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STUDIES IN AMANITA—I

Some species from Amazonia

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Eight species of *Amanita* from tropical lowland forests around Manaus, Brazil, are described, seven as new and one under a provisional name: *A. campinaranae*, *A. coacta*, *A. craseoderma*, *A. crebresulcata*, *A. lanivolva*, *A. phaea* nom. prov., *A. sulcatissima*, and *A. xerocybe*. Information is given on the types of *Amanitopsis plumbea* Rick and *Collybia sulcatissima* Rick, both remaining insufficiently known taxa. A very sketchy grouping of South American Amanitas on ecological grounds is discussed.

The number of species of *Amanita* reported from South America is relatively low. Even if two undoubtedly imported species (*A. muscaria* and *A. phalloides*) and some insufficiently known taxa, such as the several species and varieties described by Rick, are included, it is just over 25. This remarkable paucity has already been mentioned by Gilbert (*1941*: 11) when he discussed Rick's Amanitas. It has been demonstrated again e.g. by Dennis (*1970*: 50) in his 'Fungus Flora of Venezuela' in which only 3 species of *Amanita* are included.

In the natural *Amanita* flora of South America it seems possible roughly to distinguish three elements:

(i) Mycorrhizal species from the *Nothofagus* region in the South (*A. austro-olivacea* Raitelh.[1], *A. diemii* Sing., *A. gayana* sensu Sing., *A. pseudospreta* Raitelh., *A. umbrinella* sensu Sing., and *A. ushuaiensis* Raitelh.), and from the *Quercus* region in the North (*A. humboldtii* Sing.).

(ii) A group of about 8 species all belonging to section *Lepidella*, probably partly mycorrhizal and partly non-mycorrhizal, occurring in fields ('pampa'), savannas and anectotrophic[2] forests (See Bas, *1969*) from northern Patagonia to Brazil and Bolivia.

(iii) Species from tropical lowland forests. Till recently only one such species was known (*A. antillana* Dennis from Trinidad), but in the present paper eight more are described. Probably all these species are mycorrhizal.

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[1] The species enumerated under (i) are known to me only from literature.

[2] According to Singer & Moser (*1965*: 130) an anectotrophic forest is not devoid of mycorrhiza but not dominated by ectotrophs (=complex organisms consisting of trees and their ectotrophic-mycorrhizal fungi).

It is difficult to say where the seven taxa of *Amanita* described by Rick fit into this still very sketchy picture. Firstly because Rick's information on habitats is very poor and the ecological heterogeneity of Rio Grande do Sul, where Rick did nearly all his collecting, is very great (Singer, *1953*: 61); and secondly because the identity and taxonomic position of several of Rick's *Amanita* taxa is uncertain.[3]

The poor representation of *Amanita*, a genus almost certainly for the greater part mycorrhizal, in the tropical lowland of South America seems to agree with information on the ecology of ectotrophic mycorrhiza in South America given by Singer & Morello (*1960*) and Singer & Moser (*1965*). According to these authors the dominantly ectotrophic mycorrhizal forest in South America would be restricted to the *Nothofagus* region in the South, the *Quercus* area in the North (Columbia) and the *Alnus* zone along the Andes. Outside these areas the anectotrophic condition of tree and shrub vegetations would be prevailing; ectotrophic mycorrhiza would mainly occur as so-called cicatrizing mycorrhiza in places where the natural climax forest is damaged.

From a recent publication by Singer (*1978*: 421) it appears, however, that the situation is more complex. He found also the campina and campinarana vegetation in the tropical lowland of Amazonia (Brazil) to be ectotroph dominated forest communities with *Amanita* species among the fungal components.

Dr. Singer very kindly enabled me to examine his Amazonian *Amanita* collections. His material was found to comprise seven undescribed species and one probably undescribed (fruit-body still without spores). From these eight species three have been found in campina and campinarana vegetations, four in secondary rain forest and one in primary rain forest. The fruit-bodies of four species were found to be connected with ectotrophic mycorrhizae, but from their taxonomic position it may be assumed that all eight species are mycorrhizal. Among the tree-partners in mycorrhiza are *Neea* (Nyctaginaceae) and *Psychotria* (Rubiaceae).

The species described on the following pages are distributed over different habitats as follows:

Primary forest	*A. craseoderma*
Secondary rain forest	*A. coacta*
	! *A. crebresulcata*
	! *A. lanivolva*
	A. phaea
Campinarana vegetation	! *A. campinaranae*
	! *A. xerocybe*
Campina vegetation	*A. sulcatissima*

Species of which the names in the list above are preceded by an exclamation mark are proved to be mycorrhizal by Dr. Singer and his collaborators.

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[3] Singer (*1953*: 64, 95) reported on three of them, excluding one from the genus; Bas (*1969*: 561) discussed one and recently studied material of two (see p. 12 and p. 17).

From the results of Dr. Singer's observations it looks as if the tropical lowland element (category iii on p. 1) in the South American *Amanita* flora can be subdivided. It is, however, too early for that, as of most of the species in this paper only very limited material is available, so that very little can be said about the consistency in their choice of habitat.

It was necessary to compare the types of two of Rick's species, viz. *Amanitopsis plumbea* Rick (non Schaeff.) and *Collybia sulcatissima* Rick, with the material in hand. The results of these comparisons are given on respectively p. 17 and p. 12.

I am very much indebted to Dr. R. Singer for putting his *Amanita* collections from around Manaus (Brazil) at my disposal. My sincere thanks are also due to Dr. A. Sehnem, São Leopoldo, for the loan of two types from Rick's herbarium, to the Director of the Kew Herbarium for the loan of the type of *A. antillana*, to Dr. R. A. Maas Geesteranus for correcting Latin diagnoses, and to Mr. P. K. C. Austwick, London, for improving the English text.

PRELIMINARY KEY TO AMAZONIAN AMANITAS

1. Spores amyloid[4]. Margin of cap (usually) smooth (subgenus *Lepidella*).
    2. Cap white to greyish pallid (pigment indistinct) with grey volval crust at centre and patches on limb. Stem with abrupt bulbous base with ± broken volval grey rim on top. Spores 5.5–7.5 × 5.5–6.5 µm . . . . *A. campinaranae*, p. 4
    2. Cap very dark brown (pigment vacuolar and very distinct) with scattered small greyish warts and patches. Stem with subturbinate base with scattered small volval warts. Spore characters unknown. . . . . *A. phaea*, p. 6
1. Spores inamyloid. Margin of cap (usually) sulcate (subgenus *Amanita*).
    3. Stem with bulbous to subbulbous base. Volva friable or felted-submembranous. Ring present or absent (section *Amanita*).
        4. Cap very dark brown and with smooth margin (See under 2).
        4. Cap whitish, ochraceous, buff or ochraceous brown and with sulcate margin.
            5. Cap sordid whitish to ochraceous with brownish ochraceous centre, dry, with adnate subflocculose-subgranular gilvous volval remnants. Ring present but deciduous. Gills distant. Clamps absent. Spores 8–9 × 7.5–9 µm. . . . . *A. xerocybe*, p. 7
            5. Cap ochraceous brown at centre to greyish buff at margin, with large, pale, brownish grey crust-like volval patch(es). Ring absent. Gills crowded. Clamps present. Spores 8–9 × 6–7 µm. . . . . *A. sulcatissima*, p. 9
    3. Stem without basal bulb. Volva saccate to submembranous-felted, more rarely friable. Ring absent (sect. *Vaginatae*).
        6. Volva saccate or submembranous-felted and tending to break up into felted patches.
            7. Volva saccate, conspicuously grey lanose-tomentose on outside of limb. Clamps present. Cap bronze brown with depressed centre more reddish brown. Stem white. Spores 7.5–9.5 × 5.5–7 µm.. . . . . *A. lanivolva*, p. 12
            7. Volva saccate or submembranous-felted, white to pale buff or greyish, felted to, at most, appressedly fibrillose on outside of limb. Clamps absent.
                8. Volva membranous, narrowly saccate, white, leaving no remnants on cap. Stem grey in the middle. Spores 8.5–10.5 × 7–8.5 µm. Volval tissue with 45–90 × 35–75 µm large cells. *A. crebresulcata*, p. 18

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[4] Spore characters of *A. phaea, nom. prov.*, unknown; this species therefore keyed out in both subgenera.

8. Volva felted-submembranous, tending to break up into small appressed flat grey patches at base of stem and around centre of cap. Stem white. Spores 8.5–10 × 6.5–7.5 μm. Volval tissue with 20–35 μm large cells. . . . . *A. coacta*, p. 15

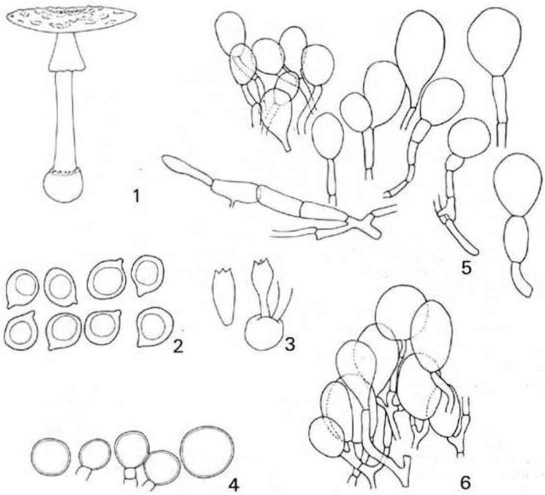
6. Volva friable, forming a dark grey-brown subfloccose belt at base of stem and evanescent small dark brown warts on dark brown cap. Spores 7.5–9 × 7–8 μm. Pileipellis consisting of 2.5–25 μm wide hyphae. . . . . *A. craseoderma*, p. 20

Amanita campinaranae Bas, *spec. nov.*—Figs. 1–6

Pileus c. 60 mm latus, convexus, dein centro depressus, tenuis, margine laevis nec appendiculatus, albus vel griseo-pallidus, viscidus, fragmentis volvae griseis crustiformibus vel applanatis ornatus. Lamellae liberae, subconfertae, angustae, albae; lamellulae attenuatae. Stipes c. 80 × 8–10 mm, sursum attenuatus, pallide griseus, bulbo abrupte globoso, sordide ochraceo alboque praeditus, margine bulbi fragmentis volvae subfloccosis-subverrucosis in circulo dispositis decoratus. Annulus apicalis, tenuiter membranaceus, pendulus, supra albus levisque, infra pallide griseus. Caro alba, immutabilis, inodora. Sporae 5.5–7.5 × 5.5–6.5 μm, (sub)globosae, forte amyloideae. Fragmenta volvae cellulis terminalibus, brunneolis, globosis vel late clavatis hyphisque ± erectis composita. Fibulae absentes. Typus: '*R. Singer B 10602*, 3 II 1978, Brasil, Amazonas, Manaus-Caracarai' (INPA, L).

Fruit-body (Fig. 1) medium-sized, rather slender, solitary. Cap about 60 mm wide in mature specimens, thin, convex, later with depressed centre, with smooth, non-appendiculate margin, white to greyish pallid, viscid, without distinct fibrillose structure, with grey, dense, subfelted volval remnants crust-like at centre but forming isolated patches on limb. Gills free, between close and crowded, often forked in both directions, narrow, white, turning cream to yellow when freshly dried, in exsiccates with entire, ± concolorous edge; short gills attenuate. Stem 77 × 8 (at apex)–10 (above bulb) mm, slightly tapering upward, with globose rather abrupt, 20 mm wide bulb, pale grey but bulb dirty ochre and white, glabrous, with greyish subfloccose-subverrucose volval rim on transitional zone between bulb and stem giving bulb a submarginate appearance. Ring apical, thin-membranous, pendulous, with white and smooth upperside and very pale grey underside. Flesh white, unchanging, inodorous. Spore print not available.

Spores [10/1] 5.6–6.7 × 5.5–6.5 μm, length-breadth ratio 1.0–1.15 (average 1.05), globose to subglobose, often slightly tapering towards apiculus, with very slightly thickened wall, very pale brownish-yellowish when resoaked in NH_4OH (particularly the oil-drops), usually 1-guttulate, strongly amyloid (Fig. 2). Basidia (Fig. 3) 21–23(–25) × 6.5–8.5 μm, 4-spored, sometimes containing yellowish (in NH_4OH) droplets, clampless. Marginal tissue (Fig. 4) consisting of scattered, usually solitary, globose cells, 11–25 × 10–22 μm, with slightly but distinctly thickened walls sometimes with yellowish (in NH_4OH) droplets against inside of wall. Trama of gills bilateral; subhymenium broad and cellular. Pileipellis (near centre): suprapellis an ixocutis about 50 μm thick; infrapellis a cutis, about 140 μm thick and made up of 5–12 μm wide, interwoven to subradial, straight hyphae; pigment difficult to localize; scattered yellowish oleiferous hyphae present; at surface with scattered inflated cells of volva even where pileipellis seems glabrous under hand-lens. Volval remnants on cap (Figs. 5, 6) consisting of — (i) very abundant, nearly always terminal, globose, spheropedunculate, obovoid, ellipsoid to broadly clavate or piriform cells, 30–75 × 25–60 μm, with pale brown vacuolar pigment and slightly thickened walls, — (ii) abundant, 4–14(–16) μm wide, colourless to very pale brownish, branching hyphae (the thicker basal ones sometimes with a fine incrustation), — (iii) a few elongate large cells, and — (iv) some oleiferous hyphae; in radial section of cap near centre the elements, particularly the hyphae bearing the inflated cells, in a predominantly erect position. Volval remnants on bulb similar to those on cap but inflated cells somewhat larger (up to 90 × 75 μm). Trama of stem acrophysalidic; acrophysalides measuring up to 300 × 35 μm; some scattered oleiferous hyphae. Clamps not found.



Figs. 1–6. *Amanita campinaranae*. — 1. Fruit-body (after field sketch and dried material; × 0.5). — 2. Spores (× 1250). — 3. Basidia and subhymenial cell (× 500) — 4. Cells of marginal tissue of gill (× 500) — 5–6. Tissue of volval wart on cap (× 250). — 5. In crushed mount. — 6. In situ on radial section of cap. (All Figs. from type.)

Habitat and distribution. — Terrestrial in Campinarana vegetation under Leguminosae and Sapotaceae in Amazonas; forming ectotrophic mycorrhiza.

Collection examined. — Brasil, Amazonas, road from Manaus to Caracarai, km 45, 3 Feb. 1978, *R. Singer B 10602* (holotype INPA; isotype L).

Observation. — In view of the slightly thick-walled and in NH_4OH somewhat yellowish-brownish spores, it is possible that the spore print of this species is slightly coloured.

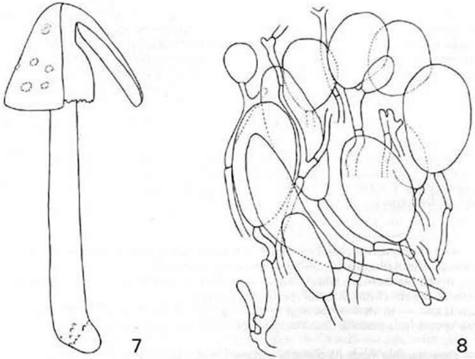
Amanita campinaranae finds its place in section *Validae* because of its small, amyloid spores combined with a friable volva, a non-appendiculate margin of the cap, a distinctly gelatinized pileipellis, and a membranous ring.

Within section *Validae* it is well characterized by its small, (sub)globose spores, its thin white to greyish pallid cap with grey, crust- to patch-like volval remnants, and its globose bulb decorated with a greyish volval rim giving the bulb a submarginate appearance.

AMANITA PHAEA, *nom. prov.*—Figs. 7–8

Fruit-body (Fig. 7) (cap just opened) large, terrestrial, solitary. Cap 65 mm wide and 45 mm high, conical with broadly rounded apex and inflexed smooth margin, uniformly spadiceous-sepia ('Hudson seal' Maerz & Paul[5], Munsell ± 5 YR 3/1), somewhat lubricous, in dried specimen shiny and very dark with only at margin a slight fibrillose structure visible, speckled with scattered small (in dried cap up to 3 mm wide), greyish-whitish volval warts and patches. Gills free, crowded, moderately broad, white (in dried specimen sordid ochraceous with pallid subflocculose edge under lens); short gills subtruncate (very short ones) to attenuate. Stem 135 × 7 mm, subcylindrical with pointed subbulbous base, solid, annulate, white above and grey below ring but white at base, fibrillose all over but particularly in upper half, glabrescent below, with scattered small whitish volval scales on lower part of subbulbous base. Ring apical, ample, pendulous, thin-membranous (in dried specimen entirely sticking to stem), white, smooth, with somewhat lacerate-fimbriate edge. Flesh white, unchanging, inodorous. Spore print not available.

Spores (lacking). Basidia clampless. Subhymenium cellular. Pileipellis a thin ixocutis of 2.5–7.5(–10) μm wide, subradial to fairly interwoven, dark brown, clampless, thin-walled hyphae with dark brown vacuolar pigment and rather closely embedded in colourless gelatinous matter. Remnants of volva on cap (Fig. 8) consisting of abundant 3–8 μm wide branching ± ascending hyphae carrying abundant ± erect, terminal, often pale brown, inflated cells mainly ellipsoid measuring from 20 × 16 to 75 × 55 μm but also quite a few



Figs. 7–8 *Amanita phaea.* — 7. Fruit-body (after field sketch and dried material; × 0.5). — 8. Crushed tissue of volval wart on cap (× 300). (Both Figs. from *Singer B 9791.*)

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[5] Checking this colour in Maerz & Paul I found it a very dark slightly purplish-brownish grey.

fusiform, elongate or subcylindrical measuring from 40 × 18 to 125 × 35 μm. No clamps observed.

HABITAT.—Terrestrial and solitary in secondary growth tropical forest (found only once).

COLLECTION EXAMINED.— Brasil, Amazonas, Manaus, grounds of INPA, 1977, *R. Singer B 9791* (INPA, L).

Although the spore characters of *A. phaea* are unknown, this species almost certainly belongs to section *Validae* (smooth non-appendiculate margin, friable volva and attenuate short gills). It bears some resemblance to *A. morrisii* Peck (U.S.A.) and *A. spissaceae* Imai (Japan), two species however with a temperate distribution and a stronger developed universal veil. *Amanita tristis* Corner & Bas (Malaya) and *A. fritillaria* (Berk.) Sacc. (S.E. Asia) bear a certain resemblance to the present species also but seem to have a heavier universal veil and, in addition, a striate ring.

Amanita xerocybe Bas, *spec. nov.*—Figs. 9–13

Pileus 40–70 mm latus, conico-convexus vel convexus umbonatusque, margine sulcatus, primo sordide albidus denique ochraceus centro brunneo-ochraceus, siccus, fragmentis volvae subflocculosis-granuliformibus gilvis dense ornatus. Lamellae liberae, remotae, latae, albidae vel cremeae; lamellulae rarissimae, truncatae. Stipes c. 90 × 5 mm, basi c. 9 mm latus, anguste farctus, annulatus, gilvus vel ochraceo-brunneus, minute flocculosus, bulbo fusiformi volvae reliquis tenuiter floccosis obtectus. Sporae 8–9 × 7.5–9 μm, (sub)globosae, inamyloideae. Fragmenta volvae cellulis turgidis, terminalibus, brunneis hyphisque plusminusve erectis composita. Fibulae absentes. Typus: '*H. St. John & R. Singer B 10730*, 28 II 1978, Brasil, Amazonas, Manaus-Caracaraí' (INPA, L).

Fruit-body (Fig. 9) medium-sized, fairly slender, fleshy, rather fragile, solitary. Cap 40–67 mm wide, from conico-convex with broadly rounded apex to convex and soon flattened around a low, obtuse umbo, with widely sulcate-striate margin (0.25–0.35 R; radial marginal ridges 1.8–2 mm broad) and crenulate edge, at first sordid whitish, later becoming ochraceous, at centre brownish ochraceous yellow to ochraceous brown ('Chipmunk' to 'Antique brown' M. & P.; Munsell between 10 YR 5/6 and 5/8 to ± 7.5 YR 5/6), subfelted-subflocculose, entirely decorated (densely at centre to sparsely at margin) with minute gilvous adnate granular-subflocculose dots of volval origin[6]. Gills distant, free, somewhat intervenose, broad, whitish but soon (particularly on drying) becoming cream, in dried specimens buff with minutely subflocculose-subgranular concolorous edge; short gills very scarce, truncate, sometimes partly adnate to long gills. Stem up to 90 × 5 mm, equally thick but with lower quarter enlarged to slenderly fusiform, up to 9 mm wide bulb, annulate, narrowly stuffed, gilvous to ochraceous tan (in dried material pallid with fine, flocculose, brownish buff to ochraceous brown covering); bulbous part entirely covered with an appressed, thin, flocculose (in dried specimens sordid brownish ochraceous) covering of volval remnants forming a narrow fragmented rim around upper part of bulb (hardly visible in dried state). Ring apical, easily separating and falling down, thickish and fluffy, smooth, concolorous with surface (dried: felted-subflocculose at underside; minutely granular at upperside). Flesh white to creamy, unchanging, inodorous. Spore print not available.

Spores (Fig. 12) [10/1] 7.8–9.1(–9.7) × 7.6–9.1(–9.5) μm, length-breadth ratio 1.0–1.05, globose to subglobose, often attenuate toward normal or rather broad apiculus, smooth, with very slightly thickened wall, one- to multiguttulate, non-amyloid. Basidia 35–45 × 9.5–11 μm, 4-spored, clampless. Marginal tissue (Fig. 13) forming a rather broad, (in NH$_4$OH)

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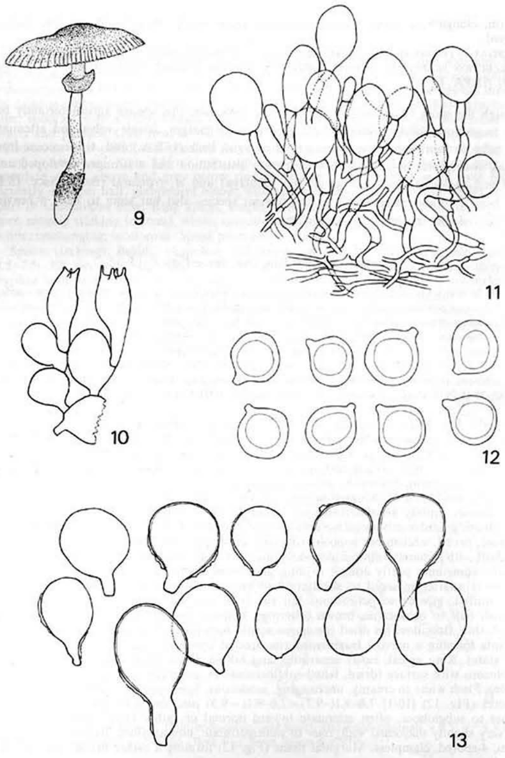
[6] In the field-notes the volval remnants are described as 'cottony-fluffy gilvous patches'.



Figs. 9–13. *Amanita xerocybe.* — 9. Fruit-body (after field sketch and dried material; × 0.5). — 10. Subhymenial cells and basidia (× 560). — 11. Tissue of volva near centre of cap in radial section (× 300). — 12. Spores (× 1400). — 13. Cells of marginal tissue of gill (× 550). (All Figs. from type.)

pale yellow-brown strip of globose to ellipsoid, often pedunculate, sometimes broadly clavate, colourless to pale brown cells, 28–50(–60) × 24–34 μm, often with slightly thickened wall and sometimes with pale amorphous substance on outside. Trama of gills (very loose and therefore difficult to section when dried); subhymenium (Fig. 10) composed of rather small (12–20 μm), mainly spheropedunculate cells. Pileipellis without gelatinized suprapellis, merely a denser layer of *c.* 3–6 μm wide hyphae between adnate volval tissue and trama of cap. Volval remnants on cap (Fig. 11) a relatively thin broken layer in upper 3 quarters consisting mainly of erect inflated terminal cells and in lower quarter mainly of more or less erect hyphae; inflated cells 28–62 × 24–54 μm, abundant, broadly ellipsoid to obovoid, more rarely broadly clavate or globose, with brown vacuolar pigment and slightly thickened walls terminal on 3–8 μm wide, colourless hyphae with thin to slightly thickened walls. Volval remnants on base of stem similar to those on cap but with more hyphae and somewhat more elongate elements. Ring made up of crowded globose to ovoid or piriform usually pedunculate, pale brown cells, 28–60 μm long, on 2.5–6 μm wide hyphae in upper layer but with relatively more hyphae and smaller inflated cells in lower layer. Trama of stem with abundant, up to 280 × 35 μm large acrophysalides. Covering of stem consisting of narrow hyphae carrying terminal, spheropedunculate to broadly clavate, brownish, often mucronate cells. Clamps not found.

HABITAT AND DISTRIBUTION.—On raw humus under trees in campinarana vegetation in Amazones, forming ectomycorrhiza with Sapotaceae and/or Leguminosae.

COLLECTION EXAMINED.—Brasil, Amazonas, road from Manaus to Caracarai, km 45, 28 Feb. 1978, *H. St-John & R. Singer B 10730* (holo-type, INPA; isotype, L).

On account of its friable volva, its non-amyloid spores, the sulcate margin of its cap and the bulbous base of its stem *A. xerocybe* belongs to section *Amanita*. In this section there are a number of species with globose to subglobose spores under 10 μm, but only very few of them have a flocculose-granular to powdery volva, a fruit-body without bright colours and a not or only slightly gelatinized suprapellis, viz. *A. farinosa* Schw. (U.S.A.) and *A. obsita* Corner & Bas (Malaya). However, bot have smaller spores (6–8 × 5–8 μm) and are ringless. *Amanita subvaginata* (Clel. & Cheel) E. J. Gilb. (Australia) seems to have the right size of spores (7.5–9 μm) but has no ring either, and its cap is ashy grey.

Amanita sulcatissima, another member of section *Amanita* described in this paper (p. 9) differs from *A. xerocybe* a.o. by ellipsoid spores (8–9 × 6–7 μm; l/b 1.2–1.4, average 1.3), the presence of clamps, more crowded gills and the absence of a ring.

For a comparison of *A. xerocybe* with *Collybia sulcatissima* Rick, see the discussion on *A. sulcatissima* (p. 12).

Amanita sulcatissima Bas, *spec. nov.*—Figs. 14–18

Pileus c. 40 mm latus, plano-convexus, margine longe et crebre sulcato-striatus (c. 0.5 R), centro brunneus, margine griseo-bubalinus, in parte volvae reliquiis crustuliniformibus, tenuibus, subtomentosis, pallide brunneo-griseis obsitus. Lamellae liberae, confertae, angustae, pallide griseo-bubalinae; lamellulae infrequentes, truncatae. Stipes c. 45 × 4.5 mm, sursum attenuatus, deorsum bulbosus, solidus (in sicco cavus), exannulatus, griseus, basi reliquiis volvae subtomentosis, griseis, subfriabilibus vel submembranaceis ornatus. Caro alba vel albida, immutabilis, subcarnosa, inodora. Sporae 8–9 × 6–7 μm, subellipsoideae vel ellipsoideae, non-amyloideae. Fragmenta volvae hyphis, 3.5–7(–11) μm latis, cellulisque praecipue globosis, 28–60 × 25–52 μm, pallide griseo-brunneis, terminalibus composita. Fibulae frequentes. Typus: '*R. Singer 10123*, 25 VII 1977, estrada Manaus-Caracarai km 45, Amazonas, Brazil' (INPA, L).

Etymology: sulcatissima, most grooved.

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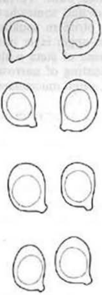

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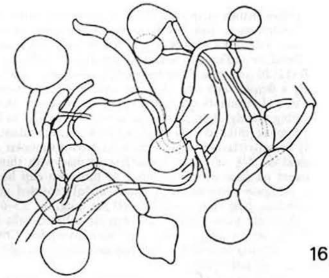

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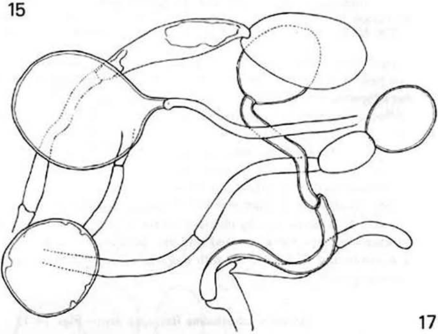

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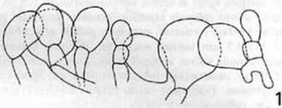

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Figs. 14–18. *Amanita sulcatissima*. — 14. Fruit-body (after field sketch and dried material; × 0.5). — 15. Spores (× 1250). — 16–17. Crushed volval remnants from cap (16, × 250; 17, × 500). — 18. Cells of marginal tissue of gill (× 500). (All Figs. from type.)

Fruit-body (Fig. 14) rather small and short-stemmed, solitary. Cap 40 mm wide, plano-convex with slightly flattened centre, with broad (0.45–0.55 R), densely sulcate-striate (14–18 grooves per 10 mm of circle half-way sulcate zone) margin, at centre fairly dark, slightly olivaceous tinged ochraceous brown (M. & P. 14 J 8 'maple sugar'; Muns. *c.* 10 YR 5/6–6/6) to slightly paler and slightly more reddish ochraceous brown (M. & P. 14 J 9 'mummy'; Muns. 7.5 YR 5/6–10 YR 5/6), at margin pale buffy grey (M. & P. 11 C 3 'sheepskin'; slightly more grey than Muns. 2.5 Y 8/4), with pallid interstriation, in dried state matt to somewhat shiny and (even under strong lens) without visible fibrillose structure, over about 1/4 of surface covered with a thin, pale brownish grey (M. & P. 13 B 6 'almond'; Muns. *c.* 7.5. YR 6/4), large volval patch (in dried state minutely tomentose and tending to disrupt into vague small patches with very pale arachnoid edges). Gills free, crowded, narrow, pale greyish buff (M. & P. 11 E 4 'maple'; slightly darker than Muns. 2.5 Y 8/4), in dried state with slightly darker (brownish ochraceous) edge; short gills 0–1(–3), scarce, truncate. Stem 45 × 4.5 mm, tapering upward, with rather abrupt, slightly flattened subglobose basal bulb *c.* 7 mm high and 10 mm wide, solid (but in dried state hollow), exannulate, grey (M. & P. 13 C 4 'hamadan'; Muns. 10 YR 6/4–5/4) with paler apex, minutely fibrillose. Volval remnants at base of stem arising from upper part of bulb, appressed, pale brownish grey, with subtomentose-sublanose surface, at one side of stem forming a thin submembranous limb up to 10 mm above bulb, but for the rest forming thin vaguely delimited patches not reaching so high as limb; lower part of bulb rather glabrous, whitish with small ochraceous-brown spots. Flesh white or whitish, unchanging, inodorous.

Spores [10/1/1] 8–9 × 6–7(–7.5) μm, length-breadth ratio 1.2–1.4 (average 1.3), broadly ellipsoid to ellipsoid, thin-walled, colourless, smooth, usually with one large oil-drop, non-amyloid (Fig. 15) Basidia [10/1/1] 32–43 × 12–14 μm, 4-spored, with clamp. Marginal tissue made up of scattered, subcylindrical-subclavate to broadly piriform, colourless, thin-walled cells, 15–35 × 10–30 μm, on broad septate hyphae (Fig. 18). Trama of gills probably bilateral (difficult to reinflate in type), with very thick subhymenium (25–30 μm) and narrow central plate of proper trama; subhymenium cellular. Pileipellis a cutis of up to 5 μm wide interwoven, poorly pigmented hyphae surmounted with a thin ixocutis of embedded, 3–4.5 μm wide, interwoven hyphae with clamps; pigment probably vacuolar, but a slight incrustation seemingly present on some narrow hyphae. Volval tissue on cap a very loose tissue of disorderly arranged, long-celled, clamped, 3.5–7(–11) μm wide hyphae with very slightly thickened, slightly yellowish wall and terminal, mostly globose but also broadly ellipsoid to pyriform, pale grey-brown cells, 28–60 × 25–52 μm, with very slightly thickened wall and often with one or more small refractive bodies against inside of wall; a few hyphae and inflated cells with golden yellow oleaceous contents (Fig. 16, 17). Volval tissue on base of stem similar to that on cap, but inner layer of submembranous limb a rather dense layer of abundant, often somewhat agglutinate hyphae and scattered inflated cells. Trama of stem acrophysalidic, with cells up to 440 × 40 μm. Clamps abundant in all parts studied.

Phenol reaction on flesh very dark reddish brown (M. & P. 7 L 12 'caldera', to 8 L 12 'mandalay'; from slightly darker than Muns. 2.5 YR 4/6 to slightly darker and more red than 5 YR 4/4).

HABITAT AND DISTRIBUTION.—In Campina-vegetation, on humus under trees (Humiriaceae, Burseraceae, Ochnaceae, Sapindaceae, Leguminosae and Sapotaceae), in Amazonian area.

COLLECTION EXAMINED.— Brazil, Amazonas, estrada Manaus-Caracarai km 45, 25 VII 1977, *R. Singer* (*& I. Araujo*) *B 10123* (holotype, INPA; isotype, L).

OBSERVATIONS.— It is remarkable that the volval limb, present only at one side of the base of the stem, has a thin but distinct membranous inner layer which is completely absent from the volval remnants elsewhere. A possible explanation for this is that this layer maintains its individuality only there where the volva loses its contact with the pileipellis in an early stage, whereas in other places where this contact is maintained longer the inner volval layer, slightly gelatinizing itself, merges in the gelatinizing pileipellis.

Although *A. sulcatissima* combines non-amyloid spores with an exannulate stem, this species belongs to section *Amanita* because even the mature stem shows the presence of a basal bulb. It strongly resembles *A. farinosa* Schw. (U.S.A.) which differs however by smaller (6.5–8 × 5.5–8 μm) and, on average, less elongate spores (1.0–1.3) and probably also in lacking or having infrequent clamps (Jenkins, *1977*: 33). Moreover the volva at the base of stem in *A. sulcatissima* is somewhat limbate because of a thin membranous inner layer which seems to be lacking in *A. farinosa*, where the volval remnants on the top of the bulb are strictly pulverulent.

Two other related species are *A. obsita* Corner & Bas (Malaya) with smaller spores (6–7.5 × 5–7 μm) and *A. subvaginata* (Clel. & Cheel) E. J. Gilb. (Australia) with, according to the original description, globose spores

Dr. Singer (in lit.) drew my attention to *Collybia sulcatissima* Rick (*1938*: 275), a species in his opinion possibly identical with or related to the present species. The lectotype of Rick's species was studied by me and found to be in a rather poor condition. It turned out to be impossible to study the basidia for clamps and to analyse the structure of volval remnants and pileipellis. The following data, including those from Rick's protologue, are now available:

Fruit-body solitary, terrestrial. Cap about 30 mm in diam., plano-convex with depressed centre, sulcate-striate from margin nearly up to centre (in type marginal striation now hardly visible), brown-grey with darker centre, pulverulent. Gills moderately crowded, adnate, white. Stem 10 × 5 mm, with subbulbous base, white with reddish granules, exannulate.

Spores [20/1/1] 8.5–10 (–10.5) × 7–8.5 μm, (1.05–) 1.1–1.3(–1.35) with 1.2 for average, subglobose to broadly ellipsoid, thin-walled, coulourless, smooth, with short abrupt apiculus, inamyloid. Pileipellis with a thin gelatinized layer at surface. Clamps not seen (but cells very difficult to reinflate).

COLLECTION EXAMINED.—Brazil, Rio Grande do Sul, Sao Leopoldo, 1932. *J. Rick 12.372* (lectotype of *Collybia sulcatissima* Rick; PACA).

If *Collybia sulcatissima* is run down in the key on p. 3 with the data available, one arrives at 5, where the choice is between *A. xerocybe* and *A. sulcatissima*. The colour of the cap and the length of its marginal sulcation, the absence of a ring and the shape of the spores agree with *A. sulcatissima*, the width of the spores and the possible absence of clamps point toward *A. xerocybe*. Considering the condition of the type collection and particularly the fact that no information on its volval structure could be gained from it, I am convinced that it is impossible to know the true identity of *Collybia sulcatissima* Rick (although it certainly is a species of *Amanita*). Therefore I prefer to describe *Amanita sulcatissima* as a new species based on recent material collected and annotated by Dr. Singer.

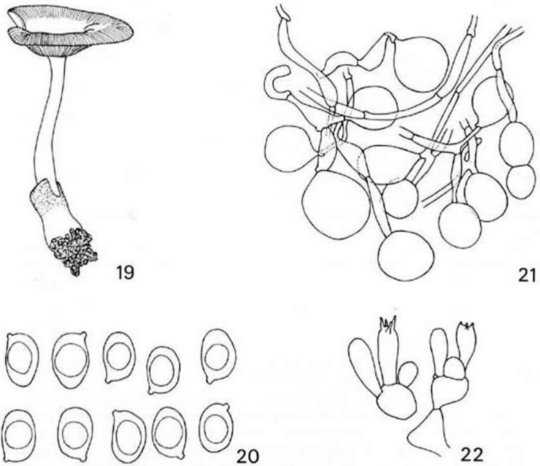
Amanita lanivolva Bas, *spec. nov.*—Figs. 19–24

Pileus 50–75 mm latus, plano-convexus, centro late depressus, interdum subumbonatus, margine longe sulcato-striatus (0.4–0.6 R), aeneo-brunneus, centro rufo-brunneus, glaber, subviscidus. Lamellae liberae, confertae, angustae, albae vel pallide griseae; lamellulae truncatae. Stipes 75–100 × c. 5–6 mm, sursum attenuatus, subbulbosus, exannulatus, volvatus, albus, glaber. Volva saccata, membranacea, anguste ocreata vel subventricosa, grisea, tomentoso-lanosa. Caro alba, inodora. Sporae 7.5–9.5 ×

5.5–7 μm, subellipsoideae vel ellipsoideae, non-amyloideae. Fibulae frequentes. Typus: '*R. Singer B 9843*, 1977, Manaus, Amazonas, Brazil (INPA 66.715, L).

Etymology: lana, wool.

Fruit-bodies (Fig. 19) solitary, medium-sized, fairly slender, fragile. Cap 50–75 mm wide, plano-convex with broad central depression, subumbonate or not, with broad sulcate-striate marginal zone (0.4–0.6 R), moderately dark slightly olivaceous tinged brown (bronze; M. & P. 15 C 2 'clove'; Muns. 7.5 YR 4/4–5/6) with centre slightly more reddish brown (M. & P. 8 H 11 'congo'; Muns. 5 YR 4/4–4/6), with white interstriation at margin, glabrous, subviscid; in dried specimens matt to somewhat shiny particularly at centre, outside centre slightly innately radially fibrillose under strong lens. Gills free, crowded, narrow, white to pallid greyish, probably with concolorous edge; short gills (0–1) truncate to obliquely truncate; in dried state edges pale buff to pale ochraceous brown. Stem 75—100 × *c*. 5–6 mm, tapering upward, with slightly bulbous base, hollow, exannulate, white, fragile, smooth and glabrous. Volva saccate, membranous, loosely sheathing basal 30–35 mm of stem, grey to fuscous grey (M. & P. 15 A 7 'soaptone' to 15 C 8 'chukker brown'; Muns. 7.5 YR 5/4–



Figs. 19–22. *Amanita lanivolva*. — 19. Fruit-body (after colour slide; × 0.5). — 20. Spores (× 1250). — 21. Cells from outer layer of volval limb (× 250). — 22. Basidia and subhymenial cells (× 500). (All Figs. from type).

4/4), but lower half paler to whitish, tomentose-lanose; in dried specimens cylindrical to somewhat ventricose, adnate to lower 8–10 mm of stem, with internal volval limb a fimbriate, 1—1.5 mm wide rim situated in angle between external volval limb and stem ('unitangent volva'). Flesh white, unchanging, odourless.

Spores [20/2/2] 7.5–9.5 × 5.5–7 µm, length-breadth ratio (1.2–)1.2^5–1.6(–1.6^5) (averages 1.3–1.5), broadly ellipsoid to ellipsoid, with apex often rounded subconical, thin-walled, colourless, smooth, usually with one oil-drop, with small apiculus (Fig. 20). Basidia [20/2/2] 27–36 × 9–11 µm, 4-spored, with clamp. Marginal tissue (Figs. 23, 24) a fairly broad brown strip of two types of cells: outer strip consisting of small, empty, basidiform cells, 12–30 × 4–9 µm, on irregularly shaped hyphae, and between this layer and hymenium an irregularly broad strip of globose, ellipsoid and broadly clavate cells, 20–30 × 14–22 µm, with slightly thickened walls and often somewhat congophilous granular contents; in Melzer abundant yellow oil-drops along edge (not in ammonia). Trama of gills bilateral, with conspicuously broad cellular subhymenium (up to 45 µm thick), with large inflated cells up to 40 µm long. Pileipellis a cutis of (1.5–)3–5(–7) µm wide, interwoven to radial hyphae with clamps and vacuolar brown pigment surmounted with a thin (on limb) to fairly thick (at centre) ixocutis with 1.5–3.5 µm wide distant colourless interwoven hyphae. Volval limb made up of a 50–80 µm thick inner layer (of 2–6 µm wide hyphae) of which 20–40 µm thick layer at inner surface gelatizinzing, and a 400–500 µm thick outer layer (Fig. 22) of very loosely interwoven 2.5–7(–12.5 ... 27) µm wide clamped hyphae with very slightly thickened, colourless to slightly yellowish walls and globose, obovoid and piriform, terminal (very rarely in rows of two) cells, 30–70 × 26–60 µm, with fairly dark grey-brown to pale or rarely colourless contents. Trama of stem acrophysalidic; acrophysalides up to 290 × 50 µm. Stipitepellis a thin layer of 2.5–4 µm wide pale brownish hyphae with slightly thickened walls.

Phenol on flesh: first dull pink (M. & P. 6 J 4; Muns. 5 R 4/6), soon purple (M. & P. 55 J 2; Muns. 10 RP 4/6), then brown (M. & P. 15 C 11 'cocoa brown'; Muns. 7.5 YR 4/4–5 YR 4/4), eventually darker (deeper than M. & P. 8 H 10 'chocolate'; Muns. 10 YR 3/4). Formaline on flesh: slowly lilac or violet.

HABITAT AND DISTRIBUTION.—Fairly common on the ground in secondary tropical rain forest, near *Neea* (Nyctaginaceae; *Singer B 9897* definitely shown to be connected with short roots of *Neea* spec.), with nearby Rubiaceae, Sapindaceae, Euphorbiaceae, Leguminosae, Flacourtiaceae and Palmae, in Amazonian area.

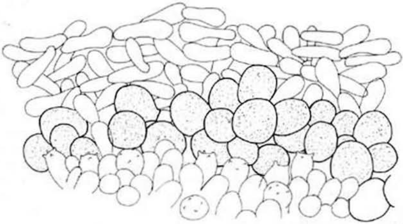
COLLECTIONS EXAMINED.—Brazil, Amazonas: Manaus, near INPA, 1977, *R. Singer B 9843* (holotype, with colour slide, INPA 66.715; isotype, L); ditto, 29 May 1977, *R. Singer B 9897* (INPA 66.716).

NOTE.—Dr. Singer (in lit.) reports that *A. lanivolva* is fairly common in secondary forest around Manaus. More material than the two collections studied here has been collected and is preserved at INPA.

Because of the greyish lanose-tomentose outside of the narrowly saccate volva, *A. lanivolva* is a very characteristic species. Moreover, the occurrence of two types of sterile cells in the marginal tissue (Fig. 23, 24) of the gills is so far a unique feature.

It is, however, not fully certain that *A. lanivolva* belongs to section *Vaginatae*. On a colourslide of the type specimen as well as in the dried fruit-body of *Singer B 9897* it seems that the lower part of the stem where the volva is adnate, is somewhat enlarged and forms a very small subglobose bulb. A study of very young stages will show if a primordial bulb is present in this species and if consequently *A. lanivolva* has to be placed in section *Amanita*.

Also in section *Amanita A. lanivolva* would stand apart on account of its lanose-tomentose volva and its marginal tissue with two types of cells, but still more so because of the truly saccate nature of its volva.



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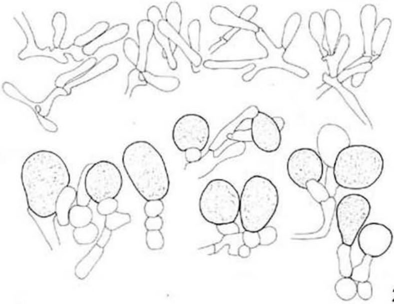

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Figs. 23–24. *Amanita lanivolva*; marginal tissue of gill (× 500). — 23. In situ. — 24. In crushed mount. (Both Figs. from type.)

