dans le genre !), mais aussi par la couleur du chapeau et du stipe : toutes deux ont le stipe légèrement jaunissant et possèdent un chapeau grisâtre à centre brunâtre, dont le revêtement est couvert d'un voile sous forme de flocons petits, fugaces et marginaux dans *R. guayarensis* et sous forme

d'écailles molles et épaisses radiant du centre dans *R. lamprocystidiata*. Chez cette dernière, comme dans *R. guayarensis*, il n'y a pas de tissus ou de cellules métachromatiques au bleu de crésyl.

Les deux espèces se distinguent entr'elles surtout par la structure différente des poils des revêtements et par l'ornementation sporale. A présent, il me semble préférable de réunir les deux espèces dans les *Guayarenses* par la présence d'innombrables lamprocystides sur l'arête des lames et par la présence d'un velum sur le chapeau.

(3) : Les deux Russula sont caractérisées en outre par l'absence de toute réaction métachromatique au bleu de crésyl. Ceci les distancie des *Metachromaticae* Singer, qui possèdent également des lamprocystides, mais la paroi de celles-ci rougit énergiquement dans le bleu de crésyl et n'atteint pas l'épaisseur relative des cystides marginales des *Guayarenses*. Dans les *Metachromaticae* les cystides marginales n'occupent pas l'arête entière et les lamprocystides s'observent également, ou surtout, sur les faces des lames.

(4) : Dans une contribution aux *Russulaceae* de la Nouvelle-Zélande, McNabb (1973) a décrit 32 *Russula* dont quelques-unes possèdent également des cystides à paroi épaissie, atteignant environ 2 à 3 µm et même 6 µm d'épaisseur dans R. tawai McNabb.

D'après mes propres observations dans les *Russula* africaines, une épaisseur de 2 à 3 µm pour la paroi des cystides n'est pas rare du tout et même fréquente dans plusieurs sous-sections tropicales (obs. pers.).

Seule *R. tawai* possède donc des cystides ou l'épaisseur relative des parois égale celle des cystides marginales des *Guayarenses*. McNabb (1973 : 708) situe *R. tawai* dans les *Amoeninae* Singer mais les caractères microscopiques contredisent cette parenté. Je n'ai pas encore étudié personnellement le type de *R. tawai* car, vu le caractère particulier de la flore Nouvelle-Zélandaise, l'examen des espèces décrites par McNabb n'est vraiment utile que lors qu'on puisse étudier la totalité de ces espèces. McNabb avait apparamment quelques problèmes de situer ses espèces nouvelles dans la classification du genre, connaissant probablement trop peu les espèces de l'Europe et de l'Amérique.

Néanmoins, l'examen du type de *R. echinospora* Heim non Singer de la Nouvelle-Calédonie nous permet de situer *R. tawai*. Ces deux Russules sont certainement très proches et peut-être même identiques (dans les deux cas R. tawai McNabb reste un nom légitime car Singer (1939 : 270) avait publié déjà le nom '*echinospora*' dans un nom alternatif mais légitime parce qu'avant 1953). Heim (1967 : 7) décrit la paroi des cystides hyméniales de *R. echinospora* comme "égale et peu épaissie", bien qu'elle soit tout à fait comparable et parfois aussi fortement épaissie que la paroi des cystides de *R. tawai*. L'ensemble des caractères,

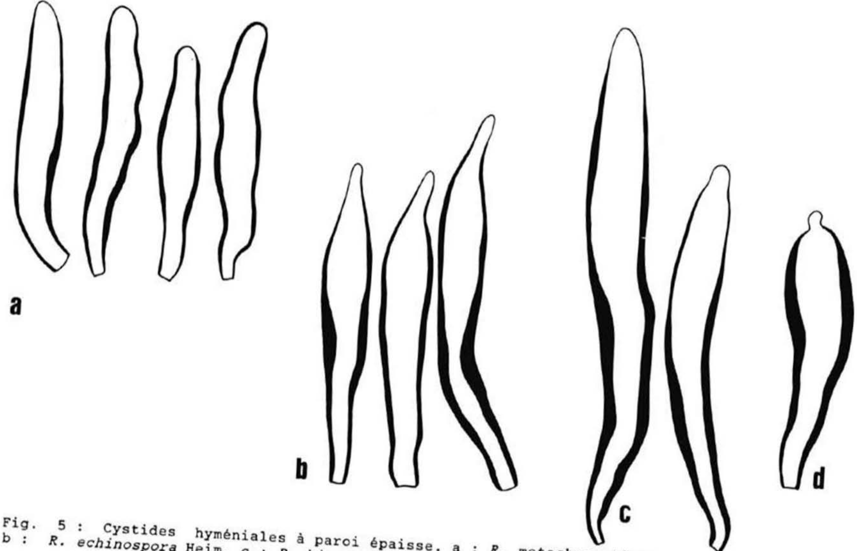

Fig. 5 : Cystides hyméniales à paroi épaisse. a : *R. metachromatica* ssp. *notoleuca* Singer, b : *R. echinospora* Heim, c : *R. binganensis* Beeli, d : *R. luteopulverulenta* Beeli.

macroscopiques et microscopiques, excluent toute parenté avec les *Guayarenses* mais sont plutôt en faveur d'une position près des *Fistulosinae* Heim ex Singer dans une sous-section nouvelle.

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Etudes microscopiques de Russules tropicales : Mimeticinae subsectio nov.

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Résumé : La sous-section *Mimeticinae*, subsect. nov. est décrite. Quatre espèces lui sont attribuées : *Russula mimetica* Heim, *R. obtusopunctata* (Singer) Buyck nom. nov. pour *R. heterochroa* Singer, *R. leguminosarum* Singer et *R. atrovinosa* Buyck sp. nov.

Summary : the subsection *Mimeticinae* subsect. nov. is described. Four species are assigned to it : *Russula mimetica* Heim, *R. leguminosarum* Singer, *R. obtusopunctata* (Singer) Buyck nom. nov. for *R. heterochroa* Singer and *R. atrovinosa* Buyck sp. nov.

INTRODUCTION

Lors de notre étude des spécimens - types des *Russulaceae* décrites par Singer de l'Amérique du Sud, nous nous sommes aperçus de quelques similitudes inattendues avec plusieurs groupes d'espèces de la flore africaine, particulièrement riche en *Russulaceae*. En étudiant les spécimens - types des *Pluviales* Singer (BUYCK 1989) nous avons été frappés par les ressemblances entre *R. leguminosarum* Singer et *R. mimetica* Heim. Nous pouvons affirmer à présent qu'il s'agit d'un nouvel ensemble d'espèces, pour lequel nous proposons le nom *Mimeticinae* subsectio nov. et auquel nous rattachons également *R. heterochroa* Singer (non Kühner 1975), ainsi que *R. atrovinosa* Buyck sp. nov. du Zaïre, dont la diagnose latine est fournie ci-dessous.

DESCRIPTION DES ESPECES

R. mimetica Heim et *R. atrovinosa* Buyck sp. nov. seront décrites et illustrées en détail dans notre révision de *Russula* en Afrique centrale, qui paraîtra prochainement dans la Flore Illustrée des Champignons d'Afrique Centrale, publiée par le Jardin botanique national de Belgique. Pour une étude détaillée des caractères microscopiques de *R. leguminosarum*, nous renvoyons le lecteur à notre étude des *Pluviales* Singer (BUYCK, l.c.). Nous nous contenterons ici d'une description des caractères microscopiques du type de *R. heterochroa* Singer.

L'exsiccatum a été traité par une solution aqueuse (ca. 20%) de KOH pour faciliter la dissociation et le regonflement des tissus, dont l'étude s'est effectuée à partir de préparations semi-permanentes dans le Congo ammoniacal additionné de 10% de glycérine. Les dimensions sporales, basées sur vingt spores, donnent la longueur et la largeur moyennes, accompagnées de leur écart type (standard deviation); suit encore, entre parenthèses, le rapport moyen de la longueur sur la largeur.

R. obtusopunctata (Singer) Buyck nom. nov.
R. heterochroa Singer Beih. Nov. Hedw. 77 : 273 (1983) non Kühner Bull. Soc. mycol. France 91 : 389 (1975).

Spores brièvement ellipsoïdes à subglobuleuses, 6,82 ± 1,12 x 6,06 ± 1,11 µm (Q = 1,13), assez densément ornées d'éléments obtus, isolés, forts, courtement cylindracés à plus ou moins coniques, atteignant env. 1 µm de haut, parfois légèrement convexes ou hémisphériques, nettement amyloïdes; plage non à très légèrement amyloïde, verruculeuse. **Basides** généralement 35-42 x 8-10(-12) µm, piriformes à clavulées, contenant des globules réfringentes et probablement lipidiques de taille variable; stérigmates 4-6 x 1-2 µm; basidioles clavées. **Cystides** assez nombreuses mais peu apparentes, effleurantes, naissant assez profondément dans le subhyménium, 45-50 x 7-9 µm, cylindracées à subfusiformes, obtuses à largement capitées par un rétrécissement subapical, à paroi très mince et fragile; contenu abondant, granuleux-réfringent. **Poils cystidiformes** non différenciés. **Revêtement piléique** composé d'hyphes emmêlées, écartées par gélification, généralement 2-3(-4) µm de diam., parfois très légèrement métachromatique au bleu de crésyl; hyphes oléifères dispersées, rares; suprapellis discontinu, formé de poils le plus souvent groupés en touffes, ramifiés, naissant généralement par plusieurs d'une même cellule basale, composés de 2-4 articles courts, globuleux, doliformes à ellipsoïdes ou brièvement cylindracés, à paroi mince mais nettement métachromatiques au bleu de crésyl; le terminal toujours plus long, atteignant parfois 30 µm, s'atténuant graduellement vers le sommet, celui-ci obtus ou subapicalement rétréci en large capitule. Pileocystides abondantes, 15-30 x 3-5 µm, constituant l'article terminal des poils et ressemblant aux articles terminaux ordinaires par la forme lancéolée, lagéniforme, conique ou subfusiforme ainsi que par la paroi métachromatique, parfois minusculement capitées, rarement arrondies au sommet; contenu granuleux-réfringent. **Revêtement du stipe** plus mince, moins gélifié, à éléments plus grêles, mais tout à fait ressemblant à ceux du chapeau.

Brésil : Amazonas, Estrada Manaus-Caracarai, Rus 125, mai 1978; Singer B11012 (INPA holotypus).

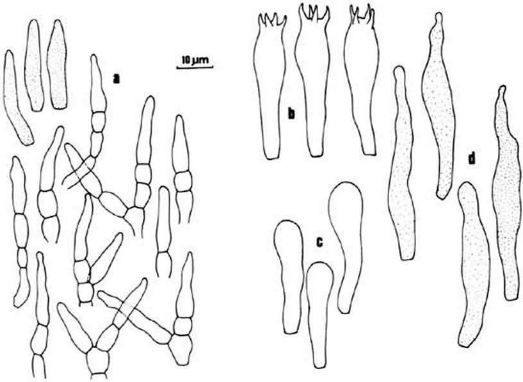

Fig. 1 : *R. obtusopunctata* (holotypus) : a : dermatocystides (à contenu schématisé) et poils du revêtement, b: basides, c : basidioles, d : cystides (à contenu schématisé).

Fig. 2 (au verso) : *R. radicans* (Gilles 71 holotypus, P) : a : extrémités de dermatocystides, remarquez le contenu pailleté; b : poils optiquement vides du revêtement piléique; c : basidioles - je n'ai pas réussi à trouver des basides bien regonflées; d : cystides à contenu partiellement schématisé; remarquez le sommet toujours obtus-arrondie et la taille parfois énorme, nettement supérieure aux dimensions fournies dans la description originale.

Fig. 3 (au verso) : *R. nanella* (Singer B 10923 holotypus, INPA) : a-c : revêtement piléique, poils aciculaires (a), articles terminaux ordinaires des poils (b) et détail d'une coupe tangentielle (c).

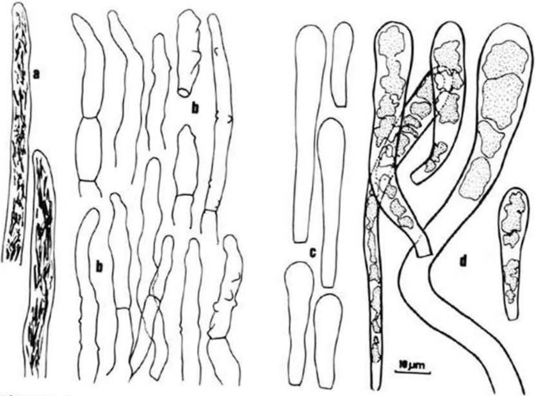

Figure 2

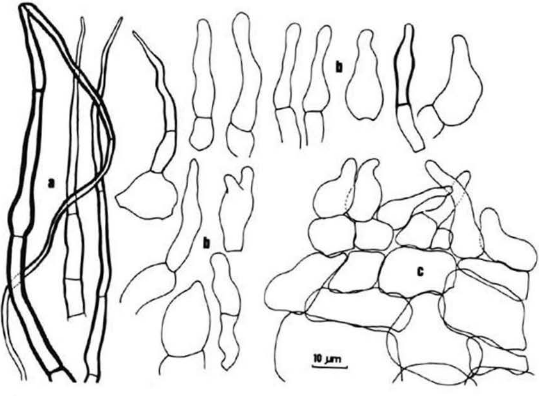

Figure 3

R. atrovinosa Buyck spec. nov. a *R. mimetica* Heim praesertim differt colore pilei stipitisque atrovinosa, sporis sublaevibus, elementis paululum convexis sejunctis generaliter dilute amyloideis ornatis.

Zaïre : Haut-Katanga, Lubumbashi, en forêt claire, mars 1986, Schreurs 1500 (BR holotypus).

DISCUSSION

R. mimetica a été décrite du Gabon par Heim (1969 : 347) et il la situa (1970 : 67) au sein des *Pelliculariae* Heim *nom. nud.* près de *R. radicans* Heim dans les *Radicantes* Heim *nom. nud.* à cause de la présence d'un anneau, le stipe radicant et les spores ovoïdes non réticulées. Dans sa description de *R. mimetica*, Heim ne dit rien sur la composition des revêtements, bien que ce soit justement ce caractère qui contredit une parenté étroite entre les deux espèces : *R. radicans* possède un chevelu de poils assez larges, généralement 4-7 µm de diam., cylindracés, rarement avec quelques articles basaux plus ou moins renflés-ampullacés, montrant fréquemment de courts diverticules latéraux et aigus; l'article terminal obtus, parfois légèrement rétréci. Les dermatocystides cylindracées, très longues, excédant parfois un peu le diamètre des poils, naissent très profondément dans le subpellis. (cf. notre Fig. 2 ou Heim 1937, fig. 46).

En ce qui concerne les caractères des éléments hyméniaux de *R. mimetica*, Heim ne se révèle pas très précis non plus : les basides sont nettement moins grandes que Heim le ferait supposer et les stérigmates "énormes" sont beaucoup plus petits que, par ex., ceux des *Nigricantinae* ou *Fistulosinae* Heim. Enfin, je ne comprend pas très bien ce que Heim veut dire par 'poils cystidiformes", car les cystides de *R. mimetica* dépassent largement les dimensions données tandis que les vrais poils cystidiformes de l'arête correspondent bien aux dimensions citées mais possèdent une structure tout à fait différente.

On pourrait difficilement envisager une insertion parmi les *Pluviales* Singer où Singer situe *R. leguminosarum*, puisque nous avons démontré (BUYCK 1988) que cette dernière diffère considérablement de *R. pluvialis* Singer par la nature très différente des cystides et dermatocystides, lesquelles, dans *R. pluvialis*, sont très apparentes, très nombreuses, à contenu nettement plus abondant et à paroi plus épaisse.

Singer (Singer et al., 1983 : 274) avait interprêté sa *R. heterochroa* au début comme une simple variété de *R. nanella* Singer, mais l'en séparait à cause de la coloration différente du chapeau et la microscopie : "although similar, not quite identical". Ayant étudié le type de *R.*

nanella j'ai trouvé les caractères microscopiques des deux espèces tellement différentes qu'on pourrait se demander si Singer ne parle pas d'un autre spécimen ! Surtout la structure du pileipellis est totalement différente (les traits schématisés de Singer illustrant les deux espèces sont d'ailleur fortement trompeurs !) : dans les *Mimeticinae*, sa structure est surtout filamenteuse avec un suprapellis nettement discontinu, formé de poils groupés en touffes, unis par leur article terminal; le suprapellis de *R. nanella* (Fig. 3), au contraire, est continu, entièrement orthochromatique au bleu de crésyl et de structure pseudoparenchymateuse (s'approchant du type 'virescens') formé d'articles renflés se poursuivant jusqu'à l'hyménium ! On n'aperçoit aucune hyphe grêle dans tout le pileipellis. A la surface du chapeau les cellules sont ampullacées, subulées ou ellipsoïdes-globuleuses avec en outre des poils très longs, dispersés, subulés, à paroi fortement épaissie (ces structures caractérisent également un groupe de Russules africaines, obs. pers.).

R. nanella et *R. heterochroa* Singer non Kühner sont classées par Singer parmi les *Cyanoxanthinae*. Bien que, à part quelques réserves pour *R. amnicola* Singer dont je n'ai reçu que deux primordia, aucun des cinq représentants sud-américaines énumérés pour cette sous-section ne soit apparenté à *R. cyanoxantha* !

Nous croyons donc justifié de décrire, pour nos quatre espèces, une nouvelle sous-section dont les caractères essentiels se résument comme suit :

Mimeticinae subsectio nov. : species versicolores, minutae (diametro pilei inferiore 40 mm), pelliculares; stipes albus vel pileo concolor; caro insipida, fere inodora; pileipellis ex pilis caespitosis dermatocystidiisque pariete dilute azureo cresylico metachromatica instructis composita; sporae breviter ellipsoideae, elementis sejunctis ornatae, macula suprahilare inamyloidea vel leviter amyloidea instructa, in cumulo probabiliter albae (certe valde pallidae).

Espèces versicolores, très petites (diam. du chapeau ne dépassant pas 40 mm), pelliculaires; stipe blanc ou concolore au chapeau; chair douce, à peu près inodore; revêtement piléique composé de poils et de dermatocystides légèrement métachromatiques au bleu de crésyl; spores brièvement ellipsoïdes, ornées d'éléments isolés, à plage non ou très légèrement amyloïde; sporée probablement blanche (en tout cas très pâle). Espèce-type : *R. mimetica* Heim.

Clé des espèces

Remarque : la clé devra être utilisée avec prudence, toutes les espèces n'étant connues que par leur type !

Spores sublisses, à ornementation ne dépassant pas 0,5 µm de haut; chapeau rouge vineux foncé; stipe concolore, sans anneau (Zaïre).- Fig. 4a, 5a
R. atrovinosa Buyck

Spores ornées d'éléments atteignant généralement 1-1,5 µm de haut.

> Espèce annelée à chapeau rose foncé et stipe plus ou moins concolore. (Gabon).- Fig. 4d
> *R. mimetica* Heim
>
> Espèce dépourvue d'anneau.
>
> > Chapeau brun ocracé subtilement mélangé de vert; stipe blanc à concolore; spores grossièrement ornées d'éléments forts et obtus. (Brésil).- Fig. 4b, 5b
> > *R. obtusopunctata* (Singer) Buyck
> >
> > Chapeau lila violacé à violacé sale mélangé de vert; stipe blanc pur; spores ornées d'éléments grêles et assez aigus. (Brésil).- Fig. 4c, 5c
> > *R. leguminosarum* Singer

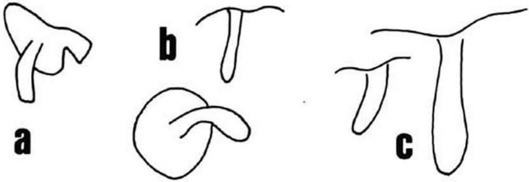

Fig. 5. Traits schématisés de l'habitus (d'après les publications originales pour b & c). a : *R. atrovinosa*, b : *R. obtusopunctata*, c : *R. leguminosarum*; toutes grandeur naturelle.

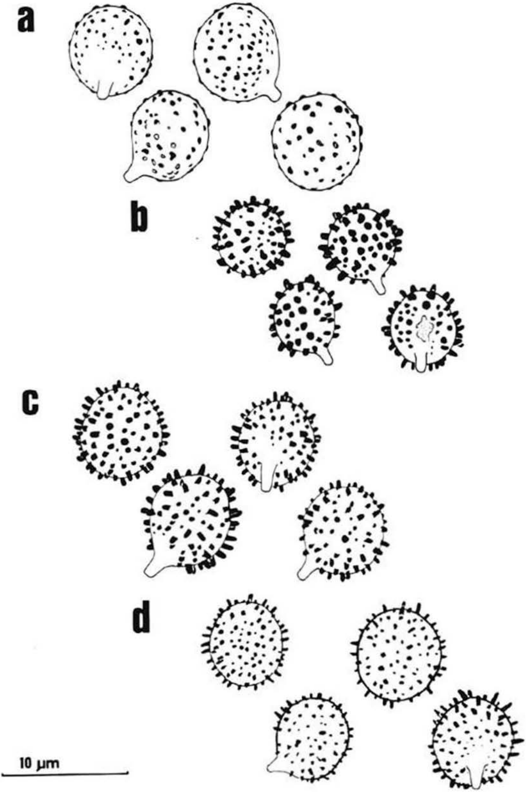

Fig. 4. Ornementation sporale. a : *R. atrovinosa*, b : *R. obtusopunctata*, c : *R. leguminosarum*, d : *R. mimetica*.

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CHEILYMENIA MEGASPORA COMB. NOV. A NEW COMBINATION IN THE GENUS CHEILYMENIA (DISCOMYCETES, PEZIZALES, PYRONEMATACEAE)

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ABSTRACT: A new combination, Cheilymenia megaspora (Gamundí) comb. nov. is proposed on the basis of the author's examination of the type material. The examination of the type of Cheilymenia coprinaria var. megaspora Gamundí (1972) revealed an outstanding cyanophilic perisporial ascospore ornamentation, well observable under light microscope and proved by SEM photomicrographs. The type of Peziza coprinaria Cooke (=Cheilymenia coprinaria (Cooke) Boud.), differs by much smaller ascospores with a smooth perisporium. The very long furcated apothecial rooting hairs well differentiate Ch. megaspora also from Cheilymenia raripila (Phill.) Dennis and other species with similar ascospore ornamentation.

Line drawings and SEM photomicrographs of ascospores of Ch. megaspora accompany the paper and complete the detailed description and illustration previously given by Gamundí (1972).

Gamundí (1972) described a new variety of Cheilymenia coprinaria (Cooke)Boud. var. megaspora Gamundí. She examined seven collections from Tierra del Fuego, Argentina, coming from cow-dung and horse excrements. The detailed description and line drawings of all features in this variety show several essential features, which differentiate, in my opinion, this taxon from Cheilymenia coprinaria (Cooke) Boud. (= Cheilymenia fimicola (De Not.)Dennis according to Dennis (1978)) not only at the infraspecific level. The examination of the type material has confirmed this opinion. The type specimen from the herbarium of M.C.Cooke, now deposited in Kew Herbarium (K) and labelled "Peziza (Sarcoscypha) hyppocopra Cooke"(an herbarium name) and designated " the type of Cheilymenia coprinaria (Cooke)Boud.: Rannoch, Scotland,(no date), on horse dung" (studied and designated as holotype by Denison (1964)), contains apothecia in a rather bad condition but with fully mature copious ascospores. The ascospores measure 15-16.5(-18) x 7.5-9.7(-10.5) µm, are hyaline without oil guttules, with a pale yellow refractive colour at their maturity seen when stained with CB; the perisporium is loosen, gentle, smooth, with only occasional secondary fine patches or stained places caused by the wrinkling as stained with CB. The rooting apothecial yellow-brownish hairs are up to 730 µm long and 45 µm diam., with walls up to 4.5 µm thick, base only shortly rooting. These features well agree with the description and illustration in Cooke (1876).
For the detailed description see also Denison (1964).

It may be noted that although Dennis (1978) transferred *Arhenia fimicola* De Notaris to *Cheilymenia* as *Cheilymenia fimicola* (De Not.) Dennis, the ascospore size given by him is larger (up to 23 x 13 µm) and this taxon may represent a different species. However, the type of *A. fimicola* have not been yet examined by me.

The examination of the type of *Ch. coprinaria* var. *megaspora*, deposited in LPS herbarium (N° 33424), revealed that this Gamundí's variety differs not merely in its ascospore size, but also in several other important features. The ascospores are without guttules and with a conspicuous yellow refractive colour (the latter feature seen when stained with CB) and measure (22.5-) 25-29.5(-31.2) x 12-13.5(-15) µm and this size itself is significantly distinct from that in ascospores of *Cheilymenia coprinaria*. However, the most important feature, which differentiates sufficiently the two taxa, is the ornamentation of the perisporium of ascospores in var. *megaspora* (fig.1 and figs 3-5). This ornamentation is well seen when the sections are stained with Cotton blue in lactic acid (CB Geigy s.123), which stains promptly without heating the slides, and, when oil immersion objective is used. It should be noted that when the slides with stained sections are heated, the perisporium is easily deformed, loosened and separated from the ascospores, and they become smooth. This is probably the reason why Gamundí (1972,1975) stated the ascospores smooth. Similar situation is also in other species of *Cheilymenia* and *Coprobia* (J. Moravec 1984, 1987,1988).

The ornamentation is strongly cyanophilic and consists of very fine and low irregular amoeboid warts and crests, which are irregularly densely distributed and connected, occasionally forming an irregular and very incomplete reticulum. The warts are 0.1-0.6 µm diam. (elongated up to 1.2 µm long crests) and only 0.05-0.15 µm high, hardly seen on the outline of ascospores. These warts and crests represent an original ornamentation of the perisporium (a loose sheet) when the membrane is tense and not deformed by the action of lactic acid and is clearly seen on SEM photomicrographs taken from dried specimens (Figs 3-5).

The other important feature is the size and shape of asci. In var. *megaspora*, the asci are much larger, simply and shortly attenuated at their base. Moreover, the apothecia are smaller in var. *megaspora* and with apothecial rooting hairs longer (up to 1100 µm), usually with more copious septa and often containing one to three juvenile hairs, broadly rooting at their base (see line drawings in Gamundí(1972, 1975)).

For these reasons, especially the ascospore size and ornamentation, the new combination is proposed here:

Cheilymenia megaspora (Gamundí) comb. nov.

Basionym: *Cheilymenia coprinaria* (Cooke) Boud. var. *megaspora* Gamundí, Bol. Soc. Arg. Bot. 14 (3):170, 1972.

For the detailed description and illustration of other features, including the apothecial structure, see Gamundí (1972, 1975).

The species is well distinguished from all known species of the genus *Cheilymenia* Boud., and is known only from Argentina

The ascospore ornamentation is similar to that in ascospores of Cheilymenia raripila (Phill.) Dennis. However, this species differs clearly by much smaller and simpler apothecia with short superficial apothecial hairs, and is not related to Ch. megaspora. Also other species are well distinguished.

For its long rooting apothecial hairs, Ch. megaspora may resemble a species of the genus Scutellinia (Cooke) Lamb. em. Le Gal. It should be noted that there seems to be a close relationship between the genera Cheilymenia and Scutellinia. As it has been already noted (J. Moravec 1984), there are several species in the genus Scutellinia (the members of the sections Minutae Svr. and Pseudocheilymeniae Svr.), which have ascospores with loosening perisporium, a feature, which was commonly overlooked in this genus. This also indigates the close relationship between the two genera. However, Ch. megaspora differs from these species of the genus Scutellinia by following features:
Its ascospores are without guttules, the mature ascospores possess the conspicuous yellow refractive colour when stained with CB, the perisporium is much feebler and easier separable, with much finer and lower ornamentation. Moreover, its habitat is entirely coprophilous.

I have examined the type of Cheilymenia rubra (Cooke ex Phill.) Boud., illustrated and described also in Cooke (1876) as Peziza (Sarcoscypha) rubra Cooke (K) and the neotype (LPS) of Cheilymenia humarioides (Rehm) Gamundí (1972). The both taxa differ from Ch. megaspora by the ascospore size, ornamentation, and by much shorter rooting apothecial hairs.

The detailed result of these examinations will be published later. It may be merely noted here that Ch. humarioides shows a certain similarity with Ch. rubra. The perisporial ascospore ornamentation in both taxa consists of rounded cyanophilic warts. However, these warts are much larger and very conspicuous (as seen also in SEM) in Ch. humarioides and the ascospore wall consists of three layers (as already stated by Gamundí (1972,1975)). In contrary, the ascospores of Ch. rubra have the perisporium with inconspicuous fine warts and the ascospore wall consists merely of two layers. Moreover, the apothecial hairs of Ch. rubra are much simpler at their base, and of a darker colour. It should be noted that the collection from Greenland, determined by me previously (J. Moravec 1988) as Ch. humarioides, has almost all features virtually identical with these in the neotype of Ch. humarioides except the ascospore wall, which consists of two layers only, a feature, which deserves further study and evaluation.

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I thank Dr. Irma Gamundí de Amos (La Plata) and Dr. B.M. Spooner (Kew) for an arrangement of the loans of the type material. Mr. Jiří Lhotecký (Brno) has made the SEM photomicrographs of the ascospores, and, Dr. Zdeněk Pouzar (Prague) kindly read the manuscript.

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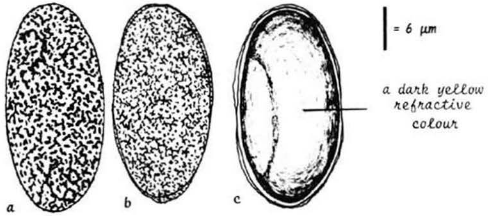

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Fig. 1. Mature ascospores of Cheilymenia megaspora stained with cotton blue in lactic acid under oil immersion:
a, b. Ornamentation of the perisporium;
c. An optical section of an ascospore. (Holotype LPS 34424).

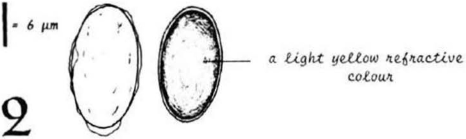

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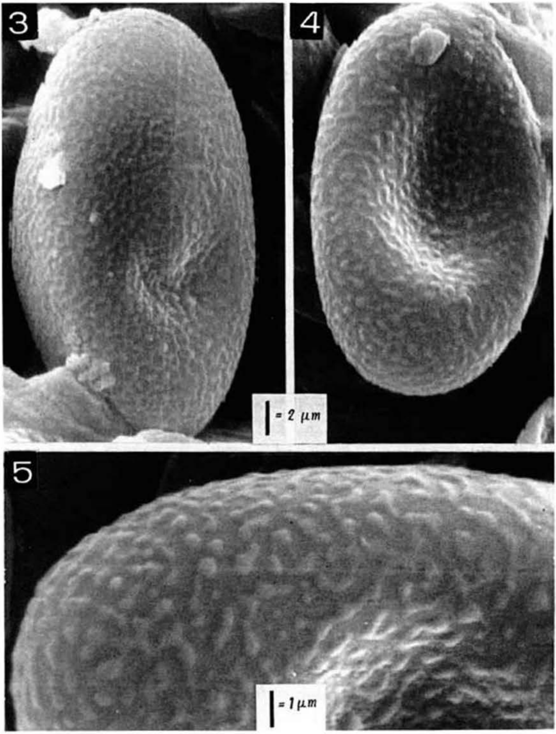
Fig. 2. Mature ascospores of Cheilymenia coprinaria stained with cotton blue in lactic acid under oil immersion: The type specimen (K).



Figs 3-5. SEM photomicrographs of ascospores of *Cheilymenia megaspora*. (Holotype LPS).

MYCOTAXON

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ON THE NEW GENUS JAPONOGASTER (LYCOPERDACEAE)

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A new fungus, described here as *Japonogaster oohashianus* gen. et sp. nov., was found on a dead trunk of *Fagus crenata* Blume at approximately 1000 m elevation in the forest at Kaifugôry, Tokushima Prefecture, by Takashi Oohashi. The holotype is preserved in the National Science Museum, Tokyo.

Japonogaster Y. Kobayasi, *gen. nov.*

Fructificatio epigaea stilpalis emortua, depresso-globosa, superficiale multifoveolata. Epidermis crassa alba, in speciem unistrata. Gleba fulva multilocularis, hymeniis obsita. Basidia clavata, 2-sterigmata.

Japonogaster oohashianus Y. Kobayasi, *sp. nov.* (FIGS. 1, 2)

Fructificatio depresso-globosa, 2.5 cm in diam., 1.5 cm crassa, superne alba, multifoveolata, alveoli cum corno polyhedrato, margine circulati praediti. Exoperidium alba, 1.5 mm crassa, e hyphis laxe tectis compositum, 1 mm crassum, pallide brunneolum, multi-foveolatum. Endoperidium 1.5 mm crassum, ochraceum, e hyphis densissime contextum. Capillitia crasseparietalia, pallide ochracea. Basidia clavata, 2-sterigmata, 19-20 x 3-4 μm. Basidiosporae globosae, 2.5-3.5 μm in diam., laevigate, hyalinae cum uniguttato. Holotypus in TNS conservatus: Epigaeous, growing on dead trunk of *Fagus crenata* Blume, in forest, about 1000 meters in altitude. Kaifugôri, Tokushima Pref. Collected by Takashi Oohashi, Jan. 2, 1981.

Fruitbody thick, discoid, 2.5 cm in diameter, 1.5 cm thick, surface white, turning pale ochraceous brown ["Pale Pinkish Buff" (Ridgway)] in the dried state. Epidermis 4 mm thick. Exoperidium white, 1.5 mm thick, composed of loosely woven hyphae, middle tissue pale brown, 1 mm thick, composed of hyphae, with many cavities, inner tissue yellowish, 1.5 mm thick, composed of densely woven hyphae. Many cavities produced on the surface of the fruitbody, containing one polyhedral cone margined with a circular elevation. Gleba ochraceous brown, composed of tramal hyphae, capillitia, basidia, and spores. Capillitium thick-walled, pale ochraceous. Basidia clavate, with two sterigmata, 19-20 x 3-4 μm. Basidiospores globose, 2.5-3.5 μm in diameter, smooth, hyaline, with one oil drop.

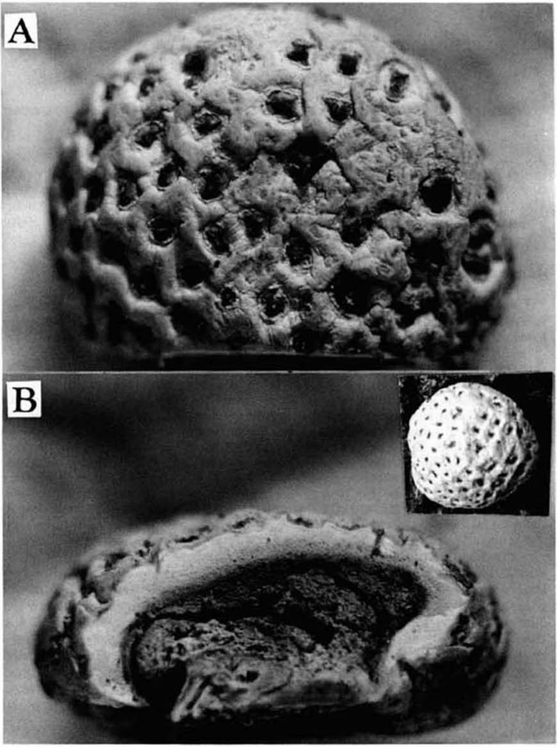

Fig. 1. A. Surface view of fruitbody. B. Section through fruitbody; insert: whole fruitbody.

