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CONTENTS

[Contents continued overleaf]

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Table of Contents, Volume Forty-One

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A NEW SPECIES OF *EXOPHIALA* RECOVERED FROM DRINKING WATER

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ABSTRACT

A new species, *Exophiala angulospora* Iwatsu, Udagawa et Takase, isolated from drinking well water in Japan, is described and illustrated. This fungus is characterized by having more commonly angular (tri- or tetragonal in longitudinal view) conidia with rounded ends rather than an obovoid, ellipsoidal or oblong form.

During a pollution assessment of drinking well water in Yokohama City in Japan, an interesting dematiaceous hyphomycete was detected and isolated. Although this fungus was found to be a typical member of *Exophiala* Carmichael (Carmichael, 1966), it is clearly distinct from all hitherto described species of the genus. Therefore, it is described herein as a new species.

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Exophiala angulospora Iwatsu, Udagawa et Takase, sp. nov. (Figs. 1, 2)

Coloniae in agaro farinae avenae restrictae, floccosae, ad centrum partim humidae, atrovirides vel nigrae; reverso atroviridi vel nigro. Coloniae in agaro "potato-carrot" restrictae, floccosae, constantes ex mycelio tenui, griseo-brunneae vel nigrae; reverso atroviridi. Mycelium ex hyphis hyalinis vel pallide olivaceo-brunneis vel brunneis, ramosis, levibus, crassiusculis, septatis, 1.5-3 μm diam, interdum irregulariter inflatis compositum; saepe fasciculatum. Cellulae gemmatae praesentes. Cellulae germinantes plerumque inflatae, leves, crassiusculae, 6-10 X 2.5-4 μm, in cellulas breves ventricosas patulae, quae deinde in hyphas longas angustatas transiens. Apparatus conidicus saepe distinctus, erectus, capitulum densum formans. Cellulae conidiogenae annellidicae, intercalares, laterales vel terminales, lageniformes vel cylindricae, 6-16 X 2.5-3 μm, prope basim septatae, ad rostrum breve angustatae. Conidia unicellularia, in capitulum mucosum aggregata, hyalina vel pallide olivacea, levia, basi subtruncata, diversiformia, (1) plerumque angulata, cum extremis rotundata, plus minusve incrassata, 2.5-4 X 2-3 μm, et (2) interdum obovoidea, ellipsoidea vel oblonga, 2.5-6 (-8) X 1.5-3 μm.

Ubiquinonum majus: Q-10.

Teleomorphosis ignota est.

Holotypus: Colonia exsiccata ex aqua potabili, Yokohama, in Japonia, 18.iv.1989, a K. Arai isolata, NHL 3101. In collectione fungorum "National Institute of Hygienic Sciences (NHL), Tokyo."

Etymology: from Latin *angulus*, angle, and *-sporus*, seed, referring to the shape of conidia.

Colonies on oat-meal agar growing restrictedly, floccose, partly wettish in the central area, Dark Green (26F3-4: Kornerup and Wanscher, 1978) to Black (1F1); reverse Dark Green (27F4) to Black (1F1). Colonies on potato-carrot agar growing restrictedly, floccose, consisting of a thin mycelium, Greyish Brown (7F3-4) to Black (1F1); reverse Dark Green (27F3). Mycelium composed of hyaline to pale olivaceous or brown, branched, smooth, rather thick-walled, septate, 1.5-3 μm diam, sometimes irregularly swollen

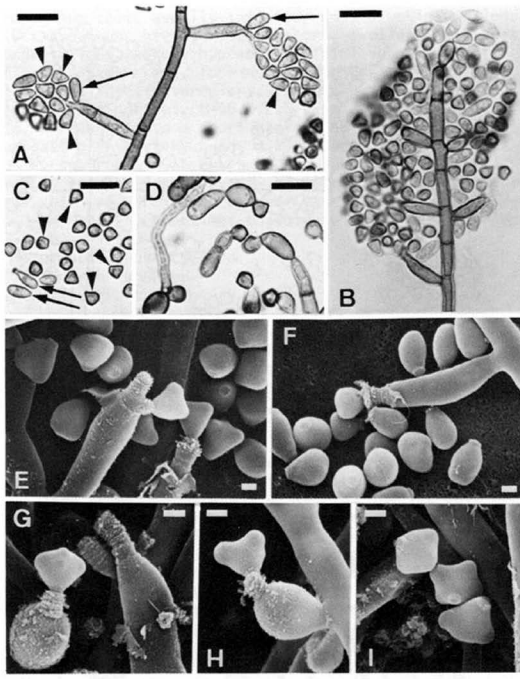

Fig. 1. *Exophiala angulospora*, NHL 3101.
A-D) Light micrographs (scale bars: 10 μm): A. Conidiogenous cells, angular conidia (arrow heads) and obovoid-ellipsoidal conidia (arrows); B. Whole conidial apparatus; C. Angular conidia (arrow heads) and ellipsoidal conidia (arrows); D. Germination of angular conidia. E-I) SEM micrographs (scale bars: 1 μm): E, G-I. Conidiogenous cells and angular conidia ; F. Conidiogenous cell and obovoid-ellipsoidal conidia.

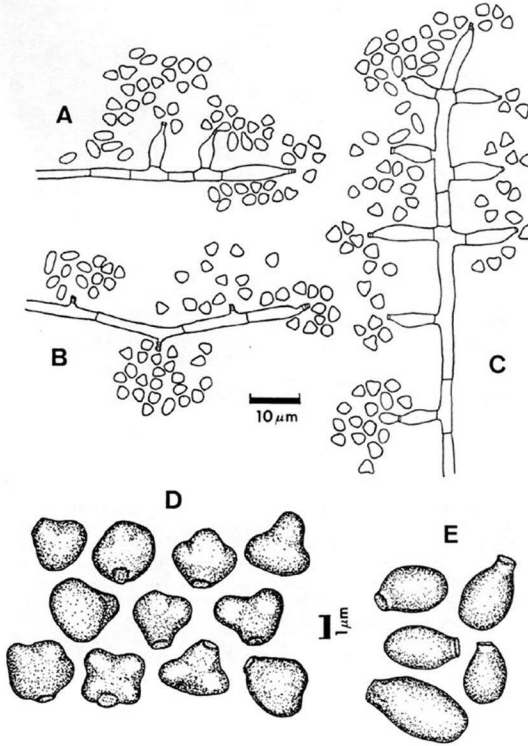

Fig. 2. *Exophiala angulospora*, NHL 3101.
A, B) Conidiogenous cells and conidia.
C) Whole conidial apparatus. D) Angular conidia.
E) Obovoid-ellipsoidal conidia.

hyphae; often forming a bundle. Budding cells present. Germinating cells usually inflated, smooth, thick-walled, 6-10 X 2.5-4 μm, giving rise to short, swollen cells that change to long, narrow hyphae. Conidial apparatus often differentiated, erect, forming a dense head. Conidiogenous cells annellidic, intercalary, lateral or terminal, flask-shaped or cylindrical, 6-16 X 2.5-3 μm, septate near the base, narrowing into a short beak. Conidia 1-celled, aggregating in a slimy head, hyaline or pale olivaceous, smooth, subtruncate at the base, variable in shape, (1) commonly angular (usually tri- or tetragonal in longitudinal view), with rounded ends, more or less thick-walled, 2.5-4 X 2-3 μm, and (2) sometimes obovoid, ellipsoidal or oblong, 2.5-6(-8) X 1.5-3 μm.

Major ubiquinone: Q-10.

Teleomorph is unknown.

At 37°C, growth is nil.

Specimens examined: NHL 3101 (holotype) and NHL 3102, isolated from drinking well water in Yokohama-shi, Japan, 18.iv.1989, coll. K. Arai. The specimens studied and living cultures derived from them are preserved at the National Institute of Hygienic Sciences, Tokyo, Japan.

The genus *Exophiala* was established by Carmichael (1966) to accommodate *E. salmonis* Carmichael, a pathogen of fingerling trout. Subsequently, several species have been added to the genus. Among them, *E. pisciphila* McGinnis et Ajello (McGinnis and Ajello, 1974), *E. spinifera* (Nielsen et Conant) McGinnis (McGinnis, 1977a), *E. jeanselmei* (Langer.) McGinnis et Padhye (McGinnis and Padhye, 1977), *E. moniliae* de Hoog (de Hoog, 1977), *E. dopicola* Katz et McGinnis (Katz and McGinnis, 1980) and *E. alcalophila* Goto et Sugiyama (Goto *et al.*, 1981) are widely accepted species (de Hoog and McGinnis, 1987). *Exophiala brunnea* Papendorf (Papendorf, 1969) is considered as a synonym of *E. salmonis* (de Hoog, 1977). A well-known human pathogen, *E. dermatitidis* (Kano) de Hoog (de Hoog, 1977), is now generally classified in *Exophiala*, although McGinnis (1977b) considered it to be the more appropriately classified in the genus *Wangiella* McGinnis. *Exophiala castellanii* Iwatsu *et al.* was described by one of the authors (Iwatsu *et al.*, 1984) to solve the taxonomic confusion surrounding *E. mansonii* (Castell.) de Hoog (de Hoog, 1977), but is now considered as one of the varieties of *E. jeanselmei* (Iwatsu and Udagawa, 1990). *Hortaea werneckii* (Horta) Nishimura et

Miyaji (Nishimura and Miyaji, 1984) was once classified in this genus as *E. werneckii* (Horta) v. Arx (von Arx, 1970), but is now separated. According to de Hoog and McGinnis (1987), most known teleomorphs with *Exophiala* anamorphs are classified in the ascomycete family Herpotrichiellaceae; viz. unnamed *Exophiala* species reported in *Capronia acutiseta* G. J. Samuels, *C. coronata* G. J. Samuels, and *C. villosa* G. J. Samuels (Müller *et al.*, 1987). Recently, Pedersen and Langvad (1989) have described *E. psychrophila* O. Pedersen et Langvad as a pathogen of Atlantic salmon.

Exophiala angulospora differs from previously described species of *Exophiala* in having more commonly angular conidia rather than an obovoid, ellipsoidal or oblong form. On the other hand, other species of the genus have only the latter form. In addition, the fertile, conidium-bearing portions of the hyphae of *E. angulospora* are rather more differentiated when compared to those of other species.

Recently, Yamada *et al.* (1989) have reported that two main groups in the genus *Exophiala* can be distinguished on the basis of coenzyme Q systems: (1) Psychrophilic fish-pathogens, containing the generic type species *E. salmonis*, and *E. pisciphila*, both having Q-10 (H_2), and (2) Human-pathogenic species, containing *E. dermatitidis*, *E. jeanselmei*, *E. moniliae* and *E. spinifera*, and non-pathogenic species of *E. alcalophila*, all of which have Q-10. *Exophiala angulospora* has Q-10 and is thought to belong to the latter group.

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We would like to thank Mrs. K. Arai for providing the isolates used in this study and Dr. K. Kodama for his assistance of the coenzyme Q analysis. We are grateful to Prof. G. Morgan-Jones for his critical review of the manuscript and Dr. Y. Otani for correction of the Latin diagnosis.

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MYCOTAXON

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NEW COMBINATIONS AND SYNONYMY IN BIPOLARIS AND CURVULARIA, AND A NEW SPECIES OF EXSEROHILUM

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Bipolaris pluriseptata (Khetarpal, Nath & Lal) comb. nov., *B. portulacae* (Rader) comb. nov., *B. salviniae* (Muchovej) comb. nov. and *Curvularia heteropogonicola* (Sivan.) comb. nov. are proposed, and some synonymy is indicated. A *Cochliobolus* teleomorph is confirmed for *B. micropus* (Drechsler) Shoem., for which *Exserohilum paspali* Muchovej & Nesio is shown to be a synonym. *Exserohilum fusiforme* sp. nov. from *Echinochloa crus-galli* is described and illustrated. Brief notes are provided on *B. palousensis* Sprague, *Cochliobolus sporoboli* Castellani, *Drechslera patereae* Carranza and *Helminthosporium atypicum* K.S. Deshpande & K.B. Deshpande.

Key words: *Bipolaris, Curvularia, Exserohilum,* Taxonomy

This paper deals with a miscellany of observations relating to new combinations and synonymy in *Bipolaris* and *Curvularia*, and a new species of *Exserohilum*. Media mentioned in the text are PDA (potato dextrose agar), SMA (Sachs agar + maize leaf), WSA (water agar + wheat straw) and V-8A (15% V-8 juice agar). Cultures were grown under near-ultraviolet light (nuv, 12 h photoperiod, room temperature) to stimulate conidial sporulation, or on SMA in darkness when producing teleomorphs.

Bipolaris pluriseptata (Khetarpal, Nath & Lal) Alcorn, comb. nov.
Drechslera pluriseptata Khetarpal, Nath & Lal, *Ind. Phytopath.* 37: 320 (1984).

Conidial morphology of *B. pluriseptata* is similar to that of *B. curvispora* (El Shafie) Sivan., and Sivanesan (1987) considers these species to be synonymous. *B. pluriseptata* is here maintained as distinct following comparisons with cultures of each species grown under identical conditions. On SMA exposed to nuv, conidiophores of *B. pluriseptata* are shorter and thicker than those of *B. curvispora*, 95-215 µm long x 6.5-7.5 µm at the tip compared with 155-475 x 5-

6 µm. Conidia of *B. pluriseptata* are darker and often have a paler basal cell, are longer (up to 290 µm compared with 235 µm) and have more septa (8-21 cf. 8-13). Also they are more strongly curved, often more or less U-shaped, occasionally horseshoe-shaped (pers. obs.; Khetarpal, Nath & Lal, 1984). *B. pluriseptata* was not interfertile with tester strains of *Cochliobolus melinidis* Alcorn, the teleomorph of *B. curvispora*, when tested in 1987 and 1989.

Cultures examined: *D. pluriseptata*. ITCC 3131 ex type, *Eleusine coracana* (L.) Gaertn., Zambia, Feb. 1981 (BRIP 14895); IMI 259810 ex ITCC 3131 (BRIP 14839).

Bipolaris portulacae (Rader) Alcorn, comb. nov.

Helminthosporium portulacae Rader, *Mycol.* 40: 344 (1948).

Drechslera portulacae (Rader) de Hoog & van Oorschot, *Proc. K. ned. Akad. Wet.* C 86: 59 (1983).

Bipolaris portulacae (Rader) Strider & Chi, *Plant Disease* 68: 826 (1984), *nom. inval.*, Art. 33.

Bipolaris novae-zelandiae Sivanesan, *Trans. Br. mycol. Soc.* 84: 406 (1985).

Drechslera helianthi Hulea, *Probleme de Protectia Plantelor*1: 78 (1973), *nom. inval.*, Art. 36.

Drechslera helianthi Iliescu, Hulea & Bunescu, *Proc. 6th Internat. Sunflower Conf. (1974) Bucharest*, p. 665 (1975), *nom. inval.*, Art. 36.

Rader (1948) showed that *H. portulacae* was a virulent pathogen of *Portulaca oleracea* L., while Strider & Chi (1984) found that *P. grandiflora* Hook. was also susceptible. Iliescu, Hulea & Bunescu (1975) concluded that *D. helianthi* was not a pathogen of *Helianthus annuus* L., and this might be expected if *B. portulacae* is host specific. *B. novae-zelandiae* was isolated from cultivated soil, but the circumstances of its occurrence were not further elaborated (Sivanesan, 1985). *P. oleracea* occurs in New Zealand but has not been recorded as a host of *B. portulacae* there (Pennycook, 1989).

A characteristic feature of *B. portulacae* is a narrow dark transverse band near the conidium apex, and sometimes also the base, coincident with or adjacent to the region where the periclinal wall curves and becomes thinner. Sivanesan (1985) reported 'a thick dark tranverse septum at one or both ends' in conidia of *B. novae-zelandiae*, but the illustrations suggest he was referring to the

bands described above. They were also noted by de Hoog & van Oorschot (1983) in the isolate they studied.

Sivanesan (1985) reported typical *Bipolaris* conidial septum ontogeny in *B. novae-zelandiae.* In cultures CBS 239.48 and NC 196 of *B. portulacae,* the position occupied by the primary conidial septum is variable, sometimes submedian and in other instances delimiting the basal cell. Iliescu *et al.* (1975) illustrated similar variability in *D. helianthi.* I have been unable to confirm Sivanesan's results for septum ontogeny with the culture IMI 222864. Germination in *B. portulacae* is predominantly bipolar, with germ tubes branching close to the conidium. The apical germ tube is axial, and the basal, semi-axial germ tube often displaces the hilum by its proximity.

In culture on PDA, isolates of *B. portulacae* produce large, feathery, branched aggregations of acicular cystals submerged in the medium. These deposits are up to 9 mm long, and occur abundantly in cultures of CBS 239.48 and NC 196, less so in IMI 222864. In cultures of BRIP 15158 the aggregations are less numerous and smaller. The microsclerotia produced by all isolates have been described by previous authors, but the presence of crystals apparently has not been noted (de Hoog & van Oorschot, 1983; Iliescu et al. 1975; Rader, 1948; Sivanesan, 1985). The possibility that the microsclerotia might be prototheca was explored by pairing the isolates listed below in all possible combinations on SMA, but no ascomata formed.

Cultures examined: CBS 239.48 from *Portulaca oleracea,* Watkins Glen, New York State, U.S.A., W.E. Rader, authentic for the name *H. portulacae* (BRIP 14541); NC 196 from *Portulaca* sp. (? *P. grandiflora*) seed, 1975, D.L. Strider (BRIP 14576); IMI 222864 from soil, Mouteka, New Zealand, 25 Oct. 1977, K.N. Brunette 12347, ex type collection of *B. novae-zelandiae* (BRIP 14837); *D. helianthi* from *Helianthus annuus,* Romania, comm. May 1986, H. Iliescu *s.n.* (BRIP 15158).

Bipolaris salviniae (Muchovej) Alcorn, comb. nov.

Drechslera salviniae Muchovej, *Trans. Br. mycol. Soc.* 72: 331 (1979).

Bipolaris curvispora (El Shafie) Sivan., *Mycological Papers (CMI)* 158: 47 (1987).

Drechslera curvispora El Shafie, *Trans. Br. mycol. Soc.* 78: 545 (1982) (issued 7 June).

Bipolaris melinidis Alcorn, *Mycotaxon* 15: 7 (1982) (issued 15 July).

The synonymy of *B. melinidis* with *B. curvispora* proposed by Sivanesan (1987) is accepted. A culture of *D. curvispora* (IMI 253986, ex type) was interfertile with an authentic isolate of *B. melinidis* (BRIP 12312) and with single-ascospore isolates of *Cochliobolus melinidis*. Single-ascospore progeny from the latter pairings produced ascomata in some paired cultures, and when back crossed to parental isolates.

The type collection of *D. salviniae* was destroyed by insects during the period 1980-1983, and no isotypes were preserved (Muchovej, pers. comm. 1989). However a culture ex type (IMI 228224) has recently become available from the IMI Culture Collection (Anon., 1988). The dried material preserved in IMI consists of the original slope culture, but it bears no conidia and therefore is unsuitable for lectotypification. Sporulating cultures on WSA and SMA, produced using the BRIP duplicate of IMI 228224, have been dried down and added to the IMI material: this specimen is here nominated as lectotype for the name *Drechslera salviniae* Muchovej. This taxon is identical with *B. curvispora* and *B. melinidis*. In addition, ascomata were formed in paired cultures with single-ascospore isolates of *C. melinidis*, and there was fertility within the first generation progeny from such pairings and in back crosses to parental isolates.

The cultures of *D. curvispora* and *D. salviniae* used in this work are of opposite mating type and form ascomata of *C. melinidis* freely in paired culture on SMA.

Cultures examined: *B. melinidis*. ex *Melinis minutiflora*, Kuranda, Queensland, Australia, 4 July 1977, K.G. Pegg (BRIP 12312); *D. curvispora*. IMI 253986 ex *Triticum aestivum*, Paraguay (BRIP 13795); *D. salviniae*. IMI 228224 ex *Salvinia auriculata*, Brazil, 1978, J.J. Muchovej (BRIP 16571).

Curvularia heteropogonicola (Sivan.) Alcorn, comb. nov.
Exserohilum heteropogonicola Sivanesan, *Trans. Br. mycol. Soc.* 83: 321 (1984).

This species is more appropriately accommodated in *Curvularia* because of the structure of the protruding hilum. It consists of a cylindrical, pedicel-like protrusion delimited by a septum (Fig. 5),

and is similar to that occurring in other *Curvularia* spp. with an exserted hilum such as *C. andropogonis* (Zimm.) Boedijn and *C. cymbopogonis* (Dodge) Groves & Skolko (Ellis, 1966; Luttrell, 1977). This hilar structure is quite distinct from that of true *Exserohilum* species (Alcorn, 1983, 1988a). In addition, the median conidial cells are thicker-walled and sometimes darker than end cells, septa are accentuated by a dark band, and conidia are commonly 4-septate (Fig. 3), all characters typical of *Curvularia.*

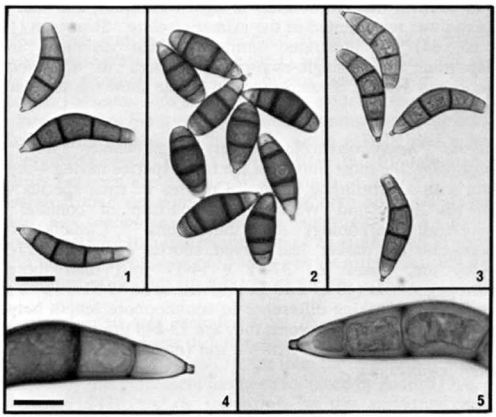


Fig. 1. *Curvularia heteropogonicola*, conidia from WSA (BRIP 16486b). Fig. 2. *C. heteropogonicola,* conidia from V-8A (BRIP 16486b). Fig. 3. *Exserohilum heteropogonicola*, conidia from WSA (IMI 268958). Fig. 4. *C. heteropogonicola*, detail of hilum (BRIP 16486b). Fig. 5. *E. heteropogonicola*, detail of hilum (IMI 268958). Bar (fig. 1) = 20 μm, figs 1-3; (fig. 4) = 10 μm, figs 4-5.

A fungus identical with *C. heteropogonicola* has been isolated from leaf spots on *Leersia hexandra* Swartz in Colombia (Figs 1,4). When grown on WSA, the latter isolate (BRIP 16486b) is indistinguishable from IMI 268958, the type culture of *E. heteropogonicola.* On V-8A the Colombian culture differs from *E. heteropogonicola* in producing

two types of conidia: some like those formed on WSA, and darker, shorter and wider conidia resembling those of *C. cymbopogonis* (Fig. 2). The latter were 38-53 x 15-19 µm (mean 43.3 x 17.2 µm) compared with 55-75 x 12.5-16.0 µm (mean 64.8 x 14.2 µm) for the normal conidia. Cultures of this isolate on V-8A exposed to nuv are markedly zonate, having very dark mycelial bands of low elevation alternating with paler zones of higher elevation. The atypical conidia predominate in the low bands, and the narrower conidia in the high bands. Single-spore cultures from each conidial type were used to confirm this relationship to light conditions, and that only one taxon was represented in the primary isolate. Sivanesan (1987, Figs 63, 64) has illustrated similar conidial variability in *C. cymbopogonis,* and single-ascospore cultures of *Cochliobolus cymbopogonis* Hall & Sivan. examined by me show the same range in shape.

Curvularia heteropogonicola differs significantly from *C. cymbopogonis,* the most similar of the other species having 4-septate conidia with a protruding hilum. Cultures of each species were grown on SMA and WSA for comparison of conidial and conidiophore morphology and dimensions. Conidia of *C. cymbopogonis* are darker, less curved, shorter and wider (27-50 x 12.5-19.0 µm, means *ca* 37-41 x 14-17 µm) than those of *C. heteropogonicola* (40-65 x 10-14 µm, means *ca* 49-51 x 11-12 µm). There is also a striking difference in conidiophore length between the species. In *C. cymbopogonis* they are 75-240 µm long (means *ca* 95-195 µm) compared with 310-740 µm (means *ca* 443-658 µm) in *C. heteropogonicola).*

Specimens and cultures examined: *Curvularia cymbopogonis:* IMI 130402 ex *Sorghum bicolor,* Sudan, 1967, Fraser (BRIP 12647); ex *S. bicolor* grain, Sudan, A.E. El Shafie, comm. May 1982 (BRIP 10754); ex *S. bicolor,* Gladstone, Queensland, Australia, Aug. 1984, R.L. Dodman B49 (BRIP 14474); ex *S. plumosum,* Rifle Ck near Mt Molloy, Queensland, Australia, 30 Apr. 1987, J.L. Alcorn 8731c (BRIP 15799); ex *Bothriochloa bladhii,* Big Mitchell Ck, 20 km north of Mareeba, Queensland, Australia, 30 Apr. 1987, J.L. Alcorn 8757 (BRIP 15835). *Curvularia heteropogonicola:* IMI 268958 ex *Heteropogon contortus,* India, 27 June 1982, R.S. Adhikari (BRIP 14579); ex *Leersia hexandra,* Santander de Quilichao Research Station, Cauca Department, Colombia, 2 Aug. 1988, R.D. Davis (BRIP 16486b).

Cochliobolus state of Bipolaris micropus

The fungus described as *Helminthosporium micropus* Drechsler (1923) was found to form 'rather immature perithecial fructifications' of *Cochliobolus* in culture (Drechsler, 1934). Luttrell (1958, 1977) produced mature *Cochliobolus* ascomata in paired cultures and proved the connection by single-ascospore isolations. An illustration showing an ascus and ascospore of this teleomorph has been published (Luttrell, 1973, p. 141), but no formal description has been offered.

In 1987 I was sent an isolate (lodged as BRIP 15689) originating from a forensic grass specimen in the U.S.A. (Rossman, pers. comm. 1987), and concluded that the fungus was *Bipolaris micropus* (Drechsler) Shoem. This supported other evidence that the host was *Paspalum notatum* Fluegge. Subsequent examination of the holotype of *Exserohilum paspali* Muchovej & Nesio (1987), and authentic cultures of this species (ATCC 62424; BRIP 16070), indicated close similarity between these taxa. When grown in paired culture with the isolate from *P. notatum* (BRIP 15689), both isolates of *E. paspali* formed a *Cochliobolus* teleomorph sparingly. Unfortunately, sufficient material to allow publication of an epithet in *Cochliobolus* for this taxon has not been produced, despite attempts using various combinations of isolates on a range of media.

Bipolaris micropus was excluded from *Exserohilum* by Leonard & Suggs (1974) on the basis of hilum structure, indicating that it is the basal part of the conidial wall rather than the hilum that protrudes. Subsequently this placement has been followed by Alcorn (1983) and Sivanesan (1987), and is supported by this confirmation of a *Cochliobolus* teleomorph. Another characteristic found useful in delimiting taxa at generic rank in the *Drechslera - Bipolaris - Exserohilum* complex is septum progression in maturing conidia. In this *B. micropus* is atypical, developing as do true *Exserohilum* spp. rather than in the usual manner of *Bipolaris* (Alcorn, 1983). This has been confirmed with the three isolates used in the work reported here.

A feature not mentioned in descriptions of *B. micropus* and *E. paspali* is roughening of the conidial wall (Drechsler, 1923; Sivanesan, 1987; Muchovej & Nesio, 1987). It is quite pronounced in the type specimen of *E. paspali* and derived cultures (Fig. 7), and less distinct in BRIP 15689 where it is commonly confined to the

median region (Fig. 6). I have examined type material of *H. micropus* but very few conidia were found and they appeared to be smooth. Two subsequent collections determined as *H. micropus* by Drechsler bear more conidia, some of which are verruculose in the lower half. Conidia in the two Luttrell collections cited by Alcorn (1983) and Sivanesan (1987) are roughened in a manner similar to that in BRIP 15689. It appears that degree of conidial ornamentation in *B. micropus* is quite variable within and between collections, and the very prominent roughening present in *E. paspali* represents one extreme of this variability. The following synonymy is proposed.

Bipolaris micropus (Drechsler) Shoem., *Can. J. Bot.* 37: 884 (1959).
Helminthosporium micropus Drechsler, *J. agric. Res.* 24: 722 (1923).
Drechslera micropus (Drechsler) Subram. & Jain, *Current Science* 35: 354 (1966).
Exserohilum paspali Muchovej & Nesio, *Trans. Br. mycol. Soc.* 89: 126 (1987).

Figs 6-8. *Bipolaris micropus*, ornamentation of conidia. Fig. 6. BRIP 15689. Fig. 7. BRIP 16070 (*Exserohilum paspali*). Fig. 8. BRIP 16067, single-ascospore progeny from ATCC 62424 x BRIP 15689. Scale bars = 5 μm.

Sivanesan (1987) lists *H. leptochloae* Nisik. & Miyake as a synonym of *B. micropus*. The culture CBS 196.29 deposited by Nisikado is very similar to *E. rostratum* (Drechsler) Leonard & Suggs, as is also suggested by the original description (Nisikado & Miyake, 1924).

Specimens and cultures examined: (anamorph) ex *Paspalum notatum*, Lakeland, Florida, U.S.A., 3 Apr. 1970, E.S. Luttrell 8452 (BRIP 6516); ex *P. notatum*, Tifton, Georgia, U.S.A., 17 July 1970, E.S. Luttrell 8530 (BRIP 6520); on *P.? boscianum* Fluegge, Wauchula, Florida, U.S.A., 2 May 1921, C. Drechsler, type (BPI; BRIP 12436); on *P.? boscianum*, Charleston, S. Carolina, U.S.A., 13 June 1932, C. Drechsler (BPI); on *P.? boscianum* Fluegge, Charleston, S. Carolina, U.S.A., 23 June 1932, C. Drechsler (BPI); ex *P.? notatum*, U.S.A., comm. 3 Apr. 1987, A.Y. Rossman (BRIP 15689); on *P. conjugatum* Bergius, Vicosa, Brazil, 10 May 1986, J.J. Muchovej, holotype of *Exserohilum paspali* (BRIP 16098); ex *P. conjugatum*, Vicosa, Brazil, 10 May 1986, J.J. Muchovej, ATCC 62424 ex holotype collection (BRIP 15966); same details, comm. Jan. 1988, J.J. Muchovej *s.n.* (BRIP 16070); single-ascospore isolate ex BRIP 15689 x ATCC 62424, Dec. 1987, J.L. Alcorn 87105 (BRIP 16067); (teleomorph) on Sachs' agar + *P. notatum* seed, BRIP 15689 x 16070, Apr. 1988 (BRIP 16318).

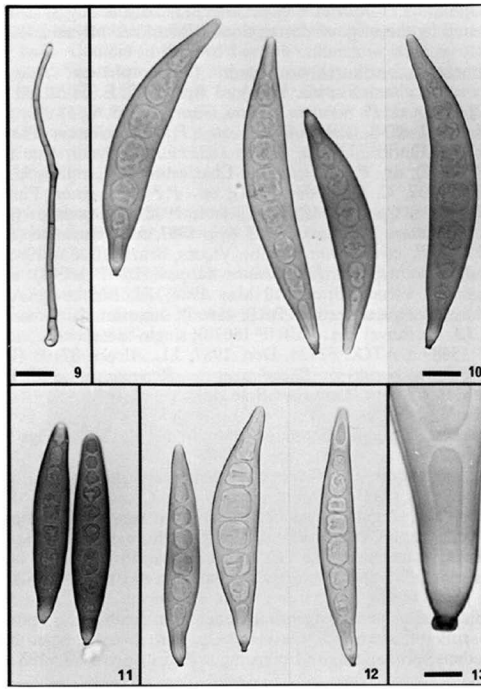
Exserohilum fusiforme Alcorn, sp. nov. (Figs 9-13)

Etym.: *fusiformis* (L) - fusiform, for conidial shape

Conidiophora singularia vel in turmis parvis aggregatis, simplicia, recta vel flexuosa, medio vel atro olivaceobrunnea, versus apicem pallidiora, cicatricata, ad cicatrices verruculosa, alibi laevia, multiseptata, 175-680 µm longa, ad basim saepe tumida 10-20 µm diam, prope basim 7.5-12.0 µm diam, ad apicem 5.5-9.0 µm diam. Conidia medio olivaceobrunnea, concoloria, fusiformia, recta vel parce curvata, saepe angustata infra septum basale, super hilum protrudens verruculosa, 3-11 plerumque 7 distoseptata, 80-193 x 15-24 µm.

Ex foliis *Echinochloae crus-galli* (L.) Beauv., Beaudesert, Queensland, Australia, 17 Mar. 1988, J.L. Alcorn 8822b, BRIP 16229 holotypus, IMI 335221 isotypus.

Conidiophores single or in small groups, simple, mid to dark olivaceous brown, paler towards apex, straight or flexuous, slightly



Figs 9-13. *Exserohilum fusiforme.* Fig. 9. Conidiophore. Figs 10-12. Conidia from WSA (fig. 10), PDA (fig. 11), infected leaves of *Echinochloa crus-galli* incubated in moist chamber (fig. 12). Fig. 13. Hilum. Bar (fig. 9) = 40 µm; (fig. 10) = 20 µm, figs 10-12; (fig. 13) = 5 µm.

geniculate at scars, multiseptate, 175-680 µm high, basal cell often swollen to 10-20 µm diam, 7.5-12.0 µm diam just above the swollen base and 5.5-9.0 µm at the apex, conidiogenous nodes 58-145 µm apart, verruculose. Conidia mid olivaceous brown, concolorous, fusiform, straight or usually moderately curved, often narrowed from basal septum to hilum, 80-193 x 15-24 µm, (3-)6-9(-11) septate, commonly 7-septate, verruculose just above the protruding hilum. Conidia formed on PDA are shorter, darker, and have less septa than those on WSA. Septum ontogeny is atypical; although the first septum is submedian (normal), the second septum forms in an approximately median position and the third is distal. Conidial germination is mono- or bipolar, with the apical germ tube axial and the basal semiaxial. The basal germ tube occasionally originates from a position some distance from the hilum and grows at a wider angle.

Of the species described from *Echinochloa, Exserohilum fusiforme* is most like *E. monoceras* (Drechsler) Leonard & Suggs and *E. echinochloae* Sivan. The former species has paler, less curved conidia which are often broader than those of *E. fusiforme* and on WSA the conidiophores of *E. monoceras* are much longer (Alcorn, 1988 b). Conidia of *E. echinochloae* are darker and broader than in *E. fusiforme* (Sivanesan, 1984; pers. obs.), the conidial hilum is more robust (2-3 x 3-4 µm compared with 1.5-2.0 x *ca* 2.8-3.0 µm), and conidiophores are wider at the tip (7-9 µm compared with 5.5-7.0 µm). Morphology in *E. fusiforme* also suggests comparison with *E. oryzicola* Sivan. (1984), described from rice in Colombia. Conidia of *E. oryzicola* are longer (up to 223 µm) than those of *E. fusiforme,* and on V-8A, SMA and WSA consistently have more septa, 7-13 (commonly 8-10; means 8.9-9.8) compared with 6-11 (commonly 7-9; means 7.7-8.3).

An additional characteristic indicating relationship between *E. fusiforme* and the two most similar species is roughening of the basal cell in the region adjacent to the hilum. Although not mentioned in the original descriptions of *E. oryzicola* and *E. echinochloae,* it is present in the specimens examined and is suggested by the published illustration of *E. echinochloae* (Sivanesan, 1984). No ascomata or prototheca developed in paired or selfed cultures of *E. oryzicola* and *E. fusiforme.* The latter species was virulently pathogenic to *Echinochloa crus-galli* when spray inoculated with conidia from V-8A, producing numerous small leaf lesions. In the same test rice (cv.

Starbonnet) developed a few small linear spots. The fungus was reisolated from both hosts.

Specimens and cultures examined: *Exserohilum fusiforme:* ex *Echinochloa crus-galli,* Beaudesert, Queensland, Australia, 17 Mar. 1988, J.L. Alcorn 8822b (BRIP 16229 holotype, IMI 335221 isotype). *Exserohilum oryzicola:* ex *Oryza sativa,* Colombia, 2 Nov. 1982, E.A. Urresta, IMI 273194 (BRIP 14577). *Exserohilum echinochloae:* ex *Echinochloa colona,* Bangladesh, 10 Apr. 1979, M.A. Miah, IMI 237838 (BRIP 16478).

Miscellaneous notes

Bipolaris palousensis Sprague, *Res. Stud. Wash. St. Univ.* 29: 77 (1961) (as '*palousense*').

No *Bipolaris* was found on the type specimen. There is a *Stenella*-like fungus present on the slide filed with the specimen, and the same species was found on a necrotic portion of leaf (some leaf lesions bear immersed immature ascomata, but no hyphomycete). Conidia taken from the host are cylindrical, yellowish-brown, straight or curved, cicatrized at one or both ends, 15-63 x 5.0-9.5 µm, 1-7 transversely septate with the septa commonly accentuated. Conidia on the slide with the specimen are 15-45 x 5-9 µm, (1-)3(-5) septate, and this is probably the fungus described by Sprague (1961) as *B. palousensis* ('spores yellowish, cylindrical, mostly triseptate, 20-58 x 5-7.3 µ').

Specimen examined: *Juncus ensifolius* Wiks., nr Colton, Whitman County, Washington, U.S.A., R. Sprague, C.G. Shaw & class, 18 May 1948, WSP 46818 (formerly 3925), holotype.

Cochliobolus sporoboli Castellani, *Mycopath. Mycol. appl.* 6: 56 (1951).

Sivanesan (1987) reported that a specimen could not be located. However in 1977, through the courtesy of Prof. Castellani, one of the collections originally cited was sent to me on loan. As indicated in the description (Castellani, 1951) there is a species of *Bipolaris* present on the specimen in association with the teleomorph. Conidia are cylindric-ellipsoid, straight, mid-brown, 32-50 x 10-15 µm, 3 or 4 septate, with a slightly protruding hilum *ca* 2.5 µm diam. A germinated conidium has a semi-axial basal germ-tube displacing

the hilum slightly. It is not possible to suggest a specific identity for this anamorph.
Specimen examined: on *Sporobolus affinis,* near Asmara, Erythrea, E. Africa, 12 Aug. 1914, I. Baldrati (ex herb. Istituto Agronomico per l'Oltremare, Florence; slides as BRIP 6482)

Helminthosporium atypicum K.S. Deshpande & K.B. Deshpande, *Sydowia* 20: 42 (1968).

The type specimen was not available to Sivanesan (1987), who suggested resemblance to *Bipolaris multiformis* (Jooste) Alcorn. A culture deposited in ATCC by the authors of the name is very similar to *B. sorokiniana* (Sacc.) Shoem..

Culture examined: ex *Triticum aestivum* L. leaf, Ajantha, India, Dec. 1963, K.S. & K.B. Deshpande (ATCC 18954, BRIP 12374).

Drechslera patereae Carranza, *Revta Fac. Agron. Univ. nac. La Plata* 59: 66 (1983).

This species was described from grains of durum wheat (*Triticum durum* Desf.) in Argentina. A culture authentic for the name is not distinguishable from *Bipolaris hawaiiensis* (M.B. Ellis) Uchida & Aragaki, although pairings with tester strains of *Cochliobolus hawaiiensis* Alcorn resulted only in the formation of cylindrical black stromata.

Culture examined: ex *Triticum durum,* Argentina, comm. 8 May 1987, M.R. Carranza *s.n.* (BRIP 14836).

Curators at ATCC, BPI, CBS, IMI, ITCC and WSP generously supplied specimens and/or cultures used in this study, as did E. Castellani, M.R. Carranza, R.D. Davis, H. Iliescu, J.J. Muchovej, A.Y. Rossman and D.L. Strider. D.H. Gowanlock provided the scanning electron micrographs.

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PORE FUNGI OF COSTA RICA 1/

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A large number of pore fungi have been collected in Costa Rica by several scientists since the beginning of the century. A first list was published by J. Carranza and J.A. Saenz (1984) which included some specimens collected by the authors and by others.

This paper will represent the first part of a more comprehensive report of the specimens collected up to date and will give an idea of the diversity present in the country.

The specimens listed are deposited in the Herbarium of the School of Biology, University of Costa Rica (USJ), the Herbarium of the USDA at Beltsville, Maryland (BPI), the Herbarium of the National Museum, Costa Rica (CR), or cited by other authors (Covington, 1980; Lowe, 1963; 1966; 1976; Murrill, 1915; Sydow, 1925).