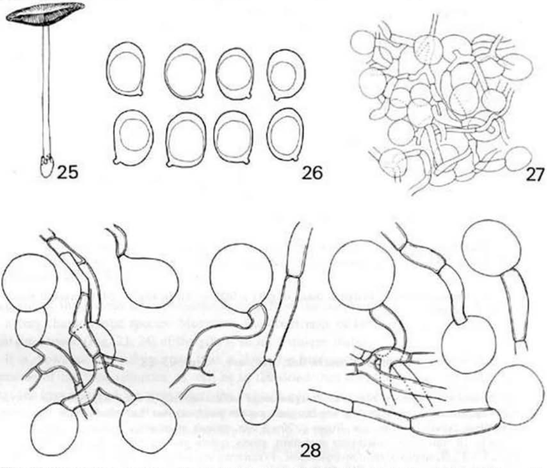
Amanita coacta Bas, *spec. nov.*—Figs. 25–28

Pileus c. 40 mm latus, demum concavus, margine longe sulcato-striatus (0.4–0.5 R), umbrinus, volvae fragmentis applanatis, irregularibus, griseo-brunneis, coactis parce ornatus. Lamellae liberae, confertae, sublatae, albae; lamellulae truncatae. Stipes c. 70 × 3 mm, sursum attenuatus, ebulbosus, exannulatus, albus, basi (c. 10 mm) volvae fragmentis applanatis, griseis, coactis vestitus. Caro alba, inodora. Sporae 8.5–10 × 6.5–7.5 μm, ellipsoideae, non-amyloideae. Fragmenta volvae cellulis globosis, 20–35 μm diam., brunneis, terminalibus atque hyphis, 5–7(–12.5) μm latis, inconditis composita. Fibulae absentes. Typus: '*R. Singer B 10160*, 27.V.1977, Manaus, Amazonas, Brazil (INPA, L).'

Etymology: coactus, felted.

Fruit-bodies (Fig. 25) solitary, small, slender. Cap *c.* 40 mm wide, concave without or with a very slight umbo, with broad rather densely sulcate-striate marginal zone (0.5 R according to field-notes; in dried specimens 0.25 to 0.45 R; 12–14 grooves per 10 mm of circle halfway sulcate zone), umber with pallid interstriation at margin, matt in dried state and then under strong lens with fibrillose structure only visible on dark marginal ridges, around centre with a few irregularly shaped, paler grey-brown, felted, thin volval patches with on their surface a few very small darker warts (under lens). Gills free, crowded, fairly broad, white, probably with concolorous edge; short gills very scarce, truncate. Stem *c.* 70 × 3 mm, tapering upward, without bulb, exannulate, white, in dried state (under strong lens) subflocculose. Volva at base of stem up to *c.* 10 mm high, thin, felted-submembranous, ± broken into partly clearly separated, partly still more or less connected, felted, grey patches with at their surface (under strong lens) appressed paler to nearly whitish short fibrils. Flesh white, unchanging, inodorous.

Spores [10/1/1] 8.5–10 × 6.5–7.5 μm, length-breadth ratio 1.2^5–1.4 (average 1.3), (broadly ellipsoid to) ellipsoid, with broadly rounded (not conical) apex, thin-walled, colourless, usually with one oil-drop, with small apiculus (Fig. 26). Basidia [10/1/1] 32–45 × 10.5–11.5 μm, 4-spored, clampless. Marginal tissue a rather broad, interrupted strip of colourless, very



Figs. 25–28. *Amanita coacta.* — 25. Fruit-body (after field sketch and dried material; × 0.5). — 26. Spores (× 1250). — 27–28. Tissue of volval patch on cap. — 27. In crushed mount (× 250). — 28. Separated elements (× 500). (All Figs. from type.)

thin-walled, easily collapsing, inflated cells measuring up to 35 µm and hyphae, hard to dissociate. Trama of gills impossible to study in type; subhymenium cellular; cells often globose but sometimes irregularly shaped, up to 25(–35) µm. Pileipellis composed of 3–5.5 µm wide, densely interwoven hyphae, without or with only a very thin ixocutis on top, with scattered volval remnants under microscope (but these not visible under hand-lens); brown pigment vacuolar but in addition seemingly at places a slight incrustation present also. Volval patches on cap (Figs. 27, 28) a rather dense tissue of (i) abundant, fairly broad, 5–7 (–12.5) µm wide, relatively short-celled branching hyphae with very slightly thickened, colourless or slightly coloured walls with slight incrustation, (ii) abundant globose, more rarely ellipsoid or somewhat ovoid, brown cells, 20–35 µm, terminal or more rarely in terminal rows of two, and (iii) a limited number of elongate to subcylindrical inflated cells. Volval patches at base of stem similar to those on cap but with on outer surface a coarse net of thick bundles of 3–7 µm wide rather straight hyphae with slightly thickened, pale yellowish walls evidently encrusted with amorphous matter (yellowish in ammonia), and some large globose, piriform and elongate cells up to 55 µm long and up to 35 µm wide, particularly in meshes of that net. Trama of stem which acrophysalides measuring up to 300 × 30 µm. Clamps absent from all parts examined.

HABITAT AND DISTRIBUTION.—Found once on the ground in secondary tropical rain forest in Amazonian area; all accompanying trees and shrubs except *Neea* and *Psychotria* with non-ectotrophic roots.

COLLECTION EXAMINED.—Brazil, Amazonas: Manaus, on grounds of INPA, 27 May 1977, *R. Singer B 9728* (holotype, INPA 66.714; isotype, L).

In the field the type-specimen of *A. coacta* was mistaken for another collection of *A. lanivolva* (see p. 12). The former can be easily distinguished from the latter, however, by the absence of clamps and the small inflated cells in the volval tissue (20–35 µm against 30–70 µm in *A. lanivolva*). In addition the grey volval limb of *A. coacta* is thinner, less coherent and not lanose-tomentose on the outside, although in the type-specimen appressed whitish fibrils are evident under a hand-lens.

The volva of *A. coacta* is so incoherent that in the type a few small volval patches are to be seen around the centre of the cap and the volval limb tends to break up into patches. (This may be different, however, in more vigorous fruit-bodies, the only specimen available being a very tiny one.)

As the stem has no bulbous base, *A. coacta* belongs to section *Vaginatae*. Its volva is much less friable than that of *A. craseoderma* (see p. 20), a species occurring in the same region and with (sub)globose spores and up to 25 µm wide pigmented hyphae in the pileipellis.

Amanitopsis plumbea Rick[7] (*1937*: 309), very inadequately described by its author, seemed sufficiently close to *A. crebresulcata* and *A. coacta* to justify a loan of the type. Unfortunately the type material turned out to be in such a poor condition that not much information could be derived from it. Only a very roughly drawn portrait of Rick's species is available now:

Terrestrial. Cap 30–40 mm in diam., grey, with (short?-) sulcate margin, rarely with a vague small paler volval patch. Gills crowded, white. Stem up to 70 mm long, without bulb, white. Volva ± saccate, grey-white. Ring absent.

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[7] Rick undoubtedly intended to describe a new species under this name, thus creating a later homonym of *Amanitopsis plumbea* (Schaeff. ex Purton) Schroeter.

Spores [15/3/1] 9.5–10.5(–11) × 6.5–7.5 µm (1/b 1.3–1.5^5 (–1.6^5), average 1.4), ellipsoid, inamyloid, thin-walled, colourless, smooth, with abrupt apiculus. Basidia clampless (only a few completely seen). Pileipellis gelatinized at surface, consisting of (sub)radial, 2.5–4.5 µm wide clampless hyphae. Volval remnants consisting of 3–5 µm wide hyphae in somewhat coiled bundles at surface, probably with inflated cells present underneath. Trama of stem acrophysalidic.

COLLECTION EXAMINED.—Brazil, Rio Grande do Sul, Porto Alegro, 1930, *J. Rick 12.220* (lectotype of *Amanitopsis plumbea* Rick, PACA).

With help of these data one arrives in the key presented in this paper (p. 3) at 8, where the choice has to be made between *A. crebresulcata* and *A. coacta*.

Size and shape of the spores of Rick's species agree best with *A. coacta*, but the colour of its cap is grey against umber in *A. coacta*. Unfortunately I was unable to measure the inflated cells in the volval tissue, which are characteristically small in *A. coacta*. *Amanita crebresulcata* has somewhat broader spores (1/b 1.1–1.4 with 1.1^5–1.3 for averages), a dark brown cap and a grey stem.

As it appears impossible to satisfactorily match Rick's species with one of these two species from Amazonia, a third species may be involved. In view, however, of the scanty information available on *Amanitopsis plumbea* Rick, it seems better to refer it to the insufficiently known taxa once and for all.

Amanita crebresulcata Bas, *spec. nov.*—Figs. 29–32

Pileus 50–75 mm latus, initio campanulatus subacute umbonatusque, postea plano-convexus, planus vel plano-concavus, centro obtuse umbonatus, margine longe et crebre sulcato-striatus (0.45–0.65 R), umbrinus vel fusco-sepiaceous, subzonatus, glaber. Lamallae liberae, confertae, angustae, albae, acie concolore vel brunnea; lamellulae infrequentes, truncatae. Stipes usque ad 120 × 10 mm, sursum attenuatus, cavus, haud bulbosus, exannulatus, volvatus, glaber, griseus, basi albus, apice saepe pallidus atque interdum innate punctulatus. Volva saccata, membranacea, anguste ocreata, alba. Caro alba vel albida, inodora. Sporae 8.5–10.5 × 7–8.5 µm, subglobulosae vel ellipsoideae, non-amyloideae. Fibulae absentes. Typus: '*R. Singer B 9680*, 19.X.1977, Manaus, Amazonas, Brazil (INPA 66.710, L).'

Etymology: creber, close; sulcatus, grooved.

Fruit-bodies (Fig. 29) medium-sized, slender, solitary or subgregarious. Cap 50–75 mm wide, in the only young specimen available campanulate with rather acute umbo, later plano-convex to flat or plano-concave with low obtuse umbo, with broad densely sulcate-striate margin (0.45 to 0.65 R; in dried specimens 14–16 grooves per 10 mm of circle halfway sulcate zone), dark umber to fuscous-sepia at umbo, somewhat paler around umbo but with narrow darker fuscous zone[8] at margin of slightly paler sulcate zone, glabrous, in dried caps matt to somewhat shiny (particularly at centre) and without or with very fine innate fibrillose structure under lens. Gills free, crowded, narrow, white, with concolorous edge or (more often?) with a very fine brown line along entire edge or only near margin of cap; short gills rather scarce, truncate. Stem up to 120 × 10 mm, tapering upward, hollow, without bulb, exannulate, with saccate volva, grey (M. & P. 15 C 7 'racquet'; Muns. 7.5 YR 5/4–5/2) with white base and often paler apex, glabrous and smooth, at apex sometimes

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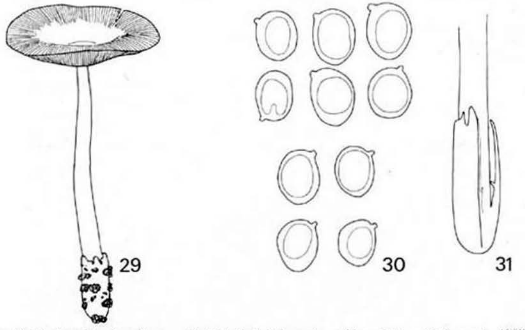
[8] In the dried specimens examined this dark zone has disappeared.

minutely innately punctulate. Volva saccate, membranous, thin, narrowly sheathing, higher than broad, white to cream or in places pale buff, minutely felted (not at all powdery or flocculose), under lens locally with minute buff patches; volva in dried specimens up to 25 mm high and 14 mm wide, with not or hardly flaring margin, adnate only to lower 5–10 mm of stem and (where visible) with a narrow, fringed internal limb on inner surface of external limb, 2–3 mm high above place of attachment to stem ('volva bitangent', Fig. 31). Flesh white to whitish, inodorous.

Spores [70/7/4] (8–)8.5–10.5(–11) × (6.5–)7–8.5(–9) μm, length-breadth ratio (1.0^{5}–)1.1–1.4 (averages 1.1^{5}–1.3), subglobose to broadly ellipsoid, rarely ellipsoid, thin-walled, colourless, smooth, usually with one large oil-drop, non-amyloid (Fig. 30). Basidia [10/1/1] (28–)34–38 × 11–12 μm, 4-spored, clampless. Marginal tissue a rather broad strip of chains of very thin-walled, soon collapsing inflated cells, up to 40 × 28 μm, and hyphae, both parallel to edge of gill; in hymenium near edge a few 18–32 μm wide spheropedunculate cells observed; pigment hard to localize. Trama of gills probably bilateral; subhymenium cellular, rather thick. Pileipellis a c. 100 μm thick brown cutis of 2–5(–8) μm wide interwoven to subradial hyphae with vacuolar pigment, intermixed with some 4–9 μm wide yellowish oleiferous hyphae, surmounted with a 25–50 μm (at centre of cap 90–125 μm) thick ixocutis with 1–3.5 μm wide distant hyphae. Limb of volva consisting of a tissue of branching, interwoven, 2–5 μm wide hyphae with scattered, globose, subglobose, ellipsoid and ovoid terminal colourless cells, 45–90 × 35–75 μm; its outer surface covered by a thin layer (inflated cells shining through) of loosely interwoven, 3.5–7 μm wide, slightly thick-walled, colourless hyphae surmounted with scattered, criss-cross running *c.* 50–60 μm wide bundles of more straight and parallel hyphae and with patches of brown, granular, extracellular matter; its inner surface with very thin layer of gelatinized, 2–5 μm wide hyphae. Trama of stem acrophysalidic, with cells up to 300 × 35 μm; hyphae and acrophysalides at surface with vacuolar brown pigment. Clamps absent in all parts examined.



Figs. 29–31. *Amanita crebresulcata*. — 29. Fruit-body (after colour slide; × 0.5). — 30. Spores (× 1250). — 31. Sectioned volva of dried specimen showing position of internal volval limb (× 1). (Fig. 29 from *Singer B 9796*, 30 from *Singer B 9680*, 31 from *Singer B 9684*.)

Phenol reaction on flesh of stem at first greyish-reddish lilac, then reddish brown to copper, finally dark grey-brown.

HABITAT AND DISTRIBUTION.—Fairly common on the ground in mixed secondary growth tropical rain forest, growing near *Neea* (Nyctaginaceae; in one case mycorrhizal connections definitely established) and *Psychotria* (Rubiaceae); also present Sapindaceae, Euphorbiaceae, Leguminosae, Palmae, Flacourtiaceae, Sapotaceae and Violaceae, in Amazonian area.

COLLECTIONS EXAMINED.—Brazil, Amazonas: Manaus, near INPA, 19 May 1977, *R. Singer B 9680* (holotype, INPA 66.710; isotype, L); ditto, 20 May 1977, *R. Singer B 9684* (INPA 66.713); ditto 27 May 1977, *R. Singer B 9729* (INPA 66.711); ditto 1977, *R. Singer B 9796* (with colour-slide; INPA 66.712).

Amanita crebresulcata is a rather typical member of section *Vaginatae*. It can be recognized by the broad, very densely sulcate margin of its cap, its small ellipsoid spores, its coloured but glabrous stem and its rather insignificant thin membranous volva. In the field a dark zone on the cap adjacent to the sulcate part of the margin may be a helpful character, but in the herbarium specimens available this zone has disappeared.

For a comparison between *A. crebresulcata* and Rick's *Amanitopsis plumbea*, see the discussion on *A. coacta* (p. 18).

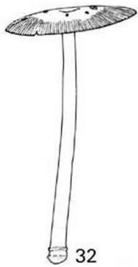
Amanita craseoderma Bas, *spec. nov.*—Figs. 32–35

Pileus c. 60 mm latus, convexo-applanatus, centro subumbilicatus, margine longe sulcato-striatus (c. 0.5 R), fuscus, volvae reliquiis verruciformibus phaeis, minutis perparce obsitus. Lamellae confertae, perpallide griseae; lamellulae infrequentes, truncatae. Stipes c. 110 × 7 mm, subcylindraceus, haud bulbosus, exannulatus, fuscidulo-griseus, basi reliquiis volvae subflocculosis, griseis, anguste annuliformibus ornatus. Caro tenuis, fragilis, inodora. Sporae 7.5–9 × 7–8 μm, globulosae vel subglobulosae, non-amyloideae. Fragmenta volvae cellulis globosis vel piriformibus, 28–53 × 23–48 μm, brunneis, hyphisque composita. Cellulae pileipellis heterogeneae, 2.5–25 μm latae. Fibulae absentes. Typus: '*R. Singer B 10160*, 30.IX.1977, 30 km N. of Manaus, Amazonas, Brazil (INPA, L).'

Etymology: *κρασιζ*, the mixing, the blending; *δέρμα*, skin (on account of the variously shaped cells in the pileipellis).

Fruit-body (Fig. 32) medium-sized, slender, solitary. Cap about 60 mm wide, plano-convex with subumbilicate centre and broad sulcate-striate margin (0.5–0.6 R), very dark brownish grey (M. & P. 8 A 8; Muns. 10 YR 3/2) with pale marginal grooves, with very few, small, dark grey-brown, irregularly shaped, wart-like volval remnants, in dried state shiny and with no fibrillose structure visible under lens. Gills free, fairly crowded, very pale greyish; short gills very rare, (obliquely?) truncate. Stem *c.* 110 × 7 mm, subcylindrical, without basal bulb, exannulate, fuscidulous grey, subglabrous to glabrous but under lens in dried specimen darkly punctate on upper part and with very fine short dark fibrils on lower part. Volva forming one nearly complete narrow, dark grey-brown, subfloccose belt about 6 mm above base of stem and a whitish (near upper margin somewhat greyish), adnate, subfloccose layer on lower 3 mm of stem. Flesh relatively thin, very fragile, inodorous.

Spores [10/1/1] 7.5–9 × 7–8 μm, length-breadth ratio 1.0^5–1.1^5 (average 1.1), subglobose, colourless, thin-walled, smooth, often with one large oil-drop, inamyloid (Fig. 34). Basidia [5/1/1] (only a few with sterigmata found; hymenium over-mature?) 44–48 × 10.5–12 μm, 4-spored, clampless. Marginal tissue not found (disappeared?). Trama of gill bilateral near edge, irregular near base; subhymenium cellular, ± 25–35 μm wide. Pileipellis (Fig. 35) a near centre of cap 50–70 μm thick cutis of agglutinated (but not distant) 2.5–25 μm wide hyphae and chains of inflated cells with very conspicuous, in dried material unevenly distributed, vacuolar brown pigment; cells disorderly arranged at centre, subradially on limb; without colourless superficial ixocutis; with rather abundant up to 10 μm wide oleiferous



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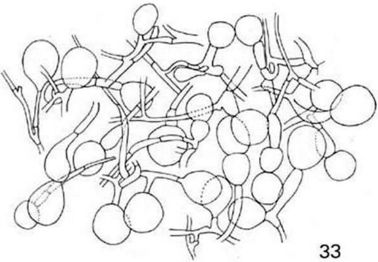

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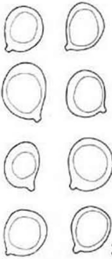

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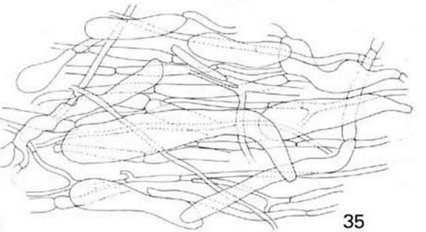

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Figs. 32–35. *Amanita craseoderma.* — 32. Fruit-body (after field sketch and dried material; × 0.5). — 33. Crushed tissue of volval wart on cap (× 250). — 34. Spores (× 1250). — 35. Pileipellis from above (× 500). (All Figs. from type.)

hyphae. Remnants of volva on cap (Fig. 33) composed of abundant, 2–7 μm wide, frequently branching and anastomosing, abundantly septate hyphae (colourless, but narrow ones often distinctly encrusted with a hyaline substance) and abundant, terminal (rarely in rows of two or three), mostly globose but also ovoid, ellipsoid and obpiriform cells, 28–53 × 23–48 μm, with conspicuous brown vacuolar pigment and slightly thickened wall; elements disorderly arranged. Volval remnants at base of stem: in grey belt similar to those on cap with hyphae 3–6 μm wide and inflated cells measuring 20–40 μm; in whitish covering of extreme base inflated cells scarcer and paler or colourless, and hyphae very abundant and locally intricately branching. Trama of stem acrophysalidic; acrophysalides measuring up to 390 μm long and 45 μm wide; with hardly differentiated cortex of 2–4 μm wide longitudinal hyphae and at surface scattered strands of ± agglutinate brown hyphae. Clamps absent in all parts studied.

HABITAT AND DISTRIBUTION.—Terrestrial in primary forest in the Amazonian area; in terra firme forest on yellow-soil hylaea, with Lecidithaceae, Leguminosae and other dicotyledonous trees, few Palmae.

COLLECTION STUDIED.—Brazil, Amazonas, 30 km N. of Manaus, 30 Sept. 1977, *R. Singer B 10160* (holotype, INPA; isotype, L).

Amanita craseoderma belongs to a small group of species in section *Vaginatae* characterized by a friable volva forming warts on the cap and belts on the base of the stem, and by a gelatinized pileipellis.

In this group *A. inaurata* Secr. (Europe; spores 10–14 µm), *A. cinctipes* Corner & Bas (Malaya; spores (8–)9–11 µm), and *A. antillana* Dennis (Trinidad; type studied; spores 11–13.5 × 9.5–11.5 µm, l/b 1.1–1.3^5 average 1.2^5) all three have larger spores and a normal pileipellis.

REFERENCES

BAS, C. (1969). Morphology and subdivision of *Amanita* and a monograph of its section *Lepidella*. *In* Persoonia **5**: 285–579.

DENNIS, R. W. G. (1970). Fungus flora of Venezuela and adjacent countries. *In* Kew Bull. addit. Ser. **3**.

GILBERT, E. J. (1941) Notules sur les Amanites (Supplement). Paris (privately printed).

JENKINS, D. T. (1977). A taxonomic and nomenclatural study of the genus *Amanita* section *Amanita* for North America. *In* Bibltca mycol. **57**.

MAERZ, A. & PAUL, M. R. (1950). A dictionary of color. New York.

MUNSELL COLOR COMPANY (1975.) Munsell soil color charts. Baltimore.

RICK, J. (1937). Agarici riograndenses. *In* Lilloa **1**: 307–358. 1937.

—— (1938). Agarici riograndenses (segunda parte). *In* Lilloa **2**: 251–316. 1938.

SINGER, R. (1953). Type studies on Basidiomycetes VI. *In* Lilloa **26**: 57–159.

—— (1978). Notes on bolete taxonomy-II. *In* Persoonia **9**: 421–438.

SINGER, R. & MORELLO, J. H. (1960). Ectotrophic forest tree mycorrhizae and forest communities. *In* Ecology **41**: 549–551.

SINGER, R. & MOSER, M. (1965). Forest mycology and forest communities in South America. *In* Mycopath. Mycol. appl. **26**: 129–191.

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NOTES ON MICROASCACEAE WITH THE DESCRIPTION OF TWO NEW SPECIES

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The Microascaceae are briefly discussed and a key to the accepted genera is given. The new species described are *Pithoascus langeronii* with an arthric anamorph (*Arthrographis langeronii*) and *Petriellidium fimeti* with a *Graphium*-like anamorph. Pure culture descriptions are given of the psychrophilic *Leuconeurospora pulcherrima* and also of *Faurelina elongata* which has an arthric anamorph with 2-celled conidia.

The Microascaceae represent a group of Ascomycetes related to the Ophiostomataceae, Xylariaceae, and Sordariaceae (including Chaetomiaceae). Malloch (*1970*) restricted the family to genera characterized by ascospores with one or two germ pores and included the genera *Microascus*, *Kernia*, *Lophotrichus*, *Petriella*, *Petriellidium*. Von Arx (*1963a*, *b*) removed some species without germ pores from *Microascus* and placed them in a separate genus *Pithoascus*. Udagawa & Furuya (*1973*) considered the genus *Leuconeurospora*, comprising two species with ornamented ascospores without germ pore, to belong to the Microascaceae. A fungus similar to the second species, *L. elongata*, was described by Locquin-Linard (*1975*) as the type of the genus *Faurelina*. An additional genus, *Enterocarpus*, has recently been described by Locquin-Linard (*1977*). It is characterized by a non-ostiolate ascoma with an apical tuft of hairs and by the presence of an hyphal 'capillitium' surrounding the ascospores.

The position of some of these genera in the Microascaceae is questionable. If it is accepted that the family is comprised of species with ascospores which may or may not have one or two germ pores, then the genera would have to be distinguished by the following key characters.—

1a. Ascospores smooth, less than twice as long as broad, with 1 or 2 germ pores 2
b. Ascospores ornamented or smooth and more than twice as long as broad, without observable germ pores 7
2a. Ascomata with a wall of 'textura epidermoidea', ascospores with 2 germ pores, anamorphs *Graphium*, *Scedosporium*, or *Arthrographis* 3
b. Ascomata with a pseudoparenchymatous wall of angular, dark cells, ascospores with 1 or 2 germ pores, anamorphs absent or *Scopulariopsis*-like 4
3a. Ascomata ostiolate, ascospores reddish-brown, often asymmetrical. . . . . *Petriella*
b. Ascomata usually non ostiolate, ascospores symmetrical, yellowish, rarely reddish . *Petriellidium*
4a. Ascospores embedded in a hyphal 'capillitium' when mature, about 12 × 9 μm, with a single, prominent germ pore . . . . *Enterocarpus*
b. Ascospores smaller or with 2 germ pores 5

5a. Ascomata ostiolate, ascospores asymmetrical, with a single germ pore . . . . . . *Microascus*
b. Above characters not combined 6
6a. Ascomata usually ostiolate, with an apical tuft of thick-walled hairs, ascospores about 8.5 × 7.5 μm, with two germ pores, yellowish or brownish . . . . *Lophotrichus*
b. Ascomata non-ostiolate, with or without tufts of hairs, ascospores of different size, with 1 or 2 germ pores, hyaline, yellowish, brownish or reddish . . . . *Kernia*
7a. Ascospores smooth, ascomata thick-walled, dark, ostiolate or non-ostiolate . . . . . *Pithoascus*
b. Ascospores ornamented, ascomata non-ostiolate, but with an easily disarticulating wall 8
8a. Ascomata spherical, cephalothecoid, ascospores nearly hyaline, with anastomosing ridges; asci not catenulate . . . . *Leuconeurospora*
b. Ascomata vertically elongated, often pustulate, ascospores reddish-brown, finely striate; asci catenulate, in vertical rows . . . . *Faurelina*

Monographic studies exist for most of the genera, e.g. *Microascus* (Barron, Cain & Gilman, *1961b*; von Arx, *1975*), *Petriella* (Barron, Cain & Gilman, *1961a*), *Petriellidium* (von Arx, *1973b*), *Pithoascus* (von Arx, *1973b*), *Kernia* (Malloch & Cain, *1971*; Locquin-Linard, *1977*). The genus *Lophotrichus* is close to *Kernia* and the three species *L. ampullus* R. K. Benjamin, *L. martinii* R. K. Benjamin and *L. bartletii* (Massee & Salmon) Malloch & Cain (= *Lophotrichus brevirostratis* Ames) are close to each other. In the last mentioned species the ascomata are usually non-ostiolate.

In this paper new species are added to the genera *Pithoascus* and *Petriellidium* and the species of the genera *Leuconeurospora* and *Faurelina* are described and discussed from pure cultures.

Pithoascus langeronii v. Arx, *spec. nov.*—Figs. 1, 4a, d.

Coloniae in agaro farina maydis addita 25°C vix 1 mm in dies crescunt, in obscuritate pro maxima parte submersae, ex hyphis plus minusve hyalinis constant, ascomatibus 14–20 diebus maturantibus fuscescentes. Ascomata submersa vel raro superficialia, globosa, primum flava, maturitate nigrescentia, non ostiolata, 75–160 μm diametro, pariete e cellulis hyphalibus 2–4 μm crassis et strato interno cellularum applanatarum, 7–13 μm diametro, composito, demum fuscescente, incrustato vel amorpho. Asci numerosi, in seriebus radiantibus dispositi, ellipsoidei, clavati vel cylindrici, nonnumquam pedicellati, tenuitunicati, fere persistentes, 8-spori, 8–13 × 4–7 μm; ascosporae fusiformes ad naviculares, primum dextrinoideae, maturitate stramineae, leves, poris germinationis carentes, 3.5–5.0 × 2.0–2.5 μm.

Typus: CBS 203.78, contaminatio culturae Petriellidii fimeti CBS 129.78.

Colonies on cornmeal agar at 25°C with a daily growth rate of less than 1 mm, in darkness flat, consisting mainly of immersed, hyaline or subhyaline hyphae, with no aerial mycelium, becoming dark due to the ascomata which ripen within 2–3 weeks; initials compact, 17–24 μm in diameter, composed of a central cell surrounded by swollen, 5–7 μm hyphal cells, soon becoming covered by a number of radial hyphae; ascomata immersed, rarely superficial, spherical, yellowish when young, black when ripe, non-ostiolate, 75–160 μm in diameter, with a wall composed of 2–4 μm broad hyphal cells and an inner layer of flattened, 7–13 μm cells, outer wall later becoming dark, encrusted and nearly amorphous; asci numerous, arranged in radiating, clustered rows, ellipsoidal, clavate or cylindrical, sometimes stalked, thin-walled, rather persistent, 8-spored, 8–13 × 4–7 μm; ascospores fusiform-navicular, dextrinoid when young, straw-coloured or yellow-brown when ripe, smooth, without germ pores, 3.5–5 × 2–2.5 μm (Fig. 4a).

Colonies incubated in daylight form aerial hyphae and buff- or tan-coloured, downy or powdery conidial tufts; vegetative hyphae hyaline, septate, 1.5–3 μm broad, forming chla-

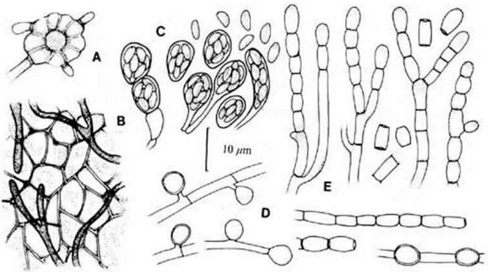

Fig. 1. *Pithoascus langeronii*. — a. Initial. — b. Ascomata wall. — c. Asci and ascospores. — d. Chlamydospores. — e. Arthroconidia.

mydospores and often disarticulate into arthroconidia; chlamydospores terminal or lateral, single or occasionally in chains, spherical or obovate, smooth, hyaline, thin-walled, 3.5–5.5 μm; conidiogenous hyphae 2–3 μm broad, usually erect and branched, forming short synchronous or basipetal rows of dry arthroconidia; arthroconidia cylindrical or swollen, clavate when apical, hyaline, 1-celled, rarely septate, without distinct disjunctive structures, 3–7 × 2–3.5 μm (Fig. 1e).

TYPE.—CBS 203.78, received as a contamination in the fresh isolate of CBS 129.78, *Petriellidium fimeti*.

Von Arx (*1973b*) distinguished six *Pithoascus* species, characterized by dark, thick-walled, ostiolate or non-ostiolate ascomata, by ascospores without germ pores and by the absence of anamorphs (conidial states). *Pithoascus langeronii* is the first species of the genus with an anamorph and can also be distinguished by its small and only slightly pigmented ascospores, and the dark ascomata wall which is nearly amorphous with age. These differentiating characters would probably allow the fungus to be classified in a separate, undescribed genus. The initials of *Pithoascus langeronii* are similar to those of *Petriellidium boydii* (Shear) Malloch (= *Allescheria boydii* Shear).

Pithoascus langeronii is the teleomorph of the hyphomycete, described as *Arthrographis langeroni* Cochet (*1939*), *Oidiodendron kalrai* Tewari & Macpherson (*1971*) and *Arthrographis kalrai* (Tewari & Macpherson) Sigler & Carmichael (*1976*). Only the conidial state was present in most of the subcultures, ascomata were mainly obtained on oatmeal agar incubated in the dark at 25°C.

Arthrographis langeroni is keratinophilic, usually isolated from humans but also from soil and dung. The description of the anamorph given by Sigler & Carmichael (*1976*) is incomplete: the chlamydospores, the swollen arthroconidia and the clavate apical conidium are not mentioned. An anamorph rather similar to that of *Pithoascus langeronii* is known in

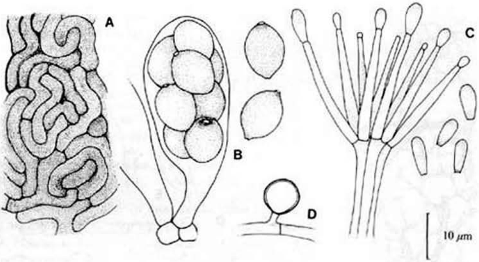

Fig. 2. *Petriellidium fimeti.* — a. Ascomata wall. — b. Ascus and ascospores. — c. *Graphium* anamorph. — d. Chlamydospore.

Petriellidium desertorum v. Arx & Moustafa (von Arx, *1973b*), a related species with larger and darker ascospores with two germ pores.

Sigler & Carmichael (*1976*) treated *Geotrichum microsporum* Smith [= *Coremiella cuboidea* (Sacc. & Ellis) Ciferri & Caretta] as a second species of *Arthrographis*. However, this cellulolytic and fast growing fungus forms compact synnemata and the short cylindrical arthroconidia develop from the conidiogenous hyphae in unbranched long chains and separate from each other by disjunctive structures. This fungus without doubt is not close to the *Arthrographis* anamorph of *Pithoascus langeronii* and should be maintained in *Coremiella* or *Briosia* (von Arx, *1972*).

Petriellidium fimeti v. Arx, Mukerji & N. Singh, *spec. nov.*—Fig. 2

Coloniae in agaro farina avenacea addita 25°C in dies 3–4 mm crescunt, primum albidae vel grisellae, mycelio aerio floccoso vel lanoso obtecta, deinde griseo-brunneae. Ascomata immersa vel fere superficialia, globosa, fusca, glabra vel nonnullis hyphis fuscis, incrustatis, 50–130 μm longis, 2–3 μm latis obtecta, non ostiolata, 230–360 μm diametro, pariete 5–8 μm crasso, e cellulis viridibrunneis, 2–4 μm latis, hyphalibus composito (textura epidermoidea). Asci clavati, saepe breviter pedicellati, fasciculati, tenuitunicati, evanescentes vel fere persistentes, 8-spori, 40–70 × 18–25 μm; ascospore ellipsoideae, primum dextrinoideae, maturitate stramineae vel brunneae, duobus poris germinationis praeditae, 11–13 × 8–10 μm; conidia seu Graphii modo seu chlamydosporae ellipsoideae vel subglobosae formata.

Typus: CBS 129.78, isolatus e fimo antilopae Nilgai dictae, in horto zoologico Delhiensi in India a K. G. Mukerji lecto, 1977.

Colonies on oatmeal agar with a daily growth rate of 3–4 mm at 25°C, at first whitish or greyish with a floccose or lanose aerial mycelium, later becoming grey brown; ascomata immersed or nearly superficial, spherical, dark, glabrous or covered with some dark, encrusted, 50–130 μm long and 2–3 μm broad hyphae, non-ostiolate, 230–360 μm in diam., with a 5–8 μm thick wall of greenish brown, 2–4 μm broad hyphal cells (textura epidermoidea); asci clavate, often with a short, broad stalk and fasciculate, thin-walled, evanescent or rather persistent, 8-spored, 40–70 × 18–25 μm; ascospores ellipsoidal, hyaline and dextrinoid when young, later straw coloured or light brown, a germ pore at both ends, 11–13 × 8–10 μm; conidia of 2 types: (1) *Graphium*-state: coremia brush-like, with a 25–120 μm long and a 5–8 μm broad, brown stalk, composed of parallel, septate, 2–3 μm broad hyphae; conidiogenous brush 70–90 μm broad; conidiogenous cells divergent, cylindrical, hyaline, 12–25 × 1.5–2.5 μm; conidia basipetal or percurrent, ellipsoidal or slightly clavate, apically rounded, with a truncate base, hyaline, 5–12 × 2–4 μm; (2) chlamydospores ellipsoidal or nearly spherical, hyaline or brownish, 5–7 μm in diam., rather thick-walled, usually arising laterally on short stalks from septate, branched, hyaline or brownish, 2.5–4 μm broad hyphae.

TYPE.—CBS 129.78, isolated from nilgai dung, collected in Delhi Zoo (India), sent by Dr. K. G. Mukerji.

Petriellidium desertorum v. Arx & Moustafa is similar in the size and shape of the ascospores, but differs by its smaller, 80–110 μm sized ascomata and by the formation of an arthric anamorph.

Faurelina elongata (Udagawa & Furuya) v. Arx, *comb. nov.*—Fig. 2, 4c, e

Leuconeurospora elongata Udagawa & Furuya *in* J. Jap. Bot. ***48***: 112. 1973. (basionym).

Colonies on oatmeal agar with a daily growth rate of 1–1.5 mm at 25°C, soon becoming dark brown, with irregular tufts of aerial mycelium; vegetative hyphae thick-walled, hyaline or light brown, usually 4–15 μm thick, often composed of swollen, up to 25 μm thick cells; arthroconidia in aerial tufts, mainly formed on thinner, aerial hyphae, cylindrical or slightly swollen, 1- to 2-celled, hyaline, with truncate ends, separating from each other by disjunc-

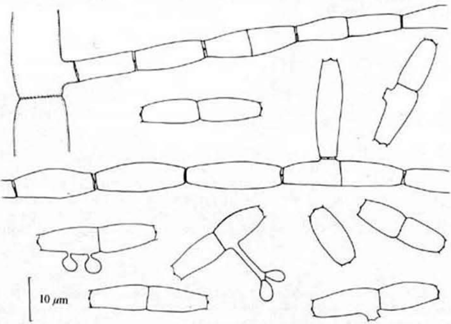

Fig. 3. *Faurelina elongata*, arthro- and blastoconidia.

tive structures, 15–30 × 4–6 μm; blastoconidia mainly formed on arthroconidia either directly or on shorter or longer stalks, clavate, with a truncate base, hyaline, 3–5 × 1.5–2.5 μm; ascomata immersed at the base, hemispherical or broadly clavate-pustulate, rounded above, smooth, 180–250 μm in diam., 170–300 μm high, non-ostiolate; wall of the ascomata at base light; in the superficial parts green to black, composed of vertical rows of elongated, 5–7 μm broad, thick-walled, encrusted hyphal cells; asci in fasciculate chains (vertical rows), formed in basipetal succession, spherical, clavate, ellipsoidal or irregular in shape, rather thin-walled, 8-spored, 12–18 × 8–12 μm; ascospores fusiform-navicular or rhomboidal, light brown, with some furrows, finely striated by irregular, usually longitudinal thickenings of the wall, without germ pores, 6–8 × 4–5.5 μm (Fig. 4c).

Fresh isolates could be compared with some specimens collected on herbivore dung in India and with the type specimen (2 slides) of *Leuconeurospora elongata*. The preceding description is based on CBS 126.78, isolated from goat dung, received from K. G. Mukerji (Delhi University).

Faurelina fimigenes Locquin-Linard, the type species of the genus *Faurelina*, is very close to *Faurelina elongata*. It can be distinguished by its more thick-walled and slightly larger, 7–10 × 4–5.5 μm sized ascospores and by the absence of an anamorph with 2-celled arthroconidia. A small dried specimen and the type strain (CBS 352.78) of *Faurelina fimigenes* could be studied.

The anamorph of *Faurelina elongata* could be observed only in pure culture (CBS 126.78 and CBS 301.78, isolated from cow dung, Nainital, Delhi, India) and not on the specimens on dung; the anamorph is rather close to the *Arthrographis* state of *Pithoascus langeronii*, but differs by much larger, usually 2-celled arthroconidia with distinct disjunctive structures.

A detailed description of the development of the ascomata of *Faurelina fimigenes* has been given by Parguey-Leduc & Locquin-Linard (1976). The classification of the genus *Faurelina* in the Microascaceae is not satisfactory, but no closer taxa are known in the Ascomycetes.

LEUCONEUROSPORA PULCHERRIMA (Winter) Malloch & Cain

Eurotium pulcherrimum Winter *in* Vid. Meddr. dansk naturh. Foren. 1876: 311. 1877. — *Cephalotheca pulcherrima* (Winter) Höhnel *in* Annls Mycol. **15**: 360. 1917. — *Leuconeurospora pulcherrima* (Winter) Malloch & Cain *in* Can. J. Bot. **48**: 1820. 1970.

Colonies developing at temperatures between 0 and 15°C, with a daily growth rate of less than 1 mm at 6°C, white or greyish, often without aerial mycelium, often developing white mycelial tufts; hyphae regularly branched and septate, 2–3.5 μm thick, sometimes forming chlamydospores; chlamydospores clavate or obpyriform, with a truncate base, thin-walled, 7–11 × 4–5 μm; initials coiled, composed of 2–3 μm broad hyphal cells; ascomata ripening within 2–4 months at temperatures between 4 and 10°C, scattered, superficial, initially light

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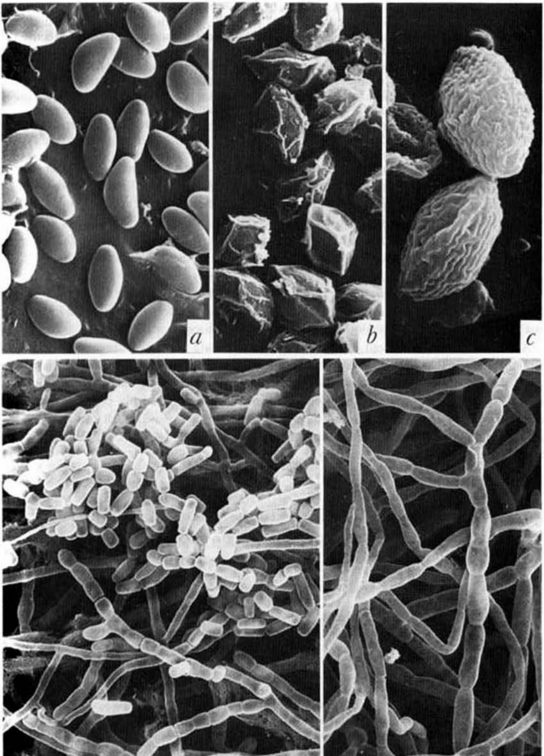
Fig. 4. Scanning electron micrographs. — a. *Pithoascus langeronii*, ascospores, × 4200. — b. *Leuconeurospora pulcherrima*, ascospores, × 3500. — c. *Faurelina elongata*, ascospores, × 6000. — d. *Pithoascus langeronii*, conidiogenous hyphae and conidia, × 1600. — e. *Faurelina elongata*, conidiogenous hyphae, × 900.


a
b
c
d
e

MALLOCH, D. (1970). New concepts in the Microascaceae illustrated by two new species. *In* Mycologia **62**: 727–740.

MALLOCH, D. & CAIN, R. F. (1970). Five new genera in the new family Pseudeurotiaceae. *In* Can. J. Bot. **48**: 1815–1825.

—— & —— (1971). The genus *Kernia*. *In* Can. J. Bot. **49**: 855–867.

—— & —— (1973). The genus *Thielavia*. *In* Mycologia **65**: 1055–1077.

PARGUEY-LEDUC, A. & LOCQUIN-LINARD, M. (1976). L'Ontogénie et la structure des périthèces de *Faurelina fimigenes* Locquin-Linard. *In* Rev. Mycol. **40**: 161–175.

SIGLER, L. & CARMICHAEL, J. W. (1976). Taxonomy of *Malbranchea* and some other Hyphomycetes with arthroconidia. *In*: Mycotaxon **4**: 349–488.

TEWARI, R. P. & MACPHERSON, C. R. (1971). A new dimorphic fungus, *Oidiodendron kalrai*: morphological and biochemical characteristics. *In* Mycologia **63**: 602–611.

UDAGAWA, S. & FURUYA, K. (1973). The genus *Leuconeurospora*. *In* J. Jap. Bot. **48**: 111–116.

UDAGAWA, S. & HORIE, Y. (1974). Notes on some Japanese Ascomycetes XII. *In* Trans. mycol. Soc. Jap. **15**: 105–112.

CHLAMYDOSPORE STATE.—*Blastotrichum puccinioides* Preuss *in* Deutschl. Fl. (Pilze) (ed. J. Sturm) **25–26**: 21. 1848. — *Mycogone puccinioides* (Preuss) Sacc. *in* Syll. Fung. **4**: 184. 1886.

REFERENCES.—Tubaki (*1955*), Gams & Hoozemans (*1970*), Arnold (*1971b*).

Colonies filling the petri-dish within 3 days, appearing fluffy, lanose, with thin, suberect tufts about 1–2 cm high, purely white, later often becoming locally brownish due to abundant formation of chlamydospores; reverse pale ochraceous on oatmeal agar. *Conidiophores* fragile, hyaline, smooth- and thin-walled, ascending to suberect, occasionally over 5 mm long but more often profusely branched without a main stalk, lower branches 6–8 μm wide, the cells being 100–250 μm long, bearing 1–2 lateral branches just below each septum; ultimate branches arising singly or in pairs, at wide angles, 4.5–7 μm wide at the base, slightly tapering towards the apex, with 0–3 septa every 30–60 μm, each with a terminal fertile cell. *Conidiogenous cells* straight, cylindrical, 45–70 μm long, widest (3.5–5 μm) at the base, tapering towards the 1.5–2.5 μm wide apex, monoblastic, forming conidia by inflation of the tip; each subsequent conidium being initiated just below the previous one; the conidiogenous cell thus gradually becoming shorter with a wider apex. *Conidia* one-, rarely two-celled, hyaline, smooth- and thin-walled, cylindrical with a rounded apex, 20–28 × 5–7.5 μm, with a prominent, butt-shaped hilum. Often multi-celled, rather thick-walled, verrucose, pale reddish-brown chlamydospores present.