This new genus recalls the genus *Calvatia* in shape, capillitium, and hyaline spores, differing, however, in the following characteristics:

Japonogaster	Peridium thick, composed of a single layer, not falling off at maturity.
Calvatia	Peridium thick, composed of two layers, falling off at maturity.

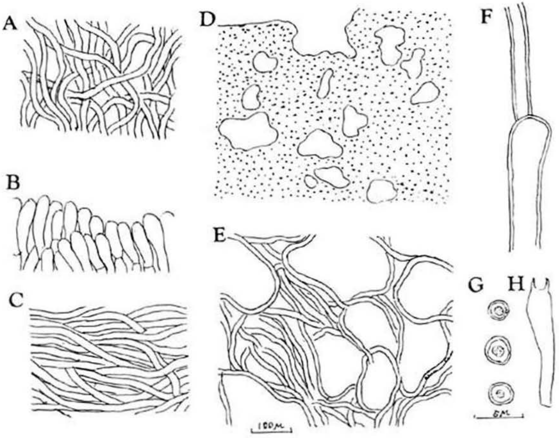

Fig. 2. A. Epidermis. B. Hymenial layer. C. Hyphae of inner tissue. D, E. Inner tissue. F. Capillitium. G. Basidiospores. H. Basidium.

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STUDIES IN THE GENUS XANTHOCONIUM (BOLETACEAE). III. CULTURAL STUDIES.

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ABSTRACT

Cultural studies of *Xanthoconium affine*, *X. affine* var. *maculosum*, *X. montanum*, and *X. montaltoensis* revealed distinct differences among them that have also supported the alpha taxonomic differences between them.

Key Words: Boletaceae, *Xanthoconium*, cultural studies.

Species of the Boletaceae are known mycobionts of ectomycorrhizae (Melin, 1922a, 1922b, 1923; Trappe, 1962; Singer, 1986; Palm and Stewart, 1984; Samson and Fortin, 1988). Pure culture isolation of the mycobionts of ectomycorrhizae has created a need for descriptions of cultures isolated from basidiomata (Zak, 1973; Palm and Stewart, 1984). Cultural studies of many boletes have been carried out by other workers (Pantidou, 1961, 1962, 1965; Pantidou and Groves, 1966; Pantidou and Watling, 1970, 1973; and Miller, Miller, and Palmer, 1983).

Wolfe (1987, 1988), Singer (1947, 1986), Snell and Dick (1970), and Smith and Thiers (1971) have summarized the suspected mycorrhizal associations of *Xanthoconium* Singer species. Ectomycorrhizal syntheses have not been conducted with *Xanthoconium* species and their suspected mycorrhizal symbionts. Additionally, descriptions of tissue cultures initiated from basidiomata of *Xanthoconium* species have not been forthcoming. Kneebone (1951), however, has germinated basidiospores of *X. affine* (Peck) Singer in vitro.

This present contribution presents the results of cultural studies of four *Xanthoconium* species.

MATERIALS AND METHODS

Pileus context tissue was aseptically removed from basidiomata of four *Xanthoconium* taxa and cultured on Hagem's agar modified by Modess (1941) that was supplemented with streptomycin sulfate and benomyl solutions (Watling, 1981). Thirty-day growth rate, morphological, and chemical spot test data were determined according to the methods of Pantidou (1961), Nobles (1965), and Miller, Miller, and Palmer (1983). Extracellular enzyme production was determined by growth on tannic acid agar (Davidson, Campbell, and Blaisdell, 1938) and chemical spot tests utilizing syringaldazine, L-tyrosine, phenol, gum guaiac, and guaiacol for the presence of laccase activity and tyrosinase activity (Marr, 1979). Hyphae were isolated from all culture zones, and the cell nuclei number (monokaryon or dikaryon) was determined by the Safranin O method (Bandoni, 1979). Color references (4A2) were determined by reference to Kornerup and Wanscher (1967) for names in quotation marks or subjectively.

Literature sources for the descriptions of the species are found in the species citations that follow, in Wolfe (1987, 1988), in Snell and Dick (1970), and in Smith and Thiers (1971).

RESULTS

Cultural characteristics of these *Xanthoconium* species were quite similar with some diagnostically significant exceptions. *Xanthoconium affine* (Peck) Singer was the only taxon to exhibit a positive guaiacol spot test. *Xanthoconium affine* and *X. montanum* Wolfe both exhibited a positive phenol test. Culture colors under ultraviolet (UV) light were diagnostically helpful. *Xanthoconium montanum* was the only taxon to exhibit the azonate culture mat.

Cultural Key to *Xanthoconium* Species

1. Mycelial mat zonate. 2
1. Mycelial mat not zonate. . . . .*X. montanum*
    2. Inner zone of mycelial mat cinnamon under UV light; vesicular hyphae absent. . .*X. affine* var. *maculosum*

2. Inner zone of mycelial mat violet, purple, or ocher-green under UV light; vesicular hyphae present . .3
3. Guaiacol spot test positive (pink); inner zone of mycelial mat ocher-green under UV light . . . *X. affine*
3. Guaicol spot test negative; inner zone of mycelial mat dingy purple to violet . . . .*X. montaltoensis*

CULTURE DESCRIPTIONS

Xanthoconium affine (Peck) Singer. 1944. Mycologia 36: 362.

≡ *Boletus affinis* Peck. 1873. Annual Rep. New York State Mus. 25: 81.

FIGS. 1, 5

MACROSCOPIC CHARACTERISTICS: Mycelial mat 3.2-6 cm, surface white, reverse pale cream (4A2), pigment diffusion into agar absent, surface heterogeneous, aerial hyphae development moderate, zonate inner 1 cm, surface exudates none, yellow-green in outer zone and ocher-green in inner zone under UV light.

MAT MACROCHEMISTRY: $FeSO_4$ positive, pale yellow-green; NH_4OH and HCl negative.

MICROSCOPIC CHARACTERISTICS: Hyphae (2.6-)3(-6.4) µm diam., pale yellow in KOH, gold in Melzer's reagent, hyphal cytoplasm blue and walls hyaline in cotton blue, dikaryotic, outer zone hyphae mostly filamentous with little vesicular differentiation, inner zone hyphae differentiated with septate vesicular swellings (9.1-) 11.2(-14.3) µm diam., hyphal branching mostly subseptal, very rarely paarige; cytoplasm lipid positive, black in Sudan Black-B and red in Sudan IV, lipoidal bodies small to quite large, random, many localized in vesicular cells.

EXTRACELLULAR OXIDASE TESTS: gum guaiac, L-tyrosine, tannic acid agar, and syringaldazine negative; guaiacol positive, faint pink; phenol positive, vinaceous to rust-brown.

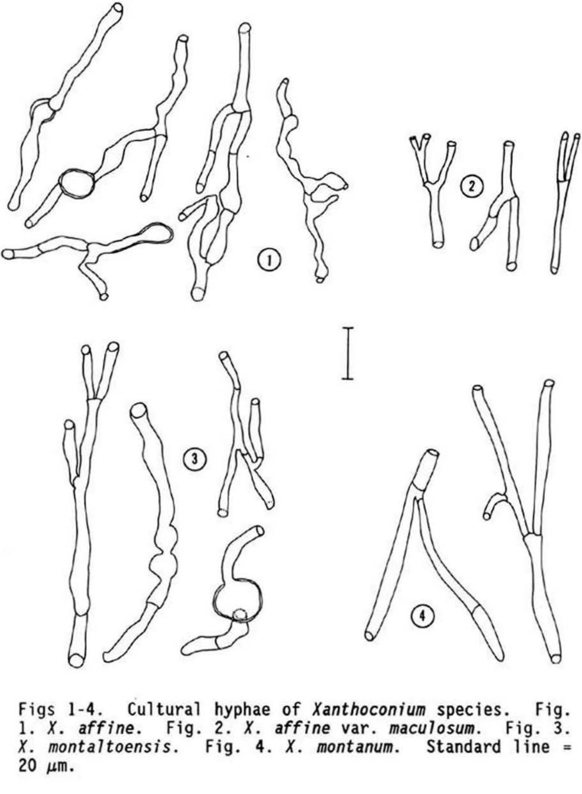
NOBLE'S KEY CODES: 1.6.7.26.32.36.47.49.56.

CULTURES EXAMINED: CBW-1671.

DISCUSSION. $FeSO_4$, guaiacol, and phenol mat spot tests were all positive as were the Sudan Black-B and Sudan IV microchemical tests. Of these, the phenol and guaiacol spot tests were unique and were of diagnostic value.

Xanthoconium affine var. *maculosum* (Peck) Singer. 1947. Amer. Midl. Naturalist 37: 89.

≡ *Boletus affinis* var. *maculosum* Peck. Annual Rep. New York State Mus. 32: 57.



Figs 1-4. Cultural hyphae of *Xanthoconium* species. Fig. 1. *X. affine*. Fig. 2. *X. affine* var. *maculosum*. Fig. 3. *X. montaltoensis*. Fig. 4. *X. montanum*. Standard line = 20 μm.

FIGS. 2, 6

MACROSCOPIC CHARACTERISTICS: Mycelial mat (2.8-)3 (-3.5) cm, surface white, reverse white to "yellowish white" to "pale yellow" (4A2,3), pigment diffusion into agar absent; surface zonate, inner zone with moderate aerial hyphae development, cottony, outer zone mostly submerged becoming progressively emergent toward the center; surface exudates absent; inner zone cinnamon colored, middle zone yellow-cinnamon colored, outermost zone pale yellow under UV light.

MAT MACROCHEMISTRY: $FeSO_4$, NH_4OH, and HCl negative.

MICROSCOPIC CHARACTERISTICS: Hyphae (1.5-)2.7(-4) µm diam., hyaline in KOH, hyaline to ocher yellow in Melzer's reagent, contents irregularly blue and walls hyaline in cotton blue, reagent positive contents scattered to gregarious in Melzer's reagent and cotton blue; dikaryotic; hyphal septation simple and distant; clamp connections absent; cytoplasm lipid positive, black in Sudan Black B and red in Sudan IV, lipoidal bodies randomly scattered and aggregated.

EXTRACELLULAR OXIDASE TESTS: guaiacol, gum guaiac, L-tyrosine, phenol, tannic acid agar, and syringaldazine tests negative.

NOBLE'S KEY CODES: 1.6.7.36.38.47.

CULTURES EXAMINED: CBW-1996.

DISCUSSION. Cultures of this taxon differ from those of *X. affine* in several ways. Mycelial mat reverse color is cream in *X. affine* but white in *X. affine* var. *maculosum*. Three color zones under UV light are evident in *X. affine* var. *maculosum* while two zones are evident in *X. affine*. Vesicular swellings are present in *X. affine* but absent in *X. affine* var. *maculosum*. Clearly there are differences between the two varieties of this taxon but the cultural differences do not appear significant enough to elevate this taxon to specific rank.

Xanthoconium montaltoensis Wolfe. 1987. Can. J. Bot. 65: 2143.

FIGS. 3, 7

MACROSCOPIC CHARACTERISTICS: Mycelial mat 5.4-6 cm diam., surface cream white, reverse pale cream yellow (3,4A2), pigment diffusion into agar absent, zonate inner 1 cm, surface heterogeneous, hyphae mostly submerged, aerial hyphae few, surface exudates none; yellow-green on submerged outer zone, light yellow on middle zone, and dingy purple to violet on inner zone under UV light.

MAT MICROCHEMISTRY: $FeSO_4$ positive, yellow-green; NH_4OH and HCl negative.

MICROSCOPIC CHARACTERISTICS: Hyphae (2.6-)4.2(-5.2) µm diam., pale yellow in KOH, gold to dark gold in Melzer's reagent, cytoplasm blue and walls hyaline in cotton blue, dikaryotic, inner zone vesicular hyphae (7.8-)14(-20.8) µm diam. and mostly non-septate, branching subseptal and interseptal; cytoplasm lipid positive, black in Sudan Black-B and red in Sudan IV, lipoidal bodies sparse in Sudan IV but more dense in Sudan Black-B.

EXTRACELLULAR OXIDASE TESTS: guaiacol, gum guaiac, and L-tyrosine, phenol, syringaldazine, and tannic acid agar negative.

NOBLE'S KEY CODES: 1.6.26.32.36.38.47.49.53.56.

CULTURES EXAMINED: CBW-1675.

DISCUSSION. Mature basidiomata of *Xanthoconium montaltoensis* and *X. affine* may appear similar but cultures of these taxa differ by the absence of positive guaiacol and phenol spot tests in the former. Additionally, the inner zone of the mycelial mat in *X. affine* is ocher-green under UV light while the inner zone of *X. montaltoensis* is dingy purple to violet under UV light. The zonate patterns and the vesicular hyphae are similar for both species. The cultural character differences observed for these species provide additional support for the recognition of *X. montaltoensis*.

Xanthoconium montanum Wolfe. 1987. Can. J. Bot. 65: 2144.
FIGS 4, 8

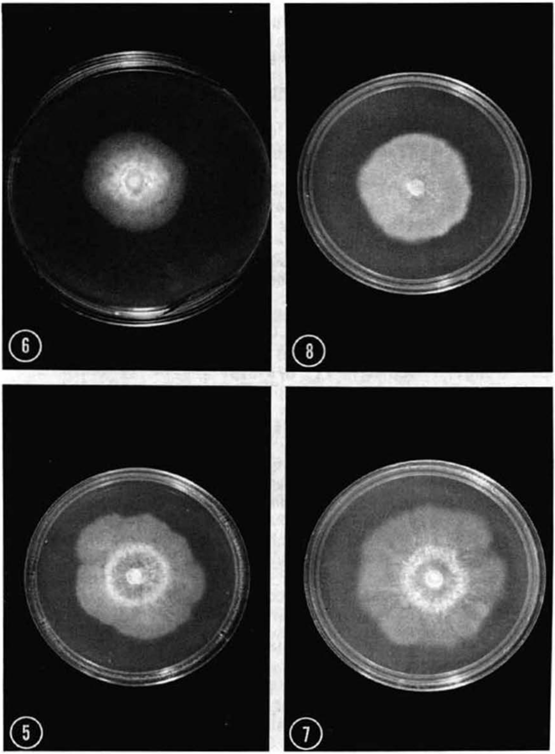
MACROSCOPIC CHARACTERISTICS: Mycelial mat 3.1-4.5 cm diam., surface white, reverse pale yellow (4A2), pigment diffusion into agar absent, uniform, zonation absent, aerial hyphae well developed, fluffy, cottony, surface exudates absent, yellow-green overall under UV light.

MAT MACROCHEMISTRY: $FeSO_4$ positive, yellow-green; NH_4OH and HCl negative.

MICROSCOPIC CHARACTERISTICS: Hyphae (2.6-)4.4(-9.1) µm diam., hyaline in KOH, pale gold in Melzer's reagent, cytoplasm blue and walls hyaline in cotton blue, dikaryotic, subseptal branching only; cytoplasm lipid positive, black in Sudan Black-B, pink to purple-red in Sudan IV, lipoidal bodies mostly small (rarely large), spherical, singular or in staphylococcal form.

EXTRACELLULAR OXIDASE TESTS: phenol positive, vinaceous purple; guaiacol, gum guaiac, tannic acid agar, L-tyrosine, and syringaldazine negative.

NOBLE'S KEY CODES: 1.6.7.32.36.38.47.49.56.



Figs. 5-8. Cultures of *Xanthoconium* species. Fig. 5. *X. affine*. Fig. 6. *X. affine* var. *maculosum*. Fig. 7. *X. montaltoensis*. Fig. 8. *X. montanum*.

CULTURES EXAMINED: CBW-1489 (HOLOTYPE).

DISCUSSION. The cultural characteristics of this taxon were relatively unremarkable except for the abundant aerial hyphae development, and there was little hyphal differentiation. The lipoidal bodies in the hyphae were remarkable in that they occurred in staphylococcal form.

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HYPHOMYCETES FROM CANADIAN STREAMS.
II. THREE NEW TAXA

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Abstract

Miniancora allisoniensis gen. et sp. nov., *Arborispora paupera* sp. nov. and *Flagellospora saccata* sp. nov. are described from acid streams in Canada.

Introduction

This is the second part of a study on freshwater hyphomycetes isolated from soft water streams in SE New Brunswick, Canada, and adjacent areas of Nova Scotia. Three new taxa were isolated from foam. A single conidium of *Miniancora allisoniensis* was observed during the original field study (April - May 1987); subsequently, morphologically identical conidia were observed repeatedly in the autumn of 1988. Conidia of *Arborispora paupera* were found on two occasions in Allen Creek. *Flagellospora saccata* appears to be the most common of the three species. It was isolated from three localities, and conidia indistinguishable from *F. saccata* were moderately abundant in foam samples.

Materials and Methods

All cultures were obtained as monoconidial isolates from freshly collected stream foam, as described by Marvanová & Bärlocher (1988). They were maintained on 1.5 % Difco Malt Agar (MA) at 10 or 12 ^{0} C. Sporulation was induced by submerging a section of the culture in standing or aerated distilled water; in *Arborispora paupera* intermittent wetting of the culture resulted in abundant sporulation.

Miniancora Marvanová et Bärlocher, gen. nov.

Etym.: mini: abbreviated from *minimus* (L.) = smallest; *ancora* (L.) = anchor.

Deuteromycetes, Moniliales. Hyphae hyalinae, ramificatae, septatae. Conidiophora singularia, plerumque apicalia, simplicia vel ramosa, hyphis valde similia. Cellulae conidiogenae incorporatae, mono vel polyblasticae, sympodialiter prolificantes, cum collari inconspicuo. Conidia T-formia, septata, cellula apicalis cum ramis duobus dichotomis, in maturitate vacua.

Species typica: *Miniancora allisoniensis*

Hyphae hyaline, branched, septate. Conidiophores single, mostly apical, simple or branched, flexuous. Conidiogenous cells integrated, mono to polyblastic, sympodial, with inconspicuous frill. Conidia T-shaped, septate, apical cell typically divided into two dichotomous branches, empty when mature.

Miniancora allisoniensis Marvanová et Bärlocher, sp. nov. (Figs. 1-3).

Etym.: *allisoniensis* (L.) to mark the sesquicentennial of Mount Allison University, where this study was carried out.

Coloniae aurantiacae, in agaro maltoso lente crescentes, restrictae, mycelium aerium delicatum, pubescens, subtiliter funiculosum in parte centrali coloniae; hyphae hyalinae, tenuitunicatae, 1-2 µm diam.; mycelium in agaro e hyphis densiter consertis, nonnumquam crustas formantibus, usque ad 3.5 µm latis, crassitunicatis, cum materia amorpha aurantiaca obtectis. Conidiophora apicalia vel lateralia, simplicia vel ramosa, usque ad 1.5 µm lata, nonnumquam absentia. Cellulae conidiogenae apicales, raro intercalares in hyphis, singulares, typice polyblasticae, cum elongationibus sympodialibus provisae, loci conidiogeni vulgo cum collari inconspicuo circumdati. Conidia singulatim formata, saepe aggregata, acrogena, raro pleurogena, T-formia; pars infra ramos recta vel paulo curvata, 23-40 x 1-1.5 µm, e 3-6 cellulis lucidis composita, basi truncata vel conica, apice attenuata, cellula apicalis in maturitate vacua, cum ramis duobus dichotomis, acutis, 9-23 x 0.5 µm, horizontalibus vel subantrorsis, pariete exiliter sinuoso.

Habitat: In spuma in rivulo parvo prope viam publicam haud procul a pago Sackville dicto, in provincia New Brunswick, Canada austro-orientalis. In Maio 1987 leg. L. Marvanová.

Holotype: IMI 328552 (ex 30487)

Colonies (Malt Extract Agar = MA) orange, growing slowly, 10 µm diam./30 days/12 °C, restricted, tough; aerial mycelium delicate, downy, finely funiculose in the colony centre, hyphae hyaline, thin-walled, 1-2 µm wide; substrate mycelium consisting of densely packed hyphae sometimes forming crusts, up to 3.5 µm wide, thick-walled, covered with amorphous orange matter. Sporulation abundant on agar and in standing water, at and below water level. Conidiophores densely covering the colony surface, apical or lateral, simple or branched, up to 1.5 µm wide, sometimes absent. Conidiogenous cells apical, rarely intercalary in vegetative hyphae, single, typically polyblastic, elongations

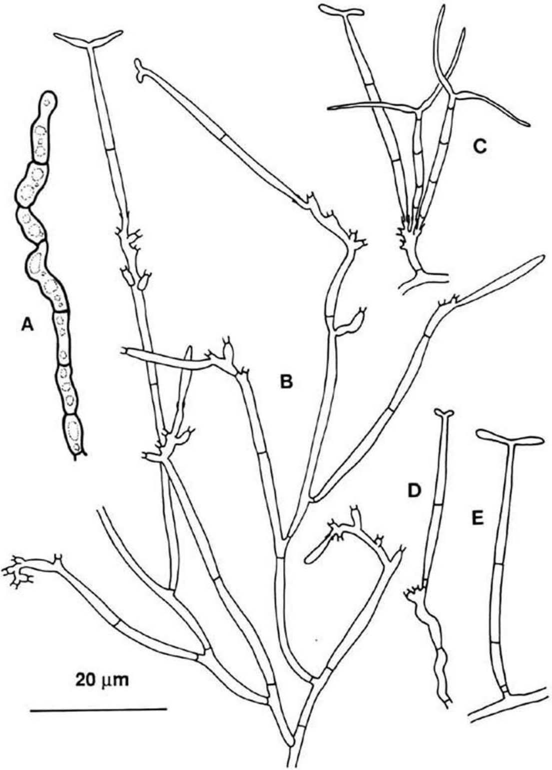

Fig. 1. *Miniancora allisoniensis,* 30487, submerged culture. A, substrate mycelium with inflated cells; B, branched conidiophore with sympodial elongations and frilled conidiogenous loci; C, short conidiophores with aggregated condidiogenous loci; D,E, developing conidia with separating cells (?) at the base.

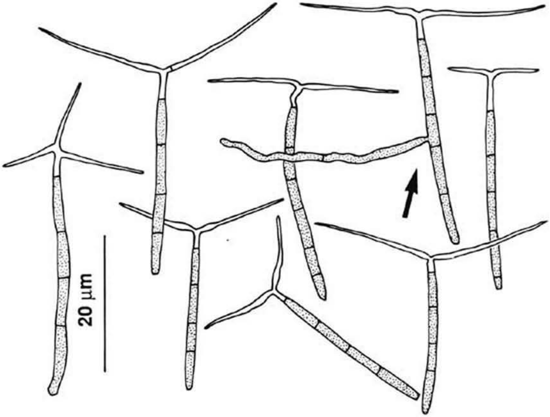

Fig. 2. *Miniancora allisoniensis*, 30487, submerged culture. Detached conidia, one germinating from the axis (arrow). Dotted parts are filled with cytoplasm.

sympodial, often unilateral, forming short branchlets (Fig. 1B) or appearing side by side on a thickened part of the conidiogenous cell (Fig. 1C); conidiogenous loci usually surrounded by an inconspicuous frill. Conidia formed singly, later aggregated, acrogenous, rarely pleurogenous, T-shaped or very rarely with an apical branch and two laterals (Fig. 2A), unbranched part straight or slightly curved, 23-40 x 1-1.5 µm, consisting of 3-4 shiny cells; truncate or shortly conical at the base, narrowed at the apex below the branches; apical cell devoid of cytoplasm at maturity, divided into two horizontal dichotomous branches attenuated distally, 9-23 x 0.5 µm, with slightly wavy outline. The conidial size seems to change with age; smaller conidia (23-33 µm long) were seen in a culture submerged for 4 days, whereas longer conidia (30-40 µm) prevailed in the same dish after 14 days. The conidial branches are cellular (sensu Sutton 1980) in origin and are filled with cytoplasm during maturation; evacuation takes place before secession.

The actual type of conidiogenesis could not be established with certainty. The thin frills around the conidiogenous loci may either be collarettes of phialides or wall remains of disarticulated separating cells. Structures resembling separating cells were seen

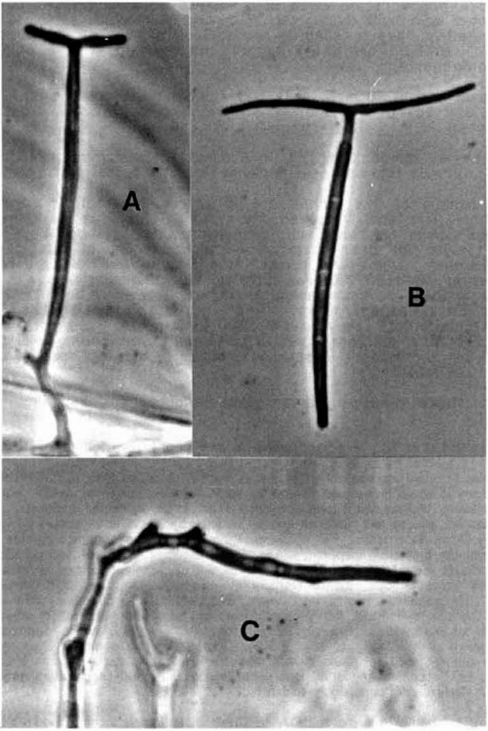

Fig. 3. *Miniancora allisoniensis*, 30487. A, developing conidium; B, detached conidium; C, spent conidiophore (approx. 1,850 x).

at the base of some developing conidia (Fig. 1 D, E), however, the corresponding cell wall remnants which should be present at the conidial bases in the case of rhexolytic secession could not be detected with light microscopy. On the other hand, some conidia appeared to have a collarette around their base when still attached (Fig. 1 B, C). This would support the hypothesis of a phialidic conidiogenesis.

On agar and at 20 ° C, detached conidia germinated within 24 h from any cell of the unbranched part and occasionally from the branches.

Cultures examined: 30487, from a small unnamed stream near the Trans Canada Highway near Sackville, May 1987, isol. L. Marvanová.

The conidia of this fungus are similar to those of *Trinacrium* Hoehnel. The latter, however, are mostly Y-shaped and wider, and all their cells are filled with cytoplasm. Conidiogenous cells with frills have not been reported in any species of this genus. *Hyalotiella americana* (Speg.) Nag Raj as well as *Libartania laserpitii* (Bresad.) Nag Raj have conidia of similar size with two (dichotomous) or more apical branches. However, both taxa are pycnidial coelomycetes. The conidiogenous cells are asynchronously polyblastic in *Libartania laserpitii* and symmpodially proliferating in *Hyalotiella americana*. Frills have not been reported or illustrated in either of the two species (Nag Raj 1979 a,b).

Arborispora paupera Marvanová et Bärlocher, sp. nov. (Figs. 4, 5, 6 C, D)

Etym.: *pauper* (L.) = poor (refers to the simple branching of conidia)

Coloniae in agaro maltoso perleniter crescentes, restrictae, pallidae, postea brunneae, praecipue in agaro immersae, glabrae vel valde rugosae, mycelium aerium sparsum, funiculosum, hyphae tenui tunicatae circa 1 µm latae, hyalinae, ramificatae, rami alternati vel subopposìti. Cellulae inflatae usque ad 2.5 µm latae adsunt in hyphis. Conidiophora inconspicua vel absentia. Cellulae conidiogenae incorporatae, per longitudinem hypharum dispersae vel in hyphis fertilibus catenatae; loci conidiogeni in denticulis lateralibus singulis vel gregariis 1-2 µm longis, interdum ex inflatione hyphae ecrescentibus, locati. Conidia singularia vel aggregata, in denticulis singulatim crescentia, typice tetraradiata; axis rectus, raro curvatus, (20-) 40-70 x 1.8-2.5 µm, cylindricus vel anguste fusoideus, basi truncatus, apice subulatus, usque ad 8-septatus; rami (0)1-2(4), usque ad 4-septati, typice oppositi vel subopposìti, raro remoti, 10-35 x 1.5-2 µm, prope partem centralem axis inserti, typice retrorsi, recti vel paulo curvati, anguste fusoidei, in parte proxima interdum inflati, basi gradatim angustati, insertione constricti. Ramus secundarius rarissime videtur. Dehiscentia conidiorum schizolytica.

Habitat: In spuma in rivulo acido Allen Creek dicto, prope locum Wood Point, in provincia New Brunswick, Canada austro-orientalis, in Aprili 1987 leg. L. Marvanová et F. Bärlocher.

Holotype: IMI 328550 (ex 28387)

Colonies (MA) growing extremely slowly, 2-4 mm diam./30

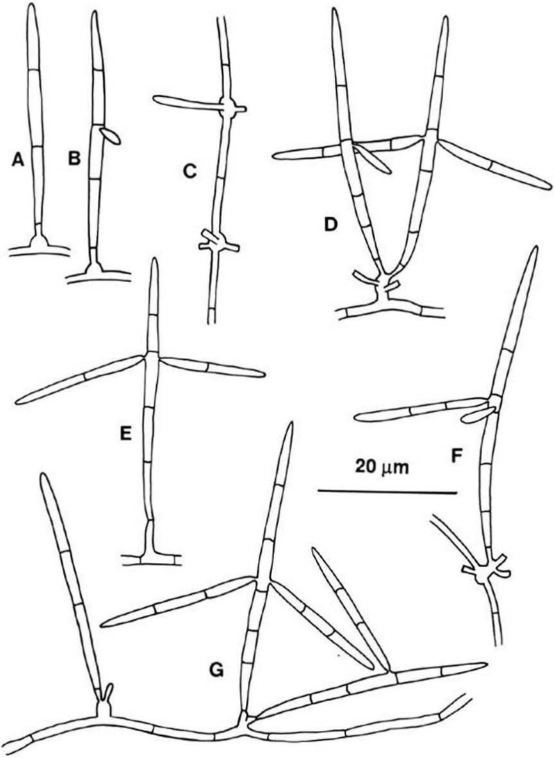

Fig. 4. *Arborispora paupera*, 28387. Developing conidia. Detailed explanation in text.

days/10-12 ° C, restricted, beige, becoming brownish with age, smooth or wrinkled, mostly immersed in agar; aerial mycelium sparse, funiculose. Hyphae thin-walled, ca. 1 µm wide, hyaline, branched, branches alternate or subopposite. Inflated cells up to 2.5 µm wide may occur in hyphae. Sporulation upon submergence, but above water, promoted by intermittent wetting. Conidiophores micronematous; conidiogenous cells integrated, intercalary, scattered or catenate in a fertile hypha, with conidiogenous loci on single or multiple denticles situated laterally on conidiogenous cells (Fig. 4 A, B, E) or on a short stalk (Fig. 4 D, F, G) or growing from a central inflation on the conidiogenous cell (Fig. 4 C). Conidia are formed singly, the primordia are rod-like, straight, later delimited by a septum situated 1-2 µm above the base of the primordium; the lower part becomes the denticle (Fig. 4 A). Branches appear laterally, in sequence, ca 15-18 µm below the apex of the axis (Fig. 4 B). Free conidia floating on water surface, axis straight, rarely slightly curved, (20-) 40-70 x 1.8-2.5 µm, cylindrical or narrowly fusoid, base truncate, apex subulate, septa up to 8; branches (0)1-2(4), up to 4-septate, opposite or nearly so (Fig. 5 B, E, G, H), sometimes both on one side (Fig. 4 F), rarely remote (Fig. 5 C) or in two superposed pairs, sometimes two opposite and one remote (Fig. 5 I), 10-35 x 1.5-2 µm, one usually shorter, inserted near the middle of the axis, narrowly fusoid with basal cells sometimes inflated, gradually tapering towards the point of attachment. On rare occasions, a secondary branch may be present (Fig. 5 D). Conidial secession schizolytic, germination from all free ends, on agar or in water.

Culture examined: 28387, from Allen Creek, April 1987, isol. L. Marvanová.

Conidia very similar to those of our species but with dimensions near the lower limit of *A. paupera* and with branches drawn antrorse are depicted as unknown by Matsushima (1975, Pl. 336, Figs. 2, 4).

Arborispora Ando (Ando & Kawamoto 1986) was established for three staurosporous species collected in humid habitats: from fallen leaves or from rainwater draining from a broad-leaved tree. They all grow rather slowly in pure culture (Miura & Kudo 1970); sporulation is promoted by submerging a piece of the culture in distilled water but occurs predominantly on exposed areas above water; the conidia are borne on micronematous conidiophores and consist of an axis and branches originating laterally near the middle of the axis. Branches may be primary, secondary, or, in the authors' words "second primary", i.e., originating near the point of attachment of the so called "first primary branches". All branches have tapering bases with a very narrow insertion point. The proximal cells of the branches and, in some species, of the axis may be slightly inflated. *A. paupera* is linked to other species of this genus by several features: The very slow growth of the colony resembles *A. multisurcularis* Ando and *A. dolichovirga* Ando; the brownish colour of the colony is shared by *A. multisurcularis*; the conidial dimensions approximate those of *A. dolichovirga*; the occasionally inflated basal cells of the branches and axis resemble those seen in *A. palma* Ando. *A. paupera* differs from all other

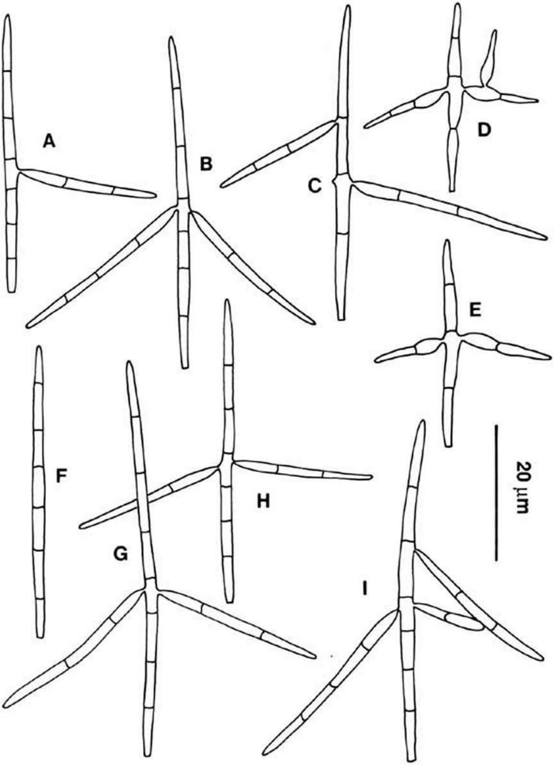

Fig. 5. *Arborispora paupera*, 28387. Detached conidia. Detailed explanation in text.

species of this genus by the lack of second primary branches and by the predominantly retrorse orientation of the laterals. The degree of branching in staurosporous anamorph genera usually varies within a genus from simple to more profuse. Examples can be found in *Dendrospora* Ingold, *Tricladium* Ingold, and *Gyoerffyella* Kol. *Descalsia cruciata* Roldán et Honrubia (sp. ined., Roldán in litt.) has cruciform conidia of similar size borne on micronematous conidiophores. However, the conidial branch bases are not constricted, the branches arise synchronously and subapically in contrast to their clearly lateral and sequential origin in *A. paupera*. This species is probably adapted to habitats that periodically dry up. Conidia matching the shapes seen in the field were obtained by briefly exposing a piece of culture to dry conditions. Under constantly moist conditions, the culture did sporulate on the area outside the water, but the conidia were much smaller and their branches, sometimes also their axis, had inflated basal cells (Fig. 5 D, E).