Unless otherwise stated, the descriptions of the specimens agree with the ones given by Furtado (1981), Gilbertson & Ryvarden (1986; 1987), and Ryvarden & Johansen (1980).

MATERIALS AND METHODS

Free hand sections were prepared from each specimen and mounted in 3% KOH to which a drop of aqueous phloxine was added, and in Melzer's reagent. Observations were done under a light microscope. All drawings of microscopic characters were made with the use of a camera lucida.

1/. This research was supported by Vicerrectoría de Investigación (Project 111-79-006) University of Costa Rica and CONICIT (Travel Grant to visit National Fungus Collection, Beltsville, Maryland).

Specimens are listed in alphabetical order. Herbarium abbreviations are from Holmgren et al. (1981). Those species preceded by an asterisk (*) are new records for the country.

LIST OF FUNGI

Corticiaceae

***Gloeoporus dichrous** (Fr.) Bres., Ann. Mycol. 14:230. 1916.
Polyporus dichrous Fr., Syst. Mycol. 1:364. 1821.

Voucher specimen examined: Santa Maria de Dota, San Jose, JCM 102-87 (USJ 22991); one collection done by Brenes in 1920 and deposited at BPI (207578). (Altitudinal distribution: 2021 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North, Central and South America; Africa.

Gloeoporus thelephoroides (Hook.) G.H. Cunn., Polyp. New Zealand p.111. 1965.
Gloeoporus conchoides. Mont., Ann. Sci. Nat. Ser. 2 Vol. 17:126. 1842.

Voucher specimens examined: Golfito, Puntarenas, JCM 12-80 (USJ 21300); Finca La Florencia,Turrialba, Cartago, JCM 28-81, (USJ 21504); Parque Nac. Corcovado, Puntarenas, S. Hernandez (USJ 28040); Atenas, Alajuela, JCM 21-85 (USJ 22266); Monteverde, Puntarenas, JCM 145-80 (USJ 21517). (Altitudinal distribution: 5-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Grammothele fuligo (Berk. & Br.) Ryv., Trans. Br. Mycol. Soc. 73:15. 1979.
Polyporus fuligo Berk. & Br., J.Linn. Soc. Bot. 14:53. 1875.

Voucher specimens examined: Finca La Selva, Sarapiqui,

Heredia, on palm, JCM 157-86 (USJ 22533); Finca La Selva, Sarapiqui, Heredia, C. Ovrebo 2239 (USJ 22979). (Altitudinal distribution: 37 m).
Type of rot: White rot.
Substrata: Monocotyledons (bamboo, palms).
Distribution: Central America; Africa; Asia.

Fistulinaceae

Fistulina hepatica Schaeff.: Fr., Syst. Mycol. 1:396. 1821.

Voucher specimens examined: Cerca del Volcan Irazu, Cartago, J.A. Saenz 2345 (USJ 21635); Patillos de Rancho Redondo, M. Boza, V.Lizano and M.Nassar, 2462 (USJ 21800). (Altitudinal distribution: 2080 - 2196 m).
Type of rot: Brown rot.
Substrata: On hardwood trees (**Quercus** sp.).
Distribution: North and Central America; Europe.

Fistulina radicata Schw., Schr. Nat. Geo. Leipzig 1:100. 1822.
Fistulina pallida Berk. & Rav., Grevillea 1:71. 1872.

Comments: There are only two collections at BPI (244153 and 244154) done by C. W. Dodge 5298 and 5323, on Retes, El Alto de Cabeza de Vaca & Chino, Cartago in 1929. (Altitudinal distribution: 2080 m).
Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Ganodermataceae

Amauroderma boleticeum (Pat. & Gail.) Torr., Brotéria Bot. 18:132. 1920.
Polyporus boleticeus Pat. & Gail., Bull. Soc. Mycol. Fr. 4: 29. 1888.

Comments: There are some differences in regards to the microscopic characters described by Furtado. The basidiospores in the Costa Rican specimens are slightly larger, viz. 8.8-12.8 x 6.4-10.4 um (Furtado: 7.0-10.0 x

7.0-9.0 um); basidia: 24.8-31.2 x 9.6-12.8 um (not observed by Furtado) (Fig.1).
Voucher specimens examined: La Selva Biological Station, Sarapiqui, Heredia, C. Ovrebo 2182 (USJ 27534) and C.Ovrebo 2761 (USJ 28160). (Altitudinal distribution: 37 m).
Distribution: Central and South America.

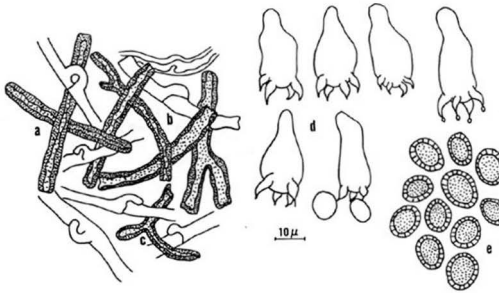

Fig. 1. **Amauroderma boleticeum** (USJ 27534). a, skeletal hyphae; b, generative hyphae; c, binding hyphae; d, basidia; e, basidiospores.

Amauroderma longipes (Lév.) Torr., Brotéria Bot. 18:135. 1920.
Polyporus longipes Lév., Ann. Sci. Nat. Bot. III, 5:124. 1846.

Comments: There is only one collection done by C.W. Dodge et al. 5658 (BPI 237124) in Limón, near Siquirres River and cited by Furtado (1981). (Altitudinal distribution: 70-170 m).
Distribution: Central and South America; Africa; Asia.

Amauroderma praetervisum (Pat.) Torr., Brotéria Bot. 18:131. 1920.

Ganoderma praetervisum Pat., Bull. Soc. Mycol. Fr. 5:78. 1889.

Comments: There is only one collection at the New York Botanical Garden 4820 ex-Ellis Herb. Collector unknown and described by Furtado (1981).
Distribution: Central and South America; Caribbean Islands.

Amauroderma schomburgkii (Mont. & Berk.) Torr., Brotéria Bot. 18. 140. 1920.
Polyporus schomburgkii Mont. & Berk., Lond. J. Bot. 3:331. 1844.

Comments: Macroscopic and microscopic characters agree with Furtado descriptions. Skeletal hyphae up to 8.8 um; binding hyphae 3.2 um; generative hyphae not seen; basidiospores 7.2-9.6 x 8.8-10.4 um; basidia not observed (Fig.2).
Voucher specimens examined: Puntarenas, near Sandoval River Jungle, C.W. Dodge (BPI 237192); Forest Reserve opposite to Esquinas Experimental Station, G.W. Martin & A.L. Welden 8241 (SP 97638 ex-NY); Carara Reserve, Puntarenas, JCM 86-87 (USJ 27909). (Altitudinal distribution: sea level-7 m).
Distribution: Central and South America; Africa; Caribbean Islands.

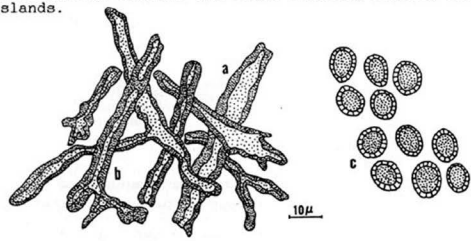

Fig. 2. **Amauroderma schomburgkii** (USJ 27909). a, skeletal hyphae; b, binding hyphae; c, basidiospores.

Amauroderma sprucei (Pat.) Torr., Brotéria Bot. 18:121. 1920.
Polyporus sprucei (Pat.) Lloyd, Mycol. Writ. (Synop. Stip. Polyp.) 3:111. 1912.

Comments: There is only one collection at BPI (237266), collected in Castilla, Limon by F. Nevermann and described by Furtado.
Distribution: Central and South America; Caribbean Islands.

Ganoderma applanatum (Pers.) Pat., Soc. Mycol. France Bull. 5:67. 1889.
Polyporus applanatus (Pers.) Wallr., Flora Crypt. Germ. 4:591. 1833.

Voucher specimens examined: Monteverde, Puntarenas, JCM 47-80, J.A. Saenz (USJ 21284); Ojo de Agua, El Empalme, San Jose, JCM 131-79 (USJ 21297); Bosque de La Hoja, Heredia, JCM 68-86 (USJ 22821); Isla del Coco, Puntarenas,G. Herrera, JCM 24-81 (USJ 21277) . (Altitudinal distribution: sea level-1853 m).
Type of rot: White rot of living and dead trees.
Substrata: On hardwood and softwood trees.
Distribution: Cosmopolitan.

Ganoderma australe (Fr.) Pat. Bull. Soc. Mycol. Fr. 5:67. 1889.
Polyporus australis Fr. Syst. Mycol. 1, 1821.

Voucher specimen examined: Monteverde, Puntarenas, L.D. Gomez & R. Alfaro 24946 (USJ 27613).(Altitudinal distribution: 1330-1900 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Cosmopolitan.

Ganoderma coffeatum (Berk.) Furt., Persoonia 4(4):383. 1967.
Polyporus coffeatus Berk., Ann. Mag. Nat. Hist. 3:385. 1839.

Comments: Basidiospores yellowish-brown, echinulate, truncate, 8.0-9.0 x 6.0-5.0 um.
Voucher specimens examined: Palo Verde, Guanacaste, L.D.

Gomez 24276 (USJ 22804); Isla San Lucas, Puntarenas, C. Garcia, JCM 279-86 (USJ 28026); Sn. Antonio de Nicoya, Guanacaste, M. Valerio 97 (BPI 235876).(Altitudinal distribution: sea level-100 m).
Type of rot: Unknown (white rot ?).
Substrata: On hardwood trees.
Distribution: Central and South America; Caribbean Islands.

Ganoderma colossum (Fr.) C.F. Baker, V Cent. Fungi Malay. No. 425. 1918.
Polyporus colossus Fr., Nov. Symb. p. 56, 1851.

Comments: Murrill (1915) cited some specimens collected in Costa Rica, but no duplicates are deposited at USJ. One collection done by Danielson 173 in 1928 and deposited at BPI (206112).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Ganoderma lucidum (W. Curt.: Fr.) Karst., Rev. Mycol. 3(9):17. 1881.
Polyporus lucidus W. Curt.: Fr., Syst. Mycol. 1:353. 1821.

Voucher specimens examined: Sixaola, Limon, A. Conejo, JCM 32-88 (USJ 28075); Alto de Lagunilla, Santa Cruz, Guanacaste, JCM 138-86 (USJ 22758); Parque Nacional de Santa Rosa, Guanacaste, L. Umana 1-89 (USJ 28199); Jardin de Dota, San Jose, JCM 16-85 (USJ 22757). (Altitudinal distribution: 37-1500 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North , Central and South America; Africa; Europe; Asia.

Ganoderma neurosporum Furtado, Persoonia 4:386. 1967.

Comments: Listed by Furtado (1967). One specimen at BPI, collected by Dodge et al. 5668 (?) No duplicates at USJ.

Ganoderna nutans (Fr.) Pat. , Bull. Soc. Mycol. Fr. 5:68. 1889.

Amauroderma nutans (Fr.) Murr., North Am. Fl. 9:117. 1908.

Comments: Listed by Murrill (1915) but no duplicates at USJ. There are not authentic specimens of this species and the name should be dropped from consideration (Ryvarden, pers. comm., 1990).

Hymenochaetaceae

***Aurificaria luteo-umbrina** (Romell) Reid, Kew Bull. 17:279. 1963.
Phaeoporus luteo-umbrinus Romell, K. Svenska Vetensk. Akad. Handl. 26, No. 16:27. 1901.

Comments: Basidiospores yellowish brown to greenish brown or olivaceous in KOH, sub-globose to globose, smooth walled, 3.2-5.0 x 3.5-5.6 um; hyphae 3.2-7.0 um, thick walled, simple septate, brown (Fig. 3).
Voucher specimens examined: Monteverde, Puntarenas, JCM 217-87 (USJ 27950); Reserva Carara, Puntarenas, JCM 114-87 (USJ 27530); Monteverde, Puntarenas, JCM 153-87 (USJ 28032). (Altitudinal distribution: 7-1330 m).
Type of rot: White rot.
Subtrata: On hardwood trees.
Distribution: North, Central , and South America; Australia.

Fig. 3. **Aurificaria luteo-umbrina** (USJ 27530). a, basidiospores.

***Coltricia cinnamomea** (Pers.) Murr., Bull. Torr. Bot. Cl. 31:343. 1904.
Polyporus cinnamomeus Pers., Mycol. Europ. 2:41. 1825.

Voucher specimens examined: Monteverde, Puntarenas, JCM 147-87 (USJ 27912); Frailes, San Jose, JCM 1-79 (USJ 21034). (Altitudinal distribution: 1330-2200 m).
Substrata: On the ground or from buried wood (hardwood).
Distribution: North and Central America; Africa; Asia; Australia; Europe.

Coltricia perennis (Fr.) Murr., J. Mycol. 9:91. 1903.
Boletus perennis L., Sp. Plant., p. 1177. 1753. **Polyporus perennis** Fr., Syst. Mycol. 1:350. 1821.

Comments: For a more detailed description see Carranza & Saenz (1984).

***Coltricia spathulata** (Hook.) Murr., North Am. Fl. 9:93. 1908.
Polyporus spathulatus Hook. in Kunth, C.S. Synopsis Plant. 1:9. 1822.

Voucher specimen examined: El Eden, Santa Marta, Buenos Aires, Puntarenas, L.D. Gomez 22979 (USJ 22830). (Altitudinal distribution: 361 m).
Substrata: On the ground.
Distribution: North, Central and South America; Africa; Asia; New Guinea.

Cyclomyces iodinus (Mont.) Pat., Essai Tax. p. 98. 1900.
Polyporus iodinus Mont., Ann. Sci. Nat. Bot. 2, 16:108. 1841.

Comments: The specimens collected in Costa Rica are described by Carranza & Saenz (1984).

***Cyclomyces tabacinus** (Mont.) Pat., Essai Tax. p. 98. 1900. **Polyporus tabacinus** Mont., Ann. Sci. Nat. Ser. 3, Vol. 3:349. 1835.

Voucher specimens examined: Costa Rica, K. Danielson 159, 1928 (BPI 222349); Cocos Island, A. Stewart 1537, 1905 (BPI 222332); Chatham Bay, Cocos Island, P.D. Ashlock 22,

1964 (BPI 222319). (Altitudinal distribution: sea level-1300 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central and South America; Africa.

Inonotus fimbriatus Gomez & Ryv., Mycotaxon 23:291-292. 1985.

Comments: No duplicates at USJ.
Distribution: Costa Rica.

Inonotus fulvomelleus Murr., N. Amer. Flora 9, p. 86. 1908.
Polyporus fulvomelleus (Murr.) Sacc. & Trott.

Comments: Listed by Covington (1980). No duplicates at USJ. One collection done by Holm and Iltis in 1949, and deposited at BPI (214186).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Caribbean Islands.

***Inonotus pertenuis** Murr., N. Amer. Flora 9, p. 86. 1908.

Comments: Basidiospores 4.0 x 2.5 um; setae 15.6-39.0 x 5.2-7.8 um.
Voucher specimens examined: Bosque de La Hoja, Heredia, JCM 49-79 (USJ 21312); Terron Colorado, Alajuela, JCM 69-81 (USJ 28028). (Altitudinal distribution: 65-1530 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America.

Inonotus porrectus Murr., Tropical Polypores, p. 68. 1915.
Polyporus porrectus (Murr.) Sacc. & Trott., Syll. Fung. 25: 374. 1925.

Comments: Listed by Covington (1980). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Caribbean Islands.

Polyporaceae

***Abortiporus biennis** (Bull.: Fr.) Sing., Mycologia 36:68. 1944.
Heteroporus biennis (Fr.) Laz., Rev. Real. Acad. Cienc. Exac. Fisc. Nat. Madrid 15:120. 1916.

Comments: There is only one collection made by C.W. Dodge in San Jose (BPI 204179). (Altitudinal distribution: 1000 - 1100 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Europe; Asia; Australia.

Anomoporia myceliosa (Peck) Pouz., Ceska Mykol. 20:172. 1966.
Poria myceliosa Peck, N.Y. State Mus. Bull. 54:952. 1902.

Comments: The specimens collected in Costa Rica are described by Lowe (1966).
Voucher specimens examined: Uvita, Heredia, on **Cupressus sp.** J.L. Lowe 13108 (USJ 9796); Tarbaca, San Jose, on hardwood, J.L. Lowe 13335 (USJ 9795); Jardin, San Jose, J.L. Lowe 13394 (USJ 9794). (Altitudinal distribution: 50-2150 m).
Type of rot: White rot.
Substrata: On softwood (**Cupressus sp.**) and hardwood trees.
Distribution: North and Central America; Europe; Asia.

***Antrodia albida** (Fr.) Donk., Persoonia 4:339. 1966.
Trametes sepium Berk., Lond. J. Bot. 6:322. 1847.

Comments: Basidiospores cylindrical to oblong ellipsoid, hyaline, thin-walled, none amyloid, 8.0-10.0 x 3.5-4.0 um.
Voucher specimen examined: Bosque de la Hoja, Heredia, on **Cupressus sp.**, JCM 69-86 (USJ 22542). (Altitudinal distribution: 1200-1530 m).
Type of rot: Brown rot.
Substrata: On softwood (**Cupressus sp.**) and hardwood trees.
Distribution: Cosmopolitan.

***Antrodia malicola** (Berk. & Curt.) Donk., Persoonia 4:340. 1966.
Trametes malicola Berk. & Curt., Acad. Nat. Sci. Phila. J. II, 3:209. 1856.

Comments: Basidiospores ellipsoid, hyaline, smooth-walled, 7.2-10.0 x 2.4-3.2 um; generative hyphae 1.6-2.4 um, skeletal hyphae 2.4-4.8 um; basidia 12.0 x 4.0 um (Fig. 4).
Voucher specimen examined: Monte de la Cruz, Heredia, L.D. Gomez 24186 (USJ 22890). (Altitudinal distribution: 1200-1800 m).
Type of rot: Brown rot.
Substrata: On hardwood trees.
Distribution: Cosmopolitan.

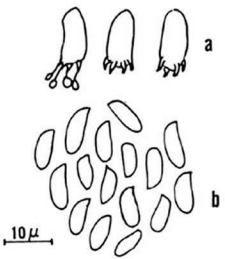

Fig. 4. **Antrodia malicola** (USJ 22890). a, basidia; b, basidiospores.

Antrodia radiculosa (Pk.) Gilbn. & Ryv., Mycotaxon 22:363. 1985.
Poria radiculosa (Pk.) Sacc., Syll. Fung. 6:314. 1888.

Comments: The specimens collected in Costa Rica are described by Lowe (1966) and Gilbertson & Ryvarden (1986).
Voucher specimen examined: Itiquis, Alajuela, J.L. Lowe 13501 (USJ 9800). (Altitudinal distribution: 1357 m).
Type of rot: Brown rot.
Substrata: On softwood and hardwood trees.

Distribution: North and Central America; Caribbean Islands.

***Antrodia vaillantii** (Fr.) Ryv., Norw. J. Bot. 20:8. 1973.
Poria vaillantii (DC.: Fr.) Cke., Grevillea 14:112. 1886.

Comments: Basidiospores oblong, broadly ellipsoid, hyaline, smooth-walled, 4.0-6.0 x 3.2-4.0 um; basidia 12.0-16.8 x 5.6-7.2 um (Fig. 5).
Voucher specimen examined: Uvita, Heredia, J.L. Lowe 13100 (USJ 9802). (Altitudinal distribution: 1900 m).
Type of rot: Brown rot.
Substrata: On softwood trees.
Distribution: North and Central America; Europe; Africa; Asia.

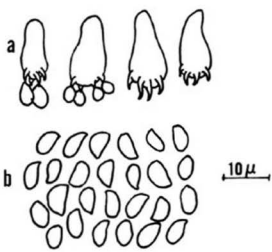

Fig. 5. **Antrodia vaillantii** (USJ 9802). a, basidia; b, basidiospores.

***Antrodiella semisupina** (Berk. & Curt.) Ryv., Prelim. Polyp. Fl. East Africa, p. 261. 1980.
Polyporus semisupinus Berk. & Curt., Grevillea 1:50. 1872.

Comments: Basidiospores ellipsoid, hyaline, smooth-walled, 2.4-3.2 x 1.6-2.0 um; generative hyphae nodose-septate, 2.4-3.0 um ; skeletal hyphae up to 4.8 um.
Voucher specimen examined: Rio Segundo, Alajuela, L.D. Gomez 24229 (USJ 22870). (Altitudinal distribution:

600-900 m).
Type of rot: White rot.
Substrata: On hardwood, rarely on softwood trees.
Distribution: North and Central America; Africa; Europe.

Bjerkandera adusta (Willd.: Fr.) Karst., Medd. Soc. Fauna Fl. Fenn. 5:38. 1879.
Polyporus adustus Willd. : Fr., Syst. Mycol. 1:363. 1821.

Comments: The specimens collected in Costa Rica are described by Carranza & Saenz (1984). (Altitudinal distribution: 120-2200 m).

***Bjerkandera fumosa** (Pers.: Fr.) Karst., Medd. Soc. Fauna Fl. Fenn. 5:38. 1879.
Polyporus fumosus Pers.: Fr., Syst. Mycol. 1:367. 1821.

Comments: Only one specimen collected in Cartago by C.W. Dodge and W.S. Thomas in 1929 (BPI 214360).
Type of rot: White rot of sapwood of hardwood.
Substrata: On hardwood trees.
Distribution: North , Central and South America; Europe; Asia; Africa; Australia.

***Ceriporia alachuana** (Murr.) Hallenb. Iran. J. Pl. Path. 15: 14. 1979.
Poria alachuana Murr., Bull. Torrey Bot. Club 65:659. 1938.

Comments: Basidiospores 3.2-4.0 x 2.4 um, hyaline, smooth-walled; hyphae 4.8 um, simple septate.
Voucher specimen examined: La Cuesta Mansion, Nicoya, Guanacaste., on hardwood JCM 291-86 (USJ 28272). (Altitudinal distribution: 87 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America.

Ceriporia purpurea (Fr.) Donk, Konn. Nederl. Akad. Wetensch. Amst. Proc. Ser. c. 74, No. 1:28. 1971.
Polyporus purpurea (Fr.) Cke., Grevillea 14:112. 1886.

Comments: The specimens collected in Costa Rica are described by Carranza & Saenz (1984).

***Ceriporia reticulata** (Pers.: Fr.) Dom., Acta Soc. Bot. Pol. 32:732. 1963.
Poria reticulata (Pers.: Fr.) Cke., Grevillea 14:114. 1886.

Voucher specimen examined: Sta. Clara, San Jose, on hardwood, J.L. Lowe 12993 (USJ 9798). (Altitudinal distribution: 900-1000 m).
Type of rot: White rot.
Substrata: On hardwood, rarely on softwood trees.
Distribution: North, Central and South America; Europe; Tunisia; Asia.

Ceriporia xylostromatoides (Berk.) Ryv. & Johan., Prelim. Polyp. Fl. East Afr., p. 276. 1980.
Polyporus xylostromatoides Berk., Lond. J. Bot. 2:637. 1843. **Poria xylostromatoides** (Berk.) Cke., Grevillea 14: 114. 1886.

Voucher specimens examined: Ciudad Colon, San Jose, on hardwood, J.L. Lowe 12995 (USJ 9781); Uvita, Heredia, on hardwood, J.L. Lowe 13258 (USJ 9778); Turrialba, Cartago, on hardwood, J.L. Lowe 13314 (USJ 9779); Alajuela, Alajuela, on hardwood, J.L. Lowe 13370 (USJ 9786). (Altitudinal distribution: 650-2000 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North, Central and South America; Africa; Caribbean Islands; India; Sri Lanka.

***Cerrena meyenii** (Kl.) Hansen, Nat. Hist. Rennel Isl. 3:129. 1960.
Polyporus meyenii Kl., Nova Acta Leop.-Carol. 19 Suppl. 1:239. 1845 (?).**Trametes obstinatus** Cke., Grevillea 12:17. 1883.

Comments: There are two sterile specimens collected in Costa Rica. One collected in San Antonio de Coronado, San Jose by L.D. Gomez 24211 (USJ 22878) and the other one collected in Turrialba by William Maxon 210, in 1906 (BPI 212998). (Altitudinal distribution: 646-1400 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

***Cerrena unicolor** (Bull.: Fr.) Murr., J. Mycol. 9:91. 1903.
Daedalea unicolor Bull.: Fr., Syst. Mycol. 1:336. 1821.

Voucher specimen examined: San Gerardo de Dota, San Jose, L.D. Gomez 24246 (USJ 22874). (Altitudinal distribution: sea level-2000 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe; Asia; Africa.

Chaetoporellus latitans (Bourd. et Galz.) Bond. et Sing., Ann. Mycol. 39:50. 1941.
Poria latitans Bourd. et Galz., Bull. Soc. Mycol. France 41:226. 1925.

Voucher specimens examined: Jardin, Santa Maria de Dota, San Jose, J.L. Lowe 13388 (USJ 9806); Santo Domingo de San Mateo, Wn. Maxon 1906 (BPI 242453). (Altitudinal distribution: 1586-2100 m).
Type of rot: Uniform white rot.
Substrata: On hardwood and softwood trees.
Distribution: North and Central America; Asia; Europe.

Coriolopsis brunneo-leuca (Berk.) Ryv., Norw. J. Bot. 19:230. 1972.
Polyporus brunneo-leucus Berk., Lond. J. Bot. 5:4. 1846.

Comments: There is only one sterile specimen collected in Palmar Norte, Puntarenas by A.L. Welden 3399 in 1974 (TU 9038, USJ 21039). (Altitudinal distribution: 26 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

Coriolopsis byrsina (Mont.) Ryv., Norw. J. Bot. 19:230. 1972.
Polyporus byrsinus Mont., Ann. Sci. Nat. 17:126. 1842.

Voucher specimens examined: Carara Reserve, Puntarenas, on hardwood, JCM 248-86 (USJ 27599); Santa Rosa, Guanacaste, on hardwood, JCM 165-79 (USJ 21044); Ciudad Colon, San Jose, on hardwood, JCM 159-79 (USJ 21045). (Altitudinal distribution: 7-900 m).

Type of rot: White rot.
Substrata: On hardwood trees **(Inga sp.)**
Distribution: North, Central and South America; Africa.

***Coriolopsis floccosa** (Jungh.) Ryv., Norw. J. Bot. 19:230. 1972.
Polyporus floccosus Jungh., Verh. Batav. Genootsch. 17:49. "1839" (print 1838).

Voucher specimens examined: Santa Rosa, Guanacaste, on hardwood, JCM 172-79 (USJ 21077); Santa Maria de Dota, San Jose, on hardwood, JCM 36-88 (USJ 27916); Monteverde, Puntarenas, on hardwood, JCM 167-87 (USJ 27553). (Altitudinal distribution: sea level-2100 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Africa.

Coriolopsis polyzona (Pers.) Ryv., Norw. J. Bot. 19 (3-4): 230. 1972.
Polyporus polyzonus Pers., Gaudichaud Voy. aut. Monde., Bot. p. 170. 1827.

Voucher specimens examined: Finca El Rodeo, Ciudad Colon, San Jose, on **Enterolobium cyclocarpum**, JCM 39-86 (USJ 22253); Cañas, Guanacaste, on hardwood, JCM 119-79 (USJ 21073); Limon, Limon, on hardwood, JCM 124-80 (USJ 21075); Orosi, Cartago, on hardwood, JCM 18-79 (USJ 21072). (Altitudinal distribution: sea level-1050 m).
Type of rot: White rot.
Substrata: On hardwood trees **(Enterolobium cyclocarpum; Gliricidia sepium; Hevea brasiliensis; Ochroma lagopus)**.
Distribution: Central and South America; Africa; Caribbean Islands.

***Daedalea aethalodes** (Mont.) Rajsch., Can. J. Botany 64: 2130-2135. 1986.
Trametes aethalodes Mont., Ann. Sci. Nat. Ser. 4,5:370. 1857.

Comments: There is only one sterile specimen collected by R. Alfaro 60 (USJ 22903), in Cerro La Carpintera, Cartago. (Altitudinal distribution: 1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.

Distribution: Central and South America.

Daedalea microsticta Cke., Grevillea 10:122. 1882.

Voucher specimen examined: Road to Volcan Poas, Alajuela, on hardwood, A.L. Welden 3182 (TU 7815; USJ 21139); Turrialba near Rio Reventazon, W.R. Maxon (BPI 254228); Puerto Viejo, Sarapiqui, Heredia, A. Raske 1614 (BPI 254286). (Altitudinal distribution: 30-1200 m).
Type of rot: Brown rot.
Substrata: On hardwood trees.
Distribution: Central America; Caribbean Islands.

***Daedalea quercina** Fr., Syst. Mycol. 1:333. 1821.

Voucher specimens examined: Finca cerca de Pension Flor Mar, Monteverde, Puntarenas, JCM 159-87 (USJ 27544); San Gerardo de Dota, San Jose, L.D. Gomez 24237 (USJ 22800); Reserva San Ramon, Alajuela, JCM 246-86 (USJ 22805); Cerro Platanar, San Carlos, Alajuela, S. Morse (JCM 216-86, USJ 22806). (Altitudinal distribution: 1057-2000 m).
Type of rot: Brown heart rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Asia; Europe; Africa.

Datronia caperata (Berk.) Ryv., Mycotaxon 23:172. 1985.
Coriolopsis caperata (Berk.) Murr., N. Am. Fl. 9:77. 1908.

Voucher specimens examined: Ciudad Colon, San Jose, JCM 286-86 (USJ 27574), Finca Las Cruces, San Vito, JCM 196-86 (USJ 22753); Tilaran, Guanacaste, JCM 200-80 (USJ 27934). (Altitudinal distribution: sea level-1200 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Datronia mollis (Sommerf.:Fr.) Donk. Persoonia 4:338. 1966.
Daedalea mollis Sommerf.:Fr., Elench. Fung. p.71. 1828.

Voucher specimen examined: Heredia, Heredia, L.D. Gomez 24361(USJ 22888). (Altitudinal distribution: 1100 m).
Type of rot: White rot.

Substrata: On hardwood trees.
Distribution: North and Central America.

Datronia scutellata (Schw.) Gilbn. & Ryv., Mycotaxon 22: 364. 1985.
Polyporus scutellatus Schw., Trans Am. Phil. Soc. II, 4: 157. 1832. **Fomitopsis scutellata** (Schw.) Bond. & Sing., Ann. Mycol. 39:55. 1941.

Only one collection done by Dodge & Goerger (9257) in 1936 and deposited at BPI (234659). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Asia; Africa; Australia.

Datronia stereoides (Fr.) Ryv., Flora over Kjuker, p. 42. 1968.
Polyporus stereoides Fr., Syst. Mycol. 1:369. 1821.

Comments: Murrill (1915) mentioned one collection done in San Jose. No duplicates are deposited at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North and Central America; Europe.

Diplomitoporus lenis (Karst.) Gilbn. & Ryv., Mycotaxon 22: 364. 1985.
Physisporus lenis Karst. in Rabenh. Wint. Fungi Eur. et Exeur. Excs. no. 3527. 1886.

Voucher specimens examined: La Virgen, Heredia, J.L. Lowe 13439 (USJ 22009); Navarro, San Jose, A.L. Welden 3018 (TU 8572, USJ 21985). (Altitudinal distribution: 260 m).
Type of rot: White rot.
Substrata: On softwood and hardwood trees.
Distribution: North and Central America; Caribbean Islands; Europe; Asia.

Earliella scabrosa (Pers.) Gilbn. & Ryv., Mycotaxon 22:364. 1985.
Polyporus scabrosus Pers. in Gaudich., Voy. aut. Monde p. 172. 1827.
Voucher specimens examined: Santa Rosa, Guanacaste, JCM

170-79 (USJ 22043); Ciudad Colon, San Jose, JCM 186-79 (USJ 22044); Monteverde, Puntarenas, JCM 212-86 (USJ 22722); Alto de Ochomogo, Cartago, JCM 31-79 (USJ 22048). (Altitudinal distribution: sea level-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa; Caribbean Islands.

Echinochaete brachyporus (Mont.) Ryv., Bull. Jard. Bot. Nat. Belg. 48:101. 1978.
Polyporus brachyporus Mont., Ann. Sci. Nat. ser. 4, 1:131. 1854.

Voucher specimens examined: Costa Rica, K.A. Danielson 158, 1928 (BPI 212777); Upala, Alajuela, A. Conejo (JCM 1-89, USJ 28164). (Altitudinal distribution: 48 m).
Type of rot: White rot (?).
Substrata: On hardwood trees.
Distribution: Central America; Africa.

Echinoporia aculeifera (Berk. & Curt.) Ryv., Mycotaxon 19: 330. 1984.
Trametes aculeifera Berk. & Curt., J. Linn. Soc. Bot. 10: 319. 1868.

Only one collection done by Standley and Valerio in 1926 and deposited at BPI (245404). No duplicates at USJ.
Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Favolus paraguayensis Speg., An. Soc. Cient. Argent. 17:71. 1884.

Comments: There is one collection mentioned by Bommer and Rousseau (1896) cited by Covington (1980). No duplicates at USJ.

Flavodon flavus (Kl.) Ryv., Norw. J. Bot. 20:3. 1973.
Irpex flavus Kl., Linnaea 8:488. 1833.

Voucher specimen examined: Palo Verde, Guanacaste, JCM 46-88 (USJ 28274). (Altitudinal distribution: 80-200 m).

Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: Pantropical.

Fomes auberianus (Mont.) Murr., Torrey Bot. Club Bull. 32: 491. 1905.
Polyporus auberianus Mont. in de la Sagra Plant Cell. Cuba p. 399. 1842.

Two collections done by Maxon (207-613) in 1906 and deposited at BPI (228254-228253). No duplicates at USJ.

Fomes fasciatus (Sw.: Fr.) Cke., Grevillea 14:21. 1885.
Polyporus fasciatus Sw.: Fr., Syst. Mycol. 1:3373. 1821.
Fomes marmoratus (Berk. et Curt.) Cke., Grevillea 14:18. 1885. **Fomes sclerodermeus** (Lev.) Cke., Grevillea 14:18. 1885.

Voucher specimens examined: Upper slopes of Poas Volcano, Alajuela, D.E. Stone (TU 522; USJ 21201); Vara Blanca, Heredia, A.L. Welden (TU 7022; USJ 21233); Cerca del puente La Vieja, Zarcero, Alajuela, JCM 236-80 (USJ 28201). (Altitudinal distribution: 1440-1800 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Fomitella supina (Swartz : Fr.) Murr., Bull. Torrey Bot. Club 32:365. 1905.
Fomitopsis supina (Fr.) Ryv., Bull. Jard. Bot. Nat. Belg. 47:102. 1978. **Polyporus supinus** Swartz : Fr., Syst. Mycol. 1:376. 1821.

Voucher specimens examined: San Ramon, Alajuela, A.L. Welden 3240 (TU 9045, USJ 27609); San Ramon, Alajuela, A.L. Welden 3231 (USJ 21293); Rio Segundo, Alajuela, L.D. Gomez 24223 (USJ 22904); Ciudad Colon, San Jose, JCM 292-80 (USJ 27535). (Altitudinal distribution: 840-1057 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; West Indies; Africa.

Fomitopsis cupreo-rosea (Berk.) Carranza & Gilbn., Mycotaxon 2:476. 1986.
Trametes cupreo-rosea (Berk.) Lloyd, Mycol. Writ. 4 (Synop. **Fomes**) 226. 1915.

Comments: For a more detailed description see Carranza-Morse & Gilbertson (1986).

Fomitopsis dochmia (Berk. & Br.) Ryv., Norw. J. Bot. 19: 231. 1972.
Fomes dochmius (Berk. & Br.) Cke., Grevillea 14:17. 1985.

Comments: For a more detailed description see Carranza-Morse & Gilbertson (1986).

Fomitopsis feei (Fr.) Kreisel, Univ. Habana (Cuba), ser. 4, Cienc. Biol. No. 16:83. 1971.
Trametes feei (Fr.) Pat., Essai Taxon. p. 92. 1900.

Comments: A more detailed description by Carranza-Morse & Gilbertson (1986).

Fomitopsis ligneus (Berk.) Ryv., Norw. J. Bot. 19:231. 1972.
Fomes ligneus (Berk.) Cke., Grevillea 13:119. 1885.

Comments: Covington (1980) mentioned one collection done by Murrill in Costa Rica. No duplicates at USJ.
Type of rot: Unknown.
Substrata: On hardwood trees.
Distribution: Central America; Caribbean Islands.

***Fomitopsis nivosa** (Berk.) Gilbn. & Ryv., North American Polypores, p. 275. 1986.
Trametes nivosa (Berk.) Murr., North Am. Fl. 9:42. 1907.
Polyporus nivosus Berk., Hook. J. Bot. 1:196. 1856.

Voucher specimen examined: Heredia, Heredia, L.D. Gomez 24365 (USJ 22892). (Altitudinal distribution: 1100 m). One collection done by Standley (42970) in 1925 and deposited at BPI (247420, 247425). No duplicate at USJ.
Type of rot: Brown rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

***Fuscocerrena portoricensis** (Fr.) Ryv., Trans. Br. Mycol. Soc. 79:280. 1982.
Polyporus portoricensis Fr., Elench. Fung. 1:115. 1828

Voucher specimens examined: Pension Flor Mar, Monteverde, Puntarenas, JCM 168-87 (USJ 27551); Jardin, Santa Maria. de Dota, San Jose, J.L. Lowe 13402 (USJ 21137); Cariblanco, Heredia, J.L. Lowe 12974 (USJ 21134); Cascajal de Coronado, San Jose, JCM 230-86 (USJ 22750). (Altitudinal distribution: 1009-2100 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

***Gloeophyllum mexicanum** (Mont.) Ryv., Nord. J. Bot. 2:79. 1982.
Daedalea berkleyi Sacc., Syll. Fung. 6:381. 1888.

Only one sterile collection done by Sigers in 1922 and deposited at BPI (252656). No duplicates at USJ.
Type of rot: Brown rot.
Substrata: On softwood trees.
Distribution: North and Central America.

Gloeophyllum striatum (Sw. : Fr.) Murr., Torrey Bot. Club Bull. 32:370. 1905.
Daedalea striata Sw.: Fr., Syst. Mycol. 1:334. 1821.

Voucher specimens examined: Bijagua, Upala, Alajuela, JCM 266-86 (USJ 27593); Palo Verde, Guanacaste, JCM 10-88 (USJ 28214); Santo Domingo, Heredia, L.D. Gomez 24339 (USJ 22798); Ciudad Colon, Finca El Rodeo, San Jose, JCM 298-80 (USJ 21325); Palmar, Puntarenas, JCM 4-80 (USJ 21327). (Altitudinal distribution: 26-1000 m).
Type of rot: Brown rot.
Substrata: On hardwood **(Calycophyllum candidissimum)**, and softwood trees.
Distribution: North and Central America; Africa; Caribbean Islands.

Hexagonia hydnoides (Fr.: Sw.) M. Fidalgo, Mem. New York Bot. Gard. 17 (2):35-108. 1968.
Polyporus hydnoides Fr., Syst. Mycol. 1:362. 1821.

Comments: A more detailed description by Carranza y Saenz (1984).

Hexagonia papyracea Berk., Ann. Mag. Nat. Hist. 10:379. 1843.
Hexagonia variegata Berk., Ibid. Ser. 2, Vol. 9:196. 1852.

Voucher specimens examined: Parque Nac. Volcan Rincon de la Vieja, Guanacaste, R. Alfaro 42 (USJ 22835); Abangares, Guanacaste, JCM 115-79 (USJ 21155); Parque Nac. Santa Rosa, Guanacaste, JCM 168-79 (USJ 21157); Rio Segundo, Alajuela, L.D. Gomez 24227 (USJ 22788). (Altitudinal distribution: 29-1500 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Caribbean Islands.

Hexagonia tenuis (Hook.) Fr., Epicr. Syst. Mycol. p. 498. 1838.
Boletus tenuis Hook., in Kunth. Syn. Pl. 1:10. 1822.