The preceding description is of CBS 828.69 on mushroom agar at 20–22°C. The type strain of *C. apiculatum*, CBS 174.56, still sporulates rather well.

Cladobotryum apiculatum is the only *Cladobotryum* species with rough-walled chlamydospores. Though it is morphologically markedly different from *C. verticillatum*, both species are very similar in their cultural characteristics.

Cladobotryum asterophorum de Hoog, *spec. nov.*—Fig. 2

Eurasina spec., Matsushima, Ic. Microf. a Matsushima lect. 71. 1975.

Coloniae rapide expansae, laxe lanosae, ad 1–2 cm altae, candidae; reversum in agaro farina avenacea decocto dilute rubrum. Conidiophora fragilia, hyalina, levia, tenuitunicata, adscendentia vel fere erecta, saepe plus quam 5 mm longa, ad 8 μm lata, intervallis 30–60 μm septata, plus minusve verticillata. Cellulae conidiogenae rectae, subulatae, 17–35 μm longae, prope basin 3–4.5 μm latae, ad 1.0–1.5 μm sursum angustatae; conidia fere sympodialiter formata, intumescentiam parvam relinquentia; conidia plerumque bicellularia, levia, tenuitunicata, ellipsoidea ad clavata, basi truncata, 14–23 × 5.5–7.5 μm.

Typus: CBS 676.77, isolatus ex agarico quodam a T. Matsushima prope Hachioji urbem in Japonia, Maio 1966.

Colonies spreading, appearing fluffy lanose, with thin, suberect tufts about 1–2 cm high, purely white; reverse on oatmeal agar pale crimson. *Conidiophores* fragile, hyaline, smooth- and thin-walled, ascending to suberect, often over 5 mm long, up to 8 μm wide, septate every 30–60 μm; branching pattern cymose, whorls on main stalks containing up to 4 conidiogenous cells, usually with 1–2 plagiotropic branches which repeatedly branch in the same way, often leading to drepanoid branching; all lateral branches about the same size, internodal cells 15–30 × 3.5–4.5 μm; lower conidiogenous cells first formed, branching later becoming more extended and profuse. *Conidiogenous cells* straight, subulate, 17–35 μm

CLADOBOTRYUM MYCOPHILUM (Oudem.) W. Gams & Hoozemans

Dactylium mycophilum Oudem. *in* Archs néerl. Sci. **2**: 42. 1867. — *Cladobotryum mycophilum* (Oudem.) W. Gams & Hoozemans *in* Persoonia **6**: 102. 1970.
PERFECT STATE.—*Hypomyces odoratus* G. Arnold

Possible synonyms in check-list under *elegans, majus, ternatum.*

REFERENCES.—Fassatiová (*1958*), Arnold (*1964*), Barron (*1968*), Gams & Hoozemans (*1970*), Matsushima (*1975*).

In *Cladobotryum* strains with broadly ellipsoidal, two-celled conidia, morphologically two approximate groups can be distinguished by relatively large or small conidia, fitting *C. mycophilum* and *C. varium* respectively. In many strains the conidia vary greatly in shape and size, hence the differences between the species are only gradational. In each of the species very similar perfect states were demonstrated (Plowright, *1882*; Nicot & Parguey, *1963*; Arnold, *1964*; Gams & Hoozemans, *1970*). Comparison of the descriptions of these states, given by authors who actually proved a connection (Table I: taxa separated on the basis of the conidial states), indicates that the differences in spore size are insufficient for the discrimination of the species. Remaining key-features are the crimson colony reverse and camphor smell of *C. mycophilum*, *C. varium* being odourless and having an ochraceous colony reverse.

TABLE I
COMPARISON OF CONIDIUM AND ASCOSPORE DIMENSIONS OF TWO CLADOBOTRYUM SPECIES AND THEIR HYPOMYCES PERFECT STATES (THE LATTER IN BRACKETS)

REFERENCE	*C. varium* (*H. aurantius*)	*C. mycophilum* (*H. odoratus*)
Plowright (*1882*)*	16–18 × 8–10 (15–24 × 4–6)	
Tubaki (*1955*)	12.5–22.8 × 7.4–11.4	
Nicot & Parguey (*1963*)	12.2–18.5 × 7.5–10.5** (14–16 × 3)	
Arnold (*1964*)		20.6–40.0 × 10.0–12.7 (25.8–34.4 × 6.0–7.7)
Gams & Hoozemans (*1970*)	10.5–16.0 × 5.0–7.0 (23.0–26.0 × 3.7–4.0)	15.0–32.0 × 7.5–12.0 (18.0–24.0 × 4.5–6.0)
Matsushima (*1975*)	10.0–24.0 × 6.0–9.5	14.0–34.0 × 6.5–10.0

* Measurements confirmed in authentic material (K).
** Measurements from CBS 621.77 = PC 1664, not mentioned in the publication.

CLADOBOTRYUM VARIUM Nees ex Steud.

Cladobotryum varium Nees, Syst. Pilze Schwämme 56. 1816; ex Steud., Nomencl. bot. 118. 1824. — *Botrytis variosperma* Link *in* Mag. Ges. naturf. Fr. Berl. **7**: 36. 1816 (name change); ex Pers., Mycol. eur. **1**: 35. 1822. — *Botrytis varia* (Nees ex Steud.) Duby, Bot. gall **2**: 919. 1830. — *Dactylium varium* (Nees ex Steud.) Fr., Syst. mycol. **3**: 414. 1832. — *Cladobotryum variospermum* (Link ex Pers.) Hughes *in* Can. J. Bot. **36**: 750. 1958.

Dactylium melleum Berk. & Br. *in* Ann. Mag. nat. Hist., Ser. IV, **11**: 345. 1873. — *Diplocladium melleum* (Berk. & Br.) Sacc. *in* Syll. Fung. **4**: 177. 1886.

Dactylium rennyi Berk. & Br. *in* Ann. Mag. nat. Hist., Ser. IV, **11**: 346. 1873. — *Diplocladium rennyi* (Berk. & Br.) Sacc. *in* Syll. Fung. **4**: 177. 1886.

Diplocladium penicillioides Sacc. *in* Syll. Fung. **4**: 177. 1886.

PERFECT STATE.—*Hypomyces aurantius* (Pers. ex Gray) Tul.

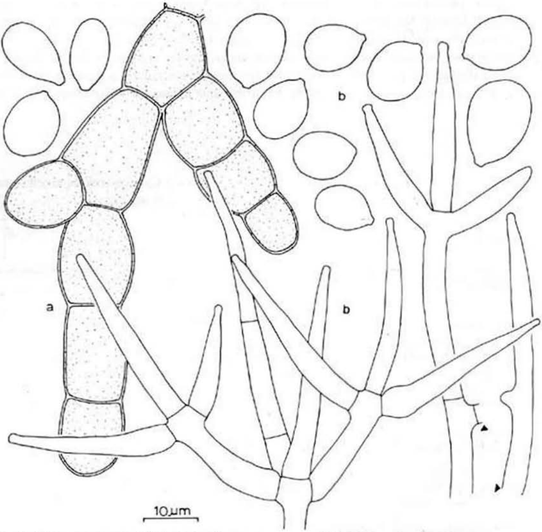


Fig. 7. *Cladobotryum verticillatum* on mushroom agar. — a. CBS 424.67. — b. CBS 535.77.

Possible synonyms in check-list under *cylindrosporum, minus, roseum, ternatum.*

REFERENCES.— Tubaki (*1955*), Fassatiová (*1958*), Barron (*1968*), Nicot (*1962*), Nicot & Parguey (*1963*), Gams & Hoozemans (*1970*), Matsushima (*1975*).

The type specimens of *Dactylium melleum* (K) and *Diplocladium penicillioides* [Plowright's (*1882*) material of the conidial state of *Hypomyces aurantius* (K)] could be re-identified as *Cladobotryum varium*. A specimen of *Dactylium rennyi* collected by J. Renny figures in the herbarium M. C. Cooke (K) and is probably authentic for the name. The synonymy with *C. varium*, as published by Massee (*1893*), could be confirmed.

Matsushima (*1975*) described and depicted the species exhaustively and also mentioned a *Cladobotryum* spec., which differed from *C. varium* by having disc-shaped connections between many conidia. In his strain MFC 1816 (=CBS 675.77) these discs are not always present, but sometimes very prominent, the conidial extremities in SEM studies appearing to be alate with minute longitudinal furrows. The character is insufficient to warrant the description of a separate taxon.

CLADOBOTRYUM VERTICILLATUM (Link ex Gray) Hughes—Fig. 7

Acremonium verticillatum Link *in* Mag. Ges. naturf. Fr. Berl. **3**: 15. 1809; ex S. F. Gray, Nat. Arrang. Br. Pl. **1**: 550. 1821. — *Mycogone verticillata* (Link ex S. F. Gray) Spreng., Linn. Syst. Veg. **4**: 555. 1827. — *Cladobotryum verticillatum* (Link ex S. F. Gray) Hughes *in* Can. J. Bot. **36**: 750. 1958.

Verticillium lactarii Peck *in* Rep. N.Y. St. Mus. nat. Hist. **35**: 140. 1882.

Possible synonym in check-list under *agaricinum.*

REFERENCES.—Fassatiová (*1958*), Gams & Hoozemans (*1970*), Arnold (*1971b*).

Colonies spreading, appearing fluffy lanose, with thin, suberect tufts about 1–2 cm high, purely white; reverse on oatmeal agar pale ochraceous. *Conidiophores* fragile, hyaline, smooth- and thin-walled, ascending to suberect, often over 5 mm long, up to 12 μm wide, sparsely septate; the cells being up to 800 μm long; branching pattern verticillate; whorls on main stalks containing up to 4 smaller, plagiotropic branches; ultimate branches bearing fertile cells ortho- or plagiotropically, verticillately in whorls of 1–3(–4); terminal conidiogenous cells first formed, branching later becoming more profuse. *Conidiogenous cells* straight if terminal, usually slightly curved upwards if lateral, subulate, 20–35 μm long, widest (5–6.6 μm) just above the base, tapering towards the 1.5–1.8 μm wide apex, monoblastic, forming conidia by inflation of the tip, each subsequent conidium being initiated just below the previous one; the conidiogenous cell thus becoming shorter with a wider apex. *Conidia* one-celled, smooth- and thin-walled, hyaline, broadly ellipsoidal, 12–20 × 7–11 μm, with protruding basal scars. Often multi-celled, smooth-walled, hyaline to subhyaline chlamydospores, present, which occasionally form irregular clusters resembling small sclerotia.

The preceding description is based on CBS 535.77 on mushroom agar at 20–22°C.

Septum formation is often retarded. Terminal whorls of branches may be formed without any septa, but these do appear later, with several being formed concurrently in one part of the system. There does not seem to be a fixed order in which the septa arise. Branching may also be irregular, ultimate branches being before or after the lower branches.

Colletoconis de Hoog & van der Aa, *gen. nov.*

Conidiomata applanata vel pulvinata, melanconiacea, setis carentia, hyalina, e prosenchymate basilari, parenchymate medio et hymenio denso phialidum cylindricarum constant. Conidia continua, levia, seu tenuitunicata, hyalina, subcylindrica, seu fere crassitunicata, dilute brunnea et late ellipsoidea.
Species typica: *Gloeosporium aecidiophilum* Speg.

Conidiomata flat or pulvinate, melanconiaceous, without setae, hyaline, consisting of basal prosenchyma, intermediate parenchyma, and a hymenium of parallel, cylindrical conidiogenous cells which form conidia in basipetal succession. Conidia one-celled, smooth-walled, of two types: thin-walled, hyaline, subcylindrical, and rather thick-walled, pale brown, broadly ellipsoidal.
TYPE SPECIES.—*Gloeospörium aecidiophilum* Speg.

The conidial dimorphism is the key-feature in *Colletoconis*. Both types of conidia are produced from identical conidiogenous cells in the same fruitbody. In this respect the genus differs from *Gloeosporidiella* Petrak e.g., in which spermatia are produced from filiform fertile cells, the main type of conidiogenous cells being more or less conical, and from *Cryptosporiopsis* Bubák & Kabát, in which spermatia are formed on smaller conidiogenous cells, in addition to secondary conidia formed by budding of the primary conidia. *Cryptosporiopsis* also differs by often having stromatic, multilocular fruitbodies and by fusiform primary conidia.

The type species of *Colletoconis* occurs in association with a rust fungus, but pure cultures of the species without any host fungus are able to sporulate abundantly over many years.

Colletoconis aecidiophila (Speg.) de Hoog, van der Aa & U. P. Singh, *comb. nov.*—Fig. 8, 9

Gloeosporium aecidiophilum Speg. *in* An. Soc. Cienc. Argent. **22**: 203. 1886 (basionym).

Conidiomata on the natural substrate in or adjoining aecidio-or uredosori of rustfungus, flat or pulvinate, often irregular in outline, about 100–300 μm in diam, melanconiaceous, hyaline; basally, particularly between host tissue cells, consisting of prosenchyma composed of thin-walled, strongly interwoven, 4–6 μm wide hyphae, gradationally passing into 5–15 cells (10–40 μm) thick intermediate parenchyma composed of thin-walled, hyaline, isodiametrical cells 3–12 μm in diam, mixed with rustspores in various stages of disintegration; uppermost cell-layer 10–40 μm thick, composed of hyaline, thin-walled, short-cylindrical cells 10–25 × 2–5 μm, in parallel arrangement, bearing the conidiogenous cells.

Colonies attaining a diameter of 3–6 mm in 14 days; ultimate diameter 20 mm but occasionally 45 mm; colonies initially smooth, more or less volcano-shaped, with a central slime droplet due to abundant sporulation, outer part almost flat, with sharp margin, pale buff, later often being covered with flat, silky white aerial mycelium; colonies later becoming irregularly, radially furrowed at the centre, with white, uniform or slightly zonate aerial mycelium; the outer parts remaining pale buff, with minute concentric furrows; reverse pale ochraceous near the margin, ochraceous to cinnamon at the centre. Colonies developing from swollen conidia which become septate and give rise to a cluster of inflated cells, smooth- or rough-walled, often rather thick-walled, hyaline, with some scattered conidiogenous cells. *Hyphae* arising from most of the swollen intercalary cells as plagiotropic branches, more or less radially oriented, smooth- and rather thin-walled, hyaline, straight or

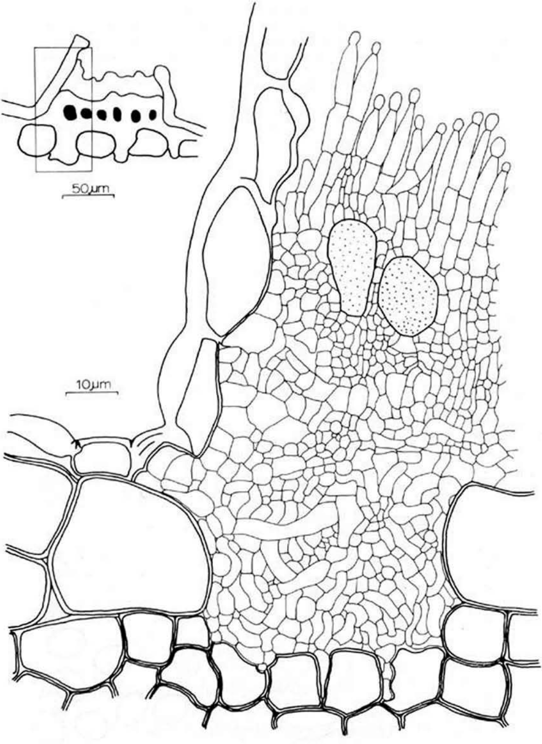


Fig. 8. *Colletoconis aecidiophila*, herb. CBS 759 on the natural substrate.

flexuose, regularly 1.2–2.5 μm wide, remotely septate, soon forming a tough and compact mycelium. *Conidiogenous cells* more or less vertical, densely packed around the less compact centre which is irregular in outline, arising laterally or terminally, ortho- or plagiotropically from undifferentiated hyphae, smooth- and thin-walled, hyaline, often basally swollen with a cylindrical neck, straight or flexuose, widest (2.5 – 4 μm) near the base, slightly tapering towards the 1.5–2.5 μm wide, truncate apex, forming conidia in basipetal order, rarely

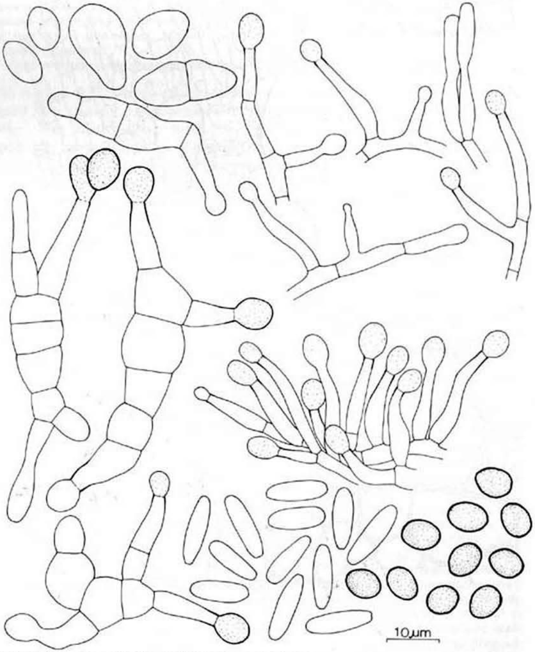


Fig. 9. *Colletoconis aecidiophila*, CBS 155.78 on oatmeal agar.

some minute annellations being discernible. *Conidia* one-celled, smooth-walled, of two types: thin-walled, hyaline, cylindrical, slightly tapering towards each obtuse end, 11–14 × 3–4.2 µm, and thin-walled and subhyaline but finally becoming rather thick-walled and pale brown, broadly ellipsoidal or subglobose, 7–9 × 4.5–6 µm, with hardly discernible basal scars.

MATERIAL EXAMINED.— CBS 273.67 = ATCC 18400, isolated by J. L. Cunningham from *Puccinia* spec. on *Hyptis capitata*, Dominica, West Indies, Dec. 1966; CBS 155.78 = herb. CBS 759, isolated by H. A. van der Aa from uredosori of *Puccinia* spec. on leaves of *Arachis hypogaea, U. P. Singh & M. Lal*, Varanasi, U.P., India, Oct. 1977.

The preceding description is based on CBS 155.78 (=Herb. CBS 759) on the natural substrate and on malt agar at 20–22°C.

The identity of the examined specimens with the type of *Gloeosporium aecidiophilum* was confirmed by J. A. von Arx (pers. commun.). Several other melanconiaceous fungi parasitizing rusts have been described. *Tuberculina persicina* (Dit.) Sacc. has a purplish hymenium of cylindrical conidiogenous cells with an abruptly tapering apex and producing globose, verruculose conidia. According to von Arx (*1970*) *Gloeosporium aecidiicola* Ranoj. is probably the same species. *Colletotrichum aeciicola* Tehon, *C. aecidiicola* Negru, and *C. uredinophilum* Hulea all have conidiomata with large, dark brown, pluriseptate setae.

DENTICULARIA Deighton

Denticularia Deighton *in* Trans. Br. mycol. Soc. **59**: 421. 1972.

Colonies on the natural substrate forming small pustules, greyish-white to pale ochraceous. Conidiophores subhyaline, thin-walled, suberect, fasciculate; branching pattern irregular. Conidiogenous cells cylindrical, sympodial, with scattered, conical denticles. Conidia arising in short chains, subhyaline, more or less fusiform, continuous or septate.

TYPE SPECIES.—*Cladosporium modestum* H. Syd.

KEY TO THE SPECIES

1a. Conidia lemon-shaped	*D. limoniformis*
b. Conidia fusiform	2
2a. Conidia one-celled	*D. modesta*
b. Conidia often septate	3
3a. Conidia 0–1-septate	*D. fici*
b. Conidia 1–6-septate	*D. tertia*

DENTICULARIA FICI Deighton

Denticularia fici Deighton *in* Trans. Br. mycol. Soc. **59**: 423. 1972.

Denticularia limoniformis de Hoog, *spec. nov.*—Fig. 10

Mycelium in substrato naturali pustulatas, ad 300–500 µm altas, 200 µm diametro, dilute ochraceas formans. Hyphae in medio pustularum 3–4 µm latae, subhyalinae ad dilute brunneae, leves, fere tenuitunicatae, sursum divaricatae et conidiophora irregulariter ramosa formantes. Cellulae conidiogenae cylindricae, flexuosae, 20 – 40 × 2–3 µm, in apice nonnullos denticulos conidiiferos conicos ad 1.5 µm longos sympodialiter proferentes; denticuli cicatrice applanata modice pigmentata 0.8 µm diametro terminati. Conidia levia vel irregulariter verrucosa, fere tenuitunicata, dilute brunnea, utrinque angustata et saepe acuminata, 9–12 × 3.8–4.5 µm, brevibus catenis connexa.

Typus: in *Hyphodontia breviseta* in trunco Piceae abietis, in parochia Västerlanda, prov. Bohuslän in Suecia, *J. Eriksson & T. Hallingbäck*, in Herb. CBS 292.

Mycelium on the natural substrate consisting of conical pustules 300–500 µm high, about 200 µm in diam., pale ochraceous. *Hyphae* in the core of the pustules 3–4 µm wide, subhyaline to pale brownish, smooth- and rather thin-walled, apically splaying out and forming irregularly branched conidiophores. *Conidiogenous cells* cylindrical 20–40 × 2–3 µm, flexuose, sympodial, in the apical region with few scattered, conical denticles up to 1.5 µm long; denticles nearly upright, angle subtended by the abaxial side almost being 180°, adaxial angle acute; with a slightly pigmented, flat scar about 0.8 µm wide. *Conidia* smooth-walled or irregularly verruculose, rather thin-walled, pale brown, tapering towards the base and the apex, often distinctly acuminate at both extremities, 9–12 × 3.8–4.5 µm, single or catenulate, frequently a basal as well as an apical scar being discerned.

TYPE SPECIMEN.—Herb. CBS. 292, associated with *Hyphodontia breviseta* (Karst.) J. Erikss. on fallen trunk of *Picea abies*, Västerlanda parish, Torrgårdsvatten, Bohunslän, Sweden, *J. Eriksson & T. Hallingbäck*, 20 Aug. 1975.

The species occurs rather frequently on old fruitbodies of *Hyphodontia breviseta* in Sweden (J. Eriksson, pers. commun.). Attempts to grow the fungus in pure culture remained unsuccessful. Conidia were detached quite easily. Considering the prominent extremities of most conidia it may be assumed that they arise in short chains, though these were never actually seen.

Denticularia limoniformis is similar to *Pseudohansfordia meliolae*, but differs by forming pustules, by short conidiiferous rhachides and by more narrow conidia. By its probably

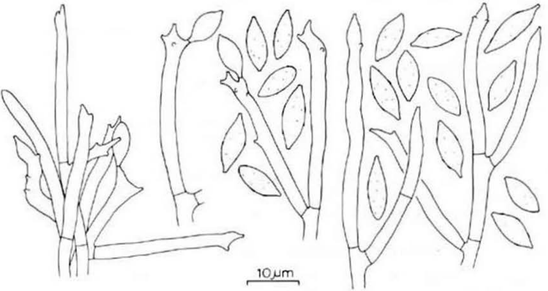


Fig. 10. *Denticularia limoniformis*, herb. CBS 292 on the natural substrate.

hyperparasitic nature, it is more close to *Pseudohansfordia* than to the remaining plant pathogenic *Denticularia* species. The genus *Denticularia* is close to *Ramularia* Unger, merely differing by the presence of conical denticles in the former.

DENTICULARIA MODESTA (H. Syd.) Deighton

Cladosporium modestum H. Syd. *in* Annls mycol. **37**: 252. 1939. — *Denticularia modesta* (H. Syd.) Deighton *in* Trans. Br. mycol. Soc. **59**: 422. 1972.

DENTICULARIA TERTIA (Chupp & Greene) Deighton

Cercospora tertia Chupp & Greene *in* Am. Midl. Nat. **34**: 269. 1945. — *Denticularia tertia* (Chupp & Greene) Deighton *in* Trans. Br. mycol. Soc. **61**: 115. 1973.

Engyodontium de Hoog, *gen. nov.*

Coloniae arachnoideae, albae. Conidiophora hyalina, tenuitunicata, repentia vel adscendentia, plus minusve verticillata. Cellulae conidiogenae subulatae ad cylindricae, polyblasticae, nonnullos denticulos obtusos vel capillariformes vel rhachidem elongatam formantes. Blastoconidia hyalina, parva, continua.
Species typica: *Rhinotrichum parvisporum* Petch

Colonies cobweb-like, white. Conidiophores hyaline, thin-walled, creeping to suberect; branching pattern subverticillate to verticillate. Conidiogenous cells subulate to cylindrical, polyblastic, forming holoblastic conidia on butt- to hair-shaped denticles on elongated rhachides. Conidia hyaline, small, one-celled.
TYPE SPECIES.—*Rhinotrichum parvisporum* Petch

Engyodontium albus (Limber) de Hoog, *comb. nov.*

Tritirachium album Limber *in* Mycologia **32**: 27. 1940 (basionym). — *Beauveria alba* (Limber) Saccas *in* Revue Mycol. **13**: 64. 1948.

REFERENCES.—Limber (*1940*), de Hoog (*1972*), Matsushima (*1975*).

By excluding the species from *Beauveria* Vuill., this genus becomes more homogeneous, being restricted to species with dense clusters of short branches and fertile cells on undifferentiated hyphae, disintegrating only when the strains are grown on artificial media. *Tritirachium* Limber differs by pigmented colonies and regularly geniculate conidiiferous rhachides with flat conidial scars.

Engyodontium parvisporum (Petch) de Hoog, *comb. nov.*—Fig. 11

Rhinotrichum parvisporum Petch *in* Trans. Br. mycol. Soc. **16**: 244. 1931 (basionym).

Mycelium forming a cobweb-like felt on remains of mites on the abaxial sides of leaves, white to cream-coloured. *Hyphae* creeping, smooth- and thin-walled, hyaline, 1–1.8 μm wide, irregularly branched, in part fertile, intermingled with suberect, hyaline conidiophores

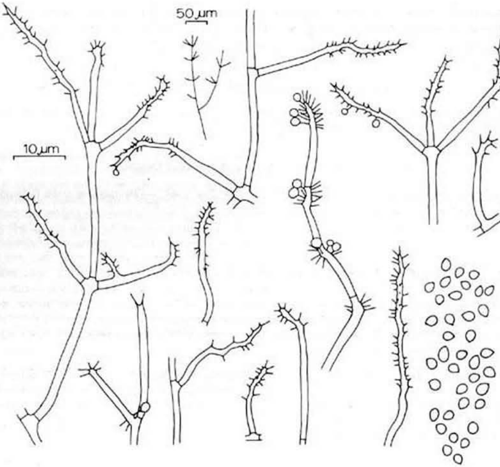


Fig. 11. *Engyodontium parisporum, Petch R-400* on the natural substrate.

with slightly thickened walls; conidiophores often over 200 µm high, regularly 1.5–2 µm wide, septate every 25–50 µm, with whorls of (1–)2–3(–5) plagiotropic conidiogenous cells just below the septa, the apical whorl being the largest, sometimes with one or two lateral branches of similar structure as the main stalk. *Conidiogenous cells* scattered or in whorls, straight, cylindrical, when arising from differentiated conidiophores often very slightly tapering towards the tip, the broadest part just above the base; basal part 10–20 × 1.2–1.8 µm, rhachis straight or flexuose, 0,8 µm wide, densely covered with hair-shaped conidiiferous denticles 1–2 µm long; conidiogenous cells on undifferentiated hyphae entirely covered with denticles, sometimes intercalary. *Conidia* hyaline, smooth- and thin-walled, subglobose to guttuliform, occasionally obovoidal, with acuminate base, 1.2–3 × 1.2–1.5 µm.

MATERIAL EXAMINED.—*Petch R-400*, on *Aspidiotus* and *Lecanium* on *Hevea brasiliensis*, Dewalakande, Sri Lanka, Jan. 1928 (type of *R. parvisporum*, K); *Petch R-494*, on cocoon, Nuwara Eliya, Sri Lanka, July 1928 (K); *Petch R-599*, Sri Lanka, Sept. 1928 (associated with *Gibellula* spec., K); Petch(without number), on *Aleyrodes* on mango (associated with type of *Gonatorrhodiella coccorum* Petch, K); *Petch R-301*, on fly, Nuwara Eliya, Sri Lanka (K).

The preceding description is of dried specimen *Petch R-400* (K) on the natural substrate.

The species is close to *Engyodontium album* in its thin, white colonies, the slightly differentiated, verticillate conidiophores and the guttuliform conidia. The general structure of *E. parvisporum* is, however, somewhat more irregular, the length of the basal parts of the conidiogenous cells being variable with equally wide, occasionally intercalary rhachides. The main feature for distinction of both species is the rhachis, which is cylindrical, slightly flexuose with extremely thin denticles in *E. parvisporum*, but geniculate with butt-shaped denticles on the edges in *E. album*.

HELMINTHOPHORA Bon.

Helminthophora Bon., Handb. allgem. Mykol. 93. 1851. — *Dactylium* Nees sect. *Helminthophora* (Bon.) Sacc. *in* Syll. Fung. **4**: 190. 1886.
Eurasina G. Arnold *in* Z. Pilzk. **35**: 305. 1969.

Colonies spreading, white or nearly white. Conidiophores hyaline, thin-walled, erect; branching pattern verticillate. Conidiogenous cells subulate, monoblastic, often proliferating laterally to form a straight or slightly flexuose rhachis with a few scattered conidium-bearing denticles. Conidia hyaline, large, usually septate.

TYPE SPECIES.—*Dactylium sphaerocephalum* Berk. (= *Helminthophora tenera* Bon.).

The process of conidiogenesis was studied by means of culture chambers slightly modified after Cole & al. (*1969*). Each conidiogenous cell first blows out at the apex to form a conidium holoblastically. It takes several days for the conidium to fully mature. The conidia may remain attached to the supporting cell for a long period, even after formation of a basal septum. Often, however, the terminal conidium is pushed aside by a lateral growing point which again blows out holoblastically at its apex. The new outgrowth usually leads to a short, straight or slightly flexuose rhachis with up to 4 large denticles at acute or nearly right angles. Each of the denticles forms one conidium only. The conidiogenous cell was rarely seen to proliferate on or through the scar of a previously seceded conidium (Fig. 12e). More often the conidiogenous cell proliferates before producing any conidium, so that a constriction of the cell remained visible (Fig. 12d), as was also shown by Gams & Hoozemans (*1970*).

Helminthophora tenera Bon., the first species described in the genus, was listed as a possible synonym of *Cladobotryum dendroides* by Gams & Hoozemans (*1970*). However, the unbranched conidiophore stalks with regular whorls of subulate conidiogenous cells in Bonorden's (*1851*) figure 137 doubtlessly point to their *Cladobotryum leptosporum* (Sacc.) W. Gams & Hoozemans, for which the older synonym *Dactylium sphaerocephalum* Berk. has now been found. Moreover, *H. tenera* was described as occurring on rotten wood, the same substratum as that of the type specimens of *C. leptosporum* (PAD) and *D. sphaerocephalum* (K), whereas *C. dendroides* is usually found on mushrooms.

In the above sense the genus *Helminthophora* is close to *Pseudohansfordia* G. Arnold, but differs because of its verticillate branching pattern and the inconspicuously sympodial conidium formation. *Calcarisporium* Preuss is also similar, but differs in having clusters of small conidium-bearing denticles at the apices of the fertile cells. *Sibirina* G. Arnold also has a verticillate branching pattern and subulate conidiogenous cells, but the latter are monoblastic, forming conidia singly or in basipetal succession (Gams, *1973*).

Helminthophora sphaerocephala (Berk.) de Hoog, *comb. nov.*—Fig. 12

Dactylium sphaerocephalum Berk. *in* Ann. Mag. nat. Hist. **6**: 347. 1841 (basionym). — *Mucrosporium sphaerocephalum* (Berk.) Sacc. *in* Syll. Fung. **4**: 190. 1886.

Helminthophora tenera Bon., Handb. allgem. Mykol. 93. 1851. — *Dactylium tenerum* (Bon.) Sacc. *in* Syll. Fung. **4**: 190. 1886.

Dactylium dendroides (Bull. ex Mérat) Fr. var. *leptosporum* Sacc. *in* Michelia **2**: 576. 1882. — *Dactylium leptosporum* (Sacc.) Lentz *in* Mycopath. Mycol. appl. **32**: 14. 1967. — *Cladobotryum leptosporum* (Sacc.) W. Gams & Hoozemans *in* Persoonia **6**: 106. 1970.

Eurasina bondarzewiae G. Arnold *in* Z. Pilzk. **35**: 305. 1969.

Possible synonyms in check-list under *agaricinum*, *fusarisporum*.

REFERENCES.—Lentz (*1967*), Arnold (*1969*, *1971a*), Gams & Hoozemans (*1970*).

Colonies attaining a diameter of 25–40 mm in 14 days, appearing lanose, about 3 mm high, with some thin, suberect tufts about 1 cm high and some flat, dense mycelium at the centre,

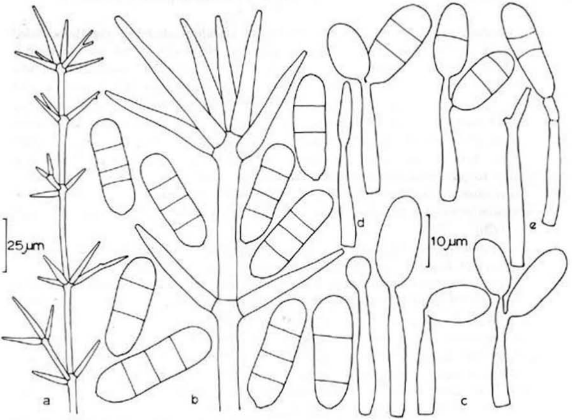


Fig. 12. *Helminthophora sphaerocephala*, CBS 974.73 on mushroom agar. — a. Branching pattern. — b-e. Fertile structures.

purely white; reverse on oatmeal agar pale ochraceous; often forming some hyaline exudate. *Conidiophores* arising orthotropically from fragile, hyaline, smooth- and thin-walled, 5–7 µm wide, aerial hyphae, suberect to erect, main stalk with slightly thickened walls, 200–700 µm long, 4–7 µm wide at the base, 2.5–3.5 µm wide near the apex, septate every 30–50 µm; branching pattern verticillate, whorls on main stalks containing (2–)4–7 conidiogenous cells, sometimes also with a short lateral branch. *Conidiogenous cells* straight, subulate, 20–35 µm long, widest (3.2–4 µm) just above the base, tapering towards the 1–1.5 µm wide apex, initially monoblastic, forming conidia singly by inflation of the tip, at a later stage proliferating sympodially, leading to a short, flexuose rhachis with 1–4 scattered, butt-shaped denticles on the edges. *Conidia* 3–4-celled, smooth- and thin-walled, short-cylindrical with broadly rounded extremities, 17–25 × 5.5–7.5 µm, often with a slightly prominent scar at the base.

The preceding description is based on CBS 974.73 on mushroom agar at 20–22°C.

PSEUDOHANSFORDIA G. Arnold

Pseudohansfordia G. Arnold *in* Z. Pilzk. **35**: 307. 1969 (non *Pseudohansfordia* Reddy & Bilgrami *in* Nova Hedwigia **26**: 152. 1975).
Sympodiophora G. Arnold *in* Nova Hedwigia **19**: 301. 1970.

Colonies spreading, purely white or pale greyish, on the natural substrate forming a dense felt. Conidiophores hyaline to subhyaline, ascending to suberect; branching pattern subverticillate or irregular. Conidiogenous cells subulate to cylindrical, polyblastic, with usually remote loci on a flexuose rhachis, each locus forming holoblastic conidia singly or retrogressively. Conidia hyaline, continuous or septate.
TYPE SPECIES.—*Pseudohansfordia irregularis* G. Arnold

In the type species, *P. irregularis*, the mode of conidiogenesis is essentially the same as in most species of *Cladobotryum*. The first conidium blows out terminally; it then becomes delimited by a septum, below which a narrow zone swells to give rise to the second conidium. On the young inflation the scar of the previous conidium often remains visible, mature conidia showing two scars on the basal region. After completion of a short series of conidia, the conidiophore tip proliferates subapically with a new fertile growing point, thus leading to a flexuose rhachis with blunt conidium-bearing denticles on the edges.

In the type species of *Sympodiophora*, *S. stereicola* G. Arnold, the same phenomena occur. In this case, however, the inflating zones are narrow, the inflations being almost restricted to the scars of the previous conidia. When directly observed in a petri-dish the conidia are sessile and form small asterisk-shaped clusters on the fertile denticles. *Sympodiophora didyma* Deighton & Pirozynski is similar to *S. stereicola*, but the conidia form singly on each locus. Hence a number of sympodial species, forming one conidium on each denticle and described by Deighton & Pirozynski (*1972*) in *Sympodiophora*, are here included in *Pseudohansfordia*.

Pseudohansfordia in the above sense differs only slightly from *Pseudofusarium* Matsushima. The latter genus now comprises only two species, but *Blastotrichum aranearum* Petch, *Nodulisporium didymosporium* Nicot and several taxa of the section *Arthrosporiella* sensu Booth of *Fusarium* are closely related. Many of these are frequently found in association with other fungi, possibly being weak hyperparasites. They mainly differ from *Pseudohansfordia* by having more densely clustered conidium-bearing denticles, the rhachis, if present, being non or hardly flexuose. The conidiogenous cells of *Pseudohansfordia* species are either indeterminate, or become intercalary, in which case they bear only one or two denticles at the most. *Sympodiophora venezuelensis* Deighton & Pirozynski is intermediate between the two groups.

Pseudohansfordia is also reminiscent of some *Pseudocercospora*-like fungi [e.g. *Elletevera parasitica* (Ellis & Everh.) Deighton], which, however, all differ by having flat, slightly pigmented, conidial scars.

The description of *Pseudohansfordia* Reddy & Bilgrami is poor. The type specimen (CMI) of the only species, *P. hughii* Reddy & Bilgrami, the causative agent of leaf spots on *Psidium guajava* L., comprises a small piece of a dried culture, which is nearly smooth, hyaline, with dark olivaceous pustules of about 120 × 90 μm. The sympodial conidia are hyaline, one-celled, broadly clavate and are borne in small numbers on the tips of cylindrical conidiogenous cells. The fungus is close to sporodochial genera, such as *Hadrotrichum* Fuckel, *Pseudoepicoccum* M. B. Ellis and *Asperisporium* Maublanc, but the poor condition of the herbarium material, possibly due to severe heating during drying, does not allow further identification.

KEY TO THE SPECIES

1a. Conidia all continuous. . . . . *P. meliolae*
b. Conidia septate, a small number of continuous conidia sometimes being present 2
2a. Conidia predominantly 4-celled, with acute apex 3
b. Conidia (1–)2(–3)-celled, with rounded apex 4
3a. Conidiophores single, with scattered, pimple-shaped denticles; conidia usually over 5.5 μm wide *P. tenuis*
b. Conidiophores fasciculate, with conic denticles partly in loose groups; conidia usually less than 5.5 μm wide . . . . *P. venezuelensis*
4a. Conidiogenous cells soon becoming transversely septate, intercalary cells being about 5 μm long; secondary conidia may be present . . . . *P. varanasiensis*
b. Conidiogenous cells, when intercalary, over 10 μm long; secondary conidia absent 5
5a. Conidia with rounded base 6
b. Conidia with acuminate base 7
6a. Conidiogenous cells, excluding rhachides, about 20–45 μm long; denticles meristematic *P. irregularis*
b. Conidiogenous cells, excluding rhachides, about 100–150 μm long; denticles each forming a single conidium . . . . *P. mycophila*
7a. Conidia about 8–11 × 3.4–4.5 μm . . . . *P. pulchella*
b. Conidia about 15–25 × 5–7 μm 8
8a. Denticles meristematic . . . . *P. stereicola*
b. Denticles each forming a single conidium . . . . *P. didyma*

Pseudohansfordia didyma (Deighton & Pirozynski) de Hoog, *comb. nov.*

Sympodiophora didyma Deighton & Pirozynski *in* Mycol. Pap. **128**: 63. 1972 (basionym).

The species is very similar to *Sympodiophora stereicola*; it is merely distinguished by the production of only one conidium per denticle.

PSEUDOHANSFORDIA IRREGULARIS G. Arnold—Fig. 13

Pseudohansfordia irregularis G. Arnold *in* Z. Pilzk. **35**: 308. 1969.

REFERENCES.—Arnold (*1969*, *1971a*).

Colonies attaining a diameter of about 20 mm in 10 days, appearing powdery to finely lanose with a smooth margin, about 1 mm high, purely white; reverse on oatmeal agar pale olivaceous. *Conidiophores* hyaline, smooth- and thin-walled, suberect, crowded, about 100–200 μm high, 4–5.5 μm wide, septate about every 30–50 μm, usually without a distinct main stalk, branched more or less verticillately in the apical part; each whorl containing 1–3 plagiotropic branches or conidiogenous cells. *Conidiogenous cells* rather straight if terminal, often slightly curved upwards if lateral, cylindrical, basal part 15–40 × 3.5–4.5 μm; co-

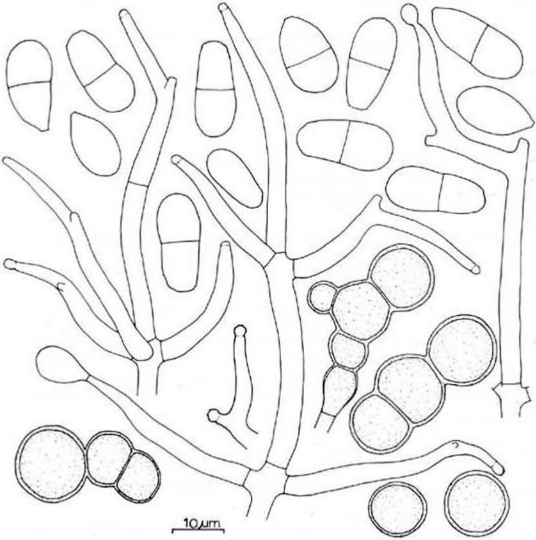


Fig. 13. *Pseudohansfordia irregularis*, CBS 459.71 on mushroom agar.

nidiiferous rhachis sympodial, flexuose with blunt denticles (about 2,5 × 1.5 μm) on the edges; denticles forming conidia by inflation of the tip; each subsequent conidium being initiated just below the previous one. *Conidia* 1–2(–4)-celled, smooth- and thin-walled, broadly ellipsoidal to broadly clavate, 13–20 × 6–9 μm, with broadly rounded bases, either with one central, slightly prominent scar or with two flat scars on both sides of the basal extremity.

The above description is based on the type strain CBS 459.71 on mushroom agar at 20–22°C. The same strain was used by Arnold (*1969*). In the latter publication, the conidiogenous cells were depicted as being rather short and firm; the ratio length/width of these cells was described as being 2.5–8. In the present study this ratio was found to be about 7.5–17.5. In his second article on the species, Arnold (*1971a*) repeated his first description, but the illustration showed much more elongate fertile cells, having a length/width ratio of about 7–11. Two available specimens were then mentioned, but no indication was made as to which of these was depicted.

Pseudohansfordia meliolae (Stev.) de Hoog, *comb. nov.*

Acremonium meliolae Stev. *in* Bot. Gaz. **65**: 234. 1918 (basionym). — *Sepedonium meliolae* (Stev.) Cif. *in* Sydowia **9**: 335. 1955. — *Sympodiophora meliolae* (Stev.) Deighton & Pirozynski *in* Mycol. Pap. **128**: 73. 1972.

REFERENCES.—Hansford (*1946*), Deighton & Pirozynski (*1972*).

Its lemon-shaped conidia remind one of the hyperparasite *Denticularia limoniformis*, but the conidial apparatus of the latter species is much more dense and stocky, and the probably catenulate conidia often have a pigmented scar at each end.

Pseudohansfordia mycophila (Tubaki) de Hoog, *comb. nov.*—Fig. 14

Dactylaria mycophila Tubaki *in* Nagaoa **5**: 17. 1955 (basionym). — *Sympodiophora mycophila* (Tubaki) Deighton & Pirozynski *in* Mycol. Pap. **128**: 72. 1972.

REFERENCES.—Tubaki (*1955*), Deighton & Pirozynski (*1972*), Matsushima (*1975*).

The type strain CBS 175.56 still sporulates rather well on mushroom agar. The conidia are formed in strict sympodial order, the rhachis often being straight or nearly straight. Each conidial peg only forms one conidium. The chlamydospores, often becoming rounded, may be liberated as large globose cells, and are very similar to those of *Pseudohansfordia irregularis*.