Flagellospora saccata Marvanová et Bärlocher, sp. nov. (Figs. 6 A, B; 7, 8).

Etym.: *saccatus* (L.) = bag-shaped, refers to the phialides.

Coloniae in agaro maltoso leniter crescentes, albidae, glabrae vel subtiliter pubescentes, densae, hyphae 1-2 µm latae, margine coloniae undulatae; cellulae inflatae, tenuitunicatae, catenatae, usque ad 5 µm latae, in parte senescente coloniae observantur. Conidiophora singularia, apicalia vel raro lateralia, usque ad 75 µm longa, simplicia vel parce ramosa, saepe modo vario flexa, septata, cellulis saepe inflatis; nonnumquam absentia. Cellulae conidiogenae phialidicae, singulares vel binae, apicales, laterales vel raro intercalares, saepe curvatae, inflatae et nonnumquam asymmetricae, 7-20 x 3-5 µm, cum collo 2-5 µm longo, interdum recurvo; collare breve, cylindricum vel infundibuliforme, inconspicuum. Conidia singularia, apicalia vel lateralia ubi e phialidis intercalaribus ecrescentia, filamentosa, sigmoidea vel arcuata, basi et apice attenuata, (35-)55-87 x 1.8-2.5 µm, ex eodem loco repetiter crescentia, 3-8 septata. Dehiscentia schizolytica.

Habitat: In spuma in rivulo acido St. George Creek dicto, haud procul a loco Fenwick dicto, in provincia Nova Scotia, Canada austro-orientalis; in Aprili 1987 leg. L. Marvanová et F. Bärlocher.

Holotype: IMI 328551 (ex 18987)

Colonies (MA) whitish to creamy, growing very slowly, restricted, 9 mm diam./30 days/10 °C, glabrous or very finely downy, tough, hyphae 1-2 µm wide, marginal hyphae typically undulate even when growing in water; inflated thin-walled cells (Fig. 7 F, H) up to 5 µm diam., catenate, appear in hyphae in older parts of the colony. Sporulation sparse after 8 days in standing distilled water at 10 °C, underwater. Conidiophores apical, rarely lateral, simple or sparsely branched, often variously curved, up to 75 µm long, septate, often with slightly inflated cells; sometimes absent. Conidiogenous cells phialidic, single or paired, apical, lateral or intercalary, sometimes with a lateral conidiogenous locus (Fig. 7 A, F); asymmetrically inflated and often slightly curved, 7-20 x 3-5 µm, with a 2-5 µm long, occasionally recurved neck (Fig. 8 I, J) with periclinal thickening and a short, cylindrical or cup-shaped

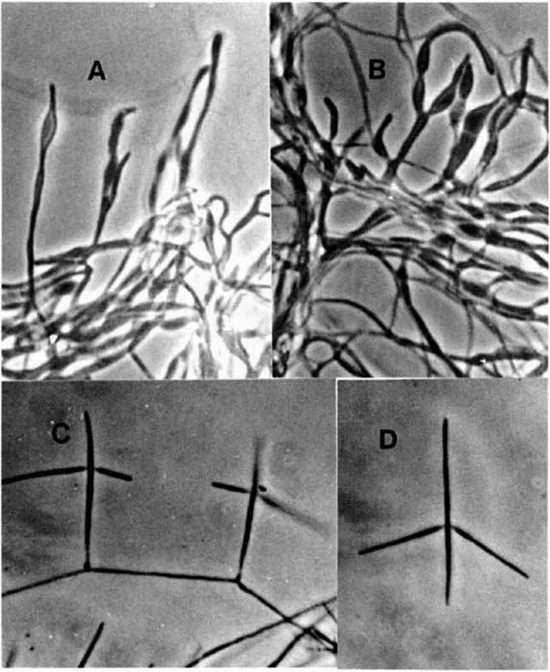

Fig. 6. *Flagellospora saccata*, 18987. Submerged culture. A, D, E, G, developing conidia; B, young phialides; C, F, conidiophores with spent phialides; F, H, chain of inflated cells.

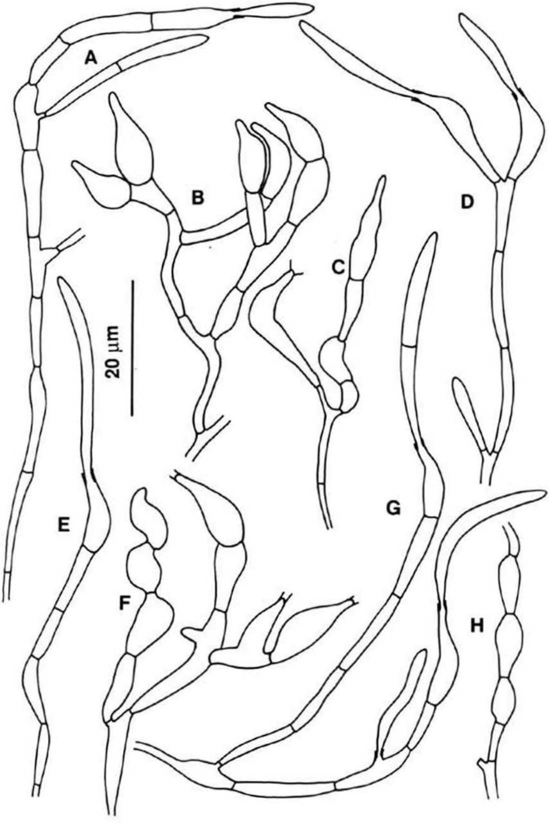

Fig. 7. *Flagellospora saccata,* 18987. Submerged culture. A-H, condidia; I-M, spent phialides.

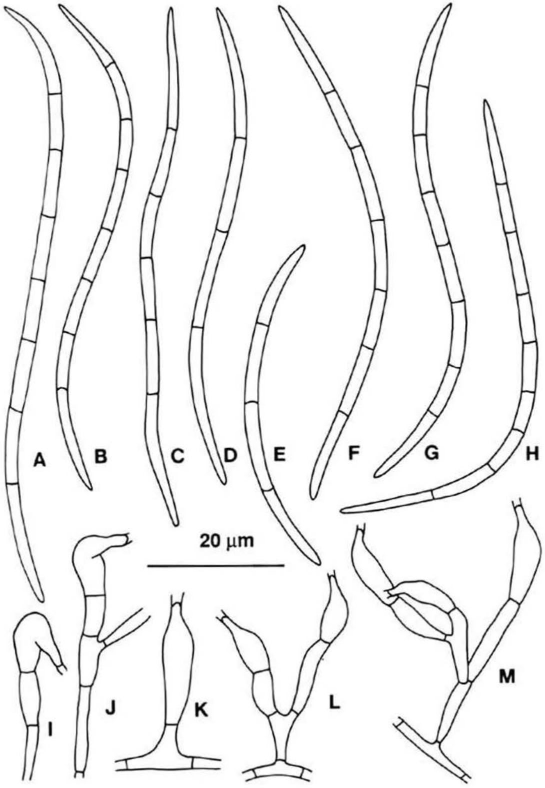

Fig. 8. A, B, *Flagellospora saccata*, 18987. Inflated phialides with long necks; approx. 600 x. C, D, *Arborispora paupera*, 28387. C, developing conidia; D, detached conidia; approx. 860 x.

collarette. Conidia single, apical, rarely lateral, when produced on intercalary phialides, filamentous, sigmoid or arcuate, attenuated towards both ends, (35-)55-87 x 1.8-2.5 µm, septa 3-8 (Fig. 8, A-H). Secession schizolytic, germination from both ends in water and on agar.

The morphology of the conidiophore stalks indicates that they may consist of proliferated phialides; the presence of lateral necks on some phialides supports this view.

Cultures examined: 13887, 18987, from St. George Creek, Nova Scotia, April 1987, isol. L. Marvanová; 22287, from Allen Creek, New Brunswick, April 1987, isol. L. Marvanová.

There are six described species in *Flagellospora*: two with conidia up to ca. 120 µm long (*F. curvula*, Ingold 1942 and *F. leucorhynchos*, Marvanová1986), three with conidia up to 55 µm long (*F. minuta*, Iqbal & Bhatty 1980, *F. penicillioides*, Ingold 1944 and *F. stricta*, Nilsson 1962) and one with conidia of dimensions matching our new species (*F. fusarioides*, Iqbal 1974). The latter, however, differs by having darker, almost cinnamon-coloured colonies and profusely penicillately branched conidiophores with more numerous (up to 5) phialides per branch. The main feature distinguishing our new species from all *Flagellospora* spp. is the presence of apparently inflated, long-necked phialides, which clearly differ from the slender structures, mostly without collarette and periclinal thickening, known from the other species.

The other waterborne conidia of similar size and shape are not produced by phialidic conidiogenous cells. It is almost impossible to identify *F. saccata* reliably on the basis of loose conidia from field samples.

Acknowledgements

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DISCOSIOSPORA CEANOTHI, A NEW COELOMYCETE

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In October, 1987, living leaves of *Ceanothus fendleri* Gray were collected and stored under moist conditions in a refrigerator until March, 1988. A new Coelomycete with 4-celled, appendaged conidia was found on the leaves. The fungus was isolated onto potato dextrose agar (PDA) for study in culture.

Discosiospora gen. nov.

Conidiomata pycnidia, separata vel interdum confluentia, subepidermalia, emergentia, aliquantum globosa depressa, brunnea, unilocularia, ostiolata; paries ex textura angulari tenuipariete compositus. Conidiophora absentia. Cellulae conidiogenae holoblasticae, determinatae, discretae, terminales, cum conidio singulari terminali. Conidiogenesis primum in conidioma summa, tum in conidioma ima reperta. Conidia dorsiventralia, tenuiparietes, tetracellulae, cellula apicalis et basalis setam subapicalem et suprabasalem insertam in latere concavo conidii ferens, appendix basalis exogena.

Sp. typ. D. ceanothi Ramaley

Conidiomata pycnidial, separate or occasionally confluent, subepidermal, emergent, somewhat depressed globose, brown, unilocular, ostiolate; wall composed of thin-walled textura angularis. Conidiophores absent. Conidiogenous cells holoblastic, determinate, discrete, terminal, with a single terminal conidium. Conidiogenesis found first at the top, then the base of the conidioma. Conidia dorsiventral, thin-walled, 4-celled, the apical and basal cell bearing a subapical and suprabasal appendage inserted on the concave side of the conidium; basal appendage exogenous.

Other genera with 4-celled conidia bearing appendages on both terminal cells include *Doliomyces* Steyaert *emend* Nag Raj & Kendrick (1), *Seimatosporium* Corda (2,3,6), *Seimatosporiopsis* Sutton, Ghaffar & Abbas (7), *Discosia* Libert(4), and *Ciliochorella* Sydow (5). Four of these genera may be easily separated from *Discosiospora*. *Ciliochorella* has phialidic conidiogenesis, an apical and a lateral appendage on the apical cell, and a single appendage on the basal cell. *Seimatosporium* has acervular conidiomata, annellidic conidiogensis, and the number and branching of the conidial appendages is variable and irregular. *Seimatosporiopsis* has immersed pycnidial conidiomata, conidiogenesis is annellidic, and the number and branching of conidial appendages is variable. *Doliomyces* has non-ostiolate, black, pycnidial conidiomata, and each conidium has a several-branched apical appendage, a simple basal appendage, and different sized middle cells. In addition, all these genera have thicker conidial appendages than does *Discosiospora*. The relationship of *Discosiospora to Discosia* must be considered in greater detail because conidia of the two genera are similar, and distinct from conidia of other taxa.

Discosiospora has a composite of the characters used by Subramanian and Chandra-Reddy to separate sections of *Discosia* (4). The middle cells of *Discosiospora* conidia are of more or less equal length, as is true in *Discosia* of Section *III*. The hair-like appendages of *Discosiospora* arise from a tiny bulge at approximately the middle of the terminal cells (Fig. 1. c,e). The appendages of *Discosia*, Section I, usually originate from a minute bulge near the septa on both ends of the conidium, while those of Sections II-IV, originate just below the apices of the end cells.

Subramanian and Chandra-Reddy (4) provide a generic description for *Discosia* including statements that: conidiomata are usually amphigenous, black, discoid; upper half sterile, brittle, and the lower half fertile; vertical columns of sterile hyphae usually present extending from base to top all round the margin or also in between, dividing the pycnidial cavity into compartments. It is also stated (4, p. 60) that in his study of conidium development and conidiogenous cell behavior, Morgan-Jones found a conidiogenous cell bore 2 conidia. After release of the first conidium, formed from the blown out apex of a conidiogenous cell, a second conidium was formed at a higher level resulting in one annellation. A minute frill was seen at the base of the conidium with phase contrast optics. In many cases, however, he noted only one conidium developed on each conidiogenous cell.

Discosiospora differs from *Discosia* in many characteristics included in the generic description. Conidiomata: are (a) epiphyllous in this single collection, (b) brown, (c) subglobose, and, (d) fertile over the entire inner surface successively from top to bottom; (e) have a soft, not brittle upper surface, and; (f) lack vertical columns of sterile hyphae from base to top. In addition, *Discosiospora* is distinguished from most Coelomycetes, including *Discosia*, by its possessing paraphyses or paraphysis-like outgrowths in areas where conidium formation is complete.

Conidial ontogeny, a major taxonomic consideration, also separates *Discosiospora* from *Discosia*. The annellophores in *Discosia* usually bear 2 conidia, the second at a higher level than the first, resulting in conidiogenous cells with one annellation (4). No annellations were seen on the conidiogenous cells of *Discosiospora*. A minute ridge was present on the basal cell of some spores.

T. R. Nag Raj (personal communication), has illustrated *Discosia* species (unpublished) with some characters that have been used here to distinguish *Discosiospora*--the presence of non-discoid conidiomata, and conidiomata bearing conidia over the entire surface of the conidiomatal cavity. However, the illustrations show annellidic conidiogenesis, sometimes on branched conidiophores. The existence of these taxa with some characteristics of both *Discosia* and *Discosiospora* suggests *Discosiospora* may eventually best be treated as a species of *Discosia*. Such a treatment may be preferred when additional intermediate taxa allow expansion of the generic concept to include forms with (a) conidiomata which are epiphyllous or amphigenous, brown or black, subglobose or discoid, soft or brittle, and paraphysate or aparaphysate, (b) conidiogenesis that is annellidic or holoblastic with one conidium per conidiogenous cell, and, (c) discrete or integrated conidiogenous cells on all surfaces of the conidiomatal cavity or only on the bottom surface. With the present generic concept, it would seem preferable to separate *Discosiospora* from *Discosia*.

Discosiospora ceanothi sp. nov. (Fig. 1, a-f)

Conidiomata pycnidia, epiphylla, separata vel interdum confluentia, subepidermalia, emergentia, in juventa complanata, extrinsecus per crescentiam expansa, aliquantum matura sublobosa, unilocularia, ostiolata, juvena diluto fulvo, atrobrunnea circum ostiolum evolvens, gradatim brunnescentes per maturationem ex ostiolo ad basem, usque ad 320 *µm diam, plerumque* 170-220 *µm; ostiolum parvum, singulare, circulare, papillatum, centrale vel excentricum* 10-15 *µm diam; paries ex textura angulari tenuipariete compositus,* 6-8 *cellulis crassis supra,* 4-6 *cellulis crassis infra. Cirri diluto fulvo. Conidiophora absentia. Cellulae conidiogenae* 7-10 *x* 2-3 *µm, holoblasticae, determinatae, discretae, terminales, hyalinae, leves, cylindricae vel lageniformes elongatae cum conidio singulari terminali. Conidia in superficiebus omnibus interioribus conidiomatorum formata. Conidiogenesis primum in conidioma summa, tum in conidioma ima reperta. Paraphyses usque ad* 50 *x* 1-1.5 *µm supra conidiomatis tum orientes. Conidia tetracellulae,* (16-)18-23(-27) *x* 3-4 [$\bar{x}$=21.3 *x* 3.4] *µm, dilute aureobrunnea, tenuiparietes, dorsiventralia,* 2 *cellulae mediae* (10-)12-15(-17) [$\bar{x}$=13.8] *µm, cellulae terminales obtuse rotundatae vel cellula basalis aliquando truncata cum costa minuta basali, cellulae apicalis et basalis setulam bifurcatam suprabasalem et subapicalem affixam circa in pariete medio in latere concavo conidii ferentes, utraque furca ca* 12-20 *µm longa, appendix basalis exogena.*

Holotypus: Ex foliis Ceanothus fendleri Gray, Hermosa Trail, *ca* 0.5 miles *ex initio*, La Plata Co., CO., U.S.A., A. W. Ramaley, October, 1987, BPI 72043.

Conidiomata pycnidial, epiphyllous, separate or occasionally confluent, subepidermal, emergent, flattened when young, expanding outward during development, somewhat depressed globose at maturity, unilocular, ostiolate, pale tan when young, dark brown around the developing ostiole, gradually browning during maturation from the ostiole toward the base, up to 320 µm in diam, mostly 170-220 µm; ostiole small, single, circular, papillate, central or excentric, ca 10-15 µm diam; wall composed of thin-walled textura angularis, 6-8 cells thick on top, 4-6 cells thick on the bottom. Cirri light brown. Conidiophores absent. Conidiogenous cells 7-10 x 2.5-3 µm, holoblastic, determinate, discrete, terminal, hyaline, smooth, cylindrical to elongate lageniform with a single terminal conidium. Conidia formed on all inner surfaces of the conidiomata. Conidiogenesis found first at the top, then the base of the conidioma. Paraphyses up to 50 x 1-1.5 µm then arise at the top of the conidioma. Conidia 4-celled, (16-)18-23(-27) x 3-4 [$\overline{x}$=21.3 x 3.4] µm, pale golden brown, thin-walled, dorsiventral, the 2 middle cells (10-)12-15(-17) [$\overline{x}$=13.8] µm, end cells obtusely rounded or the basal cell truncate with a minute basal ridge, the apical and basal cell bearing a subapical and suprabasal bifurcate appendage inserted about midway up the wall on the concave side of the conidium, each branch ca 12-20 µm long, basal appendage exogenous.

In culture on PDA at room temperature (ca 16 C) in the light, mycelium reaches 28 mm diam after 14 days, is light tan, ages apricot in early passages, and lacks apricot pigmentation in later passages. Colonies are often sectored into areas where all mycelium is appressed to the agar, and areas with limited growth of aerial hyphae. Conidiomata are scattered and variable. They first appear as raised, darkening areas on the mycelium. Some conidiomata are like those on the natural substrate, but often the upper wall encloses several small foci of conidial development, the walls are more uniformly brown, some cells are thick-walled, and there may be multiple ostioles. Conidiogenesis takes place as on the natural substrate. Conidia are 4-celled, but the size and shape may vary. Most conidia have the appearance and dimensions of those on the natural substrate. Some conidia are shorter and broader ($\overline{x}$=15.1 x 4.8 µm, 2 middle cells $\overline{x}$=10.8 µm), somewhat constricted at the septa, and the appendages may be simple (Fig. 1, f). In ageing cultures, there may be some generalized browning of the mycelium.

Discosiospora paraphyses (Fig. 1, a, d) have not been seen in areas where active conidiogenesis is occuring. They may be derived from conidiogenous cells formed late in conidiomatal development. This is suggested by the presence of some atypically long, slender conidiogenous cells bearing conidia in areas where conidiogenesis is nearly completed.

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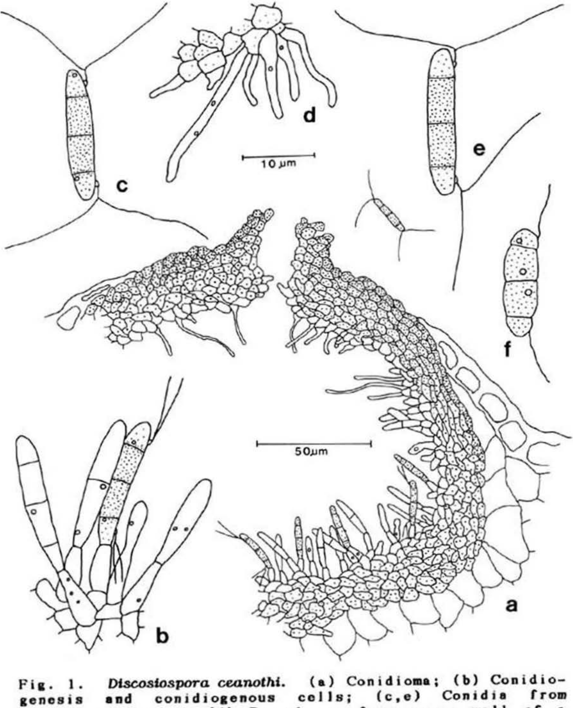

Fig. 1. *Discosiospora ceanothi.* (a) Conidioma; (b) Conidiogenesis and conidiogenous cells; (c,e) Conidia from natural substrate; (d) Paraphyses from upper wall of a conidioma; (f) Conidium from culture showing extreme of variation from normal.

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ECTOMYCORRHIZAL FUNGI ASSOCIATED WITH PINUS EDULIS IN THE PICEANCE BASIN OF COLORADO

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ABSTRACT

Ectomycorrhizae of *Pinus edulis* Engel. and sporocarps of associated fungi were collected from a pinyon-juniper woodland in northwestern Colorado. Of the eleven fungi identified, only three species, *Rhizopogon pinyonensis* Harrison and Smith, *R. ellenae* Smith and *Cenococcum geophilum* Fr. were positively determined to be ectomycorrhizal associates of *P. edulis*. Physical connections between mycorrhizae and sporocarps or sclerotia, and comparisons of cultures derived from sporocarps or sclerotia to cultures isolated from mycorrhizae provided evidence of mycorrhizal association. Thirteen types of ectomycorrhizae were described morphologically and anatomically. No endomycorrhizal associations were found.

INTRODUCTION

By recent estimates pinyon-juniper woodland occupies nearly 325,000 km^2 in the western United States (West, 1984). *Pinus edulis* Engel., pinyon pine, is an essential component of this extensive semiarid woodland ecosystem and is considered an excellent source of fuelwood and pinyon nuts as well an important habitat for wildlife (Gottfried, 1987; Lanner, 1981). Although fungal sporocarps have been collected from pinyon-juniper woodland, the mycorrhizal status of these fungi has not been positively determined (Harrison and Smith, 1968; Hesler and Smith, 1979; States, 1984). This study was undertaken to collect and describe the mycorrhizae of *Pinus edulis* and to identify putatively ectomycorrhizal fungi in a selected area of pinyon-juniper woodland.

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METHODS AND MATERIALS

Part of a pinyon-juniper woodland approximately 1.3 km by 0.6 km on a NNE to SSW oriented ridge (ca. 2070 m elevation) located in the Piceance Basin of northwestern Colorado was selected for this study. This semiarid site has a mature stand of *Pinus edulis* and *Juniperus osteosperma* (Torr.) Little (Utah juniper), with an understory of *Artemisia tridentata* Nutt. (big sagebrush) and a variety of forbs and grasses (Ward *et al.*, 1974).

The site was surveyed for the presence of sporocarps of putatively mycorrhizal fungi at two to three week intervals between May and September of the years 1983 to 1986 and once in August 1987. When sporocarps were encountered, both sporocarps and an underlying soil sample containing root samples were collected as a unit. During each visit the site also was randomly sampled for ectomycorrhizal roots of pinyon pine. Root samples were taken by collecting the duff layer and the top 10 to 15 cm of mineral soil as a unit. All root and sporocarp samples were bagged and placed in a cooler until they could be returned to the laboratory for examination.

In the laboratory, the sporocarp-root-soil units were washed free of soil and examined with a dissecting microscope for mycelial attachments between the sporocarp and ectomycorrhizae. Sporocarps associated with mycorrhizae were identified, dried and retained as voucher specimens by the author. Pinyon mycorrhizae, with and without associated sporocarps, were rinsed with tap water to remove soil as well as debris. All root samples were examined with a dissecting microscope for the presence of mycorrhizae. Mycorrhizal short roots were distinguished from uncolonized short roots by the absence of root hairs, abundance of branching, and radial swelling, and by presence of a mantle and attached mycelia and rhizomorphs. Different mycorrhizal types were distinguished on the basis of morphological and anatomical features of the mantle, attached mycelia, and rhizomorphs (Zak, 1973). Anatomical descriptions were based on characters obtained by microscopic evaluation of hand sections stained with Amman's solution (Largent *et al.*, 1977) and 10 μm microtomed sections stained with Conant's quadruple stain (Johansen, 1940). Each root sample was separated into different types and each type was provided a number-letter designation in which the collection number was followed by a letter indicating different mycorrhizal types within the same collection. The mycorrhizal types of each root sample were preserved in FAA (2:1:10:7, v:v:v:v, 37% formaldehyde:glacial acetic acid:95% ethanol:distilled water) and were retained as voucher specimens by the Biology Department, Colorado State University, Fort Collins, Colorado.

Standard techniques were used to isolate cultures from fresh sporocarps, sclerotia and subsamples of each mycorrhizal type within each collection (Molina and Palmer, 1982; Zak and Bryan, 1963; Zak and Marx, 1964). All isolates were maintained on Modified Melin Norkrans agar (Molina and Palmer, 1982) at room temperature. Where possible, the fungal symbionts of mycorrhizae were identified through observation of the physical attachment between mycorrhizae and sporocarps and by comparison of cultures derived from mycorrhizae to cultures derived from identified sporocarps or sclerotia.

RESULTS

Sporocarps of ten species of putatively mycorrhizal fungi (Table I) and sclerotia of *Cenococcum geophilum* Fr. were found during five surveys of the study area. There were no other sporocarps found during any other visits, despite intensive surveys of the area. Of the species found, only *Rhizopogon pachydermus* Harrison and Smith, *R. pinyonensis* Harrison and Smith, *R. ellenae* Smith, *Hysterangium brachyrhiza* States *nom. ined.*, *Geastrum fornicatum* (Huds.:Pers)Hook. *ex* Curt. and *Hygrophorus* sp. were successfully isolated from sporocarp tissue. *Cenococcum geophilum* was isolated from sclerotia.

Thirteen types (Types I-XIII) of ectomycorrhizae were described from 42 root samples of pinyon pine in the Piceance Basin. Single root collections yielded up to four different mycorrhizal types. Positive identification of the fungal symbionts was possible for only two of the 13 types of mycorrhizae. Similarities between cultures derived from sporocarp tissue and cultures from mycorrhizal roots were used to determine that both *R. pinyonensis* and *R. ellenae* were mycorrhizal symbionts of pinyon pine. Both species produced Type I mycorrhizae. *Cenococcum geophilum* was identified as a mycorrhizal symbiont by the characteristic appearance of the black mycorrhizae and sclerotia, by tracing connections between mycorrhizae and sclerotia of *C. geophilum*, and by the similarities between cultures derived from sclerotia and the mycorrhizae. *Cenococcum geophilum* formed Type II mycorrhizae. Cultures also were isolated from the root collections belonging to Types IV, V, VII and VIII but these cultures did not resemble any cultures derived from identified sporocarps.

All pinyon root samples contained roots that were ectomycorrhizal, whereas no endomycorrhizal roots were found. The ectomycorrhizae typically had a well-developed mantle, a Hartig net of branched or lobed fungal cells, no intracellular hyphae, and no root hairs. Descriptions of the mycorrhizal types follow. Those types in which the fungal symbiont was identified (Type I and II) and the types most common on the site (Type V and XI, each found in over 30% of the root collections examined) were extensively characterized. Short descriptions of the remaining types (each found in less than 15% of the root collections) were also included.

Type I
(Figure 1)

MANTLE: white or cream, some with lilac tinges, surface woolly or cottony, 7-100 µm thick; tissue in cross sectional view prosenchymatous; hyphae arranged both parallel and perpendicular to long axis of root, hyphae of inner layers in cross sectional view compactly arranged, cells with smooth walls, hyphae of outer layers more loosely arranged, cells of smaller diam and walls with plate-like incrustations, hyphae 1.5-3 (-5) µm diam, cells 2.5-25 µm long, hyphae in surface view loosely interwoven.

ROOT MORPHOLOGY: branching monopodial, bifurcate or coralloid with one to several branch points; individual root diam 357-630 µm; mycorrhizal clusters up to 4 mm long x 7 mm wide.

ANATOMY: cells of outer cortical tiers sometimes radially expanded; Hartig net between cells of outer two to four cortical tiers, one to

Table I. Sporocarps of putatively mycorrhizal fungi found in association with *Pinus edulis*.

Species	Date of Collection	Accession number[a]
Rhizopogon pachydermus Harrison and Smith	22 June 1983	382 (1), 383 (2), 388 (1)
	11 Aug. 1986	451 (1)
Rhizopogon pinyonensis Harrison and Smith	22 June 1983	389 (4)
	10 Aug. 1987	456 (1), 457 (1)
Rhizopogon ellenae Smith	27 Aug. 1984	402 (14)
	16 May 1985	412 (3)
Hysterangium brachyrhiza States *nom. ined.*	22 June 1983	384 (2), 385 (4) 386 (13), 390 (5)
	27 Aug. 1984	405 (9)
	16 May 1985	409 (1)
	10 Aug. 1987	451 (6)
Geastrum fornicatum (Huds.:Pers.)Hook. *ex* Curt.	27 Aug. 1984	397 (21)
Hygrophorus sp.	27 Aug. 1984	401 (7)
	11 Aug. 1986	408 (2)
Lactarius barrowsii Hesler and Smith	27 Aug. 1984	396 (4), 398 (1)
	11 Aug. 1986	449 (10)
Chroogomphus tomentosus (Murr.) Miller	27 Aug. 1984	399 (3), 400 (2), 404 (2)
Russula rosacea (Pers.:Secr.) Fr.	11 Aug. 1986	450 (8)
Inocybe sp.	22 June 1983	387 (22)

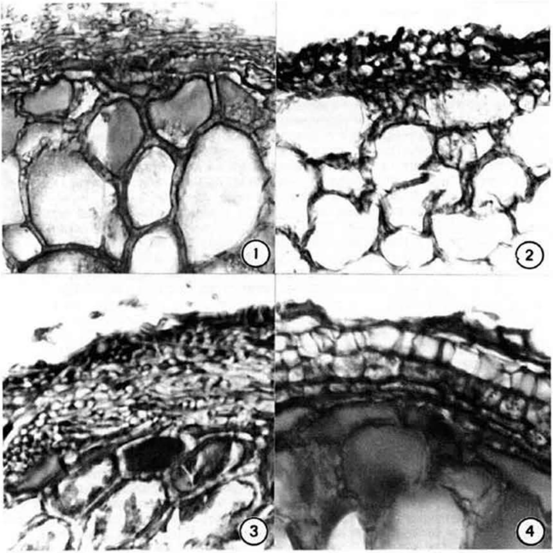
[a] Each accession number is a collection associated with a different tree on the site; numbers in parentheses are sporocarps per collection.

two hyphal cells wide, hyphae septate, 3-5 μm diam, with unevenly thickened walls.

ATTACHED MYCELIUM: hyaline, texture gossamer or cottony, densely attached to mantle; hyphae 2-6 μm diam, walls with plate-like incrustations, form straight with regular branching pattern, no clamp connections observed; crystals along outside of hyphae, no reaction to 15% KOH.

RHIZOMORPHS: white, branched, texture cottony, diam less than 0.15 mm; adhering to mantle; component hyphae septate, tightly compacted and interwoven, 2-6 μm diam, branched, with smooth, thick walls.

FUNGAL SYMBIONT: *Rhizopogon pinyonensis* or *R. ellenae*. The mycorrhizae associated with these two species could not be distinguished on the basis of morphology and anatomy. Mycelium of



Figs. 1-4. Transverse sections of Pinus edulis roots, ca. x 530. 1. Type I mycorrhiza (root sample 29B). 2. Type II mycorrhiza (root sample 34A). 3. Type V mycorrhiza (root sample 16). 4. Type XI mycorrhizae (root sample 12B).

cultures derived from sporocarps of *R. ellenae* changed from white to vinaceous red color upon application of 4% KOH while the mycelium of cultures derived from *R. pinyonenis* had no reaction. Response of mycelium derived from Type I mycorrhizae to application of KOH and morphological comparison of these cultures with those derived from sporocarps were used to associate many of the root samples with either *R. ellenae* or *R. pinyonensis*.

COLLECTIONS EXAMINED: Root samples 12C, 14B, 19B, 21B, 23B, 31A, 34C, 42A were associated with *R. pinyonenis* and 29B, 36C, 39B, and 40C were associated with *R. ellenae*. Based on morphological and anatomical criteria 30A, 33C, and 41A were included here although cultures were not obtained from these samples.

DISTINGUISHING FEATURES: Type I was distinguished from other types by a white, cottony, prosenchymatous mantle and white cottony mycelium and rhizomorphs.

Type II
(Figure 2)

MANTLE: black, surface crusty and bristly, 18-36 μm thick; tissue in cross sectional view synenchymatous; hyphae in cross sectional view 3.8-5.1 μm diam and thick, smooth, dark walls, hyphal cells 4-7 μm long; hyphae in surface view appearing as groups of oblong cells arranged in a stellate pattern, each group separated by one to several strands of hyphae.

ROOT MORPHOLOGY: branching monopodial or bifurcate with one to three branch points; individual root diam 430-475 μm; mycorrhizal clusters up to 3.5 mm long x 4.2 mm wide.

ANATOMY: cortical cells not radially expanded; Hartig net between cells of outer two to three cortical tiers, one hyphal cell wide, hyphae septate, 2-4 μm diam, with thick walls.

ATTACHED MYCELIUM: black, texture stiff, sparsely attached to mantle; hyphae 5 μm diam, walls dark, thick, sometimes warted, form straight or undulant with irregular branching pattern, no clamp connections observed.

RHIZOMORPHS: none.

FUNGAL SYMBIONT: *Cenococcum geophilum.*

COLLECTIONS EXAMINED: 17C, 34A.

DISTINGUISHING FEATURES: Type II was distinguished by a black, bristly, syenchymatous mantle with a stellate appearance from the surface, sparse, dark attached hyphae without clamps and no rhizomorphs.