Voucher specimens examined: Parque Nac. Barra Honda, C. Garcia, JCM 243-86 (USJ 22782); Alto de las Palomas, Santa Ana, San Jose, JCM 16-86 (USJ 22250); Naranjo, Alajuela, JCM 104-86 (USJ 22317); San Antonio de Belen, Heredia, JCM 9-81 (USJ 21153). (Altitudinal distribution: sea level-1330 m).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: Central America; Africa.

Hexagonia unicolor Fr.

Comments: Listed by Bommer and Rousseau (1896) cited by Covington (1980). No duplicates at USJ. There are not authentic specimens of this species and the name should be dropped from consideration (Ryvarden, pers. comm., 1990).

***Hydnopolyporus fimbriatus** (Fr.) Reid, Persoonia 2:151. 1962.
Polyporus fimbriatus Fr., Linnaea 5:520. 1830.

Voucher specimen examined: Reserva Biologica Isla del Caño, Puntarenas, R. Alfaro 222 (USJ 27632). (Altitudinal distribution: sea level).
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America.

Incrustoporia carneola (Bres.) Ryv., Norw. J. Bot. 19(3-4): 232. 1972.
Poria carneola Bres., Hedwigia 35:282. 1896.

Comments: Cited by Lowe (1966). No duplicates at USJ.
Type of rot: White rot.
Substrata: On hardwood trees.
Distribution: North, Central and South America; Africa.

Irpex lacteus (Fr.: Fr.) Fr., Elench. Fung., p. 145. 1828.
Sistotrema lacteum Fr., Obs. Mycol. 2:226. 1818.
Polyporus tulipiferae (Schw.) Overh., Wash. Univ. Studies 3, 1:29. 1915.

Voucher specimen examined: Finca El Rodeo, Ciudad Colon, San Jose, JCM 42-86 (USJ 22759). (Altitudinal distribution: 840 m).
Type of rot: White rot.
Substrata: On hardwood **(Bursera simarouba)** and softwood trees.
Distribution: North and Central America; Africa; Europe.

***Ischnoderma resinosum** (Fr.) Karst., Soc. Fauna Fl. Fenn. 5: 38. 1879.
Polyporus resinosus Fr., Syst. Mycol. 1:361. 1821.

Voucher specimen examined: San Gerardo de Dota, San Jose, L.D. Gomez 24240 (USJ 22872). (Altitudinal distribution: 2000 m).
Type of rot: White rot.
Substrata: On hardwood and softwood trees.
Distribution: North and Central America; Asia; Europe.

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MATING SYSTEMS IN MARASMIUS

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SUMMARY

Self-crosses of monokaryon isolates from single collections of thirteen species of *Marasmius* revealed the mating system for each taxon. These data, as well as previous mating reports on *Marasmius*, indicate a high consistency of mating system types at the sectional level. Sections *Alliacei*, *Androsaceus*, *Epiphylli*, and *Marasmius* are predominately tetrapolar (bifactorial), and sections *Globulares* and *Sicci* are bipolar (unifactorial).

About 90 taxa of Marasmius (Tricholomataceae, Agaricales) are known to occur in North America with 38 of these, representing eight sections, being reported from the southern Appalachian Mountains (Desjardin, 1989). While the majority of taxonomic works have treated alpha-level characters (macro- and micromorphology) (Desjardin, 1985, 1986, 1989; Desjardin and Petersen, 1989a, 1989b, 1989c; Gilliam, 1973, 1975, 1976), studies on cultural characteristics (Arnold, 1935; Desjardin, 1990) and phenoloxidase production (Marr, 1979; Desjardin, 1990) have also been produced. To date, few studies have extensively analyzed mating behavior in the genus. Relatively detailed reports on *Marasmius oreades* (Burnett and Evans, 1966; Mallet and Harrison, 1988), *Marasmius elongatipes* (= *M. pyrrhocephalus*; Arnold, 1935), and *Marasmius limosus* (Lamoure, 1957) have been made, while many studies listed in Lamoure's (1989) checklist of information on mating tests in the Agaricales have merely listed mating system type with no further information on collection deposition, unusual culture morphologies, or designation of tester strains.

Previous data suggested variability of mating systems within *Marasmius*, but with few species analyzed, resultant data, until now, have not been useful in systematic schemes. With the work by Desjardin (1989) providing a morphotaxonomic foundation for *Marasmius* in the southern Appalachian Mountains, it seemed opportune and interesting to obtain information on individual species' mating systems as well as to test generally accepted infrageneric outlines.

MATERIALS AND METHODS

COLLECTIONS - A major part of this research included extensive fieldwork throughout the southern Appalachian Mountains to collect living basidiomes from which monokaryon isolates were obtained. All collections were identified using keys by Desjardin (1989). Most collections were deposited in the University of Tennessee Fungus Herbarium (TENN) and tester strains of most collections (collection number in boldface below) have been deposited at ATCC.

CULTURE PREPARATION - Collection of spores and subsequent single-spore isolation was achieved by suspending the spore-bearing portion of a fresh basidiome from the inside cover of a tilted sterile Petri dish (to allow for greater spore dispersal) containing malt extract agar (MEA; 1.5% Difco malt extract, 2.0% Difco bacto-agar, 1 L distilled water). When a spore print became barely visible, the basidiome tissue was removed, and Petri dishes were inspected daily for spore germination.

Spore germination was detected using a dissecting microscope with substage illumination. After spores germinated, single germlings were harvested and transferred to individual Petri plates where they were allowed to grow to approximately 10-15 mm diam. These monokaryon cultures were subcultured to: 1) slanted MEA culture tubes and stored at 4°C for short-term storage; and 2) sterile vials (4 ml cap.) containing 10% glycerol and placed at -70°C for long-term storage.

DETERMINATION OF MATING SYSTEMS (SELF-CROSSES) - Monokaryons from a single collection were crossed in all possible combinations. Mycelial plugs were placed on MEA

approximately 6-7 mm apart. Isolates crossed against themselves served as controls. Matings were allowed to grow for one to several weeks after a contact zone was established, to allow differentiation of contact zone morphologies. Matings were examined microscopically for the presence of clamp connections (presumptive evidence of a compatible mating) or their absence (incompatible mating). In most cases, clamp connections were readily observed directly at 250X on hyphae at the agar surface. In some cases, when clamps were small or appeared incomplete ("false clamps"), a small plug of contact zone hyphae and agar was removed, stained with phloxine, and viewed at high magnification (600X). Presence or absence of clamp connections was noted at the periphery of each mated colony to assess if possible nuclear migration occurred away from the contact zone. Tester strains (tester spores) of each mating type were chosen on the basis of mating type, relatively fast growth rate, and ability to form abundant clamp connections with compatible mating types. Under individual taxa summarized below, tester strains are denoted by an (*) next to the strain number.

RESULTS

Section *ALLIACEI*

MARASMIUS PYRRHOCEPHALUS Berk.

Mating system: Tetrapolar (bifactorial)

Isolate mating type assignment: ASM 6147 - A_1B_1: 11*; A_2B_2: 2, 6, 7, 13*; A_2B_1: 1, 5, 8, 9, 10*; A_1B_2: 3, 14*. **TENN 48759** - A_1B_1: 5*, 6; A_2B_2: 3*, 1; A_2B_1: 8, 4, 9*, 2; A_1B_2: 7 and 10*. **TENN 48760** - A_1B_1: 5, 3*; A_2B_2: 9*, 2; A_2B_1: 4, 10*; A_1B_2: 1, 6*, 7, 8. **TENN 48752** - A_1B_1: 1*, 3, 8; A_2B_2: 2*, 4, 5, 6; A_2B_1: 9*; A_1B_2: 7*, 10.

Comments: Nuclear migration was reciprocal. Colonies of compatible matings formed a very distinctive "heart shaped" area of white, appressed hyphae surrounded by cinnamon-brown aerial hyphae. "Flat" and "barrage" morphologies were distinctive.

Specimens utilized: Illinois, Jackson Co., Touch of Nature Reserve, 20.X.89, coll. RHP, det. RHP, field no. ASM 6147 (EIU no. 6147); North Carolina, Macon Co., Bull Pen Rd., vic. Slick Rock, 6.VI.89, coll. SAG, det. SAG, field no. 1992 (TENN no. 48759); North Carolina, Swain Co., GSMNP, Kephart Prong Trail, 8.VI.89, coll. SAG, det. SAG, field no. 1999 (TENN no. 48760); North Carolina, Macon Co., Highlands Biological Station, nature trail, 9.VI.89, coll. SAG, det. SAG, field no. 2711 (TENN no. 48752).

Section *ANDROSACEI*

MARASMIUS ANDROSACEUS (L.: Fr.) Fries

Mating system: Tetrapolar (bifactorial).

Isolate mating type assignment: **TENN no. 48757** - A_1B_1: 5, 6*, 10; A_2B_2: 4*, 11, 12; A_2B_1: 2*; A_1B_2: 1*, 7, 14.

Comments: Nuclear migration was reciprocal: no distinct contact zone morphology was noted.

Specimen utilized: North Carolina, Macon Co., Blue Valley, vic. Forest Rd. 79, 9.VI.89, coll. SAG, det. SAG, field no. 2705 (TENN no. 48757).

Section *EPIPHYLLI*

MARASMIUS FELIX Morgan

Mating type: Tetrapolar (bifactorial)

Isolate mating type assignment: **ASM 6148** - A_1B_1: 1, 4*, 11; A_2B_2: 7, 12*; A_2B_1: 2, 5*; A_1B_2: 3, 6*, 8, 9, 10.

Comments: Nuclear migration was reciprocal. "Flat" and "barrage" reactions were readily visible but were most apparent when viewing colony reverse.

Specimen utilized: Illinois, Jackson Co., Touch of Nature Reserve, 20.X.90, coll. ASM, field no. 6148, (EIU no. 6148).

Section *MARASMIUS*

MARASMIUS ROTULA (Scop.: Fr.) Fries

Mating system: Tetrapolar (bifactorial)

Isolate mating type assignment: **TENN 48352** - A_1B_1: 1*, 3, 6; A_2B_2: 2*, 5; A_2B_1: 7*, 8; A_1B_2: 4*, 9. TENN 48535 - A_1B_1: 1, 8*, 10; A_2B_2: 3*, 5; A_2B_1: 4, 7, and 9*; A_1B_2: not represented in the sample. **TENN 48461** - A_1B_1: 3*, 6; A_2B_2: 1, 5, 10*; A_2B_1: 2, 8, 9, 11; A_1B_2: 4, 12*; A_2B_2 + A_2B_1: 7 (see commentary). TENN 48753 - A_1B_1: 2*, 8, 10; A_2B_2: 1, 6*, 7; A_2B_1: 4, 11*; were , A_1B_2: 3*; A_1B_1 + A_2B_1: 5 (see commentary). **TENN 48751** - A_1B_1: 1, 7*; A_2B_2: 2, 4, 5*; A_2B_1: 3, 6, 8*; A_1B_2: 9, 10*.

Comments: Nuclear migration was reciprocal, with the exception of TENN 48535, in which clamp connections were restricted to the contact zone. Only three mating types were retrieved from TENN 48535. Incompatible matings clearly exhibited "flat" and "barrage" reactions. Fluffy to cottony peripheral hyphae usually were indicative of compatible matings. Isolate 48461:7 and 48753:5 were each compatible with two other mating types: it is believed that two hemicompatible spores were initially isolated.

Specimens utilized: Georgia, Rabun Co., vic. Double Bridges, 1.5 mi. from Rt. 28, 24.VIII.89, coll. RHP, det. RHP, field no. 2080 (TENN no. 48461); North Carolina, Macon Co., Bull Pen Rd., vic. Slick Rock, 21.VI.89, coll. RHP, det. RHP, field no. 1809 (TENN no. 48352); North Carolina, Macon Co., Otto, Coweeta Hydrologic Lab, Shope Creek Rd., 22.VI.89, coll. RHP, det. RHP, field no. 1816 (TENN no. 48535); North Carolina, Macon Co., Forest Service Rd. 1.5 miles from Shortoff Baptist Church, 1.VII.89, coll. SAG, det. SAG, field no. 2760 (TENN no. 48751); Tennessee, Blount Co., GSMNP, Chimney Tops trailhead, 27.VI.89, coll. SAG, det. SAG, field no. 2726 (TENN no. 48753).

Section *GLOBULARES*

MARASMIUS CYSTIDIOSUS (Smith & Hesler) Gilliam

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48754** - A_1: 1, 2*, 4, 5, 8, 10; A_2: 3, 6, 7, 9*, 11, 12.

Comments: Nuclear migration was variable: no distinct contact zone morphology was noted.

Specimen utilized: North Carolina, Macon Co., Coweeta Hydrologic Lab, vic. 1.5 mi. from lab on Shope Creek Rd., 1.VII.90, coll. SAG, det. DED, field no. 2756 (TENN 48754).

MARASMIUS DECIPIENS Halling, Desjardin, and Tish

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48755** - A_1: 1*, 2, 4, 5, 10, 12, and 13; A_2: 7*, 9, 11. **TENN 48756** - A_1: 1, 5, 8*, 11; A_2: 2, 6, 9, 10*.

Comments: Clamp connections were mostly restricted to the contact zone. Many matings showed sparse, scattered clamps in the contact zone. Crosses performed on 1.5% MEA produced no discernably patterned grids but crossess on 0.5% MEA showed clear bipolar patterns.

Specimens utilized: Tennessee, Blount Co., GSMNP, vic. Chimney Tops trailhead, 27.VI.89, coll. SAG, det. DED, field no. 2722 (TENN no. 48755); North Carolina, Haywood Co., Cataloochee cove, 30.VI.89, coll. SAG, det. DED, field no. 2731 (TENN no. 48756).

MARASMIUS NIGRODISCUS (Pk.) Halling

Mating system: Bipolar (unifactorial)

Isolate mating type assignments: **TENN 48829** - A_1: 1, 4*, 6, 11; A_2: 2*, 3, 5, 7, 8, 9, 10, 12.

Comments: Clamp connections were restricted to the zone of contact. No distinct contact zone morphology was noted. Crosses performed on 1.5% MEA produced no discernably patterned grids, but crosses on 0.5% MEA exhibited clear bipolar patterns.

Specimen utilized: Tennessee, Knox Co., Knoxville, University of Tennessee campus, 21.VI.89., coll. DED, det. DED, field no. 4913 (TENN no. 48829).

MARASMIUS OREADES (Bolt.: Fr.) Fries

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48827** - A_1: 3, 6, 7*, 15, 16, 17; A_2: 2, 8, 11*, 12, 13, 14.

Comments: Nuclear migration was reciprocal: no distinct contact zone morphology was noted.

Specimen utilized: New York, Cortland Co., Rt. 281, vic. St. Mary's Cemetary, 18.X.89, coll. TJB, det. TJB, field no. TJB 6314 (TENN no. 48827).

MARASMIUS STRICTIPES (Pk.) Singer

Mating system: Heterothallic

Isolate mating type assignment: Inconclusive at this time

Comments: No discernable mating patterns were observed. Matings were read weekly for four weeks; mating data remained consistent at all reading times.

Specimen utilized: Illinois, Jackson Co., Touch of Nature Reserve, 21.X.89, coll. RHP, field no. 2427 (TENN no. 48761).

Section *SICCI* Series *HAEMATOCEPHALI*

MARASMIUS FLORIDANUS Murrill

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **ASM 5707** - A_1: 1, 2*, 3, 4, 5, 6, 8, 9; A_2: 7, 10*, 11, 12.

Comments: Nuclear migration was variable, some crosses

formed clamp connections which seemed restricted to the contact zone while others exhibited reciprocal migration.

Specimen utilized: Illinois, Douglas Co., Walnut Pt. State Park, 13.VII.89, coll. ASM, det. ASM, field no. ASM 5707 (EIU no. 5707).

MARASMIUS PULCHERRIPES Peck

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48758** - A_1: 1, 2, 3, 4, 5*, 8; A_2: 6, 9*. **TENN 48750** - A_1: 2*, 3, 4, 6, 7; A_2: 1, 5*, 8, 9, 10, 11.

Comments: No distinct contact zone morphology was noted. Analysis of clamp connections required high magnification (600X).

Specimens utilized: Georgia, Rabun Co., vic. Warwoman Dell Picnic Area, 18.VII.89, coll. SAG, det. SAG, field no. 2779 (TENN no. 48750); Tennessee, Blount Co., GSMNP, 1 mi. past Park Visitors' center, 1.VIII.89, coll. SAG, det. SAG, field no. 2127 (TENN no. 48758).

MARASMIUS SICCUS (Schw.) Fries

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48828** - A_1: 1, 2*, 3, 7, 8, 13, 15; A_2: 4*, 5, 6, 9, 10, 11, 12, 14. **DED 4956** - A_1: 1, 4, 5*, 7, 9, 10; A_2: 2, 3*, 6, 8.

Comments: No distinct contact zone morphology was noted. Observation of clamp connections required high magnification (600X).

Specimens utilized: North Carolina, Haywood Co., Harmon Den, 18.IX.88, coll. DED, det. DED, field no. DED 4714 (TENN no. 48828); Ohio, Loraine Co., 8 mi. west of Oberlin, vic. Girl Scout Camp, 11.IX.89, coll. DED, det. DED, field no. DED 4956 (SFSU).

Series *LEONINI*

MARASMIUS FULVOFERRUGINEUS Gilliam

Mating system: Bipolar (unifactorial)

Isolate mating type assignment: **TENN 48464** - A_1: 2, 3, 5*, 7, 12, 18; A_2: 6, 9*, 10, 19.

Comments: Nuclear migration was reciprocal.

Specimen utilized: Georgia, Rabun Co., Warwoman Dell Picnic Area, 28.VIII.89, coll. RHP, det. RHP, field no. 2099 (TENN no. 48464).

DISCUSSION

The thirteen species studied represented six sections of *Marasmius*. Eight species were bipolar, four tetrapolar, and one inconclusive (Table I). When mating system data from this study as well as those from previous reports are compared to the infrageneric system in Desjardin's (1989) regional flora, mating system types appear remarkably consistent at the sectional level. Understanding that the infrasectional sampling sizes were extremely low, the conclusions below nevertheless seem warranted.

Section *Alliacei* was represented in this study by *M. pyrrhocephalus* (4 collections), which was found to be tetrapolar. Other taxa in this section also have been shown to be tetrapolar; Kühner (1945), Piroard (1956), Terra (1953), and Yen (1950c,d) for *M. scorodonius* (Fr.: Fr.) Fr.; Piroard (1956), Terra (1959), and Yen (1950 a,b) for *M. alliaceus* (Jacq.: Fr.) Fr.; and Lamoure (1989) for *M. epidryas* Kühner. Bastouill (1977) and Viale (1961) found *M. prasiomus* (Fr.: Fr.) Fr. to be heterothallic but did not indicate a specific mating system. The section, thus far, seems consistently tetrapolar.

In section *Androsacei*, only *M. androsaceus* was obtained in single-spore culture. It was found to be tetrapolar, supporting previous reports by Piroard (1956), Terra (1953), and Yen (1950a,b,d). Because it is

TABLE I

MATING SYSTEMS OF *MARASMIUS* TAXA[1]

SECTION	MATING SYSTEM
SECTION *ALLIACEI*	
M. pyrrhocephalus (nos. 2419, 1992, 1999, 2711)	tetrapolar
SECTION *ANDROSACEUS*	
M. androsaceus (no. 2705)	tetrapolar
SECTION *EPIPHYLLI*	
M. felix (s. n.)	tetrapolar
SECTION *MARASMIUS*	
M. rotula (nos. 1809, 1816, 2080, 2726, 2760)	tetrapolar
SECTION *GLOBULARES*	
M. cystidiosus (no. 2756)	bipolar
M. decipiens (nos. 2722, 2731)	bipolar
M. nigrodiscus (no. 4913)	bipolar
M. oreades (no. 6314)	bipolar
M. strictipes (no. 2427	inconclusive
SECTION *SICCI*	
M. floridanus (no. 5707)	bipolar
M. siccus (nos. 4714, 4956)	bipolar
M. pulcherripes (nos. 2127, 2779)	bipolar
M. fulvoferrugineus (no. 2099)	bipolar

[1] collection field numbers in parenthesis

the only species in the section whose mating system is known, mating system analysis of other species in this section is necessary before conclusions can be drawn on sectional mating system consistency.

In our cultured collections, section *Epiphylli* was represented by *M. felix*, which was tetrapolar. Terra (1953) and Yen (1950a,b,d) found the same system in *M. epiphyllus* (Pers.: Fr.) Fr. *Marasmius tremulae* Vel., conversely, has been reported as haploid parthenogenetic by Kühner (1947) and Lamoure (1958).

From limited data, section *Marasmius* seems to be predominately tetrapolar. *Marasmius rotula* (5 collections) was found to be tetrapolar, agreeing with Terra (1953) and Yen (1950b,d). Moreover, Lamoure (1960, 1989) reported the European taxa *M. bulliardii* Quél. and *M. limosus* Boud. & Quél. as tetrapolar.

Mating systems of five species in sect. *Globulares* were analyzed in this study. *Marasmius decipiens*, *M. nigrodiscus*, *M. cystidiosus*, and *M. oreades* were all found to be governed by bipolar mating systems, while *M. strictipes* remains unresolved at this time. Conversely, Armand (1962), Oddoux (1957), and Terra (1959) sited a tetrapolar mating system for *M. collinus* (Scop.: Fr.) Sing., inconsistent with our mating system data on this section. Data on a bipolar mating system for *M. oreades* are in agreement with Mallet and Harrison (1988) and Burnett and Evans (1966).

Taxa of section *Globulares* seem to differ physiologically from those in other studied sections of *Marasmius*. When self-crosses of some taxa of this section (*Marasmius decipiens*, *M. nigrodiscus*, and *M. strictipes*) were performed on 1.5% malt extract agar, compatible crosses were unpatterned and less common than in crosses on 0.5% malt extract agar. It appeared that some sexually compatible monokaryons were reluctant to dikaryotize on the higher nutrient medium. Exceptions to these observations were *M. oreades* and *M. cystidiosus*, which dikaryotized in conclusive patterns on both media, and *M. strictipes* which produced no patterned mating reactions on both media.

In section *Sicci*, mating systems of taxa from two series, *Haematocephali* and *Leonini*, were elucidated. In

series *Haematocephali*, *M. floridanus*, *M. siccus*, and *M. pulcherripes* were all found to be bipolar. *Marasmius fulvoferrugineus*, of series *Leonini*, also was found to be bipolar. Armand (1962) and Vandendries (1936) found *M. cohaerens* (Pers.: Fr.) Fr., a member of section *Sicci* series *Spinulosi*, also to be bipolar, indicating consistent bipolar mating behavior throughout section *Sicci*.

Marasmius sullivantii (sect. *Sicci*, ser. *Haematocephali*) was collected but subsequent "monospore" isolates were all clamped. Suspecting that basidiospores could be binucleate and the species amphithallic, spores of dried specimens were examined using epifluorescence microscopy and the nuclear flourescent stain DAPI (4'-6-diamidino-2-phenylindole). Spores appeared to contain one nucleus, but many spores seemed closely associated with or attached to one another. This spore adhesion may have caused multiple spores to be harvested during single-spore isolation attempts.

While these data indicate heterogeneous mating systems in *Marasmius*, *Mycena* (Kühner, 1938) has also been shown to posses several mating system types. Other limited data on white-spored agarics indicate homogeneous mating system types at the generic level, with *Collybia* (Arnold, 1935; Chu, 1950; Vilgalys and Miller, 1983, 1987), and *Marasmiellus* (Gordon, unpub. data) appearing consistently tetrapolar. Limited data on *Xerula* (Redhead, *et al.*, 1987, Petersen, unpub. data) and *Hohenbuehelia* (Thorn and Barron, 1986; Petersen, unpub. data) indicate consistent bipolar mating sytems.

Our data for *Marasmius* indicate a probability that genes controlling mating system type act separately from those governing morphological characters, especially those defining generic parameters. Implicit in this hypothesis is the following dichotomy: either 1) divergence of compatibility systems (bipolar > tetrapolar; tetrapolar > bipolar) occurred more than once after stabilization of morphological infrageneric diagnostic characters; or 2) within a coherent group governed by a single mating system (i. e. bipolar; tetrapolar), morphologically divergent groups evolved. Sections *Alliacei*, *Epiphylli*, and *Globulares* exhibit a palisade pileipellis of non-setulose clavate cells (Desjardin, 1989; Singer, 1986). Our data indicate that two of these sections, *Alliacei* and

Epiphylli are tetrapolar, while section *Globulares* appears bipolar. Likewise, sections *Marasmius* and *Sicci* are characterized by pileipelli containing setulose elements (broom cells) (Desjardin, 1989; Singer, 1986). Of these, section *Marasmius* appears tetrapolar while section *Sicci* is bipolar. To cluster sexually like sections would require extraction of two morphologically dissimilar sections (*Globulares*, *Sicci*) from groups to which they are typically thought to belong (Desjardin, 1989; Singer, 1986). In summary, either the morphogenus is "natural," in which case mating systems have evolved more than once within the morphogenus, or if mating systems are used to diagnose generic units (= biogenus), then a multiplicity of morphogeneric units must be defined.

Because mating systems of only a few congeneric taxa have been analyzed, data from which to infer evolutionary relationships and positions relative to mating system analysis are still in an early state.

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SPECIES CONCEPTION AND SECTIONS DELIMITATION OF GENUS DISCOSIA

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ABSTRACT. Six new sections of genus Discosia Lib. (Sect. I. Discosia, Sect. II. Laurina Vanev, sect. nov., Sect. III. Clypeata Vanev, sect. nov., Sect. IV. Libertia Vanev, sect. nov., Sect. V. Strobilina Vanev, sect. nov., Sect. VI. Poikilomera Vanev, sect. nov.) are delimited on the basis of some morphologic characters: number of septa, relative length of the 2 middle conidial cells and different points of origin of the conidial appendages. The new sections are described and illustrated.

Genus Discosia Lib. was described by Libert in 1837 with 2 original species: D. faginea Lib. and D. strobilina Lib. From the diagnosis it is evident that the author wrongly refers the new genus to class Ascomycetes: "Char. gen. Perithecium innatum scutiforme ostiolo perforatum obtegens ascida fusiformia utrinque in productionem filiformem protensa, sporidiis globosis".

Later De Notaris (1849) described 4 new species of genus Discosia: D. vagans De Not., D. quercicola De Not., D. smilacina De Not. and D. clypeata De Not.

Fries (1849) suggests the combination D. artocreas (Tode)Fr., transfering the species Sphaeria artocreas Tode, described by Tode (1791), to genus Discosia. At present, the same species is fixed as a lectotype of the genus (Vanev, in press)

On the basis of detailed investigations on the

morphological peculiarities of some species from that genus, Fresenius (1852) finds out that the sporidia mentioned in the original description of the genus by Libert (l. c.) are oil drops, while the conidia proper have been wrongly registered as ascuses. Genus Discosia, therefore, should be excluded from class Ascomycetes and refered to the imperfect fungi.

Later, a series of investigators define and describe a huge number of new taxa, as a result of which more than 80 species, varieties and forms are known to be within the limits of that genus nowadays (Berkeley 1874, Cavara 1889, Edwards 1972, Gerard 1873, Heald 1909, Hollós 1907, Kalani 1966, Lacy 1958, Morgan-Jones 1964, Peck 1893, Petrak 1951, Saccardo 1884, 1892, 1895, 1906, Tehon 1933, Tilak & Viswanathan 1959, Vanev 1982, etc.).

The morphological similarity among the representatives of that genus, together with the lack of accurate taxonomic criteria for their differentiation are the basic reasons for the presence of a great number of species whose morphological differentiation is either difficult, or impossible.

Following the established traditions in the classification of the imperfect fungi, the investigators have described a number of new species above all on a physiological principle: on the basis of the plants, upon which they have been originally registered, with the taxa, newly differentiated with respect to nomenclature, being linked most often either with the name of the genus, or with the species epithet of the host-plant (D. pini Heald D. rhododendri Speschnev, D. platani Otth, etc.).

Genus Discosia unites both saprophytes and typical parasites. In our investigations it was established, that many of the taxa described are not firmly attached to a definit substrate, therefore it is both groundless and wrong to isolate separate, independent units out them.

Differentiating the infrageneric taxa, the investigators have been working so far on the basis of some morphological features having unequal taxonomic value,

for example: while the morphological features of the conidia are caracterized with a relative stability, their application in the differentiation of the individual taxa being perfectly reasonable, such features as size, shape and location of the pycnidia (frequently used so far) are rather variable, possessing an insignificant value in the genus classification.

One characteristic peculiarity in the systematics of genus Discosia is the presens of the collective species D. artocreas (Tode) Fr. Quite a number of investigators, not being able to refer this or that species to the ones already described in the genus, have made "use" of the collective species. In the mycological herbaria all over the world a huge number of specimens are deposited, defined as D. artocreas.

Revising more than 2500 specimens from genus Discosia, deposited in 36 well-known mycological herbaria all over the world, we established that almost 1/3 of them are kept under the name of D. artocreas.

The taxonomic scheme of the genus existing up to now, based predominantly on a physiological principle (attachment to a definite plant substrate), has obviously not satisfied some of the mycotaxonomists, who deposited the materials they had collected, as unidentified (sub Discosia sp.), or referred them to the collective species D. artocreas.

Some of the investigators have tried to break the tradition looking for other features, mostly morphological ones, to differentiate the individual species. Fresenius (l.c.) took notice in his day, both of the differences in the location of the septa in the conidia and of the formation of the conidial appendages in various species of genus Discosia. Evolving his theory, a century later, Morgan-Jones (l.c.) tried to differentiate 5 species (D. strobilina Lib., D. deflectens Sacc., D. inaequalis (Tehon & Stout) Morgan-Jones, D. violae (Tehon & Daniels) Morgan-Jones, D. pini Heald) from D. artocreas

on the basis of the conidial appendages' location.

The Indian investigators Subramanian & Chandra-Reddy (1974) have studied some specimens from that genus finding out a high degree of stability in such morphological features as the location of conidial septa and the exact place of formation of the conidial appendages. On those grounds, the above-mentioned authors have differentiated 7 species, dividing them into 4 groups. One important flaw in Subramanian & Chandra-Reddy's work is the extremely limited number of type specimens (just 5) they studied, which prevented them from taking any important taxonomic decisions.

Morgan-Jones (l.c.) and Sutton (1980) have suggested for Discosia's genus characterization and for the differentiation of the species to have in mind, first of all, the conidiogenesis and the morphology of the conidiogenous apparatus.

Notwithstanding some attempts at a new approach the species' differentiation within the limits of genus Discosia, no modern classification scheme of that genus has been elaborated so far, and, as Sutton (l.c.) says the question about the infrageneric structure of genus Discosia is still open.

A prime task, facing us when revising that genus taxonomically was to determine the species conception and to select the most appropriate taxonomic criteria.

As the base of the classification scheme we elaborated , we accepted the morphological principle to be the basic one, differentiating the infrageneric taxa predominantly on the basis both of the conidial morphology and the conidiogenous apparatus structure. Studying a huge number of specimens, originating from various parts of the world, we found out that the most constant features possessing a high taxonomic value are the following: the size, the shape and the colour of the conidia; the location of the conidial septa and appendages, together with the size and shape of the conidiogenous cells. Due to their variability, the morphological peculiarities

of the pycnidia are only of a tentative character.

The location of the conidial septa, determining the size of the conidial cells, is quite a characteristic morphological feature with a considerable taxonomic value. The conidia of all specimens we studied have 3 transverse septa each (only in D. poikilomera and D. baarnensis their number is 4), dividing them into 4 cells. In the process of the study, 3 types of location of the middle septum in the conidium werw found out: 1. Located at an equal distance from the 2 end septa, that leading to a relatively equal length of the 2 middle cells ($C_2=C_3$). 2. Located nearer to the apex, when the middle cell adjacent to the base of the conidium is longer than the middle cell adjacent to the apex ($C_2 > C_3$). 3. Located nearer to the base, when the middle cell adjacent to the apex of the conidium is longer than the other middle cell adjacent to the base ($C_2 < C_3$) .

A definite type of location of the middle conidial septum ischaracteristic for each of the studied specimens, that allowing for their allocation into 3 groups on the base of that feature. Greatest in number is the group of specimens with conidia of the second type, specimens with conidia of the third type being observed quite rarely.

Two types of formation of the conidial appendages were observed: 1. On the very margin of the conidium just next to the apex and to the base. 2. Considerably nearer to the middle of the conidium, next to the 2 end septa.

It is important from a taxonomic point of view, that one of the two types of formation of the conidial appendages is characteristic for each specimen, that allowing for allocation of the studied specimens into 2 groups on the base of that feature.

A characteristic peculiarity of the conidia of all specimens, belonging to genus Discosia, is their having a rounded apex and a truncate base, that eliminating all difficulties in defining the basal and the apical cells in the studied conidia.

Accepting Subramanian and Chandra-Reddy's idea how to group the taxa within the limits of the genus Discosia on the base of the location of the conidial septa and appendages, we delimited the following 6 sections:

Section I. DISCOSIA. Conidia quadricellularia; semper longior cellula media, vicina basis, quam cellula media, vicina apicis; appendices proxime apicem basimque conidii formantur.

Typus: Discosia artocreas (Tode) Fr.

The conidia 4-celled; the middle cell, adjacent to the base, always longer than the middle cell, adjacent to the apex; the appendages arising just next to the apex and to the base of the conidium (Fig. 1).

Section II. LAURINA Vanev, sect. nov. Conidia quadricellularia; duae cellulae mediae fere aequilongae; appendices proxime apicem basimque conidii formantur.

Typus: Discosia laurina Cald.

The conidia 4-celled; the two middle cells almost equal in length; the appendages arising just next to the apex and to the base of the conidium (Fig. 2).

Section III. CLYPEATA Vanev, sect. nov. Conidia quadricellularia; semper brevior cellula media, vicina basis, quam cellula media, vicina apicis; appendices proxime apicem basimque conidii formantur.

Typus: Discosia clypeata De Not.

The conidia 4-celled; the middle cell, adjacent to the base always shorter than the middle cell, adjacent to the apex; the appendages arising just next to the apex and to the base of the conidium (Fig. 3).

Section IV. LIBERTIA Vanev, sect. nov. Conidia quadricellularia; duae cellulae mediae fere aequilongae; appendices proxime duo septa extrema formantur.

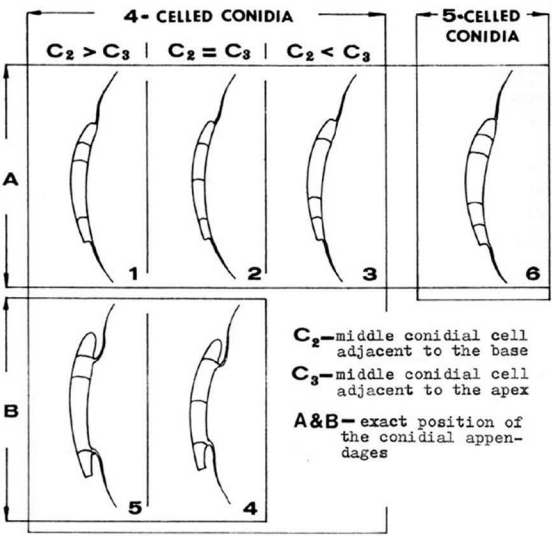
Typus: Discosia pyri Koschkelova

The conidia 4-celled; the two middle cells almost equal in length; the appendages arising next to the two end septa (Fig. 4).

Section V. STROBILINA Vanev, Sect. nov. Conidia quadricellularia; semper longior cellula media, vicina

basis, quam cellula media, vicina apicis; appendices proxime duo septa extrema formantur.

Typus: Discosia strobilina Lib.



Figs. 1-6. Sections of genus Discosia. 1. Section Discosia. 2. Section Laurina. 3. Section Clypeata. 4. Section Libertia. 5. Section Strobilina. 6. Section Poikilomera.

The conidia 4-celled; the middle cell, adjacent to the base, always longer than the middle cell, adjacent to the apex; the appendages arising next to the two end septa (Fig. 5).

Section VI. POIKILOMERA Vanev, sect. nov. Conidia quinquecellularia; cellula media semper longissima, quattuor cellulae reliquae fere aequilongae; appendices proxime apicem basimque conidii formantur.

Typus: Discosia poikilomera Fairman

The conidia 5-celled; the middle cell always the longest, the other 4 ones almost equal in length; the appendages arising just next to the apex and to the base of the conidium (Fig. 6).

The differentiation of the species within the limits of each section is made on the base of the differences in the morphology of the conidia and of the conidiogenous cells as well as the parasitism or the saprophytism of the species.

The comparative morphological studies we made on over 2500 herbarium specimens (among them more than 90% of the type and original materials from the taxa known up to now) we found out 31 good species, that must be referred to genus Discosia. Twenty-eight taxa were excluded from the genus, 9 others having an unidentified taxonomical status.

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STUDIES IN THE GENUS CLADOSPORIUM SENSU LATO. IV. CONCERNING CLADOSPORIUM OXYSPORUM, A PLURIVOROUS, PREDOMINANTLY SAPROPHYTIC SPECIES IN WARM CLIMATES

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ABSTRACT

Cladosporium oxysporum Berk. & Curt., a species occurring commonly in the tropics and subtropics on a wide range of herbaceous and woody substrates, is redescribed and illustrated from a number of collections, including its type. It has been isolated in culture and its characteristics *in vitro* are also reported upon.

INTRODUCTION

Cladosporium oxysporum Berk. & Curt. was first collected on dead leaves of a species of *Passiflora* L. in Cuba. The original description (Berkeley, 1868) reads as follows: "*C. oxysporum* B. & C. Soris pallidis olivaceis; floccis pallidis hic illic ramosis laevibus; sporis ex obovatis submetulaeformibus. On dead leaves of *Passiflora* L. Spores .0006-.0003 inch long."

The same brief description was repeated verbatim by Saccardo (1886), but conidium length was given as "7-14 µm longis". Although, according to Ellis (1971), the fungus is common and widespread in tropical regions on dead leaves and stems of herbaceous and woody plants, it remained inadequately characterized and described for over a century and there appear to have been few records of its occurrence. No mention was made of it by de Vries (1952) in his studies on the genus *Cladosporium* Link. Surprisingly, no records of it were reported by some hyphomycetologists collecting extensively in tropical or subtropical regions such as, for example, Subramanian (1971) and Matsushima (1971; 1975) [and the latter author's Matsushima Mycological Memoirs Nos. 1 through 6 (1980-1989)]. Both these authors encountered and described a number of *Cladosporium* species, but not *C. oxysporum*.

The fungus is generally regarded to be a saprophyte, although Fisher (1967) implicated it as the causal organism of a severe leaf-spot disease of young citrus trees at a nursery in Polk County, Florida. Five species of citrus showed symptoms: *Citrus aurantifolia* (L.) Swingle, *Citrus limon* (L.) N.L. Burm., *Citrus paradisi* Macfady, *Citrus reticulata* Blanco and *Citrus sinensis* (L.) Osbeck. Leaf spots were superficially similar to initial lesions on *Citrus*

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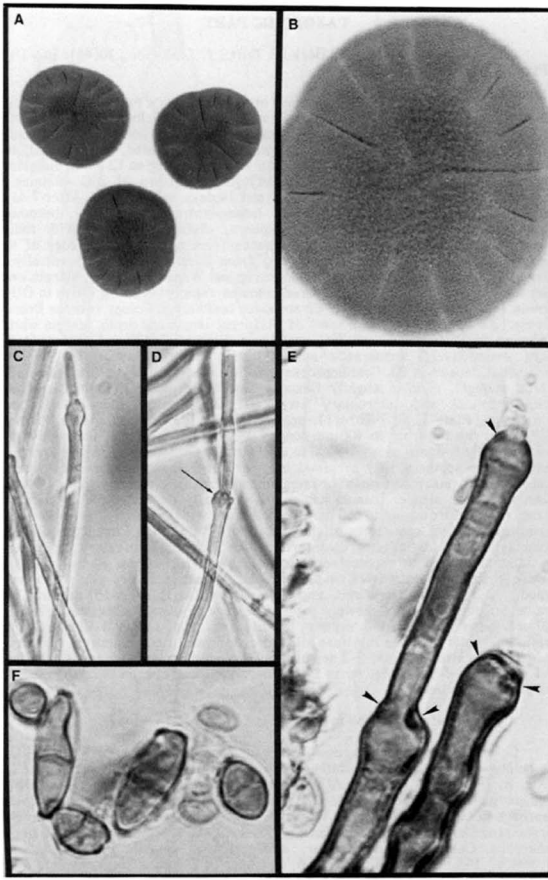
caused by *Cercospora citri-grisea* F.E. Fisher and *C. gigantea* F.E. Fisher, (Fisher, 1961). The latter species is the causal organism of tar spot. Conidiophores of *C. oxysporum* [identified at the then Commonwealth Mycological Institute by C. Booth] were found on necrotic tissue in tan to brown depressed areas bordered by a dark brown, slightly raised margin on the leaves. The fungus was not isolated *in vitro* and, since no inoculation experiments fulfilling Koch's postulates were conducted, it seems possible that *C. oxysporum* might have been a secondary invader on preexisting necrotic leaf spots. Judging by Fisher's account, however, this seems somewhat unlikely. No further report of this disease, to our knowledge, has been published; therefore, the role of *C. oxysporum* as a leaf-spot inducing fungus needs to be confirmed.