Pseudohansfordia pulchella (Deighton & Pirozynski) de Hoog, *comb. nov.*

Sympodiophora pulchella Deighton & Pirozynski *in* Mycol. Pap. **128**: 64. 1972 (basionym).

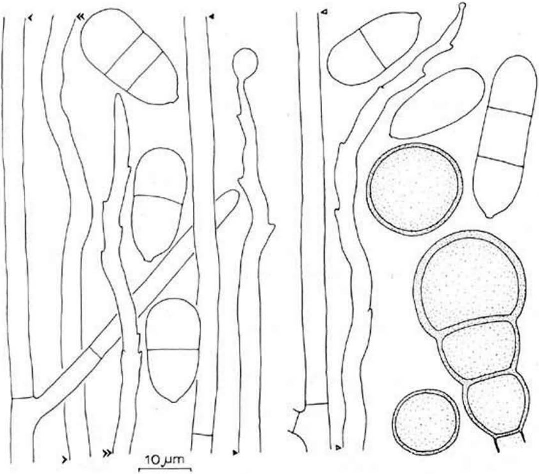


Fig. 14. *Pseudohansfordia mycophila*, CBS 175.56 on mushroom agar.

Pseudohansfordia stereicola (G. Arnold) de Hoog, *comb. nov.*

Sympodiophora stereicola G. Arnold *in* Nova Hedwigia **19**: 302. 1970 (basionym).

References.—Arnold (*1970*), Deighton & Pirozynski (*1972*).

Pseudohansfordia tenuis (H. Syd.) de Hoog, *comb. nov.*

Eriomycopsis tenuis H. Syd. *in* Annls mycol. **25**: 137. 1927 (basionym). — *Ramularia tenuis* (H. Syd.) Toro apud Seaver & Chardon *in* Sci. Survey P.R. and Virgin Isl. **8**: 222. 1932 (non *Ramularia tenuis* J. J. Davis *in* Trans. Wis. Acad. Sci. Arts Lett. **21**: 261. 1924). — *Sympodiophora tenuis* (H. Syd.) Deighton & Pirozynski *in* Mycol. Pap. **128**: 70. 1972.

References.—Sydow (*1927*), Deighton & Pirozynski (*1972*).

Pseudohansfordia varanasiensis (Deighton & Pirozynski) de Hoog, *comb. nov.*

Sympodiophora varanasiensis Deighton & Pirozynski *in* Mycol. Pap. **128**: 68. 1972 (basionym).

The one-celled conidia, described by Deighton & Pirozynski (*1972*) as possibly immature, are actually secondary conidia formed at the apices of the septate conidia, which consequently often have a scar at each end. No tertiary conidia were observed.

Pseudohansfordia venezuelensis (Deighton & Pirozynski) de Hoog, *comb. nov.*

Sympodiophora venezuelensis Deighton & Pirozynski *in* Mycol. Pap. **128**: 66. 1972 (basionym).

SPOROTHRIX Hektoen & Perkins

Sporothrix Hektoen & Perkins *in* J. exp. Med. **5**: 77. 1900; Nicot & Mariat *in* Mycopath. Mycol. appl. **49**: 61. 1973.

The genus was recently revised by de Hoog (*1974*). Some insect pathogenic species with scattered denticles on more or less flexuose rhachides, e.g. *S. ghanensis* de Hoog & Evans, remind one of *Pseudohansfordia* but are usually smaller and have continuous conidia. They may also bear similarity to *Denticularia* species which, however, have firmer, subhyaline conidiophores and conidia arising in short chains. The generic limits are arbitrary.

Sporothrix guttuliformis de Hoog, *spec. nov.*—Fig. 15

Coloniae in agaro farina avenae dicto temperatura ambiente 10 diebus ad 10 mm diametro, planae, primum leves, hyalinae, cito farinosae in medio, albae; margo regularis, vage delimitata, hyalina. Reversum albidum, in medio cremeum. Exsudatum abest, neque olet. Hyphae submersae hyalinae, leves, tenuitunicatae, juvenes omnes radiantes, dichotomae, raro septatae, constanter 2.5–3 μm latae, deinde ramos laterales 0.8–1.5 μm latos densos proferunt; rami latiores subinde densius septati et raro disrupti. Hyphae aeriae tenues, cellulas conidiogenas abundantes proferunt. Cellulae conidiogenae terminales, laterales vel intercalares, cylindricae, latitudinae hyphis basilaribus similes, longitudine variabiles; terminales et laterales conidia in apice aggregata proferunt e cicatricibus modice prominentibus haud pigmentatis. Conidia hyalina, tenuitunicata, levia, guttuliformia, hilo et cicatricibus inconspicuis praedita, singula, plerumque 2.8–3.5 × 2–3 μm, saepe 1–3 conidia secundaria e primariis majoribus, 3.5–6 × 2.5–3.4 μm, oriuntur.

Typus: CBS 437.76, isolatus ex solo in Malaysia ab T. Furukawa.

Colonies on oatmeal agar attaining a diameter of 10 mm in 10 days, appearing flat, initially smooth, hyaline, soon becoming farinose at the centre, white; margin straight, rather vague, hyaline. Reverse whitish, cream at the centre. Exudate and odour absent. Submerged *hyphae* hyaline, smooth- and thin-walled, running in a radial direction when young, dichotomously branched, sparingly septate, regularly 2.5–3 μm wide, soon bearing 0.8–1.5 μm wide lateral branches and forming a compact mycelium. The wider branches finally become septate at irregular distances and very rarely fragment into separate cells. Aerial hyphae thin, with abundant conidiation. *Conidiogenous cells* intercalary or free, cylindrical, of the same width as the supporting hypha and of variable length; lateral and terminal cells usually produce a small group of conidia at the apex; scars slightly prominent, unpigmented. *Conidia* hyaline, smooth- and thin-walled, guttuliform, with an inconspicuous hilum, mostly 2.8–3.5 × 2–3 μm, single or with 1–3 on ramo-conidia measuring 3.5–6 × 2.5–3.4 μm; apical scars of the latter hardly discernible.

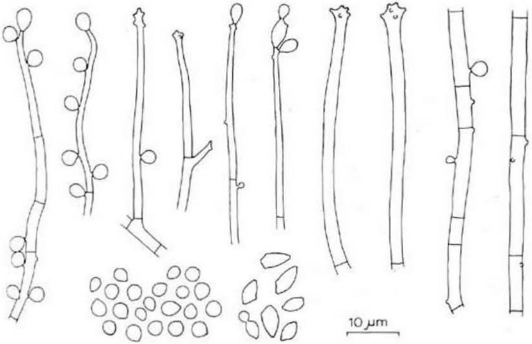


Fig. 15. *Sporothrix guttuliformis*, CBS 437.76 on oatmeal agar.

TYPE CULTURE (living and dried).—CBS 437.76, amylase producing strain, isolated from soil, Malaysia, sent by T. Furukawa, Japan.

On V-8 juice agar the colonies attain a diameter of 30 mm in 10 days. On this medium optimal sporulation is obtained, the incidence of conidia on free hyphal tips being rather high. On other media the great majority of the conidia are formed laterally on intercalary cells. Colonies on malt agar are nearly or completely colourless, and crowded with minute, less than 1 mm high, hyphal strands at the centre. On the latter medium the submerged mycelium is slightly elevated and shows regular radial furrows.

Sporothrix guttuliformis is similar to *S. schenckii* but differs by less prominent denticles and by the lateral and terminal conidia being identical in shape and size, whereas in *S. schenckii* they are lacrymoid to fusiform and (sub-)globose respectively. In addition, the submerged mycelium is relatively wide, often dichotomously branched. In this respect the species is similar to *S. ramosissima* Arn. ex de Hoog, but the latter has distinct conidiophores. Conidial states of *Ophiostoma stenoceras* (Robak) Melin & Nannf., fitting the concept of *Sporothrix schenckii* (pro parte) and of *S. pallida* (Tubaki) Matsushima, may be distinguished by their spreading, lanose colonies. In its cultural characteristics *S. guttuliformis* resembles *S. fungorum* de Hoog & de Vries, from which it differs by a much lower incidence of secondary conidia.

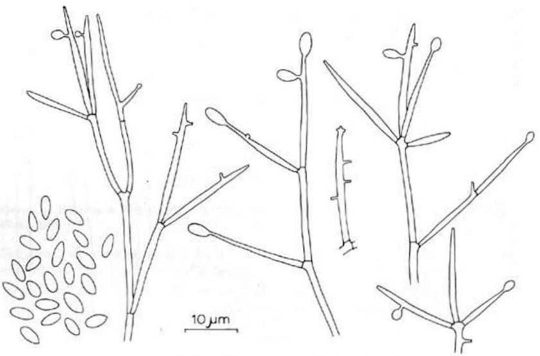


Fig. 16. *Sporothrix rectidentata*, CBS 641.74 young culture on oatmeal agar.

Sporothrix rectidentata (Matsushima) de Hoog, *comb. nov.*— Fig. 16

Tritirachium rectidentatum Matsushima, Ic. Microf. a Matsushima lect. 160. 1975 (basionym).
Acrodontium album Kushwaha & Agrawal *in* Mykosen **20**: 97. 1976.

Matsushima's (*1975*) classification of this species in *Tritirachium* Limber was based on its verticillate branching. However, all accepted *Tritirachium* species have pigmented colonies, more distinct conidiophores and regularly flexuose rhachides on which the scars are discerned with difficulty (de Hoog, *1972*). *Acrodontium* de Hoog has pigmented conidiogenous cells with denticulate rhachides, the scars being little pigmented. *Sporothrix rectidentatum* forms conidia singly, rarely in small sympodial clusters on the apices of the conidiogenous cells. When at least one terminal conidium is formed, new conidia may be initiated much lower down. Consequently the major part of the process of conidiogenesis is more or less retrogressive. The lateral conidia are strictly comparable to the so-called chlamydospores of many *Sporothrix* species, and classification in this genus is thought to be more apt.

Sporothrix sclerotialis de Hoog, *spec. nov.*—Fig. 17

Coloniae in agaro farina avenacea decocto post 5 dies 32 mm diametro, planae, leves, in medio mycelio aerio crispatae, hyalinae, ochrascentes, deinde sclerotiis copiosis brunneo-griseae. Cellulae conidiogenae sparsae, nonnumquam inconspicue verticillatae, recte vel modice flexuosae, saepe sursum modice angustatae, plerumque 12–25 µm longae et diametro 1.5–2.5 µm hypha basilari similes; rhachis conidiifera sympodialis brevis, denticulata; denticuli truncati, 0.2–1.5 μm longi. Conidia hyalina, levia, tenuitunicata, obclavata ad fusiformia, basi acuminata, 4.0 – 6.4 × 1.8–3.0 μm.

Typus: CBS 312.77, isolatus e radicibus Lolii perennis in prato prope Wageningen in Neerlandia, ab O. Gerritsma, 9 Mart. 1977.

Colonies attaining a diameter of 32 mm in 5 days, appearing flat, smooth or nearly smooth

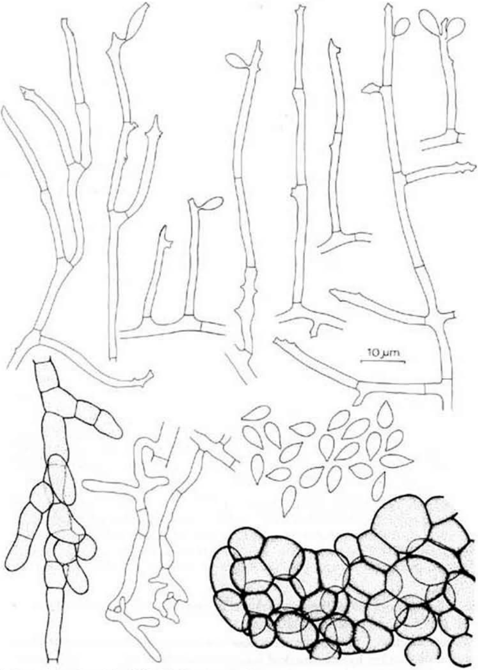


Fig. 17. *Sporothrix sclerotialis*, CBS 312.77 on oatmeal agar.

at the margin, with thin, crisped aerial mycelium near the centre, hyaline, centrally becoming whitish to pale ochraceous, finally dark brownish-grey due to abundant formation of sclerotium-like bodies; occasionally alternate dark and lighter sectors formed; margin sharp and regular. Submerged *mycelium* loose, consisting of hyaline, smooth- and thin-walled, remotely septate, regularly 2–3.5 μm wide hyphae, which later form hyphal fascicles; hyphae soon branched with thinner, flexuose branches; the mycelium becoming tough; irregular swellings on the branches formed, leading to compact clews of partly swollen hyphal cells; in addition, clusters of regularly inflated hyphal cells grow out to form tough, pseudoparenchymatous stromata composed of dull brown, thick-walled, broadly ellipsoidal cells measuring about 7–15 × 6–13 μm. *Conidiogenous cells* scattered, occasionally in inconspicuous whorls of 1–2(–3), arising orthotropically or somewhat plagiotropically from undifferentiated hyphae, often also in a terminal position or integrated into short lateral branches, straight or slightly flexuose, cylindrical but often slightly tapering towards the tip, mostly about 12–25 μm long and as wide as the supporting hypha (1.5–2.5 μm); apical part forming conidia by sympodial growth, consisting of a loose cluster of conidium-bearing denticles which may form a short rhachis; denticles blunt, nearly flat or pimple- to volcano-shaped, 0.2–1.5 μm long. The conidiogenous cell often proliferates at or somewhat below the apex and gives rise to another cluster of denticles or a conidiogenous cell, which may in turn become intercalary. *Conidia* hyaline, smooth- and thin-walled, obclavate to fusiform with acuminate bases, 4–6 × 1.8–3 μm.

TYPE CULTURE.—CBS 312.77, isolated by O. Gerritsma from roots of *Lolium perenne* meadow, Wageningen, under No. 770309–054, sent by J. W. Veenbaas-Rijks; second strain, CBS 163.77, from the same source.

The species differs from all known *Sporothrix* species by having dark, multi-celled sclerotial bodies. The sympodial state is similar to *S. ghanensis* de Hoog & Evans, but has less flexuose fertile cells and a different branching pattern; *S. schenckii* and the conidial state of *Ophiostoma epichloes* (Guerrero) de Hoog are mostly much smaller. *Denticularia* species have conidiophores in small bundles and conidia arising in short acropetal chains.

Sporothrix vizei (Berk. & Br.) de Hoog, *comb. nov.*—Fig. 18

Verticillium vizei Berk. & Br. apud Vize, Micro-fungi brit. 247. 1880 (basionym).

Colonies forming minute whitish patches; *hyphae* hyaline, smooth-walled or finely warted, 2.5–3.5 μm wide, septate every 10–20 μm, loose, forming an ascending, profusely ortho- or somewhat plagiotropically branched conidial apparatus in which no main stalks can be discerned. *Conidiogenous cells* in whorls of 1–3 on conidiophores, cylindrical, often slightly tapering towards the apex, 10–20 × 1.8–2.5 μm, apical part forming conidia by sympodial growth, consisting of a slightly inflated, up to 4 μm wide cluster of conidium-bearing denticles; denticles flat, blunt, less than 0.5 μm long, often hardly prominent at all. The conidiogenous cells may proliferate at or somewhat below the apex, leading to a short, nodose conidiiferous rhachis. *Conidia* hyaline, smooth-walled or finely warted, obconical, with rounded apex, one-celled or with a septum below the middle, 6–9 × 2.5–3.5 μm, basal scar 0.5 μm wide.

The preceding description is based on exsiccate specimens (Vize, Micro-fungi brit. 247, MANCH, PAD) on sori of ferns.

The nearest neighbour of this species is *Sporothrix ramosissima* Arn. ex de Hoog, which also shows rough-walled hyphae, marked orthotropical branching and blunt conidium-bearing denticles. These characters are all rather unusual in the genus *Sporothrix*. The present species deviates from all other species of the genus by the conidia often being two-celled.

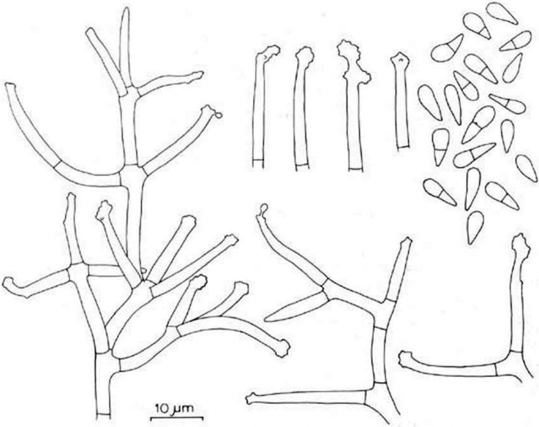


Fig. 18. *Sporothrix vizei*, Vize, Micro-fungi brit. 247 (MANCH) on the natural substrate.

Doubtful genus

CYLINDROPHORA Bon., Handb. allgem. Mykol. 92. 1851. — Original species: *Cylindrophora verticillata* Bon., *C. alba* Bon., *C. tenera* Bon.

The first listed species is a name change for *Verticillium cylindrosporum* Corda, of which the type specimen is lost. Possibly *Verticillium fungicola* (Preuss) Hassebr. was concerned. Bonorden's (*1851*) collections are all lost. Judging from his figures, *C. alba* may be close to *Cladobotryum apiculatum*, and *C. tenera* to *Acremonium strictum* W. Gams.

Epithets: *alba, albedinis, apiculata, aranearum, candida, epitrichia, fagi, hoffmannii, lindaviana, tenera, verticillata, virgata.*

Check-list of specific and subspecific names

accidiophila. — See *Colletoconis aecidiophila.*

agaricina. — *Botrytis agaricina* Link *in* Mag. Ges. naturf. Fr. Berl. **3**: 15. 1809; ex

Pers., Mycol. eur. **1**: 34. 1822. — *Cladobotryum agaricinum* (Link ex Pers.) Steud., Nomencl. Bot. 118. 1824. — *Verticillium agaricinum* (Link ex Pers.) Corda, Ic. Fung. **2**: 15. 1838.

According to Gams & Hoozemans (*1970*) the original material is lost. Referring to Ditmar's (*in* Sturm, *1817*) table 51, which was probably drawn from authentic material, they listed the species as a synonym of *Cladobotryum verticillatum* (Link ex Gray) Hughes. Fries (*1832*), who also examined an original specimen, mentioned it under *Dactylium dendroides* (Bull. ex Mérat) Fr. (syn.: *Cladobotryum dendroides*), which, however, is now known as a species with multi-celled conidia. Gams & Hoozemans (*1970*) also mentioned the binomial *Cladobotryum agaricinum* (Link) Nees, although Nees (*1816*) did not effectively publish the combination in *Cladobotryum*.

agaricinum. — *Sporotrichum agaricinum* Link *in* Jb. GewächsKde **1**: 170. 1818; ex Link, Linn. Spec. plant., Ed. 4, **6**: 7. 1824. — *Monosporium agaricinum* (Link ex Link) Bon., Handb. allgem. Mykol. 95. 1851.

The type material at Berlin (B) does not allow proper identification (Gams & Hoozemans, *1970*). The latter authors treated the species as a synonym of *Cladobotryum verticillatum*, on the basis of Bonorden's (*1851*) figure 112. It remains uncertain, however, whether Bonorden's (*1851*) and Link's (*1824*) specimens are identical, since the former author depicted a species with obclavate conidia which were said to be only initially globose, whereas the latter mentioned merely globose conidia. Bonorden's material is not known to be preserved.

agaricinum. — *Trichothecium agaricinum* Bon., Handb. allgem. Mykol. 99. 1851. — *Dactylium agaricinum* (Bon.) Sacc. *in* Syll. Fung. **4**: 189. 1886.

According to Gams & Hoozemans (*1970*) the type material is probably lost. The species was thought to be close to *Cladobotryum dendroides* by Saccardo (*1886*) and Gams & Hoozemans (*1970*), but the narrow, subulate, conidiogenous cells of Bonorden's (*1851*) figure 114 are more suggestive of synonymy with *Helminthophora sphaerocephala*.

alba. — *Cylindrophora alba* Bon., Handb. allgem. Mykol. 92. 1851.

No type material is known to be preserved. Bonorden's (*1851*) figure 131 shows a *Cladobotryum*-like species with cylindrical conidia, possibly identical to *C. apiculatum*. According to Saccardo (*1886*) it occurred inside a *Tuber* species.

albedinis. — *Cylindrophora albedinis* Killian & Maire *in* Bull. Dir. Agric. Colon. Serv. Bot. **73**: 97. 1930 (nomen provisorium); *Fusarium albedinis* Killian & Maire ex Malençon *in* C.r. hebd. Séanc. Acad. Sci., Paris **198**: 1261. 1934. — *Fusarium oxysporum* Schl. var. *albedinis* (Killian & Maire ex Malençon) Malençon *in* Rev. Mycol., Suppl. colon. **15**: 45. 1950. — *Fusarium oxysporum* Schl. forma specialis *albedinis* (Killian & Maire ex Malençon) Gordon *in* Can. J. Bot. **43**: 1310. 1965.

This *Fusarium* species is the causative agent of a serious disease of *Phloenix dactylifera* L. Killian & Maire (*1930*) described it tentatively from cultures showing chlamydospores and microconidia. Malençon (*1934*) was the first to recognize its affinity to macroconidial *Fusarium* species and validated the name by giving a short description. The original publication of *Cylindrophora albedinis* was incorrectly referred to in Petrak's List and by numerous subsequent authors.

album. — See *Engyodontium album* and *Sporothrix rectidentatum*.

aleuritidis. — *Cladobotryum aleuritidis* Sawada *in* Spec. Publ. Coll. Agric. nat. Taiwan Univ. **8**: 184. 1959 (without Latin diagnosis).

No material was available for study. Referring to the original publication, Deighton (*1972*) listed the name as a synonym of *Hansfordia pulvinata* (Berk. & Curt.) Hughes.

apiculatum. — See *Cladobotryum apiculatum*.

aranearum. — *Cylindrophora aranearum* Petch in Trans. Br. mycol. Soc. **27**: 85. 1944.

The species was described as the conidial state of *Torrubiella albolanata* Petch. In the type specimen (K) it forms a white, compact felt covering spiders. The hyphae are hyaline, thin-walled, becoming verrucose in areas with fertile cells, the latter occurring scattered or in small clusters, being flask-shaped to subulate and 7–13 × 2.4 –3.0 μm. Each conidiogenous cell mono- or polyblastically gives rise to bacilliform to sickle-shaped conidia, 8–12 × 0.8–1.0 μm (Fig. 19b).

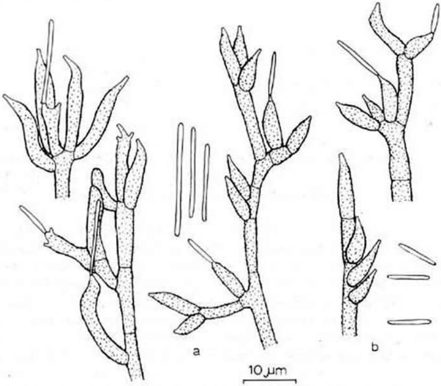


Fig. 19. *Granulomanus aranearum* on the natural substrate. a. leg. *H. C. Evans*. — b. type specimen at K.

Similar conidial structures also occur in several species of *Gibellula* (Samson & Evans, *1977*); occasionally they are found sporulating independently. The fungi superficially resemble *Aciculariella foliicola* Arn., which was invalidly published without a Latin diagnosis; no authentic material is known to be preserved. *Pseudomicrodochium aciculare* Sutton is also similar, but distinctly monophialidic. Consequently no generic name is available for these fungi, and hence the following is proposed.—

Granulomanus de Hoog & Samson, *gen. nov.*

Coloniae compactae, albae. Conidiophora indistincta, hyalina, tenuitunicata, saepe verrucosa, repentia vel adscendentia. Phialides lageniformes ad cylindricae, rostris conidiiferis singulis vel compluribus, collaro inconspicuo praedita. Conidia continua, hyalina, parva, plus minusve bacilliformia.

Species typica: *Cylindrophora aranearum* Petch.

Colonies compact, white. Conidiophores undifferentiated, hyaline, thin-walled, frequently rough-walled, creeping to suberect. Phialides flask-shaped to cylindrical, apically provided with one to several conidiiferous protrusions with indistinct collarettes. Conidia one-celled, hyaline, small, more or less bacilliform.

TYPE SPECIES.—**Granulomanus aranearum** (Petch) de Hoog & Samson, *comb. nov.* (basionym: *Cylindrophora aranearum* Petch *in* Trans. Br. mycol. Soc. **27**: 85. 1944).—Fig. 19.

asterophorum. — See *Cladobotryum asterophorum*.

australe. — *Cladobotryum australe* Viègas *in* Bragantia **6**: 365. 1946.

No material was available for study. Referring to the original publication, Deighton (*1972*) listed the name as a synonym of *Hansfordia pulvinata*.

binatum. — See *Cladobotryum dendroides*.

boletorum. — *Sporotrichum boletorum* Ehrenb., Sylvae mycol. berol. 22. 1818; ex Steud., Nomencl. bot. 401. 1824. — *Dactylium boletorum* (Ehrenb. ex Steud.) Sacc. *in* Syll. Fung. **4**: 190. 1886.

The type material is lost. Judging from the description, it is probably *Cladobotryum dendroides*, as was already pointed out by Fries (*1832*) and Gams & Hoozemans (*1970*).

bondarzewiae. — See *Helminthophora sphaerocephala*.

candida. — *Cylindrophora fagi* Oudem. var. *candida* Bres. *in* Annls mycol. **13**: 106. 1915.

The type specimen (S) consists of compact, whitish mycelial dots 1–3 mm in diam. on branchlets and needles of *Pinus sylvestris*; it can be described as follows. Hyphae hyaline, thin-walled, fragile, usually 4–5 μm wide, regularly septate, profusely branched. Conidiogenous cells arising from undifferentiated hyphae, flask-shaped to fusiform, 6–8 × 2.8–3.8 μm, apically beaked, with a minute, inconspicuous phialidic collarette which is about 1 μm wide. Conidia adhering together in packets, hyaline, thin-walled, cylindrical with slightly acuminate base, 4-celled with ultimate cells smaller than central cells, 13–16 × 1.8–2.0 μm (Fig. 20).

The variety resembles the monotypic genus *Uncigera* Sacc., which has erect to suberect conidiophores with sterile tips. *Cylindrodendrum* Bon., of which *C. album* Bon. was first

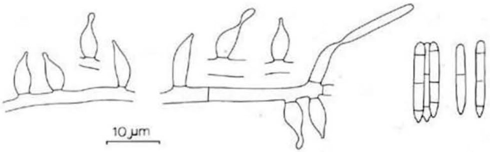


Fig. 20. *Pseudomicrodochium candidum*, herb. S on the natural substrate.

mentioned and treated by Kendrick & Carmichael (*in* Ainsworth & *al.*, *1973*) as lectotype of the genus, was described as having *Uncigera*-like conidiophores with sterile, hooked apices. The genus is probably an earlier synonym of *Uncigera*, but since Bonorden's (*1851*) material is lost, this cannot be ascertained. Some living CBS-strains of *Uncigera*-like fungi, after a few transfers rapidly lost their differentiated conidiophores and became similar to *Cylindrocarpon* Wollenw. A genus with scattered, flask-shaped conidiogenous cells on the natural substrate is *Pseudomicrodochium* Sutton, of which all the species described to date differ from *Cylindrophora fagi* var. *candida* by having only two-celled conidia and more pronounced collarettes. Some species of *Harposporium* with cylindrical conidia, e.g. *H. sicyodes* Drechsl., are also close. All these taxa need more thorough study in order to fully clear the generic limits. Pending such a study, *Harposporium* Lohde is here taken as being restricted to nematophagous species, *Uncigera* to species, on the natural substrate having differentiated conidiophores, and *Pseudomicrodochium* to species with only scattered conidiogenous cells. Bresadola's taxon should then be referred to as **Pseudomicrodochium candidum** (Bres.) de Hoog, *comb. nov.* (basionym: *Cylindrophora fagi* Oudem. var. *candida* Bres. *in* Annls mycol. **13**: 106. 1915).

candidum. — *Trichothecium candidum* Bon. (as 'Link'), Handb. allgem. Mykol. 99. 1851 (non *Trichothecium candidum* Wallr., Fl. cryptog. Germ. **2**: 285. 1833).

Bonorden (*1851*) listed the name as '*Trichothecium candidum* Link', although Link (*1824*) did not include this binomial in his account of the genus. Gams & Hoozemans (*1970*) supposed the name to be based on *Sporotrichum candidum* Link, the type of which (B) is unidentifiable. In the diagnosis of the latter species the conidia were described as being globose, whereas Bonorden (*1851*) depicted a species with clearly cylindrical conidia. Bonorden's material is now lost. Referring to his figure 167, Gams & Hoozemans (*1970*) listed *T. candidum* Bon. as a possible synonym of *Cladobotryum dendroides*. The type material of *T. candidum* Wallr. is probably lost. A secondary collection on leaves and branchlets of *Hedera* spec. (PAD), described by P. A. Saccardo *in* Syll. Fung. **4**: 179 and F. ital. fig. 955, contains an abundantly sporulating, pale yellowish-white *Ramularia*-like species mixed with small patches of a *Trichothecium* species. The latter has conidia about 19–27 × 10–12 μm and is consequently identical to the later described *T. luteum* Petch, which was fully redescribed by Rifai & Cooke (*1966*).

capitatum. — *Cladobotryum capitatum* Raybaud *in* C.r. Soc. Biol. **84**: 798. 1921.

No original material is preserved at PC or MARS. The fungus was described as having pale pigmented, erect conidiophores with whorls of flask-shaped conidiogenous cells over their entire length, each cell producing an apical cluster of small, globose, hyaline conidia on denticles. This combination of characters is only found in the genus *Costantinella* Matr. No mention was made, however, of any curved conidiogenous cells; the species is therefore regarded as doubtful.

clavariarum. — *Diplocladium penicillioides* Sacc. var. *clavariarum* Pat., Cat. rais. Pl. cell. Tunesia 130. 1897.

No authentic material is preserved at PC. The reddish colonies and the fusiform, constricted, two-celled, rather large conidia mentioned in the diagnosis, may point to *Cylindrocarpon* or a similar genus.

cordae. — *Verticillium cylindrosporum* Corda, Ic. fung. **1**: 20. 1837. — *Cylindrophora verticillata* Bon., Handb. allgem. Mykol. 92. 1851 (name change). — *Acrocylindrium cordae* Sacc. *in* Syll. Fung. **4**: 161. 1886 (name change).

Probably no authentic material has been preserved. Corda's (*1837*) figure 275 shows a *Verticillium* species close to *V. fungicola* (Preuss) Hassebr. When changing the name, Bonorden (*1851*) mentioned '*Verticillium cylindrophorum* Corda' as a synonym of his *Cylindrophora verticillata*, referring to Corda's *V. cylindrosporum*.

curvatum. — See *Cladobotryum curvatum*.

cylindrophorum, cylindrosporum. — See this list under *cordae*, under *roseum*.

cylindrosporum. — *Diplocladium cylindrosporum* Ellis & Everh. *in* Bull. Torrey bot. Club **27**: 58. 1900.

No type material was available at NY. The fungus grew on dead leaves and was described as forming hyaline bundles of conidiophores, branched in the apical region, with one-septate conidia 40–50 × 4–5 μm. Boedijn & Reitsma (*1950*) treated it as a synonym of *Cylindrocladium scoparium* Morgan.

dendroides. — See *Cladobotryum dendroides*.

didyma. — See *Pseudohansfordia didyma*.

elegans. — *Cladobotryum elegans* Arn. *in* Bull. trimest. Soc. mycol. Fr. **68**: 191. 1952 (without Latin diagnosis).

No original material is known to be preserved. The species was listed by de Hoog (*1974*) as synonymous with *Calcarisporium arbuscula* Preuss.

elegans. — *Diplocladium elegans* Bain. & Sartory *in* Annls mycol. **11**: 359. 1913.

No material is preserved at PC. The clear drawing in the original publication is suggestive of identity with *Sibirina fungicola* G. Arnold. Gams & Hoozemans (*1970*) listed it under *Cladobotryum mycophilum*, which, however, has shorter and stouter conidiogenous cells.

epitrichia. — *Cylindrophora epitrichia* Ramsb. apud Gibbs, Contr. Phytogeogr. Arfak Mount 190. 1917.

No type material is preserved at BM, CMI or K; no literature was available for study.

fagi. — *Cylindrophora fagi* Oudem. *in* Ned. Kruidk. Archf, Ser. 3, **4**: 900. 1903.

The type material (L) only consists of a drawing. The fungus was described as being sporodochial, with dark basal hyphae and hyaline, cylindrical conidia, in part arising from the tips of thread-like hyphae; it is of doubtful identity.

fici. — See *Denticularia fici.*

fusarisporum. — *Mucrosporium fusarisporum* Peyronel, Germi atmosfer. Funghi con Micelio 26. 1912.

No authentic material is known to be preserved. The species was described as being purely white, with ascending to erect, verticillately branched conidiophores and fusarioid conidia arising from small heads. This description reminds one of *Helminthophora sphaerocephala.*

gelatinosum. — *Cladobotryum* (?) *gelatinosum* Fuckel *in* Jahrb. nassau. Ver. Naturk. **23–24**: 360. 1870.

The binomial was first published as a nomen provisorium, but later included without the question-mark by Fuckel (*1871*). Four authentic collections (F. rh. 227 at K, L, NY, and S) were examined. All contained putrid *Populus* wood on which old *Cytospora*-like fruitbodies were found. In most samples remains of minute, pale pinkish-brown acervuli, more or less fitting the diagnosis, were also present. The conidia of the latter fungus were one-celled, hyaline or nearly hyaline, finely warted, ellipsoidal, 17–24 × 8–12.5 µm, with inconspicuous basal scars, and were reported to be sympodially produced (Fuckel, *1870*). A *Cryptocline*-like species was possibly concerned, but the conidiogenous cells were too poorly preserved to allow proper identification. The species was reported to be associated with the discomycete *Niptera* (?) *microcarpa* Fuckel [= *Mollisia microcarpa* (Fuckel) Sacc.]. Two authentic collections (F. rh. 2381 at L and S) contained sterile apothecia of a similar structure to the above-described *Cladobotryum gelatinosum.*

gregarium. — *Diplocladium gregarium* Bres. *in* Annls mycol. **1**: 127. 1903.

The type specimen (S) consists of some small pieces of *Pinus sylvestris* bark with numerous discrete, penicillate conidiophores, which can be described as follows. Conidiophores mononematous, erect, up to 800 µm high, stipe uniform throughout, hyaline, with walls up to 2 µm thick, densely covered with globose or confluent warts 1–3 µm in diam, stipes 10–12 septate, constricted at the cross-walls which are slightly thinner than the outer walls; cells 40–70 × 28–38 µm; stipes branched at the apex with 2–3 primary metulae; each

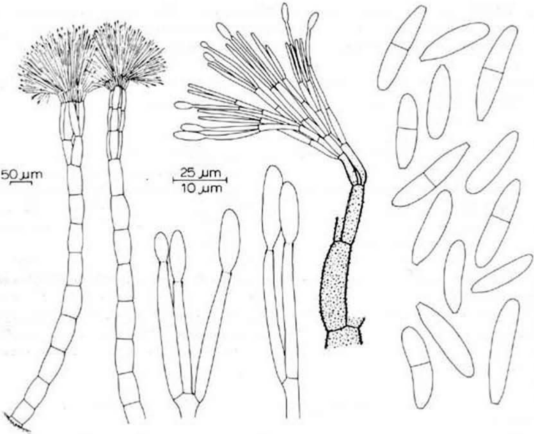


Fig. 21. *Cylindrocladium gregarium*, herb. S on the natural substrate.

metulus bearing 2–3 secondary metulae; branching becoming more profuse in the apical region of the fertile head; 5–6 series of metulae in all; metulae of first to fourth order coherent, slightly rough-walled, firm; metulae of higher order splaying out, smooth- and thin-walled; ultimate metulae each bearing 1–4 conidiogenous cells. Divergent part of conidial apparatus about 120 µm wide and 70 µm high, covered by a hyaline mass of conidia. Conidiogenous cells cylindrical, 20–25 µm long, 2.2–3.0 µm wide just above the base, slightly tapering towards the tip, with an apical phialidic channel, 1.8 µm wide. Conidia hyaline, smooth- and thin-walled, one- or two-celled, straight or slightly curved, cylindrical to cucumber-shaped, 12–23 × 4–5 µm, with a truncate, slightly prominent, basal scar (Fig. 21).

Mononematous, hyaline, rough-walled stipes bearing a head of phialides are known in *Gloiosphaera* Höhn. However, the only species accepted in this genus, *G. globuligera* Höhn. (Wang, *1971*), has a unique structure, the stipe being unbranched with numerous metulae and phialides in the apical region. The branching pattern of *Diplocladium gregarium*, on the contrary, is similar to that of *Leptographium* Lagerberg & Melin and *Phialocephala* Kendrick, but colourless, rough-walled stipes are not known in either of these genera. *Cylindrocladium* Morgan has hyaline conidiophore stalks bearing penicillately arranged phialides in their uppermost parts. Branching is usually much looser than in the present species, the conidiophores terminating in a sterile tip; in most species the conidia are strictly cylindrical. Some species with comparatively short conidia, e.g. *C. parvum* Anderson, have a branching pattern similar to *Phialocephala* and may lack sterile tips (Matsushima, *1971*). *Cylindrocladium peruvianum* Batista *& al.* often has rough-walled conidiophore stalks. Consequently the species at hand should be referred to as **Cylindrocladium gregarium** (Bres.) de Hoog, *comb. nov.* (basionym: *Diplocladium gregarium* Bres. *in* Annls mycol. **1**: 127. 1903).

guttuliformis. — See *Sporothrix guttuliformis*.

heterocladum. — *Verticillium heterocladum* Penz. *in* Michelia **2**: 462. 1882; F. ital. t. 1193. 1882 (non *Verticillium heterocladum* Penz. sensu Fawcett, Fungi paras. Aleyrodes citri 23. 1908. — *Verticillium cinnamomeum* Petch *in* Trans. Br. mycol. Soc. **16**: 233. 1931 (non *Verticillium heterocladum* Penz. sensu Fron *in* Bull. trimest. Soc. mycol. Fr. **27**: 486. 1911). — *Cladobotryum heterocladum* (Penz.) Petch *in* Trans. Br. mycol. Soc. **16**: 233. 1931.

No type material is known to be preserved. The species was described and depicted as having hyaline, ascending conidiophores with whorls of conidiogenous cells, the latter bearing apical heads of conidia on denticles. Possibly a meagre *Calcarisporium* species was concerned, as was suspected by Gams (*1971*): see also this list under *ovalisporum*. The fungus described by Fawcett (*1908*) as *V. heterocladum* had profusely branched conidiophores and lacked conidium-bearing denticles; consequently it should be retained in *Verticillium*. Fron's (*1911*) specimen was probably *V. lecanii* (Zimm.) Viégas.

hoffmannii. — *Cylindrophora hoffmannii* Daszewska *in* Bull. Soc. Bot. Genève, Ser. 2, **4**: 286. 1912.

The type strain CBS 110.13 only contained *Fusarium oxysporum* Schl. and was discarded from the CBS collection in 1965 as a supposed contamination. The original description and figure of *C. hoffmannii*, however, are those of a poorly developed microconidial state of a *Fusarium* species close to *F. oxysporum*. In the CBS records the typical purplish agar pigment of this species was mentioned immediately after receipt of the strain in 1913.

hydrangae. — *Diplocladium hydrangae* Togashi & Onuma *in* Bull. Morioka imp. Coll. For. Agric. **17**: 51. 1934.

No type specimen was available for study. The original drawing showed pale brown, branched conidiophores very similar to those of *Hansfordia pulvinata*, but the conidia were described as being cylindrical and two-celled. There is no *Hansfordia*-like species known with such conidia. Possibly a mixture of fungi was described.

irregularis. — See *Pseudohansfordia irregularis*.

lactarii. — See *Cladobotryum verticillatum*.

leptosporum. — See *Helminthophora sphaerocephala*.

leptosporum. — *Mucrosporium leptosporum* Peyronel, Germi atmosfer. Funghi con Micelio 26. 1913.

No original material was available for study; the description points to a *Cylindrocarpon*-like species.

limoniformis. — See *Denticularia limoniformis*.

lindaviana. — *Cylindrophora lindaviana* Jaap *in* Verh. Bot. Ver. Prov. Brandenb. **58**: 37. 1916.

No type material is preserved at B, BP, E, F, HBG, L, or PC; the species is doubtful.

macrospora. — See *Cladobotryum dendroides*.

major, majus. — *Diplocladium majus* Bon., Handb. allgem. Mykol. 98. 1851 (as '*major*').

The type material is probably lost. The greater part of Bonorden's (*1851*) figure 168 clearly points to *Cladobotryum mycophilum*, but in addition to *Cladobotryum* conidiophores loose, dark, four-celled conidia were depicted and described as being blackish. Since the conidia of *C. mycophilum* are hyaline and more one- to two-celled (rarely up to four-celled; Matsushima, *1975*), *D. majus* was probably based on a mixture of fungi. It should consequently be rejected as a nomen confusum. Saccardo's (*1886*) description under this name was based on another specimen (PAD), which was indistinguishable from *C. mycophilum*.

meliolae. — See *Pseudohansfordia meliolae*.

melleum. — See *Cladobotryum varium*.

minor, minus. — *Diplocladium minus* Bon., Handb. allgem. Mykol. 98. 1851 (as '*minor*').

No type material is known to be preserved. Bonorden's (*1851*) figure 119 points to synonymy with *Cladobotryum varium* or *C. mycophilum*. Though no conidial dimensions were given, the epithet '*minus*' makes the first supposition the most likely (compare this list under *majus*). Saccardo's (*1886*) specimen (PAD; F. ital. fig. 711) could be reidentified as *C. varium*.

modesta. — See *Denticularia modesta*.

multiseptatum. — See *Cladobotryum multiseptatum*.

mycophila, mycophilum. — See *Pseudohansfordia mycophila*, *Cladobotryum mycophilum*.

ovalisporum. — *Cladobotryum ovalisporum* Petch *in* Trans. Br. mycol. Soc. **16**: 233. 1932.

The type specimen *Petch R-69* and a secondary collection *Petch R-558* on insect remains are preserved at K; they can be described as follows. Mycelium effuse, flat, loose, overgrow-

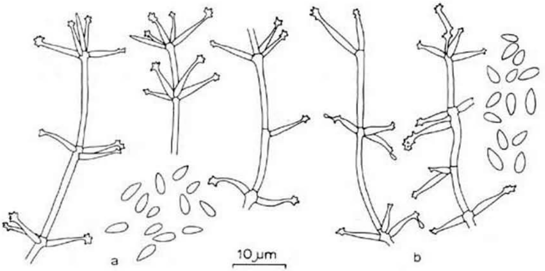


Fig. 22. *Calcarisporium ovalisporum*, herb. K on the natural substrate. — a. *Petch R-69*. — b. *Petch R-558*.

ing remains of small insects at the abaxial surface of leaves, purely white. Conidiophores ascending to erect, hyaline, fragile, thin-walled, usually 200–300 μm long, of equal width throughout (1.6–2.2 μm), septate every 10–20 μm, in the upper part bearing 3–6 whorls of 1–5 conidiogenous cells; the latter being subulate, 5–12 μm long; the widest part 1.4–1.8 just above the base, tapering towards the tip to about 0.8 μm; apically provided with an unswollen or slightly swollen cluster of pimple- to spine-shaped denticles up to 1.2 μm long, less than 0.3 μm wide. Conidia one-celled, hyaline, smooth- and thin-walled, ovoidal, navicular or fusiform, 3–5 × 1.2–1.8 μm, with an acuminate base and rounded apex (Fig. 22).

In both collections the fungus was associated with other hyphomycetes; consequently its entomogenous nature is questionable. The species was described as new by Petch (*1932*), since he was unsure about the identity of the probably similar species, *Verticillium heterocladum*. Petch's material represents a typical *Calcarisporium* species; hence the name **Calcarisporium ovalisporum** (Petch) de Hoog, *comb. nov.* (basionym: *Cladobotryum ovalisporum* Petch *in* Trans. Br. mycol. Soc. **16**: 233. 1932) is proposed for its accommodation. It differs from the closely related *C. arbuscula* by being considerably smaller and by having less markedly differentiated conidiophores. *Sporothrix setiphila* (Deighton & Pirozynski) de Hoog has about the same conidial dimensions, but has scattered, linear, conidiogenous cells.

parvisporum. — See *Engyodontium parvisporum*.

penicillioides. — See *Cladobotryum varium*.

preussii. — See this list under *uniseptatum*.

pulchella. — See *Pseudohansfordia pulchella*.

rectidentata. — See *Sporothrix rectidentata*.

rennyi. — See *Cladobotryum varium*.

roseum. — *Alytosporium roseum* Ehrenb., Sylv. mycol. berol. 11. 1818; ex Steud., Nomencl. bot. 55. 1824 [non *Sporotrichum roseum* (Rebent.) Pers., Mycol. eur. **1**: 81. 1822; non *Sporotrichum roseum* Link *in* Mag. Ges. naturf. Fr. Berl. **3**: 35. 1816; non *Sporotrichum merdarium* Link var. *roseum* Link, Linn. Spec. plant., Ed. 4, **6**: 13. 1824; non *Chrysosporium merdarium* (Link) Carmichael var. *roseum* W. Gams & Domsch *in* Nova Hedwigia **18**: 6. 1968]. — *Sporotrichum cylindrosporum* Link, Linn. Spec. plant., Ed. 4, **6**: 14. 1824 (name change). — *Acrocylindrium roseum* (Ehrenb.) Bon., Handb. allgem. Mykol. 98. 1851.