Type V
(Figure 3)

MANTLE: orange or rust brown overlain with gray, color uniform, mottled or banded with orange brown and gray brown, surface cottony, 18-51 μm thick; tissue in cross sectional view prosenchymatous; hyphae of inner layers parallel to long axis of root, outer layers perpendicular to long axis of root, hyphae in cross sectional view septate, 1.5-2.5 (-5)μm diam, with thin or thick, smooth walls; hyphae in surface view parallel and tightly compacted.

ROOT MORPHOLOGY: branching bifurcate with one to three branch points; individual root diam 320-520 μm; mycorrhizal clusters up to 7 mm long x 6.3 mm wide.

ANATOMY: cortical cells not radially expanded; Hartig net between cells of outermost three to five cortical tiers, one to two hyphal cells wide, hyphae septate, 2-4 μm diam, with thick walls near the outside surface, with thin walls deeper in cortex.

ATTACHED MYCELIUM: amber or hyaline, texture gossamer, densely attached to mantle; hyphae septate, 2-4 μm diam, walls smooth, thin or thick, form straight with regular right-angled branching pattern, no clamp connections observed.

RHIZOMORPHS: amber, branched, texture smooth, diam less than 0.1 mm, attached to mantle; component hyphae septate, tightly compacted, parallel or interwoven, 2-4 μm diam, regularly branched, with smooth, thin or thick walls.

COLLECTIONS EXAMINED: 20, 23C, 25, 26A, 29A, 30D, 33B, 35A, 36D, 37A, 40A, 42B.

DISTINGUISHING FEATURES: Type V was distinguished by an orange to rust brown, cottony, prosenchymatous mantle, hyaline or amber attached hyphae without clamp connections and amber rhizomorphs.

Type XI

(Figure 4)

MANTLE: cinnamon brown darkening to reddish brown, surface smooth, 5-69 µm thick; tissue in cross sectional view synenchymatous; hyphae in cross sectional view 3.5-18 µm diam, with smooth, dark, thick walls, cells 5-18 µm long, cells regularly rectangular and compacted; hyphae in surface view irregularly circular and plicate.

ROOT MORPHOLOGY: branching monopodial or bifurcate with, one to three (to several) branch points, constrictions along mycorrhizae give beaded appearance to root; individual root diam 300-620 µm; mycorrhizal clusters up to 7.0 mm long x 6.7 mm wide.

ANATOMY: cells of outer cortical tier sometimes radially expanded; Hartig net between cells of outer three to four cortical tiers, one to two hyphal cells wide, hypahe septate, 2-3 µm diam, with unevenly thickened walls.

ATTACHED MYCELIUM: none.

RHIZOMORPHS: none.

FUNGAL SYMBIONT: unknown.

COLLECTIONS EXAMINED: 10B, 12B, 14A, 17A, 19C, 22, 24, 26B, 30C, 32B, 34B, 36A, 39A, 40B, 42C.

DISTINGUISHING FEATURES: Type XI was distinguished by a cinnamon brown, smooth, synenchymatous mantle without attached mycelia or rhizomorphs.

Type III

Mantle gray to gray brown with a smooth surface, 30-51 µm thick, of prosenchymatous tissue; root branching monopodial or bifurcate with one to three branch points; roots 200-370 µm diam; Hartig net between cells of outer three cortical tiers, one to two hyphal cells wide; attached mycelium of hyaline, hair-like hyphae 2 µm in diam with thin, smooth walls and clamp connections; no rhizomorphs (collections examined: 8, 15D, 32A, 38).

DISTINGUISHING FEATURES: Type III was distinguished by a gray to gray brown, smooth, prosenchymatous mantle, hyaline, hair-like attached hyphae with clamp connections and no rhizomorphs.

Type IV

Mantle gray brown with a velvety surface, 15-45 µm thick, of prosenchymatous tissue; root branching monopodial or bifurcate with one to three branch points; roots 400-630 µm diam; Hartig net between cells of outer two to four (to five) cortical tiers, one to four hyphal cells wide; attached mycelium of hyaline, gossamer or hair-like hyphae 1.5-3 µm diam with thin (to thick), smooth (to punctate) walls and clamp connections; rhizomorphs amber, branched with smooth surface, made of parallel, compacted hyphae (collections examined: 10A, 15B, 17B, 18A, 31B, 33A).

DISTINGUISHING FEATURES: Type IV was distinguished by a gray brown, velvety, prosenchymatous mantle with hyaline, gossamer or hair-like attached hyphae with clamp connections and amber rhizomorphs.

Type VI

Mantle cream yellow to yellow brown with a cottony to woolly surface, 51-64 μm thick, of prosenchymatous tissue; root branching bifurcate with one to two branch points; roots 410-535 μm diam; Hartig net between cells of outer three to four cortical tiers, one to two hyphal cells wide; attached mycelium of cream yellow, gossamer hyphae 1.5-2.5 (-4) μm diam with thin, smooth walls and no clamp connections; rhizomorphs cream yellow, branched, with smooth surface, made of parallel, tightly compacted hyphae (collections examined: 16, 35B).

DISTINGUISHING FEATURES: Type VI was distinguished by cream yellow to yellow brown, cottony to woolly, prosenchymatous mantle, cream yellow, gossamer attached hyphae with no clamp connections and cream yellow rhizomorphs.

Type VII

Mantle amber to rusty brown with a velvety surface, 21-36 μm thick, of prosenchymatous tissue; root branching bifurcate with one to four branch points; roots 380-485 μm diam; Hartig net between cells of outer three (to four) cortical tiers, one hyphal cell wide; no attached mycelium or rhizomorphs (collections examined: 12A, 27).

DISTINGUISHING FEATURES: Type VII was distinguished by an amber to rusty brown, velvety, prosenchymatous mantle and no attached mycelia or rhizomorphs.

Type VIII

Mantle golden brown with a velvety surface, 51-59 μm thick, of prosenchymatous tissue; root branching monopodial or bifurcate with one to three branch points; roots 420-630 μm diam; Hartig net between cells of outer three to four cortical tiers, one hyphal cell wide; attached mycelium of hyaline to yellowish, stiff hyphae 2 μm diam with thin or thick, smooth walls and no clamp connections; no rhizomorphs (collections examined: 30B, 37B).

DISTINGUISHING FEATURES: Type VIII was distinguished by a golden brown, velvety, prosenchymatous mantle, hyaline to yellowish stiff attached hyphae with no clamp connections and no rhizomorphs.

Type IX

Mantle dark brown to black with a bristly surface, 38-46 μm thick, of prosenchymatous tissue; single-celled setae coming to an acute point, sparsely attached to mantle; root branching monopodial or bifurcate with one to two branch points; roots 400-500 μm diam; Hartig net between cells of outer two to three cortical tiers, one hyphal cell wide; no attached mycelium or rhizomorphs (collection examined: 31C).

DISTINGUISHING FEATURES: Type IX was distinguished by a dark brown to black, bristly, prosenchymatous mantle with single-celled, acutely pointed setae, no attached mycelia or rhizomorphs.

Type X

Mantle yellow brown with a velvety surface, 15-36 μm thick, of synenchymatous tissue; root branching monopodial or bifurcate with one to three branch points; roots 400-525 μm diam; Hartig net between cells of outer two to three cortical tiers, one to two (to three) hyphal cells wide; no attached mycelium or rhizomorphs (collection examined: 18C).

DISTINGUISHING FEATURES: Type X was distinguished by a yellow brown, velvety, synenchymatous mantle and no attached mycelia and rhizomorphs.

Type XII

Mantle orange brown to reddish brown with a smooth surface, 10-31 µm thick, of synenchymatous tissue; root branching monopodial or bifurcate with one to two branch points; roots 230-580 µm diam; Hartig net between cells of outer three to four cortical tiers, three to four hyphal cells wide; attached mycelium of short (less than 160 µm in length), hyaline, cystidia-like hyphae, 2-8 µm diam with thin to thick, smooth walls and no clamp connections; no rhizomorphs (collections examined: 11A, 11C, 41B).

DISTINGUISHING FEATURES: Type XII was distinguished by an orange- to reddish-brown, smooth, synenchymatous mantle, sparsely attached cystidia-like mycelia and no rhizomorphs.

Type XIII

Mantle dark brown or black with a smooth surface, (7-) 18-21 µm thick, of synenchymatous tissue; root branching monopodial or bifurcate with one branch point; roots 330-460 µm diam; Hartig net between cells of outer two cortical cell tiers, one to two hyphal cells wide; attached mycelium of brown, stiff hyphae 3-4 µm diam with thick, smooth or punctate walls and clamp connections; no rhizomorphs (collection examined: 11B).

DISTINGUISHING FEATURES: Type XIII was distinguished by a dark brown to black, smooth, synenchymatous mantle, dark, stiff attached hyphae with clamp connections and no rhizomorphs.

DISCUSSION

All of the fungal species collected on the site belong to genera previously reported to be ectomycorrhizal or putatively ectomycorrhizal (Harrison and Smith, 1968; Miller, 1982; 1983; Molina and Trappe, 1982; Smith, 1971; Smith and Zeller, 1966; Trappe, 1962). *Rhizopogon pinyonensis*, *R. pachydermus*, and *Hysterangium brachyrhiza* appear to be restricted to pinyon pine stands (Harrison and Smith, 1968; States, 1984; States, Northern Arizona University, personal communication). *Lactarius barrowsii* Hesler and Smith is found with pinyon in New Mexico, but also occurs with *Pinus ponderosa* Laws. (Hesler and Smith, 1979). Long and Stouffer (1948) note *Geastrum fornicatum* in juniper stands in the southwestern United States. *R. ellenae* has not been reported from pinyon stands, but is associated with a variety of conifers in Utah, Idaho, and Oregon (Smith and Zeller, 1966). *Chroogomphus tomentosus* (Murr.) Miller, although not known to be mycorrhizal with pines, is an associate of western hemlock (Miller, 1983). *Cenococcum geophilum* is a mycorrhizal symbiont of singleleaf pinyon, *Pinus monophylla* Torr. and Frem. and is a common associate of other pines and other ectomycorrhizal plants in a wide variety of habitats (Trappe, 1962; 1964).

Pines are generally considered to be ectomycorrhizal, and *P. edulis* is not exceptional. None of the roots examined had vesicular-arbuscular mycorrhizae (VAM). Prior to this study, Reeves *et al.*

(1979) report VAM associated with *P. edulis* roots collected in the Piceance Basin, and McDougall and Jacobs (1927) find endomycorrhizae associated with *P. monophylla*. Vesicles are common in senescent or dead roots of species that do not form functional VAM (Hirrel *et al.*, 1978). However, neither Reeves *et al.* (1979) nor McDougall and Jacobs (1927) indicate whether vesicles or arbuscules are found in pinyon roots. *Pinus edulis* may form VAM only under certain conditions, or functional VAM may not occur in this taxon.

The species diversity of putatively ectomycorrhizal fungi associated with *P. edulis* is not well documented. Harrison and Smith (1968) describe three species of *Rhizopogon* and States (1984) collected five species of hypogeous fungi associated with pinyon. States (Northern Arizona University, personal communication) indicates that at least 20 putatively ectomycorrhizal fungi have been collected in association with pinyon in the Southwest. Species diversity of ectomycorrhizal fungi can affected by a number of factors. In the Piceance Basin, during periods of the year in which the temperature is suitable for sporocarp production, moisture is a limiting factor. The mean annual precipitation is 28 to 64 cm; half of this amount occurs as winter snow. Most of the remaining moisture, which falls during intense thunderstorm activity during the summer months, is lost as runoff or evaporation (Fowells, 1965; Tiedman and Terwilliger, 1978). The infrequent production of sporocarps noted during this study indicates that in order to survive fungi must be well-adapted to the limiting environmental conditions specific to the site and the opportunities for sporocarp production rarely occur.

Species diversity of ectomycorrhizal fungi is reported to increase with age and then decrease as the stand matures (Dighton and Mason, 1985; Last *et al.*, 1987). In mature stands of *Pinus bansksiana* Lamb. only 13 species of putatively ectomycorrhizal fungal are common, whereas in young stands there are 44 species (Danielson, 1984). Dighton and Mason (1985) note a decrease in fungal diversity after canopy closure in *Pinus contorta* stands. In these stands as well as a 250 year old forest of *Pseudotsuga menziesii* (Mirb.) Franco and *Larix* sp. a single mycorrhizal fungus is dominant (Dighton and Mason, 1985; Harvey *et al.*, 1976). *P. edulis* is reported to be mature at 200 years (Fowells, 1965). Based on the height and diameter of the larger trees on the study area (personal observation) and growth rate measurement of pinyon pine by Little (1987), the stand located on the study area was estimated to be approximately 300 years. The number of fungal species found on the study area is consistent with published reports on species diversity in older stands.

There is generally a greater fungal diversity in areas where there is more than one potential host species (Mosse, *et al.*, 1981). In many locations within the range of pinyon, *Pinus edulis* is mixed with or adjacent to stands of *P. ponderosa* (Fowells, 1965; Phillips, 1909). The area in which the study site is located has pinyon-juniper woodland on the ridges and upper slopes, with sagebrush-grass communities occupying the lower slopes and valleys (Tiedman and Terwilliger, 1978; Ward *et al.*, 1974). Although *Juniperus osteosperma* may be able to form ectomycorrhizae (Reinsvold and Reeves, 1986), no ectomycorrhizae were noted associated with *J. osteosperma* on the study area (personal observation). Because *J. osteosperma* predominantly forms VAM

(Reinsvold and Reeves, 1986), this species is probably not an important alternate host for ectomycorrhizal fungi. The combination of semiarid conditions, maturity of the stand and lack of potential alternate hosts contribute to limiting ectomycorrhizal fungal species diversity on the study area.

Of the 13 mycorrhizal types collected from the site, the fungal symbiont of only two of these types was identified. The fungal symbionts of some of the unidentified mycorrhizal types may not have formed sporocarps during the time the collecting visits were made. In addition, there were cases in which physical connections could not be traced between mycorrhizae and sporocarps, the mycorrhizae or sporocarps found did not yield cultures for comparison and cultures derived from some of the mycorrhizae were not similar to any derived from sporocarps.

Failure to successfully isolate cultures from some of the field material may have been due to the media selected for isolation or the condition of some of the field material. Isolations were attempted on only one medium. Modified Melin Norkrans media is recommended for culture of ectomycorrhizal fungi (Molina and Palmer, 1982), but may not have met the growth requirements of all the fungi that were placed on it. Although attempts were made to use only fresh, insect-free sporocarps for isolation, suitable material was not always available. Sporocarps of *Russula rosacea* (Pers.:Secr.) Fr.and *Chroogomphus tomentosus* were collected on only one occasion each. The tissue of the sporocarps may not have been viable, because only dried sporocarps were found in the duff layer beneath pinyon trees.

The research presented here has established that pinyons are ectomycorrhizal in natural situations and have a unique if somewhat limited fungal flora in the Piceance Basin. Land disturbance resulting from large scale mining of oil shale, coal or minerals in western Colorado would lead to large areas of vegetation displacement. In any revegetation effort consideration must be given both to the suitability of the selected plant species and the potential of mycorrhizal fungi to affect plant survival and growth (Mikola, 1973; Trappe, 1977). A descriptive study is only a first step in determining the application of ectomycorrhizal fungi in revegetation. A mycorrhizal synthesis experiment is necessary to determine if the fungi identified and isolated from the study site are capable of forming mycorrhizae with *P. edulis*. The results of synthesis experiments involving those fungi will be presented in a later paper. Further study will indicate which species of mycorrhizal fungi are best suited to insure survival and maximum growth of *Pinus edulis* on disturbed areas.

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A NEW SPECIES OF BENJAMINIELLA (MUCORALES: MYCOTYPHACEAE)

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The genus *Benjaminiella* von Arx was introduced by von Arx (1981) for the illegitimate (Art. 64.1) *Benjaminia* Pidoplichko & Mil'ko (1971) and contained a single species, *B. poitrasii* (R.K. Benjamin) von Arx (syn. *Cokeromyces poitrasii* R.K. Benjamin, 1960). It was characterized by a homothallic species in which the anamorph comprises a globose fertile vesicle bearing monosporous sporangiola on long flexuous pedicels, and a teleomorph with *Mucor*-like zygospores. It is known from six collections from California, USA and Baja California del Norte, Mexico, where it occurs on rodent dung (including pack rat) and lizard dung. A second species of *Benjaminiella*, *B. multispora* Benny, Samson & Srinivasan (Benny, Kirk & Samson, 1985), was described based on an isolate from humus-rich soil collected in Maharashtra, India. It differs from *B. poitrasii* mainly by the production of sporangiola containing 2-9-spores.

The genus *Benjaminiella* was referred to the newly introduced family Mycotyphaceae by Benny, Kirk & Samson (1985), along with *Mycotypha* Fenner (1932).

A third species of *Benjaminiella* has been found to occur on lizard dung on the island of Tenerife (Canary Islands). It differs from the two known species in the production of usually bisporous sporangiola.

BENJAMINIELLA YOUNGII P.M. Kirk, sp.nov. (Fig 1A-F)

Etymology: For Dr T.W.K. Young, student of the Mucorales, especially their ultrastructure, mentor of the author and the person responsible for his continuing interest in this fascinating group of fungi.

Coloniae lente crescentes, exiguae, plus minusve zonatae, griseae. Sporophora simplicia, vulgo erecta, 1-3 mm alta, 5-7 (-8·5) μm lata, primo hyalina, deinde dilute brunnea, raro septata, laevia; vesiculae et sporangiola velut capitula fere globosa 60-140 μm diam apparent. Vesiculae fertiles leves, (14-) 28-42 (-55) μm diam, obpyriformes ad quasi globosae, undique sporangiola pedicellata proferentes. Pedicelli sporangiolorum longitudine variabilia, 8-130 μm longa, *c.* 0·5 μm lata, fere recta vel recurvata vel contorta, decidua, post secessionem denticulos plus minusve conicos, truncatos, 0·5-1·5 μm altos, c 0·5 μm diam, relinquentia. Sporangiola plerumque bispora, late ellipsoidea, ad sporangiosporae juncturam leviter constricta, (4·0-) 6·0-8·5 (-9·0) x (2·5-) 3·0-3·5 (-4·0) μm, levia, cito a pedicello separata; columellae minutae, indistinctae, sursum concavae, *c.* 0·5-1·0 μm diam, leves. Sporangiosporae leves, tenuitunicatae, ovoideae ad subglobosae, 3·5-6·0 x 2·5-3·5 (-4·0) μm. Hyphae submersae vulgo in cellulas hyalinas, globosas, zymoideas transeuntes usque ad 20 μm diam proferentes. Zygosporae abundantae, proximae substratum formantas; globosae vel subglobosae, (40-) 50-70 (-84) μm diam projectionibus inclusis, pariete fusco projectionibus conicis, 4·0-7·0 μm altis obtectae; suspensiores oppositi, aequales ad inaequales, leves, hyalini ad dilute brunnei. Species homothallica.

Ex stercore lacertae, Vilaflor, Tenerife, Insulae Canariae, 26 May 1988, P.M. Kirk 2085, IMI 325629, holotypus; CBS 103.89, isotypus.

Colonies on MA 3-4 cm diam in 7 days as 25°C, turf sparse, more or less zonate, Mouse Gray to Deep Mouse Gray, becoming near Light Drab in age. *Sporophores* simple at first, rarely secondarily branched, more or less erect, up to 1-3 mm high, 5·0-7·0 (-8·5) μm diam, hyaline at first, becoming light brown, sparsely septate in age; wall smooth; fertile vesicle and sporangiola forming more or less globose heads 60-140 μm diam. *Fertile vesicles* smooth, (14-) 28-42 (-55) μm diam, sometimes obpyriform but usually more or less globose, bearing pedicellate sporangiola over their entire surface.

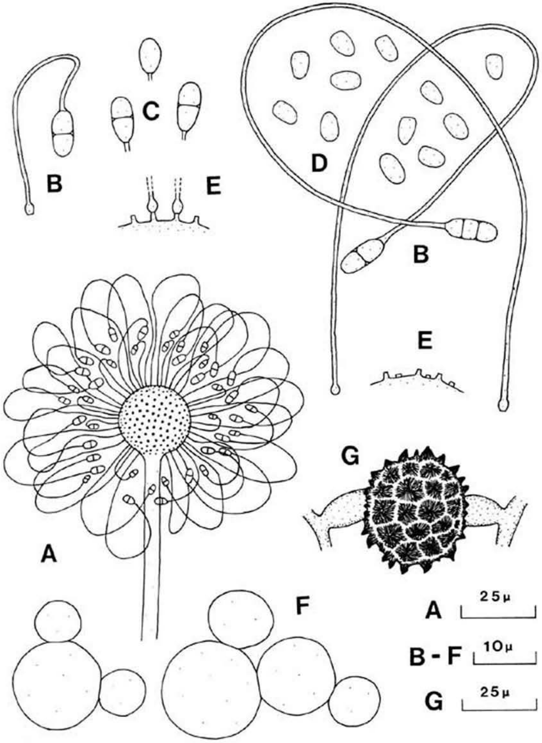

Fig. 1. *Benjaminiella youngii.* A, Sporophore. B, Pedicelate sporangiola. C, Sporangiola. D, Sporangiospores. E, Portion of fertile vesicle showing pedicel attachment. F, Yeast-like cells. G, Zygospore.

Pedicels bearing sporangiola variable in length, 8-130 µm long, *c.* 0·5 µm diam for the greater part of their length, more or less straight to recurved or strongly twisted and contorted; deciduous, with a slight basal enlargement *c.* 1·0 µm diam and 1·5-2·0 µm long immediately above the abscission zone; pedicel base after dehiscence forming a more or less conical, truncate denticle, 0·5-1·5 µm high, *c.* 0·5 µm diam at the base. *Sporangiola* bisporous or rarely uni- or trisporous, the sporangiospores in bi- and trisporous sporangiola lying parallel to the long axis of the pedicel, slightly constricted at the junction between the sporangiospores, broadly ellipsoid to obovoid, unisporous sporangiola 4·0-6·0 µm long, 2·5-3·0 µm wide, bisporous sporangiola 6·0-8·5 µm long, 3·0-3·5 (-4·0) µm wide, trisporous sporangiola 6·5-9·0 µm long, 3·0-3·5 (-4·0) µm wide, smooth, readily separating from the pedicel; columella minute, indistinct, with a concave apex, *c.* 0·5-1·0 µm diam, smooth. *Sporangiospores* smooth, thin-walled, ovoid to broadly ellipsoid, 3·5-6·0 µm long, 2·5-3·5 (-4·0) µm wide. *Substrate hyphae* at first non-septate, becoming irregularly septate in age; giving rise to hyaline, globose, yeast-like budding cells up to 20 µm diam. *Zygospores* abundant, formed near the surface of the substratum from aerial hyphae; globose to subglobose, (40-) 50-70 (-84) µm diam including the projections; wall dark brown, covered with more or less conical projections 4-7 µm high; suspensors opposed, isogamous to slightly anisogamous, smooth, hyaline to light brown. Homothallic.

DISTRIBUTION: Canary Islands, Tenerife; known only from the type locality.

NOTES: Colonies of *Benjaminiella youngii* on MA are superficially identical to those of the other two species of *Benjaminiella*, *B. poitrasii* and *B. multispora*. The anamorph formed dense colonies on the natural substratum within four days of incubation at *c.* 20°C on moist filter paper in a petri dish. After a further three days zygospores were also formed. The isolate was easily brought into culture using malt agar containing a mixture of penicillin and streptomycin. Initially the germinating sporangiospores formed colonies of yeast-like cells. However, the hyphal phase, followed by the production of sporophores and zygospores, developed within three days.

The typically bisporous, rarely uni- or trisporous, sporangiola serve to distinguish *B. youngii* from the other two species.

KEY TO SPECIES OF *BENJAMINIELLA*

1.	Sporangiola containing one sporangiospore	*B. poitrasii*
	Sporangiola usually containing more than one sporangiospore	2
2.	Sporangiola with 1-3 linearly arranged sporangiospores	*B. youngii*
	Sporangiola with 2-9 irregularly arranged sporangiospores	*B. multispora*

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ADDITIONS TO THE KNOWLEDGE OF PHAEOCOLLYBIA (AGARICALES, CORTINARIACEAE) FROM MEXICO, WITH DESCRIPTION OF NEW SPECIES*

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SUMMARY

Three new species of Phaeocollybia from Mexico are described: P. latispora Guzmán, Bandala-Muñoz & Montoya-Bello, P. martinicensis Guzmán, Montoya-Bello & Bandala-Muñoz and P. singerii Guzmán, Bandala-Muñoz & Montoya-Bello. Also three new records are discussed: P. arduennensis Bon, P. hilaris (Fr.) Heim and P. oligoporpa Sing., the first two species are known only from Europe and the last from Costa Rica. Moreover, P. californica Smith, P. christinae (Fr.) Heim and P. kauffmanii (Smith) Sing. previously recorded from Mexico are reported from new localities. A synoptical key to the 15 known species of this genus in Mexico is provided.

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INTRODUCTION

This paper is a continuation of the study of Phaeocollybia in Mexico recently started by the authors (Guzmán et al., 1986; 1987). Seven species in the Sections Phaeocollybia and Versicolores from coniferous forests were previously discussed. Three new species are described and 6 new records are presented here, from coniferous and mesophytic forests, which extends the genus into the subtropical regions of Mexico. In addition to the reviewed bibliography discussed by the authors (Guzmán et al., 1987), Pérez-Silva et al. (1986) recorded P. fallax Smith and those species reported by Guzmán et al. (1986; 1987). Recently, Díaz-Barriga et al. (1988) reported P. kauffmanii (Smith) Sing. from the State of Michoacan. Then, there are 15 species of Phaeocollybia known in Mexico as discussed below.

The present paper is based on the study of fresh specimens collected by the authors, and on exsiccata of the Herbarium of Facultad de Ciencias of the University of Mexico (FCME) and of the Herbarium of Escuela Nacional de Ciencias Biológicas of the Instituto Politécnico Nacional (ENCB). The specimens collected by the authors were deposited in FCME, ENCB and in Instituto Nacional de Investigaciones sobre Recursos Bióticos (XAL) (now named Instituto de Ecología).

DESCRIPTION OF NEW SPECIES

Phaeocollybia latispora Guzmán, Bandala-Muñoz & Montoya-Bello, sp. nov.

Figs. 1-7

Pileo 18-35 (-40) mm lato, conico vel conico-umbonato, apex subacutus, siccus vel oleosus, rufobrunneus vel brunneus aurantiacus. Lamellis pallide aurantius, marginis pallidus. Stipe (50-) 80-110 (-200) X 2-8 (-10) mm, cum pseudorrhiza, fusoideo-radicato brunneus aurantiacus cum vinaceous tinctum. Sporis (8.8-) 9.6-11.2 (-12) X 5.6-7.2 µm, crasse verrucose, limoniformibus vel sublimoniformibus. Cheilocystidia (16-) 21.6-32 (-40) X

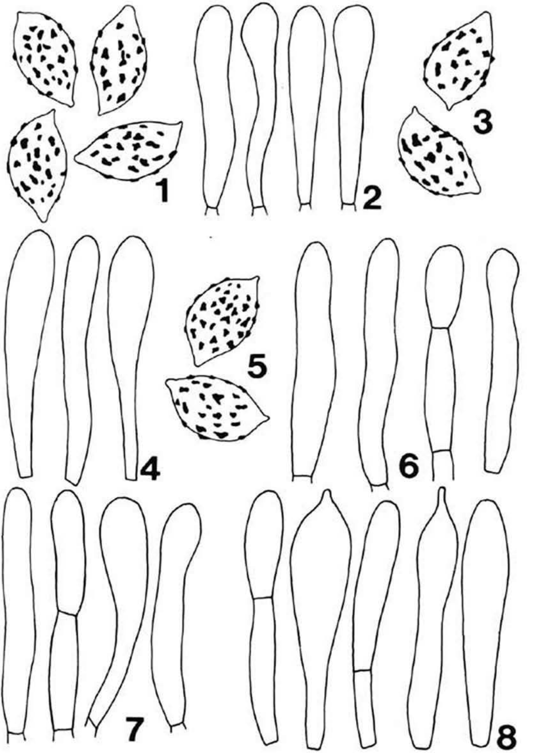
(3.2-) 4-8 (-8.8) µm, copiosus, clavatis vel cylindraceus clavatis. Epicute gelatinous. Fibulis infrequens. Ad terram in Pinus et Abies sylva. Prope El Chico sylva, ad Hidalgo (MEXICO) Typus: Chacón 8 (XAL).

Pileus 18-35 (-40) mm broad, conic or subconic to convex umbonate, subacute in the apex, dry to lubricous, glabrous, reddish-brown to orange-brown. Lamellae subadnexed to nearly free, close, pale orange, edges lighter. Stipe (50-) 80-110 (-200) X 2-8 (-10) mm, fusoid, gradually attenuating into a short pseudorrhiza buried into the ground, fibrous, orange brown with vinaceous tinges, dark vinaceous towards the basal portion.

Spores (8.8-) 9.6-11.2 (-12) X 5.6-7.2 µm, limoniform or sublimoniform, coarsely verrucose, orange-brown to yellowish brown in KOH, inamyloid, thin walled. Basidia 20-40 X 8-9 (-12) µm, tetraspored, clavate, hyaline. Pleurocystidia absent. Cheilocystidia (16-) 21.6-32 (-40) X (3.2-) 4-8 (-8.8) µm, abundant, clavate or cylindric-clavate, hyaline, thin walled, sometimes covered with a gelatinized layer. Epicutis consisting of gelatinized, thin walled, slightly incrusted hyphae 2.4-8 µm wide, hyaline to yellowish in KOH. Hypodermium with thin walled incrusted, yellowish or brown hyphae (4-) 7.2-14.4 µm thick. Context consisting of thin walled, smooth, hyaline hyphae 4.8-20 (-24) µm thick. Hymenophoral trama regular, hyphae of 4-8 (-12) µm wide, hyaline, thin walled, smooth. Clamp connections rare or absent.

HABITAT. Gregarious on humus in coniferous (Pinus and Abies) forests.

MATERIAL STUDIED. STATE OF HIDALGO, road Mineral del Monte to El Chico, National Park El Chico, Chacón 8 (Type, XAL). STATE OF MEXICO, Popocatepetl Volcano, road Amecameca to Tlamacas, Guzmán 855 (ENCB). National Park Nevado de Toluca, road to Sultepec, km. 21, El Capulín, Valenzuela 2603 (ENCB). STATE OF MORELOS, road Huitzilac to Lagunas de Zempoala, Guzmán 23993 (ENCB). STATE OF VERACRUZ, Eastern Cofre de Perote mountain, Xico Council, El Revolcadero, Villa-



Figs. 1-8.- 1-7: *Phaeocollybia latispora*, 1: spores; 2: cheilocystidia; 3: spores; 4: cheilocystidia; 5: spores; 6-7: cheilocystidia (1-2: Chacón 8, Type; 3 & 7: Valenzuela 2603; 4: Villarreal 1303; 5-6: Guzmán 855). 8: *Phaeocollybia martinicensis*, cheilocystidia (Guzmán 16380, Type).

rreal 1303 (XAL).

OBSERVATIONS. This species is mainly recognized by its bigger and coarsely verrucose spores, the gelatinized cuticle and the scarce clamp connections. It is close to P. similis (Bres.) Sing. (no P. similis sensu Smith), but that species is only known from deciduous forests of China and has not gelatinized cuticle and cheilocystidia 17-21.5 X 6-11 µm, according to Singer (1987). However, Horak (1976-1977) described a gelatinized cuticle and cheilocystidia of 25-40 X 3-7 µm based in the same type collection studied by Singer. Horak reported hyphae without clamp connections and Singer with clamp connections.

The specimens Guzmán 855 and Valenzuela 2603 mentioned above, agree with the type but not clamps were observed and their cuticle is poorly gelatinized. This fact relates these specimens to P. christinae (Fr.) Heim s.s., P. attenuata (Smith) Sing. and P. piceae Smith & Trappe (this later not known from Mexico). However, the first one has spores 4-5 µm broad, the second one with spores 8-9 (-10) X (4-) 5-6 µm and the last one with cespitose habit and slightly smaller spores 4.5-6 µm or 5-6 (-6.5) µm broad (Smith and Trappe, 1972; Horak, 1976-1977).

The presence of clamps and the spores size place P. latispora in Section Subattenuata Sing. but it is also close to Section Phaeocollybia if we consider the clamps as rare or absent. It is probably that P. latispora together with P. similis belong to another new section.

Phaeocollybia martinicensis Guzmán, Montoya-Bello & Bandala-Muñoz, sp. nov.

Figs. 8-10 & 36-37

Pileo approximatus 20 mm lato, plano-convexus, apex acutus, viscidus, ochraceus vel fulvus. Lamellis fulvus pallidus. Sporis 7.2-8 (-8.8) X 4-4.8 µm, minute verrucose, amygdalum forma vel subfusoideus. Cheilocystidia 24-32 X 4-6.4 µm, copiosus, clavatis mucronatus vel subcylindraceus. Epicutis gelatinous. Hyphis difibulatis. Ad terram in subtropicus sylva. Prope La Martinica, ad Banderilla (Veracruz, MEXICO). Typus: Guzmán 16380 (ENCB).

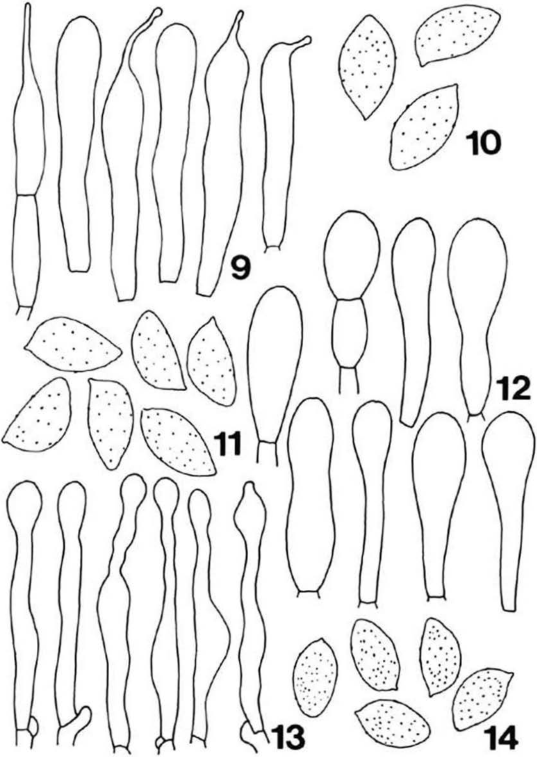
Pileus approximately 20 mm broad, plano-convex with an acute apex, margin slightly inrolled, glabrous, viscid, ochraceous to yellowish-brown. Lamellae subadnexed to nearly free, close, light yellowish-brown with whitish edges. The exsiccati studied only has a small basal portion of the stipe.