In the United States, during the past two decades, *C. oxysporum* has been reported from a number of different and diverse hosts, including *Alnus, Bambusa, Citrus, Helianthus* and *Pseudotsuga* (Farr *et al.* 1989). Sherwood and Carroll (1974) found the fungus growing on twigs of old-growth Douglas fir [*Pseudotsuga menziessii* (Mirb.) Franco] in Oregon during a study of fungal succession on needles and young twigs. Morgan-Jones (1977) reported its occurrence on leaves of *Bambusa* sp. in Alabama and Rossman and Lu (1980) reported isolating it from leaf surfaces of both red alder [*Alnus rubra* Bong.] and Douglas fir seedlings in western Oregon. Its occurrence in Oregon suggests that it might be more cosmopolitan in distribution than previously thought. Roberts *et al.* (1986), in a study of fungi occurring in achenes of sunflower [*Helianthus annuus* L.] from several production areas in Georgia, isolated *C. oxysporum* on one occasion from preharvest seed in a total sample of over twenty eight thousand seeds plated onto agar media. Other species of *Cladosporium* Link, particularly *C. cladosporioides* (Fres.) de Vries and *C. cucumerinum* Ellis & Arth., occurred at much higher frequencies. Although considered to be common, *C. oxysporum* may not be as ubiquitous as some other species of the genus *Cladosporium*.

Ellis (1971) provided a brief description of *C. oxysporum*, thereby making its characteristics, including its morphology, *in vivo* better known. No account of the fungus in culture was given except for mention of the fact that colonies on agar are cottony or loosely felted. It is interesting to note that all except one of the above cited records were published subsequent to Ellis' publication. It is assumed that the identifications made were correct. In our continuing efforts to provide modern, comprehensive accounts of *Cladosporium* species (Morgan-Jones and McKemy, 1990; McKemy and Morgan-Jones, 1990; 1991), including characteristics *in vitro*, a new description together with illustrations of *C. oxysporum* is published herein. These are based on several specimens from various localities, including its type from Cuba, and an isolate obtained from a partly decayed leaf of *Lespedeza bicolor* Turcz., collected in a greenhouse at Auburn University. Examination of the type has confirmed the interpretation of the species by Ellis (1971) to be accurate.

PLATE 1. *Cladosporium oxysporum*. A, 7-day-old colonies on PDA at 25C; B, enlargement of one of the same, illustrating surface texture; C, conidiophore from culture on PDA showing characteristic terminal extension above a fertile, swollen, conidiogenous portion; D, conidiophore from culture on PDA showing very slightly papillate conidiogenous loci (one indicated by arrow); E, macronematous conidiophores from nature showing darkened conidial scars (indicated by arrowheads); F, conidia from nature.


A
B
C
D
E
F

TAXONOMIC PART

Cladosporium oxysporum Berk. & Curt., *J. Linn. Soc.*, 10(46): 362, 1868 (Plate 1, Figures 1 and 2).

Colonies in nature effuse, greyish brown, somewhat thin, hairy. Mycelium mostly immersed in the host tissue, composed of branched, septate, smooth, subhyaline to pale-brown hyphae, 3-4 µm wide. In older colonies, hyphal cells often becoming variously inflated, somewhat more pigmented, thick-walled, and occasionally assuming chlamydospore-like morphology, up to 12 µm in diameter. Colonies on potato dextrose agar (PDA) [Difco] grown at 25C attaining a diameter of 25 mm and 55 mm after 7 and 14 days, respectively. After 7 days (Plate 1, A & B), colonies densely lanose toward the center, becoming progressively velvety toward the periphery, distinctly sulcate, with radial furrows extending outward various distances from near or at the edge of the central lanose portion, coloration varying from Dark Green [30F5] centrally to Greenish Grey [30E2] peripherally (Kornerup and Wanscher, 1978), margin even and whitish. After 8 or 9 days, same colonies rapidly becoming Olive to Olive Green [1F6 to 2F6] as a result of abundant conidiation. Colony reverse Bronze Green [30F3] with radial furrows of different length and depth, margin white. Colonies on PDA at 20C and 30C attaining a diameter of 22 and 10 mm after 7 days, respectively; appearance and coloration similar to those at 25C, but somewhat denser at 30. Conidiophores in nature macronematous, mononematous, erect, straight, rigid to slightly flexuous, smooth, cylindrical, distinctly nodose, with terminal and intercalary swellings, thick-walled, cicatrized, scars prominent (Plate 1, E; Figure 1), septate, rarely branched, mid to pale brown, bulbous at the base, up to 400 µm long X 4-5 µm wide, up to 10 µm wide at the base, usually 6-8 µm; nodes 6-9 µm in diameter. In the terminal, fertile portions, conidiophore septae mostly proximal to, above or below, the nodes. In culture, conidiophores macronematous or semi-macronematous, mononematous, mostly flexuous, more slender than in nature and generally thinner-walled, pale olive green to light brown, up to 650 µm long X 4-5 µm wide, nodes 5-6 µm wide, with conidiogenous loci sometimes slightly papillate (Plate 1, D). Conidiogenous cells holoblastic, polyblastic, integrated, terminal but becoming intercalary, sympodial. Conidiation limited to successively produced swollen portions. Ramo-conidia in nature cylindrical to clavate or ampulliform, sometimes very slightly curved, smooth, 0-3 septate, cicatrized, mid to pale brown, up to 25 (6-15) µm long, 5-6 µm wide, occasionally somewhat papillate at one or more conidiogenous loci; in culture, paler in color, 0-1 septate, up to 30 µm long, mostly 8-12 µm, 4-5 µm wide. Intercalary conidia in nature ellipsoidal to limoniform, oblong or fusiform, pale olive brown, smooth, 0-2 septate, 3-8 µm wide, up to 20 µm long; in culture 0-1 septate, 3-5 µm wide, up to 15 µm long. Terminal conidia globose to mostly subglobose, 3-5 µm.

Plurivorous; widespread in tropical and subtropical regions.

Collections examined: on dead leaves of *Passiflora*, Cuba, C. Wright (489), K, holotype; on pods of *Adenanthera pavonina* L., Boyama, Cuba, November 13, 1967, R. Urtiago, IMI 130161, AUA; isolated ex *Arachis hypogeae* L., Lundhiana, Punjab, India, September 7, 1968, J.S. Chohan, IMI 134246, AUA; on *Triticum aestivum* L. [as *T. vulgare* Vill.], from El Salvador, intercepted at San Francisco, California, U.S.A., January 12, 1973, BPI 427305, AUA; on *Ullucus tuberosus* Caldas, from Ecuador, intercepted at Miami, Florida, U.S.A., December 14, 1975, BPI 427306, AUA; on leaves of *Bambusa* sp., Chewacla State

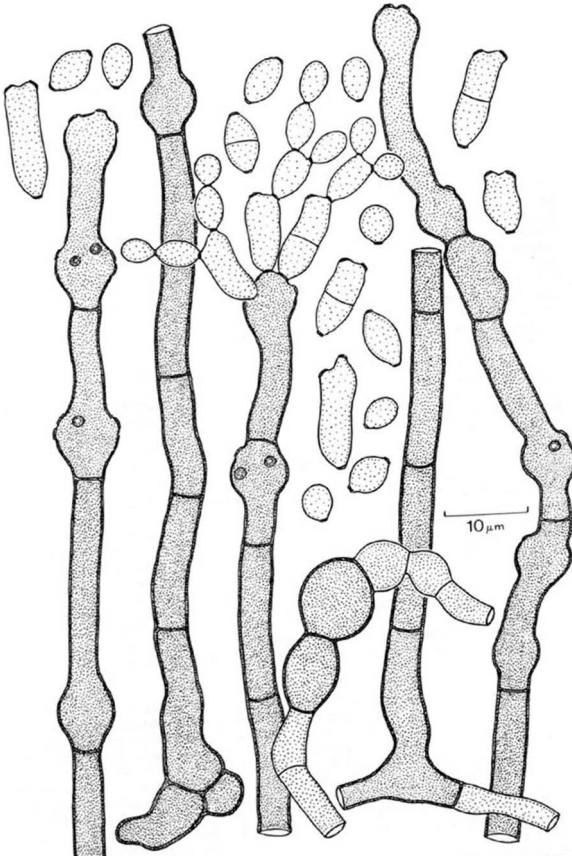


FIGURE 1. *Cladosporium oxysporum*. Conidiophores, conidia and swollen chlamydospore-like cells from nature.

Park, Lee Co., Alabama, U.S.A., April 1976, G.W. Karr, Jr., AUA; on dead leaves of *Quercus* sp., Pienaar's River Bank, Pretoria, South Africa, April 3, 1979, R.C. Sinclair, AUA; on a partly decayed leaf of *Lespedeza bicolor*, Auburn University, Lee Co., Alabama, U.S.A., March 1990, J.M. McKemy, AUA [Isolate derived from this collection has been deposited at ATCC.]

DISCUSSION

The intermittently determinate conidiophores of *C. oxysporum* are, together with those of *C. colocasiae* Sawada, unique in the genus *Cladosporium*. These two species are, in fact, closely similar, differing mainly in the latter having wider, thicker-walled, darker, more septate conidia that are often broader toward each end than in the middle. Conidia of *C. colocasiae* also bear distinctly protuberant scars and its conidiophores are, generally, somewhat more robust than those of *C. oxysporum*. In addition, it is host-specific to *Colocasia* spp., causing round or irregular, brown, necrotic leaf-spots. The morphological differences between *C. colocasiae* and *C. oxysporum* are akin, and similar in degree, to those distinguishing *C. herbarum* (Pers.) Link, the lectotype species of the genus, and *C. macrocarpum* Preuss, two entities considered to be conspecific by some (e.g. Barr, 1958), but kept separate by others (e.g. de Vries, 1952; Ellis, 1971). *Cladosporium herbarum* is the anamorph of *Mycosphaerella tassiana* (de Not.) Johans. (von Arx, 1950, 1983; Barr, 1958; Corlett, 1988). Barr (1958) believed the binomials *C. herbarum* and *C. macrocarpum* to be based on a variable anamorph and Corlett (1988) found an anamorph closer to *C. macrocarpum* than *C. herbarum* in association with the teleomorph *M. tassiana*.

During the process of conidiogenesis in *C. colocasiae* and *C. oxysporum*, as a prelude to conidiation, conidiophores become temporarily determinate. That is, linear apical growth ceases. The conidiophores swell appreciably at the extreme apex and a sequence of usually one to four or, more rarely five, ramo-conidia are formed in close proximity to one another at the surface of the inflated portion. Following such conidiation, apical meristematic terminal growth resumes giving rise, initially, to a narrow, hypha-like extension above the fertile node (see Plate 1, C; Figure 2). This grows to varying lengths, depending upon growing conditions, and eventually assumes the morphology of the subtending portion of the conidiophore. The extended distal portion usually becomes separated from the node below by a transverse septum and then ceases growth. Terminal swelling and conidiation then ensue at the higher level and the sequence of events is repeated a number of times to give rise to the characteristically nodose morphology.

The morphology of *C. oxysporum*, as is the case in many other species of *Cladosporium*, varies somewhat depending upon growth conditions. Appreciable differences occur in morphology of conidiophores in nature as compared to that of those produced *in vitro* on agar media. *In vivo*, the conidiophores tend to be shorter, more robust and pigmented, and thicker-walled than in culture. Also, the swellings along the conidiophore are usually closer together and more numerous in nature than *in vitro*. In fact, some conidiophores produced in nature are closely nodose along much of their length. Close spacial succession of fertile, intercalary nodes probably reflects lower nutrient availability and lower humidity levels in nature as opposed to in culture. Ramo- and intercalary conidia are generally septate in nature, whereas *in vitro* ramo-conidia are rarely septate and intercalary conidia are almost invariably non-septate. *Cladosporium*

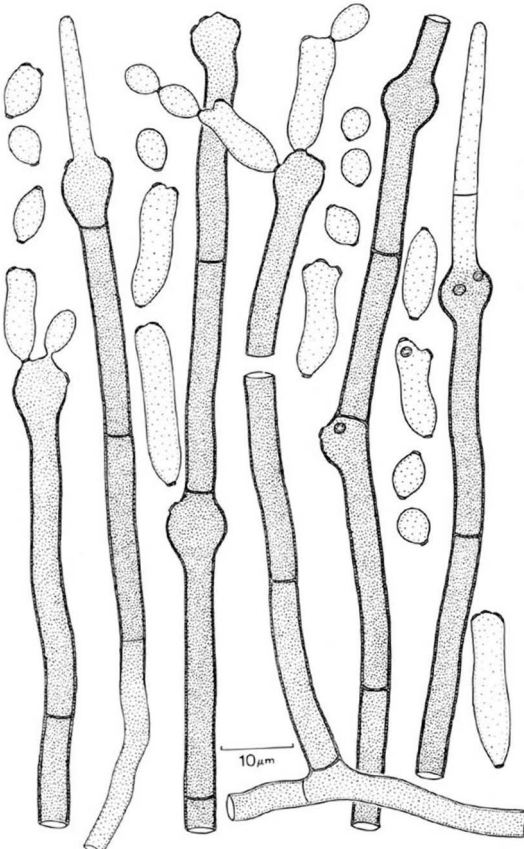


FIGURE 2. *Cladosporium oxysporum in vitro*. Conidiophores and conidia from culture.

oxysporum bears some resemblance to *C. chlorocephalum* (Fres.) Mason & M.B. Ellis, *C. geniculatum* Morgan-Jones and *C. sphaerospermum* Penz. with respect to morphology and, particularly, shape of its terminal conidia. These four species possess subglobose to globose terminal conidia. *Cladosporium geniculatum* differs from the other species in having larger, more pigmented conidia. Those of *C. sphaerospermum* are verrucose (Ellis, 1971), whereas the conidia of *C. oxysporum* are smooth. Apart from these differences, the taxa can be easily distinguished by the morphology of their conidiophores. The *Periconia*-like macroconidiophores of *C. chlorocephalum* are very distinctive (see McKemy and Morgan-Jones, 1991), as are the geniculate ones of *C. geniculatum* (see Morgan-Jones and Jacobsen, 1988). The frequently long, narrow ramo-conidia of *C. sphaerospermum* also serve to distinguish that species, and its conidiophores are usually appreciably shorter than those of *C. oxysporum*.

Cladosporium oxysporum colony morphology and coloration vary very little at different growth temperatures. When grown on PDA at 25C colony coloration changes abruptly after seven days as a result of the advent of prolific conidiation.

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COMPUTER CODING OF STRAIN FEATURES OF THE SAPROLEGNIAN FUNGI

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ABSTRACT

Saprolegnian fungi are the best known and most widely distributed of the water molds and are important in systematic, ecological, physiological, and biochemical research and teaching. A coding system that was developed for computer storage and analysis of microbial strain data has been expanded to include strain features specifically applicable to the identification of saprolegnian fungi.

BACKGROUND AND DISCUSSION

There are three basic types of living things in our environment from the point of view of ecological relationships: producers, consumers, and decomposers. The producers have chlorophyll or chemosynthetic pigments that, along with sunlight, are used to manufacture organic substances from inorganic materials thereby providing for the needs of the other groups. The consumers digest the organic substances provided by the producers and discard the indigestible materials. The decomposers destroy the products from the activities of both producers and consumers and ensure the return of the original inorganic elements into the cycle of matter, enabling the producers to again produce new organic substances.

Fungi depend on the elaborated organic substances as food sources and reduce them to the inorganic elements;

therefore, they are decomposers or scavengers. They are abundant everywhere decaying organic substances are found. The principal reservoirs of fungus populations in nature are water and soil. It has long been recognized that the most primitive fungi probably evolved in water. As their morphology and nutritional requirements became more complex, they migrated into the soil where their natural habitats diversified. Some of these soil fungi appear to have returned to the water in response to availability of nutrients in polluted and sewage waters (Sparrow, 1960).

The best known and most widely distributed water molds are members of the saprolegnian fungi. Most of them will grow readily in pure culture. Investigations of populations of saprolegnian fungi in natural environments involve the isolation, characterization, and identification of large numbers of strains (Coker, 1923). Data associated with these strains are of importance to systematic, ecological, physiological, and biochemical research and teaching. The needs for computerizing these data are now well recognized by both scientific and industrial communities.

Genera of saprolegnian fungi are distinguished by their asexual reproductive apparatus. Features of zoosporangium production and mode of zoospore release are also important for delimiting the genera. Species are distinguished primarily by their sexual reproductive organs (Dick, 1969, 1973; Johnson, 1956; Scott, 1961; Seymour, 1970). However, species of the saprolegnian fungi are often difficult to identify. There is a great need for a protocol that combines all previously described features that have been found to be important in the identification of saprolegnian fungi to species level.

The Microbial Information System (MICRO-IS) is a comprehensive system of computer programs for storage, management, and analysis of data on microbial strains (Krichevsky, 1987). MICRO-IS has been used by the staff of the American Type Culture Collection (ATCC) in collaborative efforts with other microbiologists to share information resources. MICRO-IS enables the investigator to enter data on a new strain and use the computer to aid identification by use of probability calculations. The identification program analyzes a matrix of the frequency of occurrence of each feature within each taxon to find the "best fit". Even when computer analysis does not give a positive identification, the results reduce the number of

species that have to be considered and may suggest additional tests that can be performed to improve the identification. If multiple organisms are indicated, research into specific literature may be needed. This is less time consuming and more accurate than doing the whole process manually.

Features of individual strains are encoded for MICRO-IS using the RKC Coding system. The RKC Code (after the original authors -- Rogosa, Krichevsky, and Colwell, 1971) is a statement-oriented controlled vocabulary of descriptors of strain features in which an unique six-digit code number is assigned to each feature of an individual microbial strain. The Code currently includes more than 12,000 features descriptive of bacteria, algae, protozoa and some fungi (Rogosa *et al.*, 1971; von Valkenburg *et al.*, 1977, Daggett *et al.*, 1980; Philpot *et al.*, 1982). The expanded and revised RKC Code is now available in book form (Rogosa *et al.*, 1986). Recently, the Code was further expanded to include characteristics of yeasts and the fungal genus *Phytophthora* (Jong *et al.*, 1988, 1989).

In this communication, we present a set of characteristics that have been developed for use in identification of saprolegnian fungi. New features added to the RKC Code specifically for the saprolegnian fungi are marked with an "*" in the list below. The features include both the qualitative morphologic characters and the size of vegetative hyphae, zoosporangia, zoospores, chlamydospores, oogonia, oospores, and antheridia as well as the presence and relative abundance of these structures. The terms used for morphological descriptors are based on the descriptions given in Hawksworth *et al.* (1983).

ASEXUAL REPRODUCTION

- **Sporangia**

008173: Asexual spores (sporangiospores) are produced in sporangia (spore vesicles).
008539: Sporangia are on sporophores (sporangiophores).
008566: Sporangia occur singly.
008567: Sporangia occur in clusters.
008568: Sporangia occur in rows.
008569: Sporangia are produced acropetally.
008570: Sporangia are produced laterally.

008779: Sporangia are produced on agar medium.
008780: Sporangia are produced evenly on agar medium.
008781: Sporangia are produced in water.
008782: Sporangia are produced in liquid growth medium.
008809: Sporangia proliferate internally.
008810: Sporangia proliferate externally.
008811: Sporangia are terminal.
008812: Sporangia are intercalary.
008800: Sporangia have papillae.
008801: Sporangium has one papilla.
008802: Sporangium has two papillae.
008803: Sporangium has three papillae.
008826: Sporangia have appendages.
008549: Sporangia are apiculate.
008551: Sporangia are clavate (club-shaped).
008552: Sporangia are cylindrical.
008554: Sporangia are fusiform.
008558: Sporangia are spherical (length to breadth ratio is 1.0-1.05).
008966: Sporangia are broadly ellipsoidal (length to breadth ratio is 1.16-1.30).
008774: Sporangia are ellipsoidal (length to breadth ratio is 1.31-1.6).
008773: Sporangia are ovoid (egg-shaped, attached at broad end).
008816: Sporangia are obovoid (egg-shaped, attached at narrow end).
008818: Sporangia are pyriform (pear-shaped, attached at narrow end).
008819: Sporangia are obpyriform (pear-shaped, attached at broad end).
008817: Sporangia are limoniform (lemon-shaped, citriform).
008557: Sporangia are pod-like.
008555: Sporangia are irregular in shape.
008828: Sporangia are hyaline.
008563: Sporangial walls are smooth.

- Sporangial Dimensions

008571: Sporangia are 1.0-2.0 μ long.
008572: Sporangia are 2.1-5.0 μ long.
008573: Sporangia are 5.1-10 μ long.
008574: Sporangia are 11-15 μ long.
008575: Sporangia are 16-20 μ long.
008576: Sporangia are 21-30 μ long.
* 008981: Sporangia are 31-40 μ long.

* 008982: Sporangia are 41-50 μ long.
  008838: Sporangia are 51-60 μ long.
  008839: Sporangia are 61-70 μ long.
  008840: Sporangia are 71-80 μ long.
  008841: Sporangia are 81-90 μ long.
  008842: Sporangia are 91-100 μ long.
  008843: Sporangia are > 100 μ long.
  008578: Sporangia are 1.0-2.0 μ wide.
  008579: Sporangia are 2.1-3.0 μ wide.
  008580: Sporangia are 3.1-4.0 μ wide.
  008581: Sporangia are 4.1-5.0 μ wide.
  008582: Sporangia are 5.1-10 μ wide.
  008583: Sporangia are 11-15 μ wide.
  008584: Sporangia are 16-20 μ wide.
  008585: Sporangia are 21-30 μ wide.
  008844: Length to breadth ratio of sporangium is < 1.6.
  008845: Length to breadth ratio of sporangium is 1.6-1.9.
  008846: Length to breadth ratio of sporangium is > 1.9.

- **Sporangial Exit Pore Dimensions**

  008847: Exit pores of sporangia are 5-7 μ wide.
  008848: Exit pores of sporangia are 8-10 μ wide.
  008849: Exit pores of sporangia are > 10 μ wide.
  008850: Length to breadth ratio of exit pore is < 0.2.
  008851: Length to breadth ratio of exit pore is 0.2-0.3.
  008852: Length to breadth ratio of exit pore is > 0.3.

- **Zoospores**

  008752: Zoospores (motile spores) are produced.
  008607: Zoospores are spherical.
  008608: Zoospores are cylindrical.
  008609: Zoospores are 0.1-1.0 μ long.
  008610: Zoospores are 1.1-2.0 μ long.
  008611: Zoospores are 2.1-3.0 μ long.
  008612: Zoospores are 3.1-4.0 μ long.
  008613: Zoospores are 4.1-5.0 μ long.
  008614: Zoospores are 0.1-1.0 μ wide.
  008615: Zoospores are 1.1-2.0 μ wide.
  008616: Zoospores are 2.1-3.0 μ wide.
* 008983: Zoospores are monoplanetic (monomorphic; only one type of zoospore (primary zoospores) produced and only one swarm period occurs).

* 008984: Zoospores are diplanetic (dimorphic; two types of morphologically distinct zoospores (primary and secondary zoospores) produced at separate stages (swarm periods)).
* 008985: Zoospores are polyplanetic (secondary zoospores undergo repeated cycles of encystment and excystment).
* 008986: Zoospores are formed in a single row in the sporangium.
* 008987: Zoospores are formed in a single row in the evacuation tube.
* 008988: Zoospores germinate within sporangia by germ tubes which penetrate sporangial walls.
  008194: Sporangial walls are loose and clearly separated from spores.
  008853: Zoospores of sporangia are released.
  008858: Sporangia collapse after zoospore release.
  008859: Sporangia collapse partially after zoospore release.
  008854: Zoospores of sporangia are released naked (unencysted).
* 008989: Zoospores encyst after release from sporangia.
* 008990: Zoospores encyst within sporangium.
* 008991: Zoospores encyst at mouth of sporangium.
  008860: Zoospores emerge repeatedly from cysts.
* 008992: Zoospores emerge separately from cysts, leaving nets of empty cysts.

- Zoospore Flagellation

* 013381: Zoospores have flagella.
* 013382: Zoospores are biflagellate.
  013018: Flagellum (or flagella) is inserted frankly laterally (from middle of cell).
* 013383: Insertion of flagellum (or flagella) is anterior (end that leads while swimming).
  013352: Insertion of flagellum (or flagella) is posterior (end that trails while swimming).
* 013384: Whiplash flagella (lacking obvious scales or mastigonemes) are produced.
* 013385: Tinsel flagella (bearing mastigonemes) are produced.
* 013386: Anterior flagella are of whiplash type.
* 013387: Anterior flagella are of tinsel type.
* 013388: Posterior flagella are of whiplash type.
* 013389: Posterior flagella are of tinsel type.

* 013390: Lateral flagella are of whiplash type.
* 013391: Lateral flagella are of tinsel type.

- **Chlamydospores**

  008363: Chlamydospores are present.
  008421: Chlamydospores are terminal.
  008422: Chlamydospores are intercalary.
* 008993: Chlamydospores occur singly.
* 008994: Chlamydospores are catenulate (in chains).
* 008995: Chlamydospores are filiform (thread-like).
* 008996: Chlamydospores are spherical.
* 008997: Chlamydospores are clavate (club-shaped).
* 008998: Chlamydospores germinate to produce hyphae.
* 008999: Chlamydospores germinate to produce short-stalked zoosporangia.

SEXUAL REPRODUCTION

  008617: Sexual reproduction occurs.
  008618: Strain is homothallic (both mating types on same mycelium).
  008619: Strain is heterothallic (mating types on separate mycelia).
  008620: Gametangia are formed.
  008621: Gametangia are morphologically similar to vegetative hyphae (no sexual differentiation).
  008622: Male gametangia are produced.
  008623: Male gametes are produced.
  008625: Female gametangia are produced.
  008626: Female gametes are produced.
* 043001: Male and female gametangia are morphologically distinct.

- **Antheridia**

  008880: Antheridia are present.
* 043002: Antheridia are androgynous (on same hypha as oogonium).
* 043003: Antheridia are hypogynous (directly under oogonium on same hypha).
* 043004: Antheridia are exigynous (arise directly from oogonial cell).
* 043005: Antheridia are monoclinous (on oogonial stalk).

* 043006: Antheridia are diclinous (not on same hypha as oogonium).
* 043007: Antheridia are laterally appressed to oogonial walls.
* 043008: Antheridia are apically appressed to oogonial walls.
* 043009: Antheridia are attached to oogonial wall by finger-like projections.
  008890: Antheridia twist around oogonial stalks.
  008891: Antheridia are hidden in knots of hyphae.
  008895: Antheridia are unicellular.
  008886: Antheridia are inflated.
  008887: Antheridia are contorted.
  008888: Antheridia are lobed.
  008889: Antheridia are branched.
  008897: Antheridia are clavate (club-shaped).
  008898: Antheridia are prolate spheroidal (length to breadth ratio is 1.06-1.15).
* 043010: Antheridia are tubular.
  008892: Antheridia are < 12 μ long.
  008893: Antheridia are 12-20 μ long.
  008894: Antheridia are > 20 μ long.
  008896: Antheridia are < 20 μ long.

- **Oogonia**

  008899: Oogonia are present.
  008912: Oogonia are observed in intraspecific pairings.
  008913: Oogonia are observed in interspecific pairings.
  008900: Oogonia occur singly.
  008901: Oogonia are clustered around common point of origin.
  008903: Oogonium has two antheridia.
  008904: Oogonium has three antheridia.
  008905: Surfaces of oogonia are smooth.
  008906: Surfaces of oogonia are reticulate.
  008907: Surfaces of oogonia are verrucose.
  008908: Surfaces of oogonia are bullate.
  008909: Surfaces of oogonia are wrinkled.
  008910: Surfaces of oogonia are undulate.
* 043011: Surfaces of oogonia are pitted.
* 043012: Surfaces of oogonia are papillate.
* 043013: Surfaces of oogonia are spiny.
* 043014: Surfaces of oogonia are crenulate.
* 043015: Oogonia are thick-walled.
  008911: Oogonia walls are unevenly thickened.
  008902: Oogonia are pigmented.

008915: Oogonia are spherical (length to breadth ratio is 1.0-1.05).
* 043016: Oogonia are prolate spheroidal (length to breadth ratio is 1.06-1.15).
* 043017: Oogonia are broadly ellipsoidal (length to breadth ratio is 1.16-1.30).
* 043018: Oogonia are ellipsoidal (length to breadth ratio is 1.31-1.6).
* 043019: Oogonia are ovoid (egg-shaped, attached at broad end).
* 043020: Oogonia are obovoid (egg-shaped, attached at narrow end).
008914: Oogonia are pyriform (pear-shaped, attached at narrow end).
* 043021: Oogonia are doliform (barrel-shaped).
* 043022: Oogonia are navicular (boat-shaped; spindle-shaped with one end truncated).
* 043023: Oogonia are fusiform.
* 043024: Oogonia are apiculate.
* 043025: Oogonia are filiform (thread-like).
008916: Oogonia are < 35 μ in diameter.
008917: Oogonia are 35-45 μ in diameter.
008918: Oogonia are > 45 μ in diameter.
008919: Oogonia are < 40 μ in diameter.
008920: Oogonia are 40-60 μ in diameter.
008921: Oogonia are > 60 μ in diameter.

- **Oospores**

* 043026: Oospores are present.
* 043027: Oogonium has one oospore.
008922: Oospores are plerotic.
008923: Oospores are < 21 μ in diameter.
008924: Oospores are 21-30 μ in diameter.
008925: Oospores are 31-40 μ in diameter.
008926: Oospores are 41-50 μ in diameter.
008927: Oospores are > 50 μ in diameter.
* 043028: Oospores are centric (with one or two peripheral layers of small oil droplets completely surrounding the central ooplasm).
* 043029: Oospores are eccentric (with one large oil globule disposed on one side of the oospore and not entirely enclosed by the ooplasm).
* 043030: Oospores are subcentric Type I (with one layer of small oil droplets on one side of the ooplasm and two or three layers on the opposing side).

* 043031: Oospores are subcentric Type II (with two or three layers of small oil droplets on one side of the ooplasm).
* 043032: Oospores are subcentric Type III (with a single, circular layer of small oil droplets located eccentrically to the oospore wall).
* 043033: Oospores germinate to produce hyphae.
* 043034: Oospores germinate to produce germ hyphae terminated by zoosporangia.
* 043035: Oospores are formed parthenogenetically.

SOURCE OF ISOLATION AND PATHOGENICITY

002012: What was the specific source of isolation (e.g., kind of water, soil, etc., species and organ and tissue of plant, animal, etc.)?
016426: Strain is parasitic.
016093: Strain has not been cultivated free of living host cells (obligate parasite).

NOTE: Parasitism or pathogenicity must be demonstrated by direct test, NOT source of isolation.

* 039140: Strain is parasitic on animals.
* 039141: Strain is parasitic on fish.
* 039142: Strain is parasitic on amphibians.
* 039143: Strain is parasitic on roots of higher plants.
* 039144: Strain is parasitic on diatoms.
* 039145: Strain is parasitic on Phycomycetes.
* 039146: Strain is parasitic on marine algae.

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NOTES ON AND ADDITIONS TO NORTH AMERICAN MEMBERS OF THE HERPOTRICHIELLACEAE

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SUMMARY

A brief discussion of the value of ascospore septation and of octospory and polyspory of asci results in the genera *Acanthostigmella* and *Capronia* being accepted in the Herpotrichiellaceae. North American representatives of *Capronia* include eight new species: *C. apiculata*, *C. arctica*, *C. borealis*, *C. dryadis*, *C. epimyces*, *C. exigua*, *C. montana*, *C. populicola*. The new combinations *C. chlorospora* (Ellis & Everh.) Barr, *C. collapsa* (Mathiassen) Barr, *C. commonsii* (Ellis & Everh.) Barr, *C. episphaeria* (Peck) Barr, *C. minima* (Ellis & Everh.) Barr, *C. nigerrima* (Bloxam) Barr, *C. porothelia* (Berk. & Curtis) Barr are proposed. A dichotomous key is presented to aid in identification of species in *Capronia*.

The Herpotrichiellaceae is a family that is known by small sizes of superficial ascomata that usually bear short setae or protruding cells over the surface and often have a grayish brown or olivaceous peridium. The ostioles are usually periphysate and the upper part of the centrum is lined with short, downhanging periphysoids. Aparaphysate asci are oblong to saccate, often thickened at the apex, octosporous or polysporous. The ascospores are hyaline at first and usually become light dull brown, olivaceous brown or grayish brown; they may be one or several septate, with longitudinal septa formed at times.

Munk (1953) erected the family and (1957) accepted five genera: *Herpotrichiella*, *Didymotrichiella*, *Dictyotrichiella*, *Capronia*, *Berlesiella*. Barr (in Bigelow and Barr 1969) accepted *Berlesiella*, in 1972 recognized *Herpotrichiella* and *Capronia* and added *Polytrichiella* and in 1977 included *Acanthostigmella*. Luttrell (1973) suggested that *Berlesiella* and *Dictyotrichiella* should be united under *Capronia*. Von Arx and Müller (1975) accepted five genera also: *Herpotrichiella*, *Polytrichiella*,

Berlesiella, *Dictyotrichiella*, *Capronia*. The genera proposed over the years, with their type species and distinguishing characteristics are summarized below.

Capronia sexdecemspora (Cooke) Sacc. has separate ascomata, polysporous asci and hyaline muriform ascospores.
Berlesiella nigerrima (Bloxam) Sacc. forms a basal stroma beneath gregarious ascomata that may form as locules in the stroma, octosporous asci and brown muriform ascospores.
Caproniella juniperi (Richon) Berlese was segregated for *Capronia*-like species with brown ascospores; the genus was not utilized since.
Acanthostigmella genuflexa v. Höhnel has pallid ascomata, setae and ascospores, octosporous asci and transversely septate ascospores.
Herpotrichiella moravica Petrak has separate ascomata, octosporous asci and brown transversely septate ascospores.
Didymotrichiella inconspicua Munk has separate ascomata, octosporous asci and oblong brown one-septate ascospores.
Dictyotrichiella pulcherrima Munk has separate ascomata, octosporous asci and brown, muriform ascospores.
Polytrichiella polyspora Barr has separate ascomata, polysporous asci and hyaline to brownish, transversely septate ascospores; species with scolecospores have been included.

Müller et al. (1987) discussed the criteria used and accepted only two genera, *Acanthostigmella and Capronia*. Barr (1987b) preferred to recognize five genera according to ascospore septation and octo- or polysporous asci. She recognized that separate, gregarious ascomata, ascomata grouped on a stromatic basal layer, and locules in stromatic tissues are specific rather than generic characteristics in this family as in others, for example some species of *Mycosphaerella*, and placed *Dictyotrichiella* as a synonym of *Berlesiella*. O. Eriksson and Hawksworth (1990) followed Müller et al. to accept only *Acanthostigmella* and *Capronia*. They included too *the extralimital Berkelella* and questionably *Pleomelogramma* and *Taphrophila* in the family. For the last-named, judging by the description and especially by setae whose apices are branched, *T. cornu-capreoli* Scheuer (Scheuer 1988) seems likely to be a member of the Dimeraceae rather than the Herpotrichiellaceae.

Different ascospore shapes and septation are features that are considered to be valid in a number of loculoascomycete families. Within the Herpotrichiellaceae, ascospores may be wide, broadly obovoid, oblong or ellipsoid, and form three or more transverse septa and usually one or more longitudinal septa in several cells. They may be narrow, obovoid, fusoid, oblong or cylindric, and form one

to several transverse septa, at times a longitudinal septum in one or few cells. Because of the variability in septation within single collections of a species, this character cannot be the sole one used to separate genera in this family. Should future studies on anamorphs (Müller et al. 1987) offer additional separating characters, some genera whose species have particular ascospore shapes and septation may again be recognized.

The issue of octospory versus polyspory as a generic character requires more consideration. The great majority of ascomycetous fungi produce eight ascospores per ascus, the result of meiosis followed by mitotic division to provide eight nuclei around which ascospore initials form. Later nuclear divisions are usual within the developing ascospore. In a number of taxa, apparently no mitotic division takes place before initials are delimited, or one or more of the initials may abort, so that asci may contain one, two, four or more but less than eight mature ascospores. Such a situation evidently is genetically fixed in some taxa and is regarded as an integral part of the organism, e.g. in all of the Meliolaceae, in some of the Erysiphaceae. In taxa where other characteristics are in accord, specific rank may be given to those that have less than eight ascospores, e.g. in some species of *Gnomonia*. In other taxa, more than eight ascospores may develop, polyspory.

Polyspory occurs in different groups of ascomycetous fungi. One concern of systematists is the value assigned to this character state: Is it of generic or of specific importance? First, a precise definition is required. Apparent polyspory may be the result of different processes. The production within the ascus by budding of primary ascospores may result in secondary spores, conidia, ultimate cells, at times formed from intermediate cells as in species of *Tympanis* (Helotiales) (Ouellette and Pirozynski 1974). Other taxa in the Helotiales may become polysporous by budding, such as species of *Ascocoryne* (Christiansen 1963, Dennis 1956), *Claussenomyces* (Korf and Abawi 1971, Ouellette and Pirozynski 1974), *Rutstroemia* (Dennis 1978); octosporous species are also known in each genus. Several species of *Nectria* (Hypocreales) have polysporous asci following budding of the primary ascospores; *Scoleconectria and Thyronectria* have been separated for this reason (e.g. Booth 1959), but Rossman (1989) replaced these species into *Nectria*. *Rhamphoria pyriformis* (Fr.) v. Höhnel (Xylariales) frequently buds from ascospores (Müller and Samuels 1982). In all of these cases, apparent polyspory may be utilized at the species but not the generic level.

Apparent polyspory may also occur by disarticulation of septate ascospores within the ascus, which results in

the formation of sixteen to many partspores. In the Hypocreales, *Hypocrea*, *Podostroma*, *Trichosphaerella* are partially defined by the separation of one-septate ascospores into 16 partspores, as is the case of *Melanopsammella* in the Sordariales. In several taxa with elongate, multiseptate ascospores, these may disarticulate within the ascus, e.g. in *Mycomedusiospora* (Sordariales), *Torrubiella*, *Dussiella*, *Hyriogenospora*, some species of *Cordyceps*, (Clavicipitales). In none is this the sole criterion for generic separation, although it may be one of the criteria. Among Loculoascomycetes, *Westerdykella* and some species of *Preussia* (Pleosporales) have three-septate, disarticulating ascospores, part of the constellation of characters that defines a genus or species.

True polyspory, where additional mitosis or mitoses give rise to 16 or more ascospore initials and eventually mature ascospores, is where most of the problems lie. The classical polysporous genera of the Diatrypaceae, *Diatrypella and Cryptovalsa*, are generally accepted for species whose stromata, ascoma configuration, and anamorphs are similar to those of *Diatrype and Eutypa* respectively (see e.g., Glawe and Rogers 1984, Rappaz 1987). The specialists in these organisms are invited to determine if such separation is logical. Similarly, *Valsella* (Diaporthales) is usually accepted as the polysporous counterpart of *Leucostoma*, although Müller and von Arx (1973) synonymized the two, following Petrak (1923, 1940). Petrak had argued, not only that species in *Valsella* had counterparts in *Leucostoma*, but that these should be regarded as polysporous forms of the respective species. Kern (1957) and Hubbes (1960) reported that polyspory was a constant character in the specimens that they examined and cultured, that is that it was at least a character of specific value.