No original material has been preserved. Saccardo (*1886*) listed the species on page 161 as being related to *Cladosporium varium*, but on page 719 both *A. roseum* and *S. cylindrosporum* were treated as synonymous with *Fusarium longum* (Wallr.) Sacc. Fries (*1832*) and Gams & Hoozemans (*1970*) listed it as a possible synonym of *C. varium*.

The identity of the various taxa described as *Sporotrichum roseum* is doubtful, since for not one of these has authentic material been preserved. The taxonomic position of *Chrysosporium merdarium* var. *roseum* will be discussed elsewhere.

schlechtendalianum. — See *Cladobotryum dendroides*.

sclerotialis. — See *Sporothrix sclerotialis*.

sphaerocephalum. — See *Helminthophora sphaerocephala*.

stereicola. — See *Pseudohansfordia stereicola*.

tenellum. — *Dactylium tenellum* Fr., Syst. mycol. **3**: 413. 1832. — *Mucrosporium tenellum* (Fr.) Sacc. *in* Syll. Fung. **4**: 191. 1886.

No authentic material is preserved at UPS. Judging from the original description, possibly *Cladobotryum dendroides* was concerned.

tenera. — *Cylindrophora tenera* Bon., Handb. allgem. Mykol. 92. 1851.

The type material is probably lost. Judging from the original description and figure, an *Acremonium* species close to *A. strictum* W. Gams might have been concerned.

tenera. — See *Helminthophora sphaerocephala*.

tenue. — *Diplocladium tenue* Rostr. *in* Dansk bot. Ark. **2**: 43. 1916.

No authentic material is preserved at C. Judging from the original article, which shows a verticillately branched fungus with two-celled, fusiform conidia measuring 8–11 × 2.5 μm, possibly a *Verticillium* species close to *V. falcatum* (Petch) W. Gams was concerned.

tenuis. — See *Pseudohansfordia tenuis*.

ternatum. — See *Cladobotryum dendroides*.

ternatum. — *Cladotrichum ternatum* Bon., Handb. allgem. Mykol. 78. 1851. — *Didymocladium ternatum* (Bon.) Sacc. *in* Syll. Fung. **4**: 187. 1886.

The type material is probably lost. Referring to the original diagnosis and illustration, Gams & Hoozemans (*1970*) suspected synonymy with *Cladobotryum varium*. Isolates described by Tubaki (*1955*) and Nicot & Parguey (*1963*) as *D. ternatum* were also reidentified as *C. varium*.

terrigenum. — See *Cladobotryum dendroides*.

tertia. — See *Denticularia tertia*.

theobromae. — *Fusarium theobromae* Lutz *in* Bull. Soc. bot. Fr. **53**: 50. 1907 ('1906') (non *Fusarium theobromae* Appel & Strunk *in* Zentbl. Bakt. ParasitKde, Abt. 2, **11**: 635. 1903). — *Diplocladium theobromae* (Lutz) Sacc. & Trott. *in* Syll. Fung. **22**: 1309. 1913.

The species was listed by Booth (*1971*) as a synonym of *F. decemcellulare* Brick. It outdates the latter by a year, but was invalidly published as a later homonym of *F. theobromae* Appel & Strunk, which is *F. solani* (Mart.) Sacc. according to Booth (*1971*).

thuemenii. — *Cladobotryum thuemenii* Sacc. *in* Michelia **1**: 272. 1878; F. ital. fig. 709. 1881.

The type specimen (PAD) was reidentified by Gams & Hoozemans (*1970*) as *Athelia*.

uniseptatum. — *Mucrosporium uniseptatum* Preuss *in* Linnaea **25**: 728. 1852. — *Diplocladium preussii* Sacc. *in* Syll. Fung. **4**: 177. 1886 (name change).

The scanty type material (B) contained a fungus with mainly two-celled conidia, probably identical to *Cladobotryum varium*.

varanasiensis. — See *Pseudohansfordia varanasiensis*.

variospermum, varium. — See *Cladobotryum varium*.

venezuelensis. — See *Pseudohansfordia venezuelensis*.

verticillatum. — See *Cladobotryum dendroides, C. verticillatum* and see this list under *cordae*.

virgata. — *Cylindrophora virgata* Bon. *in* 'Bot. Zeit. **62**: 202, t. VIII, Fig. 5'.

The type specimen is probably lost. No description could be found with the above reference from Saccardo (*1886*); possibly it contains a misprint. Saccardo (*1886*) described a *Cladobotryum*-like fungus occurring on *Gloeosporium fructigenum* Berk. (=stat. con. *Glomerella cingulata* (Stonem.) Spauld. & v. Schrenck; v. Arx, *1970*).

vizei. — See *Sporothrix vizei*.

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References

Ainsworth, G. C., Sparrow, F. K. & Sussman, A. K. (1973). The fungi. IV-A. A taxonomic review with keys: Ascomycetes and Fungi imperfecti. New York, London.

Arnold, G. R. W. (1964). Über eine neue Hypomyzetazee, *Hypomyces odoratus* Arnold sp. nov. *In* Česká Mykol. **18**: 144–146.

—— (1969). Über zwei neue Imperfekten-Gattungen, *Eurasina* gen. nov. und *Pseudohansfordia* gen. nov. *In* Z. Pilzk. **35**: 305–310.

—— (1970). Über *Sibirina* und *Sympodiophora*, zwei neue Gattungen der Moniliales. *In* Nova Hedwigia **19**: 299–304.

—— (1971a). De nonnullis fungis raris vel novis vel pro URSS primum indicatis. *In* Nov. syst. Plant. non Vasc. **8**: 130–138.

—— (1971b). De stationibus novis fungorum imperfectorum mycophilorum pro URSS novis. *In* Nov. syst. Plant. non Vasc. **8**: 139—146.

—— (1971c). Über einige neue Taxa und Kombinationen der Sphaeriales. *In* Z. Pilzk. **37**: 187–198.

Arx, J. A. von (1970). A revision of the fungi classified in *Gloeosporium*. *In* Bibl. Mycol. **24**: 1–203.

Barron, G. L. (1968). The genera of Hyphomycetes from soil. Baltimore.

Boedijn, K. B. & Reitsma, J. (1950). Notes on the genus *Cylindrocladium* (Fungi: Mucedinaceae). *In* Reinwardtia **1**: 51–60.

Bonorden, H. F. (1851). Handbuch der allgemeinen Mykologie. Stuttgart.

Booth, C. (1971). The genus *Fusarium*. Kew.

Cole, G. T. & Kendrick, W. B. (1968). Conidium ontogeny in hyphomycetes. The imperfect state of *Monascus ruber* and its meristem arthrospores. *In* Can. J. Bot. **46**: 987–992.

—— & —— (1971). Conidium ontogeny in hyphomycetes. Development and morphology of *Cladobotryum*. *In* Can. J. Bot. **49**: 595–599.

Cole, G. T., Nag Raj, T. R. & Kendrick, W. B. (1969). A simple technique for time-lapse photomicrography of microfungi in plate culture. *In* Mycologia **61**: 726–730.

Cole, G. T. & Samson, R. A. (in prep.). Patterns of development in conidial fungi.

Deighton, F. C. (1972). Synonymy of *Hansfordia pulvinata* (Berk. & Curt.) Hughes. *In* Trans. Br. mycol. Soc. **59**: 531–536.

Deighton, F. C. & Pirozynski, K. A. (1972). Microfungi. V. More hyperparasitic hyphomycetes. *In* Mycol. Pap. **128**: 1–110.

Fassatiová, O. (1958). Imperfektní houby parasitující na vyšších houbach. *In* Česká Mykol. **12**: 151–157.

Fawcett, H. S. (1908). Fungi parasitic upon *Aleyrodes citri*. *In* Spec. Stud. Univ. State Florida **1**: 1–41.

Fries, E. M. (1832). Systema mycologicum **3**: 261–524. Gryphiswaldae.

Fron, M. G. (1911). Note sur quelques Mucédinées observées sur *Cochylis ambiguella*. *In* Bull. trimest. Soc. mycol. Fr. **27**: 482–487.

Fuckel, K. W. G. L. (1870). Symbolae mycologicae. Beiträge zur Kenntniss der Rheinischen Pilze. *In* Jb. nassau. Ver. Naturk. **23–24**: 1–459 ('1869').

—— (1871). Symbolae mycologicae. Erster Nachtrag. *In* Jb. nassau. Ver. Naturk. **25–26**: 287–346.

Gams, W. (1971). *Cephalosporium*-artige Schimmelpilze (Hyphomycetes). Stuttgart.

—— (1973). Phialides with solitary conidia? Remarks on conidium ontogeny in some hyphomycetes. *In* Persoonia **7**: 161–169.

Gams, W. & Holubová-Jechová, V. (1976). *Chloridium* and some other dematiaceous hyphomycetes growing on decaying wood. *In* Stud. Mycol. **13**: 1–99.

Gams, W. & Hoozemans, A. C. M. (1970). *Cladobotryum*-Konidienformen von *Hypomyces*-Arten. *In* Persoonia **6**: 95–110.

Hansford, C. G. (1946). The foliicolous Ascomycetes, their parasites and associated fungi. *In* Mycol. Pap. **15**: 1–240.

Hoog, G. S. de (1972). The genera *Beauveria*, *Isaria*, *Tritirachium* and *Acrodontium* gen. nov. *In* Stud. Mycol. **1**: 1–41.

—— (1974). The genera *Blastobotrys*, *Sporothrix*, *Calcarisporium* and *Calcarisporiella* gen. nov. *In* Stud. Mycol. **7**: 1–84.

—— (1977). *Rhinocladiella* and allied genera. *In* Stud. Mycol. **15**: 1—140.

Hoog, G. S. de & Hermanides-Nijhof, E. J. (1977). Survey of the black yeasts and allied fungi. *In* Stud. Mycol. **15**: 178–221.

Kendrick, W. B. (1971). Taxonomy of Fungi imperfecti. Toronto.

—— (in prep.). Proc. 2nd int. Workshop-Conf. at Kananaskis.

Kendrick, W. B. & Cole, G. T. (1969). Conidium ontogeny in hyphomycetes. *Trichothecium roseum* and its meristem arthrospores. *In* Can. J. Bot. **47**: 345–350.

Killian, C. & Maire, R. (1930). Le Bayoud, maladie du Dattier. *In* Bull. Dir. Agric. Colon. Serv. Bot. **73**: 89–101.

Lentz, P. L. (1967). Delineations of forest fungi. Several species of Deuteromycetes and a newly described *Botryobasidium*. *In* Mycopath. Mycol. appl. **42**: 1–25.

Limber, D. B. (1940). A new form genus of the Moniliaceae. *In* Mycologia **32**: 23–30.

Link, H. F. (1824). Caroli a Linné Species Plantarum, Ed. 4, **6**. Berolini.

Malençon, G. (1934). Nouvelles observations concernant l'étiologie du Bayoud. *In* C.r. hebd. Séanc. Acad. Sci., Paris **198**: 1259–1261.

Massee, G. (1893). British fungus-flora **3**. London.

Matsushima, T. (1971). Microfungi of the Solomon Islands and Papua-New Guinea. Kobe.

—— (1975). Icones microfungorum a Matsushima lectorum. Kobe.

Morquer, R. (1931). Recherches morphogéniques sur le *Dactylium macrosporum*. Toulouse.

Nees von Esenbeck, C. G. (1816). Das System der Pilze und Schwämme. Würzburg.

Nicot, J. (1962). En marge du salon du champignon: la flore des moisissures d'un Polypore. *In* Revue Mycol. **27**: 87–92.

Nicot, J. & Parguey, A. (1963). Obtention de la forme parfaite *Hypomyces* dans des cultures de l'hyphomycète fungicole *Didymocladium ternatum* (Bon.) Sacc. *In* C.r. hebd. Séanc. Acad. Sci., Paris **257**: 1331–1334.

Plowright, C. B. (1882). A monograph of the British *Hypomyces*. *In* Grevillea **11**: 41–51.

Preuss, C. G. T. (1851). Synopsis fungorum hucusque cognitorum praesertim prope Hoyerswerda. *In* Linnaea **24**: 101–153.

Rifai, M. A. & Cooke, R. C. (1966). Studies on some didymosporous genera of nematode-trapping hyphomycetes. *In* Trans. Br. mycol. Soc. **49**: 147–168.

Saccardo, P. A. (1886). *In* Sylloge Fungorum **4**.

Samson, R. A. & Evans, H. C. (1977). Notes on entomogenous fungi from Ghana. IV. The genera *Paecilomyces* and *Nomuraea*. *In* Proc. K. Akad. Wet., Amsterdam, Ser. C, **80**: 128–134.

Sturm, J. (1817). Deutschlands Flora in Abbildungen nach der Natur mit Beschreibungen. Abt. 3, **4**. Nürnberg.

Sydow, H. (1927). Fungi in itinere costaricensi collecti. Pars tertia. *In* Annls mycol. **25**: 1–160.

Tubaki, K. (1955). Studies on the Japanese Hyphomycetes (II). Fungicolous group. *In* Nagaoa **5**: 11–40.

Wang, C. J. K. (1971). *Gloiosphaera clerciana* from New York State. *In* Mycologia **63**: 890–893.

Zycha, H. (1935). Ueber *Hypomyces rosellus* (Alb. & Schw.) Tul. *In* Zentbl. Bakt. ParasitKde, Abt. II, **92**: 449–459.

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SIDEROPHILOUS GRANULES IN THE BASIDIA OF HYMENOMYCETES

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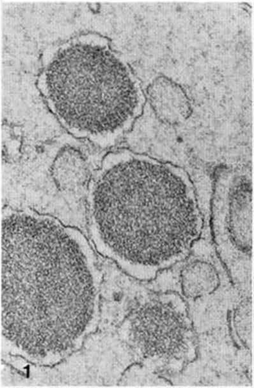
Siderophilous granules of postmeiotic basidia are protein filled vesicles derived from the endoplasmic reticulum capable of binding relative large amounts of metal ions thus standing out with high opacity in the electron microscope and becoming stainable with acetocarmine or hematoxylin for light microscopy. They range from very small, submicroscopic, single and rare particles to easily observable granules almost filling the basidium. The number and size of the granules can be used to describe five types of granulation, the crypto, micro, oligo, macro, and gigas type. The macrotype is taxonomically important for the Lyophylleae, and it seems that the micro type has taxonomic significance in the Rhodophyllaceae (Entolomataceae) and the Russulaceae.

Historically, the siderophilous granules are a key character of the genera *Lyophyllum* (including *Tephrocybe*) and *Calocybe*. Here they are easily observed with the light microscope. But investigation with the electron microscope indicated that siderophilous granules are more widely distributed in Hymenomycetes, but frequently are too small to be readily identified with the light microscope.

LIGHT MICROSCOPY

When heated with iron-acetocarmine the mature basidia of several agarics belonging to different genera are seen to contain many small, intensely stained granules. This is the 'granulation carminophile' of Kühner (*1938*), described from species of the genera *Lyophyllum* and *Calocybe*. These granules contain basic proteins capable of binding large amounts of metal ions, such as iron, cobalt, osmium, copper, lead, hafnium, thorium, uranium, and others. The carmine only acts as an indicator for the presence of these metals, giving dark purple to blackish complexes when heated in acid solutions. It may be replaced by other relevators, such as sodium sulphide or hematoxylin. Based on the fact that it is the metal rather than the carmine that is responsible for the positive staining reaction the term 'siderophilous' has been proposed to replace 'carminophilous' (Clémençon, *1967*, *1969*).

To intensify the staining and to obtain clean preparations exempt of precipitations Clémençon (*1968a*) introduced a method which separates the application of metal ions from the staining with acetocarmine. The folowing is a simplified method avoiding the radioactive and dangerous thorium nitrate and the not always available zirconyl chloride. These two metals enhance somewhat the final staining, but for routine observations they are not necessary. It should be noted that this method gives good nuclear staining well suited for



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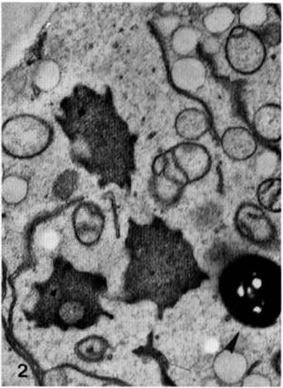

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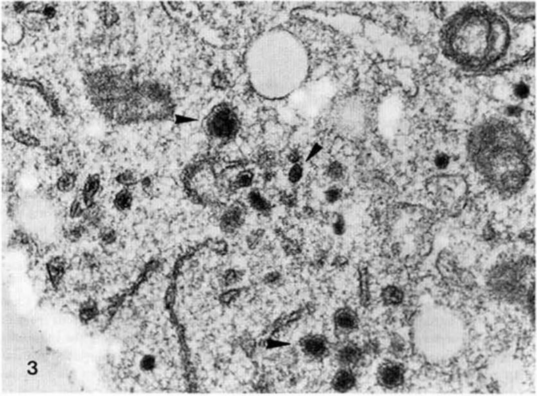


3

phase microscopy. Other siderophilous structures, such as some spore walls (e.g. in *Rhodophyllus*, *Lyophyllum*) are equally well stained.

(1) A small fragment of a gill of living material or of a herbarium specimen is immersed in a few drops of the following fixing and mordanting solution:

Ferric chloride, 10% sol. in acetic acid 50%	5 ml
Copper acetate, 10% sol. in acetic acid 50%	5 ml
Picric acid, saturated sol. in dist. water	5 ml
Formaldehyde, saturated sol. in dist. water	5 ml
Lead acetate, 1% sol. in acetic acid 50%	1 ml

The lead acetate solution is added last, drop by drop while stirring constantly. The final solution is stable for years.

Fix for a few minutes.

(2) Pick up the fragment, blot off the excess of the fixing and mordanting solution and transfer directly into acetocarmine. Add one or two small pieces of broken porcelain or brick to avoid explosive boiling, and heat gently over a small flame. Keep boiling for 1 or 2 minutes. The solution should turn dark from the metal-carmine complexes formed.

Small Pyrex beakers with a capacity of 1 ml are ideally suited for this step, but other small recipients may of course be used as well.

Commercial acetocarmine solutions frequently do not work well because of low carmine content. Prepare your own solutions by boiling under reflux a few grams of carmine (e.g. Merck 2233) with 200–300 ml of 50% acetic acid for 2–3 hours. Filter next day.

(3) After boiling, the entire content of the small beaker is poured onto a paper towel. The fungus fragment is picked up with a needle and transferred into a solution of chloral hydrate prepared from 70 g chloral hydrate and 30 ml of distilled water. Here the fragment is rinsed and infiltrated for a few minutes.

Avoid chloral hydrate solutions older than a few months. They will destain the granules and nuclei very rapidly.

(4) Mount in chloral hydrate solution between slide and coverglass, squash, and observe with high resolution optics. For permanents mounts use Hoyer's medium. Here the stain is durable for many years (in my collection preparations more than 10 years old did not fade appreciably), but do not expose them to frost.

For the preparation of Hoyer's medium see Cunningham (*1972*).

Figs. 1–3. Types of siderophilous granulation in maturing basidia, × 50.000. — 1. Macro type, *Asterophora lycoperdoides*. — 2. Gigas type at the very beginning of its growth, the granules still being irregular in shape. They will grow up to 2–3 μm and form hollow spheres. To the right of the three young granules there is a mature granule in very tangential section (arrow). — 3. Micro type, *Lactarius griseus*. Some granules indicated by arrows.

TABLE I

	GIGAS	MACRO	OLIGO	MICRO	CRYPTO
Size range, µm*)	2–3	0.2–0.6	0.2–0.6	0.05–0.18	0.05–0.15
Extreme size (rare), µm	5	1.4	1	0.3–0.4	unknown
Frequency	low	very high	low	very high	extremely low
Distribution in the basidium	uniform	uniform	basal	uniform/peripheral	anywhere
Visibility, light microscope	striking	very good	very good	from none to good	none or overlooked
Lindtneria	*trachyspora*				
Tylopilus	*felleus*		*felleus*		
Lyophyllum (incl. *Tephrocybe*)		*leucophaeatum* *favrei* *fumosum* *anthracophilum*	*connatum* *ulmarium*		
Calocybe		*gambosa* *ionides*			
Asterophora		*lycoperdoides*			
Rhodophyllus (*Entoloma*)				*bicolor* *prunuloides* *hirtipes* *incanus* *turci* *viridulus*	
Rhodocybe		*suburens* *leucopaxilloides* *Clémençon 77/73*		*nitellina*	*parilis*
Russula				*fragilis* *sardonia* *adusta*	
Lactarius				*maculatus* *griseus*	
Melanoleuca				*alboflvida*	
Agrocybe					*praecox*

Normal size range of full-grown granula. Since the formation of grana continues after kayryogamy, there are always very small granules present in a mature besides the ones that reached final size.

ELECTRON MICROSCOPY

In ultrathin sections siderophilous granules can easily be identified. They are dense fibrillar bodies, mostly circular to elliptic, rarely irregular in outline, surrounded by a unit membrane, and of high electron opacity after staining with uranyl acetate and lead citrate. They are formed by the endoplasmic reticulum in connection with the nuclear cycle. The first granules can be seen at the time of karyogamy. Their number and size increase during the ripening process of the basidium. The nature and significance of this correlation are still unknown (Clémençon, *1968b*).

Vesicles derived from the endoplasmic reticulum (called ERV) occur in every agaric so far studied (over 200 species) and seem to be a common feature of the meiotic and postmeiotic basidium. Siderophilous granules differ from common ERV in their ability to accumulate greater amounts of metal ions, thus standing out with high electron density and with their light microscopic stainability discussed above. Siderophilous granules are a special kind of ERV.

TYPES OF SIDEROPHILOUS GRANULES

Using the light and electron microscope several types of siderophilous granules may be described, depending on the size, abundance, and distribution in the basidium. It is evident from the observed material and from Table I that the types do not represent isolated classes. They intergrade to some extent, but still proved usefull in my laboratory.

(A) THE MACRO TYPE

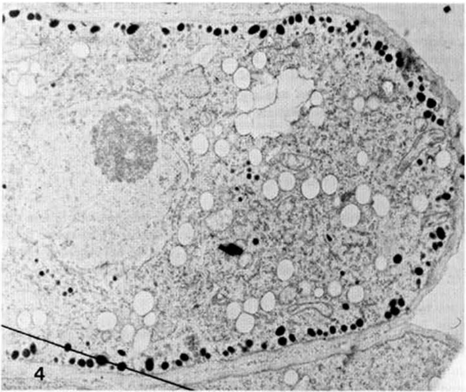
This is the classical siderophilous granulation found in *Lyophyllum*, *Calocybe*, and *Asterophora*. Mature basidia contain very numerous, heavily stained, mostly round granules 0.2–0.6 μm in size, rarely reaching 1.5 μm. The granules are more or less uniformly distributed in the basidium, but mostly leaving a zone of lower density just above the middle of the cell. Because of the high number, size, and good stainability they are easily seen and identified with the light microscope.

This type of granulation occurs outside the Lyophylleae in three closely related species of *Rhodocybe*, actually classified in the Rhodophyllaceae. This lead Clémençon (*1968c*) to transfer two of them into *Lyophyllum* (Tricholomataceae), a proposition that has not been accepted by Singer (*1975*). Since siderophilous granules commonly occur in Rhodophyllaceae, I see no objection in placing the species in question in the genus *Rhodocybe*. These are *Rhodocybe suburens* and *R. leucopaxilloides*. The third species, my collection *77/73* could not be identified yet and represents perhaps a new species close to *Rhodocybe alutacea* Singer.

There is some variation in the final size and form of the siderophilous granules. In most species they stay moderately small and round or even spherical, but in *Lyophyllum* section *Difformia* they grow bigger and become elongate-difform in age. It is quite possible that this behaviour is taxonomically significant.

(B) THE OLIGO TYPE

It is well known that in basidia of *Lyophyllum ulmarium* there may be none or only very few siderophilous granules, a situation that is frequent in an unrelated species, *L. connatum*. If well developed granules are present, they are not very numerous and are situated in the lower part of the basidium. The granules are of the same size and form as in the macro type, but they develop later and rather unwillingly.



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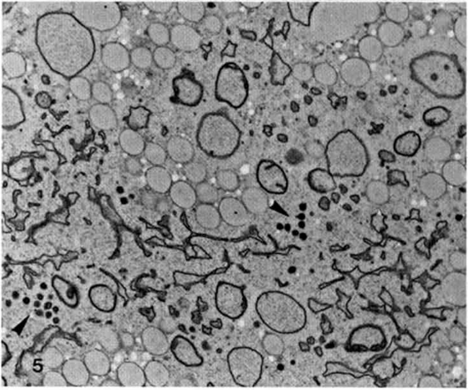

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There is considerable hesitation about the generic distinction of *Lyophyllum ulmarium* and *Hypsizygus tessulatus*, the latter mainly differing in the absence of siderophilous granules. I am not at all convinced that '*Pleurotus ulmarius*' is a *Lyophyllum*; rather would I admit that there is a *Hypsizygus* type of siderophilous granulation. The other species with the oligo type, *L. connatum*, is not a typical member of *Lyophyllum*, and perhaps should be removed, too.

For the time being I refrain from proposing taxonomical changes waiting for culture work to give better answers.

(C) THE GIGAS TYPE

In 1975 Clémençon reported siderophilous granules in the basidia and cystidia of American *Tylopilus felleus*. At first the few granules are small and easily overlooked, but in the cystidia and in some basidia they grow very large and become striking features of the cell. Frequently the very big granules are hollow.

A very similar though not hollow granulation occurs in the basidia of quite unrelated a fungus, *Lindtneria trachyspora* (Aphyllophorales). Here they have been described as cyanophilous granules (e.g. Eriksson & Ryvarden, *1976*). They are more or less uniformly distributed in the basidium and measure up to 2–3 µm. It is not unfrequent that the granules become somewhat difform, especially in *Tylopilus felleus*, and then obscure entire parts of the cell.

(D) THE MICRO TYPE

It is a known fact that many species of *Rhodophyllus* (*Entoloma*) show distinct but small siderophilous granules in some of their very mature basidia (e.g. Moser, *1978*). It was therefore not very surprising to find nice siderophilous granules in almost every mature basidium of that genus so far studied. In comparison with the macro type the granules of the micro type are rather small, the typical size ranging from 0.05 to 0.18 µm. But it is not infrequent to see isolated granules reaching a diameter of 0.3 or even 0.4 µm, thus overlapping somewhat in size with the macro type. Therefore they are sometimes easily seen with the light microscope, but very frequently they are overlooked or go undetectable.

The distribution of the micro type siderophilous granules in the basidium may be uniform in the cell, including the sterigmata and even the young spore, but frequently they take a predominantly peripheral position, as in many species of the section (or subgenus) *Entoloma* of *Rhodophyllus*.

Siderophilous granules of the uniformly distributed micro type have also been detected in *Rhodocybe nitellina*.

Figs. 4, 5. Distribution of micro type siderophilous granulation in mature basidia. — 4. Distribution mainly peripheral. In the center there are small groups of small granules. The peripheral granules are just visible in the light microscope. The two rectangular bodies just below the center are cristals of uranyl acetate used to stain the section. *Rhodophyllus* (*Entoloma*) *bicolor*, × 12,500. — 5. Micro type more or less uniformly distributed in the basidium. *Russula adusta*, × 25,000.

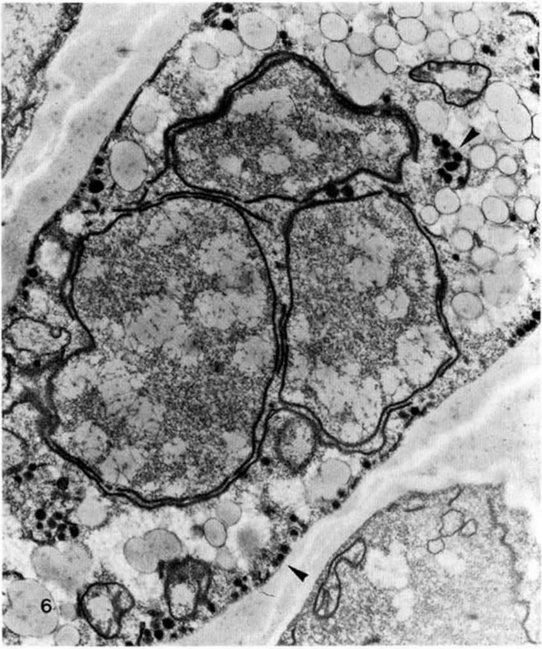
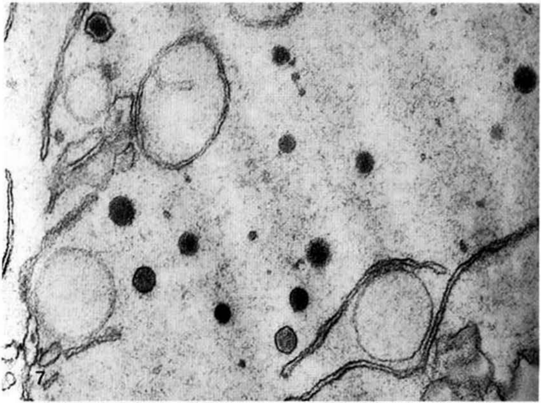


Fig. 6. Micro type siderophilous granulation with peripheral and central distribution in the basidium of *Melanoleuca alboflavida*, × 25,000. Arrows indicate some granules. The three big membrane bound bodies in center are postmeiotic nuclei.

Figs. 7, 8. Micro type granulation with uniform distribution, × 50,000. — 7. *Rhodophyllus incanus*. — 8. *Russula sardonia*.



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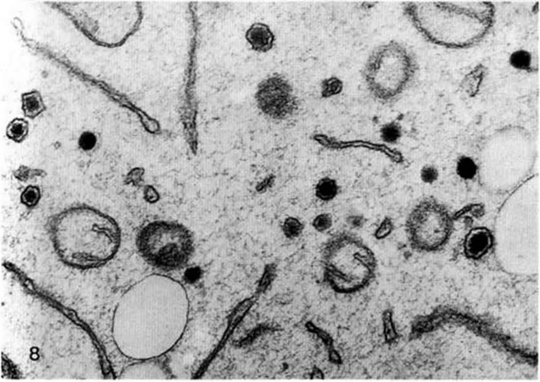

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It came as a big surprise that every species of *Russula* and *Lactarius* so far studied has plenty of uniformly distributed siderophilous granules of the micro type in mature basidia. It seems that in some species the ability to bind metal ions is somewhat attenuated, giving less intense staining in the light microscope and less electron opacity in the electron microscope. Thus some of the *Russula* type siderophilous granules may intergrade with common ERV, and then become totally undetectable with the light microscope. In most species, however, the ERV are quite typical and strongly stained micro siderophilous granules.

It may be mentioned here that in *Melanoleuca alboflavida* from Michigan, U.S.A. the mature basidia contain numerous siderophilous granules of the micro type, arranged peripherally. Unfortunately I do not have data on other species, but my research continues in this direction.

(E) THE CRYPTO TYPE.

When the micro type of siderophilous granules becomes sparse, so that there remain only a few isolated, single granules in a basidium, then they are very hard to discover. Common ERV usually are present in these basidia, differing strikingly from the isolated, dark and small siderophilous granules. So far, this type has been detected in two quite unrelated agarics, *Rhodocybe parilis* and *Agrocybe praecox*, both from Michigan, U.S.A. The main difference between the micro type and the crypto type is the paucity and rare occurrence of the latter in the cell.

Actually, since this type is easily overlooked, it may be more frequent than our experience suggests.

General considerations

It is a fact that vesicles derived from the endoplasmic reticulum and filled with fibrillar masses are formed in every meiotic and postmeiotic holobasidium so far studied. In most species these ERV have no special affinity for metal ions and therefore do not exhibit enhanced electron density after treatment with uranyl acetate and lead citrate, nor do they stain with acetocarmine or hematoxylin. In some species, however, they do accumulate large amounts of metal ions and then they stand out with high contrast both in the electron microscope, and in the light microscope. These siderophilous granules range from very small to very large (approx. 0.05–5 μm) and their frequency in a baidium goes from very low (a few granules per basidium) to very high (the basidium seems 'filled' with granules).

If only very few granules are present they may go totally undetected with the light microscope if they stay very small (crypto type), but they may become very conspicuous if they grow very large (gigas type). It is therefore not surprising to observe both types in the same carpophore, as in *Tylopilus felleus*. Here the crypto type is propably merely an early phase

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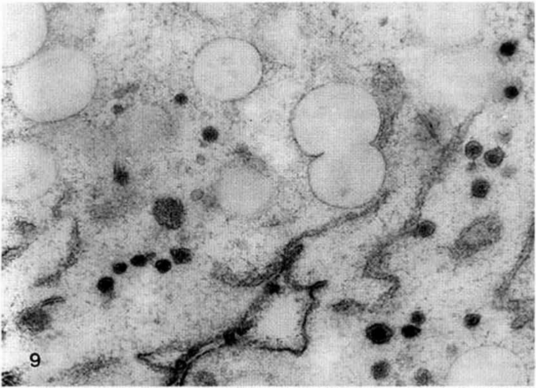
Figs. 9, 10. Micro type siderophilous granulation with uniform distribution, × 50,000. — 9. *Russula fragilis*. — 10. *Russula adusta*.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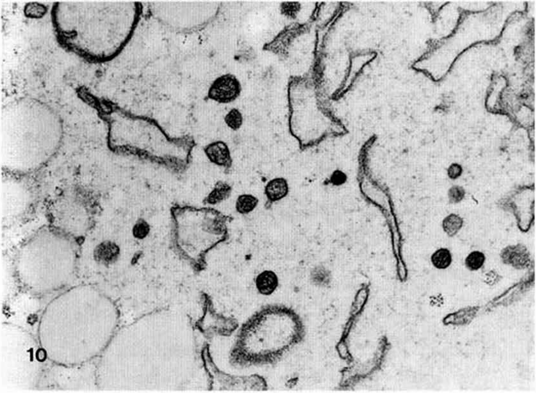
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of the gigas type. In other fungi, e.g. *Agrocybe praecox*, the granules never grow big enough to be seen, and the crypto type stays that way all the time.

For taxonomical mycology the easily observable macro type certainly is of significance. I think that the micro type is of equally high importance for *Rhodophyllus* (*Entoloma*) and for the Russulaceae.

For the moment being, I do not believe that the crypto type, the gigas type and the oligo type have comparable taxonomic weight, although here more observations could give valuable help for taxonomists on the specific level. It is certainly worth while to continue this work.

Collecting data of the fungi mentioned

Lindtneria trachyspora (Bourd. & Galz.) Pilát, *J. Kubička*, Sept. 2, 1976, Switzerland, Bulle FR, Bois de Bouleyres (LAU, Fungarium Clémençon).

Tylopilus fellus (Bull. ex Fr.) Karst., *A. H. Smith & H. Clémençon*, U.S.A., Michigan, Aug. 1, 1968 (LAU, 68081 N).

Lyophyllum leucophaeatum (Karst.) Karst., *H. Clémençon*, September 1962, Switzerland, Belp BE, Groβe Au. (LAU, Fungarium Clémençon).

Lyophyllum favrei Haller & Haller, *H. Clémençon*, September 1962, Switzerland, Belp BE, Groβe Au. (LAU, Fungarium Clémençon).

Lyophyllum fumosum (Pers. ex Fr.) Kühn. & Romagn., *H. Clémençon*, Aug. 21, 1973, Biel BE, Bözingenberg (LAU, 73/42).

Lyophyllum anthracophilum (Lasch) M. Lge & Silvertsen, *H. Clémençon*, Nov. 25, 1967, U.S.A., Missouri (LAU 671125 A).

Calocybe gambosa (Fr.) Donk, *H. Clémençon*, May 6, 1973, Switzerland, Bremblens VD (LAU, 73/11).

Calocybe ionides (Bull. ex Fr.) Kühner, *H. Clémençon*, September 1962, Switzerland, Belp BE, Groβe Au. (LAU, Fungarium Clémençon).

Asterophora lycoperdoides (Bull.) Ditm. ex S. F. Gray, *H. Clémençon*, July 7, 1968, U.S.A., Michigan (LAU, Fungarium Clémençon).

Rhodophyllus prunuloides (Fr.) Quél. *H. Clémençon*, Switzerland, Lausanne, Bot. Gard., May 18, 1971 (LAU, 710518).

Rhodophyllus hirtipes (Schum. ex Fr.) Quél., *H. Clémençon*, May 9, 1973, Switzerland, Le Mont sur Lausanne, Les Liaises (LAU 73/13).

Rhodophyllus incanus (Fr.) Quél., *H. Clémençon*, July 12, 1967, U.S.A., Michigan (LAU, Fungarium Clémençon).

Rhodophyllus turci (Bres.) Romagn., *H. Waridel*, April 24, 1975, Switzerland, Lausanne (LAU, 75/2).

Rhodophyllus viridulus Herink,. *H. Clémençon*, June 24, 1977, Switzerland, Le Mont sur Lausanne, Les Liaises (LAU 77/43).

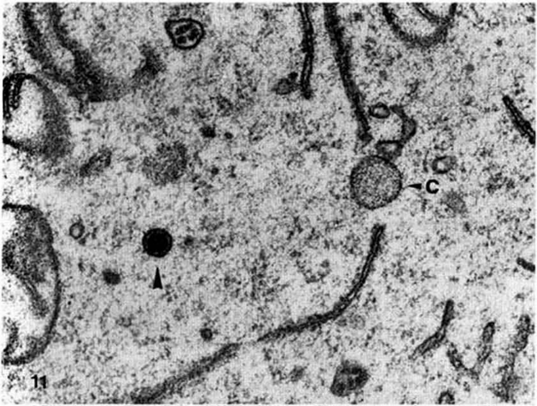
Rhodophyllus bicolor (Murr.), *H. Clémençon*, July 4, 1967, U.S.A., Michigan (LAU, 670704 A).

Rhodocybe suburens (Clémenç.) Sing. & Clémenç., *H. Clémençon*, July 26, 1967, U.S.A., Michigan (LAU, 670726 O).

Rhodocybe leucopaxilloides (Smith & Bigelow) Sing., *H. Clémençon*, July 24, 1967, U.S.A., Michigan (LAU, 670724 C).

Rhodocybe spec. Clémenç. 77/73, *F. Marti*, Aug. 18, 1977, France, Klingenthal-Rothbach (LAU).

Figs. 11, 12. Crypto type siderophilous granulation, × 50,000. — 11. *Agrocybe praecox*, c indicates a common ERV. — 12. *Rhodocybe parilis*. — Arrow indicates the isolated siderophilous granule.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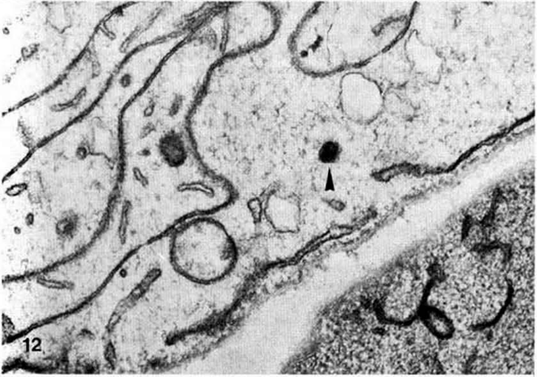
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Rhodocybe parilis (Fr.) Sing., *H. Clémençon*, July 19, 1967, U.S.A., Michigan (LAU, 670719 B).

Russula fragilis (Pers. ex Fr.) Fr., *H. Clémençon*, July 21, 1967, U.S.A., Michigan (LAU, 670721 A).

Russula adusta Fr., *H. Clémençon*, July 21, 1967, U.S.A., Michigan (LAU, 670721 B).

Russula sardonia Fr. em. Romagn., *H. Clémençon*, June 30, 1967. U.S.A., Michigan (LAU, 670630 B).

Lactarius maculatus Peck, *H. Clémençon*, July 30, 1967, U.S.A., Michigan (LAU, 670730 A).

Lactarius griseus Peck, *H. Clémençon*, Aug. 14, 1967, U.S.A., Michigan (LAU, 670814 D).

Melanoleuca alboflavida (Peck) Murr., *H. Clémençon*, June 25, 1967, U.S.A., Michigan (LAU, 670625 C).

Agrocybe praecox (Bolt. ex Fr.) Sing., *H. Clémençon*, April 19, 1967, U.S.A., Missouri (LAU, 670419 A).

REFERENCES

CLÉMENÇON, H. (1967). Beiträge zur Kenntnis der Gattungen *Lyophyllum* und *Calocybe* (Agaricales, Basidiomycetes). II. Cytochemie und Feinstruktur der Basidie von *Lyophyllum urbanense* spec. nov. *In* Nova Hedwigia **19**: 127–142.

—— (1968a). Bemerkungen zum Nachweis der siderophilen Granulation in der *Lyophyllum*-Basidie. *In* Schweiz. Z. Pilzk. **46**: 55–59.

—— (1968b). Beiträge zur Kenntnis der Gattungen *Lyophyllum* und *Calocybe* (Agaricales, Basidiomycetes). VI. Die Entwicklung der siderophilen Granulation. *In* Cytologia **33**: 498–507.

—— (1968c). Beiträge zur Kenntnis der Gattungen *Lyophyllum* und *Calocybe* (Agaricales, Basidiomycetes). III. Zwei Chlamydosporen bildende *Lyophyllum*-Arten. *In* Nova Hedwigia **26**: 417–427.

—— (1969). Das Metallbindungs-Vermögen der *Lyophyllum*-Granulation. *In* Z. Pilzk. **35**: 21–28.

CUNNINGHAM, J. L. (1972). A miracle mounting fluid for permanent whole-mounts of microfungi. *In* Mycologia **64**: 906–911.

ERIKSSON, J. & RYVARDEN, L. (1976). The Corticiaceae of North Europe. Vol. **4**. Oslo.

KÜHNER, R. (1938). Utilisation du carmin acétique dans la classification des Agarics leucosporés. *In* Bull. mens. Soc. linn. Lyon **7**: 204–211.

MOSER, M. (1978). Die Röhrlinge und Blätterpilze. 4. Aufl., Suttgart.

SINGER, R. (1975) The Agaricales in Modern Taxonomy. Ed. 3, Vaduz.

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CONNECTED AND DISCONNECTED CHAINS OF PHIALOCONIDIA AND SAGENOMELLA GEN. NOV. SEGREGATED FROM ACREMONIUM

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Subramanian's concept of true and false chains of phialoconidia is rejected and replaced by a distinction between connected and disconnected chains. In connected conidial chains the primary conidial wall is strongly thickened at both ends and a connective is formed. This criterion allows the distinction between trichocomaceous or eurotiaceous (connected) and sphaeriaceous (disconnected) catenulate phialoconidia. The ultrastructure of conidiogenesis is described. On the basis of this criterion, the species of the *Acremonium diversisporum* series as well as the anamorph of *Sagenoma viride* Stolk & Orr with connected chains are transferred from *Acremonium* to the new genus *Sagenomella* to which four new species are added.

The concept of *Acremonium* Link ex Gray as an admittedly artificial and heterogeneous genus (Gams, *1971*) has received some criticism. The GC-contents of DNA have been found to be discordant even within sections and series (Kedrova *& al.*, *1973*), but as only a few species have been examined no taxonomic conclusions can be drawn. The inclusion of *Gliomastix* Guéguen in *Acremonium* has repeatedly been criticized because some species of *Gliomastix* with pigmented conidia are conspicuous and easily recognizable, in contrast to the species of *Acremonium* with hyaline conidia. None of the critics, however, could disprove the fact that some species with hyaline conidia (e.g. *A. longisporum* and *A. persicinum*) are most closely related to dark-spored species of this section, thus rendering the generic distinction on the basis of conidial pigmentation impracticable. An analogous case is the distinction between pigmented *Stachybotrys* Corda and hyaline *Hyalostachybotrys* Srinivasan which is now abandoned by most mycologists (Jong & Davis, *1976*).

The present paper is concerned with another aspect of the section *Gliomastix* which was so far unnoticed. This section was characterized by Gams (*1971*) as having chondroid hyphae and (or) pigmented conidia. It is now apparent that the admission of species with pigmented conidia and thin-walled hyphae introduced too much heterogeneity into this section. This conclusions was reached after critical consideration of Subramanian's (*1971*, *1972a*, *1972b*; Subramanian & Pushkaran, *1976*) studies on chain formation in phialidic Hyphomycetes.