Spores 7.2-8 (-8.8) X 4-4.8 µm, almond-shaped, slightly subfusoid in frontal view, minutely verrucose to nearly verrucose-punctate, light orange-brown to yellowish-brown in KOH, inamyloid, thin walled. Basidia (25-) 32-45 (-50) X (5-) 6-8 µm, tetraspored, clavate, hyaline. Pleurocystidia none. Cheilocystidia 24-32 X 4-6.4 µm, abundant, clavate-mucronate, subcylindric or subcylindric-mucronate, hyaline, thin walled, sometimes slightly strangulate, flexuous or with a medial septum or short-cylindric with a thin, short or long apical portion 2-7 (-10) X 1-2 µm. Pileus cuticle with gelatinized hyphae, hyaline, 2.4-3.2 µm wide, thin walled, smooth; subcutis with yellowish-orange, thin walled, incrusted hyphae 2.4-3.2 (-4) µm wide. Pileus trama consisting of thin walled, yellowish hyphae 4-5.6 µm thick. Hymenophoral trama subregular, hyphae 4.2-5.6 µm wide, yellowish, thin walled. Clamp connections absent.

HABITAT. Solitary on humus in a mesophytic forest.

MATERIAL STUDIED. STATE OF VERACRUZ, SW of Banderilla, Cerro de La Martinica, Guzmán 16380 (Type, ENCB).

OBSERVATIONS. The form of the cheilocystidia and size of the spores separate this species from <u>P. californica</u> Smith and <u>P. cidaris</u> (Fr.) Heim <u>no s. Ricken</u>. The first one has spores of 9-10 (-11) x 4-5 µm (Guzmán et al., 1987) and the later has cylindric-capitate cheilocystidia



Figs. 9-14.- 9-10: *Phaeocollybia martinicensis*, 9: cheilocystidia ; 10 spores (Guzmán 16380, Type). 11-12: *Phaeocollybia singerii*, 11: spores; 12: cheilocystidia (Bandala-Muñoz 1008,Type). 13-14: *Phaeocollybia arduennensis*, 13: cheilocystidia; 14: spores(Villarreal 2622).

(Horak, 1976-1977). Moreover both species are associated to coniferous forests. In spite of the poor condition of the exsiccati studied, it has been described here as new species, because of its conclusive distinguish features. The absence of clamps, the spore size and the cheilocystidia form suggest affinities with the Section Versicolores Sing.

The name of the species refers to the type locality, Cerro La Martinica, where some endemic species had been founded,such as Psilocybe banderillensis Guzmán and P. xalapensis Guzmán & López (Guzmán, 1983).

Phaeocollybia singerii Guzmán, Bandala-Muñoz & Montoya-Bello, sp.nov.

Figs. 11-12 & 33-35

Pileo approximatus 50 mm lato, crasso campanulatus, cum minutus conicus umbo, oleosus, fulvus pallidus. Lamellis griseolus badius, marginis pallidus. Stipe approximatus 158 X 10 mm, cum longus pseudorrhiza, brunneus aurantiacus, rufobrunneus vel nigrans ad basis. Sporis (7.2-) 8-8.8 X 4-4.8 (-5.6) µm, amygdalum forma vel subfusoideus, minute verrucose vel verrucose punctatus. Cheilocystidia 17.6-25.6 X 4-6.4 (-7.2) µm, copiosus, clavatis, clavatis subcapitatis vel clavatis subglubosis, interdum sublageniformis vel subutriformis, interdum uniseptatus. Epicutis gelatinous. Hyphis defibulatis. Circa Coatepec Viejo, ad Coatepec (Veracruz, MEXICO). Typus: Bandala-Muñoz 1008 (XAL).

Pileus approximately 50 mm diam., broadly campanulate with a small conic umbo, margin slightly inrolled, glabrous, lubricous, light yellowish-brown. Lamellae subadnexed to nearly free, crowded, grayish brown with light edges. Stipe approximately 158 X 10 mm, tapering into a long pseudorrhiza which is buried into the ground almost half its lenght, glabrous, fibrous, elastic, orange-brown, vinaceous-brown to nearly blackish towards the base. Context whitish with superficial brown or gold brown tinges; odour slightly farinaceous.

Spores (7.2-) 8-8.8 X 4-4.8 (-5.6) µm, almond-shaped, subfusoid in frontal view, minutely verrucose or verrucose punctate, yellowish in KOH, inamyloid, thin walled. Basidia (20-)24-28.8 X 6.4-8 µm, tetraspored, clavate, hyaline. Pleurocystidia none. Cheilocystidia 17.6-25.6 X 4-6.4 (-7.2) µm, abundant, clavate, clavate-subcapitate, clavate-subglobose, sometimes sublageniform, subutriform or with a medial septum, hyaline, thin walled. Pileus cuticle with gelatinized hyphae, hyaline, 2.4-5.6 µm thick, thin walled, smooth. Subcutis poorly diferentiated, consisting of thin walled, 2.4-3.2 (-4) µm wide hyphae, yellowish or orange-brown in KOH. Pileus trama with hyphae 4-5.6 µm broad, yellowish, thin walled. Hymenophoral trama regular, hyphae (4-) 9.6-19.2 µm broad, hyaline to yellowish in KOH, thin walled. Clamp connections absent.

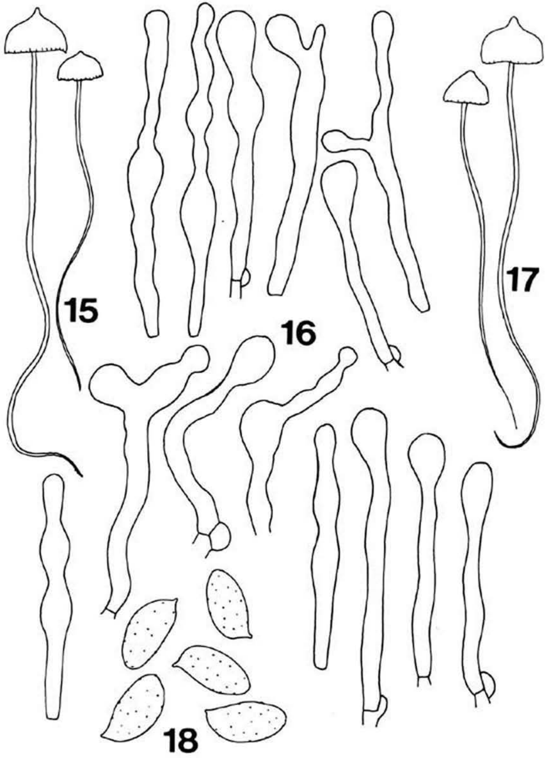
HABITAT. Solitary, on humus in a mesophytic forest.

MATERIAL STUDIED. STATE OF VERACRUZ, Coatepec Council, 3 km northwest from Coatepec, road to Coatepec Viejo, Bandala-Muñoz 1008 (Type, XAL; Isotype, IBUG).

OBSERVATIONS. This species is distinguished by the pileus color, the gelatinized cuticle, spores size and the cheilocystidia form and size. It is close to P. procera Horak from Nothofagus forests of Papua New Guinea, but differs for the cheilocystidia distinctly cylindric, 20-30 X 5-8 µm and the spores "with low warts, ornamentation often cloudy-marbled" (Horak, 1976-1977).

P. singerii is stated in the Section Phaeocollybia because of the cheilocystidia form, clampless hyphae and the spore size, following Singer's concept (1987).

The name of the species is in honor to Dr. Rolf Singer, because of his great contribution to



Figs. 15-18.- 15-17: *Phaeocollybia arduennensis*, 15: basidiocarps; 16: cheilocystidia; 17: basidiocarps (15-16: Villarreal 2683; 17: Villarreal 2244). 18: *Phaeocollybia hilaris*, spores (Sampieri 540).

the knowledge of the Mexican mycology since 1949.

NEW RECORDS OF PHAEOCOLLYBIA IN MEXICO

Phaeocollybia arduennensis Bon, Doc. Mycol. 9: 42, 1979.

Figs. 13-17

Pileus 5-18 mm broad, conic, slightly acute in the apex to subconvex-umbonate, hygrophanous, glabrous, lubricous to dry, sometimes with an undulated margin, orange brown. Lamellae adnexed, close, light orange-brown to pallid yellowish-brown, edges whitish. Stipe 70-130 X 1-2 (-3) mm, fusoid, gradually attenuating, into a long pseudorrhiza, silky, subcartilaginous, concolorous with the pileus surface or yellowish-orange above and reddish brown or blackish in the base. Context yellowish with slightly raphanoid odor.

Spores 6.4-8 X 4-4.8 (-5.6) µm, ovoid to subellipsoid, minutely verrucose, pale orange-brown to yellowish in KOH, inamyloid, thin walled. Basidia 25.6-37.6 X 6.4-8 (-8.8) µm, clavate hyaline, tetraspored, rarely bi or trispored, frequently clamped. Pleurocystidia absent. Cheilocystidia (21.6-) 25.6-52 (-74.4) X 2.4-4.8 µm, numerous, cylindric-capitate, moniliform or submoniliform, sublageniform capitate with a thin and long neck, sometimes inflated basaly or medialy, others with a small lateral prolongation, flexuous, (3.2-) 4-8 µm thick in the apical portion (capitulum), frequently clamped, hyaline, thin walled. Epicutis poorly diferentiated, consisting of hyaline, thin walled, nongelatinized hyphae 1.6-4.8 µm thick, sometimes incrusted. Subcutis not gelatinized, orange brown or yellowish pigmented with distinct incrustations, consisting of hyphae 7.2-12 (-18.4) µm broad, thin walled, forming a layer which is well differentiated from the epicutis. Pileus trama with hyphae 4-14.4 (-23.4) µm wide, hyaline to yellowish in KOH, thin walled, rarely incrustated. Gill trama subregular, hyphae 4-16 µm thick, hyaline or yellowish in group, smooth and thin walled. Clamp connections common.

HABITAT. Subgregarious among mosses, on humus in *Pinus*-*Abies* forests.

MATERIAL STUDIED. STATE OF VERACRUZ, Eastern Cofre de Perote mountain, Xico Council, 1 km Northern Ingenio El Rosario, Los Gallos, Villarreal 2244, 2622, 2683 (all in XAL).

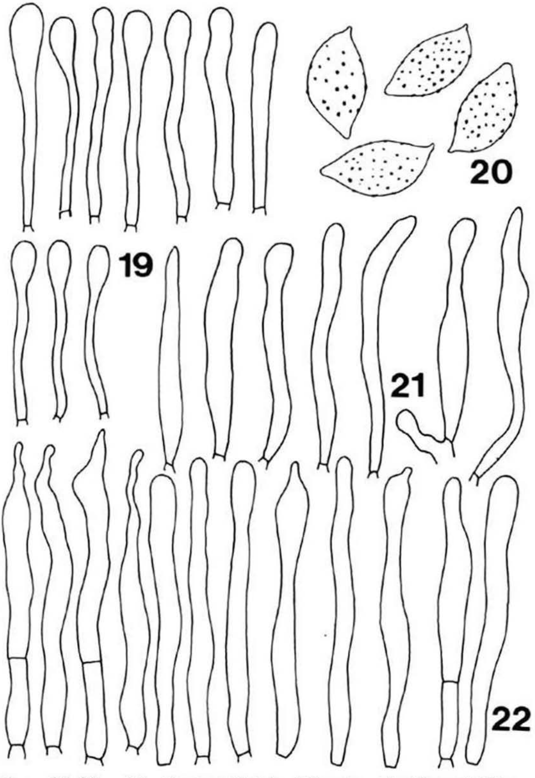
OBSERVATIONS. The polymorphous and conspicuous cheilocystidia seem the most typical features of this species. The specimens studied agree with Bon (1979) and Singer (1987) but these authors considered spores 5-6 X 3-4.5 µm or 5.5-7 X 4-4.7 µm and cheilocystidia 25-35 µm long or 26-43 µm long, respectively. It is posible to mistaken this species with the related *P. subarduennensis* Sing., but this differs in growing under *Quercus* and *Chusquea* forests from Costa Rica (Singer, 1987). *P. radicata* (Murr.) Sing. is another close species, but it has more robust basidiocarp (pileus up to 40 or 60 mm diameter) and cheilocystidia 18-30 µm long (Murrill, 1917; Smith, 1957; Horak, 1976-1977; Singer, 1987). *P. arduennensis* was known only from *Picea* and *Picea-Pinus* forests in Europe (Bon, 1979; Singer, 1987). This is the first record in Mexico. The small spores and presence of clamp connections placed *P. arduennensis* in Section Radicatae following the concept of Singer (1987).

Phaeocollybia hilaris (Fr.) Heim, Le genre *Inocybe*, p. 71, 1931.

[non *P. hilaris* (Fr.) Heim s. auct.]
= *P. cidaris* (Fr.) Heim s. Bresinsky, 1958.

Figs. 18-19

Pileus approximately 27 mm broad, convex-umbonate with a conic umbo, margin inrolled at first then becoming plane, viscid, smooth, with slightly marked short marginal striations, brown to orange-brown with some dark zones when moist,



Figs. 19-22.- 19: *Phaeocollybia hilaris*, cheilocystidia (Sampieri 540). 20-22: *Phaeocollybia oligoporpa*, 20: spores; 21-22: cheilocystidia (20-21: Guzmán 24553; 22: Bandala-Muñoz 1009).

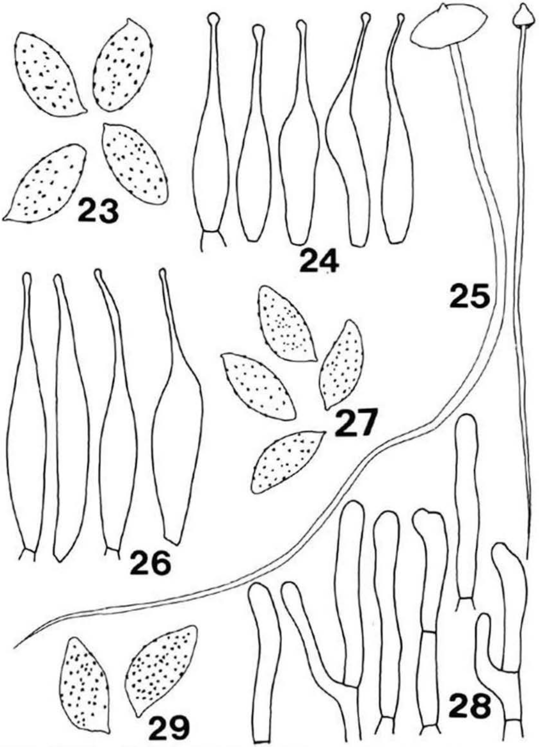
ochraceous and dark brown on the center or reddish-brown when dried. Lamellae subfree, close, yellow-brown to ferruginous brown, with whitish edges. Stipe approximately 65 X 2-3 mm, attenuated towards the base forming a short pseudorrhiza, concolorous with the pileus surface or reddish-brown, dark in the base, smooth, fibrous.

Spores 4.8-6.4 X 3.2-4 (-4.8) µm, ovoid to subellipsoid, verruculose-punctate to nearly smooth, thin walled, yellowish in KOH, inamyloid. Basidia 20-28 X 5.6-6.4 µm, cylindric-clavate, tetraspored, rarely tri or bispored, hyaline. Pleurocystidia absent. Cheilocystidia 21.6-37.6 (-44) X 1.6-3.2 µm, abundant, cylindric-capitate or filamentous-capitate, 4-5.6 µm broad in the apical region, hyaline, thin walled. Epicutis an ixocutis of hyaline, filamentous, thin walled hyphae, 1.6-3.2 (-4) µm thick, incrusted. Hypodermium consisting of thin walled, sometimes rusty incrusted hyphae, 5.6-9.6 µm broad, yellowish-brown in KOH. Context with hyaline to yellowish hyphae 5.6-20 µm thick, smooth, thin walled. Hymenophoral trama subregular, with hyaline, smooth, thin walled hyphae 4-16 µm thick. Clamp connections absent.

HABITAT. Solitary on humus, in <u>Pinus</u> forest.

MATERIAL STUDIED. STATE OF MEXICO, near Tlamacas, Popocatepetl Volcano, Sampieri 540 (XAL).

OBSERVATIONS. Determination of this species is based on the criteria of Horak (1976-1977) and Jacobson and Stridvall (1982-1983). The studied specimen agrees well in the clamp connections absence, spores size and in the cheilocystidia. <u>P. hilaris</u> s. Ricken (1915) has spores 8-9 X 4-5 µm and filamentous cheilocystidia and is considered by Kühner and Romagnesi (1957), Moser (1978), Laber (1982) and Singer (1986) as synonym of <u>P. christinae</u> (Fr.) Heim s. Heim 1931 (non s. Heim 1930). <u>P. cidaris</u> (Fr.) Heim s. Bresinsky 1958 is synonym of <u>P. hilaris</u> according



Figs. 23-29.- 23-26: *Phaeocollybia californica*, 23: spores; 24: cheilocystidia; 25: basidiocarps; 26: cheilocystidia (23-25: Peralta, Aug. 13, 1984; 26: Guzmán 5959). 27-28: *Phaeocollybia christinae*, 27: spores; 28: cheilocystidia (Bandala-Muñoz 298). 29: *Phaeocollybia kauffmanii*, spores (Montoya-Bello 1100).

to Horak (1976-1977), Jacobson and Stridvall (1982-1983) and Singer (1987), but Laber (1982) considered it as synonym of P. arduennensis Bon which has clamps (Bon, 1979; Singer, 1987).

P. hilaris was known only from coniferous forests of Europe. This is the first record of the species in Mexico. Because of its small spores and clampless hyphae it belongs to the Section Microsporae (Singer, 1986).

Phaeocollybia oligoporpa Sing., Myc. Helvetica 2: 250, 1987.

Figs. 20-22

Pileus 20-30 mm broad, conic, slightly acute umbonate to subconvex-umbonate with the apical portion obtuse, smooth, viscid to slimy, orange brown to yellowish brown or ochraceous, blackish in some parts when dried. Lamellae adnexed to subadnexed, fuscous brown or ferruginous with clear edges, close. Stipe 100-180 X 5-10 mm, fusoid, tapered downwards, forming a long pseudorrhiza which is buried into the ground, orange brown, vinaceous brown towards the base, smooth, polished, subcartilaginous. Context yellowish with reddish brown tones.

Spores (9-) 10-11.2 X 5.6-7.2 µm, sublimoniform, ellipsoid in frontal view, minutely verrucose, with a distinct mucro, pale orange-brown in KOH, inamyloid, thin walled. Basidia 28-40 X 7.2-10.4 µm, tetraspored, rarely trispored, clavate, hyaline, most clamped in the base. Pleurocystidia absent. Cheilocystidia (21.6-) 22-48 (-57.6) X 3.2-5.6 µm, abundant, mostly cylindric-flexuos, variable in form, being filamentous, fusoid, clavate-mucronate, subventricose-capitate, sometimes with the basal or medial portion inflated, hyaline, thin walled. Epicutis gelatinized, consisting of thin walled, hyaline, sometimes incrusted hyphae 1.6-6 µm thick. Subcutis of yellowish brown or pale orange to yellowish hyphae 4-8 µm wide, thin walled, incrusted. Context consisting of hyaline, thin walled, smooth 4-10.4 (-12) µm wide hyphae. Hymenophoral trama subregular, thin walled, 4-8 µm broad hyphae, hyaline to yellowish in KOH. Clamp connections present but rare.

HABITAT. Subgregarious on humus in mesophytic forests and coniferous forests both with *Quercus*.

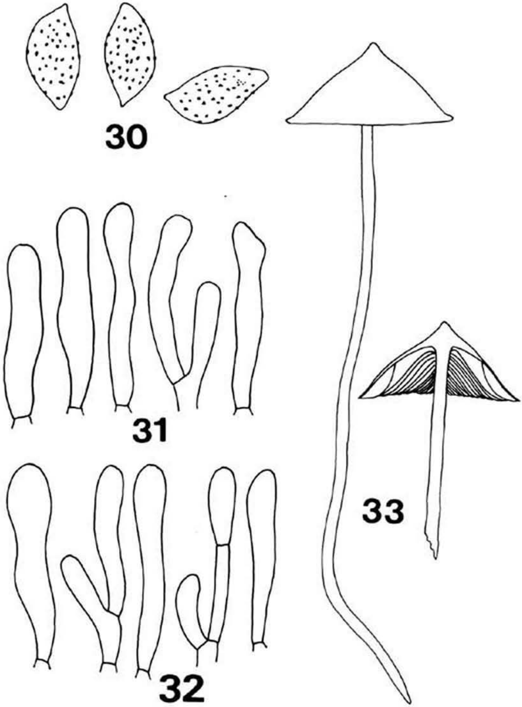
MATERIAL STUDIED. STATE OF MORELOS, Lagunas de Zempoala, Guzmán 24553 (XAL). STATE OF VERACRUZ, Huatusco Council, road Totutla-Huatusco, near Huatusco, Bandala-Muñoz 1009 (XAL).

OBSERVATIONS. This species was known only from *Quercus* forests in Costa Rica (Singer, 1987), and is distinguished by the variable cheilocystidia. *P. latispora* Guzmán, Bandala-Muñoz & Montoya-Bello and *P. similis* (Bres.) Sing. (see above) are close to *P. oligoporpa*, but they have more acute and coarsely verrucose spores and the cheilocystidia are claviform and cylindric. This is the first record of *P. oligoporpa* from Mexico. Singer (1986; 1987) considered *P. oligoporpa* along with *P. similis*, in the Section Subattenuata, because of the presence of clamps and large spores.

NEW LOCALITIES OF SPECIES PREVIOUSLY KNOWN FROM MEXICO

P. californica Smith, *P. christinae* (Fr.) Heim and *P. kauffmanii* (Smith) Sing., were reported from different localities in Mexico (Guzmán et al., 1987). These species have been found now in new localities in the States of Guerrero, Mexico and Veracruz, as follows:

P. californica: GUERRERO, Chilpancingo Council, Omiltemi region, Cañada de Agua fria, *Pinus-Quercus* forest, Peralta, Aug. 13, 1984 (FCME). STATE OF MEXICO, Popocatepetl Volcano, road Amecameca to Tlamacas, Barranca de Ameyalco, *Abies religiosa* forest, Guzmán 5583 ; 5959 (ENCB) (Figs. 23-26).



Figs. 30-33.- 30-32: *Phaeocollybia kauffmanii*, 30: spores; 31-32: cheilocystidia (30-31: Montoya-Bello 1100; 32: Montoya-Bello 1102). 33: *Pheocollybia singerii*, basidiocarps (Bandala-Muñoz 1008, Type).

P. christinae: VERACRUZ, Eastern Cofre de Perote mountain, Xico Council, road to Presa Alto Pixquiac, *Pinus* forest, Bandala-Muñoz 298 (XAL) (Fig. 27-28).

P. kauffmanii: VERACRUZ, road Xalapa to Perote, Villa Aldama Council, near Las Minas, *Pinus* forest, Montoya-Bello 1100 (XAL) (Figs. 29-32).

DISCUSSION

It is interesting to note that there are 15 species of *Phaeocollybia* in Mexico, which represent almost the 50% of the known species in the genus. Horak (1976-1977) described 34 species and Singer (1986) considered 31 species. Of the known Mexican species, *P. mexicana* Corner & Horak, *P. neosimilis* Sing., and the three new species here described seems to be endemics, but not so common, except *P. latispora* that seems common in *Pinus* and *Abies* forests. *P. mexicana* is known only from Desierto de Los Leones, D. F. (type locality, Horak, 1976-1977), and from Cofre de Perote mountain in Veracruz, and *P. neosimilis* from the Popocatepetl Volcano in the State of Mexico (Singer, 1957). The remaining species are known from U.S.A., Costa Rica and Europe as was discussed.

The five major subdivisions of the genus are well represented in the country, as we show in table 1. Four are represented in coniferous forest and only *P. singerii* and the two species known until now in Mexico belonging to Section Subattenuata (*P. latispora* and *P. oligoporpa*), occur in coniferous as well as in mesophytic forests (this last also called subtropical forest because it is close related to the tropical forest). *P. martinicensis* also grows in a mesophytic forest and belongs to Section Versicolores.

Table 1. Sections and species of *Phaeocollybia* in Mexico

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1. SECT. SUBATTENUATA SING.

   Hyphae clamped; spores over 7.5 µm long.

   - *P. latispora* Guzmán, Bandala-Muñoz & Montoya-Bello
   - *P. oligoporpa* Sing.

2. SECT. RADICATAE SING.

   Hyphae clamped; spores no more 7.5 µm long.

   - *P. arduennensis* Bon

3. SECT. PHAEOCOLLYBIA

   Hyphae clampless; spores over 6.5 µm long.; cheilocystidia cylindric or clavate, never capitate.

   - *P. attenuata* (Smith) Sing.
   - *P. christinae* (Fr.) Heim
   - *P. fallax* Smith
   - *P. kauffmanii* (Smith) Sing.
   - *P. neosimilis* Sing.
   - *P. singerii* Guzmán, Bandala-Muñoz & Montoya-Bello.

4. SECT. VERSICOLORES SMITH

   Hyphae clampless, spores over 6.5 µm; cheilocystidia sublageniform and attenuated or capitate in the apex.

   - *P. californica* Smith
   - *P. lugubris* (Fr.) Heim
   - *P. martinicensis* Guzmán, Montoya-Bello & Bandala-Muñoz
   - *P. mexicana* Corner & Horak
   - *P. spoliata* Horak

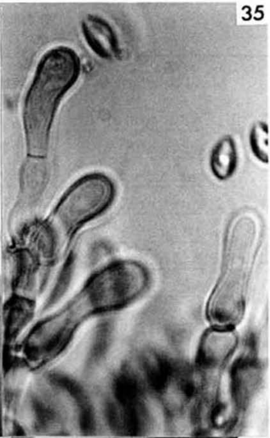
5. SECT. MICROSPORAE SING.

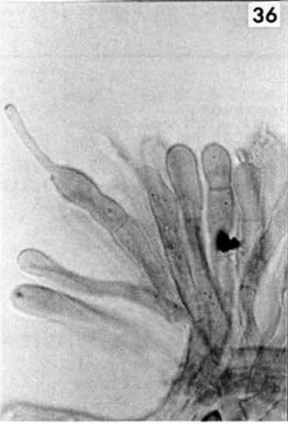
   Hyphae clampless; spores no more 6.5 µm long.; cheilocystidia variable.

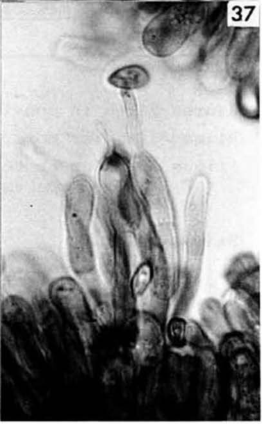
   - *P. hilaris* (Fr.) Heim

Figs. 34-37.- 34-35: *Phaeocollybia singerii*, cheilocystidia (Bandala-Muñoz 1008, Type). 36-37: *Phaeocollybia martinicensis*, cheilocystidia (Guzmán 16380, Type). Both X400.


34


35


36


37

SYNOPTICAL KEY TO SPECIES OF *PHAEOCOLLYBIA* IN MEXICO

Species considered

1. *P. arduennensis*
2. *P. attenuata*
3. *P. californica*
4. *P. christinae*

*5. *P. fallax*

6. *P. hilaris*
7. *P. kauffmanii*
8. *P. latispora*
9. *P. lugubris*
10. *P. martinicensis*
11. *P. mexicana*

*12. *P. neosimilis*

13. *P. oligoporpa*
14. *P. singerii*
15. *P. spoliata*

* Neither species studied by the authors. Data for *P. fallax* were based on Smith (1957) and Horak (1976-1977) and those for *P. neosimilis* (as *P. attenuata* spp. *mexicana* Sing.) on Singer (1970).

Features taken in consideration:

Pileus diameter more than 40 mm	5,7,4
Pileus diameter up to 40 mm	1,2,3,4,6, 8, 9,10,11, 12,13,15
Pileus color	
gray olivaceous or olive brown	5,9
orange brown	1,2,3,4,6, 8,13,15
ochre brown	2,10,12,13

reddish brown	7,8,15
reddish orange	3
cinnamon brown	4,7
yellowish brown	4,7,9,10,13,14
vinaceous	11
gray brown	9,11
brown	6
chestnut brown	12
Pileus viscid	3,4,5,6,7,9,10,11,13,15
Pileus dry to lubricous	1,2,8,12,14
Lamellae subadnexed or subfree	2,3,4,5,6,7,8,9,10,11,12,13,14,15
Lamellae adnexed	1,11,13,15
Stipe up to 8 mm thick	1,2,3,5,6,8,9,11,12,15
Stipe broader than 8 mm	4,7,13,14
Spores	
small (up 8 µm long)	1,6
medium (no more than 10 µm long)	2,3,5,7,9,10,11,12,14
large (more than 10 µm long)	4,8,13,15
coarsely verrucose	8
minutely verrucose	2,3,4,5,7,9,11,12,13,15
verrucose punctate	1,6,10,14
Cheilocystidia	
clavate, cylindric or subfilamentous	2,4,5,7,8,12

ventricose, subventricose or subcylindric with a thin, long neck capitate	3,9,11
cylindric capitate or filamentous capitate	6
heteromorphy	1,10,13
clavate-subglobose, sublageniform of subutriform	14
sublageniform capitate or ventricose-fusoid capitate	15
frequently septated	2,4,7,12
frequently forked	1,9
Clamp connections	
absent	2,3,4,5,6,7,8,9,10,11,12,14,15
present	1,8,13
Habitat	
coniferous forest	1,2,3,4,5,6,7,8,9,11,12,13,15
mesophytic forest	10,13,14
Distribution	
D.F. (Federal District)	11

Durango	7,9
Guerrero	3
Hidalgo	7,8,9
Michoacan	7
Mexico State	6,12
Morelos	7,8,9,13
Veracruz	1,2,3,4,7,8, 10,11,13,14,15

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TAXONOMICAL STUDIES ON USTILAGINALES. IV.

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ABSTRACT

New combinations proposed: Sphacelotheca rhei (Zundel) Vánky, based on Tilletia rhei (on Rheum franzenbachii); Sporisorium catharticum (R. Maire) Vánky, based on Sorosporium catharticum (on Cenchrus biflorus); Sporisorium guaraniticum (Speg.) Vánky, based on Ustilago guaranitica (on Schizachyrium condensatum).

The following names are considered synonyms: Cintractia caricis (Pers.) P. Magnus f. minor Camara & Oliveira (type on Carex pendula) is Farysia thuemenii (Fischer v. Waldheim) Nannfeldt. Doassansia lythropsidis Lagerheim (type on Lythrum hyspidulum), and D. peplidis Bubák (type on Lythrum volgense) are synonyms of D. punctiformis Winter (type on Lythrum hyssopifolia). Entyloma ludwigianum Sydow (type on Chrysanthemum segetum) is E. scalianum Ciferri (type on Chrysanthemum coronarium). Both Sphacelotheca titovii Golovin (type on Rheum maximoviczi), and Ustilago hsuii Wang (type on "Rumex" sp. = misnamed Rheum sp.) are Sphacelotheca rhei (Zundel) Vánky. The right name for Urocystis polygonati Moesz & Ulbrich (type on Polygonatum multiflorum) is Urocystis miyabeana Togashi & Onuma (type on "Convallaria majalis" = misnamed Polygonatum sp.). Ustilago ixiolirii Guo (type on Ixioliron tataricum) is Urocystis nevodovskyi Schwarzman (type on Ixioliron tataricum).

A lectotype is selected for Urocystis miyabeana Togashi & Onuma. A neotype is selected for Cintractia caricis (Pers.) P. Magnus f. minor Camara & Oliveira.

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

Camara & Oliveira (1945:108) described Cintractia caricis (Pers.) P. Magnus f. minor Camara & Oliveira, on Carex pendula Huds. from Portugal, Prov. Estremadura, near Sao Pedro de Muel, VI.1940, coll. Pinto da Silva. Cintractia caricis, a collective name, is known today as Anthracoidea caricis (Pers.) Bref. The collective species A. caricis has been split into several species, each distinguished by small but constant morphological characters. The host range of each segregate species is restricted, usually, to a single section in the genus Carex (Savile 1952, Kukkonen 1963, Nannfeldt 1979, Vánky 1979). Consequently, I was interested in the identity of Cintractia caricis forma minor. Unfortunately, the holotype of C. caricis f. minor was destroyed (Isabel Saraiva, LISE, Oeiras, Portugal; in letter). However, there is another sample (LISE 24030), also on Carex pendula, (Portugal, Prov. Estremadura, near Sintra, Parque da Pena, 8.VII.1945, coll. M.L. Borges), identified by S. Camara as C. caricis f. minor. This sample is not mentioned in the protologue but it was cited by Camara later (1958:204), together with the holotype, in his Catalogus, under Cintractia caricis f. minor. I am proposing this specimen for neotype (LISE 24030!). Based on the description of Cintractia caricis f. minor ("Sporis valde minoribus, 4.5–10 x

3.5–7.5 μ"), and the study of the above-mentioned specimen, it is clear that this taxon refers to *Farysia thuemenii* (Fischer v. Waldh.) Nannf. (syn. *F. olivacea* (DC.) H. & P. Sydow), a smut fungus widely different from *Anthracoidea* (*Cintractia*) species.

The *Doassansia* species of *Lythrum*.

Common to all *Doassansia* species is the agglutination of hundreds of thin-walled, subhyaline spores into permanent balls surrounded by a cortex of sterile cells. The spore balls are embedded in the host tissue. Spore germination of Tilletia type (See also Vánky 1987:30).

In the course of 17 years, four names were published for *Doassansias* from different *Lythrum* species, all but one (no. 2) apparently without reference to the others. Their names are: 1) *D. punctiformis* Winter, 1886:207 (not Schröter, in Cohn 1887:287). 2) *D. winteriana* P. Magnus, 1891:253. 3) *D. lythropsidis* Lagerheim, 1889:127. 4) *D. peplidis* Bubák, 1903:51.

Of these names, *D. winteriana* was created due to a misinterpretation of the rule of priority by Magnus. The Winterian name, *D. punctiformis*, was validly published, one year earlier than that of Schröter's. Consequently, the Magnusian name is superfluous.

A study of the type specimens of *D. lythropsidis* and *D. peplidis* revealed no essential differences between them. On the contrary, it turned out that the morphological characters of the spore balls, spores and sterile cells are similar. Moreover, both specimens have an interesting and rather unusual morphological character, namely that the inner surface of the wall of the empty, cortical cells is provided with warts. Consequently, *D. lythropsidis* and *D. peplidis* must be considered conspecific.