In several other nonlichenized Hymenoascomycetes, polyspory is accepted as of specific value in genera that may have octosporous representatives as well, or may have only polysporous representatives, as in the Pezizales, *Thecotheus* and the genera of the Theleboleae (Kimbrough 1966, Kimbrough and Korf 1967, Cain and Kimbrough 1969, Bezzerra and Kimbrough 1975). Sordariaceous genera such as *Arnium*, *Podospora*, *Schizothecium*, have both octosporous and polysporous species (e.g., Cain 1934, Lundqvist 1972). Nannfeldt (1975) did not accept polyspory as the sole character for separating genera in the Nitschkiaceae. In the Calosphaeriales, *Pleurostoma* is separated from *Erostella* (Barr 1985 as *Togninia*) chiefly because of polyspory, but one should question that separation.

Several Loculoascomycetes exhibit polyspory. In the Dothideales, *Sydowia* has been maintained separately from *Dothiora* for that reason (Barr 1972, 1987b, Froidevaux

1973, Sivanesan 1984). In the Pleosporales *Lizonia* includes a polysporous species once separated under *Pseudolizonia* (Döbbeler 1978). In the Melanommatales, a few species of *Delitschia* are polysporous (Luck-Allen and Cain 1975). In the Herpotrichiellaceae of the Chaetothyriales, *Capronia and Polytrichiella* have been recognized as polysporous genera having close affinities with *Berlesiella and Herpotrichiella* (Barr 1972, 1987b), or as Müller et al. (1987) advocate, polyspory is accorded only specific value.

The foregoing brief review summarizes the steps taken to convince myself on the validity or nonvalidity of polyspory as a generic character. Logically, it must be admitted that, no matter how convenient, polyspory cannot be utilized as the sole character state to separate genera that are otherwise similar and whose species are closely related. Polyspory does provide a valid criterion in the delimitation of species.

The evaluation of North American taxa that now are accepted to belong in *Capronia* led to the conclusion that only a few of these could be identified with described European species. Because of their inconspicuous nature, it is quite likely that many more species will be found. In the present contribution, several new species are described, some new combinations are proposed, and a key to those recognized is presented. *Acanthostigmella* is recognized to house nonpigmented or slightly pigmented, setose species, whose ascospores are transversely septate (Barr 1977, Barr and Rogerson 1983).

Capronia apiculata Barr, sp. nov. Figs. 1-3

Ascomata gregaria, collabentia 100-150 µm lata vel 75-100 µm alta, cellulae protrudentes praedita. Asci 35-45 x 12-16 µm bitunicati oblongi sexdecemspori. Paraphyses desunt. Ascosporae 32-45 x 3-3.5 µm fuscae dilutae fusoideae apiculatae 6-12 septatae fasciculatae. Insidens ramo *Betulae glandulosae* Michx., "USA: Alaska, Mt. McKinley Nat'l Park, Wonder Lake Campground, 25 Jun 1970," lecti W. B. et V. G. Cooke 43253, holotypus in NY depositus.

Ascomata gregarious on thin mycelium, collabent, 100-150 µm wide, 75-100 µm high, apex rounded, pore small; peridium brown, thin, with few protruding cells and short setae. Asci 35-45 x 12-16 µm, 16-spored. Ascospores 32-45 x 3-3.5 µm, light dull brown, long fusoid, ends apiculate, 6-12-septate, not constricted at septa; wall smooth; minutely guttulate; in fascicle in the ascus.

Known only from the type collection.

Ascospore shape is much as in *C. fungicola* Samuels & Müller (Samuels and Müller 1978), but ascospores there are shorter and ascomata are setose.

Capronia arctica Barr, sp. nov. Fig. 4

Ascomata solitaria vel gregaria globosa (75-)105-190(-225) µm diametro, cellulae protrudentes praedita. Asci 45-88 x 13.5-27 µm bitunicati saccati. Paraphyses desunt. Ascosporae 18-32(-45) x 6.5-9 µm cinereofuscae dilutae fusoideae 3-7 transversalibus et unum longitudinalibus septatae confertae. Insidens ramo *Salicis reticulatae* L., "Canada: Northwest Territories, Baffin I., Frobisher Bay, 1 Jun 1955," lectus R. T. Wilce, holotypus in NY depositus.

Ascomata separate to gregarious, globose, (75-)105-190(-225) µm diam; apex rounded; peridium narrow, dull brown pseudoparenchymatous cells, bearing scattered protruding darker cells near apex, on thin mycelium. Asci 45-88 x 13.5-27 µm, saccate, octosporous. Ascospores 18-32(-45) x 6.5-9 µm, light grayish brown, fusoid, 3-7-septate, one longitudinal septum in mid or most cells; wall smooth; homogeneous; crowded in the ascus.

On branches of *Salix reticulata*.

Additional collection examined. Newfoundland: Labrador, Hebron Fjord, 9 Jul 1954, R. T. Wilce (NY).

Capronia borealis Barr, sp. nov. Figs. 5-6

Ascomata solitaria vel gregaria globosa vel collabentia 100-150 µm lata 90-100 µm alta, ostiola pallida vel flava, cellulae protrudentes praedita. Asci (33-)39-60 x (11-)15-24 µm bitunicati ovoidei vel saccati octospori. Paraphyses desunt. Ascosporae (10-)15-27.5 x (3.5-)4.5-6 µm hyalinae vel olivaceofuscae dilutae fusoideae (1-3-)5-septatae confertae. Insidens caulo et ramo *Cassiope mertensianae* (Bong.) D. Don, "Canada: British Columbia, Garibaldi Prov. Park, 8 Aug 1952," lectus M. E. Barr 683, holotypus in NY depositus.

Ascomata separate to gregarious, globose collabent, 100-150 µm wide, 90-100 µm high, apical pore inconspicuous, pallid to yellowish; peridium grayish brown, narrow, roughened by protruding groups of dark brown cells, seated

Figs. 1-26. Species of *Capronia*. 1-3. *C. apiculata*: 1, outline of ascomata, 2, ascus, 3, ascospore. 4. *C. arctica*: ascospores. 5-6. *C. borealis*: 5, outline of ascoma, 6, ascospores. 7-8. *C. chlorospora*: 7, outline of ascoma, 8, ascospores. 9-11. *C. collapsa*: 9, outline of ascomata, 10, ascus, 11, ascospores. 12-14. *C. commonsii*: 12, outline of ascoma, 13, outline of stroma, 14, ascospores. 15-16. *C. dryadis*: 15, outline of ascoma, 16, ascospores. 17-18. *C. epimyces*: 17, ascoma in vertical section, 18, ascospores. 19-20. *C. exigua*: 19, ascus, 20, ascospores. 21-22. *C. montana*: 21, outline of ascoma, 22, ascospores. 23-24. *C. pleiospora*: 23, outline of ascoma, 24, ascospores. 25-26. *C. populicola*: 25, ascoma in vertical section. 26. ascospores, indicating sequence in development of septa. Standard line = 15 µm for asci and ascospores, 150 µm for ascomata and stroma.


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on thin brown mycelium. Asci (33-)39-60 x (11-)15-24 µm, ovoid or saccate, octosporous. Ascospores (10-)15-27.5 x (3.5-) 4.5-6 µm, hyaline becoming light olive brown, fusoid, straight to inequilateral or curved, (1-3-) 5-septate, rarely longitudinal septum in one cell, not constricted at septa; wall smooth; guttulate; crowded in the ascus.

On woody stems and branches.

Additional collections examined. Canada: Quebec: *Taxus canadensis* Marsh., Mt. Albert, Gaspesian Prov. Park, 11 Jul 1957, M. E. Barr 2016 (NY). British Columbia: *Cassiope mertensiana*, Garibaldi Prov. Park, 5 Aug 1952, M. E. Barr 647 (NY). USA: Michigan: *Vaccinium angustifolium* Aiton, Cheboygan Co., Topinabee Oaks, 19 Jul 1953, M. E. Barr 999b (NY).

Although on quite disparate substrates, these collections seem to be so closely related that they comprise a single species. The ascomata with protruding groups of cells and the wide asci separate *C. borealis* from the other species that have similar ascospores, *C. fusispora* (Barr) Müller et al. and *C. montana* Barr. The type and second collection on *Cassiope* were identified originally as *C. fusispora* (Barr 1972) but are separable from that species.

Capronia chlorospora (Ellis & Everh.) Barr, comb. nov.
Figs. 7-8

Teichospora chlorospora Ellis & Everh. North Amer. Pyrenomyc. 219. 1892.

Pleosphaeria chlorospora (Ellis & Everh.) Sacc. Syll. Fung. 11: 347. 1895.

Ascomata separate, globose, 80-220 µm diam, apical pore minute, lined with short dark setae; peridium bright or dull brown, ca. 15 µm wide, setose over upper half, setae brown to blackish, one-celled, 25-65 µm long, some light brown hyphae below and on substrate. Asci 45-70 (-80) x 10-18 µm, oblong, often inflated, octosporous. Ascospores (11-)12-18(-20) x (5.5-)7-9 µm, dull grayish brown or olivaceous, ellipsoid, ends obtuse, 3-7-septate, longitudinal septum through mid cells, rarely into end cells, usually constricted at first septum; wall smooth; guttulate or globule in each cell; crowded biseriate in the ascus.

On decorted wood and loosened periderm, occasionally over other ascomycetes.

Collections examined. USA: Massachusetts: *Acer saccharum* Marsh, Franklin Co., Conway, Baptist Hill, 27 Mar 1968, M. E. Barr 5117; *Carya*, 11 Oct 1987, M.E.Barr 7126 (both NY). New Jersey: *Ailanthus*, Gloucester Co., Newfield, J. B. Ellis, 24 Mar 1893 (NY); *Acer*, Nov 1880 (NY, on Ellis NAF 580 of *Sphaeria microtheca*). Ohio: Morgan 1045 (NY as *Teichospora modesta?*). Arizona: *Lemaireocereus (Cereus) thurberi* (Scheidw.) Britton & J.

Rose, Organ Pipe Nat'l Monument, 30 Apr 1987, M.F. & P. J. Rohman (NY). Vermont: old *Hypoxylon* on *Fagus*, Lamoille Co., Stowe, Goldbrook Road, 13 Aug 1964, M. E. Barr 4517 (NY).

The holotype of *Teichospora chlorospora*, on *Quercus* wood, was not located, but these collections fit the description well, and the Ellis specimen on *Ailanthus* was determined by Ellis as *T. chlorospora*. *Capronia minima* is related but has collabent ascomata bearing very short setae or protruding cells and somewhat smaller ascospores.

Capronia collapsa (Mathiassen) Barr, comb. nov.
Figs. 9-11
Herpotrichiella collapsa Mathiassen, Sommerfeltia 9: 51. 1989.

Ascomata separate or somewhat gregarious, collabent, (90-)120-240(-385) µm wide, (60-)100-150(-275) µm high; apex minutely papillate, ostiole periphysate; peridium brown, (7.5-)15-30 µm wide, bearing scattered short or elongate setae, 12-35(80-130) µm and sparse brown hyphae toward base. Asci 45-65 x 9-12 µm, octosporous. Ascospores (10-)12-18 x 3.5-5.5 µm, grayish brown, ellipsoid or somewhat obovoid, ends obtuse, 3-septate, not constricted; wall smooth; granular; overlapping biseriate to triseriate in the ascus.

On old wood.

Collections examined. USA: California: *Populus trichocarpa* Torr. & A. Gray, Shasta Co., Manzanita Lake, Lassen Volcanic Nat'l Park, 12 Jul 1968, W. B. & V. G. Cooke 39384 (NY with *Glyphium elatum* and immature Helotiales); *Arctostaphylos patula* Greene, Manzanita Creek Trail, 13 Jul 1972, W. B. & V. G. Cooke 45611 (NY). Washington: *Vaccinium myrtilloides* Michx., Skamania Co., 'Mountains', 19 Jul 1894, W. N. Suksdorf, Flora Wash. 507 (NY).

The collection on *Vaccinium* has small collabent ascomata, 90-100 x 60-70 µm, and ascospores that are similar in shape and septation, 13-16.5 x 3.5-4.5 µm. The specimen is the holotype of *Trichopeziza coarctata* Ellis & Everh., which is immature and is considered to be a doubtful species (Seaver 1951). As Mathiassen (1989) observed, *C. collapsa* is evidently a collabent counterpart of the smaller *C. pilosella* (Karst.) Müller et al.

Capronia commonsii (Ellis & Everh.) Barr, comb. nov.
Figs. 12-14
Melanomma commonsii Ellis & Everh. Proc. Acad. Nat. Sci. Philadelphia 42: 239. 1890.

This species, whose ascomata are velvety with protruding cells and short setae over stromata of *Hypoxylon*, differs from *C. parasitica* (Ellis & Everh.) Müller et al.

in obovoid ascospores with obtuse ends. A collection on *Graphostroma platystoma* (Schwein.) Pirozynski (USA: Illinois: Carroll Co., Mississippi Palisades St. Park, 13 Apr 1983, D. A. Glawe 86-35, IL) has ascomata aggregated into small stromata; the short inflated asci and obovoid ascospores are identical to other collections of *C. commonsii*.

Capronia dryadis Barr, sp. nov. Figs. 15-16

Ascomata solitaria globosa circa 120 µm, cellulae protrudentes praedita. Asci 60-67 x 18-21 µm bitunicati ellipsoidei vel saccati octospori. Paraphyses desunt. Ascosporae 18-23.5 x 6.5-9 µm cinereofuscae obovoideae 7-8-(9-) transversalibus et 1-3 longitudinalibus septatae confertae. Insidens *Dryadi integrifoliae* Vahl pubescentiae, "Canada: Northwest Territories, Baffin Island, head of Clyde Inlet, 16 Jul 1950," lectus P. Dansereau 5007160857d, holotypus in NY depositus.

Ascomata separate in pubescence of peduncle, globose, ca. 120 µm diam; apex rounded, pore small; peridium light brown, narrow, dark brown around pore with protruding cells and short chains of cells. Asci 60-67 x 18-21 µm, ellipsoid to saccate. Ascospores 18-23.5 x 6.5-9 µm, grayish brown, obovoid, ends obtuse, 7-8-(9-)septate with one complete longitudinal septum and 2-3 in some cells, not constricted; wall smooth; homogeneous; crowded in the ascus.

Known only from the type collection.

Capronia epimyces Barr, sp. nov. Figs. 17-18

Ascomata gregaria vel solitaria globosa 80-200 µm diametro, setae vel cellulae protrudentia praedita, setae 26-120 µm longae. Asci (55-)65-88 x 17.5-24(-30) µm bitunicati oblongi vel saccati octospori. Paraphyses desunt. Ascosporae 18-27 x 7.5-12 µm cinereofuscae ellipsoideae 5-9- transversaliter et 1-2(-3) longitudinaliter septatae biseriatae vel confertae. Insidens *Nectriae* stromatibus in *Pini strobi* L., "USA: Massachusetts, Franklin Co., Conway, 19 Apr 1971," lectus M. E. Barr 5745, holotypus in NY depositus.

Ascomata gregarious or separate, globose, 80-200 µm diam; apex short papillate, ostiole lined with short setae; peridium brown, 12-20 µm wide, surface of dark protruding cells, 4.5-5.5 µm, interspersed with dark elongate, unicellular setae, 26-120 µm long, light brown hyphae below connecting to thin mycelium. Asci (55-)65-88 x 17.5-24(-30) µm, oblong saccate. Ascospores 18-27 x 7.5-12 µm, dull grayish brown, ellipsoid, tapered to obtuse ends, 5-9-septate, not constricted, 1-2(-3) longitudinal septa; wall smooth; granular or one globule per cell; overlapping biseriate or crowded in the ascus.

Gregarious on old *Nectria* stromata on *Pinus* or scattered on periderm.

Additional collections examined. USA: Wisconsin:

Dane Co., Madison, Arboretum, 5 Sep 1953, M. E. Barr 1527a (NY). Spain: *Pinus pinaster* Aiton, Coco (Segovia) 2 May 1985, P. Yebes & J. Checa 9280 dupl.(NY).

Capronia acutiseta Samuels (in Müller et al. 1987) was described on decorticated wood from New Zealand and has much in common with *C. epimyces*. In addition to the differing substrates, *C. epimyces* has longer setae, narrower asci and ascospores.

Capronia episphaeria (Peck) Barr, comb. nov.
Basionym: *Dothidea episphaeria* Peck, Ann. Rep. New York State Museum 30: 64. (for 1876) 1878.

Barr (1987a) transferred the species to *Berlesiella* as a nonsetose, stromatic, larger-spored entity than *B. nigerrima* (Bloxam) Sacc., where it was placed earlier (Bigelow and Barr 1969, Barr et al. 1986). Both taxa form locules in stromata that develop over diatrypaceous fungi. Figures 10 I and J in Barr (1987b) illustrate the differences in ascospores.

Capronia exigua Barr, sp. nov. Figs. 17-18
Ascomata vel stromata pauciloculata gregaria globosa 104-140 µm diametro, papillae pusillae; cellulae protrudentes praedita. Asci 40-50 x 10-11 µm, bitunicati oblongae sexdecemsporae. Paraphyses desunt. Ascosporae 8-10 x 3-4 µm olivaceocinereae oblongae vel obovoideae 3-transversalibus et unum longitudinalibus septatae confertae. Insidens *Yuccae* folio et in *Kellermania* conidiomatibus "USA: California, San Francisco State University Campus, Dec 1980," lectus H. E. Bigelow s.n., holotypus in NY depositus.
Ascomata superficial or in old conidiomata, gregarious and at times forming stromata with few locules, globose, 104-140 µm diam, apex very short papillate; peridium dull dark brown, narrow, ca. 15 µm, surface roughened by protruding cells especially toward apex. Asci 40-50 x 10-11 µm, 16-spored. Ascospores 8-10 x 3-4 µm, grayish olivaceous, ends pallid, oblong to obovoid, ends obtuse, 3-septate, longitudinal septum often in one or both mid cells, not constricted; wall smooth; guttulate; crowded in the ascus.
In leaf of *Yucca* and in old conidiomata of *Kellermania*. Known only from the type collection.

This is a small species, probably on other overmature fungi also mixed with the *Kellermania* conidiomata.

Capronia minima (Ellis & Everh.) Barr, comb. nov.
Basionym: *Teichospora minima* Ellis & Everh. Proc. Nat. Acad. Sci. Philadelphia 47: 419. 1895.

Barr (1990) made the combination into *Berlesiella* and

provided a description and illustrations of the species. Several other collections of this collabent species are known, usually associated with old ascomata. *Apiosporium ? erysiphoides* Sacc. & Ellis (Michelia 1: 566. 1882) could arguably be the earlier name. An ascoma was illustrated in North American Pyrenomycetes (Ellis and Everhart 1892, Pl. 8, Fig. 6); otherwise, with no information on asci and ascospores it was termed a doubtful species. A later collection NAF 1232 (over valsoid stromata on *Magnolia glauca* L. (= *M. virginiana* L.), Newfield, N. J. Nov 1883) identified as *Apiosporium ? erysiphoides* can be referred to *C. minima*.

Collections examined. USA: Massachusetts: *Acer saccharum* over *Graphostroma platystoma*, Franklin Co., Conway State Forest, 29 Aug 1967, M. E. Barr 5044a (NY); *Populus tremuloides* Michx., Hampshire Co., Hadley, 5 Dec 1979, 22 Feb 1980 (as Barr 6701), H. E. Ahles (NY). Kansas: weathered pine, Rockport, Feb 1894, E. Bartholomew, NAF 3112 as *Melanomma sparsum (NY)*.

Capronia montana Barr, sp. nov. Figs. 21-22

Ascomata solitaria vel gregaria collabentia 100-200 µm lata 90-130 µm alta, papillae pusillae anthracinae, setae 15-44 µm longae praedita. Asci 47.5-80 x 11-16 µm bitunicati oblongi octospori. Paraphyses desunt. Ascosporae 15.5-21 x 5.5-6.5(-8) µm olivaceofuscae dilutae fusoideae (1-)3-4-(7-) transversalibus et unum longitudinalibus aliquando septatae confertae. Status anamorphosis ad *Exophialam* pertinens. Insidens ligno arboro conifero, "Canada: British Columbia, Garibaldi Prov. Park, 4 Aug 1952," lectus M. E. Barr 688a, holotypus in NY depositus.

Ascomata separate to gregarious on thin crust of olivaceous brown hyphae, collabent, 100-200 µm wide, 90-130 µm high, apex short papillate, shining black; peridium olivaceous brown, 10-12 µm wide, dark brown setae around sides and from basal crust, 15-44 µm long. Asci 47.5-80 x 11-16 µm, octosporous. Ascospores 15.5-21 x 5.5-6.5(-8) µm, light olivaceous brown, fusoid, ends acute, straight to inequilateral, (1-)3-4(-7) septate, at times longitudinal septum in one cell, not or slightly constricted; wall smooth, one globule per cell; crowded in the ascus. *Exophiala* anamorph: Conidiophores from basal crust, simple or branched, conidiogenous cells integrated or terminal, holoblastic; conidia 3.5-4.5 x 2-2.5 µm, grayish brown, ellipsoid, one celled.

On old conifer wood.

Additional collection examined. USA: *Pinus contorta* Douglas ex Loud., Idaho: Bonner Co., Sec. 11,T16N R5W, 9 Jun 1940, A. W. Slipp 690 (part NY).

Capronia montana is related to *C. fusispora* (Barr) Müller et al., where ascomata are globose, and *C. borealis* where ascomata are collabent but asci are wider.

Capronia nigerrima (Bloxam) Barr, comb. nov.
Basionym: *Sphaeria nigerrima* Bloxam ex Currey, Trans. Linn. Soc. London 22: 272. 1858.

This species was re-described in Bigelow and Barr (1969) under *Berlesiella*, where my concept then included the glabrous, larger-spored *C. episphaeria*. Collections of *C. nigerrima* typically have short setose, crowded ascomata over the surface or are sunk as locules in a stromatic base, and ascospores 12-18 x 5-6.5 µm. Specimens in NY labelled with the unpublished herbarium name *Dearnessia canadensis* Ellis & Everh. are this species. The combination into *Capronia* is proposed here, for although Müller et al. (1987) mentioned *"C." nigerrima*, they did not make the formal disposition, nor have I found that it has been made elsewhere.

Capronia pleiospora (Mouton) Sacc. Figs. 23-24

A North American collection that agrees well with Munk's (1957) description has setose ascomata, 16-spored asci and ascospores 13-16 x 6-7 µm [on *Lonicera ciliosa* (Pursh.) Poir., Canada: British Columbia, Sidney, 29 Jul 1990, M. E. Barr 7235, DAOM].

Capronia populicola Barr, sp. nov. Figs. 25-26
Ascomata solitaria collabentia 245-275 µm lata 190-220 µm alta, papillae pusillae, setae 15-20 µm longae protrudentia praedita. Asci 70-100 x 14-18 µm bitunicati oblongi octospori. Paraphyses desunt. Ascosporae 25-36 x 6-7 µm fuscae dilutae fusoideae (4-)8-(9-11-) transversalibus et unum longitudinalibus septatae, ad septum supramedium constrictae, biseriatae vel triseriatae. Insidens *Populi balsamiferae* L. peridio, "USA: Massachusetts, Franklin Co., Baptist Hill, Conway, 9 Dec 1979," lectus M. E. Barr 6640, holotypus in NY depositus.
Ascomata separate, collabent, 245-275 µm wide, 190-220 µm high; apex short papillate, ostiole periphysate; peridium dark brown, ca. 20 µm wide, short setose over much of surface, setae black, 15-20 µm long, brown hyphae from lower sides. Asci 70-100 x 14-18 µm. Ascospores 25-36 x 6-7 µm, hyaline becoming light brown, fusoid, ends acute, inequilateral or slightly curved, (4-)8-(9-11-) septate, finally longitudinal septum in 1-3 mid cells, constricted at first-formed, supramedian septum, at times at second septum; wall smooth; one globule per cell; overlapping biseriate to triseriate in the ascus.
On old periderm of *Populus balsamifera*. Known only from the type collection.

This species is similar in most aspects to *B. fungicola* Samuels & Müller (Samuels and Müller 1978) which has smaller ascospores 17-25 x 3-5 µm with 5-7 septa. *Herpotrichiella longispora* Remler (Remler 1979) has

similar ascomata and asci but longer, narrower ascospores, 39.5-64.5 x 4-6.5 µm.

Capronia porothelia (Berk. & Curtis) Barr, comb. nov.
Basionym: *Sphaeria porothelia* Berk. & Curtis, Grevillea 4: 142. 1876.

Barr (1976) redescribed the species under *Herpotrichiella porothelia* (Berk. & Curtis) Barr. Müller et al. (1987) suggested that it was likely to be identical with *C. spinifera* (Ellis & Everh.) Müller et al. Narrower, oblong asci and slightly smaller ascospores separate *C. porothelia* for the present.

Key to North American Species of *Capronia*

1. Ascospores relatively wide, 2-2.5:1, broadly oblong, obovoid or ellipsoid, almost always with longitudinal septum in one or more cells.....2
1. Ascospores relatively narrow, (2.5-)3-4: 1 or narrower, obovoid, fusoid, oblong or cylindric, with or lacking longitudinal septum.....8
2. Asci octosporous.....3
2. Asci polysporous.....6
3. Ascospores 18-27 µm long; ascomata globose.....4
3. Ascospores (9-)10-18(-20) µm long; ascomata globose or collabent.....5
4. Ascospores obovoid, 18-23.5 x 6.5-9 µm, 7-8-(9-)septate; ascomata bearing protruding cells, in pubescence.....*C. dryadis*
4. Ascospores more ellipsoid, 18-27 x 7.5-12 µm, 5-9-septate; ascomata bearing setae, gregarious over hypocreaceous stromata on conifers.....*C. epimyces*
5. Ascospores (9-)10-15.5 x 4.5-7.5 µm, (1-)3-7-septate; ascomata collabent, bearing protruding cells or short setae, gregarious on wood or periderm, often over other ascomycetes.....*C. minima*
5. Ascospores (11-)12-18(-20) x (5.5-)7-9 µm, 3-7-septate; ascomata globose, bearing setae; separate to gregarious on old wood.....*C. chlorospora*
6. Ascospores 8-10 x 3-4 µm, 3-septate; ascomata bearing protruding cells; on and in *Kellermania* condiomata among other fungi on *Yucca*.....*C. exigua*
6. Ascospores larger.....7
7. Ascospores 13-16 x 6-7 µm, 3-(4-)septate; ascomata setose, on wood.....*C. pleiospora*
7. Ascospores 15-22.5 x 5-9 µm, 3-6-(7-)septate; ascomata bearing protruding cells.....*C. irregularis*
8. Asci octosporous.....9
8. Asci polysporous.....22
9. Ascospores 18-45 x 6-9 µm.....10
9. Ascospores shorter or narrower if reaching 27 µm 11
10. Ascospores 25-36 x 6-7 µm, (4-)8-(11-)septate; ascomata collabent, setose.....*C. populicola*

10. Ascospores 18-32(-45) x 6.5-9 µm, 3-7-septate; ascomata globose, bearing protruding cells.....*C. arctica*

11. Ascospores 9-14 µm long, 3-septate.....12

11. Ascospores (10-)12-24(-27) µm long, septation variable.....14

12. Ascospores fusoid with acute tips, 9-13 x 3.5-4.5 µm; ascomata short setose, over ascomycete stromata..*C. parasitica*

12. Ascospores obovoid with obtuse tips, 10-14 µm long; ascomata short setose or bearing protruding cells.....13

13. Ascospores 3-4 µm wide in narrow asci; over basidiomycete hymenium.....*C. porothelia*

13. Ascospores 3.5-5 µm wide in inflated asci; over ascomycete stromata.....*C. commonsii*

14. Ascospores obovoid, inequilateral, 3-7-septate with one longitudinal septum; ascomata usually gregarious or immersed in stromatic base over diatrypaceous ascomycetes.....15

14. Ascospores oblong, fusoid or somewhat obovoid, 1-3-5-septate, rarely longitudinal septum in one cell; ascomata usually separate.....16

15. Ascospores 12-18 x 5-6.5 µm, 3-5-septate; ascomata short setose.....*C. nigerrima*

15. Ascospores 16.5-24 x 6-7.5 µm, 5-7-septate; ascomata lacking setae.....*C. episphaeria*

16. Ascospores oblong obovoid, ends obtuse.....17

16. Ascospores fusoid, ends acute.....20

17. Ascomata collabent, short setose; ascospores (10-)12-18 x 3.5-5.5 µm.....*C. collapsa*

17. Ascomata globose, short setose or bearing protruding cells.....18

18. Ascomata bearing protruding cells or minute setae; ascospores (10-)13-15.5 x 3.5-4.5 µm; in old basidiomycetes.....*C. spinifera*

18. Ascomata setose, over decorticated wood or arctic-alpine on stems.....19

19. Ascospores 11-15.5 x 3.5-6 µm; on decorticated wood.....*C. pilosella*

19. Ascospores 15-21 x 3-5 µm; arctic-alpine on stems.....*C. setosa*

20. Ascomata globose, setose; ascospores 13.5-20(-27) x 3-5 µm.....*C. fusispora*

20. Ascomata collabent, setose or bearing protruding cells.....21

21. Ascomata setose; ascospores 15.5-21 x 5.5-6.5(-8) µm in relatively narrow asci, 47-80 x 11-16 µm.....*C. montana*

21. Ascomata bearing protruding cells; ascospores (10-)15-27.5 x (3.5-)4.5-6 µm in shorter, wider asci (33-)39-60 x (11-)15-24 µm.....*C. borealis*

22. Ascomata globose, setose; ascospores 9-18 x 3-4.5(-7) µm, 1-3-septate.....*C. polyspora*

22. Ascomata collabent, setose or bearing protruding

cells; ascospores longer.....23
23. Ascomata bearing protruding cells; ascospores 32-45 x 3-3.5 µm, 6-12-septate.....*C. apiculata*
23. Ascomata setose; ascospores narrower, 1-2(-2.5) µm, 1-7-septate.....24
24. Ascospores 17.5-27.5 x 1-2(-2.5) µm, 1-septate.....*C. albimontana*
24. Ascospores 46-60 x 1.5-2(-2.5) µm, (3-)5-7-septate.....*C. longispora*

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IN VITRO SYNTHESIS OF ECTOMYCORRHIZAE BETWEEN *SUILLUS COLLINITUS* (FR.) O. KUNTZE AND *RHIZOPOGON ROSEOLUS* (CORDA) TH. M. FR. WITH *PINUS HALEPENSIS* MILLER

by

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Suillus collinitus and *Rhizopogon roseolus* are two ectomycorrhizal species commonly found in forests of *Pinus halepensis* in Southern Spain (HONRUBIA & LLIMONA, 1983; HONRUBIA et al., 1982). Carpophores of these species have been collected each of several years in plantations of *P. halepensis* of different ages. Both appear to be well adapted to xeric conditions of this mediterranean region and are potentially useful in inoculation programs for *P. halepensis*. It is therefore essential to verify the association between these fungi and the putative symbiotic tree species and the "in vitro" synthesis of ectomicorrhizae is the first step (PALM & STEWART, 1984). In this work we have isolated *S. collinitus* and *R. roseolus* in pure culture and have experimentally confirmed the formation of ectomycorrhizae with *P. halepensis*.

The morphology and anatomy of the most common ectomycorrhizae of this species from Israel were described by WAHL (1950) and WAHL & REICHERT (1955) . They also described the production of mycorrhizae on seedlings of *P. halepensis* after inoculation with mycelium obtained in pure culture from *Suillus granulatus* in sterile soil. TRAPPE (1962) cited this fungal species as the only symbiont of *P. halepensis*.

Few later studies mention mycorrhizal formation in *P. halepensis* (PALENZONA et al., 1972; GAY et al., 1982; RUEHLE et al., 1981; CHEVALIER & DETOLLE, 1984).

Pure culture isolates were obtained by placing small pieces of pileus tissue from *S. collinitus* and glebal tissue from *R. roseolus* in Petri dishes with Modified-Melin-Norkrans agar (MMN) (MARX, 1969). Isolates were grown in darkness at 23°C and successive subcultures were also made in MMN. At the same time, seeds of *P. halepensis* were sterilized in 30% H_2O_2 for 15 minutes and sown in trays of sterile sand. The root systems of the seedlings were kept under observation until the short roots appeared. Seedlings were immediatly transferred to growth pouches (FORTIN et al., 1980).

From the edge of the colonies small square pieces (5mm) of mycelium were taken and placed in MMN liquid. These pieces were then transferred to the pouches containing the 3 month old seedlings with their short roots (according to the method described by FORTIN et al., 1980, and modified by S. Miller, *in litt.*).

The pouches were placed in a culture chamber with an average temperature of 22°C and photoperiod of 16 hours light/8 hours darkness.

Once the mycorrhizae were synthesized the most representative structures were selected and fixed in FAA (1:5:1). Semifine (15µm) sections were then made in paraffin without staining for observation in phase-contrast-microscope.

The mycelia obtained after isolation in MMN is described as follows:

Suillus collinitus : mycelium initially white, then greyish brown, superficial, clearly defined margin, lobulated, with dark brown reverse side.

Rhizopogon roseolus : mycelium initially cream then reddish brown, with abundant mycelial strands, irregular margin with reddish brown reverse.

Description of ectomycorrhizae

Suillus collinitus + *Pinus halepensis* (fig.1)

Morphological characteristics: simple dichotomies, sessile or stiped, in some cases branched, white initially and finally cream, 3-4 mm in length and 400-500 µm in diameter. Smooth surface with extramatrical hyphae between the dichotomies sometimes forming mycelial strands but not rhizomorphs.

Anatomical characteristics in section: well developed mantle of prosenchymatous (felt prosenchyma, ss. CHILVERS, 1968), 40-100 µm wide, formed by hyphae of 2.5-3.75 µm diameter, with clamp connections; near the host tissue, the hyphae form a parenchymatous tissue. The mantle surface is formed of lax hyphae; no type of

ornamentation appears. The Hartig net is very branched and penetrates as far as the endodermis (hyphae 4.5-5 µm in diameter).

Rhizopogon roseolus + *Pinus halepensis* (fig.2)

Morphological characteristics: simple dichotomies, sessile or stiped, branched and even coraloid, white initially, and finally light brown, 3-5 mm long and 350-600 µm in diameter. Smooth surface, with extramatrical hyphae between the dichotomies, forming mycelial strands.

Anatomical characteristics in section: mantle of 40-75 µm wide, of prosenchymatous structure (CHILVERS, 1968). Hyphae 2-2.5 µm in diameter. Smooth mantle surface. Hartig's net developed between the first layers of cortical cells (in some cases reaching the endodermis).

Suillus and *Rhizopogon* are two cosmopolitan ectomycorrhizal genera with a wide range of hosts, principally among the conifers. Many members of both genera have been isolate in pure culture and used in the synthesis of mycorrhizae (GRAND, 1968; LAMB & RICHARDS, 1970; MEJSTRIK & KRAUSE, 1973; PACHLEWSKI & PACHLEWSKA, 1974; MARX, 1969, 1979; MOLINA, 1979; CHU-CHOU & GRACE, 1984; CHU-CHOU, 1985; ACSAI & LARGENT, 1983; PALM & STEWART, 1984; RIFFLE & TINUS, 1985, among others).

R. roseolus has been described in association with different conifers, but never with *Pinus halepensis* . However, *S. collinitus* was noted in association with *P. halepensis* (CHEVALIER & DETOLLE, 1984), although inoculation was peformed with mycorrhizal roots from pines under which *S. collinitus* had fructified in previous years.

Anatomical and morphological characteristics of ectomycorrhizae synthesized between *Suillus collinitus, Rhizopogon roseolus* with *Pinus halepensis* seedlings are described. It is proved experimentally that these fungi are indeed ectomycorrhizal with Aleppo pine.

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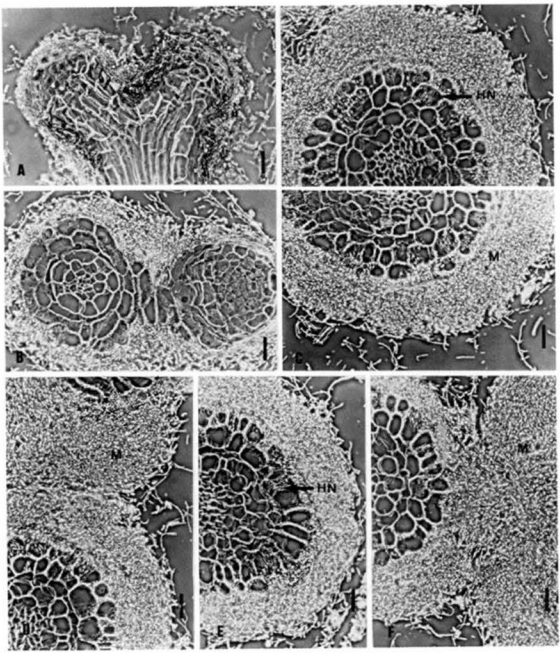

Fig.1.- Laboratory-synthesized ectomycorrhizae of *Suillus collinitus* + *Pinus halepensis*. Bar= 30 μm.

A.- Longitudinal section of bifurcate ectomycorrhiza and tightly appressed mantle.

B.- Cross section of bifurcate ectomycorrhiza.

C,D,E, and F.- Cross sections of mature ectomycorrhizae. Note the thick mantle (M) and development of Hartig net (HN).

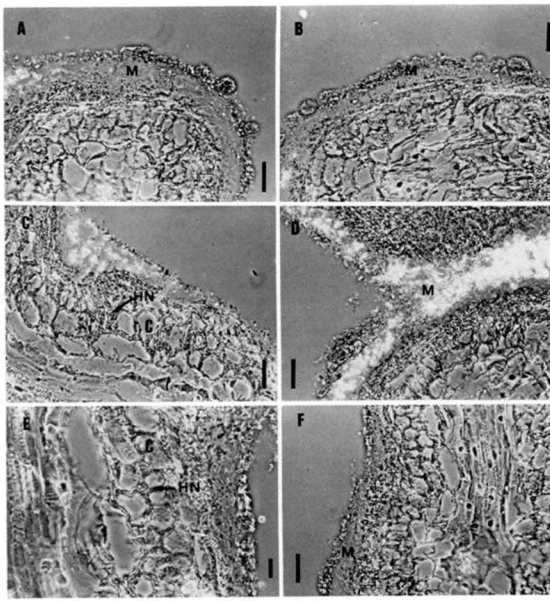

Fig.2.- Laboratory-synthesized ectomycorrhizae of *Rhizopogon roseolus* + *Pinus halepensis*.

A-F.- Cross sections of mature ectomycorrhizae. Note development of Hartig net (HN) and deformation of cortical cells (C). Bar= 35 μm.

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HELICOGOOSIA, A NEW GENUS OF LIGNICOLOUS HYPHOMYCETES

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ABSTRACT

A new genus and species of helicosporous hyphomycetes - **Helicogoosia paradoxa** - occurring on dead bark of **Pinus sylvestris** in south-west of Bohemia, Czechoslovakia, is described and illustrated. From all known helicosporous genera the fungus is well distinguished by different conidiogenous cells and conidia. Conidiogenous cells are lanceolate and very easily detachable leaving pores in the wall in places of their secession. Conidiogenous cells develop by enteroblastic-tretic manner, while conidia develop holoblastically. Conidia are brown, septate, mostly tightly coiled in excentric direction having the apical end outside and the basal end inside the helicoid body.

TAXONOMIC PART

Helicogoosia Hol.-Jech. **gen. nov.**

Deuteromycotina, Hyphomycetes.