Subramanian (*1971*) distinguished between dry-persistent and loose chains and he subsequently (*1972a*) specified these as 'false' and 'true' chains. True chains (as in *Aspergillus niger*) were characterized by the fact that 'the wall around the successive conidia in the chain is a continuum'. True chains were said to occur in *Penicillium corylophilum*, *P. clavi-*

forme, *Aspergillus niger*, *Paecilomyces*, *Memnoniella*, *Phialomyces* and in Subramanian's (*1972a*) new genus *Sagrahamala*. An arbitrary selection from the species treated by Gams (*1971*) in *Acremonium* was transferred to *Sagrahamala* (Subramanian, *1972a*; Subramanian & Pushkaran, *1976*), while other similar species passed unnoticed. The type species, *S. luzulae* (Grove) Subram. (Fig. 7e, f), was taken from section *Gliomastix* together with four other species, including *Sagrahamala murorum* (Corda) Subram., which is considered as a variety of the type species of *Gliomastix* by other mycologists (e.g. Dickinson, *1968*) or completely synonymous with it (Gams, *1971*). Surprisingly, the hyaline counterpart of *Acremonium murorum*, *A. persicinum* (Nicot) W. Gams, was regarded as having false chains and therefore representative of *Acremonium*, while four species of the section *Acremonium* were transferred to *Sagrahamala*. In addition, four species treated by Onions & Barron (*1967*) in the monophialidic *Paecilomyces* and by Gams (*1971*) in the *A. striatisporum* series of sect. *Gliomastix* were transferred to *Sagrahamala*, although the phialidic nature of the conidiogenous cells in *S. striatispora* (Onions & Barron) Subram. has been questioned (Subramanian & Pushkaran, *1976*).

ULTRASTRUCTURE OF THE CONIDIAL CHAINS

According to numerous studies with transmission electron microscopy (TEM), phialoconidia are generally produced endogenously within the phialide tip and the conidial wall is formed *de novo* (Cole & Samson, *1979*). The new wall formation involves the apposition of wall material along a zone which becomes progressively thickened within the phialide tip (thus always 'novotunicogenous' sensu Subramanian, *1972b*). The newly formed conidium is cut off at its base by a septum, along which schizolytic liberation sooner or later takes place (Fig. 1). The ease of separation depends on various modifications of the conidial ends: rounded or truncated shape, exudation of slime, or development of wall thickenings.

Fig. 1. Schematic representation of the ontogeny of conidial chains on phialides. Note the progressive wall apposition inside the phialide tip.

Contrary to Subramanian (*1971*, *1972a*), many mycologists principally consider basipetal chains of phialoconidia as 'false chains' (if a distinction from 'true chains' is required at all), since each conidium is completely cut off before the next one is formed and the primary conidial wall is not continuous within the chain but incorporates a new layer with each conidium formed, see Fig. 1. In this sense, true chains can only be acropetal with a considerable continuity of wall and cell contents during the development of the whole chain. There may be a thin, electron-dense, continuous, outer layer which encloses all the conidia of a phialidic chain, but this amorphous layer is exuded secondarily and does not represent a proper wall layer.

TAXONOMIC IMPLICATIONS

Subramanian includes some discordant elements in his category of true chains: the bulk undoubtedly represent anamorphs of Trichocomaceae (Eurotiaceae), particularly the genera *Penicillium* and *Aspergillus*. No teleomorph connections are known in *Sagrahamala*. *Memnoniella* is very close to *Stachybotrys* which is known to be connected with the sphaeriaceous *Melanopsamma* Niessl (Booth, *1957*; Jong & Davis, *1976*). The distinction between trichocomaceous and hypocreaceous–sphaeriaceous phialidic anamorphs is a problem so far unsolved and, therefore, the above criteria and some additional characters were tested for their suitability in distinguishing trichocomaceous from other, sphaeriaceous, phialidic conidia.

CONNECTED AND DISCONNECTED CHAINS

As is evident from previous studies on *Acremonium* (Gams, *1971*), both true and false conidial chains, as defined by Subramanian, would occur in the sections *Acremonium* and *Gliomastix*. The relative width of the delimiting septum which determines the truncate, rounded, or pointed shape of the conidial ends and often also the persistent character of a chain, is not regarded as an important criterion in classification.

A suitable character, however, is found in the structure of the connectives. Connectives remain when during conidial maturation the contents round off and become surrounded by a secondary wall (Fig. 2c). During this process the primary wall forms a narrowed but more or less thickened structure at either end of the conidium and this is generally termed the connective. Persistent chains of conidia provided with connectives at both ends are characteristic of the Trichocomaceae Fischer sensu Malloch & Cain (*1972*; = Eurotiaceae Clem. & Shear), and are here termed *connected chains* (cf. Fig. 2c). Persistent or caducous chains without connectives or with basal apiculations only (e.g. *Metarrhizium*, Hammill, *1972*), are found in the Hypocreaceae, Sphaeriaceae, Chaetomiaceae, and other pyrenomycetous families, and are termed *disconnected chains*. Examples are listed in Table I. Genera and species with slimy conidial heads are often closely related to the latter group.

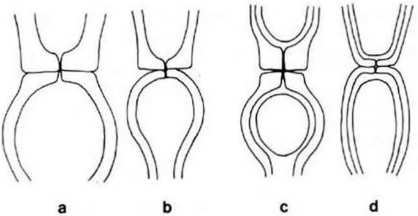

Fig. 2. Schematic representation of the development of caducous (b) and persistent (c, d) phialidic chains. The delimiting septum (a) may round off (b) or remain more or less broadly connected and then either form connectives by further differentiation of the conidial wall (c) or retain a uniform wall thickness throughout (disconnected, d).

From Table I it is evident again that *Acremonium* sensu Gams (*1971*) is a heterogeneous genus. The *A. striatisporum* series is distinguished by its connected chains as well as by its connection with *Sagenoma* Stolk & Orr (*1974*) of the Trichocomaceae. The other cleistocarpous teleomorphs known in *Acremonium*, *Emericellopsis* van Beyma, and *Nigrosabulum* Malloch & Cain, do not affect this conclusion, since they do not belong to the Trichocomaceae.

Since a renewed study of *Acremonium sagenomatis* Stolk & Orr also showed connected conidial chains and the frequent occurrence of reduced, irregularly swollen or sympodially proliferating phialides, like in the *A. striatisporum* series, all these species are regarded as related and removed from *Acremonium*.

Sagenomella W. Gams, *gen. nov.*

Genus Hyphomycetum Acremonii simile. Coloniae lente crescentes, conidiis pulverulentae, albae, griseae, viridulae vel brunneae. Conidiophora plus minusve distincta, erecta, plerumque phialides simplices, raro verticillatas proferunt; phialides aculeatae vel saepe in medio paulo inflatae, saepe irregulariter sympodialiter proliferentes. Conidia continua, hyalina, vel pigmento incrustata et ornamentata, in catenis longis vel brevibus persistentibus connexa, utrinque connectivo terminata.

Species typica: *Sagenomella diversispora* (van Beyma) W. Gams.

A genus of Hyphomycetes close to *Acremonium*. Colonies slow-growing, generally not exceeding 10 mm diam. in 10 days at 20–23°C on MEA, powdery due to the conidial chains, white, grey, greenish or brown. Conidiophores not much differentiated from the vegetative hyphae, erect, usually ending in a simple phialide or rarely bearing several whorls of phialides; phialides aculeate but often centrally swollen, in old cultures often sympodially proliferating. Conidia one-celled, hyaline, or with pigmented incrustations and ornamentations, coherent in long or short persistent chains, with connectives on both ends.

TABLE I

EXEMPLES OF ANAMORPHIC GENERA WITH CATENULATE PHIALOCONIDIA
(TELEOMORPHIC CONNECTIONS IN PARENTHESIS)

Connected chains	Disconnected chains	
Acremonium striatisporum series (*Sagenoma*) *Torulomyces* *Aspergillus* (*Emericella*, *Eurotium*, etc.) *Penicillium* (*Eupenicillium*, *Talaromyces*, etc.) *Thysanophora* *Paecilomyces* p.p. (*Talaromyces*, *Thermoascus*, *Aphanoascus* sensu Udagawa, *Hamigera*) *Acrophialophora* *Phialomyces* *Phialotubus* *Polypaecilum* (*Dichotomomyces*, *Thermoascus*) *Septofusidium herbarum*	*Acremonium* p. max. p. *Monocillium indicum* (*Niesslia*) *Memnoniella* (? *Melanopsamma*) *Riclaretia* (? = *Stachybotryna*) *Phialophora* (*Lasiosphaeria*) *Fusarium* (*Gibberella*, *Calonectria*) *Paecilomyces* p.p. (*Byssochlamys*) *Septofusidium* *Gabarnaudia* (*Sphaeronaemella*) *Penicillifer* (*Chaetomium*) (*Thielavia terrestris*)	*Metarrhizium* *Mariannaea* *Catenularia* (*Chaetosphaeria*) *Sporoschisma* (*Chaetosphaeria*) *Exochalara* *Monilochaetes* *Chalara* (*Ceratocystis*, *Cryptendoxyla*) *Sporendocladia* *Fusichalara* *Scopulariopsis* (*Microascus*, *Kernia*) *Wardomyces* (particularly *Gamsia*) (*Microascus*)

KEY TO THE SPECIES

1a. Conidia (at least partly) distinctly pigmented, ornamented 2
b. Conidia not or faintly pigmented, smooth-walled or slightly ornamented 4
2a. Conidia in short chains (up to 7), covered with irregularly arranged coarse warts . . *S. oligospora*
b. Conidia in long chains, ornamented with longitudinal ribs or rows of warts 3
3a. Conidia variable, onion-shaped to fusiform, always ribbed . . . . *S. striatispora*
b. Conidia of two distinct kinds, onion-shaped, pigmented and coarsely warted, or smaller, fusiform, hyaline and smooth-walled . . . . *S. diversispora*
4a. Dark brown chlamydospores formed singly or in short chains, mostly terminal; conidia ovoid *S. humicola*
b. Chlamydospores absent or paler brown and in chains; conidia mostly fusiform 5
5a. Colonies greyish green due to the conidia 6
b. Colonies white 7
6a. Young colonies grey-olivaceous; phialides generally solitary; chlamydospores absent, even in old cultures . . . . *S. griseoviridis*
b. Young colonies glaucous to greyish citrine-green; phialides often in whorls; chlamydospores often abundant in old cultures, pale brown, often in long, intercalary chains . . . . . *S. verticillata*
7a. Osmophilic hyaline sclerotia present; conidia provided with a conical apical refringent connective; odour often suggesting actinomycetes . . . . *S. sclerotialis*
b. Not osmophilic; sclerotia absent 8
8a. Conidia provided with short truncate connectives at either end, 2.5–3.5 × 1.5–2.2 μm; odour pungent *S. sagenomatis*
b. Conidia with narrow prominent connectives, 3.0–4.5 × 1.2–1.7 μm; odour absent . . . . *S. alba*

Sagenomella striatispora (Onions & Barron) W. Gams, *comb. nov.*—Figs. 3c, d

Paecilomyces striatisporus Onions & Barron *in* Mycol. Pap. **107**: 19. 1967 (basionym). — *Acremonium* striatisporum (Onions & Barron) W. Gams, Cephalosp. Schimmelp. 97. 1971. — *Sagrahamala striatispora* (Onions & Barron) Subram. *in* Curr. Sci. **41**: 49. 1972.

Sagenomella diversispora (van Beyma) W. Gams, *comb. nov.*— Figs. 3a, b

Scopulariopsis diversispora van Beyma *in* Zentbl. Bakt. ParasitKde (Abt. 2) **96**: 430. 1937 (basionym). — *Acremonium diversisporum* (van Beyma) W. Gams, Cephalosp. Schimmelp. 97. 1971.

Paecilomyces variabilis Barron *in* Can. J. Bot. **39**: 1576. 1971. — *Sagrahamala variabilis* (Barron) Subram. & Pushkaran *in* Kavaka **3**: 87. 1976.

Sagenomella humicola (Onions & Barron) W. Gams, *comb. nov.*

Paecilomyces humicola Onions & Barron *in* Mycol. Pap. **107**: 20. 1967 (basionym). — *Acremonium humicola* (Onions & Barron) W. Gams, Cephalosp. Schimmelp. 99. 1971. — *Sagrahamala humicola* (Onions & Barron) Subram. *in* Curr. Sci. **41**: 49. 1972.

Sagenomella griseoviridis (Onions & Barron) W. Gams, *comb. nov.*—Figs. 4a–c

Paecilomyces griseoviridis Onions & Barron *in* Mycol. Pap. **107**: 22. 1967 (basionym). — *Acremonium griseoviride* (Onions & Barron) W. Gams, Cephalosp. Schimmelp. 99. 1971. — *Sagrahamala griseoviridis* (Onions & Barron) Subram. & Pushkaran *in* Kavaka **3**: 89. 1976.

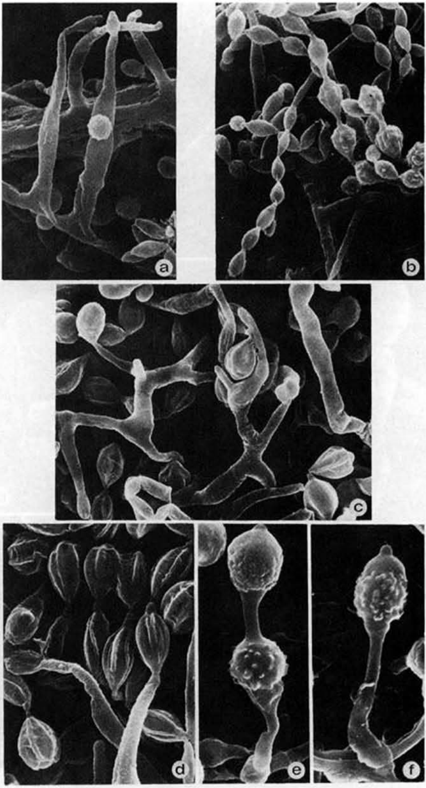

Fig. 3. Scanning electron micrographs of phialides and conidia. — a, b. *Sagenomella diversispora*, CBS 354.36 (Fig. a, × 2880; Fig. b, × 2520). — c, d. *Sagenomella striatispora*, CBS 429.67 (Fig. c, × 2520; Fig. d, × 3600). — e, f. *Sagenomella oligospora*, CBS 615.76, × 2880.

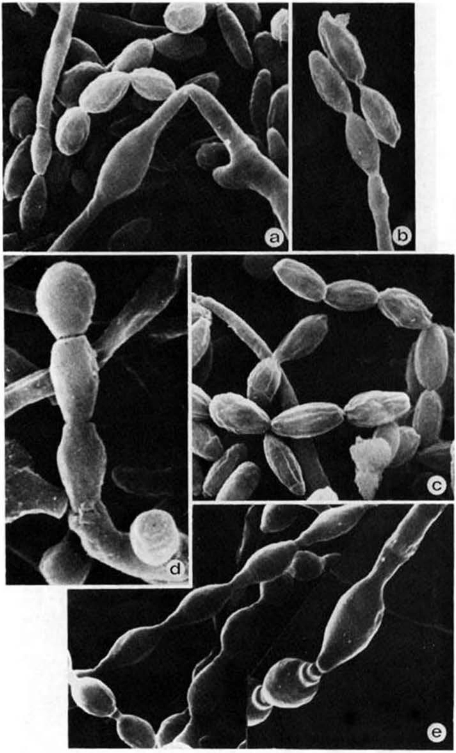

Fig. 4. Scanning electron micrographs of phialides and conidia. — a–c. *Sagenomella griseoviridis*, CBS 426.67 (Fig. a, × 6050; Fig. b, × 6300; Fig. c, × 6050). — d. *Sagenomella sagenomatis*, CBS 114.72, × 8100. — e. *Sagenomella alba*, CBS 167.74, × 6000 (with detail × 8000).

Good growth occurs in the range 18–30°C, with the optimum at 27°C.

ADDITIONAL ISOLATES EXAMINED.— CBS 155.76 and CBS 470.78, isolated from B-horizon of mature *Pinus sylvestris* forest and clear-cut forest, respectively, Jädraås, Prov. Gästrikland, Central Sweden, *B. E. Söderström & E. Bååth*, 1975 and 1977.

Sagenomella sagenomatis (Stolk & Orr) W. Gams, *comb. nov.*—Fig. 4d

Acremonium sagenomatis Stolk & Orr *in* Mycologia **66**: 676. 1974 (basionym).

TELEOMORPH.—*Sagenoma viride* Stolk & Orr, l.c.

Sagenomella oligospora W. Gams & Luiten, *spec. nov.*—Figs. 3e, f, 5

Coloniae in agaro maltoso vel farina avenacea addita post 15 dies 20–25°C ad 36 mm diam., albidae, exigue floccosae, tarde conidiis maturantibus olivascentes. Hyphae vegetativae leves, 1–3 µm latae. Phialides singulae ex hyphis prostratis ascendunt, lageniformes, hyalinae, leves, 7–17 µm longae, e 2–3 µm in ventro ad 1 µm apicem chromophilum versus angustatae, nonnumquam percurrenter proliferentes. Conidia catenis brevibus (1–7) connexa, subglobosa, crassitunicata, connectivis pigmentatis basilari conico prominente et apicali breviore praedita, episporio conspicuo verrucoso vel irregulariter incrustato circumdata, 6.5–8.5 × 4.5–6.0 µm. Chlamydosporae absunt.

Typus: CBS 168.74, isolatus e terra agresti prope Naaldwijk in Neerlandia, *B. van der Pol-Luiten*, 1974.

Colonies on 2% MEA or OA reaching 24–36 mm diam. in 15 days at 20–25°C, whitish, thinly floccose, tardily becoming pale olivaceous-grey due to scanty conidia. Vegetative hy-

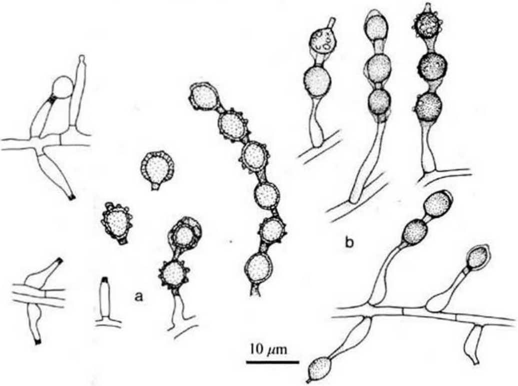

Fig. 5. *Sagenomella oligospora*. — a. CBS 615.76. — b. CBS 168.74.

phae hyaline, smooth-walled, 1–3 μm wide. Phialides arising singly from prostrate hyphae, erect, flask-shaped, hyaline, smooth-walled, 7–17 μm long, tapering from 2–3 μm in the swollen venter to 1.0 μm at the strongly chromophilic tip, only percurrently proliferating. Conidia formed in short chains of 1–5(–7) conidia, subglobose, thick-walled, with a very pronounced basal and a shorter apical pigmented connective, surrounded by a conspicuous brown warted or irregularly spreading incrustation, 6.5–8.5 (including the connectives) × 4.5–6.0 μm (including the ornamentation). Chlamydospores absent.

Good growth occurs in the range 15–33°C with the optimum at 30°C and very little growth occurring at 36°C.

ADDITIONAL ISOLATES EXAMINED.—CBS 404.76, isolated from human nail, comm. O. Fassatiová, Prague, 1976. CBS 615.76, isolated from composted chicken manure, Braunschweig, comm. K. H. Domsch, 1976.

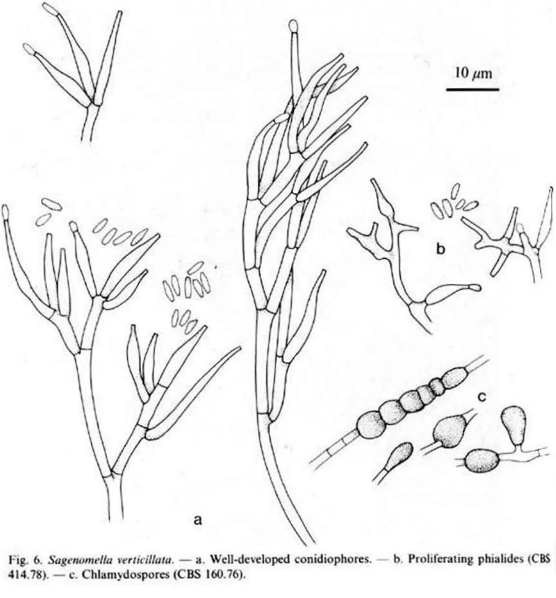

Fig. 6. *Sagenomella verticillata*. — a. Well-developed conidiophores. — b. Proliferating phialides (CBS 414.78). — c. Chlamydospores (CBS 160.76).

Sagenomella verticillata W. Gams & Söderström, *spec. nov.*—Figs. 6, 7a, b

Coloniae in agaro maltoso post 10 dies 20–30°C 6–10 mm diam., pulverulentae vel minute tomentosae, primum glaucae vel citrino-virides, margine angusta hyalina circumdatae, deinde olivascentes; reversum primum album vel electrinum, deinde chlamydosporis maturantibus brunnescens. Hyphae vegetativae hyalinae, leves, 1.0–2.5 µm latae, in coloniis vetustis nonnumquam brunnescentes. Conidiophora erecta, ab hyphis vegetativis vix diversa, plerumque pluries ramosa et nonnullos verticillos binarum ad quaternarum phialidum proferentia; phialides e ventro plus minusve cylindrico, 7–14 × 2–3 µm, et apice latitudine ad 0.5–1.0 µm diminuto, 5–12 µm longo constant. Alterae phialides breviores, forma variabiles et saepe sympodialiter proliferentes. Conidia longis catenis connexa, fusiformia, utrinque truncata et minute apiculata, hyalina ad subhyalina, levia vel minute incrustata, 3.4–4.0 × 1.5–2.2 µm. Chlamydosporae in coloniis vetustis plerumque copiosae, intercalares vel terminales, vulgo catenulatae, plus minusve elongatae, leves, subhyalinae ad brunneae, 3.0–5.5(–9) µm diam.

Typus: CBS 414.78, isolatus e terra pineti in Suecia.

Colonies on 2% MEA reaching 6–10 mm diam. in 10 days at 20–30°C, powdery due to the conidia, smooth or slightly tufted in the centre, in young cultures glaucous to greyish citrine-yellow with a narrow hyaline margin, later becoming olivaceous-grey; reverse at first white or amber, later becoming tardily brown in the centre. Vegetative hyphae hyaline, smooth-walled, 1.0–2.5 µm wide, in old cultures partly becoming brown. Conidiophores erect, hardly differentiated from the vegetative hyphae at the base, usually repeatedly branched and bearing several whorls of 2–4 phialides. Well developed phialides differentiated into an almost cylindrical or somewhat inflated venter, 7–14 × 2–3 µm, and a tapering neck which is 5–12 µm long and 0.5–1.0 µm wide at the tip; atypical phialides appearing in old cultures, shorter and of irregular shape and often sympodially proliferating. Conidia cohering in long chains, fusiform, with slightly apiculate and truncate ends, hyaline, to slightly pigmented, smooth-walled or very finely encrusted, 3.5–4.0 × 1.5–2.2 µm. Chlamydospores usually abundant in old cultures, intercalary or terminal, often in chains, more or less elongate, smooth- and thick-walled, subhyaline to brown, 3.0–5.5(–9) µm diam.

Good growth occurs in the range 18–33°C with the optimum at 27°C; no growth occurring at 36°C.

ISOLATES EXAMINED.—CBS 450.71, isolated from agricultural soil, Wageningen, *J. H. van Emden*, 1971. CBS 119.72 (71–48), CBS 120.72 (71–52), CBS 145.72 (71–50), all isolated from soil, Francis Park, Vancouver Island, B.C., Canada, *J. Paden*, 1972. CBS 985.73, isolated from vaginal fluor of a patient at Zeist, Netherlands, comm. Dr. Rebholz. CBS 481.74, isolated from B-horizon soil, Lago Indio, Tierra del Fuego, Argentina, *A. Godeas*, Jan. 1973 (527). CBS 160.76, isolated from B-horizon of mature pine forest (*Pinus sylvestris*), 1975; CBS 414.78 (type strain) and CBS 417.78, isolated from A_2-horizon of a clear-cut pine forest, 1977 and 1976; CBS 415.78 A and B, and CBS 416.78, isolated from B-horizon, of clear-cut pine forest, 1977, all collected at Jädraås, Prov. Gästrikland, Central Sweden, *B. E. Söderström & E. Bååth.*

Sagemonella verticillata has for some years been confused with *S. griseoviridis*, until it was realized that the absence of chlamydospores and the constantly solitary phialides in the latter were quite constant features. Moreover, SEM studies confirm their distinction, in that no trace of a longitudinal ornamentation could be found in conidia of *S. verticillata*. The verticillate arrangement of the phialides in this species is similar to that in *Paecilomyces* Bain. (Samson, *1974*), but the more or less basitonous ramification of the hardly differentiated conidiophores distinguishes it from this genus. The biapiculate conidia and the frequent irregular sympodial proliferation show its affinity to other species of *Sagenomella*. The species can thus easily be recognized even if chlamydospores are almost absent as in

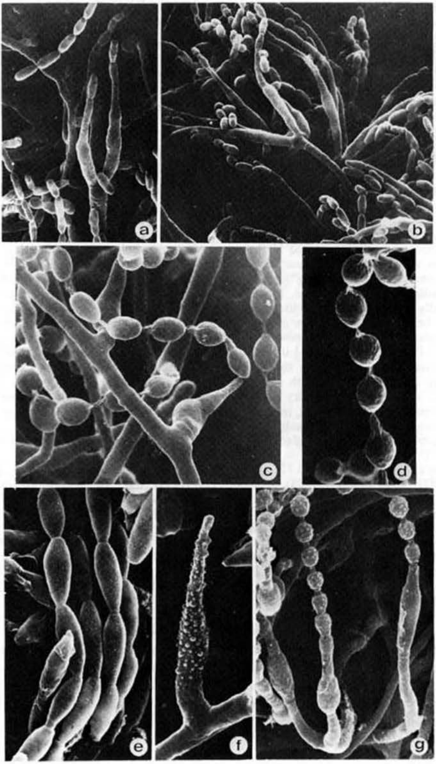

Fig. 7. Scanning electron micrographs of phialides and conidia. — a, b. *Sagenomella verticillata*, CBS 414.78, × 1600. — c, d. *Sagenomella sclerotialis*, CBS 366.77 (Fig. c, × 3000; Fig. d, × 3600). — e, f. *Acremonium luzulae*, CBS 494.67 (Fig. e, conidial chains, × 3000; Fig. f, phialide, × 2400). — g. *Torulomyces lagena*, CBS 185.65, × 3000.

CBS 120.72, CBS 415.78 A and B, and CBS 417.78. It differs from *S. humicola*, which can also form verticillate phialides, by having generally catenulate chlamydospores and fusiform conidia.

Sagenomella sclerotialis W. Gams & Breton, *spec. nov.*—Figs. 7c, d, 8

Coloniae in agaro maltoso 15% saccharosio addito lente crescunt 25°C, sed multo melius 33–36°C, albae, floccosae, deinde sclerotiis granulatae. Hyphae vegetativae leves, (1–)2–3 μm latae, nonnumquam ad 5 μm inflatae. Phialides plerumque simplices ex hyphis repentibus submersis vel aeriis oriundae, 5–15 μm longae, e 1.2–1.8 μm sursum ad 1.0 μm modice angustatae, rectae vel flexuosae; phialides brevissimae saepe septo basilari carent. Conidia longis catenis connexa, ovoidea, basi truncata, apice acuto refringenti praedita, 3.0–4.5 × 1.5–2.0 μm. Chlamydosporae absunt, sclerotia plus minusve globosa, firma, alba, 125–350 μm diam. in coloniis vetustis copiosa.

Typus: CBS 366.77, isolatus e pabulo Lolii, Montoldre in Gallia, ab *A. Breton & P. Zwaenepoel*, 1976.

Colonies on MEA with 15% saccharose reaching 12 mm diam. at 24°C and 25 mm at 33–36°C, white, somewhat lanose, later becoming granular due to sclerotia. Odour suggesting actinomycetes in colonies grown at 27°C or above. Vegetative hyphae smooth-walled, (1–)2–3 μm wide, sometimes inflated to 5 μm. Phialides mostly arising singly from prostrate submerged or aerial solitary or fasciculate hyphae, 5–15 μm long, slightly tapering from 1.2–1.8 μm to 1.0 μm, straight or flexuous; the shortest phialides often not delimited from the subtending hypha by a basal septum. Conidia cohering in long chains, ovoid, with a truncate base; the apical connective transformed into a conspicuous refringent cone which collapses when dry (Figs. 7c, d), 3.0–4.5 × 1.5–2.0 μm. Chlamydospores absent; sclerotia abundant in old cultures, more or less globose, firm and almost smooth-walled but surrounded by some loose hyphae, white, 125–350 μm diam., consisting of isodiametric cells 4–10 μm diam.

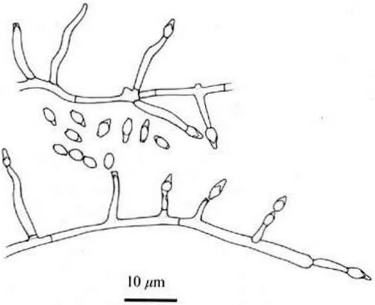

Fig. 8. *Sagenomella sclerotialis*, CBS 366.77.

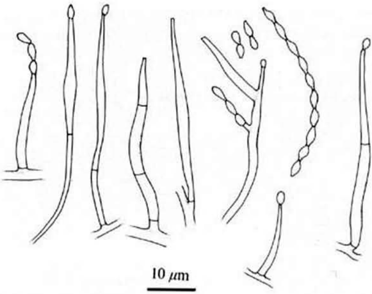

Fig. 9. *Sagenomella alba*, CBS 210.74.

Growth on MEA with 15% saccharose or Czapek's agar with 20% saccharose is better than on 2% MEA, no growth occurring on MEA with 12% NaCl. Growth is scanty at 18–21°C but luxuriant at 30–36°C.

This species was commonly isolated from fodder of Ray-grass and lucerne in the region of Montoldre, 03-France, in 1976 and 1977, on malt and Czapek agars at 24°C.

Sagenomella alba W. Gams & Söderström, *spec. nov.*—Figs. 4e, 9

Coloniae in agaro maltoso post 10 dies 20–23°C 6 mm diam. (30°C non crescunt), pulverulentae, albae. Hyphae vegetativae leves, 1.0–2.5 µm latae. Phialides orthotropicae vel terminales ex hyphis submersis oriuntur, plerumque simplices sed nonnumquam irregulariter sympodialiter proliferentes, aculeatae, saepe inflatae in medio, 12–30 µm longae, 2 µm latae in medio et ad 0.5–1.0 µm sursum angustatae. Conidia longis catenis connexa, hyalina, levia, fusiformia vel connectivis prominentibus limoniformia, 3.0–4.5 × 1.2–1.7 µm. Chlamydosporae et sclerotia absunt.

Typus: CBS 167.74, isolatus e terra piceeti in Suecia, *B. E. Söderström*, 1974.

Colonies on 2% MEA reaching 6 mm diam. in 10 days at 20–23°C (no growth at 30°C), pure white, powdery. Odour absent. Vegetative hyphae hyaline, smooth-walled, 1–2.5 µm wide. Phialides arising orthotropically or terminally from undifferentiated submerged hyphae, usually simple but sometimes irregularly sympodially proliferating, aculeate, often centrally swollen, 12–30 µm long, 2 µm wide at the widest part, and tapering to 0.5–1.0 µm at the tip. Conidia cohering in long chains, hyaline, smooth-walled, fusiform or lemon-shaped due to the prominent connectives, 3.0–4.5 × 1.2–1.7 µm. Chlamydospores and sclerotia absent.

Good growth occurs in the range 15–21°C, none at 27°C or above.

ISOLATES EXAMINED.—CBS 167.74 (type strain) and CBS 210.74, isolated from A_{02}-horizon of planted spruce forest (*Picea abies*), Prov. Skåne, South Sweden, *B. E. Söderström*, 1974.

DISCUSSION

Apart from the somewhat deviating *S. oligospora* and *S. sclerotialis*, *Sagenomella* seems to be a rather homogeneous genus which is distinct from *Acremonium* not only by the connected conidial chains but also by the sympodially proliferating and often centrally swollen phialides. Whilst in *Acremonium* an apiculation of both conidial ends may be indicated in some rare cases, this feature is visible in *Sagenomella* in all but the terminal conidia.

The similar genus *Torulomyces* Delitsch has very conspicuously connected conidial chains but conidiophores which are regularly differentiated into a slender stalk cell and a flask-shaped phialide, thus warranting the generic distinction (Fig. 7g).

The recognition of connected conidial chains in this study is based on both light-microscopic and SEM observations. In *S. sagenomatis* and the other pale species, the former technique gives more conclusive evidence than the latter. Further TEM work will be necessary to verify the assumptions made in this study.

The conidial chains of *Acremonium luzulae* (Figs. 7e, f) and the remaining species of section *Gliomastix* are regarded as disconnected. It might be predicted that a sphaeriaceous teleomorph could be connected with these species. Consequently *Sagrahamala* Subram. is regarded as a synonym of *Acremonium* section *Gliomastix*. Once again it is emphasized, that *Wallrothiella subiculosa* Höhn. (anamorph known as *Gliomastix protea* Sacc.) is not related to species of this section, since the hyphae are pigmented and the conidial pigment is localized in the wall itself and not superficially encrusted as in typical *Gliomastix*. The species hitherto placed in *Paecilomyces* also require further study in the light of these considerations.

ACKNOWLEDGEMENTS

The author is grateful to Professor C. V. Subramanian for his stimulating ideas which led to this study, although the opionions turned out to differ, and to Dr. R. A. Samson for several helpful suggestions. Mycologists contributing cultures have been gratefully recorded in the text. Miss M. Nieuwstad skilfully assisted in the SEM work and Miss I. ten Hoedt in inking the drawings.

REFERENCES

BOOTH, C. (1957). Studies of Pyrenomycetes: II. *Melanopsamma pomiformis* and its *Stachybotrys* conidia. *In* Mycol. Pap. **68**: 16–27.

COLE, G. T. & SAMSON, R. A. (1979). Patterns of development in conidial fungi. London.

DICKINSON, C. T. (1968). *Gliomastix* Guéguen. *In* Mycol. Pap. **115**: 1–24.

GAMS, W. (1971). *Cephalosporium*-artige Schimmelpilze (Hyphomycetes). Stuttgart.

HAMMILL, T. M. (1972). Electron microscopy of phialoconidiogenesis in *Metarrhizium anisopliae*. *In* Am. J. Bot. **59**: 317–326.

JONG, S. C. & DAVIS, E. E. (1976). Contribution to the knowledge of *Stachybotrys* and *Memnoniella* in culture. *In* Mycotaxon **3**: 409–485.

KEDROVA, O. S., TARASOV, K. L. & ANTONOV, A. S. (1973). (Composition of DNA of some species belonging to *Acremonium* Link ex Fr. genus as correlated with its systematic position.) *In* Mikol. Fitopatol. **7**: 93–95.

MALLOCH, D. & CAIN, R. F. (1972). The Trichocomataceae: Ascomycetes with *Aspergillus*, *Paecilomyces*, and *Penicillium* imperfect states. *In* Can. J. Bot. **50**: 2613–2628.

ONIONS, A. H. S. & BARRON, G. L. (1967). Monophialidic species of *Paecilomyces*. *In* Mycol. Pap. **107**: 1–25.

SAMSON, R. A. (1974). *Paecilomyces* and some allied Hyphomycetes. *In* Stud. Mycol. **6**: 1–119.

STOLK, A. C. & ORR, G. F. (1974). *Sagenoma*, a new genus of Eurotiaceae. *In* Mycologia **66**: 676–680.

SUBRAMANIAN, C. V. (1971). The phialide. *In* B. Kendrick (ed.), Taxonomy of Fungi Imperfecti: 92–119.

—— (1972a). Conidial chains, their nature and significance in the taxonomy of Hyphomycetes. *In* Curr. Sci. **41**: 43–49.

—— (1972b). Conidium ontogeny. *In* Curr. Sci. **41**: 619–624.

SUBRAMANIAN, C. V. & PUSHKARAN, M. (1976). Conidium ontogeny in some monophialidic Hyphomycetes. *In* Kavaka **3**: 77–99 ('1975').

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THE OPERCULATE ASCUS AND ALLIED FORMS*

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The features of the operculate ascus and allied non-operculate forms are discussed. An outline of the results of recent research on fine structure and function of the different types of asci in Pezizales is presented.

When the Crouan brothers (*1857, 1858*) discovered the operculum at the top of asci, they placed all species with asci opening by such a structure in the genus *Ascobolus*.

Boudier (*1879, 1885*) was the first to recognize the importance of the operculate mode of ascus dehiscence for the classification of the Discomycetes. Accordingly he divided the cup fungi on the base of this character into two groups, (i) the Operculatae and (ii) the Inoperculatae.

It is a notable fact that none of Boudier's contemporaries (e.g. Quélet, Karsten, Fuckel, De Notaris, Schroeter, Saccardo, Rehm, Cooke, Phillips, Lindau) accepted this division. It became accepted only much later by Gäumann (*1926*), Seaver (*1927, 1928*), Nannfeldt (*1932*), and Le Gal (*1947, 1953*).

A subdivision of the cup fungi based on the mode of ascus dehiscence is now accepted by most mycologists.

All operculate Discomycetes belong to the order Pezizales, but on the other hand, not all fungi arranged within the Pezizales show operculate asci.

Already more than a century ago Boudier (*1869*) described the typical operculate ascus with an apical ring-shaped indentation delimiting the operculum. But he also found in *Peziza cunicularia* (Boudier, *1869*) asci opening at their tips by a bilabiate split.

Shortly afterwards Renny (*1871, 1873*) described several such fungi, which he placed in *Ascobolus* section *Ascozonus*.

Other non-operculate asci were studied and described in *Thelebolus* and allied genera (Zukal, *1886*; Ramlow, *1906, 1915*; Kimbrough, *1966, 1972*; Kimbrough & Korf, *1967*). Here mature asci open by an irregular tear in the apical part of the ascus wall.

A special type of operculate ascus has been described by Chadefaud (*1946*) and Le Gal (*1946a, 1946b*) as 'para-operculate' and 'sub-operculate' respectively. They regarded this

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structure important enough to distinguish a separate order or suborder between Inoperculatae (Helotiales) and the remainder of the Operculatae.

The published terminology for structural details of this type of ascus is rather confusing as both French authors used mostly different terms for the same detail and sometimes slightly altered ones for quite different elements (cf. Le Gal, *1946b*; van Brummelen, *1975*).

The term 'suboperculate ascus' as introduced by Le Gal has been generally accepted.

The suboperculate ascus was considered the most important character of the Suboperculati. It is defined by the 'coussinet apical', which Le Gal described as an interrupted ring located in the 'chambre apical' in the top of the ascus.

However, both Eckblad (*1968*, *1972*) and I (van Brummelen, *1975*) could not find sufficient evidence for the existence of the sub-operculate ascus in the original sense (cf. also Samuelson, *1975*).

From the drawings published by Le Gal (*1946b*) it was possible to conclude that the 'coussinet apical' rather represents different structures in the top of the ascus.

Although the ascus of *Sarcoscypha* and a few related genera may represent a special type of operculate ascus within the Pezizales, there is little left of the hypothesis that the Suboperculati (or Sarcoscyphineae) should represent a taxon intermediate between Inoperculatae and Operculatae.

THE ASCUS

The shape and the structure of the asci in Pezizales show a wide range of possibilities. The shape of the asci depends on their number within each fruit body, the number of spores per ascus, as well as the pressure exerted upon the ascus by the surrounding hymenium and excipulum. In closed (cleistohymenial) fruit bodies with a single ascus this shape is often subglobular (e.g. in *Thelebolus stercoreus*, *Trichobolus zukalii*, *Lasiobolus monascus*). Obovoid asci are found in species with only a few asci within each fruit body (e.g. in the genera *Thelebolus*, *Leptokalpion*, *Ascodesmis*, *Dennisiopsis*, *Saccobolus*). Clavate and cylindrical asci, however, are most frequently met with in the Pezizales. As a rule the clavate forms prevail in the smaller fruit bodies which have a less developed lateral excipulum, whereas cylindric ones occur in the larger fruit bodies.

The ascus demonstrates a clear polarity in the distribution of its contents, which even changes during development. After the formation of ascospore nuclei from the diploid nucleus two zones can be distinguished: the upper part which becomes the sporogenous zone and the basal part filled with cytoplasm, containing reserves like glycogen. The structure of the latter was described by Schrantz (*1968*).

The ultrastructure of the ascoplasm varies considerably. As shown by the studies of Merkus (*1975*, *1976*), in some genera and groups of species it is more complex than in others, while the presence of electron-dense globular structures in the epiplasm seems to be correlated with the formation of oil drops in the sporoplasm.

During sporogenesis and the ripening of the ascospores the epiplasm becomes continuously more vacuolized. Meanwhile glycogen and organels are disappearing. Only at the end of this stage the ascus is ripe and ready to discharge its spores.

In most asci of the Pezizales one meiosis and two mitoses take place to form eight nuclei, each of which initiates the formation of a unicellular ascospore. In a few species of some unrelated genera four-spored asci seem to be a constant character (cf. Eckblad, *1968*). In some of these, four of the eight spores degenerate.

Cytological investigations by Berthet (*1964*) revealed that in most operculate Discomycetes the ascospores are uninucleate, save in Sarcoscyphaceae and Morchellaceae, where the spores are plurinuclear with maturity, and in Helvellaceae, where they are tetranuclear. In several genera of coprophilous Thelebolaceae meiosis is followed by more than two mitoses, resulting in asci having 16 to over 4000 spores.

THE ASCOSPORES

Ascosporogenesis of operculate Discomycetes was studied with electron microscopy in *Saccobolus kervernii* by Carroll (*1966, 1967, 1969*), in *Ascodesmis sphaerosporus* by Moore (*1963*) and Carroll (*1966*), in *Ascodesmis nigricans* by Bracker & Williams (*1966*), in Pyronema by Reeves (*1967*) and Griffith (*1968*), in *Ascobolus immersus* by Delay (*1966*), in *Ascobolus viridulus* by Oso (*1969*), in *Ascobolus stercorarius* by Wells (*1972*), and in *Pustularia cupularis* by Schrantz (*1966, 1967*).

While the ascospores of the Inoperculatae are always smooth, many operculate Discomycetes develop a more or less complex spore sculpturing.

Le Gal's (*1947*) detailed studies on ascospore ornamentation with the aid of light microscopy, have exercised a far-reaching influence on the taxonomy of the operculate Discomycetes. She described a great variation of the patterns of ornamentation, of which the development often seemed to be extremely complex.

Submicroscopical investigations in this field were rather fragmentary and not focused on taxonomic comparison.

Recently a comparative study of the ultrastructure and development of ascospore ornamentation with the Pezizales was published by Merkus (*1973, 1974, 1975, 1976*). She demonstrated that, in principle, the development of the ascospore ornamentation is a single common process with a certain number of variations.

In smooth-spored species an initial ornamentation is formed, which disappears again during further ripening of the ascospores. In a few other smooth-spored species a permanent smooth ornamentation is deposited on the ascospore wall (Merkus, *1976*).

It is clear from these studies that the ascospore ornamentation should be used with great caution in the delimitation of genera or families.

MATERIALS AND METHODS

Up to now over 45 species of Pezizales belonging to about 30 genera have been studied by me with light and electron microscopy to analyse the dehiscence mechanism of their asci. The light microscope revealed information about the structure and function of the living ascus. Vital and subvital observations have been made in squash mounts in a slightly hypotonic solution of glycose in distilled water. The slides were examined with phase contrast and Nomarski's interference contrast optics. Of special value proved to be the observation of unstained asci with polarized light. For light microscopy asci were also stained with a wide variety of dyes, of which Congo red, acid fuchsin, trypan blue, methyl blue, and methylene blue gave satisfactory results. Also, sections about 0.5 μm thick of material fixed in glutaraldehyde and osmium tetroxide and subsequently embedded in epoxy resin proved to be of great value. These sections were stained with toluidine blue.

When using Congo red as a stain for wall material one should be aware that this stain shows two staining mechanisms: one which is by chemical linkage (a 'true staining'), and a second which is by physical adsorption of the long dipolar molecules by the surfaces of microfibrillae where there is sufficient space for them to penetrate.

For electron microscopy material was fixed as usual in buffered glutaraldehyde or in $KMnO_4$ and postfixed in 1% OsO_4 (cf. van Brummelen, *1974*).

For studies of the ascus wall, material fixed in $KMnO_4$ proved to be most valuable.

OBSERVATIONS

The lateral wall of the operculate ascus consists of at least two layers. The outer layer is usually rather thin and strongly birefrigent. It stains red with Congo red and bluish violet with toluidine blue. The inner layer is usually thicker, less rigid and only weakly anisotropic. It stains reddish with toluidine blue and does not stain with Congo red. In the electron microscope the inner layer is more electron transparent in permanganate-OsO_4-fixed material.