The fourth, and oldest name is *D. punctiformis*. Winter (1886:207) provided this species with what was, for the time, a very good original description. He described the morphological characters of the sori, spore balls, spores and cortical cells, including the "minutissime granulata" cortical cells. These characters all fit very well with the results obtained by the study of the two above-mentioned type specimens. I had thought that the type specimen of *D. punctiformis* Winter was lost in Berlin, but later detected part of it in BPI under the name "*Doassansia winteri* P. Magnus". The study of this specimen confirmed that it is conspecific with the two, above-discussed species. Consequently, all four names of *Doassansia* on *Lythrum* represent a single species: *D. punctiformis*. Its description and synonyms follow:

Doassansia punctiformis Winter, 1886:207 (not Schröter, in Cohn 1887:287). *D. winteriana* P. Magnus, 1891:253, nomen novum superfluum. Type on *Lythrum hyssopifolia* L., Australia, Victoria, near Melbourne, 20.X.1885, coll. Reader (140; BPI 178786!). – *D. lythropsidis* Lagerheim, 1889:127. Type on *Lythropsis peploides* Welwitsch ex Koehne (= *Lythrum hispidulum* (Dur.) Koehne), Portugal, "inter Torre et Perum, tr. Tagum", July, coll. F. Welwitsch (LISU!). – *D. peplidis* Bubák, 1903:51. Type on *Peplis alternifolia* Bieb. (= *Lythrum volgense* D.A. Webb), Bulgaria, between Haskovo and Haskovo spa, VI.1900, C.J. Podpera (BPI!).

Sori in leaves forming first yellowish-, later dark brown spots in which the scattered or gregarious spore balls appear as minute, dark brown, punctiform, amphigenous elevations. Spore balls embedded in the host tissue, 150–250 μm in diameter, composed of a central mass of more or less firmly united spores surrounded by a cortex of usually a single layer of sterile cells. Spores globose, rounded polyangular, ovoid, somewhat irregular of mutual pressure, 8–11(–12) x 9.5–15(–16) μm, pale yellow; wall thin (c. 0.5 μm), smooth. Cortical cells variable in form and size, irregularly polyhedral, 8–20 μm long, yellowish-brown; wall 1–1.5(–2) μm thick, often (especially in the large cells) prominently echinulate on the inner surface with spines up to 1 μm high.

On Lythraceae: *Lythrum* spp. (*L. hyspidulum* Koehne, *L. hyssopifolia* L., *L. volgense* D.A. Webb), Europe (Bulgaria, France, Portugal), Australia. Probably more common but overlooked.

Entyloma ludwigianum Sydow is *E. scalianum* Ciferri.

Ciferri (1924:49) described *Entyloma scalianum*, on *Pinardia coronaria* (L.) Less. (= *Chrysanthemum coronarium* L.) from Italy, Sicilia, prov. Catania, Mascalucia, II.1901, coll. Scalia; isotypes in Saccardo, Mycotheca italica 720 (HUV 1222!). Sydow (1932:396) published *Entyloma ludwigianum*, on *Chrysanthemum segetum* L., from Germany, Westfalen, Kreis Siegen, near Dirlenbach, 8.VIII.1931, A. Ludwig; isotypes in Sydow, Mycotheca germanica 2508 (HUV 9793!). The comparison of the two isotypes revealed no morphological differences between the spores or sori of these two species. Consequently, I consider them conspecific.

Sporisorium catharticum (R. Maire) Vánky, comb. nov. Basionym: *Sorosporium catharticum* R. Maire, In Recueil de traveaux cryptogamiques dédiés à Louis Mangin, 1931, p. 359. Type on *Cenchrus catharticus* Delile (= *C. biflorus* Roxb.), Algeria, South Sahara, near Tilemsi, coll. T. Monod (467; MPU!).

Sori in hypertrophied ovaries covered with a delicate, greyish-brown peridium which flakes away exposing the semiagglutinated to granular-powdery mass of spore balls and a short, central columella. Spore balls globose to elliptical, 40–110 µm long, dark reddish-brown, composed of a great number of spores which separate rather easily. Spores on the periphery of the balls globose to elliptical, 9–13 x 10–14.5 µm, medium reddish-brown, finely and densely echinulate, those in the center subpolyhedral, smaller (7–10 µm), lighter colored and finely pitted or apparently smooth. Sterile cells of the peridium variable in form and size, often elongated, 4–16 µm long, arranged in parallel chains, hyaline, smooth.

Based on the descriptions, *S. catharticum* could be conspecific with *Ustilago penniseti* Rabenhorst (type on *Pennisetum fasciculatum* Trin. = *P. orientale* Rich.). Rabenhorst (1871:18) described his species as being smooth-spored whereas spores of *Spor. catharcticum* are pitted to finely echinulate. Probably, the spores of *U. penniseti* are also echinulate but the fine ornamentation was beyond Rabenhorst's 1871 limit of resolution. Reexamination of type material of *U. penniseti* is necessary to resolve this problem.

Sporisorium guaraniticum (Spegazzini) Vánky, comb. nov. Basionym: *Ustilago guaranitica* Spegazzini, Anales Soc. Ci. Argent. 17:87, 1884. Syn. *Sphacelotheca guaranitica* (Speg.) Zundel, 1930:135. Type on *Andropogon condensatus* H.B.K. (= *Schizachyrium condensatum* (H.B.K.) Nees, Paraguay, between Paraguari and Valenzuela, V.1883 ("HMAS"!).

Sori destroy the racemes and are 2–3 cm long, linear, partly hidden by the spathes, covered by a thin membrane which ruptures disclosing the blackish-brown, granular-powdery mass of spore balls and a long, thin, slender, central columella. Spore balls loose, subglobose to long ellipsoidal, 50–120 µm long, dark reddish-brown. Spores subglobose, usually ellipsoidal or slightly irregular, 12–16 x 13–20 µm, light to medium reddish-brown, free surface of the outer spores with fine, dense verrucae just affecting the spore profile, inner spores smooth; wall typically unevenly thickened, with (0–)2–4(–6) protuberances or thicker and darker areas (0.8–2.5 µm) alternating with thin and light areas of the spore wall (0.5–1 µm).

The identity of *Tilletia rhei*.

From the mycological herbarium of the Institute of Microbiology of the Chinese Academy of Science ("HMAS"), I obtained in exchange a fragment of the holotype of *Ustilago hsuii* Wang, collected on "*Rumex*" sp. in China. The study of this specimen revealed that the host is actually a *Rheum* sp. /On the fruits of the host plant, up to 8 stamens are detectable (*Rheum* has 9 stamens; *Rumex* 6), the stigmata are head-like (as in *Rheum*) and not brush-like (typical for *Rumex*), furthermore, the inner segments of the perianth are not enlarged as they would be in ripe fruits of *Rumex* (R. Bernt, pers. comm.)/ and its smut is identical with

"*Tilletia*" *rhei* Zundel.

Zundel (1944:410) described *Tilletia rhei* from the seeds of *Rheum franzenbachii* Mürt, collected in China. *T. rhei* is characterised by sori in the seeds, swollen, 2–4 mm in diameter, covered by a hard, dark reddish-brown, somewhat shiny pericarp lined by a whitish layer of immature spores. Sori open from their apices, like tulips, to reveal the agglutinated, purplish-black mass of spores, and a central, irregular columella which also produces spores. Spores variable in size and grade of maturity, mature ones globose, subglobose or ellipsoid, rarely elongated or somewhat irregular, 13–22 x 15–24 µm, violet tinted reddish-brown; spore surface variously sculpted: from very finely reticulate (9–18 meshes per spore diameter), with uniformly thick muri or with verrucose thickenings in the common points of the meshes to only verrucose by the reduction and disappearance of the muri; wall 2.5–3.5 µm wide including the 1–1.5 µm high reticulum. Sterile cells (or immature spores?) larger than the spores, hyaline, thick-walled, smooth.

Golovin (1950:10) described *Sphacelotheca titovii* in the seeds of *Rheum maximoviczi* A. Los., from Kazakhstan. The description of this species agrees with that of *Tilletia rhei*. I have not seen the type of *S. titovii*, but I have studied one collection on *Rheum maximoviczi* from Tadzhikistan (AA), and another on *R. wittrockii* Lundstr. from Kazakhstan (AA). Both agree with the type of *T. rhei*. (The sorus diameter given by Golovin as 26–30 mm refers certainly to 2.6–3.0 mm). Following germination, Golovin (1950:10) obtained a 3–4-celled promycelium giving rise to hyphae.

Production of a septate promycelium excludes "*Tilletia*" *rhei* from the genus *Tilletia*. I am proposing for it the following name and synonyms:

Sphacelotheca rhei (Zundel) Vánky, comb. nov. Basionym *Tilletia rhei* Zundel, Mycologia 36:410, 1944. Type on *Rheum franzenbachii* Mürt (= *R. rhabarbarum* L.), China, Shanshi prov., Chiao-Ch'eng distr., Yünting-Shan, 2500 m, 2.IX.1924, H. Smith (Plantae sinenses 7451; S!, UPS!). – *Sphacelotheca titovii* Golovin, in Sredneaz. Gos. Univ., N.S., Publ. XIV, Biol. Nauk. Book 5:10, 1950. Type on *Rheum maximoviczi* A. Los., USSR, Kazakhstan, valley of Karapchur river, Myndzhelike, south from Bol'shoi Tsimgan, 2700 m, V. Titov. – *Ustilago hsuii* Wang, in Acta Bot. Sinica 10:133, 1962. Type on "*Rumex*" sp. (= misnamed *Rheum* sp.), China, Sinkiang prov., Barto muchong, alt. 2100 m, 30.VIII.1958, Hsu Lian-wang (377; HMAS 31558, HUV 13602!).

The identity of *Ustilago ixiolirii* Guo.

Guo recently (1988:222) published a new smut species from China, under the name *Ustilago ixiolirii*, producing its sori in the capsules of *Ixioliron tataricum* (Pall.) Herb. (Amaryllidaceae). On examination, part of the holotype ("HMAS" 51934, obtained courtesy of Mrs L. Guo), prowed to be identical to the type of *Urocystis nevodovskyi*, described by Schwarzman (1960:327) on *Ixioliron tataricum*, from Kazakhstan. The "cerebriform surface" of the "spores" of "*Ustilago ixiolirii*" is actually produced by the numerous, small, collapsed, hyaline sterile cells which surround completely the 1(–2–3) central, fertile spores in the spore balls. Consequently, *Ustilago ixiolirii* Guo is a synonym of *Urocystis nevodovskyi* Schwarzman.

Urocystis miyabeana instead of *Urocystis polygonati*.

Togashi and Onuma (1930:25) published a new *Urocystis* species, *U. miyabeana*, "on leaves and sheaths of *Convallaria majalis* L., Japan, Prov. Rikuchu, Mt. Himekami, June 1 & 15, 1928, K. Togashi and F. Onuma". No one since has reported *Urocystis* species on *Convallaria*. My repeated attempts to find this smut in different parts of the world failed. However, one should keep in mind, that *Urocystis* species on Liliaceae often are very rare, even where the host plants are growing in abundance. There is no specimen of *U. miyabeana* in the Herbarium of Plant Pathology Laboratory, Faculty of Agriculture, Iwate University, Morioka. The "Type", collected on 15.VI.1928, originating from

"Herbarium Kogo Togashi No. 3927" is in Sapporo (SAPA). Several infected plants from the type had, however, the leaf characters of Polygonatum rather than those of Convallaria. Unfortunately no rhizomes were collected. A good differentiating character for these two genera is, i.a., that the leaves of Convallaria arise from the rhizome, while in Polygonatum and the host plants of U. miyabeana, they arise from the stem. The spore balls and spores of the types of these two Urocystis species are also similar. These facts indicate that the two names are taxonomical synonyms. The right name and the synonyms of this Polygonatum smut are:

Urocystis miyabeana Togashi & Onuma (1930:25). – Tuburcinia miyabeana (Togashi & Onuma) Togashi, in Ito (1935:95). Lectotype on "Convallaria majalis" (= misnamed Polygonatum sp.), Japan, Rikuchu Province (= Iwate Prefecture), Mt. Himekami, (sel. here) 15.VI.1928, F. Onuma (SAPA!). – Urocystis polygonati Moesz & Ulbrich (1941:395). Lectoype on Polygonatum multiflorum (L.) All., Hungary, Budapest, Mt. Jánoshegy, (sel. by Vánky 1985:174) 11.VI.1927, G. Moesz (BP!). – Tuburcinia polygonati Lavrov (1937:3). – Urocystis polygonati (Lavrov) Zundel (1953:330; later homonym). – Urocystis polygonati (Lavrov) T. Săvulescu (1957:1071; later homonym). Type on Polygonatum officinale All., USSR, Sibiria, region Zabaykal, near Ust.-Kiran, 3.VI.1913, P. Mikhno (LEP!). – Urocystis ungeri Zundel (1945:372). Lectotype on Polygnatum multiflorum (L.) All., (sel. by Zundel 1953:336) Czechoslovakia, Moravia, Doubrava, 14.V.1898, F. Bubák (BPI!). – Tuburcinia polygonati Mayor & Viennot-Bourgin (1948:11; later homonym). Type on Polygonatum verticillatum (L.) All., France, Mt. Jura, Joux forest, 1.VI.1947, E. Mayor.

From the two collections of Urocystis miyabeana, mentioned in the protologue ("June 1 & 15, 1928."), I could detect in Japan only one, namely that collected on 15th of June by F. Onuma, which I select as lectotype (SAPA!).

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ABBREVIATIONS

The abbreviations for herbaria follow Index Herbariorum (Stafleu et al. 1981).

HMAS = Herb. Mycol. Acad. Sinica, Beijing.

HUV = Herb. Ustilag. Vánky, the author's private herbarium.

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A NEW COMBINATION FOR HELMINTHOSPORIUM EUPHORBIAE

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A new Bipolaris combination is presented for Helminthosporium euphorbiae Hansford, 1943.

Considerable attention has been given in the past decade to the taxonomy of species of Helminthosporium Link:Fries **sensu lato** which produce conidia upon geniculate conidiophores (Alcorn, 1983; Muchovej et al., 1988; Sivanesan, 1987). A majority of these species are pathogenic to grasses and many represent major pathogens of cereals (Zillinsky, 1983) and amenity grasses (Couch, 1973). However, a few species appear to be limited to dicotyledonous hosts and these have received little attention taxonomically. Among these is Helminthosporium euphorbiae Hansford, which produces a leaf spot of Euphorbia spp. which can cause defoliation of these plants.

The genus Helminthosporium was originally divided based on the presence of macronematous erect conidiophores which produced enteroblastic conidia terminally and from pores located below the septa of the conidiophore; or on the presence of macronematous erect conidiophores which produce enteroblastic conidia singly at the apex followed by sympodial branching (Ellis, 1971). The former were retained in Helminthosporium while the latter were placed in Drechslera Ito (1930). Drechslera was further subdivided into Bipolaris Shoemaker (1959) and Exserohilum Leonard & Suggs (1974) based on bipolar germination and the presence of a protuberant hilum respectively.

Alcorn (1983) after studying a vast majority of the species of Drechslera, Bipolaris and Exserohilum found that the generic concepts of these were sound.

A few species remain undisposed by this changing classification (Muchovej, et al., 1988) and we have found one such species producing leaf spots of Euphorbia in Brazil. Based on morphological characteristics, our species agrees with descriptions of Helminthosporium euphorbiae Hansford (1942) [Drechslera euphorbiae (Hansford) M. B. Ellis (Ellis, 1971)]. Based on the characteristics described by Alcorn (1983), this species should be transferred to Bipolaris.

Bipolaris euphorbiae (Hansford) Muchovej comb. nov.
- Helminthosporium euphorbiae Hansford, 1943, Proc. Linn. Soc. London 1942-43:49.
- Drechslera euphorbiae (Hansford) M. B. Ellis, 1971, Dematiaceous Hyphomycetes, pg 440.

Brazil, Viçosa, MG, on leaves of Euphorbia sp., March 1988, Herbario UFV neotypus (ATCC 64939, BRIP ex neotypus). Other collections were deposited at BRIP 16567. Attempts to obtain Hansford's type (number 1230) have confirmed that it is not housed at PREM, IMI or BRIP, therefore a neotype has been designated.

Conidia are light to mid brown in color with the tips often lighter in color. They are subcylindrical to fusiform, rounded at the ends, often slightly flexed, and widest near the middle. Germination is bipolar with the germ tube originating near the hilum and proceeding along the long axis of the conidium. The first septum is produced about one third the way up the conidium from the hilum, the second septum delimits the basal cell and the third septum is distal to the first. Conidia are 63-96(-145) x 14.7-17.5 um and typically 7-8 distoseptate, with only a small number of conidia having fewer or more septa. The hilum is truncate and 2.3-3.8 um wide. Conidiophores are geniculate in and have a clear apex which was flattened. There was no significant variation between conidia produced on the host or in culture.

These characteristics fit well in those for Bipolaris. Alcorn (1983) inspected a collection of H. euphorbiae (IMI 161577) from which he alluded that this species showed characteristics of Bipolaris.

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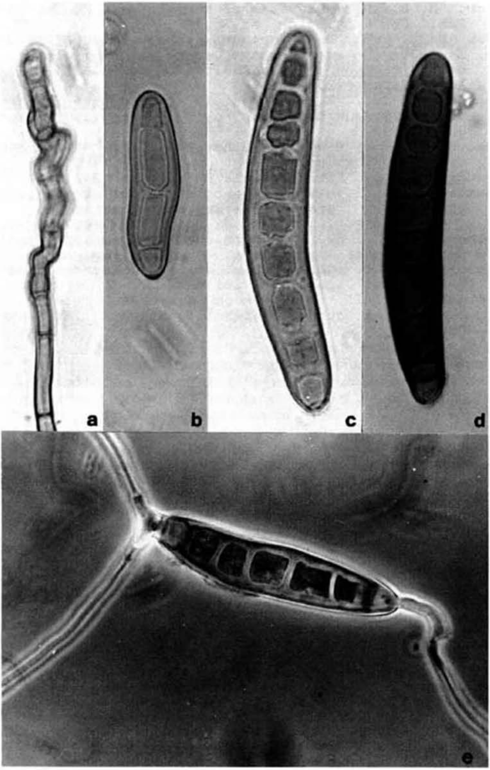
The authors are extremely grateful to Dr. J. L. Alcorn for improving the quality of the manuscript. This research was funded in part by CNPq (Brazil).

Figure 1. Bipolaris euphorbiae x 700. a) geniculate conidiophore, b) forming conidium with 3 septa, c,d) conidia, e) germinating conidium.


a
b
c
d
e

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TWO NEW SPECIES OF LABOULBENIA (LABOULBENIALES) PARASITIC ON ENDOGEAN CARABID BEETLES

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SUMMARY

Two new species of *Laboulbenia* (Laboulbeniales, Ascomycotina) parasitic on endogean carabid beetles (Coleoptera, Carabidae) are described and illustrated: *L. reicheiae* sp. nov. on *Reicheia* spp. (Coleoptera, Carabidae, Scaritinae) from Spain, France and Algeria and *L. speluncae* sp. nov. on *Iberanillus vinyasi* Español (Coleoptera, Carabidae, Bembidiinae, Anillini), from Spain.

INTRODUCTION

The genus *Laboulbenia* Montagne & Robin in Robin is the largest in number of taxa among the laboulbeniaceous fungi, with more than 500 species described. *Laboulbenia* species chiefly parasitize carabid beetles, but they also occur on other families of Coleoptera and other groups of arthropods. *Laboulbenia* is a cosmopolitan genus (Tavares, 1985).

The two new species proposed here have some morphological peculiarities which distinguish them from most of the other species of *Laboulbenia*. However, the species are being placed in *Laboulbenia* because of the perithecial wall, the position of the primary septum, the structure of the upper receptacle, and the production of an evanescent antheridium from the first cell of the appendage.

DESCRIPTIONS

Laboulbenia reicheiae Santamaria, sp. nov. (figs. 1-9)

Coloratio generalis porphyrea, cellula I clarior. Cellula II subdivisa in alias duas cellulas aequales altitudine. Cellula IV parva, caulicuneata versus cylindrica, a cellula III separata septo obliquo. Cellula V fusiformis versus cuneiformis, longa et angusta, limitem inferiorem cellulae III fere attingens. Septum IV-V longitudinale. Cellula VI cuneiformis, maxime parva. Perithecium fusiforme, apicem detruncatum versus rotundatum habens. Septum primarium intense pictum brunneo, constrictionem in cellula IV formans. Appendix primaria simplicissima, inconspicua, cellulam basalem intense pictam habens.

Tota longitudo: 100-118 µm. Perithecium: 42-58 µm x 19-27 µm. Ascosporae: 25 µm.

Holotypus: SS513, BCB-Mycotheca. Super Reicheia lucifuga, Le Perthus incolente (Gallia Narbonense).

Overall color pale red brown, with the basal cell (I) nearly hyaline.

Receptacle: Suprabasal cell (II) subdivided into two cells of equal length. Cell IV small, superimposed on cell III, truncated cone to cylindrical, separated from cell III by an oblique septum. Cell V spindle-shaped or wedge-shaped, long and narrow, nearly reaching the lower margin of cell III. Septum IV-V longitudinal.

Appendage: Primary septum deeply pigmented, marked by a constriction over cell IV. Primary appendage simple, with the basal cell deeply pigmented but not flattened (therefore is not the typical insertion cell named melanopsallium). The primary appendage, in spite of appearing damaged in all specimens, is very short and simple and, in my opinion, doesn't develop more than is illustrated in the figures (cf. figs. 2, 4). Probably, the terminal cell of the short branch arising from the internal side of the primary appendage acts as a single antheridium (figs. 3-5); its position over the brief trichogyne would be in accordance to its spermatic function. The antheridium degenerates when the perithecium matures.

Perithecium: Stalk cell (VI) wedge-shaped, very short. Body of the perithecium elliptical, with a truncated or rounded apex. In each vertical row of outer wall cells of the perithecium there are 4 cells of unequal height. The ventral surface of the perithecium is marked by a prominence due to the septum which separates the two lower wall cells.

Measurements: Perithecium, 42-58 µm x 19-27 µm. Total length, 100-118 µm. Ascospores, 25 µm.

Etymology.- Named after *Reicheia*, generic name of the host.

Holotype.- FRANCE: Le Perthus (Pyrénées orientales). On elytron of *Reicheia lucifuga* Saulcy (Coleoptera, Carabidae, Scaritinae, Reicheini). Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, SS513.

Other material examined.- SPAIN: La Rabassada (Barcelona, Catalunya), 25-V-17. On elytron and pronotum of *Reicheia lucifuga* ssp. *zariquieyi* Holdhaus. Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). SS615, sent to Dr. I. I. Tavares herbarium.

Vallvidrera (Barcelona, Catalunya), XI-15. On elytron and legs of *Reicheia lucifuga* ssp. *zariquieyi* Holdhaus. Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, SS616.

Riells del Fai (Barcelona, Catalunya). On elytron of *Reicheia lucifuga* ssp. *zariquieyi* Holdhaus. Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, SS617.

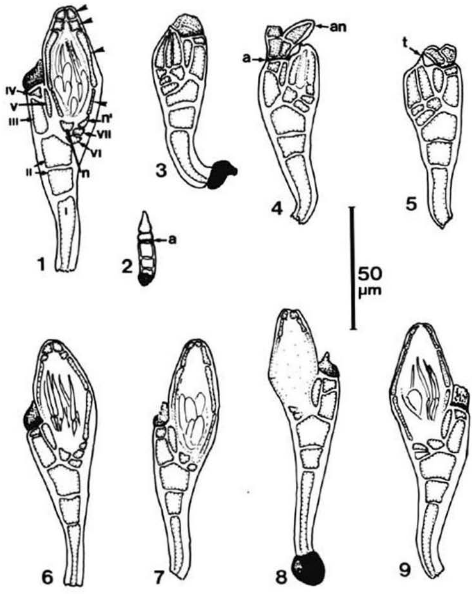
FRANCE: Morellàs (Pyrénées orientales). On elytron and legs of *Reicheia lucifuga* Saulcy. Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, SS614.

Montbollo (Pyrénées orientales), IV-65, leg. Tempère. On elytron of *Reicheia lucifuga* Saulcy. Herbarium J. Balazuc.

ALGERIA: Bou-Berak (Kabylie). On elytron of *Reicheia brisouti* Bedel. Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, SS613.

Bosc d'A-kahcra, 23-II-55, leg. de Miré. On left elytron of *Reicheia kabyliana* ssp. *quezeli* Miré. Herbarium J. Balazuc.

Bosc de Guerrouch, 21-II-55, leg. de Miré. On right elytron and pronotum of *Reicheia subterranea* ssp. *saldoensis* Miré. Herbarium J. Balazuc.



Figures 1-9. *Laboulbenia reicheiae*. **1**. Mature holotype (SS513). General arrangement of cells. Arrows indicate the wall cells of the perithecium. **2**. Immature specimen. a, primary septum. (SS616). **3-5**. Immature specimens showing the antheridium (an) and trichogyne (t). (SS613). **6-9**. Mature specimens. (6, SS513, holotype; 7, SS615; and 8-9, SS616).

Laboulbenia speluncae Santamaria, sp. nov. (figs. 10-17)

Cellula I apicem perithecii et extremam appendicem primariam hyalinus habet. Thallus reliquus fuscus, parvas maculas obscuriores in receptaculo habens. Cellula I subdivisa in alias duas cellulas, inferiorem minorem quam superiorem. Cellula III-IV indivisa. Cellula V cuneiformis, a cellula III-IV disjuncta septo obliquo. Cellula VI valde applanata. Perithecium fusiforme, apicem indistinctum habens. Septum primarium constrictionem bene notatam format super cellulis III-IV et V, praeter intense pictum brunneo. Cellula insertionis absens. Basis appendicis primariae duabus cellulis inaequalibus et intense pictis fusco formata; cellula externa maxima est, et basem appendici simplici format, bicellulari vel tricellulari, nunquam superanti in longitudine apicem perithecii; cellula interna valde parva est, et, in exemplis immaturis, brevem appendicem uno antheridio terminatem sustinet; haec appendix interna caduca est.

Longitudo unguis-apex perithecii: 72-105 µm. Perithecium: 39-48 (-57) µm x 13-25 µm. Ascosporae: 37 µm.

Holotypus: SS216/1a. BCB-Mycotheca. Super Iberanillo vinyasi, Cueva Hondero incolente, Ahín, in provincia Castellón (Valentino regno, Hispania).

Cell I, apex of perithecium and top of primary appendage hyaline. Remainder of thallus brown, with small dark spots in the receptacle.

Receptacle: Suprabasal cell (II) subdivided into two cells, the lower being smaller than the upper. Cell III-IV undivided. Cell V wedge-shaped, separated from the undivided cell III-IV by an oblique septum.

Appendage: The primary septum is marked by a constriction over cells III-IV and V, and is deeply pigmented. The typical flattened insertion-cell (melanopsallium) is absent. The base of the primary appendage is made up of two unequal, dark-colored cells; the external cell is the largest and supports a simple bi- or tricellular branch; the branch does not reach the top of the mature perithecium; the internal basal appendage cell is very small and bears, in immature specimens, a short branch with a single apical antheridium (fig. 11); this internal branch is deciduous.

Perithecium: Stalk cell (VI) short. Body of the perithecium elliptical. In each vertical row of outer wall cells of the perithecium there are 4 cells of unequal height. Secondary stalk cell (VII) and basal cells (m, n, n') of the perithecium very small but easy to observe on immature specimens.

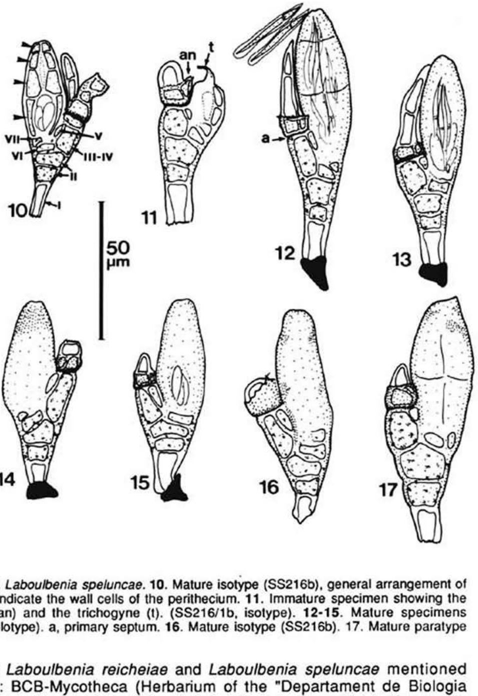
Measurements: Perithecium, 39-48 (-57) µm x 13-25 µm. Total length, 72-105 µm. Ascospores, 37 µm.

Etymology.- From spelunca, cave, referring to the habitat of the host and its parasite.

Holotype.- SPAIN: Cova Hondero, Ahín (Castelló), 25-IX-77. On *Iberanillus vinyasi* Español (Coleoptera, Carabidae, Bembidiinae, Anillini). Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, SS216/1a.

Isotypes.- SPAIN: Ibidem, 25-IX-77. On the same host. Entomological collection of the "Museu de Zoologia de Barcelona" (Spain). BCB-Mycotheca, slides SS216a, SS216b, SS216/1b.

Paratypes.- SPAIN: Ibidem, 13-XII-78. On the same host. Entomological collection of the "Museu de Zoologia de Barcelona" and entomological collection of J. Comas. BCB-Mycotheca, slides SS216c and SS216d. Slide SS541 sent to Dr. I. I. Tavares herbarium.



Figures 10-17. *Laboulbenia speluncae*. **10**. Mature isotype (SS216b), general arrangement of cells. Arrows indicate the wall cells of the perithecium. **11**. Immature specimen showing the antheridium (an) and the trichogyne (t). (SS216/1b, isotype). **12-15**. Mature specimens (SS216/1a, holotype). a, primary septum. **16**. Mature isotype (SS216b). 17. Mature paratype (SS216c).

All slides of *Laboulbenia reicheiae* and *Laboulbenia speluncae* mentioned here are in: BCB-Mycotheca (Herbarium of the "Departament de Biologia Animal, Biologia Vegetal i Ecologia, Unitat Botànica, Universitat Autònoma de Barcelona"); personal herbarium of Dr. J. Balazuc, and personal herbarium of Dr. I. I. Tavares (slides SS615 and SS541). The hosts are in the entomological collection of the "Museu de Zoologia de Barcelona", the entomological collection of J. Comas and the J. Balazuc collection.

DISCUSSION

The two *Laboulbenia* species proposed here have significant morphological similarities: (1) suprabasal cell of receptacle (II) divided into two cells by a transverse septum, (2) lack of a black, flattened insertion cell (melanopsallium), (3) compact primary appendage with a single deciduous antheridium and, (4) a modified thallus like other endogean *Laboulbenia* species (e.g. *Laboulbenia coiffaitii*).

Laboulbenia reicheiae parasitizes *Reicheia* spp. from Spain, France and Algeria. On *Reicheia* we find *Scalenomyces endogaeus* (Picard) Tavares (= *Laboulbenia endogaea* Picard, cf. Tavares, 1985) and *Laboulbenia pedicellata*. The former is a highly modified species related to *Laboulbenia* and some allied, undescribed taxa (Tavares, 1985). *Laboulbenia pedicellata* is a common, ubiquitous species. *Laboulbenia reicheiae* doesn't agree with the *Scalenomyces* description because of the short primary appendage and its distinctive receptacular structures.

Laboulbenia speluncae parasitizes *Iberanillus vinyasi* Español, a small endogean carabid beetle, endemic in Cova Hondero in the Central part of eastern Spain. The genus *Iberanillus* belongs to the tribe Anillini (Carabidae); several laboulbeniaceous fungi are known on this group, among them *L. coiffaitii* Balazuc (1971) which differs from *L. speluncae* because of its long primary appendage, separate cells III and IV, and its single suprabasal cell (II). In Santamaria (1986) I misidentified this material as *L. coiffaitii*; its comparison with the type of *L. coiffaitii* (sent to me by Dr. Jean Balazuc) convinced me of the necessity to describe this new taxon.

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CHEMICAL VARIATION IN THE LICHEN LECANORA EPIBRYON S. AMPL. (LECANORACEAE: ASCOMYCOTINA)

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ABSTRACT : A total of 20 lichen substances were detected in collections of *Lecanora broccha* from the Southern Hemisphere. These substances occurred in 14 combinations within this species, but a phenetic comparison of the races using the chemical data and their distribution did not show any clear pattern. *L. broccha* appears to be morphologically indistinguishable from the Northern Hemisphere species *L. epibryon,* but for the present they are maintained as distinct species because of their chemical dissimilarities and distinctive geographic distributions.

Natural product chemistry has played an important role in lichen taxonomy ever since Nylander (1866) introduced chemical reagents as an aid for the identification of lichen species. Current concepts in lichen chemotaxonomy and the alternative views on the taxonomic value of chemical characters have been reviewed recently by Egan (1986) and Culberson (1986).

While most species are characterized by a constant combination of lichen substances irrespective of their geographic origin, others are not. Indeed in some cases no correlation between chemical constituents and geography or morphology are apparent. Such species include *Cetraria islandica* (L.) Ach. (Kärnefelt 1979) and *Pertusaria oculata* (Dicks.) Th. Fr. (Dibben 1980).

In the course of conducting a detailed comparison of *Lecanora broccha* Nyl. [syn.: *L. parmelina* Zahlbr. according to Galloway, who gives a detailed description of this taxon (Galloway 1985)] from the Southern Hemisphere with the circumpolar Northern Hemisphere *L. epibryon* (Ach.) Ach. (Brodo 1984), we examined the chemical constituents of both species. In contrast to *L. epibryon, L. broccha* exhibited very variable chemistry throughout its broad geographic range. The secondary metabolites, their distribution and the relationship between *L. epibryon* and *L. broccha* are discussed.

Material and Methods

Lichen material from the following herbaria was examined: ANUC, BM, HO and herb. Lumbsch. The lichen fragments were freed of all obvious organic substrate material and extracted with warm acetone for thin layer chromatography (t.l.c.), or with warm methanol for high performance liquid chromatography (h.p.l.c.). T.l.c. analyses were conducted using the standardized methodology developed by Culberson (Culberson 1972; Culberson & Johnson 1982; Culberson, Culberson & Johnson 1981; Elix, Johnston & Parker 1987, 1988). H.p.l.c. was performed using a Perkin-Elmer Series 1LC pump fitted with a HS-5 C18 column and a LC-85 spectrometric detector operating at 254 nm. Elution was effected with 90% methanol-water containing orthophosphoric acid (80µl/400ml) with a flow rate of 0.6 ml min^{-1} (Lumbsch & Elix 1985).

Phenetic comparison of the chemical races was carried out with the computer program MANHATT (Mietzsch, unpubl.). The distance of the OTU's was measured in Manhattan distance. The similarities were demonstrated by a phenogram using the single-linkage cluster analysis of Estabrook (1966).

Results and Discussion

The species *L. epibryon* and *L. broccha* are morphologically indistinguishable and show no substantial differences in their anatomy. However where the Northern Hemisphere populations (*L. epibryon*) has a relatively uniform chemistry, the Southern Hemisphere specimens (*L. broccha*) exhibit remarkable chemical diversity.

The following lichen substances were identified in the specimens examined.

β-Orcinol Depsides : atranorin (1), chloroatranorin (2), barbatic acid (3), 4-*O*-demethylbarbatic acid (4), methyl barbatate (5).

β-Orcinol Depsidones : connorstictic acid (6), constictic acid (7), cryptostictic acid (8), hypoprotocetraric acid (9), menegazziaic acid (10), norstictic acid (11) and stictic acid (12).