Coloniae laxe gossypinae vel tomentosae, brunneae, effusae. Mycelium superficiale ex hyphis repentibus, pallide brunneis, laevibus et ex hyphis aeriis non ramosis, brunneis, rectis vel leviter flexuosis, septatis, crassitunicatis, laevibus, anastomosantibusque compositum. Conidiophora semimacronemata, mononemata, non ramosa vel plus minusve ramosa, determinata vel proliferata, mediobrunnea vel brunnea, aseptata vel septata, crassitunicata, laevia. Cellulae conidiogenae monoblasticae, in conidiophoris incorporatae et terminales vel laterales, determinatae vel aliquando proliferantes, lanceolatae, pallide brunneae usque brunneae, fere crassitunicatae et laeves, saepe facile secedentes; post secretionem pori pellucidi in pariete patefacti. Conidia holoblastica, acrogena, solitaria, sicca, simplicia, circinata, in cursum excentricum helicoidea, septata, non constricta, brunnea, fere

crassitunicata, laevia; cellula apicalis obtusa in peripheria locata et cellula basalis in centro corporis conidii locata; conidia facile cadentia.

Species typica: **Helicogoosia paradoxa** Hol.-Jech.

Colonies loosely cottony or tomentose, brown, effuse. Mycelium superficial, composed of repent, pale brown, smooth hyphae and of aerial unbranched, erect or ascending, straight or slightly flexuous, brown, septate, thick-walled, smooth, occasionally anastomosing hyphae.

Conidiophores arising laterally and singly on the hyphae, semimacronematous, mononematous, unbranched or sometimes loosely branched, straight, determinate or occasionally proliferating, pale brown to brown, aseptate or septate, thick-walled, smooth. Conidiogenous cells monoblastic, integrated, terminal or lateral, determinate or proliferating, lanceolate, pale brown to brown, moderately thick-walled and smooth, becoming easily detached; after secession leaving clear minute pores in the lateral walls of hyphae or conidiophores.

Conidia holoblastic, acrogenous, solitary, dry, simple, circinate, tightly coiled in excentric direction, septate, not constricted, brown, moderately thick-walled, smooth, with an obtuse apical end at the periphery and conical basal end at the center of the conidium body; easily schizolitically seceding.

Etymology: The new genus is named in honour of Prof. Dr. Roger D. Goos, Department of Botany, University of Rhode Island, U.S.A., a student of the helicosporous hyphomycetes.

Helicogoosia paradoxa Hol.-Jech., **spec. nov.**

Coloniae laxe gossypinae vel tomentosae, 2 - 5 mm diam. Hyphae aeriae rectae vel leviter flexuosae, non ramosae, brunneae, saepe ultra 2500 µm longae, 1.8 - 2.8 µm latae, crassitunicatae, laeves, interdum anastomosantes. Conidiophora ut rami laterales enteroblastice in hyphis evoluta, non ramosa vel plus minusve ramosa, aseptata usque 1-3 septata, 8 - 35 µm longa. Cellulae conidiogenae incorporatae, terminales et laterales, lanceolatae, ad basem et apicem angustatae, pallide brunneae usque brunneae, 8 - 20 µm longae, 1.8 - 2 µm latae, saepe facile secedentes, pori pellucidi distincti in pariete patefacti. Conidia circinata, arcte in cursum excentricum 1 1/2 usque 2 1/4 helicoidea, 5-12 septata, non constricta, pallide brunnea usque brunnea, fere crassitunicata, laevia, 3.5 - 5 µm lata, cum cellulis apicalibus obtusis in peripheria locatis et cellulis basalibus conicis in centro corporis conidii locatis; conidia helicoidea 13 - 18 µm in diam.; cellula basalis cum cicatrice

truncata, pallida, 1 μm lata.

Habitat in cortice emortuo deiecto **Pini sylvestris.**

Holotypus: Czechoslovakia: Bohemia merid.-occid., distr. Domažlice, in silva inter pagos Poběžovice et Drahotín, sept.-occid. ab oppido Domažlice, 26. VII. 1990, coll. V. Holubová-Jechová (PRM 842854).

Colonies loosely cottony to tomentose, brown, up to 2 - 5 mm in diam.

Aerial hyphae straight or slightly flexuous, unbranched, brown, often more than 2500 μm long, 1.8 - 2.8 μm wide, thick-walled, smooth, occasionally anastomosing.

Conidiophores developing enteroblastically, laterally on the hyphae, unbranched or loosely branched, aseptate to 1-3 septate, 8 - 35 μm long. Conidiogenous cells integrated, terminal or lateral, developing enteroblastically, lanceolate, narrowing both to the apex and to the base, pale brown to brown, 8 - 20 μm long, 1.8 - 2 μm wide, very easily detachable, leaving a distinct clear minute pores in the walls of hyphae, conidiophores or conidiogenous cells. A small pore on the base of the conidiogenous cell is distinct after secession.

Conidia circinate, tightly coiled 1 1/2 to 2 1/4 times, with excentric coiling, 5-12 septate, not constricted at the septa, pale brown to brown, moderately thick-walled, smooth, 3.5 - 5 μm wide, with the apical obtuse cell at the periphery and the basal conical cell at the center of each helicoid conidium, 13 - 18 μm in diam.; the basal cell with a truncate, pale to hyaline, 1 μm wide scar.

Habitat: on dead bark of **Pinus sylvestris** lying on the ground.

DISCUSSION

Helicosporous fungi were reviewed in detail by Goos (1987). Forty- three genera with helicoid conidia are now known. The important characters of the new described taxon above are not, however, found in any of known helicosporous genera.

Interesting and important features of the new taxon are the development of the conidiophores and the conidiogenous cells laterally on unbranched aerial hyphae in an enteroblastic-tretic manner. The conidiogenous cells are solitary and can also proliferate percurrently. Occasional branching of the conidiophores occurs by the lateral development of new conidiogenous cells on short conidiophores

and primary conidiogenous cells, again in the enteroblastic-tretic manner.

The conidiogenous cells are lanceolate and narrow, becoming distinctly narrower on the apex and also on the basal end. They are easily detached from the conidiophore, leaving only minute, clear pores in the lateral walls of the hyphae, conidiophores and conidiogenous cells, and leaving no wall remnants on the conidiophore or the conidium.A small pore becomes distictly visible on the base of each conidiogenous cell after secession.

A very similar mode of conidiogenous cell development can be seen in **Edmundmasonia** Subram., and was described in **E. villosa** Hol.-Jech. (Holubová-Jechová 1983). Small, clear pores in the wall of the conidiogenous cells after seccesion can be seen in Matsushima 's figures of **Edmundmasonia pulchra** Subram. (Matsushima 1975). However,they cannot be observed in the walls of the conidiophores of the apparently morphologically similar **Brachysporiella gayana** Batista. This feature leads me to consider **Brachysporiella** Batista and **Edmundmasonia** Subram. as distinct taxa, although other authors do not agree. The conidia of **Edmundmasonia** species are obovoid to pyriform, however, never helicoid.

The conidia of **Helicogoosia paradoxa** resemble those of some species of **Helicoma** Corda, having relatively thick conidial filaments in proportion to their length, and in being non-hygroscopic. Conidia of the new taxon are tightly coiled, circinate to planate, very rarely slightly cochleate (terminology of Goos, 1987). The mode of coiling in the new taxon is distinctly excentric. The base of the conidium is found with the apex of the conidiogenous cell in the centre of the helix, and the apex of the conidium is always found at the periphery. This is in contrast to **Helicoma** and other genera, as **Helicosporium** Nees, **Drepanoconis** Schroet. et Henn., etc. This form of coiling is found only in a few genera - as **Cirrenalia** Meyers et Moore, **Zalerion** Moore et Meyers, **Slimacomyces** Minter (Sutton 1973, Goos 1987). All known genera with excentric coiling, however do not produce tightly coiled conidia; their conidia are often only partly coiled or irregularly coiled in several planes and are mostly constricted at the septa. The characters of colonies and conidiophores in **Cirrenalia, Slimacomyces** and **Zalerion** are also fully different from those occurring in the newly described genus.

Three other species of lignicolous hyphomycetes occur together with **Helicogoosia paradoxa** on the collected sample of **Pinus sylvestris** bark: **Septonema fasciculare** (Corda) Hughes and **Hormiactella fusca** (Preuss) Sacc., both very common microscopic fungi on **Pinus** bark, and **Sporidesmium doliiforme** Minter et Hol.-Jech. The latter fungus is very rare; it was first collected in 1979

on cones of **Pinus mugo** in the Šumava Mts. in south of Bohemia and was found also in Scotland and Finland.

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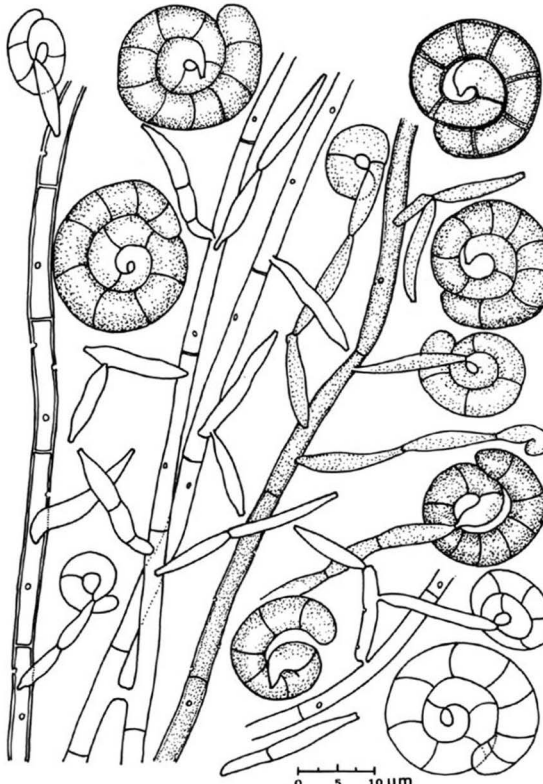

Fig. 1. **Helicogoosia paradoxa** Hol.-Jech.: unbranched aerial hyphae with clear minute pores in the walls and with lateral short conidiophores and conidiogenous cells; helicoid conidia in different stages of their development.

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SCANNINIG ELECTRON MICROSCOPY OF CONIDIOPHORE DEVELOPMENT AND CONIDIOGENESIS IN *CHAETOPSINA FULVA*

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Abstract

Conidiophore morphology and development, and conidiogenesis in *Chaetopsina fulva* were investigated with S.E.M.; generic limits and conidial arrangement after their production are discussed. Enteroblastic (phialidic) conidiogenesis is confirmed.

Specimens (on dead needles of *Cedrus* spp.) of *Chaetopsina fulva* Rambelli, the type species of the genus, recently collected near Rome, have provided the opportunity for further studies of the morphology, conidiophore development and for confirming the conidiogenesis of this species, utilizing the S.E.M..

Methods and Materials

Specimens from pure cultures on soil extract agar and from needles of *C. atlantica*, were fixed in 5% glutaraldehyde in 0.2 M sodium phosphate buffer (pH 7.2) and post-fixed in 1% OsO_4 in 0.2 M cacodylate buffer (pH 7.2); dehydrated in a graded acetone series, critical point dried, coated with gold and then observed with a Cambridge Stereoscan 200.

Specimens examined: - strain N. 1, *C. fulva* Rambelli, pure culture from needles of *Cedrus* sp., leg. M. Leone, III.1987, c/o C.S.A.F., Casalotti, Rome, Italy; specimen N. 2, *C. fulva* Rambelli, on needles of *Cedrus atlantica* (Endl.) Carrière, leg. M. Leone, 3.IX.1987, c/o C.S.A.F., Casalotti, Rome, Italy; strain N. 2, pure culture from the specimen N. 2.

Strain N. 1 was analyzed only in pure culture, because of the impossibility to obtain a good S.E.M. preparation from the original material, which had been dried for herbarium conservation.

Results

a) Development

A seta (fig. 1, a) originates from the submerged (fig. 1, b) or superficial (fig. 1, c) mycelium. During development the apex of the seta is rounded and becomes sharp at maturity. When the seta is close to its maximum length, it produces one, or sometimes more, lateral branches, adherent to it (fig. 1, d), envelopping it and producing secondary, tertiary (or more) branches (fig. 1, e). Conidiogenous cells arise from this repeatedly branched apparatus (figs. 1, f, g). Later, conidiogenous cells begin producing conidia (fig. 2, a).

b) Morphology

S.E.M. observation shows a verrucose surface of mature conidiophore stipes (fig. 2, b) and markedly of the conidiogenous cells (fig. 2, c). The conidia and the neck of the conidiogenous cells are finely echinulate in strain N.1 (fig. 3, b) and smooth in specimen and strain N.2 (fig. 2, f); the two strains are identical in all other features.

c) Conidiogenesis

The conidia are produced from the interior of the conidiogenous cell (fig. 2, d). After the conidia have seceded, the slightly flaring collarette remains open (fig. 2, e), confirming the phialidic nature of the conidiogenous cell.

Each conidiogenous cell produces numerous conidia, which tend to remain in a parallel package, near the point of production (fig. 2, g). The collarette presents a slightly asymmetric shape (fig. 3, a) and the conidia are asymmetrically tapered at the proximal end (fig. 3, b).

Discussion

The morphology of the setiform conidiophore has been clearly described by Rambelli (1956); moreover he described "conidiis .... ex conidiogenis phialiformibus hyalinis exilientibus": in fact conidiogenesis is surely enteroblastic (phialidic), conidia being produced from the interior of the conidiogenous cell. Kirk & Sutton (1985) applied the terminology of conidiogenesis proposed by Minter *et al* (1983) to *Chaetopsina*: "*Conidial ontogeny* holoblastic by apical wall building. *Conidial maturation* synchronous with conidial ontogeny. *Conidial secession* schizolytic. *Proliferation* of two types: (1) enteroblastic without progression, leading to periclinal thickening; (2) holoblastic and

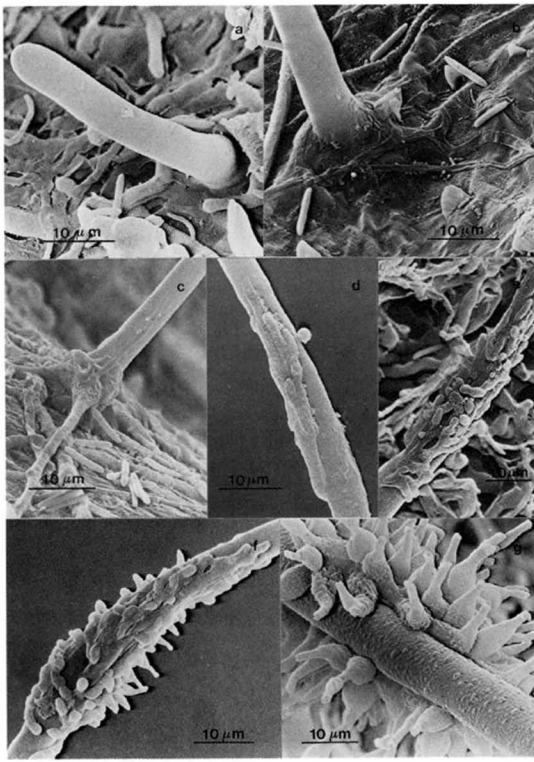

Fig. 1 - *Chaetopsina fulva* : a) initial development of the setiform conidiophore; b, c) submerged and superficial colonization; d, e, f, g) different developmental stages of lateral branches and conidiogenous cells.

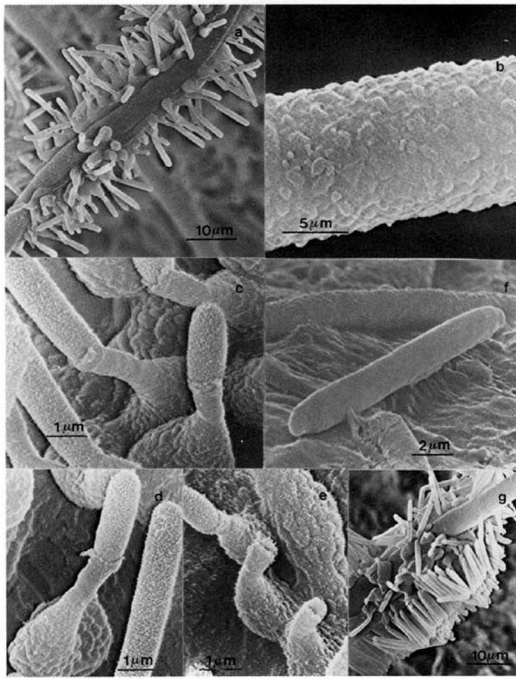

Fig. 2 - *Chaetopsina fulva* : a) conidiogenous apparatus in early stage of conidial production; b) upper part of the stipe markedly verrucose; c, d, e) conidiogenous cells producing conidia from the interior; f) smooth conidia typical of the specimen N. 2; g) parallel package of conidia.

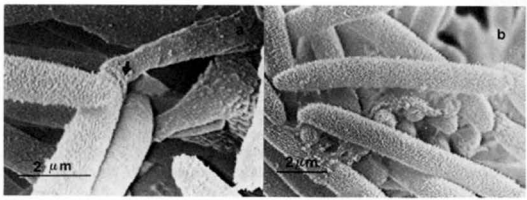

Fig. 3 - *Chaetopsina fulva* : a) asymmetrically shaped neck of a conidiogenous cell; b) finely echinulate conidia (strain N. 1) showing the asymmetrically tapered proximal end.

irregularly sympodial leading to multiple conidiogenous loci". Accepting the method of Minter *et al.* (1983), the above is substantially correct, but the description of two types of proliferation is rather perplexing. In fact, while the first type concerns proliferation within a single conidial locus, which produces numerous conidia through the apposition of new wall layers, without elongation of the conidiogenous cell, the second type concerns conidiogenous cell proliferation, leading to the production of new conidiogenous loci, each proliferating through the apposition of new wall layers. The contemporary presence of these two types of proliferation is commonly accepted for *Dictyochaeta* Speg. (=*Codinaea* Maire).

Accepting the possibility of the presence of a sympodial proliferation in *Chaetopsina*, the distinction between this genus and *Chaetopsis* Greville could also become very slight, based only on the presence of aseptate or 1-septate conidia and this, exactly as suggested by Rambelli (1987), is a specific and not generic characteristic. The discriminant is probably collocated in the distinction (Minter *et al.*, 1982) between proliferation *(Codinaea* and *Chaetopsis)* and regeneration *(Chaetopsina).* Proliferation

is a mechanism evolved by numerous fungal species in order to improve the conidiogenous cell efficiency. This mechanism is typical of the species and is normal for all its conidiogenous cells. Regeneration is a mechanism occasionally utilized to overcome damage or other impediments to the function of the conidiogenous cell. In fact, the occasional presence of "polyphialidic" structure is more easly evident in old cultures of *Chaetopsina* spp., where regeneration phenomena are more common.

The occasional presence of polyphialidic structures may be considered a result of a regeneration process, whereas *C. polyblastia* Samuels appears to be more of a case of polyblastic proliferation (Samuels, 1985). At present we do not have sufficient data to verify this, but, if we did, *C. polyblastia*, exactly as suggested by Rambelli (1987), would have had a different collocation. Using cluster analysis, Arambarri and Cabello (1989) showed that *C. polyblastia* is closer to *Chaetopsis grisea* (Ehrenberg) Saccardo than to other species of *Chaetopsina* and *Kionochaeta* Kirk & Sutton.

The surfaces of the conidia are finely echinulate in strain N. 1 and smooth in specimen and strain N. 2. Considering that the conidia in latter case are smooth both on natural substratum and in pure culture, this morphological characteristic could be considered as the unique difference between the two strains, that are identical even in their dimentions.

All species of *Chaetopsina* are characterized by a parallel aggregation of the conidia. This feature has an adaptative value. The presence of packed conidia is in fact common in such genera as *Codinaea* and *Circinotrichum* Nees which are characterized by thin walled scolecospores. In these genera the conidia are probably stored and initially dispersed as packets. They are more resistant to low humidity, while in the presence of water the mucilage is dissolved and the conidia are separately dispersed. All the species of these genera present conidia with an asymmetrically rounded proximal end. This characteristic, together with the shape of the collarettes and a delicate equilibrium between the cohesion and lubrification due to the presence of mucilage, determine the characteristic conidial arrangement: each conidium, pushed by the following one, runs on the collarette with the curved proximal end and remains attached to it, while the following conidium runs at its side. When the collarette is large and regularly shaped, as in *Codinaea*, the conidia form conspicuous slimy masses on the conidiogenous locus and around the main axis of the conidiogenous cell. When the collarette is slightly asymmetric, as in *Chaetopsina fulva*, the parallel conidia are moved laterally to the main axis of the conidiogenous cell. Considering the prominence and the probable adaptative value of this feature, the latter can be regarded as a characteristic peculiar to *Chaetopsina*. From this viewpoint, inclusion of species with catenulate conidia ought to be avoided (Rambelli, 1987). *C. catenulata* Samuels has been described as possessing phialides with periclinal wall thickening (Samuels, 1985); and this agrees

with the observations concerning the type species of the genus. However, the presence of flat protuberant scars at each end of the catenulate conidia could be due to a different type of conidiogenesis.

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NOTES ON HYPHOMYCETES. LXII. CONCERNING CHLORIDIUM VIRESCENS VAR. ALLANTOSPORUM, A NEW TAXON, C. VIRESCENS VAR. CAUDIGERUM, AND CHLORIDIUM PHAEOSPORUM, FROM SOUTHERN AFRICA

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ABSTRACT

A new variety of *Chloridium virescens* (Pers.) W. Gams & Hol.-Jech., var. *allantosporum*, is described and illustrated from a collection on dead wood made in the Transvaal, South Africa. Var. *allantosporum* differs from the three presently recognized varieties of this species (vars. *virescens*, *caudigerum* (Höhn.) W. Gams & Hol.-Jech., and *chlamydosporum* (van Beyma) W. Gams & Hol.-Jech.), as the name indicates, by possession of allantoid conidia. Collections of *C. virescens* var. *caudigerum* and *Chloridium phaeosporum* W. Gams & Hol.-Jech., known previously only from its type material on decaying wood in West Virginia, U.S.A., are reported from southern Africa and the fungi are redescribed and illustrated.

INTRODUCTION

In their monographic study of the genus *Chloridium* Link, Gams and Holubová-Jechová (1976) treated three previously recognized taxa [see Hughes (1958), Ellis (1971)], namely *C. viride* Link, *C. caudigerum* (Höhn.) Hughes, and *C. chlamydosporis* (van Beyma) Hughes, as a single species. They adopted the binomial *C. virescens* [basionym *Dematium virescens* Pers.] for the type species, *C. viride*, and the latter name was listed as a synonym. The name *D. virescens*, applied to the same fungus, predates *C. viride* by some years [see Persoon (1797), Link (1809)]. Although a specimen [910.25-753] labeled '*Dematium virescens* Pers.' in Herb. Persoon (L) was found, when examined by Gams and Holubova-Jechova (1976), not to bear *C. virescens*, but rather the *Helicosporium* anamorph of *Tubeufia cerea* (Berk. & Curt.) Booth [*Helicosporium vegetum* Nees], the authors concluded, on the basis of Persoon's

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description, that *D. virescens* was the same as that named *C. virens* by Link (1809). They expressed the opinion that this specimen could not be the holotype of *D. virescens* and that Persoon's original material has probably been lost. Furthermore, they thought it probable that Persoon had mistaken the *H. vegetum* specimen for his *D. virescens* as a result of only macroscopic examination. Sivanesan (1984) took up the binomial *Dematium virescens* Pers. for the anamorph of *Tubeufia cera* and transferred it into *Helicosporium* Nees as *Helicosporium virescens* (Pers.) Sivanesan. Since *D. virescens* predates *H. vegetum*, the binomial applied by Nees (1817) to the type species of his genus, *H. virescens* took priority over it. Goos (1989) followed Sivanesan (loc. cit.) in adopting the name *Helicosporium virescens* but was unaware (R. D. Goos, personal communication) that *Chloridium virescens* (Pers.) W. Gams & Hol.-Jech. was based upon the same basionym. No mention of this was made by Sivanesan (loc. cit.) either. Since Persoon's generic diagnosis of *Dematium virescens* reads "sporulis globosis aut ovalibus" it seems highly unlikely that he was describing *Helicosporium vegetum* and therefore it is reasonable to assume that the original specimen to which he applied the name *D. virescens* has been lost. Despite the fact that a specimen of *H. vegetum*, bearing the binomial *D. virescens*, exists in Persoon's herbarium, the use of this name for the *Helicosporium* seems questionable. The reasoning behind the decision of Gams and Holubova-Jechova (1976) to adopt the name *Chloridium virescens* for *C. viride* appears to be sound. The binomial *H. vegetum* should, therefore, be reinstated for the anamorph of *T. cera*. Persoon (1822) considered *D. virescens* and *C. viride*, to be conspecific. The specific epithet '*virescens* Pers.' was also recognized by Fries (1832) as having precedence over '*viride* Link'. Gams and Holubova-Jechova (1976) designated Link's holotype of *C. viride* [Rostock, Herb. Link (B)] as neotype of the species. The differences in the three taxa originally recognized as separate species lie in form and coloration of conidial aggregations at the tip of conidiogenous cells, occurring either as, in the case of *C. chlamyosporis*, heads, or as, in the others, elongated cirrhi. Cirrhi of *C. virescens* and *C. caudigerum* differ in the former, as the name indicates, being yellowish-green, whereas those of the latter are invariably whitish. In addition, these entities are distinguished by the precise shape and size, particularly length/width ratios, of their conidia. Their conidia vary in shape from more or less subglobose in *C. virescens* to ellipsoidal in the others.

Opinions as to the most appropriate classification of the above mentioned taxa have revolved around whether or not the three entities should be recognized as separate species, considered synonymous, or given subspecific taxonomic rank. Mangenot (1952) documented the differences distinguishing *C. caudigerum* [as *Cirrhomyces caudigerus* Höhn.] and *C. chlamydosporis* [as *Bisporomyces chlamydosporis* van Beyma]. These include mycelium pigmentation, chlamydospore characteristics, particularly whether solitary or in chains, as well as size and arrangement of conidia. Hughes (1958) accepted the distinctiveness of these taxa, transferring them into *Chloridium*, thereby making *Cirrhomyces* Höhn., and *Bisporomyces* van Beyma synonyms of that genus. This taxonomy was accepted by Ellis (1971), who used conidial size and arrangement to separate the three species. Tubaki (1963), Barron (1968), and Matsushima (1975) also treated *C. chlamydosporis* as a separate species and likewise *C. caudigerum* by Sivasithamparam (1975). Meyer (1959), however, considered *C. caudigerus*, *B. chlamydosporis* and *Sphaeromycetella leucocephala* Arnaud [now accepted as a synonym of *C. virescens* var. *caudigerum* (see Gams and Holubová-Jechová, 1976, and below)] to be synonymous. Gams and Holubová-Jechová (1976) reached a compromise between

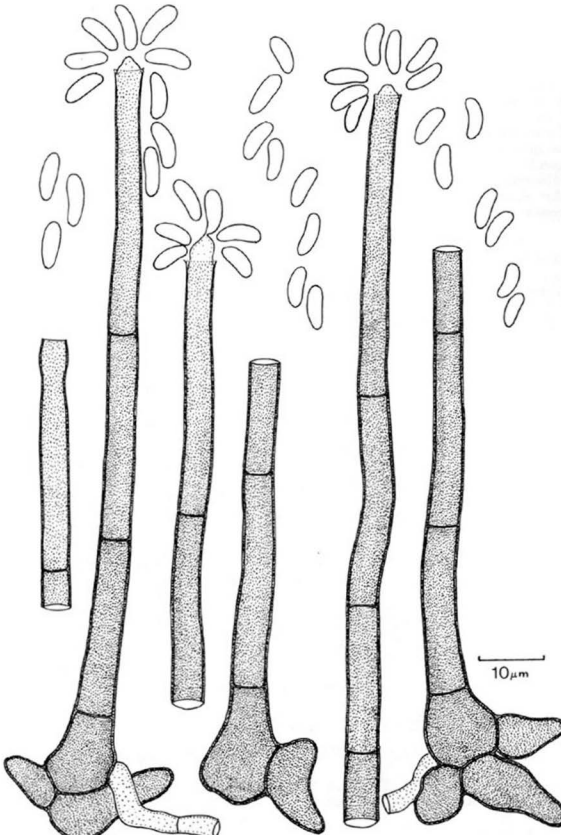

FIGURE 1. *Chloridium virescens* var. *allantosporum*. Conidiophores and conidia.

these positions by recognizing the differences between the taxa at varietal rank. Thus, three varieties were established; namely *C. virescens* var. *virescens* (autonym), var. *caudigerum*, and var. *chlamydosporum*.

Gams and Holubová-Jechová (1976) reported proving *Chaetosphaeria vermicularioides* (Sacc. & Roum.) W. Gams & Holubová-Jechová [≡ *Eriosphaeria vermicularioides* Sacc. & Roum.] to be the teleomorph of *Chloridium virescens* by isolating the fungus *in vitro* from ascospores. Furthermore, cultures from ascospores of three collections identified as *C. vermicularioides*, together with examination of eight additional herbarium specimens, showed that all three varietal forms are associated with the same teleomorph. In spite of consistent differences in the anamorph types, the fact that their connected teleomorphs are indistinguishable provides a compelling reason for classifying them as varieties of a single species.

During the course of collecting saprophytic, dematiaceous hyphomycetes on dead leaves and decorticated wood in southern Africa (Sinclair, 1990; Sinclair *et al.*, 1990), a number of *Chloridium* species have been encountered. These include *C. matsushimae* W. Gams & Hol-Jech., and two novel species, *C. smithii* Sinclair & Eicker and *C. transvaalense* Morgan-Jones, Sinclair & Eicker (Morgan-Jones *et al.*, 1983; Sinclair and Eicker, 1985). In addition to these, two collections of *C. virescens* have been made. One bears similarity to *C. virescens* var. *chlamydosporum* in possessing conidiophores at whose apex the meristematic conidiogenous tip protrudes a short distance beyond the terminal collarette, and in having narrowly ellipsoid conidia aggregated in heads. It differs from that, and the two other recognized varieties, however, in bearing longer conidia that are slightly curved and allantoid in shape. It differs from var. *chlamydosporum* also in lacking chlamydospores, or at least such structures are not present in the specimen examined , other than a few thick-walled, swollen, mid-brown cells proximal to the base of the conidiophores. Because of these differences, this collection, made in the Transvaal, is named and described herein as a fourth variety of *C. virescens*. The other collection, made in the Transkei, has been identified as C. virescens var. *caudigerum*, and is also described.

Chloridium phaeosporum W. Gams & Hol.-Jech., was described from a single collection made on rotten wood in Morgantown, West Virginia, and originally tentatively identified by its collector, H.L. Barnett, as '*Haplochalara* ?' (Gams and Holubova-Jechova, 1976). A second collection of this species, with conidiophores that are better developed, has been made in South Africa, and has provided an opportunity to give further account and illustration of it. A comparison with the type material has been made.

TAXONOMIC PART

Chloridium virescens var. *allantosporum* var. nov. (Figure 1).

A varietate typica conidiis allantoideis, 4 - 6 X 1.8 - 3.3 µm differt.

In ligno decorticato, Mariepskop, N.E. Transvaal, South Africa, September 1984, R.C. Sinclair, AUA, holotypus.

Colonies effuse, brownish black, rather sparse, thinly hairy. Mycelium mostly immersed in the substratum, composed of branched, septate, smooth,

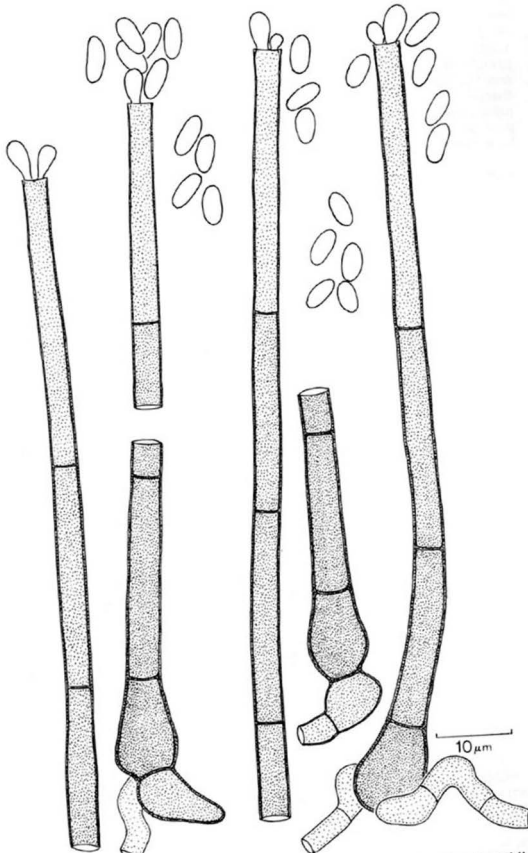

FIGURE 2. *Chloridium virescens* var. *caudigerum*. Conidiophores and conidia.

subhyaline to pale brown, 2 - 3 µm wide hyphae. Conidiophores macronematous, *mononematous, straight or very slightly flexuous, simple, cylindrical,* thick-walled, up to seven-septate, smooth, pale to mid brown, attenuating slightly and somewhat paler toward the apex, determinate or, very rarely, proliferating percurrently, 90 - 150 X 4 µm, wider, up to 5 µm, at the non-flaring apical collarette, often with a bulbous base, up to 8 µm wide. Stubby, thumb-like, swollen cells often projecting from the extreme base. Conidiogenous cells monophialidic, terminal, integrated, with a conical, meristematic extension protruding up to 4 µm beyond the collarette, giving rise to a sequence of conidia holoblastically in the manner of a sympodula. Conidia hyaline, smooth, unicellular, narrowly ellipsoid to mostly allantoid, accumulating in a compact, whitish, slimy mass at the tip of each conidiophore, often bi-guttulate, 4 - 6 X 1.8 - 3.3 µm. Chlamydospores absent.

On decorticated wood; South Africa.

Collection examined: Mariepskop, N.E. Transvaal, South Africa, September 1984, R.C. Sinclair, AUA, PREM 48911, type.

The conidia of *C. virescens var. allantosporum*, when viewed on a microscope slide, appear as a fan-shaped, radiating cluster, surrounding the protruding, fertile conidiogenous cell extension. This protrusion, as indicated above, is akin to that occurring in *C. virsecens* var. *chlamydosporum*, but is even more pronounced than in that taxon. The process of conidium ontogeny that gives rise to this morphology is similar to that in *Blastophorum truncatum* Matsushima, *Cacumisporum capitulatum* (Corda) Hughes, and *Chaetoblastophorum ingramii* Morgan-Jones (see Goos, 1969; Matsushima, 1971; Morgan-Jones, 1977). The conidiophores of var. *allantosporum* are similar in length to those of vars. *caudigerum* and *chlamydosporum*. Those of var. *virescens* tend to be shorter (see Ellis, 1971; Gams and Holubová-Jechová, 1976). In this regard, it should be noted that there are appreciable differences in conidiophore lengths cited in the literature. Gams and Holubová-Jechová gave no conidiophore dimensions for var. *caudigerum* but Höhnel (1903) gave their length as 100 - 160 µm. Mangenot (1952) stated that conidiophores of this variety can be up to 250 µm long *in vitro*. Those of our collection from South Africa (see below) are somewhat shorter. Van Beyma (1940) reported conidiophores of var. *chlamydosporum* to be 60 - 180 µm long, whereas Gams and Holubová-Jechová gave their length as 70 - above 100 µm, before proliferation. Mangenot (1952) stated that they may be as long as 600 µm *in vitro*.

Chloridium virescens var. *caudigerum* (Höhn.) W. Gams & Hol.-Jech., *Stud. Mycol.* 13: 19, 1976 (Figure 2).

≡ *Cirrhomyces caudigerus* Hohn., *Ann. Mycol.* 1: 529, 1903.

= *Sphaeromycetella leucocephala* Arnaud, *Bull. Trimest. Soc. Mycol. Fr.* 69: 274, 1953 [invalidly published because of lack of Latin diagnosis: Article 36 (ICBN)].

Colonies effuse, blackish, sparse, hairy. Mycelium mostly immersed in the substratum, composed of branched, septate, smooth, pale brown, 2 to 3.5 µm wide hyphae. Conidiophores macronematous, mononematous, more or less erect, mostly straight, simple, cylindrical but attenuating very gradually toward the apex, up to seven-septate, smooth, pale to mid brown, paler distally, 60 - 110 X 3

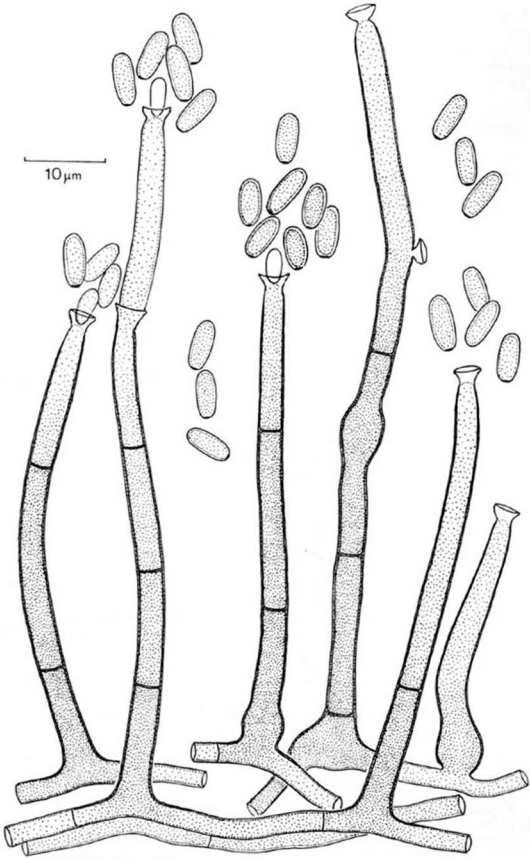

FIGURE 3. *Chloridium phaeosporum*. Conidiophores and conidia.

- 3.5 µm, somewhat bulbous and up to 7 µm wide at the base. Conidiogenous cell monophialidic, terminal, integrated, with a non-flared collarette at the extreme apex; conidiogenous loci below level of collarette. Conidia hyaline, smooth, unicellular, ellipsoidal, accumulating at the apex as a whitish cirrhus, 3 - 5 X 1.5 - 2.5 µm..

Collection examined; on dead wood, Mbotyi, Transkei, southern Africa, December 1982, R.C. Sinclair, AUA.

Varieties *caudigerum* and *chlamydosporum* are very close, differing only in a very slight difference in conidial size and the fact that the former bears conidia in cirrhi rather than heads. Gams and Holubová-Jechová (1976) stated that they are hardly distinguishable in culture. Both form chlamydospores and although in var. *chlamydosporum* these are produced more abundantly, this characteristic seems too variable to be a reliable criterion for differentiating the two. No chlamydospores were observed in the above described collection of var. *caudigerum*. Formation of cirrhi, as opposed to heads, seems also to be variable, dependent upon age and, in nature, possibly growth conidiotions. Young conidiophores at first bear conidia in heads, cirrhi only forming following production of many conidia. The collection from the Transkei is assigned to var *caudigerum* advisedly since no well-developed cirrhi could be observed. In it, however, conidia are formed from conidiogenous loci within the collaratte and not from an apical meristematic protrusion as is sometimes the case in var. *chlamydosporum* (see Gams and Holubová-Jechová, 1976). Persiani and Maggi (1990) recently described the same method and details of conidiogenesis in *Gonytrichum macrocladum* (Sacc.) Hughes and adopted the term 'sympodulophialides' coined by Hammill (1972) for conidiogenous cells of *C. virescens* var. *chlamydosporum* [as *C. chlamydosporis*]. When conidia are formed from conidiogenous loci at or just below the level of the collarette, as in varieties *virescens* and *caudigerum*, two conidia usually remain attached (see Figure 2) at the conidiophore tip when a microscope slide preparation is made. In var. *virescens*, the meristematic tip of the conidiogenous cell may sometimes protrude slightly above the collarette (Gams and Holubová-Jechová, 1976; Cole and Sampson, 1979). When van Beyma (1940) erected the genus *Bisporomyces* [based on *C. virescens* var. *chlamydosporum* = *Bisporomyces chlamydosporis* van Beyma], as the name indicates, this characteristic was noted. With regard to position of conidiogenous loci, var. *chlamydosporum* seems variable and there may well, therefore, be a continuum between it and var. *caudigerum*. Hammill (1972) also noted variability in the position of the conidiogenous apex in var. *chlamydosporum*. Whether or not position of the conidiogenous loci in relation to the collarette affects the final arrangement of the conidia is an interesting question. It may well be that when the meristematic, conidiogenous tip extends as a protrusion a short distance above the collarette, as in var. *allantosporum*, the conidia, as they are produced, tend to splay out and accumulate as a head, whereas when they originate slightly below the collaratte a columnar aggregation occurs.