It is my experience that the outer layer is the more variable in appearance. In young asci its surface is usually sharply delimited, but under other circumstances it may sometimes become swollen and mucilaginous with a rather diffuse delimitation at the outside. This is in agreement with recent findings of Reisinger & *al.* (*1977*) on the ultrastructure of hyphal walls of Ascomycetes and Basidiomycetes. In asci with thick walls (e.g. Thelebolaceae) or in strongly swollen layers (e.g. some Sarcoscyphaceae) a sublayering or lamellation is often visible.

In many Operculates the ascus wall is covered by an extra-ascan layer, the periascus of Chadefaud, which is usually more apparent in the apical part of the ascus. In genera with the ascus wall staining blue with iodine, this reaction is strictly confined to the mucilagenous substance of the periascus.

During ripening, the apical wall of the ascus develops certain structures to form an opening mechanism. The apical part of the wall tends to become more complex and may consist of three to four layers. Certain parts of the apical wall may become weakened by the formation of indentations, fracturing lines and weakened zones or by local breakdown or gelatinization of the wall. In other, often adjoining, parts the wall may become strengthened and more rigid. The moment at which these changes in the wall become manifest differs greatly. Sometimes they are scarcely visible before the moment of ascus dehiscence. The study of emptied asci is always necessary to decide with certainty on the structure and the mechanism of ascus dehiscence.

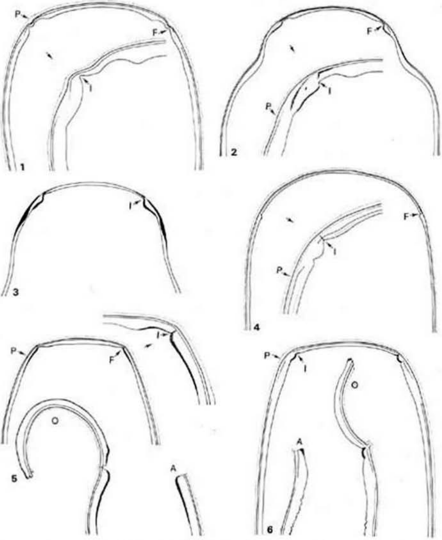
Types of asci

The following principal types of asci can be distinguished in the Pezizales.

(1) Ascobolus type [=The traditional standard model of the operculate ascus].—

Operculum very large, sharply delimited by a circular internal indentation just at the inner side of a strengthened ring. The operculum and region under the ascostome are strengthened and rigid. This causes the typical sinuous outline of the apex. Ascostome smooth. Periascus of rather uniform thickness; staining blue with iodine. Funiculus present.

Examples: *Ascobolus furfuraceus* (Fig. 1), *A. sacchariferus*, *Saccobolus glaber* (Figs. 2, 3), *Thecotheus* spec. (Fig. 5), *Boudiera echinulata* (Fig. 4), and *Iodophanus carneus* (Fig. 6).



Figs. 1–6. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Fig. 1. *Ascobolus furfuraceus*. — Fig. 2. *Saccobolus glaber*. — Fig. 3. The same, as seen with light microscopy in sections stained with toluidine blue. — Fig. 4. *Boudiera echinulata*. — Fig. 5. *Thecotheus* spec. — Fig. 6. *Iodophanus carneus*.

(2) Peziza type.—

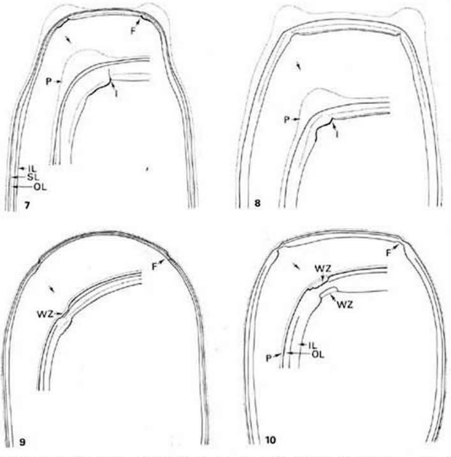
Operculum sharply delimited by a circular internal indentation just at the inner side of a weakly developed ring. The operculum and a region under the ascostome are strengthened and rigid. Wall structure rather complex. Ascostome smooth. Periascus strongly developed, with ring-shaped thickening over the ascostome, tapering towards the base; staining blue with iodine. Funiculus present.

Examples: *Peziza badia, P. succosella* (Fig. 7), *P. depressa, P. ammophila* (Fig. 8), and *P. cerea.*

(3) Ascodesmis type.—

Operculum very large, sharply delimited by a weak indentation and a circular zone of two-sided wall desintegration. Ring only weakly developed. Operculum strengthened but not rigid. Ascostome smooth. Periascus very thin; not blued with iodine. Funiculus and funnel absent.

Examples: *Ascodesmis nigricans* (Fig. 9) and *A. microscopica* (Fig. 10).

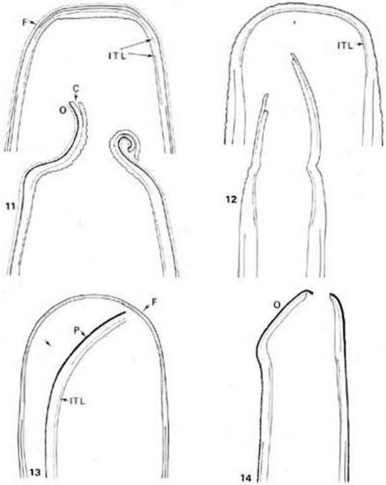


Figs. 7–10. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Fig. 7. *Peziza ammophila.* — Fig. 8. *Peziza succosella.* — Fig. 9. *Ascodesmis nigricans.* — Fig. 10. *Ascodesmis microscopica.*

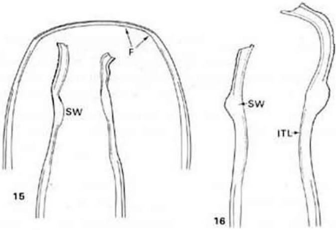
(4) OCTOSPORA TYPE..—

Operculum rather roughly delimited, without indentation or prominent ring, sometimes strengthened at its inner side by an electron-transparent layer. Apical wall with thimble-shaped electron-dense lamina interrupted by a thick ring-shaped electron-transparent zone. Dehiscence takes place in a weakened zone between the electron-transparent ring and the strengthened operculum. If the operculum is not strengthened the operculum may be torn irregularly. Cleavage of wall and operculum along the thimble-shaped lamina above the electron-transparent ring is rather frequent after dehiscence. Ascostome rough. Periascus thin if present; not blued with iodine. Funiculus present.

Examples: *Pyronema omphalodes* (Fig. 11), *Anthracobia maurilabra* (Fig. 12), *Aleuria aurantia* (Figs. 13, 14), *Otidea onotica*, *Coprobia granulata* (Figs. 15, 16), *Cheilymenia pulcherrima*, *C. vitellina* (Fig. 17), *Scutellinia armatospora* (Fig. 18), *Octospora musci-muralis* (Fig. 19), and *Sowerbyella unicolor* (Fig. 20).



Figs. 11–16. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Fig. 11. *Pyronema omphalodes*. — Fig. 12. *Anthracobia maurilabra*. — Figs. 13, 14. *Aleuria aurantia*.



Figs. 15–16. Diagrammatic sections of ascus tops, as seen with electron microscopy. *Coprobia granulata*.

(5) HELVELLA TYPE.—

Operculum sharply delimited at its basal side by a ring-shaped breaking-line just at the inner side of a narrow, scarcely proliferating ring. Apical wall with a thimble-shaped electron-dense lamina, which is only interrupted by the proliferating ring. Ascostome smooth. Periascus very thin; not blued with iodine. Funiculus present.

Examples: *Helvella crispa* (Fig. 21) and *Geopyxis carbonaria* (Fig. 22).

(6) URNULA TYPE.—

Operculum rather roughly delimited by an external ring-shaped zone of wall desintegration, without indentation or proliferating ring, not strengthened. In the inner wall layer of the top a thimble-shaped electron-dense lamina is formed, which is intercepted at the apex by a broad ring-shaped electron-transparent zone. Near the upper margin of this zone the operculum is torn loose. Ascostome rather rough. Periascus very thin, not staining blue with iodine. Funiculus not yet recorded.

Example: *Urnula platensis* (Figs. 23, 24).

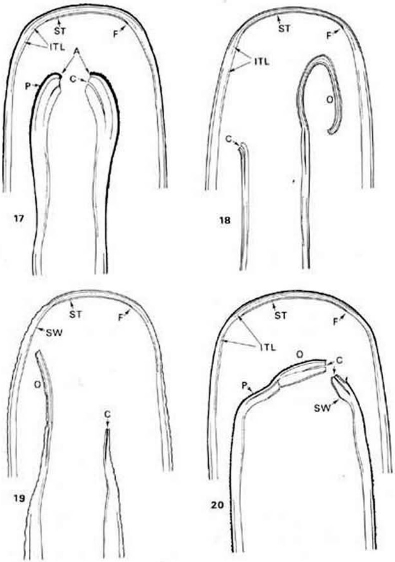
(7) SARCOSCYPHA TYPE.—

Operculum very thick, rather narrow, centrally or obliquely placed, sharply delimited in the inner layer and more roughly in the outer layer. Inner layer strongly swollen, often stratified and laminated, forming a thick lenticular body (opercular plug) at the top. Ascostome smooth. Periascus clearly developed; not blued with iodine. Funiculus present.

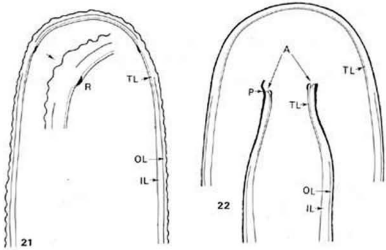
Examples: *Sarcoscypha coccinea* (Figs. 25, 26; cf. van Brummelen, *1975*), *Pithya cupressina* (Fig. 27), *Pseudoplectania nigrella* (Fig. 28), and *Desmazierella acicula* (cf. also Samuelson, *1975*.).

(8) Thelebolus type.—

Operculum absent in multispored asci or rather roughly delimited in some 8-spored asci. Usually opening by an irregular tear or with a bilabiate split starting from the margin of a small, rigid, apical disk. Sometimes external forces produce a more or less circular tear



Figs. 17–20. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Fig. 17. *Cheilymenia vitellina*. — Fig. 18. *Scutellinia armatospora*. — Fig. 19. *Octospora musci-muralis*. — Fig. 20. *Sowerbyella unicolor*.



Figs. 21–22. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Fig. 21 *Helvella crispa*. — Fig. 22. *Geopyxis carbonaria*.

(*Leptokalpion*). A usually pronounced ring in the wall prevents the tear to pass this level. Ascostome rough (if present). Wall thick and often strongly stratified or laminated. Periascus and funiculus absent.

Examples: *Thelebolus stercoreus* (Figs. 29–32), '*Rhyparobius*' *myriosporus* (Figs. 33–38), '*R.*' *crustaceus* (Fig. 39), '*R.*' *caninus* (Fig. 40), '*Ascophanus*' *coemansii* (Fig. 41), *Coprotus* spec., *Lasiobolus monascus* (Fig. 42), *L. pilosus* (Fig. 43), and *Ascozonus woolhopensis* (Fig. 44).

The *Thelebolus* type of ascus covers a wide range of possibilities, many of which have been studied in detail by Kimbrough (*1966*, *1972*) and Kimbrough & Korf (*1967*).

As our knowledge about ascus-structure in the genera of the Pezizales is still very incomplete, it is well possible, and even probable, that further types of asci will turn up in future.

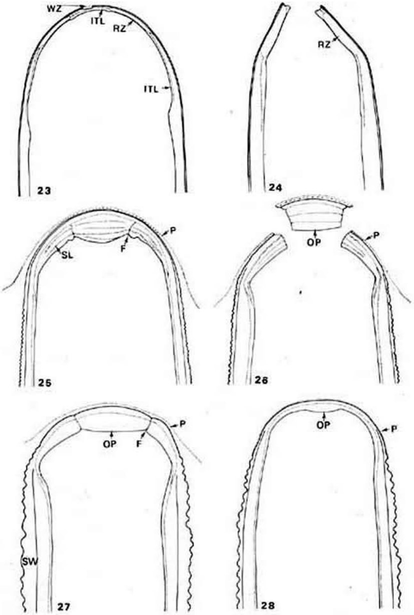
A more detailed study of the Thelebolaceae will almost certainly lead to a further subdivision of the *Thelebolus* type.

A great deal of information on the structure of the ascus top is still required from many important genera, especially from those with a tropical distribution.

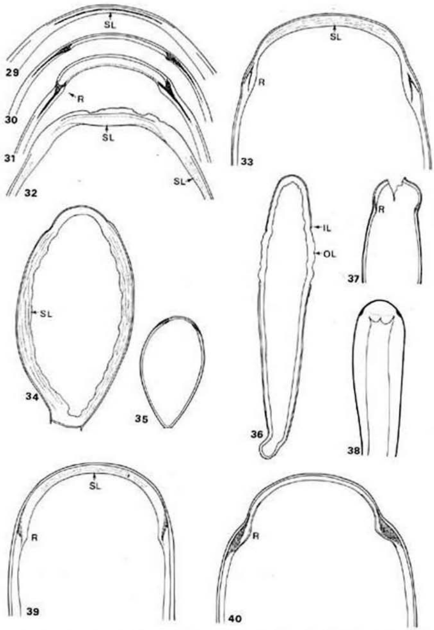
Most of the Tuberales should be classified among the Pezizales, but as these fungi have lost their mechanism of ascus dehiscence it is not possible to fit them in on this character.

CONCLUSIONS

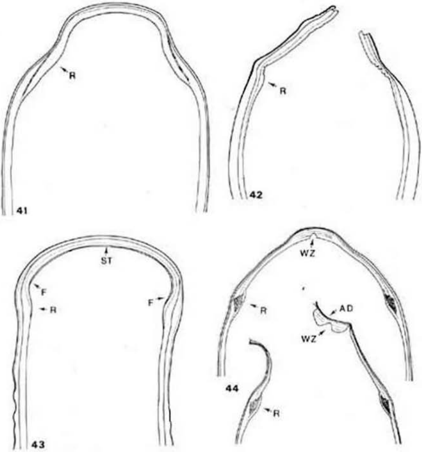
If we consider the information available and compare the different structures it is possible to recognize certain affinities and trends. This has led me in the first place to distinguish the



Figs. 23–28. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Figs. 23, 24. *Urnula platensis*. — Figs. 25, 26. *Sarcoscypha coccinea*. — Fig. 27. *Pithya cupressina*. — Fig. 28. *Pseudoplectania nigrella*.



Figs. 29–40. Diagrammatic sections of asci and ascus tops (as seen with electron microscopy, if not otherwise stated). — Figs. 29–32. *Thelebolus stercoreus* (with over 1000 spores). — Fig. 29. Very young stage, before ascosporogenesis. — Fig. 30. Ripening ascus, as seen with light microscopy in sections stained with toluidine blue. — Fig. 31. Ripening ascus. — Fig. 32. Mature ascus. — Figs. 33–38. '*Rhyparobius*' *myriosporus* (128–512 spores). — Fig. 33. Ripening ascus (with about 256 spores). — Figs. 34, 35. Asci (with about 512 spores), as seen with light microscopy, stained with Congo red. — Figs. 36–38. Ripening and mature asci (with about 256 spores), vital observation. — Fig. 39. '*Rhyparobius*' *crustaceus* (with about 64 spores). — Fig. 40. '*Rhyparobius*' *caninus* (with about 32 spores).



Figs. 41–44. Diagrammatic sections of ascus tops, as seen with electron microscopy. — Fig. 41. '*Ascophanus*' *coemansii*. — Fig. 42. *Lasiobolus monascus*. — Fig. 43. *Lasiobolus pilosus*. — Fig. 44. *Ascozonus woolhopensis*.

eight types described above, and in the second place to visualize their possible interrelationship in a scheme (Fig. 45).

The following trends can be recognized.—

(1) All asci with 'amyloid walls' studied thus far form a compact and closely related group.
(2) The *Ascodesmis* type takes a rather isolated position.
(3) There is a rather complete scale of structures ranging from *Thelebolus* via *Lasiobolus* and *Coprotus* via *Pyronema* – *Aleuria* – *Coprobia* – *Cheilymenia* – *Octospora* – *Scutellinia* – *Sowerbyella* to members of the Sarcoscyphaceae.
(4) No direct relation with the asci of Inoperculatae has been detected.

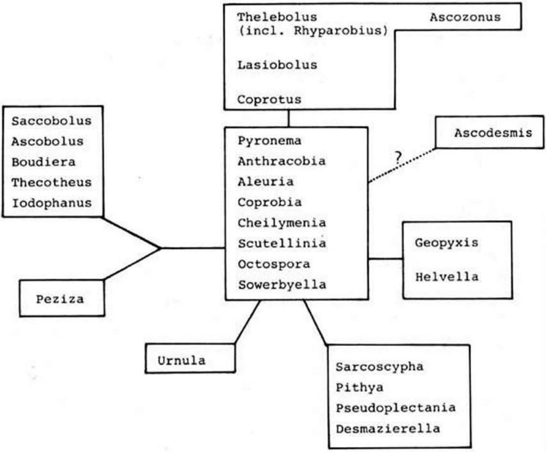


Fig. 45. Tentative scheme of possible interrelationships between different types of opening mechanisms of asci in Pezizales.

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ABBREVIATIONS USED IN TEXT-FIGURES

A, ascostome; AD, apical disk; C, cleavage of ascus wall; F, line or zone of fracturing; I, indentation of ascus wall; IL, inner layer of the ascus wall (The boundary between inner and outer layer is indicated by a continuous line.); ITL, interrupted thimble-shaped lamina (indicated by a dotted line); O, operculum; OL, outer layer of the ascus wall; OP, opercular plug; P, periascus (extra-ascan layer); R, prominent ring; RZ, ring-shaped, electron-transparent zone of the ascus wall; SL, sublayering of the ascus wall (usually indicated by dotted lines); ST, strengthened layer; SW, strongly swollen wall region; TL, thimble-shaped lamina (indicated by a dotted line); WZ, weakened zone.

References

Boudier, J. L. É. (1869). Mémoire sur les Ascobolacès. *In* Annls Sci. nat. (Bot.) V, **10**: 191–268, pls. 5–12.

— (1879). On the importance that should be attached to the dehiscence of asci in the classification of the Discomycetes. *In* Grevillea **8**: 45–49.

— (1885). Nouvelle classification naturelle des Discomycètes charnus connus généralement sous le nom de Pézizes. *In* Bull. Soc. mycol. Fr. **1**: 91–120.

Bracker, C. E. & Williams, C. M. (1966). Comparative ultrastructure of developing sporangia and asci in fungi. *In* Electron Microscopy, Proc. 6th intern. Congr. Electron Microsc., Kyoto, II: 307–308.

Brummelen, J. van (1974). Light and electron microscopic studies of the ascus top in *Ascozonus woolhopensis*. *In* Persoonia **8**: 23–32, pls. 15–18.

— (1975). Light and electron microscopic studies of the ascus top in *Sarcoscypha coccinea*. *In* Persoonia **8**: 259–271, pls. 46–47.

Carroll, G. C. (1966). A study of the fine structure of ascosporogenesis in *Saccobolus kerverni* and *Ascodesmis sphaerospora*. Ph. D. Thesis, Univ. of Texas, Austin [unpublished].

— (1967). The ultrastructure of ascospore delimitation in *Saccobolus kerverni*. *In* J. Cell Biol. **33**: 218–224.

— (1969). A study of the fine structure of ascosporogenesis in *Saccobolus kerverni*. *In* Arch. Mikrobiol. **66**: 321–339.

Chadefaud, M. (1946). Les asques para-operculés et la position systématique de la Pézize *Sarcoscypha coccinea* Fries ex Jacquin. *In* C.r. hebd. Séanc. Acad. Sci., Paris **222**: 753–755.

Crouan, P. L. & Crouan, H. M. (1857). Note sur quelques *Ascobolus* nouveaux et sur une espèce nouvelle de *Vibrissea*. *In* Annls Sci. nat. (Bot.) IV, **7**: 173–178, pl. 4.

— & — (1858). Note sur neuf *Ascobolus* nouveaux. *In* Annls Sci. nat. (Bot.) IV, **10**: 193–199, pl. 13.

Delay, C. (1966). Étude de l'infrastructure de l'asque d'*Ascobolus immersus* Pers. pendant la maturation des spores. *In* Annls Sci. nat. (Bot.) XII, **7**: 361–420.

Eckblad, F.-E. (1968). The genera of the Operculate Discomycetes. A re-evaluation of their taxonomy, phylogeny and nomenclature. *In* Nytt Mag. Bot. **15**: 1–191.

— (1972). The suboperculate ascus — a review. *In* Persoonia **6**: 439–443.

Gäumann, E. A. (1926). Vergleichende Morphologie der Pilze. 626 pp. Jena.

Griffith, H. B. (1968). The structure of the Pyrenomycete ascus. Ph. D. Thesis. Univ. of Liverpool.

Kimbrough, J. W. (1966). Studies in the Pseudoascoboleae. *In* Can. J. Bot. **44**: 685–704.

— (1972). Ascal structure, ascocarp ontogeny, and a natural classification of the Thelebolaceae. *In* Persoonia **6**: 395–404, pls. 16–19.

Kimbrough, J. W. & Benny, G. L. (1978). The fine structure of ascus development in *Lasiobolus monascus* (Pezizales). *In* Can. J. Bot. **56**: 862–872.

Kimbrough, J. M. & Korf, R. P. (1967). A synopsis of the genera and species of the tribe Theleboleae (= Pseudoascoboleae). *In* Am. J. Bot. **54**: 9–23.

Le Gal, M. (1946a). Mode de déhiscence des asques chez les *Cookeina* et les *Leotia*, et ses conséquences du point de vue phylogénétique. *In* C.r. hebd. Séanc. Acad. Sci., Paris **222**: 755–757.

— (1946b). Les Discomycètes suboperculés. *In* Bull. trim. Soc. mycol. Fr. **62**: 218–240.

— (1947). Recherches sur les ornementations sporales des Discomycètes operculés. *In* Annls. Sci. nat. (Bot.) XI, **8**: 73–297, 1 pl.

— (1953). Les Discomycètes de Madagascar. 1–465. Paris.

Merkus, E. (1973). Ultrastructure of the ascospore wall in Pezizales (Ascomycetes) — I. *Ascodesmis microscopica* (Crouan) Seaver and *A. nigricans* van Tiegh. *In* Persoonia **7**: 351–366.

— (1974). Ultrastructure of the ascospore wall in Pezizales (Ascomycetes) — II. Pyronemataceae sensu Eckblad. *In* Persoonia **8**: 1–22.

— (1975). Ultrastructure of the ascospore wall in Pezizales (Ascomycetes) — III. Otideaceae and Pezizaceae. *In* Persoonia **8**: 227–247.

— (1976). Ultrastructure of the ascospore wall in Pezizales (Ascomycetes) — IV. Morchellaceae, Helvellaceae, Rhizinaceae, Thelebolaceae, and Sarcoscyphaceae; general discussion. *In* Persoonia **9**: 1–38.

Moore, R. T. (1963). Fine structure of Mycota. I. Electron microscopy of the Discomycete *Ascodesmis*. *In* Nova Hedwigia **5**: 263–278.

Nannfeldt, J. A. (1932). Studien über die Morphologie und Systematik der nicht-lichenisierten inoperculaten Discomyceten. *In* Nova Acta R. Soc. Sci. upsal. IV, **8**(2): 1–368, 20 pls.

Oso, B. A. (1969). Electron microscopy of ascus development in *Ascobolus*. *In* Ann. Bot. **33**: 205-209.

Ramlow, G. (1906). Entwicklungsgeschichte von *Thelebolus stercoreus*. *In* Bot. Ztg. **64**: 85–99, pl. 4.

—— (1915). Beiträge zur Entwicklungsgeschichte der Ascoboleen. *In* Mycol. Cbl. **5**: 177–198, pls. 1-2.

Reeves Jr., F. (1967). The fine structure of ascospore formation in *Pyronema domesticum*. *In* Mycologia **59**: 1018–1033.

Reisinger, O., Kiffer, E., Mangenot, F. & Olah, G. M. (1977). Ultrastructure, cytochimie et microdissection de la paroi des hyphes et des propagules exogénes des Ascomycétes et Basidiomycétes. *In* Rev. Mycol. **41**: 91–117, pls. I–VII.

Renny, J. (1871). A description of some species of the genus *Ascobolus* new to England. *In* Trans. Woolhope Nat. Field Club 1871: 45–48.

—— (1873). New species of the genus *Ascobolus*. *In* Trans. Woolhope Nat. Field Club 1872–3: 127–131, 4 pls.

Samuelson, D. A. (1975). The apical apparatus of the suboperculate ascus. *In* Can. J. Bot. **53**: 2660 -2679.

—— (1978a). Asci of Pezizales. I. The apical apparatus of iodine-positive species. *In* Can J. Bot. **56**: 1860-1875.

—— (1978b). Asci of Pezizales II. The apical apparatus of representatives in the *Otidea-Aleuria* complex. *In* Can. J. Bot. **56**: 1876 -1904

Schrantz, J.-P. (1966). Contribution à l'étude de la formation de la paroi sporale chez *Pustularia cupularis* (L.) Fuck. *In* C.r. Acad. Sci., Paris **262**: 1212–1215.

—— (1967). Présence d'un aster au cours des mitoses de l'asque et de la formation des ascospores chez l'Ascomycète *Pustularia cupularis* (L.) Fuck. *In* C.r. Acad. Sci., Paris **264**: 1274–1277.

—— (1968). Ultrastructure et localisation du glycogéne chez l'Ascomycète *Galactinia plebeia* Le Gal. *In* Rev. Cytol. Biol. végét. **31**: 151–157, 2 pls.

Saever, F. J. (1927). A tentative scheme for the treatment of the genera of Pezizaceae. *In* Mycologia **19**: 86-89.

—— (1928). The North American Cup-fungi (Operculates). 284 pp. New York.

Wells, K. (1972). Light and electron microscopic studies of *Ascobolus stercorarius*. II. Ascus and ascospore ontogeny. *In* Univ. Calif. Publ. Bot. **62**: 1–93.

Zukal, H. (1886). Mykologische Untersuchungen. *In* Denkschr. (K.) Akad. Wiss. Wien (Math.-nat. Kl.) **51**: 21–36.

ADDENDUM

Just after receiving the galley proofs, three studies on the ascus structure of Pezizales came to my notice.

Kimbrough & Benny (1978) studied the ascus structure in *Lasiobolus monascus*.

Samuelson (*1978a*) published on the structure of iodine-positive asci in *Peziza succosa*, *Ascobolus crenulatus*, *Saccobolus depauperatus*, *Thecotheus pelletieri*, and *Iodophanus granulipolaris*. He (Samuelson, *1978b*) also published on the asci of the so-called *Otidea-Aleuria* complex. He studied the 'apical apparatus' of asci in *Otidea leporina*, *Jafnea fusicarpa*, *Humaria hemisphaerica*, *Sphaerosporella brunnea*, *Aleuria aurantia*, *Anthracobia melaloma*, *Scutellinia scutellata*, *Ascozonus woolhopensis*, *Geopyxis majalis*, and *Sowerbyella imperialis*.

Although most of their results and illustrations agree with my findings, some of their interpretations are strikingly different.

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CLAMP CONNECTIONS AT THE CHEILOCYSTIDIA IN MYCENA

R. A. MAAS GEESTERANUS

Oegstgeest

Clamp connections at the cheilocystidia in *Mycena* are invariably correlated with their presence in other elements of hymenium and subhymenium. In some species of the genus clamped cheilocystidia occur in both the four- and two-spored forms; in others, the cheilocystidia are clampless in the two-spored form. Two of the sections examined are shown to comprise species with clamped and species with clampless cheilocystidia, suggesting that the presence of clamps at the cheilocystidia is a character of specific rather than sectional importance. Two examples are given to illustrate the value of clamps at cheilocystidia as a distinguishing character. *Mycena jacobi* and *M. niveipes*, long regarded as being identical, are here considered to represent two separate species.

The incidental observation of a clamp connection at the base of cheilocystidia in some species of *Mycena* and the apparent absence in others elicited a more directed investigation, the result of which seems worth recording. Before presenting my own findings, a brief survey of the literature should precede.

Josserand (*1937*) reported on various species of *Omphalia* which were subsequently transferred to *Mycena* by Kühner. Josserand neither described nor depicted clamps at the cheilocystidia, although they are known to be present in *Mycena gracilis* (Quél.) Kühn.

Kühner in his monograph (*1938*) occasionally did observe clamps, usually at the septa of hyphae, but did not accord special importance to them. In figure 94 (page 299) one of the cheilocystidia (depicted by R. Maire) is shown to possess a clamp. In his chapter on cystidia (pp. 77–84) Kühner did not mention the presence of clamps.

Smith (*1947*) was reticent about clamp connections, and so was Favre (*1955*, *1960*).

A change took place with the appearance of the publications of Kühner & Valla (*1972*) and Malençon & Bertault (*1975*) in that these authors described and depicted clamps whenever they saw them, sometimes at septa of hyphae, sometimes at hymenial elements. But, whereas Malençon & Bertault ignored the significance of the clamps, Kühner & Valla frequently used them for the distinction of two closely resembling species.

The above review is by no means an exhaustive one, but suffices to show that if clamp connections were noticed at the cheilocystidia, the observation was rarely and only quite recently put to use with a view to facilitate the distinction between species.

In the course of my investigation I found that the ostensible lack of clamps at the cheilocystidia in mature basidiomata was not necessarily evidence of their absence also in a younger stage.[1] During, or perhaps in the later stages of, the development of the hymenial region, the cheilocystidia in some species would appear to lose every trace of the earlier presence of a clamp connection at their base. It may be reminded that a similar phenomenon is also known in the basidia of some species of *Rhodophyllus*. Clamp connections found to occur at the younger basidia may be hard to distinguish at a later stage. To avoid uncertainties of a similar nature in the work I had undertaken, the investigation was extended to include also other hymenial elements. It was found that in all species examined the presence or absence of clamps at the cheilocystidia is invariably correlated with their presence or absence at the basidia and at the septa of the subhymenial hyphae. This was to be expected since cheilocystidia and basidia both arise from subhymenial hyphae, but I wanted confirmation of my assumption. This principle sometimes facilitates the search for clamps at the cheilocystidia (since clamps at the septa of subhymenial hyphae are less subject to change) and may, under circumstances, prove the only means of demonstrating the presence or absence of clamps.

The next question that arose was whether the presence (or absence) of clamps at the cheilocystidia would or would not depend on the species being in its four-spored or two-spored form. Four- and two-spored forms of the same species are known (or reputed) to occur in various sections throughout the genus *Mycena*. The following species were selected for closer inspection. They are arranged according to the sections and subdivisions as indicated by Kühner & Romagnesi (*1953*), while their nomenclature follows the Check List by Dennis *& al.* (*1960*).

1. *Filipedes: M. filopes* (Bull. ex Fr.) Kummer (Figs. 1, 2), *M. metata* (Fr.) Kummer (Figs. 3–5), *M. sepia* J. E. Lange (Figs. 6–8).
2. *Rigidipedes: M. galericulata* (Scop. ex Fr.) S. F. Gray (Figs. 9–11).
3. *Adonidae* § *Hiemales: M. hiemalis* (Osb. apud Retz. ex Fr.) Quél. (Figs. 12–14), *M. olida* Bres. (Figs. 15–18).
4. *Adonidae* § *Amabilissimae: M. flavoalba* (Fr.) Quél. (Figs. 19, 20).
5. *Adonidae* § *Lacteae: M. lactea* (Pers. ex Fr.) Kummer (Fig. 21; for illustration of the cheilocystidia in the four-spored form, see Kühner & Valla, *1972*: fig. III 3).

Examination showed the species of sections 1, 4, and 5 to possess clamps at the cheilocystidia in both the four- and two-spored forms. The species of sections 2 and 3 were found to possess clamped cheilocystidia in the four-spored form, clampless cheilocystidia in the two-spored form.

Yet another species, which does not figure in the above enumeration, is *M. delectabilis* (Peck) Sacc. It was regarded by Kühner & Romagnesi (*1953*: 118) as a member of the genus *Delicatula*, but afterwards restored in *Mycena* by Kühner & Valla (*1972*: 48). Like in e.g. *M. galericulata* of section 2, the four-spored form has cheilocystidia with clamps, the two-spored form has clampless cheilocystidia (Kühner & Valla, *1972*: 48–49).

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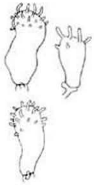
[1] In this respect I am and have been constantly aware of the truth of the admonition: 'Absence of evidence is not evidence of absence.'



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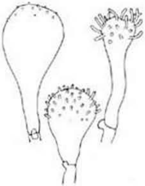

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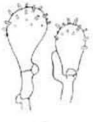

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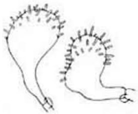

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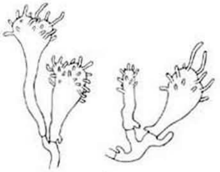

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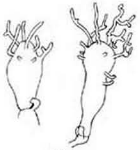

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Figs. 1, 2. *Mycena filopes*, cheilocystidia. — 1. Two-spored form; Netherlands: Wieringermeer, Robbenoord, 23 Oct. 1976, *C. Bas 7106* (L). — 2. Four-spored form; Netherlands: Breda, 15 Nov. 1964, *P. B. Jansen* (L).

Figs. 3–5. *Mycena metata*, cheilocystidia. — 3. Two-spored form; Netherlands: Oost-Flevoland, 9 Dec. 1976, *F. & G. J. M. G. Tjallingii* (L). — 4. Four-spored form; as preceding. — 5. Four-spored form; Sweden: Fgi exs. suec. praes. upsal. 119 (UPS).

Figs. 6–8. *Mycena sepia*, cheilocystidia. — 6. Two-spored form; Netherlands: Drongelens kanaal, 1 Nov. 1970, *P. B. Jansen* (L). — 7. Four-spored form; Netherlands: Kootwijkerveld, Oct. 1970, *G. S. de Hoog* (L). — 8. Four-spored form; Denmark: Silkeborg, Østerskov, 24 Oct. 1947, *M. Lange* (C).

Figs. 9–11. *Mycena galericulata*, cheilocystidia. — 9. Two-spored form; Netherlands: Laag Soeren, 27 Sept. 1976, *R. A. Maas Geesteranus 15510* (L; note abortive clamps). — 10. Two-spored form; Netherlands; Baarn, 15 Apr. 1977, *W. Gams* (L). — 11. Four-spored form; Netherlands: Koning's Hof, 5 Dec. 1976, *J. van Brummelen 5162* (L.) — All figures × 2800.

From these observations the fact emerges that two kinds of two-spored forms appear to exist — one which has clamp connections at the cheilocystidia, and another which has cheilocystidia devoid of clamps. The cytological, genetic, and taxonomic implications would seem well worth investigating, but are beyond the scope of the present note. The urgency of such an investigation is the more pressing since matters may well prove more complicated than they appear on the outside. A. H. Smith (*1934*) published a paper on two-spored forms in various species of *Mycena*. His investigations, however, rather more concerned the nuclear behaviour of the basidia, offering no clue in answering the questions posed in the present note. Kühner (*1938*: 125), in his chapter on parthenogenetic forms in *Mycena*, stated that '... la forme bisporique de *M. galericulata* possède des hyphes sous-hyméniales et des basidioles à un seul noyau ....' He proceeded by referring to A. H. Smith who '...a eu le mérite de montrer que les formes à basidioles uninucléées que l'on rencontre dans la nature, ne sont pas forcéments bisporiques... mais qu'elles peuvent présenter, sur le même chapeau ... des basides 2-, 3- et 4-sporiques, ou même des basides en majorité tétrasporiques ...' As an example for the last named Kühner mentioned *M. citrinomarginata* which, as will be shown presently, has clamped hymenial elements. The uninucleate condition of the basidia apparently does not necessarily imply that the basidia (and the cheilocystidia) must be devoid of clamps. Would it be too bold a thought to assume that some of the uninucleate species of *Mycena*, irrespective of the number of spores produced per basidium, may present themselves as a dikaryotic population (with clamped cheilocystidia) or a monokaryotic one (with clampless cheilocystidia)? It seems we still have a long way to go.

A further question which required investigation was whether it would be correct to assume the character to have general applicability if within a section of four-spored species some of its randomly selected members are found to possess clamps at the cheilocystidia. The 'Fragilipedes typiques' (Kühner & Romagnesi, *1953*: 106) is a case in point. Of this group, *M. abramsii* Murrill (2 North American collections, L), *M. aetites* (Fr.) Quél. (3 Dutch coll., L; 1 Swedish coll., UPS), *M. alcalina* (Fr. ex Fr.) Kummer (3 Dutch coll., L; 2 Danish coll., C; 2 Swedish coll., UPS), *M. jacobi* Maire[2] (2 Dutch coll., L; see also Malençon & Bertault, *1975*: 279, as *M. niveipes*), *M. leptocephala* (Pers. ex Fr.) Gillet[3] (6 Dutch coll., L; 1 Swedish coll., C; 2 Swedish coll., UPS), *M. praecox* Vel. (2 Dutch coll., L; 3 Czechoslovakian coll., L), and *M. zephirus* (Fr. ex Fr.) Kummer (1 Austrian coll., L) have cheilocystidia with clamps. Two others, *M. niveipes* Murrill[2] (2 North American coll., L) and *M. strobilicola* Favre & Kühn. (1 Swiss coll., L), have their cheilocystidia devoid of clamps.

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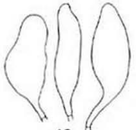
[2] It may cause some surprise that *M. jacobi* and *M. niveipes*, regarded as being identical ever since Kühner (*1938*: 486), are here taken to represent two independent species. In view of the preceding, however, I do not wish to exclude the possibility that these two taxa, both of which are four-spored, are specifically different, precisely because of the presence of clamps in the former and the lack of clamps in the latter. This seems the more prudent course as long as there is no knowing what exactly the presence of clamps portends.

[3] There seems to be a growing, but unwarranted, tendency to use the name *M. chlorinella* (J. E. Lange) Sing. for this species.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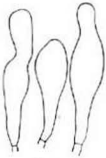
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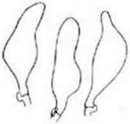
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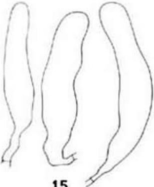
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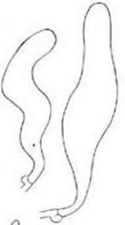
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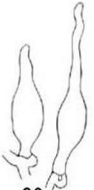
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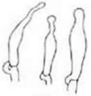
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Figs. 12–14. *Mycena hiemalis*, cheilocystidia. — 12. Two-spored form; Netherlands: Amsterdam, Amsterdamse Bos, 10 Oct. 1977, *J. Reijnders* (L). — 13. Two-spored form; Sweden: Fgi exs. suec. praes. upsal. 1746 (UPS). — 14. Four-spored form; Netherlands: Fortmond, Duursche Waarden, 18 Dec. 1977, *G. & H. Piepenbroek 1074c* (L).

Figs. 15–18. *Mycena olida*, cheilocystidia. — Two-spored form; Netherlands: St. Odiliënberg, Munnicksbos, 7 Oct. 1962, *C. Bas 2839* (L). — 16. Two-spored form; Czechoslovakia: Moravia, Zdravá Voda near Zărošice, 5 Sept. 1945, *V. Vacek* (PRM 13465). — 17. Four-spored form; Netherlands: Overveen, Elswout, 7 Nov. 1974, *E. Kits van Waveren* (Herb. v. W.). — 18. Four-spored form; Great Britain: Wales, Lake Vyrnwy, 2 Sept. 1960, *E. Kits van Waveren* (Herb. v.W.).

Figs. 19, 20. *Mycena flavoalba*, cheilocystidia. — Two-spored form; Netherlands: De Lutte, 30 Oct. 1948, *H. S. C. Huijsman* (L). — 20. Four-spored form; Netherlands: Heusden, 19 Nov. 1976, *P. B. Jansen* (L).

Fig. 21. *Mycena lactea*, cheilocystidia. — Two-spored form; Netherlands: Kuinderbos, 9 Oct. 1976, *P. B. Jansen* (L). — All figures × 2800.

The group of species designated by Kühner & Romagnesi (*1953*: 104) as the 'second group of the Calodontes' may serve as another instance. Of the species examined, *Mycena atromarginata* (Lasch) Kummer (1 Belgian coll., L) has cheilocystidia without clamps. *Mycena capillaripes* Peck (2 Dutch coll., L), *M. citrinomarginata* Gillet (2 Dutch coll., L), *M. olivaceomarginata* (Massee apud Cooke) Massee (4 Dutch coll., L), *M. purpureofusca* (Peck) Sacc. (1 Belgian, 1 Polish coll., both L), *M. rubromarginata* (Fr. ex Fr.) Kummer (1 German coll., L; 2 Swedish coll., UPS), and *M. seynii* Quél. (2 Dutch coll., L) all possess clamped cheilocystidia.

Thus, it would seem from the few examples examined that the presence of clamps at the cheilocystidia (or their absence, as the case may be) is a character of specific rather than sectional significance. The following cases are recorded to demonstrate the value of the character.

Mycena leptocephala and *M. vitilis* (Fr.) Quél. are both common members of the genus, and yet of either species there may be found forms which are hard to recognize. Kühner (*1938*: 468) described the former species as *M. metata* sensu Schroeter, the latter (504) as *M. filopes* sensu Schroeter. Although his descriptions do show points of difference, there is ample occasion for the two taxa to be confused on account of the many characters they have in common. It is true that Kühner & Romagnesi (*1953*: 107) placed *M. leptocephala* in section *Fragilipedes* and *M. vitilis* in section *Rigidipedes* (108), but a great deal of experience is required to appreciate such a qualitative character as is the rigidity of a slender stipe in fresh condition, let alone the difficulty of judgment once the material is dried. However, there is one infallible differential character — *M. leptocephala* possesses clamped cheilocystidia, whereas those of *M. vitilis* are clampless.

As a second example I may refer to the remark accompanying Kühner's description of *M. polygramma* f. *ambigua* (*1938*: 503): 'Cette forme relie le *M. polygramma* au *M. filopes* [= *M. vitilis*] et serait peut-être mieux placée comme forme de cette dernière espèce, dont elle ne diffère guère que par le pied strié.' I do not know this form but if its cheilocystidia should prove to possess clamps, the taxon definitely belongs to *M. polygramma*.

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REFERENCES

DENNIS, R. W. G., ORTON, P. D. & HORA, F. B. (1960). New check list of British agarics and boleti. *In* Suppl. Trans. Br. mycol. Soc.

FAVRE, J. (1955). Les champignons supérieurs de la zone alpine du Parc National suisse. *In* Résult. Rech. sci. Parc natn. suisse V, **33.**

—— (1960). Catalogue descriptif des champignons supérieurs de la zone subalpine du Parc National suisse. *In* Résult. Rech. sci. Parc natn. suisse VI, **42.**

JOSSERAND, M. (1937). Description de quelques Omphales blanches. *In* Annls Soc. linn. Lyon **80**: 77–96. '1936'.

KÜHNER, R. (1938). Le genre *Mycena* (Fries). *In* Encycl. mycol. **10**.

KÜHNER, R. & ROMAGNESI, H. (1953). Flore analytique des champignons supérieurs (Agarics, bolets, chanterelles). Paris.

KÜHNER, R. & VALLA, G. (1972) Contribution à la connaissance des espèces blanches à spores non amyloïdes du genre *Mycena* (Fries) S. F. Gray (Basidiomycètes Agaricales). *In* Trav. Lab. "La Jaysinia" **4**: 25–71.

MALENÇON, G. & BERTAULT, R. (1975). Flore des champignons supérieurs du Maroc. **2.** Rabat.

SMITH, A. H. (1934) Investigations of two-spored forms in the genus *Mycena*. *In* Mycologia **26**: 305–331.

—— (1947). North American species of *Mycena*. *In* Univ. Mich. Stud., Scient. ser. **17.**

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STUDIES IN RESUPINATE BASIDIOMYCETES—V

Some new genera and species

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The following new taxa are proposed: *Australohydnum* gen. nov. (based on *Hydnum griseo-fuscescens* Reich.), *Ceraceohydnum brunneum* gen. et spec. nov. *Crustomyces* gen. nov. (based on *Odontia subabrupta* Bourd. & Galz.), *Megalocystidium* gen. nov. (based on *Corticium leucoxanthum* Bres.), *Phlebiopsis* gen. nov. (based on *Thelephora gigantea* Fr.), and *Scotomyces* gen. nov. (based on *Corticium fallax*). Seven new combinations are proposed.

Phlebiopsis Jülich, *gen. nov.*

Carposoma ceraceo-gelatinosum, crassum, adnatum, pallide coloratum. Hymenophorum laeve ad odontioideum. Systema hypharum monomiticum. Hyphae hyalinae, basales distinctae, incrassate tunicatae, basales ad 10 µm in diam., fibulis raris. Cystidia incrassate tunicata et incrustata. Basidia anguste clavata. Sporae hyalinae, tenui-tunicatae, cylindraceae vel ellipsoideae, inamyloideae.

Typus: *Thelephora gigantea* Fr.