Orcinol Depsides : lecanoric acid (13).

Xanthones : unknown xanthones x-1 (14), x-2 (15), thiophanic (16), x-4 (17) and isoarthothelin (18).

Triterpenoids : Lgr-1* (19), Lgr-2* (20), zeorin [hopan-6α,22-diol](21) and ursolic acid (22).

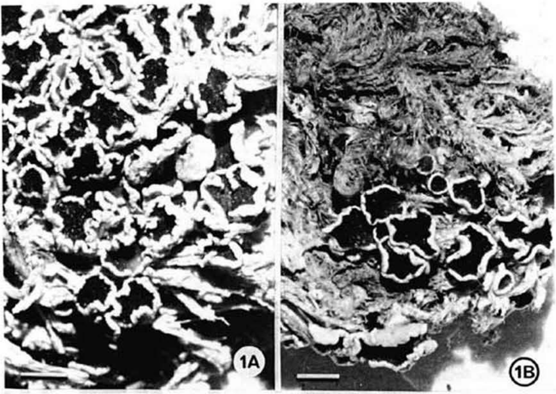
β-Orcinol Derivative : methyl β-orsellinate (23).

Unknown substances : unknown-7 (24) and Lcm-1* (25).

* These unknown substances were first described by Brodo (1984).

The standardized chromatographic data for these compounds are listed in Table 1 and the distribution of these substances among the chemical races of *L. epibryon* s. amp. is shown in Table 2. While races A-N represent the Southern Hemisphere specimens (*L. broccha*), races O, P and Q were observed only in Northern Hemisphere specimens (*L. epibryon*). The chemical diversity of this species complex is quite unexpected: more substances are found in this species complex than in the whole of *Lecanora* s. str. in North America (Brodo 1984).

Throughout their distribution, the Southern Hemisphere specimens were morphologically and anatomically comparable (Figures 1A, 1B) with one another and could not be distinguished without chemical analysis. There was no apparent correlation of chemistry with geographic distribution. For example, although the races C, K-N all



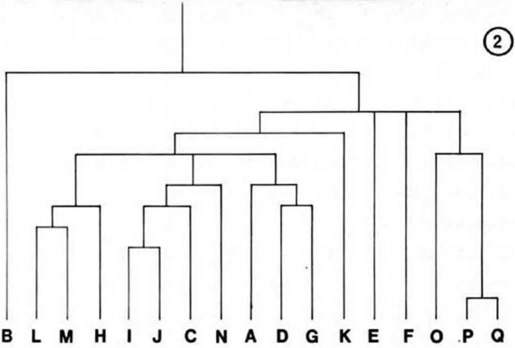


Figure 1 : *Lecanora broccha*, habit ; A, Lectotype of *L. broccha* (BM); B, Isotype of *L. parmelina* (BM). Scale = 1 mm.
Figure 2 : Phenogram of the chemical strains in the *L. epibryon* group.

Table 1. Standardized Chromatographic Data for *Lecanora* Metabolites

Standard R_F values (x 100) were determined in solvent systems: (A) toluene / dioxane / acetic acid (180:45:5); (B) hexane / diethyl ether / formic acid (130:80:20); (B*) hexane / *t*-butyl methyl ether / formic acid (140:72:18); (C) toluene / acetic acid (170:30); (E) ethyl acetate / cyclohexane (25:75); (G) toluene / ethyl acetate / formic acid (139:83:8). Standard R_T values in h.p.l.c. are given in minutes.

Compound R_F	(A)	(B)	(B*)	(C)	(E)	(G)	R_T
Atranorin (**1**)	75	78	73	79	57	--	7.37
Chloroatranorin (**2**)	74	79	73	81	30	--	8.43
Barbatic Acid (**3**)	44	69	67	52	--	--	7.52
4-*O*-Demethylbarbatic Acid (**4**)	39	60	54	36	--	--	4.82
Methyl barbatate (**5**)	77	--	73	86	--	--	10.04
Connorstictic Acid (**6**)	11	11	11	3	--	26	3.23
Constictic Acid (**7**)	7	3	1	2	--	9	3.15
Cryptostictic Acid (**8**)	14	14	10	10	--	27	3.38
Hypoprotocetraric Acid (**9**)	25	43	37	22	--	48	4.75
Menegazziaic Acid (**10**)	19	--	14	12	--	36	3.59
Norstictic Acid (**11**)	40	29	32	30	--	57	3.91
Stictic Acid (**12**)	32	9	9	18	--	34	3.60
Lecanoric Acid (**13**)	28	44	44	22	--	56	4.00
Xanthone x-1 (**14**)	--	--	--	65	12	--	8.60
Xanthone x-2 (**15**)	--	--	--	60	6	--	8.49
Thiophanic Acid (**16**)	55	56	52	49	--	--	8.20
Xanthone x-4 (**17**)	--	--	--	38	--	--	6.10
Isoarthothelin (**18**)	45	--	44	36	6	--	6.61
Lgr-1* (**19**)	58	63	--	55	--	--	--
Lgr-2* (**20**)	50	44	--	39	--	--	--
Zeorin (**21**)	52	42	43	43	19	50	--
Ursolic Acid (**22**)	52	50	54	49	25	--	--
Methyl β-orsellinate (**23**)	64	70	--	55	--	--	4.12
Unknown-7 (**24**)	--	--	--	7	--	--	--
Lcm-1* (**25**)	63	25	--	39	--	--	--

Table 2. Distribution of Lichen Acids in the *Lecanora epibryon* Complex

(# = major substance; + = minor substance; - = absent)

Race:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Substance																	
1	#	-	-	#	#	-	#	#	#	#	+	+	#	#	-	#	#
2	#	-	-	#	#	-	#	#	#	#	+	+	#	#	-	#	#
3	#	-	-	-	-	#	+	-	-	-	#	-	-	-	-	-	-
4	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
5	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
7	+	+	+	+	-	-	-	-	+	+	-	-	-	+	-	-	-
8	-	+	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	#	-	-
10	-	+	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-
11	-	+	+	-	-	-	-	-	+	+	-	-	-	#	-	-	-
12	+	#	#	+	-	-	+	-	#	+	-	-	-	+	-	-	-
13	-	-	-	-	-	-	-	-	-	-	#	-	-	-	-	-	-
14	-	#	-	-	-	+	#	#	-	-	-	#	#	-	-	-	-
15	+	#	#	#	-	+	#	#	+	-	+	#	#	-	-	-	-
16	-	-	-	-	+	-	+	-	-	-	+	#	-	-	-	-	-
17	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
22	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
23	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-

occurred in Tasmania, they were morphologically variable as well as being chemically distinguishable - but not more dissimilar from one another than from other specimens collected in Australasia or South America. A phenogram comparing the chemical - races using all the chemical data and their distribution - did not show any clear patterns (Figure 2). Table 3 illustrates the distribution of lichen products within the chemical races according to the major classes of substances. We again could not find any correlation of these classes with geographic distribution (Table 4).

The number of chemical races within this species complex is quite unusual within the lichenized Ascomycetes. Although Filson (1981) reported 50 different chemical races for *Cladia aggregata* (Sw.) Nyl., the species concept in this group has since changed with two additional taxa segregated from *C. aggregata* s. lat. (Kantvilas & Elix 1987), so that the chemical variation in *C. aggregata* s. str. now is less dramatic.

Table 3. Classes of Lichen Acids in the *Lecanora epibryon* Complex

(# = major substance; + = minor substance; - = absent)

Race:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Substance																	
Orcinol Depsides	-	-	-	-	-	-	-	-	-	-	#	-	-	-	-	-	-
ß-Orcinol Depsides	#	-	-	#	#	#	#	#	#	#	#	+	#	#	-	#	#
ß-Orcinol Depsidones	+	#	#	+	-	-	+	-	#	+	-	-	-	-	#	-	-
Xanthones	+	#	#	#	+	+	#	#	+	-	+	#	#	-	-	-	-
Triterpenoids	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	+	+

Table 4. Distribution of Chemical Races in the *Lecanora epibryon* Complex

Race:	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Location																	
Australia	-	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Kerguelen	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
New Zealand	+	+	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Northern Hemisphere	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+
South America	-	-	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-
Tasmania	-	-	+	-	-	-	-	-	-	-	+	+	+	+	-	-	-

Probably further studies in the *L. epibryon* complex will show that it too is heterogeneous. Possibly some of the chemical races may be adapted to different habitats or will show other minute, as yet undiscovered, differences which may enable the delimitation of some populations at the species level. However at this time we are unable to delimit any natural groups among the chemical races or draw any taxonomic conclusions from our chemical survey - and it appears highly likely that future investigations will elucidate further chemical races within the species complex.

Given the chemical and morphological uniformity of *L. epibryon* in the Northern Hemisphere versus the chemical and morphological diversity of *L. broccha* in the Southern hemisphere, for the interim we propose to maintain the distinction of these two species. Possibly this is an unnatural distinction which will be superceded by further studies. Certainly some of the Southern Hemisphere races are chemically more closely related to *L. epibryon* s. str. than to other races of *L. broccha.*

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A MONOGRAPH OF THE LICHEN GENUS KAROOWIA HALE (ASCOMYCOTINA: PARMELIACEAE)

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Abstract. A new lichen genus, *Karoowia* Hale, is described. It is related to *Xanthoparmelia* but differentiated by the subcrustose, marginally effigurate-lobate growth form, presence of rhizoid-like structures on the lower surface, and relatively long, cylindrical conidia. The 16 species presently recognized occur chiefly in South Africa. *Karoowia microscopica* Hale, *K. protocetrarica* Hale, *K. salazinica* Hale, and *K. subchalybaeizans* Hale are described as new. New combinations are made for these species: *K. adhaerens* (Nyl.) Hale, *K. adligans* (Brusse) Hale, *K. arquata* (Brusse) Hale, *K. ganymedea* (Brusse) Hale, *K. insipida* (Brusse) Hale, *K. leptoplaca* (Brusse) Hale, *K. perspersa* (Stizenb.) Hale, *K. ralla* (Brusse) Hale, *K. saxeti* (Stizenb.) Hale, *K. scitula* (Brusse) Hale, *K. spissa* (Brusse) Hale, and *K. squamatica* (Brusse) Hale.

Introduction

While completing a monograph of *Xanthoparmelia* (Ascomycotina: Parmeliaceae), I found a small group of 16 species, occurring almost exclusively in South Africa, which did not fit well in this otherwise quite homogeneous genus. They are very tightly adnate and subcrustose in appearance, often with a strongly areolate-cracked center and effigurate-lobate thallus margins, not unlike *Dimelaena oreina* (Ach.) Massal., *Lecanora (Protoparmelia) muralis* (Schreber) Rabenh., and other marginally lobate crustose lichens. More significantly, they lack rhizines and either have a nearly bare lower surface or one covered with rhizoid-like attachment organs which have been misinterpreted as poorly developed rhizines.

In many of the species the apothecia are immersed to flush and aspicilioid, remaining that way at maturity or becoming emergent to sessile and typically parmelioid with a distinct lecanorine rim. The conidia are cylindrical and rather long, 6 – 12 μm, in contrast to the short bifusiform conidia of *Xanthoparmelia*. On the other hand, the positive (I+) lichenin reaction (R. Common, personal communication), colorless, subspherical to ellipsoidal spores, and the presence of a pored epicortex are unmistakably parmelioid.

The group has been recognized as unique by Brusse (1986), who refers to them as "effigurate-crustose Xanthoparmelias" and has already described 8 of the 16 species presently known. He could not justify placing them in *Protoparmelia* Choisy or *Protoparmeliopsis* Choisy because of differences in ascal structure. I believe that these species, although obviously closely related to *Xanthoparmelia*, represent a new genus, *Karoowia*, in the Parmeliaceae.

Thallus aspect and adnation:—At first glance, specimens of *Karoowia* appear to be small, very tightly adnate *Xanthoparmeliae*. However, it is impossible to remove them with a knife and even in the laboratory it is extremely difficult to scrape off thallus fragments for extraction with acetone prior to doing TLC analysis. None of the 16 species has lobes more than about 1 mm wide and most are in the range of 0.2 – 0.8 mm. The smallest species of *Xanthoparmelia* with lobes in this range, such as *X. keralensis* Hale or *X. mougeotii* (Schaerer) Hale, can still be separated from the rock with a razor blade or dissecting needle to reveal a lower surface covered with normal cylindrical rhizines.

The lobes are flat and very tightly appressed in *K. adligans*, *K. ganymedea*, *K. insipida*, *K. leptoplaca*, *K. protocetrarica*, and *K. ralla*. The thallus center in these species is also strongly areolate-cracked. The remaining species have more or less convex, less tightly appressed lobes. In addition the thallus center is either less strongly areolate, areolate-bullate, or simply lobate. The thallus, while very thin (100 - 300 μm), has a normal internal structure with an upper cortex, algal layer, medulla, and lower cortex (Figs. 1, 5, 6).

Upper surface:—The thallus surface of all species is continuous and emaculate. Many produce white pruina (Fig. 2). The fine structure with SEM is variable. All species appear to have a pored epicortex (Fig. 3), identical with that in other parmelioid genera, including *Xanthoparmelia*. A few specimens of some of the species, in particular *K. perspersa*, have a surface composed of exposed truncated tips of palisade-oriented cortical cells (Fig. 4). Other species sometimes showing this trait include *K. ganymedea*, *K. leptoplaca*, *K. ralla*, and *K. scitula*. In these cases the epicortex has apparently eroded away, a condition which may be observed even in *Xanthoparmelia colorata* (Gyel.) Hale and other *Xanthoparmelia* species adapted to very arid habitats.

Lower surface:—When one tries to examine the lower surface of a *Karoowia* species, the thallus is so tightly appressed to the rock that it is difficult to get any idea of its structure. Using a razor blade and cutting through the thallus to the rock surface or teasing up an occasional free lobe tip under 10 - 20X magnification, one can see a fine spongy or felty layer but no true cylindrical rhizines. Viewed with a scanning electron microscope, one observes a fragile, thin but distinct lower cortex more or less covered with separate, tomentum-like rhizoids (Figs. 7, 8, 9) or irregular, flattened, lamella-like, loose aggregations of rhizoids (Figs. 10 - 12), similar in fact to the attachment structures found in the subcrustose genus *Dimelaena*. As far as I know, this structure is unique for the Parmeliaceae, and is being reported here for the first time.

Seven species are black below: *K. adhaerens*, *K. arquata*, *K. adligans*, *K. ganymedea*, *K. leptoplaca*, *K. microscopica*, and *K. saxeti*. The remaining species are pale brown.

Vegetative structures:—Thirteen of the species produce no isidia, soredia or other vegetative propagules. Two, *K. microscopica* and *K. saxeti*, are isidiate, and one, *K. ganymedea*, is pustulate-sorediate.

Reproductive structures:—Brusse (1986) concluded that the internal structure of apothecia in *Karoowia* is consistent with that of *Parmelia* s.l. The main differences among the 16 species lie in the degree of immergence of the apothecia. In one group, including *K. leptoplaca* (*K. adligans* (Fig. 14), *K. arquata*, *K. insipida*, and *K. protocetrarica*), the apothecia are immersed and the disc is flush with the thallus surface, superficially similar to the aspiciloid apothecia of *Aspicilia*. A thalline rim may or may not be present, but the subhymenium is always underlain by algae. These apothecia reach 0.2 - 0.5 mm in diameter.

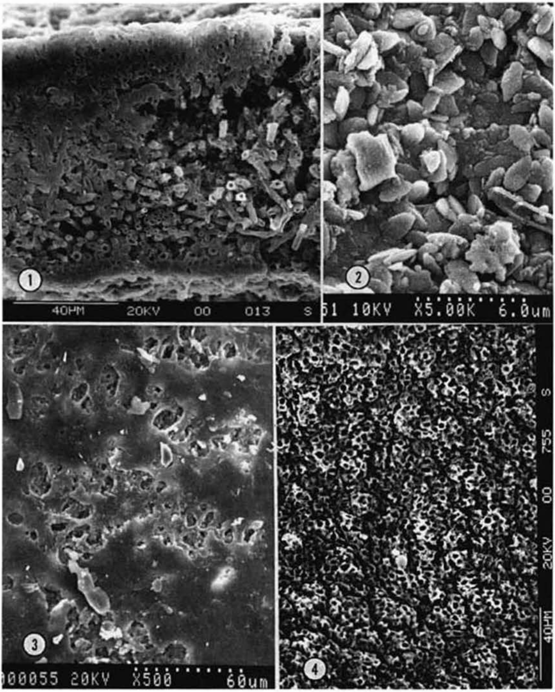
A second group, including *K. adhaerens*, *K. ralla* (Fig. 22), *K. salazinica*, *K. saxeti*, *K. scitula*, and *K. spissa*, also has aspicilioid apothecia in the early stages but they soon emerge to become sessile with a distinct thalline rim. These apothecia are up to 1 mm in diameter.

The third group with two species, *K. perspersa* (Fig. 20) and *K. subchalybaeizans*, has emergent apothecia from the earliest stages. At maturity they are sessile to adnate and up to 5 mm in diameter, as in typical, tightly adnate *Xanthoparmelia* species.

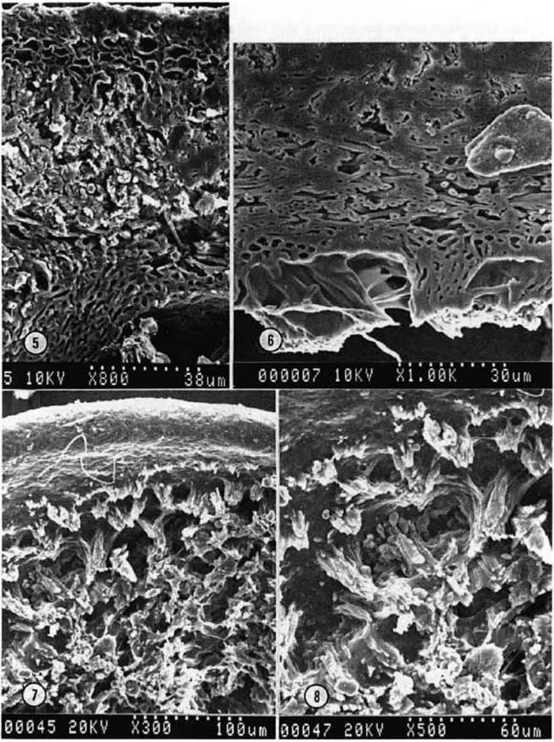
Pycnidia are produced in nearly all species, appearing as black dots immersed in the thallus. Conidia are relatively long (6 - 12 μm) and cylindrical. In *Xanthoparmelia* the conidia are bifusiform (or only rarely cylindrical) and 5 - 8 μm long.

Chemistry:—Considering the small number of species involved, *Karoowia* has a rich chemistry, largely paralleling that of *Xanthoparmelia*. The K+ depsidones are well represented by norstictic acid, salazinic acid, stictic acid, and the chalybaeizans unknown. Echinocarpic acid, a presumed depsidone of unknown structure, is also rarely present. K- depsidones and *para*-depsides include norlobaridone, protocetraric acid, psoromic acid, squamatic acid, and hypoprotocetraric acid. The depsides evernic and lecanoric acids are also found in a few species.

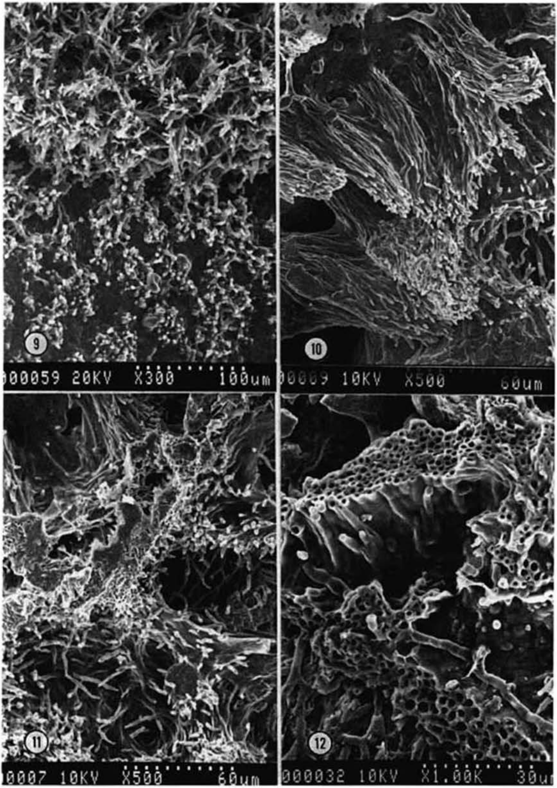
Ecology and habitats:—The species of *Karoowia* occur in exposed or extremely arid habitats in the Great Karoo and Namaqualand in Cape Province as well as in semi-arid to relatively moist areas of Natal, Transvaal, and Lesotho on a variety of rocks such as dolerite, sandstone, and granite. In the arid karoo where rainfall is less than 100 mm/year *K. leptoplaca* is often the last surviving foliose lichen, taking over from the hardiest species of *Xanthoparmelia*. I have not found any *Karoowia* species in areas with less than 50 mm rainfall.



Figures 1–4. Cross section and surface structure of *Karoowia*: 1, vertical cross section of *K. insipida* (*Hale* 74895); 2, pruina on surface of *K. perspersa* (*Hale* 79238); 3, epicorticate surface of *K. adhaerens* (Hale 78158); 4, abraded surface of *K. perspersa* showing palisade layer without overlying epicortex (*Hale* 73060).



Figures 5 – 8. Lower surface features of *Karoowia*: 5, vertical cross section of *K. spissa* to show lower cortex and origin of rhizoidal lamellae (*Hale* 74889); 6, vertical cross section of *K. saxeti* to show lower cortex and origin of rhizoidal lamellae (*Hale* 79251); 7, oblique view of lower surface of *K. adhaerens* showing mixture of lamellae and rhizoids (*Hale* 71059); 8, close-up of fig. 7.



Figures 9 – 12. Lower surface features of *Karoowia*: 9, dense rhizoidal layer on *K. adhaerens* (*Hale* 78128); 10, clumped rhizoids as lamellae form in *K. adhaerens* (*Hale* 71021); 11, mixed rhizoids and lamellae in *K. subchalybaeizans* (*Hale* 77655); 12, cross section of lamellae of *K. adhaerens* (*Hale* 73809).

Karoowia Hale, gen. nov.

Thallus arcte adnatus, margine lobatus, centrum versus subcrustaceo-areolatus, lobis sublinearibus, 0.2–1.2 mm latis, superne continuus, emaculatus, epicorticatus, saepe albo-pruinosus, subtus rhizoideis vel lamellis instructus. Conidia cylindrica. Apothecia immersa, saepe aspicilioidea, vel emergentia, sporis incoloribus, simplicibus.

Type species: *Parmelia adhaerens* Nyl.

Key to the Species of *Karoowia*

1. Thallus coarsely sorediate . . . *K. ganymedea*
1. Thallus not sorediate . . . 2
    2. Thallus isidiate . . . 3
    2. Thallus not isidiate . . . 4
3. Lobes broad, to 1 mm wide; medulla K+ yellow (stictic acid). . . *K. saxeti*
3. Lobes narrower, less than 0.6 mm wide; medulla K– (norlobaridone) . . . *K. microscopica*
    4. Lower surface black . . . 5
    4. Lower surface tan to brown . . . 8
5. Apothecia persistently aspicilioid; salazinic acid present . . . *K. leptoplaca*
5. Apothecia aspicilioid to sessile; salazinic acid lacking. . . 6
    6. Psoromic acid present . . . *K. arquata*
    6. Stictic acid present . . . 7
7. Lobes flat and appressed; apothecia persistently aspicilioid . . . *K. adligans*
7. Lobes flattish to convex; apothecia sessile at maturity . . . *K. adhaerens*
    8. Medulla P+ yellow to orange-red . . . 9
    8. Medulla P– . . . 11
9. Lobes flat and appressed; apothecia persistently aspicilioid; protocetraric acid present . . . *K. protocetrarica*
9. Lobes flattish to convex; apothecia sessile; salazinic acid present . . . 10
    10. Thallus areolate-cracked at the center; chalybaeizans unknown lacking . . . *K. salazinica*
    10. Thallus lobate at the center; chalybaeizans unknown present . . . *K. subchalybaeizans*
11. Medulla C+ red (lecanoric acid (major)) . . . *K. scitula*
11. Medulla C– (lecanoric acid if present minor) . . . 12
    12. Squamatic acid present . . . *K. squamatica*
    12. Squamatic acid lacking . . . 13
13. Norlobaridone present . . . *K. ralla*
13. Norlobaridone lacking . . . 14
    14. Hypoprotocetraric acid present; apothecia large, adnate . . . *K. perspersa*
    14. Hypoprotocetraric acid lacking; apothecia small, initially aspicilioid . . . 15
15. Lobes flat and appressed; evernic acid present (major) . . . *K. insipida*
15. Lobes convex; evernic and lecanoric acids present . . . *K. spissa*

1. **Karoowia adhaerens** (Nyl.) Hale, comb. nov.

Parmelia adhaerens Nyl. in Crombie, Journ. Bot. Brit. For. 14:19.1876. Type collection: Table Mountain, Cape of Good Hope, Cape Province, South Africa, *Eaton s.n.* (BM, lectotype; H-Nyl, no. 34823, isolectotype).

Parmelia interrupta Stizenb., Ber. Tätig. St. Gall. Naturw. Gesell. 1888–1889:154. 1890. Type collection: Ceres, Bokkeveld Mountains, Cape Province, South Africa, *MacOwan s.n.* (ZT, lectotype).

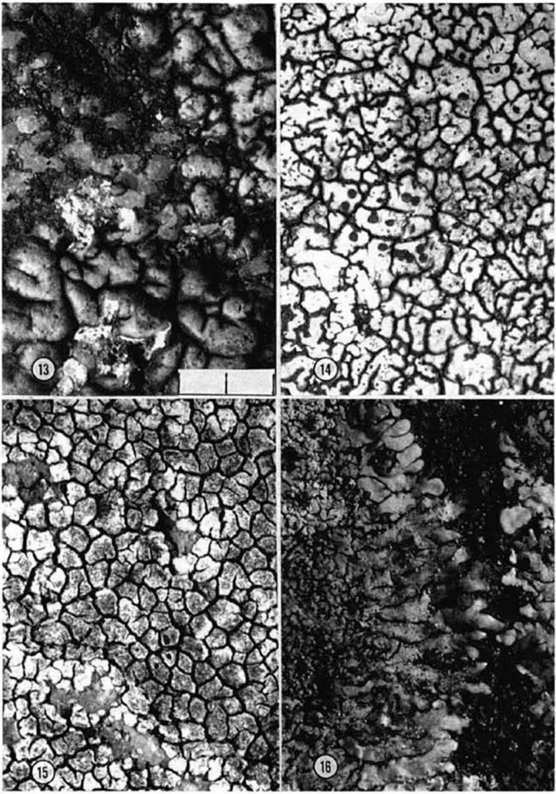
Squamaria interrupta (Stizenb.) Gyelnik, Ann. Hist.-Nat. Mus. Nat. Hungarici, 29:36. 1935.

Xanthoparmelia adhaerens (Nyl.) Hale, Phytol. 28:486. 1974.

Xanthoparmelia interrupta (Stizenb.) Krog & Swinscow, Lichenologist 19:427. 1987.

Thallus (Fig. 13) saxicolous, subcrustose, the center areolate to more or less bullate-areolate with marginally effigurate lobes, 3–6 cm broad, yellowish green or darkening; lobes sublinear, 0.3–0.8 mm wide, convex, rather short, little branched, contiguous, usually black-rimmed; upper surface continuous, emaculate, shiny to dull, epruinose, soredia and isidia lacking; lower surface black, nearly bare to spongy with rhizoids and lamellae. Pycnidia common; conidia cylindrical, 0.5 × 7–9 μm. Apothecia initially flush, sessile to adnate at maturity, 0.5–1 mm in diameter; spores 5–6 × 9–10 μm.

Chemistry: Stictic, constictic, peristictic, hypostictic (±trace), hypoconstictic (±trace),



Figures 13–16. Species of *Karoowia*: 13, *K. adhaerens* (lectotype in BM); 14, *K. adligans* (*Hale*, 75912); 15, *K arquata* (isotype in US); 16, *K. ganymedea* (*Hale* 76104). Scale = 2 mm (in Fig. 13).

hyposalazinic (±trace), and usnic acids.

Before the true nature of the lower surface was understood, this species was thought to be a *Xanthoparmelia* and to occur not only in southern Africa but also in Australia (Elix, et al., 1986). The reported Australian specimens have been re-identified as *X. xanthomelaena* (Müll. Arg.) Nash & Elix; *K. adhaerens* does not occur in Australia (Hale, 1989).

While the hypostictic acid complex is often produced with stictic acid, it is not constant (cf. Krog & Swinscow, 1987). One other stictic acid-containing species in the genus, *K. saxeti*, is isidiate and also differs in having a more lobate, nonareolate center and pale-rimmed lobes. Another nonisidiate species, *K. adligans*, has the same chemistry but persistently aspicilioid apothecia and a tightly appressed thallus.

This is one of the more commonly collected species in the genus, occurring on sandstone, generally in the mountains from the Cape of Good Hope through southern Cape Province, Natal, the Drakensberg escarpment in Transvaal, and the Soutpansberg mountains (Map 1).

Representative specimens examined (all in US). South Africa. Venda: Tschikadeni Mine area, Grid 2231 AC, *Hale* 79116. Transvaal: Long Tom Pass, Grid 2430 BA, *Hale* 73913; Mt. Sheba Nature Reserve, Grid 2430 DC, *Hale* 76109. Natal: 14 km S of Nkandla, Grid 2831 CA, *Hale* 76378. Cape Province: Sir Lowry's Pass, Grid 3418 BD, *Hale* 78141; 21 km S of Worcester, Grid 3319 CB, *Hale* 78212; Uniondalespoort, Grid 3323 CA, *Hale* 73809. Swaziland: Mbabane Nature Reserve, Grid 2631 AA, *Hale* 79035.

2. **Karoowia adligans** (Brusse) Hale, comb. nov.

Parmelia adligans Brusse, Mycotaxon 31:533. 1988. Type collection: Clearwater Falls, Blydesrivier Nature Reserve, Transvaal, South Africa, *Brusse* 4452 (PRE, holotype (not seen); BM, COLO, LD, isotypes).

Thallus (Fig. 14) saxicolous, subcrustose and very tightly adnate, the center strongly aeolate-cracked, margins lobate, 3-6 cm broad, light yellowish green; lobes appressed, flat and splaying out at the tips, 0.2–0.6 mm wide, pale to dark rimmed, contiguous; upper surface continuous, emaculate, dull, coarsely pruinose at the tips with age, soredia and isidia lacking; lower surface black, spongy, consisting of rhizoids and weakly developed lamellae. Pycnidia common; conidia cylindrical, 0.5 × 5–7 μm. Apothecia aspicilioid, 0.2–0.3 mm in diameter, the disk dark brown; spores ellipsoidal, 5–6 × 10–14 μm.

Chemistry: Stictic, constictic, norstictic (±trace), hypostictic (±trace), hyposalazinic (±trace), and usnic acids, atranorin (±trace).

Illustration: Brusse, *Mycotaxon* 31:553. 1988 (Fig. 4).

This species, largely confined to Transvaal and adjacent northern Cape Province (Map 2), resembles salazinic acid-containing *K. leptoplaca* very closely in apothecial morphology and lobe configuration. Formerly misidentified as *K. adhaerens*, it differs from that species in the tighter adnation and aspicilioid apothecia.

Representative specimens examined (all in US). South Africa. Transvaal: 10 km NW of Rustenberg, Grid 2527 CA, *Hale* 80868; Long Tom Pass, Grid 2430 BA, *Hale* 73910; 2 km S of Lejuma Summit, Soutpansberg Mountains, Grid 2329 AB, *Hale* 73914. Cape Province: 5.5 km W of Olifantshoek, Grid 2722 DC, *Hale* 79480.

3. **Karoowia arquata** (Brusse) Hale, comb. nov.

Parmelia arquata Brusse, Mycotaxon 31:535. 1988. Type collection: Linksfield Ridge, Johannesburg, Transvaal, South Africa, Grid 2628 AA, *Brusse* 1126 (PRE, holotype (not seen); ANUC, BM, COLO, LD, MEL, US, isotypes).

Thallus (Fig. 15) saxicolous, subcrustose, areolate at the center with effigurate marginal lobes, to 4 cm broad, yellowish green; lobes sublinear, 0.2–1 mm wide, contiguous; upper surface continuous, emaculate, becoming pruinose at the tips; lower surface black with a spongy layer of rhizoids. Pycnidia common; conidia cylindrical, 0.5 × 5–8.5 μm. Apothecia immersed and aspicilioid, to 0.8 mm in diameter; spores ellipsoidal, 4–7 × 8–11 μm.

Chemistry: Psoromic and usnic acids, atranorin.

Illustration: Brusse, *Mycotaxon* 31:553. 1988 (Fig. 5).

This species is known only from the type locality in Johannesburg. It is a member of the *K. leptoplaca* group.

4. Karoowia ganymedea (Brusse) Hale, comb. nov.

Parmelia ganymedea Brusse, Mycotaxon 31:536. 1988. Type collection: Linksfield Ridge, Transvaal, South Africa, *Brusse* 5089 (PRE, holotype (not seen); BM, COLO, LD, US, isotypes).

Thallus (Fig. 16) saxicolous, subcrustose, rimose-areolate at the center with small effigurate marginal lobes, 1–8 cm broad, dark yellowish green; lobes sublinear, 0.3–0.5 mm wide, tightly appressed, flat, sparsely dichotomously branched, contiguous to subimbricate, becoming densely sorediate-isidiate to coarsely pustulate-sorediate along the margins; upper surface continuous, emaculate, lightly pruinose; lower surface black with a black spongy layer of rhizoids. Pycnidia and apothecia lacking.

Chemistry: Evernic and usnic acids.

Illustration: Brusse, *Mycotaxon* 31:553. 1988 (Fig. 6).

This is the only species in the genus with marginal isidiate soredia. It occurs on sandstones, mostly in Transvaal with one locality in eastern Cape Province (Map 3). It does not seem to be related to nonsorediate, evernic acid-containing *K. insipida*, a larger lichen with a pale lower surface.

Specimens examined (all in US). South Africa. Transvaal: Lejuma Summit, Soutpansberg Mountains, Grid 2329 AB, *Hale* 72967, 72968; Mt. Sheba Nature Reserve, Grid 2430 DC, *Hale* 76104; Long Tom Pass, Grid 2430 BA, *Hale* 72966, 72969. Cape Province: 18.5 km WNW of Molteno, Grid 3126 AC, *Hale* 80535.

5. Karoowia insipida (Brusse) Hale, comb. nov.

Parmelia insipida Brusse, Mycotaxon 27:238. 1986. Type collection: Lootsberg Pass between Graaff-Reinet and Middelburg, Cape Province, South Africa, Grid 3124 DD, *Brusse* 4692 (PRE, holotype (not seen); BM, LD, US, isotypes).