Chloridium phaeosporum W. Gams & Hol.-Jech., *Stud. Mycol.* 13: 27, 1976 (Figure 3).

Colonies effuse, olivaceous brown, often dense, velvety to hairy, frequently in tufts. Mycelium partly immersed in the substratum, partly superficial and forming a loose felt, composed of branched, septate, smooth, pale to mid brown, 2 to 3.5 µm wide hyphae. Superficial hyphae sometimes

aggregated in strands of a few, generally thicker-walled and more pigmented than immersed hyphae. Conidiophores macronematous, mononematous, frequently arising more or less perpendicularly from the repent, superficial hyphae, erect, straight or slightly flexuous, simple, cylindrical, septate, smooth, pale to mid brown, progressively paler and attenuating gradually toward the apex, determinate or, occasionally, proliferating percurrently, or, more rarely, sympodially, 26 - 58 X 2 - 3.5 µm, following proliferation up to 74 µm in length. Conidiogenous cells monophalidic or, where sympodial, polyphialidic, terminal, integrated, more or less cylindrical, constricated abruptly immediately below the collarattes. Collarettes cupulate, 1 - 2 µm wide, 1.5 - 2.5 µm deep, with a conidiogenous locus at the base, displaced laterally following sympodial growth and lying sideways on the conidiogenous cell. Conidia very pale olivaceous brown, smooth, unicellular, ellisoidal to oblong, obtuse at the apex, with a dark hilum at the subtruncate base, aggregated in heads, 3 - 6 X 1.5 - 2.5 µm.

Collections examined: on appreciably decayed wood, Morgantown, West Virginia, U.S.A., May 1953, H.L. Barnett, DAOM 40413, holotype; on dead wood, Golden State Highlands National Park, Orange Free State, South Africa, March 14, 1979, R.C. Sinclair, AUA.

Chloridium phaeosporum is unique in the genus in having pigmented conidia. It is classified in section *Gongromeriza* (Preuss) W. Gams & Hol.-Jech. because of possession of pronounced collarettes and percurrently proliferating phialides. The fact that these can also proliferate sympodially is a feature that it shares in common with members of section *Psilobotrys* (Sacc.) W. Gams & Hol.-Jech.

ACKNOWLEDGMENTS

We thank Dr. J. Ginns, Curator, National Mycological Herbarium, Biosystematics Research Centre, Ottawa, Canada, for the opportunity to examine the type of *C. phaeosporum* housed in DAOM. Dr. Roger D. Goos, Department of Botany, University of Rhode Island, Kingston, reviewed the manuscript, for which we are grateful.

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MYCOTAXON

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SCOLICOSPORIUM PAUCISEPTATUM NOM. NOV.

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During the examination of fungi present on *Robinia*, a new species of the monotypic genus *Scolicosporium* Lib. apud Roum., was detected. This species is here described and illustrated.

Scolicosporium pauciseptatum O. Const., nom. nov. – Figs 1, 2.

Synonym: *Hendersonia fusarioiodes* Sacc. – Mycotheca veneta 998. 1876; also in Michelia 1: 213. 1878.

Conidiomata immersed, appearing as brown to dark brown, discoid bodies, c. 200 μm diam, stromatic, base composed of thick–walled, brown cells, 4–10 μm diam, fertile part with paler cells with thinner wall. *Conidiophores* hyaline, simple or rarely branched, septate. *Conidiogenous cells* integrated, terminal, more or less cylindric, hyaline, annellidic, 6–10 x 2–3 μm. *Conidia* falcate, rarely sinuous, smooth–walled, (22–) 30–35 (–50) μm long, 3.5–5 μm wide in the median part, (3–) 5 (–7)– septate, olivaceous, terminal cells paler and with thinner walls, base truncate, 1.5–2 μm broad, apical cell subulate. *Teleomorph* unknown.

Type on decorticated wood of *Robinia pseudoacacia* L., Italy, Conegliano, May 1876, coll. C. Spegazzini (PAD! - lectotype; UPS! - isolectotype).

Additional specimens examined: (all under *Hendersonia fusarioides*, on *Robinia pseudoacacia*): Italy, near Conegliano, Aug. 1877, C. Spegazzini in Thümen, Herb. mycol. oec. 588 (UPS); ditto, summer 1877 in Thümen, Myc. univ. 1076 (PAD, UPS); France, Pyrénées centr., Bagnères-de-Luchon, summer, coll. Ch. Fourcade in Roumeg., Fungi sel. exs. 4751 (UPS).

The available epithet *fusarioides* could not be used in *Scolicosporium* because it is already preoccupied under *S. fusarioides* (Sacc.) B. Sutton, now considered a synonym of *Excipularia fusispora* (Berk. & Broome) Sacc. (Spooner & Kirk 1982).

Although several taxa have been described in *Scolicosporium*, the only accepted species is *S. macrosporium* (Berk.) B. Sutton (Spooner & Kirk 1982). *Scolicosporium pauciseptatum* differs from *S. macrosporium* by its much shorter (average 30–35 vs. over 100 μm) and narrower (3.5–5 vs. over 10 μm) conidia with fewer (av. 5 vs. over 10) septa. In addition, the length/width ratio of most of the median cells in mature conidia is <1 in *S.*

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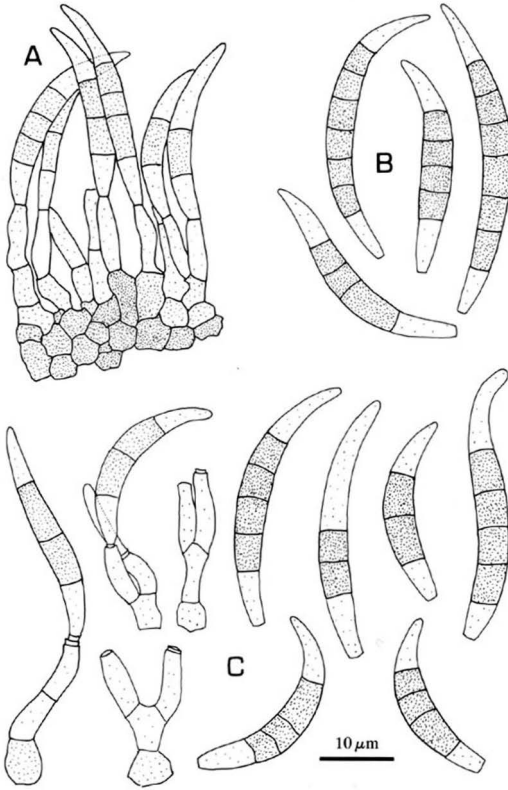

Fig. 1. *Scolicosporium pauciseptatum*. Conidioma, conidiogenous cells and conidia. A. From Sacc., Myc. veneta 998 (UPS). B. From Roumeg., Fungi sel. exs. 4751 (UPS). C. From Thümen, Myc. univ. 1076 (PAD).

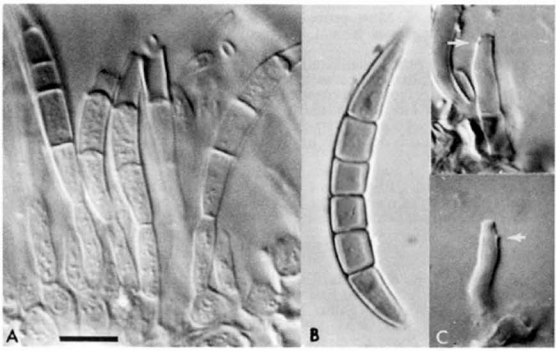

Fig. 2. *Scolicosporium pauciseptatum*. A. Conidioma. B. conidium. C. Conidiogenous cells. Arrows show the annellations. Bar = 10 μm.

macrosporium, but >1 in *S. pauciseptatum*. The annellidic condition of the conidiogenous cells in *S. pauciseptatum* is less visible in immature specimens (Figs 1A, 2A), as is the case with the type, but is obvious in fully developed ones (Figs 1C, 2C).

The genus *Scolicosporium* was placed by Sutton (1977, 1980) within the Coelomycetes although this fungus also shows Hyphomycetes affinity (Spooner & Kirk 1982). The conidioma of *S. pauciseptatum* exhibits the same intermediate pattern. It is embedded into the substratum, a character of a coelomycete, but it has a sporodochium–like structure and is not covered by the host tissue, which places it within hyphomycetous fungi.

Saccardo (1880: 120) suggested that *Hendersonia fusarioides* is the acervular state of *Coryneum fusarioides* Sacc. (now known as *Excipularia fusispora* (Berk. & Broome) Sacc.). This assumption was rejected by Sutton (1975: 110), and the studies by Spooner & Kirk (1982) clearly pointed out the different conidiogenesis patterns of these two fungi. During this study several coelomycetes were found on the pieces of substratum on which *S. pauciseptatum* is present but no connection could be traced between them and *S. pauciseptatum*. As the substratum consist of old, decorticated wood, these fungi are most probably colonizers.

As pointed out by Sutton (1975: 111) *Scolicosporium* is heterogeneous. Almost all described species belong to other genera. The taxonomic status of most species was commented upon or clarified by Sutton (1975), and Spooner & Kirk (1982). However, the following three taxa were left:

Scolicosporium barringtoniae Viennot-Bourgin – Bull. trim. Soc. mycol. Fr. 79: 108. 1963. Described from Madagascar as a leaf parasite of *Barringtonia racemosa*. Having 60–100 μm long, 'helicoidal' conidiophores and cylindric

to obclavate, 1–2-septate conidia, this is a *Cercosporidium*-like fungus rather than *Scolicosporium*. Most probably it is conspecific with *Cercosporidium barringtoniae-acutangulae* Kamal, Gupta & Verma (1987) described from India.

Scolicosporium gei Chona, Munjal & Kapoor – Indian Phytopath. 10: 154. 1957. Found in India on leaves of *Geum urbanum*. Its uniseptate conidia exclude this fungus from *Scolicosporium*.

Scolicosporium lactucae Munjal & Kapoor – Indian Phytopath. 16: 91. 1963. A parasite of *Lactuca* sp. in India, described as having uniseptate conidia. This fungus is definitely not related to *Scolicosporium*.

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STUDIES ON THE GENUS PHYLLOPORUS IN MEXICO, I. DISCUSSION OF THE KNOWN SPECIES AND DESCRIPTION OF A NEW SPECIES AND A NEW RECORD

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RESUMEN

Se describe a *Phylloporus guzmanii* Montoya & Bandala como especie nueva, la cual se distingue por la forma y tamaño de las basidiosporas, el color del píleo y el caracter cerulescente del contexto; dicha especie se distribuye en los bosques de *Pinus* y *Quercus*, en los Estados de Guerrero, México y Morelos. Además, se registra a *P. centroamericanus* Sing. & Gómez por vez primera de México en bosques subtropicales del Estado de Veracruz. Por otra parte, se presenta una discusión sobre las especies del género previamente citadas en México.

ABSTRACT

Phylloporus guzmanii Montoya & Bandala is described as new. It is distinguished by the shape and size of the basidiospores, the pileus color and the bluing of the context. It occurs in *Pinus* and *Quercus* forests in the States of Guerrero, Mexico and Morelos. In addition, *P. centroamericanus* Sing. & Gómez is reported for the first time from Mexico where it occurs in subtropical forests from the State of Veracruz. A brief discussion of the previously known species of the genus that occur in Mexico is also included.

INTRODUCTION

The examination of several collections made by the authors and exsiccati from the herbaria at ENCB, FCME and XAL has resulted in the discovery of two new records of *Phylloporus* in Mexico, one of which is new. Microscopic study was carried out with material mounted in 5 % KOH and Melzer's reagent. Colors indicated in the descriptions are taken from the color chart of Kornerup and Wanscher (1984).

Phylloporus IN MEXICO

There are only a few references to this genus from Mexico in the literature. It has been reported mainly from subtropical forests where it is associated with *Quercus* at altitudes of 1000-2000 m and, in a few cases, in *Pinus* or *Abies* forests at altitudes above 2500 m. *P. rhodoxanthus* (Schw.) Bres. ssp. *rhodoxanthus* was the first species to be reported from this country (Singer, 1957; Guzmán, 1977). It is known from several localities in Mexico, particularly from the States of Hidalgo (Frutis & Guzmán, 1983), Jalisco (Téllez-Bañuelos *et al.*, 1988), Michoacán (Díaz-Barriga, *et al.*, 1988), Nuevo León (García & Castillo, 1981; Garza *et al.*, 1985) and Veracruz (Guzmán, 1975; Welden & Guzmán, 1978; Guzmán & Guzmán-Dávalos, 1984).

Other species of *Phylloporus* known to occurr in Mexico are *P. bellus* (Masc.) Corner, reported from Oaxaca (Singer, 1978); *P. coccineus* Corner, from Guerrero (Pérez-Ramírez *et al.*, 1986) which will be discussed below, and *P. phaeoxanthus* var. *simplex* Sing. & Gómez and *P. foliiporus* (Murr.) Sing., both from Veracruz (Singer & Gómez, 1984; Montoya-Bello *et al.*, 1987). Some of the Mexican collections of *P. rhodoxanthus* ssp. *rhodoxanthus* have been reported to have flesh which turns blue when exposed, so they belong to *P. rhodoxanthus* complex but are not conspecific with ssp. *rhodoxanthus*, since Murrill (1946), Corner (1970), Singer (1978), Singer *et al.* (1983) and Singer & Gómez (1984) reported the absence of this character in ssp. *rhodoxanthus*.

SPECIES STUDIED

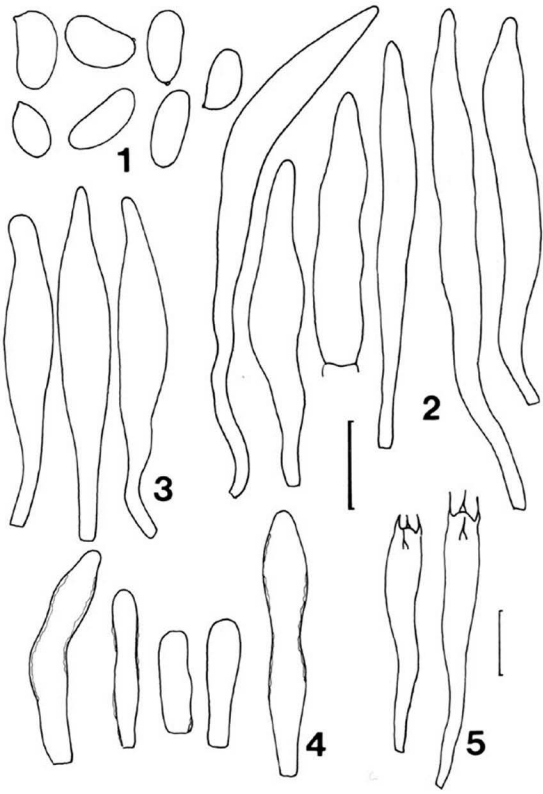
Phylloporus guzmanii Montoya & Bandala *sp. nov.*

Figs. 1-5 & 11-12

Pileo vinaceum, purpureum, rufobrunneum, parce flavobrunneum, subtomentoso, convexo vel applanato, 15-45 (-71) mm lato. Lamellis flavis, viridantibus, subdecurrentibus, subdistantibus et moderatim intervenosis. Stipe pilei concolor, lentis subtomentoso, aequali, 25-50 (-65) x 4-8 mm; velo nulo; mycelio basali flavo. Carne flava, caerulescentes; odore et sabore debil. Sporis (6.4-) 7.2-8.8 (-10.4) x (3.2-) 4-4.8 (-5.6) µm, subellipsoidis vel subglobosis, sub microscopio flavovirens, inamyloideis. Basidiis 47-65.6 x (5.6-) 7.2-8 µm, tetrasporis, claviformibus. Pleurocystidiis (41.6-) 45-105.6 (-116.8) x 5.6-11 (-12) µm, lanceolatis, subfusiformibus vel sublageniformis, flavovirens, tenuitunicatis. Cheilocystidiis 72-80.4 x 6.4-11.2 µm, pleurocystidiis similis. Epicute pilei trichodermium, sublaxus sed non gelatinoso, hiphis elongatis 2.4-3.2 (-4.8) µm crassis. Tramate hymenophorali bilaterali. Hyphis afibulatis. State of Guerrero, Prope Chilpancingo, Omiltemi, sub Pinus-Quercus. Typus Pérez-Ramirez 565 (FCME; Isotipus XAL).

Pileus 15-45(-71) mm in diam., convex to plano-convex, margin undulated, surface velutinous to tomentose, vinaceous red (10D8, 9F7, 9F8), dark purple (10F8) to reddish brown or ferruginous brown (8C8, 8D8, 8F8), with yellowish or yellowish brown tinges. Lamellae decurrent, close to subdistant, intervenose in mature specimens, never poroid, bright yellow (4A7, 4A8, 5A7) to mustard yellow (4B7), bluing (23 F8-24F8) when bruised, bluing areas finally staining reddish brown (7F8, 8E8); margin entire, sometimes with vinaceous red tinges when dried. Stipe 25-50(-65) x 4-8 mm, cylindric, subfibrillose to subvelutinous, concolorous with pileus to brownish (6E6) at base and purplish (9E8, 10D8) toward the apex, sometimes with irregular yellowish tinges; basal mycelium yellow. Context pale yellow (3A5) to mustard yellow (4B7), bluing (23F8-24F8) when exposed. Odor and taste mild. Macrochemical reactions unknown.

Spores (6.4-) 7.2-8.8 (-10.4) x (3.2-) 4-4.8 (-5.6) µm, subelliptic to subalantoid in lateral view, subglobose in frontal view, greenish to yellowish green in KOH, inamyloid, smooth, slightly thick walled (up



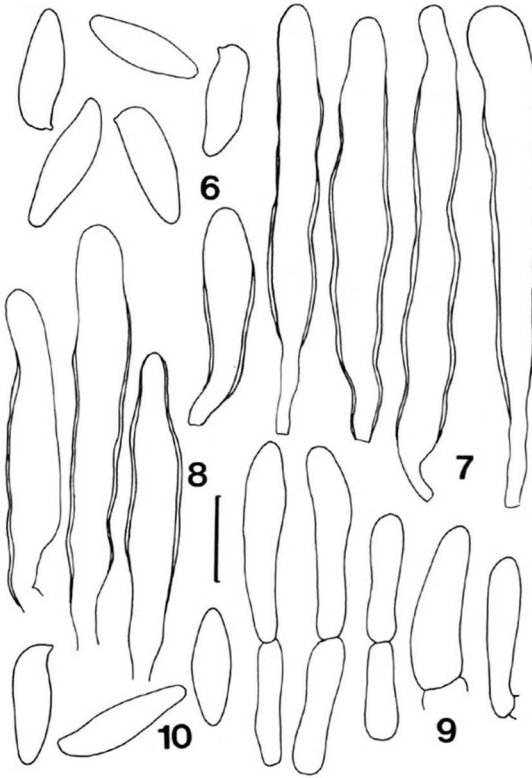
Figs. 1-5: *Phylloporus guzmanii*, 1: spores, 2: pleurocystidia, 3: cheilocystidia, 4: epicutis elements, 5: basidia (all from type) (scale bar, 1= 10 µm; 2-4= 20 µm; 5= 15 µm).

to 0.8 µm thick). Basidia 47-65.6 x (5.6-)7.2-8 µm, clavate, tretrasporic, hyaline, thin walled. Pleurocystidia (41.6-) 45-105.6 (-116.8) x 5.6-11 (-12) µm, lanceolate, subfusiform or sublageniform, often with constrictions, thin walled. Cheilocystidia 72-80.4 x 6.4-11.2 µm, yellowish green, similar to pleurocystidia. Context hyphae 3-8.8 µm wide, cylindric, interwoven, yellowish hyaline, sometimes with dense yellowish content, thin walled, some with pale yellowish green incrustations 0.8(-1.6) µm thick. Hymenial trama bilateral; hyphae yellowish to hyaline, (3.2-)4.8-10 µm wide, thin walled, sometimes with pale yellowish green incrustations which cause the walls to appear thickened. Subhymenium hyphae 2.4-3.2 (-4.8) µm wide, yellowish. Pileus cuticle a trichodermium, with interwoven or suberect chains of elements, tinged yellowish; terminal elements, subclavate to subcylindric, (20-) 22-78 (-80) x 5.6-9.6 µm, thin walled, some intercalary elements with incrustations 0.8(-1.6) µm thick. Hyphae clampless, exuding an intense yellow pigment in KOH.

HABITAT. Terrestrial in subtropical (mesophytic), *Pinus-Quercus* and *Pinus* forests, between 2000 and 2200 m in altitude.

SPECIMENS EXAMINED. STATE OF MEXICO, 10 km from Valle de Bravo, road to Temascaltepec, Guzmán 21880 (ENCB). GUERRERO, Municipio de Taxco, km 2 deviation to Cerro del Huizteco, Wong & Pérez-Ramírez 603 (FCME). Municipio de Chilpancingo, Omiltemi, Pérez-Ramírez 565 (Holotype, FCME; Isotype XAL); Uribe, Aug. 13, 1984 (FCME). MORELOS, Valle del Tepeite, NW Santa María, Valenzuela 4276 (ENCB).

DISCUSSION. This species is characterized by the distinctive shape of the spores, color of the basidiocarp, and the bluing of the context. *Phyllopporus coccineus* Corner from Africa is closely related but is distinguished by the noticeably subglobose spores [7.5-9 (-10) x 6.5-7.5 (-8) µm], broader pleurocystidia (10-18 µm), larger cheilocystidia (-200 x 10-16 µm) and shorter epicutis elements (25-40 µm long) (Corner, 1970). The collections Pérez-Ramírez 565, Uribe, s. n., Aug. 13, 1984 and Wong & Pérez-Ramírez 603 were originally thought to be *P. coccineus Corner* by Pérez-Ramírez *et al.* (1986).



Figs. 6-10: *Phylloporus centroamericanus*. 6 & 10: spores, 7: pleurocystidia, 8: cheilocystidia, 9: epicutis elements (6-9: Montoya 555; 10: Guzmán 29147) (scale bar, 6 & 10= 10 µm; 7-9= 20 µm).

This species is named in honor to Dr. Gastón Guzmán in commemoration of his thirty-five years of dedication to Mexican mycology.

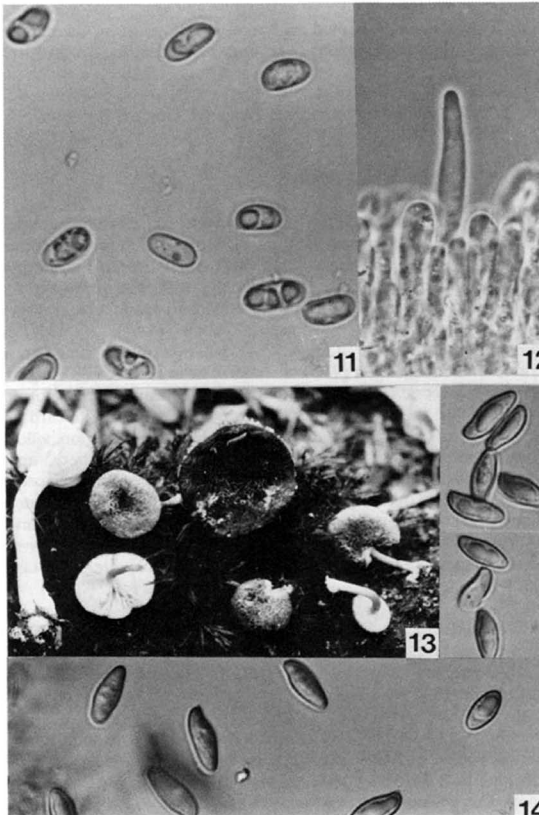
Phylloporus centroamericanus Singer & Gómez, Brenesia 22:169, 1984.

Figs. 6-10 & 13-16

Pileus 7-50 mm diam., plano convex, sometimes depressed toward the disc, dark brown (6F4, 8F4), brown (8F5) or ligth brown with reddish or pinkish tinges (8E6, 8F4), paler toward the margin, velutinous in young basidiocarps, areolate with age revealing the yellow (3A3, 3A5) context. Lamellae adnate to subdecurrent, close, greenish yellow (2A8) or mustard yellow (4A7), slowly or instantaneously bluing (23F8-24F8) when bruised, blue areas eventually staining brown (7F8) to reddish brown (8F8, 9F8); slightly intervenose becoming more so in mature basidiocarps, never poroid. Stipe 16-55 (-65) x 3-7 (-9) mm, cylindric to slightly bulbose toward the base, sometimes sinuous, striate and pruinose in apical region, villous at base to more or less fibrillose-squamose elsewhere, leathery, apex concolorous with lamellae to brown (6F8), reddish brown or vinaceous brown (7F8, 9F8) otherwise, basal mycelium white or whitish. Context yellow (3A6) or pale yellowish brown (5E7) at stipe base, sometimes with irregularly reddish (8E5-8E4) or vinaceous (9F8) stains all over, and sometimes irregularly bluing (23F8-24F8). Odor agreeable; taste mild. Basidiospores olivaceous (4E8, 4F8) in mass.

MACROCHEMICAL REACTIONS. 14 % NH4OH blue (23F8) on the pileus surface, sometimes negative in usually young basidiocarps or only darkening vinaceous brown (11F4). Pileus surface darkening with 5 % KOH.

Spores (8.8-) 11.2-15.2 (-17.6) x 4-4.8 (-5.6) µm, subfusiform, greenish yellow in KOH, smooth, slightly thick walled (-0.8 µm), inamyloid. Basidia (30.4-) 32-48 x 7.2-10.4 µm, tetrasporic, subclavate, smooth, thin walled. Pleurocystidia (48-) 60-127.9 x (9.6-) 12-16 (-22.4) µm, clavate or subfusiform with constrictions, incrusted, appearing thick walled, apex and base naked, incrustations 0.8-3.2 µm thick; base cylindric (4-) 4.8-8 (-9.6) µm in diam. Cheilocystidia (28-) 50.4-96 (-



Figs. 11-14.- 11-12: *Phylloporus guzmanii*, 11: spores, 12: pleurocystidium (from type; x 400). 13-14: *P. centroamericanus*, 13: basidiocarps (Montoya 1433), 14: spores (Ventura 5608, x400).

97.6) x (9.6-) 12-18 (-20) µm, versiform or similar to pleurocystidia; incrustations 0.8-2.4(-3.2) µm thick, sometimes in patches; base subcylindric, 4.8-8.8 µm wide. Pileus cuticle with interwoven or suberect chains of elements; terminal elements (17.4-) 20-66.6 (-86.2) x (5.6-) 6.4-17.7 (-20.5) µm, subcylindric, some subovoid or subpyriform; some intercalary elements 14.6-18.4 x 11.2-12.8 µm, yellowish or yellowish green, often with yellowish to yellowish orange incrustations. Context hyphae (2.4-) 4.8-14.4 (-16.6) µm, interwoven, yellowish hyaline. Hymenial trama bilateral, hyphae 3.9-14.7 (-16.6) µm wide, yellowish hyaline. Hyphae clampless.

HABITAT. Terrestrial among mosses, often in sandy soil, in subtropical (mesophytic) forests associated with *Quercus*, at 1300-1860m altitude.

SPECIMENS EXAMINED. MEXICO: STATE OF VERACRUZ, 4 km by the deviation to Plan de Sedeño, road Xalapa-Perote, Ventura 5608. 2 km SW from Xalapa, near Coapexpan River, Bandala 1351, 1363, 1367, 1370; Guzmán 29147; Montoya 1397, 1398, 1431. Mpio. de Banderilla, SW Banderilla, Cerro de La Martiníca, Montoya 555; Ortega 11 (all in XAL). COSTA RICA: San José, La Perla, Gómez & Alfaro 20630 (FM).

DISCUSSION. This is the first report of *P. centroamericanus* from Mexico. Singer & Gómez (1984) described the species from Costa Rica. The Mexican material not only agrees well with their description but also with data taken from a specimen studied by them, except, perhaps for the cystidia which are more consistently incrusted.

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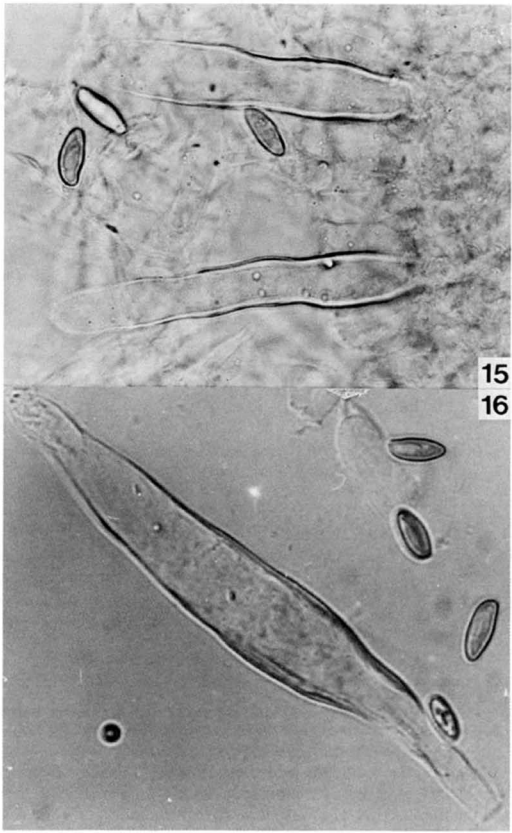
The authors express their thanks to Instituto de Ecología and to Sistema Nacional de Investigadores at Mexico for the support given to their researches. Appreciation is also given to Dr. Gastón Guzmán from Instituto de Ecología and Dr. Harry D. Thiers from San Francisco State University, who kindly and critically discussed and revised the manuscript. They also wish to express their gratitude to the curators of the herbaria ENCB, F and FCME for the loan of specimens.



Figs. 15-16: *Phylloporus centroamericanus*, pleurocystidia (15: Gómez & Alfaro 7-1983, x450; 16: Montoya 555, x400).

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TAXONOMICAL STUDIES ON USTILAGINALES. VIII.*

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ABSTRACT

NEW SPECIES proposed: Ustilago gardnerii McKenzie & Ványky (type on Cyperus ustulatus); Ustilago onopordi Ványky (type on Onopordum bracteatum subsp. ilex).

NEW COMBINATION proposed: Ustilentyloma brefeldii (Krieger) Ványky, based on Entyloma brefeldii (type on Phalaris arundinacea).

The following names are considered SYNONYMS: Urocystis castellana (González Fragoso) Zundel (type on Agrostis castellana) is Entyloma dactylidis (Passerini) Ciferri, s. lat. (type on Dactylis glomerata); Urocystis multispora Wang (type on Stipa sp.) is Urocystis granulosa G. P. Clinton (type on Stipa comata); Tuburcinia ranunculi-muricati Viennot-Bourgin (type on Ranunculus muricatus) is Urocystis ranunculi (Libert) Moesz (type on Ranunculus repens); both Ustilago arthurii Hume (type on Panicularia americana), and U. scolochloae Griffiths (type on Scolochloa festucacea) are synonyms of Ustilago echinata Schröter (type on Phalaris arundinacea).

LECTOTYPES are selected for Entyloma podospermi Unamuno & Ciferri, and for Ustilago scitaminea H. Sydow.

On Cruciferae three species of Urocystis are recognized: U. coralloides Rostrup, U. sophiae Griffiths, and U. brassicae Mundkur.

EXCLUDED SPECIES: Sporisorium maydis Cesati (type on Zea mays) is Aspergillus sp.; Thecaphora aurantiaca Fingerhuth (type on Urtica dioica) is a Puccinia sp. (aecia of P. urticae-caricis Klotsch, s. lat., or P. iridis (DC.) Wallroth); Thecaphora pallescens Fingerhuth (type on "Fragaria collina" =? Potentilla sp.) is probably aecia of Frommeella tormentillae (Fuckel) Cummins & Y. Hiratsuka (Uredinales); Tilletia nigrifaciens Langdon & Boughton (type on Phragmites australis) is an ascomycete.

Since finishing the manuscript of my book, European Smut Fungi, I am continuing taxonomical and nomenclatorial investigations of this interesting and economically important group of plant parasitic fungi, in order to pave the way towards a world monograph of Ustilaginales. New results obtained are presented in this current paper, one of a series.

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*Studies in Heterobasidiomycetes, part 89

Entyloma on Scorzonera.

Ciferri (1933:260) published Entyloma podospermi Unamuno & Ciferri on Podospermum laciniatum (L.) DC. (= Scorzonera laciniata L.). In the protologue two syntypes are mentioned: "Ribera de Ortiz, prope Vallisoleti, leg. P. R. Fernandez, V-VI.1926; Caudete, prope Albacete, Hispania, leg. P. Unamuno, IV.1928." In Herbarium MA (Madrid) there are two collections preserved (both under No. 7741). One is identical with the second syntype. The few leaves are heavily infected by aecia of Puccinia podospermi, and apparently devoid of any sori of Entyloma. The other collection is labelled: "Entyloma podospermi Unam. cum Puccinia podospermi in foliis Podospermi laciniati, prope Valladolid ap. fl. Pisuerga, VI.1926, coll. P. Unamuno, Typus." This specimen is more abundant and, besides telia of P. podospermi, contains sori of Entyloma. It is selected here as lectotype. A description of this species, based on the lectotype, is as follows:

Entyloma podospermi Unamuno & Ciferri, in Ciferri, 1933:260.

Lectotype on Scorzonera laciniata L., Spain (sel. here), near Valladolid, at the Pisuerga River, VI.1926, coll. P. Unamuno (MA!). Sori in leaves as small, rounded or angular, yellowish, amphigenous spots, 3–5 mm in diameter. Spores more or less crowded, subglobose to subpolyhedrally irregular, 7–12 x 8.5–14.5 µm, subhyaline to pale yellowish-brown; wall smooth, two-layered, 1–1.5(–2.5) µm thick, equal to slightly unequal.

Urocystis species on Stipa.

Several Urocystis have been reported on Stipa. The following four species can be distinguished:

1. U. fraserii G. P. Clinton & Zundel, in Zundel, 1939:1018. – Type on Stipa comata Trin. & Rupr., Canada, Saskatchewan, Saskatoon, 5.VI.1922, W. B. Fraser & J. W. Scannell (BPI 182124!).

2. U. granulosa G. P. Clinton, 1902:151. – Type on Stipa comata Trin. & Rupr., USA, Idaho, 1859, F. V. Hayden (BPI 182149!).

3. U. stipae McAlpine, 1910:198. – Type on Stipa luehmanni Reader, Australia, Victoria, Mallee, X.1898, C. French.

4. U. corsica (Mayor & Terrier) Vánky, 1982:12. – Sorosporium corsicum (Mayor & Terrier) Guyot & Massenot, in Guyot, Malençon & Massenot, 1969:208. – Type on Stipa tortilis Desf. (= S. capensis Thunb.), Corsica, near Ile-Rousse, VIII.1957, E. Mayor.

U. multispora Wang, 1962:136 (Type on Stipa sp., China, Tsinghai, Char-han-wu-su, alt. 3800 m, 6.VIII.1959, Ma Chi-ming & Hsing Juen-chuang 1304, HMAS 26443; isotype in HUV 7988!) is conspecific with U. granulosa G. P. Clinton.

The main differentiating characters of these species are:

1. Spores per spore ball 1–10 2
– Spores per spore ball 6–20 3
2. Sori in the spikelets. Spores per spore ball 1–10 ..... U. granulosa
– Sori in the leaves and stems. Spores per spore ball 1–5(–7) ..... U. stipae
3. Sterile cells inconspicuous, thin-walled (0.5 µm). Sori in upper parts of the stems and rachis of the inflorescence ..... U. fraserii
– Sterile cells conspicuous, thick-walled (1.5–3 µm). Sori in uppermost leaves and aborted inflorescence ..... U. corsica

Urocystis species on Cruciferae.

Four Urocystis (Tuburcinia) have been described on Cruciferae, all producing galls on the roots: U. coralloides Rostrup (type on Turritis glabra); U. sophiae Griffiths (type on Sophia andrenarum); U. brassicae Mundkur (type on Brassica campestris); and Tuburcinia coralloides (Rostrup) Liro var. cantonensis Ciferri (type on Brassica sp.).

The first of these to be described was Urocystis coralloides on the roots of Turritis glabra (Rostrup, 1881:126).

Griffiths (1907:209) describing U. sophiae from the roots of Sophia andrenarum, did not mention the earlier published U. coralloides. Ciferri (1957:93) studied the type of U. sophiae and considered that "it is allied with U. coralloides, the differences being of the same order of the fungus on Brassica in India and in China".

Mitra (1928) reported U. coralloides on Brassica campestris from India. On the basis of differences in the size of the spore balls, spores and sterile cells between the Brassica-smut and the type of U. coralloides, and because infection experiments with spores of Brassica-smut on Turritis and Matthiola gave negative results, Mundkur (1938) described the smut on Brassica as a new species, U. brassicae. My study of the types of U. coralloides and U. brassicae confirms that U. brassicae has spore balls composed of more spores than those in U. coralloides.

Ciferri (1957) studied a specimen of Urocystis on the roots of a Brassica sp. from China. Despite stating that the Chinese specimen "agrees with Urocystis brassicae Mundkur", Ciferri described it as a new variety, var. cantonensis. Ciferri's statement that "The peripherical, sterile cells are about the same number and about the same size of the fertile spores" is evidently erroneous and is in contradiction with what he wrote a few lines below: "The fertile spores are 13–17 µ diam., as a rule 14–16 µ, and the sterile cells smaller, 3–8 µ diam, as a rule 3–5 µ". "Either for biological or biometrical characteristics" Ciferri (1957:93) considered all known species of Urocystis on Cruciferae to belong to Tuburcinia coralloides as "infraspecific taxa" (var. coralloides, var. sophiae, var. brassicae, var. cantonensis).

1. Urocystis coralloides Rostrup, 1881:126.

Tuburcinia coralloides (Rostrup) Liro, 1922:86. – Type on Turritis glabra L., Denmark, Funen, Vejstrup, Aaskov, 5.VI.1880, E. Rostrup (C; isotype HUV 9122!).

"Ustilago coralloides (Rostr.) Rostr." is sometimes cited as synonym of Urocystis coralloides. However, Rostrup never made this combination and the binomial "Ustilago coralloides Rostr.", in Rostrup, 1885:235, is a slip of the pen.

Sori on roots as globose to coralloid galls up to 4 cm in diameter, filled with an agglutinated, black mass of spore balls, hyphae and remnants of host tissue. Spore balls globose, ovoid to irregular, 25–40 x 28–52 µm, composed of 1–4(–5) spores surrounded by a continuous layer of dark, sterile cells. Spores globose, ovoid to elongated, often slightly irregular, 11–19 x 16–25 µm, dark reddish-brown. Sterile cells subglobose to irregular, 5–16 µm long, dark yellowish- or reddish-brown, with smooth, 1.5–4 µm thick wall.

Known on Arabis (incl. Turritis), Lepidium, Matthiola, from Europe.

2. Urocystis sophiae Griffiths, 1907:209.

Type on Sophia andrenarum Cockerell (= Descurainia a. (Cockerell) Cory), USA, Arizona, Tucson, 14.III.1903 (BPI 182515!); paratype: 1.III.1901 (BPI 182516!).

U. sophiae differs from U. coralloides in having lighter coloured spore balls, composed of more spores (1–5), and by the thin-walled (1–2 µm), light coloured sterile cells which often form an incomplete layer around the spores, or sterile cells lacking in the spore balls.

3. Urocystis brassicae Mundkur, 1938:141.

Type on Brassica campestris L. (= B. rapa L.), India, Bihar, Pusa, I.1925, M. Mitra; isotypes in Herb. crypt. Ind. Orient. exs., II. Indian Ust. 32 (HUV 5779!).

U. brassicae has spore balls composed of 1–6(–8) spores, whereas in U. coralloides the spore balls have 1–4(–5) spores.

Known on Brassica rapa L. from Asia. Artificially also on B. juncea (L.) Czern., B. napus L., B. nigra (L.) Koch, B. rapa L. var. lorifolia Bailey, and Raphanus sativus L., Asia.