Basidiocarp annual, resupinate, effused, ceraceous. Hymenial surface even to odontioid. Hyphal system monomitic. Hyphae hyaline, cylindrical to torulose, compactly arranged, at least in the subhymenial part, more loose in the trama; the basal hyphae thickwalled and up to 10 µm wide; clamps lacking or rare. Cystidia hyaline, thick-walled, incrusted. Basidia hyaline, narrowly clavate. Spores hyaline, thin-walled, cylindrical to ellipsoidal, not amyloid.

Phlebiopsis gigantea (Fr.) Jülich, *comb. nov.*; basionym, *Thelephora gigantea* Fr., Syst. Mycol. **1**: 448. 1821. — Type locality: Sweden.

The type species has been placed in Phlebia and Phanerochaete. It belongs certainly not to Phlebia and shows only a very weak relationship with Phanerochaete (wide, thick-walled basal hyphae with rare or multiple clamp-connexions). There are some other species which very probably belong to this genus. They will be dealt with later on.

Australohydnum Jülich, *gen. nov.*

Carposoma resupinatum vel effuso-reflexum, firme membranaceum, adnatum, margine delimitata; rhizomorphae desunt. Hymenophorum hydnoideum. Systema hypharum monomiticum vel indistincte dimiticum. Hyphae hyalinae, cylindraceae, hyphae subhymenii tenui-tunicatae, hyphae tramae crasse-

tunicatae (usque ad 1 μm), laeves, afibulatae. Cystidia (skeletocystidia) adsunt, ex hyphis generativis crescentia, pars apicis paulum incrustata. Basidia hyalina, clavata, circa 13–20 μm longa, afibulata. Sporae hyalinae, plus minusve ellipsoideae, circa 4–6 μm longae, tenui-tunicatae, laeves, inamyloideae.
Typus: *Hydnum griseo-fuscescens* Reichardt.

Basidiocarp annual, resupinate to effuso-reflexed, several cm large, firm-membranaceous, adnate; context homogeneous; margin determinate; rhizomorphs or hyphal strands lacking. Hymenial surface hydnoid. Hyphal system monomitic or indistinctly dimitic. Hyphae hyaline, cylindrical, compactly arranged, 4–9 μm in diam., thin-walled in the subhymenium, thick-walled in the trama (up to 1 μm), smooth; clamps lacking throughout. Cystidia (skeletocystidia) present, abundant, arising from thick-walled, clampless, generative hyphae; the projecting part loosely incrusted. Basidia hyaline, clavate, *c.* 13–20 μm long; a basal clamp lacking. Spores hyaline, more or less ellipsoid, about 4–6 μm long, thin-walled, smooth, not amyloid.

Australohydnum griseo-fuscescens (Reichardt) Jülich, *comb. nov.*; basionym, *Hydnum griseo-fuscescens* Reichardt *in* Verh. zool-bot. Ges. Wien **16**: 374. 1866. — Type locality: Australia.

Ceraceohydnum Jülich, *gen. nov.*

Carposoma resupinatum, effusum, ceraceum, margine indistincta, rhizomorphae desunt. Hymenophorum hydnoideum, brunneum, systema hypharum dimiticum. Hyphae generativae hyalinae, cylindraceae, compactae, circa 2–4 μm in diam., incrassate tunicatae, fibulatae. Hyphae skeletales hyalinae, crasse tunicatae, circa 3–5 μm in diam. Basidia hyalina, clavata, parva, fibulata, tetraspora. Sporae hyalinae, plus minusve ellipsoideae, parvae, tenui-tunicatae, leaves, inamyloideae.
Typus: *Ceraceohydnum brunneum* Jülich.

Basidiocarp annual, resupinate, effused, ceraceous; margin indistinct; rhizomorphs or hyphal strands lacking. Hymenial surface brownish, hydnoid; the teeth up to 7 mm long. Hyphal system dimitic, with skeletals. Generative hyphae hyaline, cylindrical, compactly arranged, thick-walled, with clamps. Skeletals hyaline, thick-walled. Basidia hyaline, narrowly clavate, small, with smooth surface, with four sterigmata; a basal clamp present. Spores hyaline, more or less ellipsoid, small, thin-walled, smooth, not amyloid.
TYPE LOCALITY.—New Guinea

Ceraceohydnum brunneum Jülich, *spec. nov.*

Carposoma resupinatum, late effusum, circa 20 cm latum, ceraceum, adnatum, margine indeterminata et sine rhizomorphis. Hymenophorum brunneum, hydnoideum, dentes usque ad 7 mm longi. Systema hypharum dimiticum. Hyphae generativae hyalinae, cylindraceae, compactae, 2.5–4 μm in diam., crasse-tunicatae (usque ad 1 μm), laeves, fibulatae. Hyphae skeletales hyalinae, crasse-tunicatae, 3.5–4 μm in diam. Cystidia desunt. Basidia hyalina, anguste clavata, 6–10 × 2.5–3 μm, tenui-tunicata, laeves, fibulata, tetraspora. Sporae hyalinae, fere globosae vel late ellipsoideae, 2.8–3.4 × 2.2–2.6 μm, tenui-tunicatae, laeves, inamyloideae.

Basidiocarp annual, resupinate, broadly effused, up to 20 cm large, ceraceous, separable; context homogeneous; margin indistinct, thinning out; rhizomorphs or hyphal strands lacking. Hymenial surface hydnoid; the teeth slender, up to 7 mm long. Hyphal system dimitic, with skeletals. Generative hyphae hyaline, cylindrical, compactly arranged in the subhymenium, more loosely arranged in the trama, often branching from the clamps, 2.5–4 μm in diam., thick-walled (up to 1 μm), with smooth surface; clamps present; contents homogeneous. Skeletals hyaline, thick-walled, 3.5–4 µm, thin-walled, with smooth surface, with four sterigmata; a basal clamp present; contents homogeneous. Spores hyaline, subglobose to broadly ellipsoid, with small apiculus, 2.8–3.4 × 2.2–2.6 µm, not glued together, thin-walled, smooth, not amyloid or dextrinoid; contents homogenous.

TYPE.—New Guinea, Papua, Boridi, 22.XI.1935, *C. E. Carr 13470* (L).

Scotomyces Jülich, *gen. nov.*

Carposoma resupinata, effusa, circa 100 µm crassa, plus minusve adnata, laxe membranacea, margine indistincta, sine rhizomorphis. Hymenophorum laeve. Systema hypharum monomiticum. Hyphae hyalinae, tenui-tunicate, cylindraceae, fibulatae, guttulatae. Cystidia desunt. Basidia hyalina, anguste clavata, tenui-tunicata, fibulata, tetraspora, circa 20–40 µm longa, sterigmatis latis et usque ad 15 µm longis. Sporae hyalinae, plus minusve late ellipsoideae, tenui-tunicatae, laeves, circa 7–9 µm longae, guttulatae.

Typus: *Corticium fallax* Cunn.

Basidiocarp annual, resupinate, effused, about 100 µm thick, more or less adnate, soft-membranaceous; the margin indistinct; rhizomorphs or hyphal strands lacking. Hymenial surface even. Hyphal system monomitic. Hyphae hyaline, thin-walled, cylindrical, with clamps, guttulate. Cystidia lacking. Basidia hyaline, cylindrical to narrowly clavate, thin-walled, about 20–40 µm long, with four very large and up to 15 µm long sterigmata. Spores hyaline, more or less ellipsoid, thin-walled, smooth, about 7–9 µm long, guttulate.

Scotomyces fallax (Cunn.) Jülich, *comb. nov.*

Corticium fallax Cunn. *in* Trans. Proc. R. Soc. N.Z. **82**: 309. 1954 (basionym). — Type locality: New Zealand.

Basidiocarp annual, resupinate, effused, up to several cm large, about 100 µm thick, adnate or separable in small pieces, soft-membranaceous; context homogeneous; margin thinning out; rhizomorphs or hyphal strands lacking. Hymenial surface even, under a lens finely reticulate, medium brown. Hyphal system monomitic. Hyphae hyaline, mostly erect, thin-walled, 3–4.5 µm in diam., cylindrical, with clamps at all septa, branching often from the clamps; contents guttulate; crystals lacking or few. Cystidia lacking. Basidia hyaline, cylindrical to narrowly clavate (young basidia of similar shape), thin-walled, 23–40 × 4.4–6.7 µm, with a clamp at the base, with four cylindrical to subulate, very large sterigmata (up to 15 × 1.5–2.5 µm); contents guttulate. Spores hyaline, broadly ellipsoid to pyriform, thin-walled, smooth, 6.7–8.9 × 4.4–5.5 µm, with large apiculus not amyloid; contents guttulate; germ-tube more or less cylindrical, *c.* 1.5 µm wide.

DISTRIBUTION.—Known only from New Zealand.

Megalocystidium Jülich, *gen. nov.*

Carposoma resupinatum, effusum, plus minusve adnatum, crassum (usque ad 1.5 mm), margine byssoidea. Hymenophorum laevum. Systema hypharum monomiticum. Hyphae hyalinae, cylindraceae vel torulosae, fibulatae vel afibulatae, plus minusve tenui-tunicatae, circa 2–4 µm latae. Gloeocystidia adsunt, longa, flexuosa, globulis oleiferis completa. Basidia hyalina, longa, circa 40–60 µm, tetraspora, cum vel sine fibulis basalis. Sporae hyalinae, plus minusve tenui-tunicatae, amyloideae, cylindricaceae vel ellipsoideae, apiculis parvis.

Typus: *Corticium leuxoxanthum* Bres.

Basidiocarp annual, resupinate, effused, up to 1.5 mm thick, membranaceous to ceraceous; margin byssoid or thinning out. Hymenial surface even. Hyphal system monomitic. Hyphae hyaline, cylindrical to torulose, with or without clamps, more or less thin-walled, about 2–4 μm wide. Gloeocystidia present, long, flexuous, with oily contents or granular. Basidia hyaline, about 40–60 μm long, four-spored; a basal clamp present or lacking. Spores hyaline, more or less thin-walled, cylindrical to ellipsoid, with small apiculus, amyloid.

TYPE LOCALITY.—Italy.

Megalocystidium leucoxanthum (Bres.) Jülich, *comb. nov.*; basionym, *Corticium leucoxanthum* Bres., Fungi trident. **2**: 57, pl. 166, fig. 3. 1898.

Megalocystidium lactescens (Berk.) Jülich, *comb. nov.*; basionym, *Thelephora lactescens* Berk. *in* Hook., Engl. Fl. **5** (2) 169. 1836.

Megalocystidium luridum (Bres.) Jülich, *comb. nov.*; basionym, *Corticium luridum* Bres., Fungi trident. **2**: 59, pl. 169. 1892.

Crustomyces Jülich, *gen. nov.*

Carposoma resupinatum, effusum, circa 100–300 μm crassum (sine aculeis), crustaceum, adnatum, pallide coloratum, laeve vel odontioideum aut breviter hydnoideum. Systema hypharum dimiticum. Hyphae generativae hyalinae, cylindraceae vel torulosae, compacte compositae, circa 2–3 μm latae, tenuitunicatae, fibulatae. Hyphae skeletales hyalinae. Gloeocystidia (circa 20–50 μm longa) et/aut dendrohyphidia adsunt. Basidia hyalina, parva, circa 12–20 μm longa, tetraspora, fibulata. Sporae hyalinae, plus minusve ellipsoideae, circa 3–4.5 μm longae, tenui-tunicatae, laeves, inamyloideae.

Typus: *Odontia subabrupta* Bourd. & Galz.

Basidiocarp annual, resupinate, effused, several cm large, about 200–300 μm thick (without the warts or spines), crustaceous, adnate; rhizomorphs or hyphal strands lacking. Hymenial surface even, odontioid or hydnoid, pale coloured. Hyphal system dimitic. Generative hyphae hyaline, cylindrical or torulose, compactly arranged in subhymenium and trama, c. 2–3 μm in diam., rather thin-walled; clamps present. Skeletals hyaline, about 3 μm in diam. Gloeocystidia and/or dendrohyphidia present; gloeocystidia about 20–50 μm long. Basidia hyaline, clavate, about 12–20 μm long, thin-walled, smooth, with four sterigmata; a basal clamp present. Spores hyaline, more or less ellipsoid, about 3–4.5 μm long, thin-walled, smooth, not amyloid.

TYPE LOCALITY.—France.

Crustomyces subabruptus (Bourd. & Galz.) Jülich, *comb. nov.*; basionym, *Odontia subabrupta* Bourd. & Galz., Hymen. France 430. 1928.

Crustomyces pini-canadensis (Schw.) Jülich, *comb. nov.*; basionym, *Radulum pini-canadense* Schw. *in* Trans. Am. phil. Soc., Ser. II, **4**: 164. 1832.

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NOTES AND BRIEF ARTICLES

LEUCOSPHAERA, A NEW GENUS OF THE PSEUDEUROTIACEAE

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In the course of a study of herbivore dung collected in the Zoological Garden in Delhi, an ascomycete was observed and isolated which could not be accomodated in any known genus. It is therefore described below.

Leucosphaera v. Arx, Mukerji & Singh, *gen. nov.*

Coloniae expansae, albae, mycelio aerio obtectae. Ascomata ex initialibus convolutis oriuntur, pallida, globosa, non ostiolata, pariete molli ex hyphis hyalinis, indistinctis constante circumdata. Asci irregulariter dispositi, clavati, obovati vel globosi, tenuitunicati, evanescentes, 8-spori; ascosporae ellipsoideae vel reniformes, hyalinae, continuae, strato gelatinoso circumdatae. Cellulae conidiogenae cylindricae vel aculeatae, plerumque sympodialiter vel percurrenter elongatae; blastoconidia continua vel septata, hyalina.

Species typica: *Leucosphaera indica* v. Arx *& al.*

Colonies spreading, white, with aerial mycelium; ascomata developing from coiled initials, light, spherical, non-ostiolate, with a fleshy wall composed of hyaline, indistinct hyphal cells; asci irregularly disposed, clavate, obovate or spherical, thin-walled, evanescent, 8-spored; ascospores ellipsoidal or reniform, hyaline, 1-celled, sheathed; conidiogenous cells cylindrical or tapering, usually sympodially or percurrently elongating; conidia 1-celled or septate, hyaline.
TYPE SPECIES.—*Leucosphaera indica* v. Arx *& al.*

Leucosphaera indica v. Arx, Mukerji & Singh, *spec. nov.*—Fig. 1.

Coloniae in agaro maltoso expansae, in dies 2–3 mm crescentes 24°C, albae, plerumque mycelio aerio denso hyalino partim obtectae. Hyphae fere crassitunicatae, hyalinae, regulariter septatae, 2–3.5 μm latae. Initialia ascomatum in mycelio aerio irregulariter convoluta; ascomata in strato myceliali immersa, globosa vel modice oblata, non ostiolata, hyalina vel roseola, 150–300 μm diam., pariete persistente, fere hyalino, 10–13 μm crasso circumdata, saepe nonnullis hyphis hyalinis obtecta. Asci numerosi, irregulariter dispositi, in hyphis ascogenis acervati, clavati, obovati vel globosi, tenuitunicati,

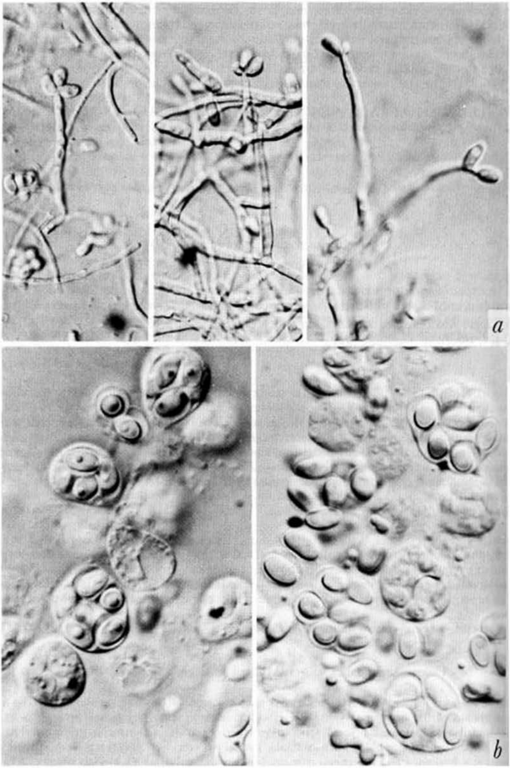

Fig. 1. *Leucosphaera indica*. — a. Hyphae, conidiogenous cells, and conidia (× 750). — b. Asci and ascospores (× 1200).

evanescentes, 8-spori, 10–13 μm diam.; ascosporae ellipsoideae vel reniformes, fere crassitunicatae, strato gelatinoso 1–1.5 μm crasso circumdatae, leves vel tenuiter striatae, hyalinae vel aggregatae flavidae ad roseae, poro germinationis carentes, 6–7 × 3–4 μm. Cellulae conidiogenae saepe aggregatae in hyphis vegetativis, 10–25 × 2.0–3.5 μm; conidia ellipsoidea, obovata, cylindrica vel clavata, continua vel raro septata, rotundata vel deorsum modice truncata, hyalina, 5–16 × 3–5 μm.

Typus: CBS 123.78, isolatus e fimo antilopae Nilgai dictae in horto zoologico Delhiensi, 28 Apr. 1977.

Colonies on malt agar expanding, with a daily growth rate of 2–3 mm at 24°C, usually white, often forming dense patches of aerial, hyaline mycelium; hyphae rather thick-walled, hyaline, regularly septate, 2–3.5 μm broad; ascomatal initials developing on the aerial hyphae and forming irregular coils; ascomata imbedded in the mycelial mat, spherical or slightly oblate, non-ostiolate, colourless or slightly pink, 150–300 μm, ascomatal wall fleshy, persistent, nearly colourless, 10–13 μm thick, composed of indistinct, 5–8 μm sized hyphal cells, often covered with some hyaline hyphae; asci numerous, irregularly disposed, formed in brushes on ascogenous hyphae, clavate, obovate or spherical, thin-walled, evanescent, 8-spored, 10–13 μm wide; ascospores ellipsoidal or reniform, rather thick-walled, with a 1–1.5 μm broad sheath, smooth or finely striate, hyaline, yellow to pink en masse, without germ pore, 6–7 × 3–4 μm; conidiogenous cells often in clusters on the aerial hyphae, cylindrical or tapering, sympodially or percurrently elongating, 10–25 × 2–3.5 μm; conidia ellipsoidal, obovate, cylindrical or clavate, 1-celled or rarely septate, rounded or slightly truncate at the base, hyaline, 5–16 × 3–5 μm, leaving rather distinct scars after release.

TYPE.—CBS 123.78, isolated from dung of nilgai, (short-horned, Indian antilope), collected in Delhi Zoo, 28 April 1977.

The teleomorph alone was observed on the dung and it was only present in fresh isolates. The anamorph was observed in subcultures of the fungus, usually together with the teleomorph.

The genus *Leucosphaera* has to be classified in the family Pseudeurotiaceae sensu Malloch & Cain (*1970*). The anamorph is rather similar to that of some *Pseudeurotium* species, but there is no generic name available. The genus *Pseudeurotium* van Beyma differs from *Leucosphaera* by having dark ascomata with a wall composed of distinct, pigmented cells and by the pigmented and unsheathed ascospores. The only genus classified in Pseudeurotiaceae with light ascomata is *Emericellopsis* van Beyma characterized by pigmented ascospores with wing-like appendages and by a phialidic, *Acremonium*-like conidial state (Gams, *1971*).

Among the ostiolate Pyrenomycetes (Sphaeriales, including Hypocreales), the only genus comparable to *Leucosphaera* is *Sphaeronaemella* Karst. The coprophilous species, *S. fimicola* Marchal, has particularly similar ascospores, but the *Gabarnaudia* anamorph is again phialidic (Cain & Weresub, *1957*; Samson, *1974*).

REFERENCES

CAIN, R. F. & WERESUB, L. K. (1957). Studies in coprophilous Ascomycetes V. *Sphaeronaemella fimicola*. *In* Can. J. Bot. **35**: 119–131.

GAMS, W. (1971). *Cephalosporium*-artige Schimmelpilze (Hyphomycetes). Stuttgart.

MALLOCH, D. & CAIN, R. F. (1970). Five new genera in the new family Pseudeurotiaceae. *In* Can. J. Bot. **48**: 1815–1825.

SAMSON, R. A. (1974). Paecilomyces and some allied Hyphomycetes. *In* Stud. Mycol. **6**: 1–119.

A NEW COPROPHILOUS ASCOMYCETE FROM INDIA

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In the course of a study of coprophilous fungi collected in the Zoological Garden in Delhi, an ascomycete belonging to the genus *Achaetomium* was isolated. It differs from previously described species by larger ascospores and almost colourless ascomata with a wide apical opening.

Achaetomium thielavioides v. Arx, Mukerji & Singh, *spec. nov.*—Fig. 1.

Coloniae in agaro farina maydis confecto 25°C in dies 2–3 mm crescunt, hyalinae, saepe lanosae; hyphae vegetativae 3–6 μm latae. Ascomatum initialia convoluta, cito plectenchymatica, hyalina. Ascomata hyalina vel modice brunnescentia, uniformia vel lageniformia, 150–240 μm diametro, ostiolo apicali 60–80 μm lato perforata; paries 7–10 μm crassus, carnosus, textura epidermoidea, hyalinus vel dilute brunneus. Asci fasciculati, clavati, pedicellati, 8-spori, evanescentes, 50–78 × 18–35 μm; ascosporae late fusiformes, biapiculatae, crassitunicatae, leves, viridibrunneae, poro germinationis subapicali distincto praeditae, 21–27 × 13–16 μm. Paraphyses filiformes, 2–3 μm latae, cito evanescentes. Anamorphosis abest.

Typus: CBS 122.78, isolatus e fimo antilopae Nilgai dictae, lectus in horto zoologico Delhiensi in India, 1976.

Colonies on cornmeal agar at 25°C with a daily growth rate of 2–3 mm, colourless, often lanose due to aerial hyphae; hyphae hyaline, branched, regularly septate, thin-walled, 3–6 μm broad; initials coiled, soon becoming plectenchymatous, hyaline; ascomata colourless or turning light brown with age, urn- or flask-shaped, 150–240 μm in diameter, with a 60–80 μm wide apical opening; ascoma wall 7–10 μm thick, fleshy, of textura epidermoidea, hyaline or light brown, composed of thin-walled, 3–5 μm broad hyphal cells which are vertically arranged around the apical opening; asci fasciculate, clavate, stalked, 8-spored, evanescent, 50–78 × 18–35 μm; ascospores broadly fusiform, biapiculate, thick-walled, smooth, greenish brown, with a distinct, usually sub-apiculate germ pore, 21–27 × 13–16 μm, adhering to form a dark, slimy ball when liberating; paraphyses filiform, hyaline, 2–3 μm broad, disappearing early; anamorphs absent.

TYPE.—CBS 122.78, isolated from nilgai dung, collected in Delhi Zoo, India, 29 Dec. 1976.

This fungus can be distinguished from all species described as *Achaetomium* (Mukerji & Saxena, *1974*; Kulshreshtha *& al.*, *1977*) by its larger ascospores with a subapical germ pore and by the usually colourless wall of the ascomata. Occasionally the ascomata are non-ostiolate in which case the fungus is similar to *Thielavia hyalocarpa* v. Arx (*1975*), except in

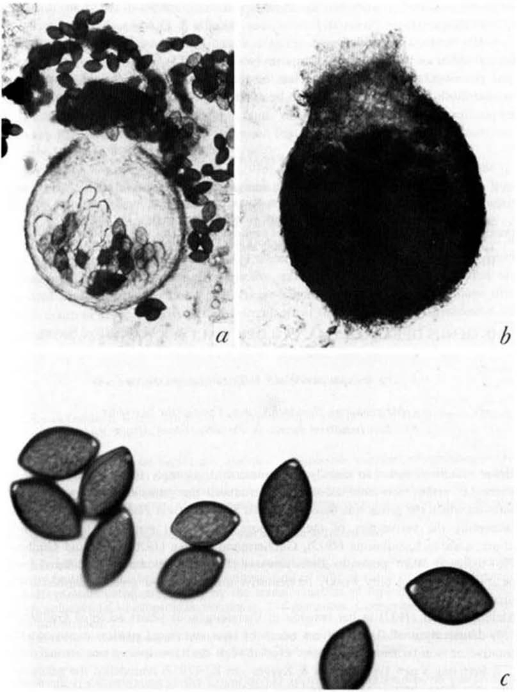

Fig. 1. *Achaetomium thielavioides*. — a, b. Ascomata (× 180). — c. Ascospores (× 750).

that the ascospores have an apical germ pore. In *A. thielavioides* the germ pore is usually subapical, but also occasionally lateral or nearly lateral (Fig. 1c).

Some additional *Thielavia* species can be considered as non-ostiolate counterparts of

Achaetomium species. *A. globosum* Rai & Tewari, the type species of the genus, is close to *T. octospora* (Natarajan) v. Arx and *T. tetrasperma* (Lodhi & Mirza) v. Arx (*Boothiella tetraspora* Lodhi & Mirza). These species are characterized by light ascomata, cylindrical asci and spherical-oblate or broadly ovate ascospores (von Arx, *1975*).

The genus *Achaetomium*, therefore, can be considered to be the ostiolate counterpart of *Thielavia*. Both these genera are seen to be related to the Sordariaceae and Chaetomiaceae; their position being intermediate.

REFERENCES

ARX, J. A. VON (1975). On *Thielavia* and some similar genera of Ascomycetes. *In* Stud. Mycol. **8**: 1—29.

KULSHRESHTHA, D. D., RAYCHAUDHURI, S. P. & KHAN, A. M. (1977). Studies on some soil fungi associated with maize rhizosphere. I. Three new Ascomycetes. *In* Acta Bot. Ind. **5**: 16–19.

MUKERJI, K. G. & SAXENA, A. S. (1975). Notes on *Achaetomium*, *Anixiella*, *Boothiella*, *Chaetomidium*, *Lophotrichus*, *Pseudeurotium*, *Pycnidiophora* and the classification of the Chaetomiales. *In* Nova Hedwigia, Beih. **47**: 373–404.

THE GENUS DEBARYOZYMA VAN DER WALT & JOHANNSEN, NOM. NOV.

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Klöcker (*1909*) in order to classify an undescribed, strongly fermentative yeast forming sphaeroidal, visibly verrucose ascospores, introduced the genus *Debaryomyces*. The single species on which the genus was based he named *Debaryomyces globosus* Klöcker.

Accepting the verrucosity of the ascospore as cardinal generic criterion, subsequent authors, notably Konokotina (*1913*), Guilliermond & Péju (*1920*, *1921*) and Guilliermond (*1928*) assigned other species to *Debaryomyces*. These species, however, differed from the type species by being only weakly fermentative and utilizing a greater number of carbon sources.

Stelling-Dekker (*1931*) in her revision of the ascogenous yeasts accepted Guilliermond's (*1928*) demarcation of *Debaryomyces* which by now comprised predominantly weakly fermentative or non-fermentative species even though the type species was strongly fermentative. Selecting a new type, Lodder & Kreger-van Rij (*1952*) remodelled the genus so as to retain only those species characterized by a predominantly oxidative metabolism.

In contravention of Articles 7 and 52 of the International Code of Botanical Nomenclature (Stafleu *& al.*, *1972*), Lodder & Kreger-van Rij retained the name *Debaryomyces* for the remodelled taxon from which they had excluded the type species, *D. globosus*. This innovation in terms of Article 48 of the Code resulted in the introduction of the name *Debaryomyces* Lodder & Kreger-van Rij to designate the remodelled taxon, based on the type *Debaryomyces hansenii* (Zopf) Lodder & Kreger-van Rij (Syn.: *Saccharomyces hansenii* Zopf, *1889*). As *Debaryomyces* Lodder & Kreger-van Rij is a later homonym of *Debaryomyces* Klöcker, it is in terms of Article 64, illegitimate and must be rejected.

Van der Walt & Johannsen (*1975*) in a revision of the yeasts forming verrucose, sphaeroidal ascospores, concluded that the maintenance of *Debaryomyces* Lodder & Kreger-van Rij on the basis of criteria such as differences in rates of fermentation and more varied carbon assimilation patterns was tenuous and, since the name *Debaryomyces* Lodder & Kreger-van Rij contravened the Code, proposed that this taxon together with *Debaryomyces* Klöcker be united in *Torulaspora* Lindner (*1904*).

More recently, however, Yamada *& al.* (*1976, 1977*) in their study of the coenzyme Q (or ubiquinone) systems in the ascogenous yeasts provided a more substantial basis for the demarcation of *Debaryomyces* Lodder & Kreger-van Rij. It was demonstrated that, whereas *Debaryomyces globosus* and the species of *Torulaspora* were all characterized by the coenzyme Q-6 system, the species assigned to *Debaryomyces* Lodder & Kreger-van Rij, were consistently differentiated by the presence of the coenzyme Q-9 system. As this difference in the coenzyme Q systems provides an objective, rational basis for the demarcation of the taxon cited as *Debaryomyces* Lodder & Kreger-van Rij, it is proposed to rename this remodelled taxon in accordance with the requirements of the Code, while *D. globosus* Klöcker will be retained in *Torulaspora*.

Debaryozyma van der Walt & Johannsen, *gen. nov.*

Debaryomyces Lodder & Kreger-van Rij *in* The Yeasts, Ed. 1. 277. 1952; non *Debaryomyces* Klöcker *in* C.r. Trav. Lab. Carlsb. 7: 273. 1909.

Cellulae vegetativae praecipue haploideae, globosae, subglobosae, ovoideae vel ellipsoideae, propagantes per gemmationem. Asci ex conjugatione cellularum aequalium vel inaequalium aut ex autogamia somatogamica, raro e transformatione cellularum vegetivarum diploidearum oriuntur. Ascosporae globosae vel ellipsoideae, verrucosae, ad 4 in singulis ascis. Systema coenzymatis Q-9 adest. Nitrato non utitur.

Species typica: *Debaryozyma hansenii* (Zopf) van der Walt & Johannsen.

Vegetative cells predominantly haploid, sphaeroidal, subglobose, ovoid or ellipsoidal, reproducing by budding. Asci arise from the conjugation of cells of equal or unequal dimensions, by somatogamous autogamy, rarely by the transformation of diploid, vegetative cells. Ascospores sphaeroidal or ellipsoidal, verrucose, 1–4 per ascus. Coenzyme Q-9 system present. Nitrate not utilized.

TYPE SPECIES.— **Debaryozyma hansenii** (Zopf) van der Walt & Johannsen, *comb. nov.* (basionym, *Saccharomyces hansenii* Zopf *in* Ber. dt. bot. Ges. 7: 95. 1889).

On the basis of data relating to the Coenzyme Q system and the ascosporal morphology of the species, as provided by Yamada *& al.* (*1976, 1977*) and Kurtzman *& al.* (*1975*) respectively, the following transfers are effected. —

Debaryozyma castellii (Capriotti) van der Walt & Johannsen, *comb. nov.* (basionym: *Debaryomyces castellii* Capriotti *in* Arch. Mikrobiol. **28**: 344. 1958).

Debaryozyma coudertii (Saëz) van der Walt & Johannsen, *comb. nov.* (basionym: *Debaryomyces coudertii* Saëz *in* Bull. mens. Soc. linn. Lyon **29**: 288. 1960).

Debaryozyma polymorpha (Klöcker) van der Walt & Johannsen, *comb. nov.* (basionym: *Pichia polymorpha* Klöcker *in* Zentbl. Bakt. ParasitKde (II. Abt.) **35**: 373. 1912).

Debaryozyma pseudopolymorpha (Ramirez & Boidin) van der Walt & Johannsen, *comb. nov.* (basionym: *Pichia pseudopolymorpha* Ramirez & Boidin *in* Microbiol. esp. **6**: 405. 1953).

Debaryozyma tamarii (Ohara & Nonomura) van der Walt & Johannsen, *comb. nov.* (basionym: *Debaryomyces tamarii* Ohara & Nonomura ex van der Walt & Johannsen *in* C.S.I.R. Res. Rep. **325**: 16. 1975. (Ohara & Nonomura, *1954*).

Debaryozyma vanriji (van der Walt & Tscheuschner) van der Walt & Johannsen, *comb. nov.* (basionym: *Pichia vanriji* van der Walt & Tscheuschner *in* J. gen. Microbiol. **15**: 459. 1956).

REFERENCES

GUILLIERMOND, A. (1928). Clef dichotomique pour la détermination des levures. Paris.

GUILLIERMOND, A. & PÉJU, G. (1920). Une nouvelle espèce de levures du genre *Debaryomyces. D. Klöckerii*, n. sp. *In* Bull. trimest. Soc. mycol. Fr. **36**: 164–171.

—— (1921). Une nouvelle espèce de levure du genre *Debaryomyces. Debaryomyces Nadsonii* n. sp. *In* Bull. trimest. Soc. mycol. Fr. **37**: 35–38.

KLÖCKER, A. (1909). Deux nouveaux genres de la famille des Saccharomycètes. *In* C.r. Trav. Lab. Carlsberg **7**: 273–278.

KONOKOTINA, A. G. (1913). O novykh drožževykh gribkakh: *Nadsonia* (*Guilliermondia*) *elongata* i *Debaryomyces tyrocola*. *In* Izv. impr. S.-Peterb. bot. Sada **13**: 32–44.

KURTZMAN, C. P., SMILEY, M. J. & BAKER, F. L. (1975). Scanning electron microscopy of ascospores of *Debaryomyces* and *Saccharomyces*. *In* Mycopathologia **55**: 29–34.

LINDNER, P. (1904). Neue Erfahrungen aus dem letzten Jahre in Bezug der Hefen und Gärung. *In* Jb. Vers.- u. Lehranst. Brau. Berl. **7**: 441–464.

LODDER, J. & KREGER-VAN RIJ, N. J. W. (1952). The Yeasts, a taxonomic study. Amsterdam.

OHARA, Y. & NONOMURA, H. (1954). Yeast occurring in a mash and koji of Tamari soya. Part. 4. On four strains including *Debaryomyces tamarii*. *In* J. agric. Chem. Soc. Japan **28**: 837–840.

STAFLEU, F. A. & AL. (Eds.) (1972). International Code of Botanical Nomenclature adopted by the Eleventh International Botanical Congress, Seattle, Aug. 1969. Utrecht.

STELLING-DEKKER, N. M. (1931). Die Hefensammlung des 'Centraalbureau voor Schimmelcultures'. I Teil. Die sporogenen Hefen. *In* Verh. K. Ned. Akad. Wet. (Natuurk.) **28**: 1–547.

WALT, J. P. VAN DER & JOHANNSEN, E. (1975). The genus *Torulaspora* Lindner. *In* C.S.I.R. Res. Rep. **325**, 1–23.

YAMADA, Y., ARIMOTO, M. & KONDO, K. (1977). Coenzyme Q systems in the classification of some ascosporogenous yeast genera in the families Saccharomycetaceae and Spermophthoraceae. *In* Antonie van Leeuwenhoek **43**: 65–71.

YAMADA, Y., NORJIRI, M., MATSUYAMA, M. & KONDO, K. (1976). Coenzyme Q systems in the classification of the ascosporogenous yeast genera *Debaryomyces, Saccharomyces, Kluyveromyces* and *Endomycopsis*. *In* J. gen. appl. Microbiol., Tokyo **22**: 325–339.

ZOPF, W. (1889). Oxalsäuregährung (an Stelle von Alcoholgährung) bei einem typischen (Endosporen) Saccharomyceten (*S. Hansenii* n. spec.). *In* Ber. dt. bot. Ges. **7**: 94–97.

A NEW LICHENIZED ATHELIA FROM FLORIDA

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Several species of the genus *Athelia* show a close relationship with either free-living algae or algae within lichens. Although most taxa of *Athelia* live as saprophytes, a growing number of species is known to form basidiolichens and as such grow constantly together with algae which do not seem to be much damaged.

Apart from the species which are known as parasites of algae and lichens, there are three species which live symbiotically with filamentous Cyanophyceae (Algae), viz. *Athelia andina* Jülich, *A. epiphylla* Pers., and *A. phycophila* Jülich. *Athelia epiphylla* occurs mostly as a saprophyte on a variety of substrates, whereas the other two species are only known as basidiolichens. *Athelia andina* and *A. phycophila* are devoid of clamps at every septum of the basidiocarp, but *A. epiphylla* shows some clamp-connexions on the basal hyphae.

The specimen which I received from Professor J. Poelt (Graz, Austria) develops a clamp at every septum and deviates in this respect clearly from the three above mentioned species. The spores are distinctly broadened at the basal part, a feature also known from *A. andina*, but rather uncommon within the Corticiaceae. In all characters it is a typical *Athelia*: the basidiocarp is more or less pellicular, the subiculum is rather loose, the hyphae are straight, more or less cylindrical and clearly visible, and in the hymenial part a tuft of clavate basidia is formed; the spores are thin, hyaline, smooth, and inamyloid.

Thus the specimen which Prof. Poelt collected in Florida just prior to the Second International Mycological Congress, belongs undoubtedly to the genus *Athelia*, but is not conspecific with any of the known species of that genus. Hence it is here described as a new species, dedicated to Prof. Poelt who not only collected the specimen but who, as my teacher, also introduced me into the exciting world of fungi and guided my work on the taxonomy of the Corticiaceae.

Athelia poeltii Jülich, *spec. nov.*—Fig. 1a

Carposoma resupinatum, effusum, molle, membranaceum vel pelliculare, margine indistincta; rhizomorphae desunt. Hymenium laeve vel paulum grandinioideum, albidum. Systema hypharum monomiticum. Hyphae hyalinae, cylindraceae, 4–6.5 μm latae, fibulatae. Cystidia non evoluta. Basidia hyalina, maturitate clavata, 15–18 × 5.5–6.5 μm, laeves, fibulata, tetraspora. Sporae hyalinae, ovatae, 5.5–6 × 4–4.5 μm, tenui-tunicatae, inamyloideae. — Hab.: supra filamenta Cyanophyceae.

Typus: *J. Poelt*, Black Hammock prope Oviedo, Sandford Co., Florida, America septentrionalis, 27.8.1978 (GZU, L).

Basidiocarp annual, resupinate, small, effused up to several mm, 80–150 μm thick, loosely adnate; consistency soft-membranaceous to pellicular; context homogeneous; margin whitish, indistinct; rhizomorphs or hyphal strands lacking. Hymenial surface whitish, even to very slightly grandinioid. Hyphal system monomitic. Hyphae hyaline, cylindrical, sometimes slightly flexuous, loosely arranged in subhymenium and trama, branching near the septa, 4–

6.5 μm in diam. in subhymenium and trama, rather firm-walled in all parts of the basidiocarp, with smooth surface; clamps present at every septum; contents homogeneous. Cystidia lacking. Basidia hyaline, clavate when mature, more or less ellipsoidal when young, 15–18 × 5.5–6.5 μm, thin-walled, with smooth surface, with four subulate sterigmata; a basal clamp always present; contents homogeneous. Spores hyaline, ovate, distinctly broadened near the base, with a small apiculus, 5.5–6 × 4–4.4 μm, not glued together, thin-walled, with smooth surface, not amyloid; contents homogeneous.

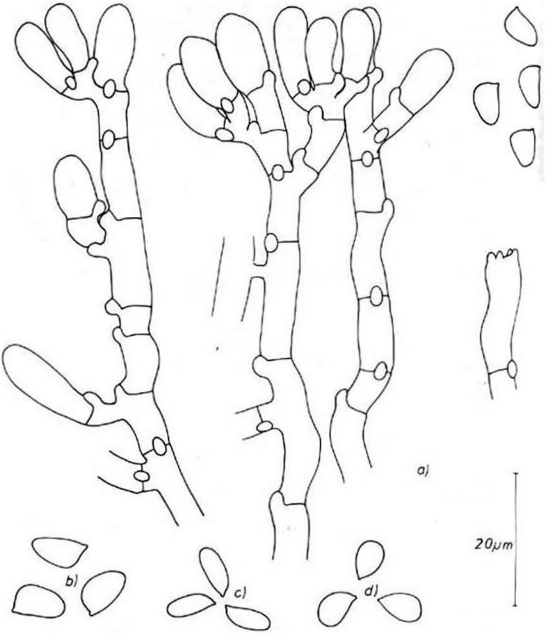

Fig. 1. Lichenized species of *Athelia*. — a. *A. poeltii* (holotype). — b. *A. andina*, spores. — c. *A. epiphylla*, spores. — d. *A. phycophila*, spores.

REACTIONS.—No part of the basidiocarp is amyloid or dextrinoid.

CYTOLOGY.—Spores 1-, hyphae 2-, young basidia 2-nucleate.

SUBSTRATE.— Weakly parasitic on filamentous Cyanophyceae.

DISTRIBUTION.—Only known from the holotype-collection.

SPECIMEN STUDIED.—U.S.A., Florida, Sanford Co., Black Hammock near Oviedo, Sabal-Quercus-forest, 27.VIII.1978, *J. Poelt* (Holotype in GZU, part of holotype in L).

KEY TO THE LICHENIZED SPECIES OF ATHELIA

(for a full description see Jülich, *1972*)

1a. Clamps present at all septa of the hyphae, also at the base of the basidia. Spores 5.5–6 × 4–4.4 μm. Known only from Florida . . . . *A. poeltii* Jülich

b. Clamps absent or only occasionally present at some septa of the trama, never present in the subhymenium or at the base of the basidia 2

2a. Spores more or less cylindrical or narrowly ellipsoid, (5.5–)6–7.5(–8) × 2.8–3.2 μm. Known from Europe, North America, Russia, and Venezuela . . . . *A. epiphylla* Pers.

b. Spores broader, distinctly pyriform or ovate 3

3a. Spores pyriform, the apical part distinctly broadened, 5–6.5 × 3.5–4.2 μm. Known only from Venezuela . . . . *A. phycophila* Jülich

b. Spores ovate, the basal part distincyly broadened, 5.5–6 × 4–4.5 μm. Known only from Venezuela *A. andina* Jülich

REFERENCE

JÜLICH, W. (1972). Monographie der Athelieae (Corticiaceae, Basidiomycetes). *In* Willdenowia, Beih. **7**: 1–283.

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BOOKS RECEVIED BY THE RIJKSHERBARIUM LIBRARY

W. FREY, H. Hurka & F. OBERWINKLIER, *Beiträge zur Biologie der niederen Pflanzen. Systematik. Stammesgeschichte. Ökologie.* (G. Fisher, Stuttgart, New York, 1977.) Pp. 233, 118 Text-figs. Price: DM 58.–.

This book is dedicated to Prof. Dr. K. Mägdefrau (Münster, Germany) at the occasion of his 70th birthday. Several of his colleagues and former students have contributed on the theme 'Adaptation of cryptogamic organisms to their environment'. Modern opinions about the fungi in this respect are given in the chapters: Chemotaxonomy of the fungi (18 pp, by A. Bresinsky), Problems concerning the system of the Ascomycetes (15 pp, by E. Müller), and The new system of the Basidiomycetes (45 pp, by F. Oberwinkler).

F. FLÜCK-WIRTH, *Krypto Gesamt-Katalog Nr. 4 Botanik (Biologie).* (Krypto, Teufen, Switzerland, 1977). Pp. 719. Price: sFr. 17.50 (or free, when orders for books over sFr. 100.– are placed).

In this catalogue of botanical literature an enormous amount of bibliographical work has been involved. Of about 5600 titles of available and forthcoming botanical literature, bibliographical data are given with great accuracy. Summaries of contents for most entries are provided. The greatest weight is placed with algae, mosses, fungi, lichens, ferns, and flowering plants. An author index and an extensive subject index aid in locating individual or special works more quickly.

THE RIJKSHERBARIUM, 150 YEARS OLD

On March 29 and 30, 1979, the Rijksherbarium at Leiden commemorated in a modest way its foundation by King William I, 150 years ago.

On the first day of the celebration a large company, including several distinguished foreign botanists, gathered in the old central building of the University for a festive meeting during which a number of speakers dwelt upon past, present and future of the Rijksherbarium as well as on its role in botany.

On the second day a symposium was held on the future of plant taxonomic research in the Netherlands and an exposition was opened which gave an attractive survey of collections of and work at the Rijksherbarium. Another exhibition of botanical illustrations from the vaults of the Rijksherbarium opened its doors a few weeks later, followed in mid-summer by an exhibition on the relation between plants and animals, organized in co-operation with the Museum of Natural History at Leiden, in the Leiden Botanical Garden.

Also in print, ample attention has been given to the Rijksherbarium jubilee. A profusely illustrated fascicle of the University journal TCHAF, titled '150 Jaar Rijksherbarium', has been widely distributed among the workers of the Leiden University. A part of Blumea Volume 25 Part 1 has been transformed into a jubilee volume, edited by C. Kalkman and P. Smit, entitled 'Rijksherbarium 1829–1979', containing a series of English papers on the history of the Rijksherbarium, its collections and its activities, among which a contribution by J. van Brummelen (pp. 83–87) on mycology and lichenology at the Rijksherbarium.

For those subscribers of Persoonia who do not receive Blumea and did not receive the jubilee volume as a gift, a limited number of copies is still available.*

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* To be requested from: Mr. L. Vogelenzang, Librarian of the Rijksherbarium, Schelpenkade 6, Leiden.

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