Thallus (Fig. 17) saxicolous, subcrustose, strongly areolate-cracked at the center with lobate margins, 2–9 cm broad, pale yellowish green; lobes sublinear, 0.2–0.6 mm wide, flat and tightly appressed, rather short and irregularly branched, contiguous; upper surface continuous, emaculate, shiny to dull and white pruinose towards the tips, transversely cracked with age, soredia and isidia lacking; lower surface pale brown with a pale spongy layer of rhizoids and lamellae. Pycnidia common; conidia cylindrical, 0.5 × 6–12 μm. Apothecia at first aspicilioid, 0.2–0.7 mm in diameter, only in part slightly emergent, becoming sessile at maturity, the disk dark brown; spores subspherical to ellipsoidal, 5–8 × 7–10 μm.

Chemistry: Evernic, lecanoric (±trace), and usnic acids.

Illustration: Brusse, *Mycotaxon* 27:243. 1986 (Fig. 4).

Externally this species is very similar to *K. adligans* and *K. leptoplaca* because of the aspicilioid apothecia and flat, appressed lobes. Lecanoric acid, if detectable, is in very low concentration. Another evernic acid-containing species, *K. spissa*, has significant amounts of lecanoric acid, as well as a thicker thallus and emergent apothecia. *Karoowia insipida* occurs on sandstones from eastern Orange Free State and Natal westward into Cape Province (Map 4).

Representative specimens examined (all in US). South Africa. Orange Free State: Golden Gate National Park, Grid 2828 BC, *Hale* 74895. Cape Province: Moltenopas, Grid 3222 BA, *Hale* 73806; Naudesbergpas, Grid 3124 DD, *Hale* 75716. Transkei: 16 km NW of Matatiele, Grid 3028 BA, *Hale* 81296. Lesotho: Sani Pass, Grid 2929 CB, *Hale* 74888; 8.3 km ENE of Ramats'Eliso's Gate, Grid 3028 BB, *Hale* 81064.

6. Karoowia leptoplaca (Brusse) Hale, comb. nov.

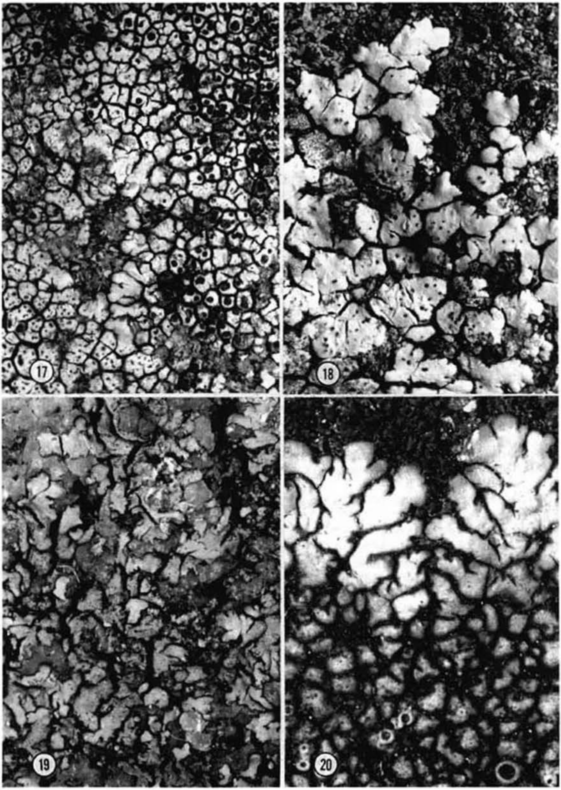
Lecanora leptoplaca Zahlbr., Ann. Crypt. Exot. 5:249. 1932. Type collection: Lainsburg, Grosse Karroo, Cape Province, South Africa, *Brunnthaler* s.n. (WU, lectotype). Not *L. leptoplaca* Nyl.

Parmelia leptoplaca [Zahlbr.] Brusse, Mycotaxon 27:242. 1986.

Thallus (Fig. 18) saxicolous, subcrustose, more or less dispersed or continuous and strongly areolate-cracked at the center, 2–10 cm broad, bright greenish yellow; lobes subirregular, 0.3–0.7 mm wide, flat and tightly appressed, irregularly branched, contiguous; upper surface continuous, emaculate, dull, pruinose at the tips, transversely cracked, soredia and isidia lacking; lower surface black, nearly bare to sparsely rhizoidal or with a weakly developed lamellar layer. Pycnidia common; conidia cylindrical, 0.5 × 6–8 μm. Apothecia aspicilioid to barely emergent, 0.3–0.5 mm in diameter, the disk dark brown with a pruinose rim; spores 6 × 9 μm.

Chemistry: Salazinic, consalazinic, and usnic acids, atranorin (±).

This is a common species on basaltic rocks, more rarely sandstone, on the southern and western fringes of the Great Karoo (Map 5). It is in fact often the last parmeliaceous lichen found as one



Figures 17 – 20. Species of *Karoowia*: 17, *K. insipida* (isotype in US); 18, *K. leptoplaca* (*Hale* 73808); 19, *K. microscopica* (holotype in US); 20, *K. perspersa* (lectotype in ZT). See Fig. 13 for scale.

goes north into the very arid central part of the Great Karoo. Morphologically similar *K. adligans* (stictic acid) and *K. insipida* (evernic acid) have different distributions in South Africa. Since Zahlbruckner's epithet is a homonym, Brusse becomes the author of the species in the genus *Parmelia*.

Representative specimens examined (all in US). South Africa. Cape Province: 28 km NW of Graaff-Reinet, Grid 3224 AB, *Hale* 80511; 22 km NE of Prince Albert, Grid 3322 AB, *Hale* 75906; Bloukrans Pass, Grid 3119 DB, *Hale* 79845; Winterhoek Pass, Grid 3124 BD, *Hale* 80524.

7. **Karoowia microscopica** Hale, sp. nov.

Thallus subcrustaceus, 2–6 cm latus, lobis sublinearibus, 0.3–0.6 mm latis, superne continuus, sparse isidiatus, subtus niger, rhizoideis instructus.

Thallus (Fig. 19) saxicolous, subcrustose, dispersed and lobate to weakly areolate at the center, 2–6 cm broad, dull yellowish green but lighter at the tips; lobes sublinear, 0.3–0.6 mm wide, short, separate to contiguous, black rimmed; upper surface continuous, emaculate, shiny to dull, transversely cracked, sparsely isidiate, the isidia cylindrical or subglobose (but not erumpent), black tipped, 0.05–0.09 mm in diameter, to 0.1 mm high; lower surface black, sparsely rhizoidal or with poorly developed lamellae. Pycnidia and apothecia lacking.

Chemistry: Norlobaridone, echinocarpic (trace), and usnic acid (det. J. A. Elix).

Type: On sandstone outcrop in grassy veld, trail to Langalibalele Cave, Bushman's Nek, Natal, South Africa, Grid 2929 BC, *Hale* 76636, 3 Oct. 1986 (US, holotype; PRE, isotype).

The only other isidiate species in the genus, *K. saxeti*, contains stictic acid and is much larger. *Karoowia microscopica* is a rarely collected lichen, known from sandstones in north-central Transvaal and in the Drakensberg foothills in Natal (Map 6). It seems to have no relation with the other norlobaridone-containing species in the genus, *K. ralla*, a larger, nonisidiate lichen.

Specimens examined (all in US). South Africa. Transvaal: Near junction of Hwy N1 and Njelele Dam road, Grid 2229 DD, *Hale* 76306; 11 km SW of Naboomspruit, Grid 2428 DA, *Hale* 79448; 8.7 km SW of Tinmyne, Grid 2428 BA, *Hale* 79437.

8. **Karoowia perspersa** (Stizenb.) Hale, comb. nov.

Parmelia perspersa Stizenb., Ber. Tätig. St. Gall. Naturw. Gesell. 1888–1889:152. 1890. Type collection: Montis Leonis, Cape Town, Cape Province, South Africa, *MacOwan s.n.* (ZT, lectotype).

Parmelia encrustans Hale, Bot. Not. 124:348. 1971. Type collection: Between O'okiep and Springbok, Cape Province, South Africa, *Almborn* 4792 (LD, holotype; US, isotype).

Xanthoparmelia encrustans (Hale) Hale, Phytol. 28:487. 1974.

Thallus (Fig. 20) saxicolous, subcrustose, thick and areolate-cracked to areolate-bullate at the center with conspicuous marginal lobes, 2–8 cm broad, pale yellow green or darkening at the center; lobes sublinear, 0.3–1.1 mm wide, convex, black-rimmed, contiguous; upper surface continuous, emaculate, shiny to dull and becoming lightly to densely pruinose, transversely cracked with age, soredia and isidia lacking; lower surface pale brown or darkening somewhat, with a sparse to very dense layer of rhizoids and lamellae. Pycnidia common; conidia cylindrical, 0.5 × 5–6 µm. Apothecia commonly developed, initially sessile, becoming adnate and conspicuous with age, 0.5–5 mm in diameter, the disk brown with a pruinose rim; spores subspherical, 4–6 × 7–9 µm.

Chemistry: Hypoprotocetraric, 4-*O*-demethylnotatic, and usnic acids.

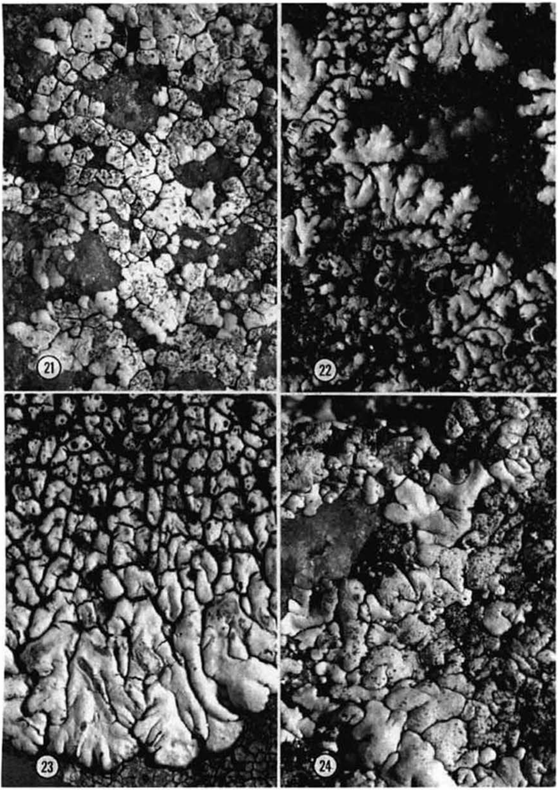
Illustration: Hale, *Bot. Notiser* 124:350. 1971 (Fig. 2A, as *Parmelia encrustans*).

This is the largest and most commonly collected *Karoowia* species. It was long considered to be a *Xanthoparmelia*. The apothecia are sessile and clearly parmelioid from the earliest stages. It is especially common in the Namaqualand karoo of northwestern Cape Province (Map 6), where is occurs on granites, and in the southwestern part of the province on sandstones.

Representative specimens examined (all in US). South Africa. Cape Province: 1 km S of Nuwerus, Grid 3118 AB, *Hale* 72949; Pakhuis Pass, Grid 3218 BB, *Almborn* 4530 (LD); Schoemanshoek, Grid 3322 AC, *Hale* 74883; 32.6 km W of Lainsburg, Grid 3320 AC, *Hale* 77790; 33.8 km W of Dordrecht, Grid 3126 BC, *Hale* 73802; 78.6 km S of Sutherland, Grid 3220 DC, *Hale* 73795.

9. **Karoowia protocetrarica** Hale, sp. nov.

Thallus subcrustaceus, saxicola, lobis subirregularibus, 0.2–0.4 mm latis, appressis, superne continuus, laeviter pruinosus, sorediis isidiisque destitutus, subtus niger, rhizoideis instructus. Apothecia aspicilioidea, sporis nullis.



Figures 21 – 24. Species of *Karoowia*: 21, *K. protocetrarica* (holotype in US); 22, *K. ralla* (*Hale* 73718); 23, *K. salazinica* (*Hale* 73903); 24, *K. saxeti* (*Hale* 79251). See Fig. 13 for scale.

Thallus (Fig. 21) saxicolous, subcrustose, dispersed to continuous and areolate-cracked, 4–6 cm broad, bright yellow green; lobes subirregular, 0.2–0.4 mm wide, flat and appressed, short and irregularly branched, contiguous; upper surface continuous, emaculate, dull and lightly pruinose with age, soredia and isidia lacking; lower surface with a pale spongy layer of rhizoids and lamellae. Pycnidia common; conidia cylindrical, 0.5 × 6–9 µm. Apothecia immersed and aspicilioid, lacking a rim, 0.2–0.3 mm in diameter; spores not developed.

Chemistry: Protocetraric and usnic acids.

Type collection: On steep uplifted sandstone cliff, Schoemanshoek, 24 km N of Oudtshoorn on west side of Hwy R29, Cape Province, South Africa, Grid 3322 AC, *Hale* 71023, 31 Jan. 1986 (US, holotype).

Externally this rare species is indistinguishable from *K. adligans* and *K. leptoplaca*, but the chemistry is distinctive. It is known only from the type collection (Map 8).

10. **Karoowia ralla** (Brusse) Hale, comb. nov.

Parmelia ralla Brusse, Mycotaxon 27:240. 1986. Type collection: Seweweekspoort, Swartberg Range, Cape Province, South Africa, Grid 3321 AD, *Brusse* 4935 (PRE, holotype; BM, COLO, LD, MEL, US, isotypes).

Thallus (Fig. 22) saxicolous, subcrustose, more or less dispersed with a lobate center, at most weakly areolate, 2–4 cm broad, yellowish green; lobes subirregular, 0.2–0.5 mm wide, rather short and irregularly branched, flat, minutely lobulate along the margins, contiguous; upper surface continuous, emaculate, shiny to dull, pruinose at the tips, soredia and isidia lacking; lower surface pale brown with a well developed spongy layer of rhizoids and poorly developed lamellae. Pycnidia common; conidia cylindrical, 9–11 µm. Apothecia initially aspicilioid, mostly emergent and sessile at maturity, 0.3–0.5 mm in diameter; spores 5–6 × 10–14 µm.

Chemistry: Norlobaridone and usnic acid.

Illustration: Brusse, *Mycotaxon* 27:244. 1986 (Fig. 6).

This species is relatively rare but widespread from central Transvaal southward to Lesotho and Transkei and westward into Cape Province (Map 7). There is one remarkable disjunct collection from south-central Australia.

Representative specimens examined (all in US). South Africa. Transvaal: 11 km SW Naboomspruit, Grid 2428 DA, *Hale* 79444. Orange Free State: Golden Gate National Park, Grid 2828 BC, *Hale* 74107. Transkei: Moordenaarsnek, Grid 3028 DC, *Hale* 76903. Cape Province: Winterhoek Pass, Grid 3124 BD, *Hale* 80523; Seweweekspoort, Grid 3321 AD, *Hale* 73718. Lesotho: 9 km W of Mpiti, Grid 3028 BA, *Hale* 81287. Australia. South Australia: Brachina Gorge, Flinders Mountains, *Hale* 58424.

11. **Karoowia salazinica** Hale, sp. nov.

Thallus subcrustaceus, centrum versus areolato-rimosus, saxicola, lobis subirregularibus, convexis, superne continuus, pruinosus aetate, subtus rhizoideis instructus. Apothecia emergentia ad sessilia, 0.5–1 mm lata, sporis 4–6 × 6–9 µm.

Thallus saxicolous (Fig. 23), subcrustose with an areolate-cracked center and distinct marginal lobation, 3–6 cm broad, darkish yellow green; lobes subirregular, 0.3–0.8 mm wide, rather short and irregularly branched, flat to convex, contiguous to subimbricate; upper surface continuous, emaculate, pruinose with age at the tips, transversely cracked, soredia and isidia lacking; lower surface pale with a spongy layer of rhizoids and lamellae. Pycnidia well developed; conidia cylindrical, 0.5 × 5–7 µm. Apothecia numerous, initially aspicilioid, becoming emergent to sessile, 0.5–1 mm in diameter, the disc convex, dark brown; hymenium 55 µm high; spores subspherical, 4–6 × 6–9 µm.

Chemistry: Salazinic, consalazinic, and usnic acids.

Type collection: low sandstone ridges in karoo, 11 km SE of Middelpos on Hwy R354, Cape Province, South Africa, Grid 3120 CD, *Hale* 73902, 29 Jan. 1986 (US, holotype).

Only two other species in the genus, *K. leptoplaca* and *K. subchalybaeizans*, have salazinic acid as the main component. *Karoowia leptoplaca* differs in having a bright yellow, more appressed thallus with flattened lobes, a black lower surface, and persistently immersed apothecia. In addition, *K. salazinica* occurs on sandstones south of the basaltic rock area in the arid Great Karoo where *K. leptoplaca* is so common (Map 3). *Karoowia subchalybaeizans* has a lobate center, darker, yellowish green lobes, and initially sessile apothecia.

Representative specimens examined (all in US). South Africa. Cape Province: 22 km NE of Prince

Albert, Grid 3322 AB, *Hale* 75903; Spektakel Pass, Grid 2917 DA, *Hale* 79536; 17.5 km SE of Murraysburg, Grid 3123 DD, *Hale* 80449.

12. **Karoowia saxeti** (Stizenb.) Hale, comb. nov.

Parmelia saxeti Stizenb., Ber. Tätig. St. Gall. Naturw. Gesell. 1888–1889:153. 1890. Type collection: Lubombo Mountains, Natal, South Africa, *Wilms s.n.* (ZT, lectotype).

Parmelia squamariaeformis Gyelnik, Fedde, Repert. Spec. Nov. Reg. Veg. 36:163. 1934. Type collection: Tamsui, Taiwan, *Faurie* 76 (BP, lectotype).

Parmelia seto-maritima Asahina, Jour. Jap. Bot. 36:228. 1961. Type collection: Marugame, Shikoku, Japan, *Togashi* 61511 (TNS, holotype; H, isotype).

Thallus saxicolous (Figs. 24, 25), subcrustose, more or less lobate at the center with clearly lobed margins, 2–6 cm broad, pale yellowish green; lobes subirregular, variable. 0.4–1.1 mm wide, sparingly branched, flat to more or less convex, contiguous to subimbricate; upper surface continuous, emaculate, shiny, somewhat transversely cracked with age, moderately isidiate, the isidia subglobose to cylindrical, 0.06–0.08 mm in diameter, 0.1–0.2 mm high, darkening at the tips, unbranched; lower surface black with a spongy rhizoidal and lamellar layer. Pycnidia common; conidia cylindrical, 0.5 × 6–8 μm. Apothecia initially aspicilioid but soon emergent and sessile, the disk brown, 0.5–0.8 mm in diameter; spores 5–6 × 9–11 μm.

Chemistry: Stictic, constictic, hypostictic (±trace), hyposalazinic (±trace), and usnic acids.

Karoowia saxeti is easily recognized by chemistry and the presence of isidia. It is the most widespread species in the genus on the world level and occurs commonly on sandstones from Transvaal south to Transkei and Natal in South Africa, in South West Africa/Namibia and Angola (Map 8), and in Brazil, Uruguay, Australia, Hong Kong, Taiwan, Japan, and India.

Representative specimens examined (all in US). Angola. Huila: Bimbe, *Degelius* s.n. South West Africa/Namibia: Waterberg Plateau National Park, Grid 2017 CA, *Hale* 80980. South Africa. Venda: Tschikadeni Mine area, Grid 2231 DB, *Hale* 79121. Transvaal: 2 km S of Lejuma Summit, Soutpansberg Mountains, Grid 2329 AB, *Hale* 72944. Natal: Umtamvuna Nature Reserve, Grid 3130 AA, *Hale* 76783; Mtunzini, Grid 2931 BA, *Hoeg* s.n. (LD). Cape Province: 20 km WSW of Elliott, Grid 3127 BC, *Hale* 72943. Lesotho: 1 km E of Mpiti, Grid 3028 BA, *Hale* 81378. Australia. Queensland: Horseshoe Bay near Bowen, *Hale* 65001. Hong Kong: New Territories, *Hale* 50992. India. Karnataka: Belgaum, *Hale* 47656. Uruguay. Durazno: Arroyo El Cordobes, *Osorio* 2813. Brazil. Rio Grande do Sul: Sao Sepe, *Fleig* 2597.

13. **Karoowia scitula** (Brusse) Hale, comb. nov.

Parmelia scitula Brusse, Bothalia 15:317. 1984. Type collection: 8 km S of Lainsburg, Cape Province, South Africa, Grid 3320 BB, *Brusse* 3522 (PRE, holotype; LD, isotype).

Thallus saxicolous (Fig. 26), subcrustose, dispersed and lobate to weakly areolate at the center and with effigurate-lobate margins, 2–10 cm broad, yellowish green; lobes sublinear, 0.3–0.5 mm wide, convex, dichotomously branched, contiguous to subimbricate; upper surface continuous, emaculate, shiny to dull, rarely pruinose, transversely cracked, soredia and isidia lacking; lower surface pale or darker brown with a pale spongy rhizoidal or lamellar layer. Pycnidia common; conidia cylindrical to weakly bifusiform, 0.5 × 6–7 μm long. Apothecia numerous, initially immersed but soon emergent and sessile, 0.5–0.8 mm in diameter; spores subspherical, 4–6 × 6–9 μm.

Chemistry: Lecanoric and usnic acids.

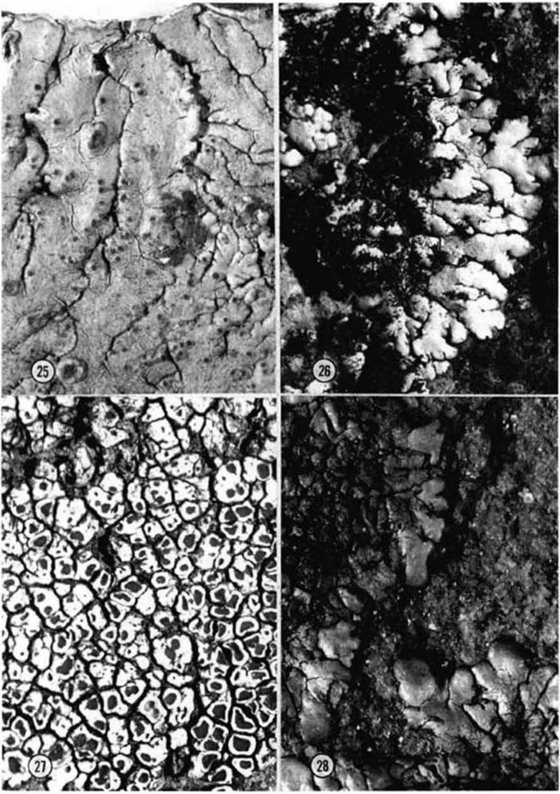
Illustration: Brusse, *Bothalia* 15:318. 1984 (Fig. 7).

The presence of lecanoric acid and the conspicuous thallus with convex lobes and sessile apothecia characterize this species. It occurs on sandstones (granite in Namaqualand) over a wide area in southern Africa (Map 9), from South West Africa/Namibia southward into western Cape Province and in eastern Cape Province, Orange Free State, Lesotho, and Natal.

Representative specimens examined (all in US). South West Africa/Namibia: 14.2 km S of Otjiwarongo, Grid 2016 DA, *Hale* 80906. Lesotho: 6.3 km SE of Oxbow Lodge, Grid 2828 DC, *Hale* 81458. Orange Free State: Ladybrand, Grid 2927 AB, *Maas Geesteranus* 11967 (LD). Natal: Bushman's Nek, Grid 2929 CC, *Hale* 76556. Cape Province: W of Bitterfontein, Grid 3118 AB, *Hale* 79804; Mountain Zebra National Park, Grid 3225 AB, *Hale* 77283.

14. **Karoowia spissa** (Brusse) Hale, comb. nov.

Parmelia spissa Brusse, Mycotaxon 31:158. 1988. Type collection: 31 km S Witsieshoek, Mont-aux-Sources, Natal, S. Africa, Grid 2828 DD, *Brusse* 4524, 21 Jan. 1986 (PRE, holotype; LD, isotype).



Figures 25–28. Species of *Karoowia*: 25, *K. saxeti* (lectotype in ZT); 26, *K. scitula* (*Hale* 77283); 27, *K. spissa* (*Hale* 74889); 28, *K. subchalybaeizans* (holotype in US). See Fig. 13 for scale.

Thallus saxicolous (Fig. 27), subcrustose, weakly lobate to distinctly areolate at the center, 2–4 cm broad, light yellowish green; lobes short and subirregular, 0.2–0.5 mm wide, more or less convex, separate and scattered to contiguous or subimbricate; upper surface continuous, emaculate, shiny to dull, pruinose with age, soredia and isidia lacking; lower surface pale brown with a pale spongy layer of rhizoids and lamellae. Pycnidia common; conidia cylindrical, 0.5 × 6–9 µm. Apothecia initially aspicilioid but soon emergent and sessile, 0.3–1 mm in diameter, the rim becoming pruinose; spores subspherical, 5–6 × 8–9 µm.

Chemistry: Evernic (major), lecanoric (minor), and usnic acids.

Illustration: Brusse, *Mycotaxon* 31:160. 1988 (Fig. 5).

This is a rather common species in eastern Cape Province and Lesotho, occurring in a restricted area at over 3000 m on the basaltic escarpments and at lower elevations on sandstone in the Drakensberg foothills from Orange Free State and Natal into eastern Cape Province (Map 10). In this range it is sympatric with evernic acid-containing *K. insipida*, a more appressed, flat lobed species with more persistently aspicilioid apothecia.

Representative specimens examined (all in US). South Africa. Orange Free State: Golden Gate National Park, Grid 2828 BC, *Hale* 74893. Natal: Mzintlava River bridge on R394, Grid 3029 AD, *Hale* 81265. Lesotho: Sani Pass, Grid 2929 CB, *Hale* 74889, 74894.

15. **Karoowia squamatica** (Brusse) Hale, comb. nov.

Parmelia squamatica Brusse, Mycotaxon 27:242. 1986. Type collection: Pakhuis Pass, Cape Province, South Africa, Grid 3219 AA, *Brusse* 772 8-2-1, 2 Aug. 1977 (J, holotype; not available for study).

Thallus saxicolous, subcrustose and strongly areolate at the center with an effigurate-lobate margin, 2–5 cm broad, yellowish green; lobes subirregular, 0.2–0.7 mm wide, flat and appressed, contiguous; upper surface continuous, emaculate, soredia and isidia lacking; lower surface pale brown with a spongy rhizoidal or lamellar layer. Pycnidia common; conidia cylindrical, 0.5 × 7–11 µm. Apothecia lacking.

Chemistry: Squamatic and usnic acids.

Illustration: Brusse, *Mycotaxon* 27:244. 1986 (Fig. 7).

I was not able to recollect this very rare species, known only in Namaqualand, nor was the original author (personal communication). It appears to be related to salazinic acid-containing *K. leptoplaca*.

16. **Karoowia subchalybaeizans** Hale, sp. nov.

Thallus subcrustaceus, 2–3 mm latus, lobis subirregularibus, 0.3–0.7 mm latis, superne continuus, sorediis isidiisque destitutus, subtus pallide brunneus, rhizoideis instructus.

Thallus saxicolous (Fig. 28), subcrustose, somewhat dispersed to lobate or weakly areolate at the center, 2–5 cm broad, dark yellowish green; lobes subirregular, 0.3–0.7 mm wide, short and irregularly dichotomously branched, weakly to distinctly convex, contiguous; upper surface continuous, shiny or dull and becoming light pruinose, transversely cracked with age, soredia and isidia lacking; lower surface pale brown with a dense layer of rhizoids and well developed lamellae. Pycnidia well developed; conidia cylindrical, 0.5 × 7–9 µm. Apothecia numerous, emergent initially to sessile at maturity, the disc dark brown, 1–3 mm in diameter; spores subspherical, 4–6 × 7–9 µm.

Chemistry: Salazinic, consalazinic, norstictic (±trace), hypostictic (±trace), hyposalazinic (±trace), and usnic acids, chalybaeizans unknown, atranorin (±).

Type collection: On dolerite, 54.7 km E of Willowmore (29.5 km W of Steytlerville) on Hwy R329), elev. 550 m, Cape Province, South Africa, Grid 3324 AC, *Hale* 77655, 18 Oct. 1986 (US, holotype; PRE, isotype).

This species occurs rarely from Namaqualand southward to the Cape region and eastward into southern Cape Province (Map 10). It does not seem to be related to any others in the genus and in fact would be identified as a *Xanthoparmelia* until the nature of the lower surface is recognized.

Specimens examined (all in US). Cape Province: 1 km E of Springbok, Grid 2917 DB, *Hale* 79658; Bainskloof Pass, Grid 3319 CA, *Hale* 72970; 22.6 km W of junction N7 and R364, Grid 3218 BA, *Hale* 80001; 21 km S of Worcester, Grid 3319 CB, *Hale* 78189; 54.7 km E of Willowmore, Grid 3324 AC, *Hale* 77652.

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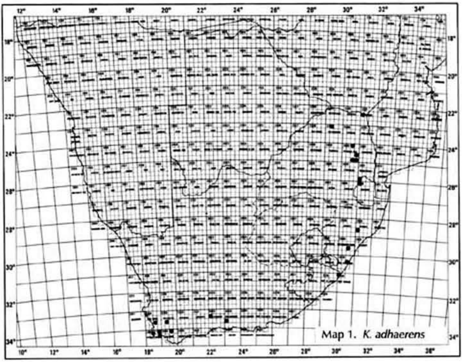
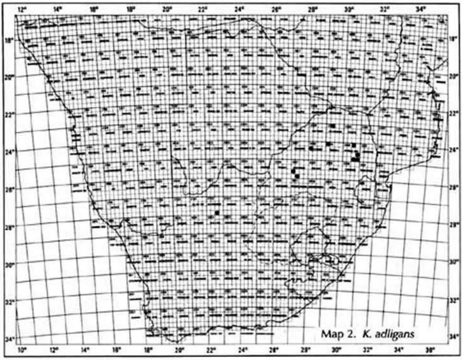
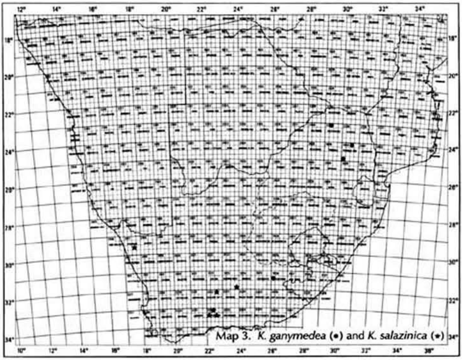


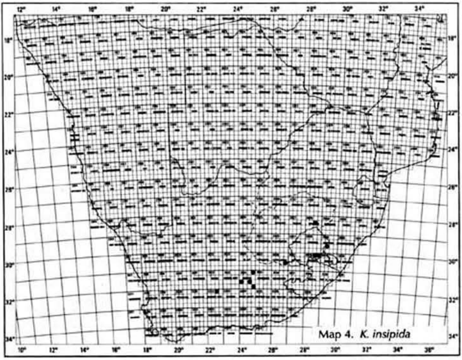
Map 1. *K. adhaerens*



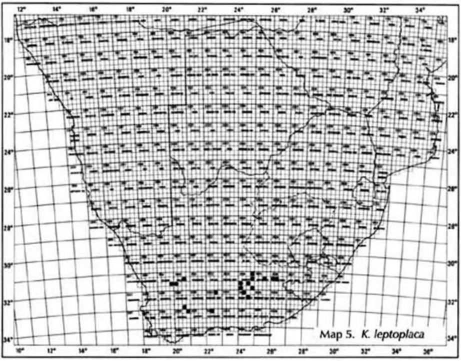
Map 2. *K. adligans*



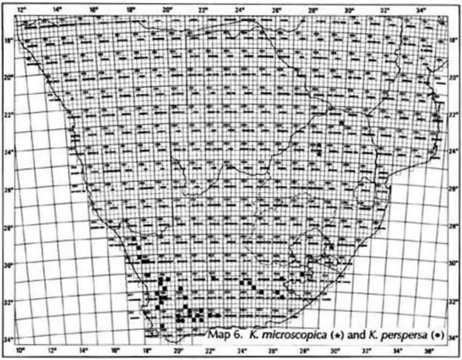
Map 3. *K. ganymedea* (•) and *K. salazinica* (*)



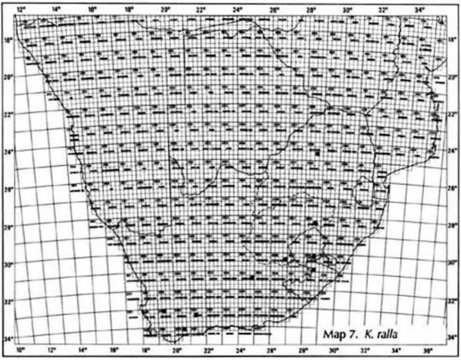
Map 4. *K. insipida*



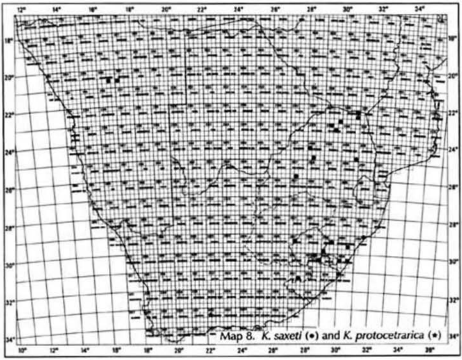
Map 5. *K. leptoplaca*



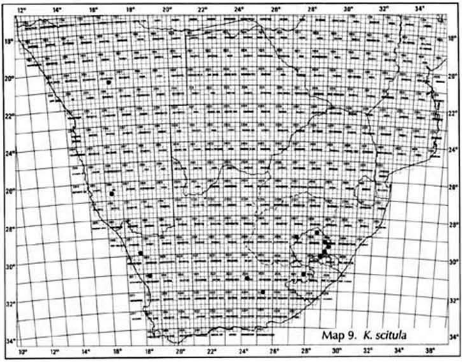
Map 6. *K. microscopica* (★) and *K. perspersa* (●)



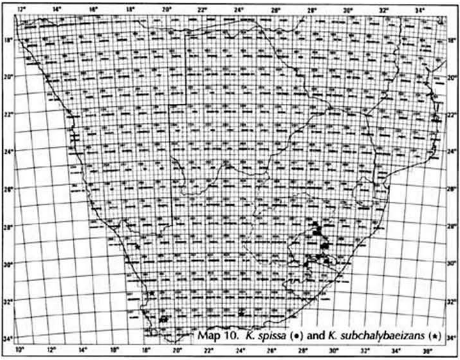
Map 7. *K. ralla*



Map 8. *K. saxeti* (•) and *K. protocetrarica* (⋆)



Map 9. *K. scitula*



Map 10. *K. spissa* (●) and *K. subchalybaeizans* (★)

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