Probably to this species belongs also Tuburcinia coralloides (Rostr.) Liro var. cantonensis Ciferri, 1957:93. – Type on Brassica sp. cult., China, Canton, 1953.

Yellow-spored Ustilago species on Cyperaceae and Juncaceae.

In connection with a presumably unknown Ustilago species in the capsules of Cyperus ustulatus from New Zealand, kindly sent by Dr. E. H. C. McKenzie, I checked the Ustilago species on Cyperaceae and Juncaceae possessing yellow or light cinnamon-brown spore masses. These are:

1. U. subnitens Schröter & P. Hennings, in Hennings, 1896:215. – Type on Scleria pratensis Lindl., Brazil, Rio de Janeiro.

2. U. cyperi-lucidi Walker, 1971:99. – Type on Cyperus lucidus R. Br., Australia, New South Wales, W. of Pambula, Wyndham, 11.VII.1969, J. Hindle (DAR 17587/a; isotype in HUV 14062!).

3. U. capensis Reess, 1875:70; in Buchenau, 1875:486 + Pl. XI. – Type on Juncus capensis Thunb., and J. lomatophyllus Sprengel, South Africa, Cape of Good Hope (n. v.).

4. U. vuyckii Oudemans & Beijerink, in Oudemans, 1895:55. – Type on Luzula campestris (L.) DC., Netherlands, near Voorschoten, 22.V.1894 (L!, LE!).

5. U. abstrusa Malençon, 1929:256. – Type on Juncus gerardii Loisel., France, Dépt. Manche, Gatteville near Cherburg, 19.IX.1926, G. Malençon (MPU).

The fungus from New Zealand differs from these species, and is described here as:

Ustilago gardnerii McKenzie et Vánky, sp. nov.

Typus in matrice Cyperus ustulatus A. Rich. f. grandispiculosus Kük. ex Carse, New Zealand, North Island, Auckland, Western Springs Lake, 17.II.1989, leg. R. O. Gardner. Holotypus in PDD 57462!, isotypi in BPI & HUV 14850. Paratypi in matrice C. ustulatus, NZ: Auckland, Western Springs Lake, 1. & 15.V.1990, R. O. Gardner (PDD 57731 & 57624 = HUV 15156 & 15160); Taupo, Tokaanu, 5.V.1990, E. H. C. McKenzie (PDD 57584 = HUV 15157); Coromandel, Little Barrier Is., 8. & 10.V.1990, R. E. Beever (PDD 57625 & 57626 = HUV 15158 & 15159); Northland, Whangarei Heads, 31.V.1990, R. O. Gardner (PDD 57463 =HUV 14851).

Sori (Fig. 1) in nuculis tumefactis, massa pulverea pallide, ochraceo-flava sporarum, rupto pericarpio libera refertis. Sporae (Figg. 2, 3) subglobosae, ovoideae usque parum subangulariter irregulares, 13–18(–20) x 15–20(–21) µm, valde subtiliter minuteque interdum incomplete reticulatae, 10–15 maculis per diametrum sporarum, pariete addito reticulo, 2–2,5 µm crasso, muri reticuli 0,8–1 µm alti. Infectio plantarum systematica: nuculae omnes inflorescentiae affectae.

Sori (Fig. 1) in swollen nutlets, filled by a light ochraceous-yellow, powdery mass of spores exposed upon the rupture of the pericarp. Spores (Figs. 2, 3) subglobose, ovoid to slightly subpolyhedrally irregular, 13–18(–20) x 15–20(–21) µm, very finely and minutely reticulate, sometimes incompletely, 10–15 meshes per spore diameter, wall 2–2.5 µm thick including the reticulum, muri 0.8–1 µm high. Infection systemic, all nutlets in the inflorescence being affected.

U. gardnerii differs from U. cyperi-lucidi Walker (Figs. 4, 5) especially by smaller spores, thinner spore wall, and lower muri. In U. cyperi-lucidi the spores measure (12–)16–20(–24) x (15–)17–24(–26) µm, the spore wall is 2.5–4 µm thick, and the muri 1–2 µm high.

The main differences between these species are presented in the following key.

1. On Cyperaceae 2
– On Juncaceae 4
2. On Scleria. Spores smooth ..... U. subnitens
– On Cyperus. Spores very finely reticulate, 10–15 meshes per spore diam. 3
3. Spore wall 2.5–4 µm thick. Muri 1–2 µm high ..... U. cyperi-lucidi
– Spore wall 2–2.5 µm thick. Muri 0.8–1 µm high ..... U. gardnerii
4. On Luzula. Spores deeply reticulate (muri 1.5–2.5 µm high), 5–8 meshes per spore diam. ..... U. vuyckii
– On Juncus 5
5. Spores shallowly reticulate, 7–12 meshes per spore diam. ..... U. abstrusa
– Spores (judged from Rees' illustrations) deeply reticulate, c. 5 meshes per spore diam. ..... U. capensis

Ustilago species on Compositae.

Dr. Siraj Hasan kindly sent me some smutted Silybum and Onopordum. In connection with the identification of the fungi, I checked the known Ustilago species on Compositae. These are: 1. U. cardui Fischer von Waldheim, 1867:255 (type on Carduus acanthoides L.), 2. U. cichorii H. Sydow, 1929:413 (type on Cichorium intybus L.), 3. U. scolymi Roumeguère & Trabut ex Juel, 1901:257 (type on Scolymus hispanicus L.), 4. U. scorzonerae (Albertini & Schweinitz) Schröter, in Cohn, 1887:274 (type on Scorzonera humilis L.), and 5. U. tragopogonis-pratensis (Persoon) Roussel, 1806:47 (type on Tragopogon pratensis L.). The smut on Silybum marianum is referred to U. cardui, though the spores are somewhat smaller than those of the type specimen, a fact which is considered to lie within the variability of this species. The smut on Onopordum turned out to be an unknown species and it is described as:

Ustilago onopordi Vánky, sp. nov.

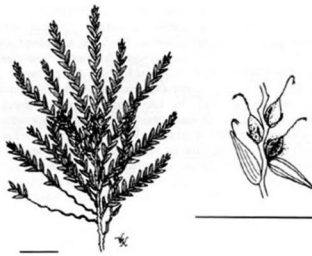
Typus in matrice Onopordum bracteatum Boiss. & Heldr. subsp. ilex (Janka) Franco (syn. O. ilex Janka; det. A. Shepard), Graecia, Thessalia div., Lárisa prov., pr. pag. Halkiades inter Lárisa et Farsala, 5.VII.1989, leg. D. T. Briese & A. Shepard, comm. S. Hasan (HUV 15101); isotypi in BPI, MPU.

Sori (Fig. 6) in floribus achaeniisque evoluti, eos massa sporarum pallide brunneolo-violacea pulverea partim substituentes. Flores omnes eiusdem inflorescentiae infectae. Sporae (Figg. 7, 8) subglobosae, ovoideae usque ellipsoideae, 13,5–17,5 x 14,5–20 µm, subhyalinae usque pallide flavido-brunneae, pariete alte reticulatae, (4–)5–7 maculis per diametrum sporae, muri maculorum 1,5–3 µm alti ad margines sporarum sicut aliae in sectione media autem sporarum sicut projectiones acutae spiniformes apparentes; sub SEM maculae plus-minus rotundatae vel subpolygonales, interstiis levibus. Germinatio (Fig. 9) cum basidio 4-cellulari (4–5 x 25–36 µm), basidiosporas 2–3,5 x 4–6 µm, ovoideas, laterales vel terminales gerenti. Post fusionem basidiosporarum vel cellularum basidii compatibilium, filamenta dicaryotica crescentes. In mediis nutrientibus artefactis e basidiosporis culturae illis fermentorum similes evolventes.

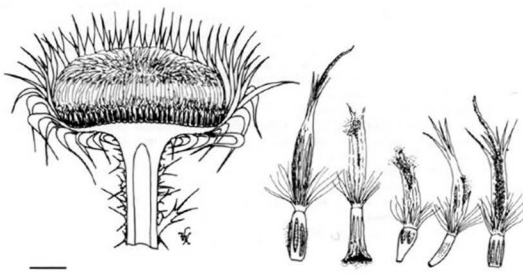
Sori (Fig. 6) in the flowers and seeds which are partly replaced by a pale brownish-violet, powdery spore mass. All flowers in a head are affected. Spores (Figs. 7, 8) subglobose, ovoid to ellipsoidal, 13.5–17.5 x 14.5–20 µm, subhyaline to pale yellowish-brown; wall deeply reticulate, (4–)5–7 meshes per spore diameter, muri 1.5–3 µm high appearing as wings on the spore margin, in median view forming acute, spiniform projections; in SEM meshes more or less rounded or subpolygonal, interspaces smooth. Germination (Fig. 9; on water-agar, at room temperature, in 2 days) results in four-celled basidia (4–5 x 25–36 µm) producing laterally and terminally ovoid basidiospores (2–3.5 x 4–6 µm). After fusion of compatible basidiospores or of basidial cells, dikaryotic filaments result. In nutrient media basidiospores give rise to yeast cultures.

The main differences between the Ustilago species of Compositae are presented in the following key.

1. Spore mass light. Muri in median view spiniform. On Onopordum. . U. onopordi
– Spore mass dark. Muri not so 2
2. Muri over 1.5 µm high. Spores uniformly pigmented 3
– Muri up to 1.5 µm high. Spores often lighter on one side 4
3. Muri in median view appear as radiate marginal wings. Meshes per spore diameter (4–)5–8(–9). On Carduus and Silybum . . . . . U. cardui
– Muri not so. Meshes per spore diameter 6–10. On Scolymus . . . . . U. scolymi
4. Spores 10–15 µm long. On Scorzonera . . . . . U. scorzonerae
– Spores 13–19 µm long 5
5. Interspaces with evident warts. On Tragopogon . . . . U. tragopogonis-pratensis
– Interspaces without or with inconspicuous warts. On Cichorium . . . U. cichorii



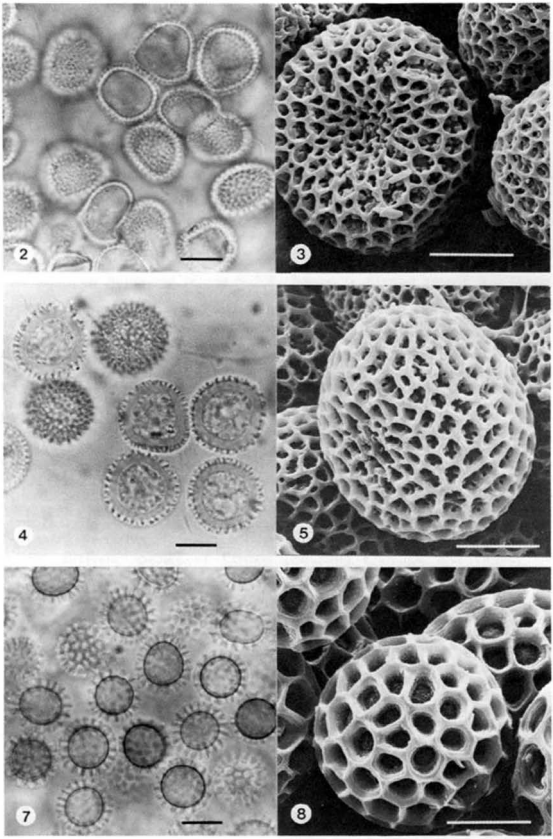
1



6

Fig. 1. Sori of Ustilago gardnerii in the nutlets of Cyperus ustulatus f. grandispiculosus (type. Bars = 1 cm).
Fig. 6. Sori of Ustilago onopordi in the flowers and seeds of Onopordum bracteatum subsp. ilex (type; bars = 1 cm).
Figs. 2, 3. Spores of Ustilago gardnerii (type) in LM and in SEM.
Figs. 4, 5. Spores of Ustilago cyperi-lucidi (type) in LM and in SEM.
Figs. 7, 8. Spores of Ustilago onopordi (type) in LM and in SEM.

(Bars of LM pictures = 10 µm, those of SEM pictures = 5 µm).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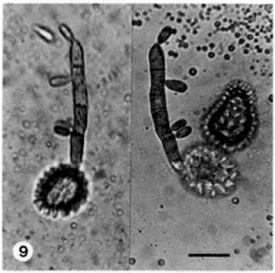

Fig. 9. Germinating spores of Ustilago onopordi (type) (bar = 10 µm).

Ustilago serpens and related species.

Several stripe smuts that were described on Gramineae have spores varying in ornamentation from coarsely echinulate to verrucose or semireticulate. Most of these species have turned out to be synonymous with previously described species. In some cases, the hosts of "new species" were actually misidentified plants. Ustilago arthurii Hume (1902; type on Panicularia americana), and U. scolochloae Griffiths (1904; type on Scolochloa festucacea) were merged by American mycologists under the older name. In spite of the statement by Griffiths (1904:86) that U. scolochloae is "Closely related to Ustilago echinata Schröt." (type on Phalaris arundinacea), they never had been critically compared. A study of the types of U. echinata and U. arthurii revealed no differences in the sorus and spore characteristics and, therefore, they are considered synonyms. In contrast, in spite of the variability in spore morphology, there are some differences between U. echinata and U. serpens (type on Elymus repens), two closely related species (e. g. higher and coarser spines in U. echinata). They were merged by some authors but I prefer to maintain them as separate species (comp. also Vánky, 1985:208). The synonyms and the main characters of these two species are:

1). Ustilago echinata Schröter, 1869:4. – Type on Phalaris arundinacea L., Germany, Schlesien, "Schwarzwasserbruch" near Liegnitz (= Poland, Legnica), VI.1869, W. G. Schneider; isotypes in Rbh., Fgi. eur. 1497 (HUV 3650!).

Ustilago verrucosa Vestergren, 1897:3, (later homonym; non U. verrucosa Schröter, in Hennings, 1896:214). – Ustilago baldingerae Vestergren, in Vgr., Micr. rar. sel. 13, 1899, January. – Ustilago vestergrenii Saccardo & P. Sydow, in Saccardo, 1899:413, August. – Type on Baldingera arundinacea (L.) Dumort. (= Phalaris arundinacea L.), Sweden, Gotland, Björlunds near Källunge, 4.VII.1896, T. Vestergren (HUV 5800!); topotype 9.VII.1898, in Vgr., Micr. rar. sel. 13 (HUV 3651!), and Sydow, Ust. 153 (as U. echinata; HUV 3652!).

Ustilago arthurii Hume, 1902:233. – Type on Panicularia americana (Torr.) MacM. (= Glyceria grandis S. Watson), USA, Iowa, Spirit Lake, 5.VII.1899, J. C. Arthur; isotypes in Seymour & Earle, Econ. fgi., Suppl. C. 135 (HUV 9723!).

Ustilago scolochloae Griffiths, 1904:86. – Type on Scolochloa festucacea (Willd.) Link, USA, Oregon, Harney Valley, Donner & Blitzen River, VII.1902, D. Griffiths & Hunter.

Ustilago arctagrostis Roivainen, 1953(1954):66 (without Latin diagn.), on "Arctagrostis" (sphalm. pro Arctophila) pendulina (Laest.) N. J. Andersson (=

misnamed Phalaris arundinacea, comp. Lindeberg, 1959:116), Finland, Ostrobottnia borealis, Tornio, 21.VII.1946, I. Karaila; in Liro, Mycoth. fenn. 790 (HUV 7720!).

Sori in leaf-blades and sheaths as long, often interrupted, conspicuous streaks; the youngest leaves develop typical undulations; the dark brown, semi-agglutinated to powdery spore mass is early exposed. Infection systemic, infected plants do not flower. Spores ovoid to globose, 10–16 x 12–18(–20) µm, olivaceous-brown, provided with conspicuous, irregular, conical, c. 1.5 µm high spines, in some specimens partly anastomosing and forming an irregular and incomplete reticulum.

On Phalaris arundinacea L., Scolochloa festucacea (Willd.) Link, and Glyceria grandis S. Watson: Europe, Asia, North America.

2). Ustilago serpens (Karsten) B. Lindeberg, 1959:133. – Tilletia serpens Karsten, in Karsten, Fgi. fenn. exs. 599, 1866. – Type on "Dactylis glomerata L." (= misnamed Elymus repens, comp. Lindeberg, 1959:133), Finland, Merimasku, VII.1862, P. A. Karsten, in Fgi. fenn. exs. 599 (UPS!).

Ustilago macrospora Desmazières, Pl. crypt. Fr., Ed. 2, ser. 1, 1727. 1850 (nomen ambiguum; comp. Nannfeldt, in Lindeberg, 1959:152).

Tilletia aculeata Ule, 1884:213. – Ustilago aculeata (Ule) Liro, 1915:34. – Lectotype on Agropyron repens (L.) P. Beauv. (= Elymus repens (L.) Gould), Germany, (sel. by Lindeberg, 1959:134) Bavaria, Coburg, Festung, VI.1879, E. Ule; isolectotypes in Rbh., Fgi. eur. 3603 (HUV 4488!).

Ustilago elymicola H. Sydow, 1934:286. – Type on Elymus canadensis L., USA, South Dakota, Northville, 12.VIII.1927, J. F. Brenckle; isotypes in Sydow, Fgi. exot. exs. 942 (HUV 4506!).

Ustilago michnoana Lavrov, 1936:17. – Lectotype on Elymus (sel. by Vánky, 1985:234) sibiricus L., USSR, E. Siberia, near Ust'-Kiran, 7.VII.1916, P. Mikhno (LE!).

Sori in leaves and sheaths as short to long streaks between the veins, usually confluent on the youngest leaves and distributed over the whole blade, at first dark lead-coloured, covered by the epidermis, later bursting, the dark brown, semi-agglutinated to powdery spore mass becomes scattered and the leaves often rupture longitudinally. Infection systemic, infected plants remain sterile. Spores ovoid to globose, 12–15(–17) x 13–19 µm, olivaceous-brown, coarsely verruculose, warts 0.5–1 µm high, often grouped or partly confluent; in SEM coarsely verruculose or echinulate, sometimes arranged in an almost reticulate pattern, and finely verruculose between the warts or spines.

On different species of Elymus (including Elytrigia and Clinelymus): worldwide.

NEW COMBINATION PROPOSED

Ustilentyloma brefeldii (Krieger) Vánky, comb. nov.

Basionym: Entyloma brefeldii Krieger, in Krieger, Fgi. saxon. 1104, 1896; Hedwigia 35:(145), 1896. – Type on Phalaris arundinacea L., Germany, Sachsen, Sächsische Schweiz, Polenzthal, near "Waltersdorfer Mühle", 25.VI.1892, 27.V. & 13.VI.1894, W. Krieger; isotypes in Krieger, Fgi. saxon. 1104 (HUV 9076!).

Entyloma sydowianum Ciferri, 1928:20 (nomen confusum, fide Liro, 1938:98, 385-386).

Entyloma poae Liro, 1938:92 (nomen illeg., diagn. german. tantum); 1939:112. – Lectotype on Poa pratensis L., (sel. by Lindeberg, 1959:33) Finland, Helsinki, Seurasaari, J. I. Liro (H); topotype (isotype?) 31.VII.1915, J. I. Liro (HUV 13460!).

The genus Ustilentyloma was instituted by Savile (in Savile & Parmelee, 1964:708) for a graminicolous, Entyloma-like fungus with a Ustilago (not Tilletia)-type germination (type Ustilentyloma pleuropogonis Savile on Pleuropogon sabinei R. Br.). Entyloma fluitans Liro on Glyceria species was the second graminicolous, Entyloma-like fungus with an Ustilago-type of

germination (Ustilentyloma fluitans (Liro) Vánky, 1970:328). It was suspected, by analogy, that other, light-spored graminicolous "Entyloma" species would have an Ustilago-type of germination, i. e. belong to the genus Ustilentyloma. Indeed, Liro (1938:93) described the spore germination of Entyloma poae Liro, a species morphologically indistinguishable from E. brefeldii. According to Liro the spores of E. poae germinated in water, after a few days, giving rise to four-celled promycelia. Each promycelial cell developed 2–3, up to 15 µm long, hyaline, cylindrical conidia which copulated by pairs.

Ustilentyloma brefeldii is characterised by sori in the leaves and sheaths as inconspicuous, long, whitish, pale green, yellowish or light brown striae along the veins. Infected shoots remain sterile. Spores globose, subglobose, ovoid or rarely irregular, 10–14 x 11–18 µm, subhyaline to light yellow; spore wall smooth, two-layered, even, 1.5–3 µm thick. Germination of Ustilago-type (Liro, 1938:93). Anamorph may be present. It is known from Europe and has been reported on: Arrhenatherum elatius (L.) P. Beauv. ex J. & C. Presl, Calamagrostis arundinacea (L.) Roth, C. canescens (Weber) Roth, C. purpurea (Trin.) Trin., and its subsp. phragmitoides (Hartman) Tzvelev (= C. phragmitoides Hartman), Elymus repens (L.) Gould (= Agropyron repens (L.) P. Beauv.), Holcus lanatus L., H. mollis L., Phalaris arundinacea L., and Poa pratensis L.

Key to the known Ustilentyloma species.

1. Spore wall thick (1.5–3 µm). On several genera of Poaceae ..... U. brefeldii
– Spore wall thin (0.5–1 µm) 2
2. Spores 8.5–15.5(–17) µm long. On Glyceria ..... U. fluitans
– Spores 11.5–19(–21) µm long. On Pleuropogon ..... U. pleuropogonis

SYNONYMS

Tuburcinia ranunculi-muricati Viennot-Bourgin = Urocystis ranunculi.

Viennot-Bourgin (1968:500) described Tuburcinia ranunculi-muricati and considered it to be different from Tuburcinia ranunculi (Libert) Liro "par les dimensions relatives des cellules fertiles par rapport aux cellules stériles, et aussi par l'organisation du glomérule." For his species, Viennot-Bourgin gave spore dimensions of 14–16 µm, and for those of sterile cells 4–8 µm. Comparing the types of T. ranunculi-muricati and Urocystis ranunculi (Libert) Moesz, I could not find any essential differences. In T. ranunculi-muricati Viennot-Bourgin (type on Ranunculus muricatus L., Iran, Gilan prov., Bandar-e Pahlavi, V.1967, coll. Mirkamali; IRAN, isotype HUV 15122!) the spores measure 11–15 x 12–21.5(–24) µm, the sterile cells 5–10.5(–13) x 8–17 µm, the number of spores per spore ball is 0–4 (0=1.5%, 1=56.5%, 2=34.5%, 3=6.5%, 4=1%). In Urocystis ranunculi (Libert) Moesz, 1950:213 (based on Sporisorium ranunculi Libert, Pl. crypt. Ard. Ed. 2, 195, 1832, type on Ranunculus repens L., France, Dépt. Ardennes; isotypes in Libert, Pl. crypt. Ard. Ed. 2, 195, HUV 9265!) the spores measure 10.5–15 x 12–22.5 µm, the sterile cells 6.5–10.5(–11) x 7–14.5(–16) µm, the number of the spores per spore ball is 0–5 (0=1.5%, 1=61%, 2=28.5%, 3=6.5%, 4=2%, 5=0.5%). Consequently, I consider Tuburcinia ranunculi-muricati Viennot-Bourgin to be a synonym of Urocystis ranunculi (Libert) Moesz.

Urocystis castellana (González Fragoso) Zundel = Entyloma dactylidis (Pass.) Cif. González Fragoso (1926:101) described and illustrated Tuburcinia castellana Gz. Frag. on Agrostis castellana Boiss. & Reuter, Spain, Guadarrama Mts., near El Aular, 1.VIII.1925, S. Corona (MA 1677!). The study of the type specimen, and of the illustration of the "spore balls", revealed that it is Entyloma dactylidis s. lat.

LECTOTYPIFICATION

When H. Sydow (1924:281) demonstrated that the sugarcane smut is different from Ustilago sacchari Rabenhorst (type on Erianthus ravennae), he described it as Ustilago scitaminea on Saccharum officinarum from East India, Java and the Philippines, without designating a type. As lectotype, I am proposing one of the

sugarcane smuts distributed in Sydow's exsiccata, namely that from E. India, Bhagalpur, Bengal, 26.VIII.1907, E. J. Butler (HUV 4454!); isolectotypes in Sydow, Ust. 384 (as Ustilago sacchari). Syntypes on Saccharum officinarum, Java, Djatibarang, 1898, M. Racoborski, in Sydow, Ust. 406 (as U. sacchari; HUV 4455!); E. India, Pusa, 20.II.1913, E. J. Butler, in Sydow, Fgi. exot. exs. 119 (as U. sacchari; HUV 4456!).

Ustilago scitaminea H. Sydow is characterised by: Sori in floral stems which are transformed into long, leafless, flagelliform, often curved bodies, basal part of the sori concealed by leaf sheath, free and tapering distally, first covered by a silvery membrane of host tissue which flakes away disclosing the blackish-brown, dusty mass of spores intermixed with irregular groups of sterile cells. Spores globose, subglobose to subovoid, 5.5–7.5 x 6.5–8(–9) µm, reddish-brown; wall uniform, 0.5–0.8 µm thick, from nearly smooth, finely and sparsely punctate-verruculose to sparsely or moderately densely echinulate. Sterile cells variable in form and size, larger than the spores (8–23 µm in diameter), yellow or pale yellowish-brown, smooth.

In addition to Saccharum officinarum L., Ustilago scitaminea was also reported on other Saccharum species. Two varieties of U. scitaminea were also described, mainly on the basis of slight differences in spore measurements and surface ornamentation. These data must be verified.

The presence of groups of sterile cells between the spores are not characteristic for Ustilago. Further studies may show the necessity of a generic recombination.

EXCLUDED SPECIES

Sporisorium maydis Cesati, Diar. Synh. Phys. Ital. 1844 ad diem 23. Sept. (n. v.); in Rabenhorst, Herb. viv. myc. 1070, 1848 (HUV 13282!). Type in immature seeds of Zea mays L., "In Insubria legit Cesati". It is an Aspergillus sp. (det. F. Spaay), being present both anamorph and teleomorph (cleistothecia, which may belong to the same sp.), associated with acari.

Fingerhuth (1836) describing Thecaphora, published three new species: 1. T. hyalina Fingerh., in the seeds of Convolvulus sepium L., 2. T. aurantiaca Fingerh., on the leaves of Urtica dioica L., with the description "Thecis pentagonis flavo-aurantiacis, sporidiis minutis oblongis (Ich lasse hier das sogenannte peridium spurium . . . . . unberücksichtigt)", and 3. T. pallescens Fingerh., on the leaves of Fragaria collina Ehrh. "Thecis pentagonis majusculis flavescentibus, sporidiis oblongo-ovatis vel subglobosis." The first species, T. hyalina, was selected by Clements & Shear (1931) as typus generis. The second and third species are certainly aecia of rust fungi; probably Puccinia urticae-caricis Klotzsch, s. lat., or P. iridis (DC.) Wallr. on Urtica, and of Frommeella tormentillae (Fuckel) Cummins & Y. Hiratsuka (Uredinales) on "Fragaria collina Ehrh." (= probably misidentified Potentilla sp.).

Langdon & Boughton (1978:457) described an unusual Tilletia species, T. nigrifaciens, producing external sori on the surface of the leaves of Phragmites australis (Cav.) Trin. ex Steudel (type: Australia, Queensland, Logan River, 18.V.1974, R. F. N. Langdon, BRIU 2533; isotype HUV 7178!). An external sorus is typical for the smut genera Orphanomyces Savile and Clintamra Cordas & Durán, and also occurs in some species of Ustilago, e. g. in U. hypodytes (Schlecht.) Fries, s. lat. External sorus was previously unknown in Tilletia and this lead me to investigate the type of T. nigrifaciens. The globose or subglobose, brown spores of 18–24 µm diameter, possessing a reticulate, 1–4 µm thick wall with a thin gelatinous sheath, and the presence of hyaline "sterile" cells of 16–32 µm diameter fit well with the characters of a typical Tilletia. The spore germination is not known. However, study of the ultrastructure, kindly executed by Dr. R. Bauer, solved the problem: the septal pore is simple and Woronin bodies are present demonstrating that the fungus is an ascomycete.

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ABBREVIATIONS

The abbreviations for herbaria follow Index Herbariorum (Stafleu, 1981).
HMAS = Herb. Institute of Microbiology, Academia Sinica, Bejing, China.
HUV = Herb. Ustilaginales Vánky, the author's private herbarium.

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ENTOMOPHTHORA CHROMAPHIDIS (ENTOMOPHTHORALES): THE CORRECT IDENTIFICATION OF AN APHID PATHOGEN IN THE PACIFIC NORTHWEST AND ELSEWHERE

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A survey for fungal pathogens of cereal aphids in the Pacific Northwest of the United States found several entomophthoraleans. A species of *Entomophthora* (in the strict sense) causing minor early-season mortality of aphids was of special taxonomic interest. Evaluation of this fungus indicated that it was best identified as *E. chromaphidis* Burger & Swain, a species long treated as a synonym of *E. planchoniana* Cornu. *E. chromaphidis* has primary conidia that are appreciably smaller than those of European collections of *E. planchoniana*, and can be isolated in culture whereas similar media and techniques have never yielded cultures of *E. planchoniana*. This study recognizes the aphid-pathogenic species of *Entomophthora* to comprise a globally distributed species complex; *Entomophthora planchoniana* is a major pathogen whose distribution is primarily European whereas *E. chromaphidis* appears to be a comparatively minor pathogen with a wide distribution outside of Europe.

Key Words: Entomophthorales, *Entomophthora planchoniana*, *Entomophthora chromaphidis*, aphid pathogens, cereal aphids, *Metopolophium dirhodum*, *Schizaphis graminum*, *Sitobion avenae*.

Surveys for fungal pathogens of cereal aphids on wheat in southwestern Idaho found several entomophthoralean fungi attacking these host species during the years 1986-1989 (Feng et al., 1990). No aphid infected by any fungus resembling *Entomophthora planchoniana* Cornu (MacLeod *et al.*, 1976) was found until late

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October 1988. At that time, a single cadaver of *Schizaphis graminum* (Rondani) discharging the campanulate conidia of an *Entomophthora* species (sensu Remaudière & Keller, 1980) was collected from winter wheat at the Southwestern Idaho Research and Extension Center at Caldwell. In July 1989, this *E. planchoniana*-like fungus was found attacking *Metopolophium dirhodum* (Walker) and *Sitobion avenae* (F.) on irrigated spring wheat at the Southwestern Idaho Research and Extension Center at Parma and also on *M. dirhodum* collected from spring wheat at Prosser, Washington.

This *Entomophthora* sp. was the earliest-occurring pathogen of aphids on wheat in 1989 but was soon replaced by *Pandora neoaphidis* (Rem. & Henn.) Humber, *Conidiobolus obscurus* (Hall & Dunn) Rem. & Kell., and *Conidiobolus thromboides* Drechs.. The incidence of this *Entomophthora* sp. never exceeded 2.5% in laboratory rearings of weekly field collections of *M. dirhodum*, and was even lower in similar laboratory rearings of *S. avenae*.

The color of aphids freshly killed by the fungus from Idaho and Washington varied among the host species but was typically yellowish or reddish brown. The general morphologies of the conidiophores (Fig. 1a), primary and secondary conidia (Figs. 1b-e), hyphal bodies (Fig. 1f), and stout bundle of rhizoids terminating in a spreading plate (Fig. 1g) strongly resembled those of *E. planchoniana* Cornu, the only *Entomophthora* species generally recognized from aphids.

In most circumstances, the fungus from Idaho and Washington would be automatically identified as *E. planchoniana*. However, as noted in Table 1, primary conidia from the Idaho and Washington collections were (12.5)-14.4-(16.3) × (10.3)-12.3-(13.5) µm (n=40; 8 conidia mounted in aceto-orcein from each of 5 individuals of *M. dirhodum*). These conidia were notably smaller than the sizes – (14)-19-(23) × (12)-14-(19) µm – recorded from European collections of *E. planchoniana* reported by MacLeod *et. al.* (1976). *E. planchoniana* was described from France (Cornu, 1873) and has always been most commonly reported from Europe. The importance of this discrepancy in conidial size was underscored by the fact that a similarly small-spored species from California was described as *Entomophthora chromaphidis* Burger & Swain (1918), and that still another fungus with such small conidia from Australia was tentatively identified as *E. planchoniana* and cultured *in vitro* (Holdom, 1983, 1984).

Burger and Swain (1918) reported that *E. chromaphidis* caused significant mortality of walnut aphids, *Chromaphis juglandicola* (Kalt.), in southern California. Although the campanulate primary conidia of *E. chromaphidis*, at 11-14 × 10-11 µm, are distinctly smaller than the variable European collections of *E. planchoniana* (Table 1), this species is usually synonymized with *E. planchoniana* (Gustafsson, 1965; MacLeod *et al.*, 1976; Waterhouse and Brady, 1982). Unfortunately, Burger and Swain (1918) preserved no type or authentic specimens of *E. chromaphidis*, and we have been unable to obtain infected *C. juglandicola* from the few remaining walnut groves near Riverside, California, the locality in which Burger and Swain found their fungus. The identity of the fungus from the Pacific Northwest and the status of *E. chromaphidis* became the major concerns of this study.

Despite the unavailability of enough diverse collections of aphid-pathogenic *Entomophthora* material to seek biochemical confirmation for the separation of these apparently distinct morphs, several characters suggest a functional need to recognize two related species, *E. planchoniana* and *E. chromaphidis*: These characters include the sizes of primary conidia and conidial nuclei, and the rela-

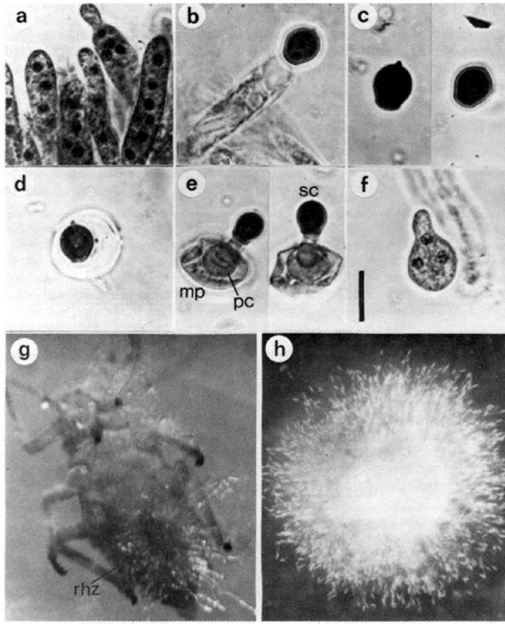

FIGURE 1. Morphology of *Entomophthora chromaphidis* infecting cereal aphids.

(a) Developing conidiophores; **(b)** mature 5-nucleate conidium and conidiophore containing residual cytoplasm; **(c)** primary conidia; **(d)** primary conidium embedded in mass of discharged protoplasm; **(e)** secondary conidia [sc] forming on primary conidia [pc] embedded in discharged protoplasm [mp]; **(f)** germinating conidium; **(g)** pseudorhizomorphic bundle of rhizoids [rhz] spreading into a terminal plate on the substrate.; **(h)** hyphal bodies in Grace's medium + 10% fetal bovine serum. **Fiduciary bar:** a-f = 15 μm, g-h = 0.3 mm. **Stains:** aceto-orcein in a,b,c (right), f; with cotton blue in c (left), d, e.

tive ease with which the fungus may be isolated and grown *in vitro*. Other characters that seem to separate these taxa, *e.g.*, the relative virulence and host spectrum, may be artifacts influenced by local climatic factors and/or geographic differences in distribution of particular aphid species.

Primary conidial morphology and nuclear characteristics: Figures for the dimensions of primary conidia of *Entomophthora* species from aphids collected in diverse locations on three continents are shown in Table 1; references to collec-

TABLE 1. Comparative sizes of primary conidia and nuclei in collections of *Entomophthora* species affecting aphids.

Country	Mean [Range] (µm)	Nuclear diameter (µm)	Reference
Australia			
Queensland	[14-20 x 13-18]	—	Milner *et al.*, 1981
Queensland	15 x 13 [13-19 x 11-15]	4-5 [a]	Holdom, 1984
Chile	17.5 x 14.6 [14.1-18.0 x 13.2-15.8]	—	Aruta *et al.*, 1974
Finland	18.8 x 15.5 [16.7-20.5 x 14.1-17.9]	—	Papierok & Havukkala, 1986
	19.5 x 15.4 [15.4-21.8 x 11.5-17.9]	—	Papierok & Havukkala, 1986
	18.1 x 14.9 [13-22 x 10-18]	—	Papierok, 1989
Sweden	19 x 15 [16-22 X 13-17]	—	Gustafsson, 1965
Switzerland	15.5-19.5 x12.5-16 [15-23 x 11-19]	3.3-3.5 [b] 2.5-2.8 [c] 2.8 [d]	Keller, 1987
UK – England			
	[17-23 x 12-20]	—	Petch, 1937
	18 x 13 [14-20 x 11-15]	—	Byford & Reeve, 1969
USA			
California	[11-14 x 10-11]	—	Burger & Swain, 1918
Idaho/Washington	14.4 x 12.3 [12.5-16.3 x 10.3-13.5]	3.5-4.5 [b]	[this study]
Montana	18.9 x 15.5 [5.0-22.5 x 12.0-17.8]	—	Feng *et al.*, 1991

[a] from cultures; [b] in aceto-orcein; [c] after Feulgen reaction; [d] from histological sections

tions identified as *Entomophthora planchoniana* from several countries are omitted if they included no information about conidial sizes.

MacLeod *et al.* (1976) reported that conidia of [European material of] *E. planchoniana* contain 4-6 nuclei. Collections referable to *E. chromaphidis* have a similar number of conidial nuclei. Four to six nuclei were found in 82.5% of conidia from the Pacific Northwest; 3, 7, and 8 nuclei were found in 7.5%, 5%, and 5% of the conidia, respectively. Holdom (1984) reported 5-9 nuclei in the small-spored Australian fungi.

The conidial nuclei of the Idaho/Washington fungus (mounted in aceto-orcein) were 3.5-4.5 µm in diameter. Nuclei in histological sections of aphids infected by a British strain of *E. planchoniana* (Brobyn and Wilding, 1977) are estimated to be 3.2–4.6 µm in diameter; this is appreciably larger than the diameter of 2.8 µm nuclei in similarly treated Swiss material (Keller, 1987). It should be noted that the sizes of structures in fixed, embedded, and sectioned material of entomophthoralean fungi tend to be appreciably smaller than in fresh material (Humber, 1976).

So few of the collections in Table 1 include information about nuclear sizes in the primary conidia because the taxonomic values for *Entomophthora* species of both the number and size of conidial nuclei were only recently noted (Keller, 1986) but has not yet been universally adopted. Only the study of more numerous and diverse collections of both large- and small-spored fungi will determine whether the number and size of conidial nuclei differ appreciably in *E. chromaphidis* from those reported for *E. planchoniana.*

***Natural incidence of* Entomophthora *on aphids*:** Dean and Wilding (1971, 1973) noted that *E. planchoniana* caused heavy mortality of *M. dirhodum* and *S. avenae* in southcentral England from early June throughout the summer although these mycoses were most prevalent at the beginning and end of the season (Dean and Wilding, 1971). A similar bimodal incidence of *E. planchoniana* was noted for several aphid species in France (Remaudière *et al.*, 1981). In Europe, *E. planchoniana* is often noted to be a major pathogen occurring during the warmest (middle) part of the summer (Wilding, 1975; Keller, 1980), and has been noted to be a minor pathogen of aphids on potatoes in the United States during mid summer (Shands *et al.*, 1962).

Entomophthora infections of aphids are relatively rare in North America and, seemingly, many other parts of the world (Thaxter,[1] 1888; Hutchison, 1963; Remaudière *et al.*, 1978). By comparison, *E. planchoniana* (sensu stricto) is a very common aphid pathogen in Europe (Gustafsson, 1965; Thoizon, 1970; Dean and Wilding, 1971; Remaudière *et al.*, 1981).

The collection in Montana (Feng *et al.*, 1991) as well as in Australia (Milner *et al.*, 1981) of an *Entomophthora* species that appears to be indistinguishable from *E. planchoniana* (s.str) raises the possibility that the geographical ranges of *E. planchoniana* and *E. chromaphidis* may overlap in some regions even though no small-spored fungus corresponding to *E. chromaphidis* has yet been reported from Europe.

[1] *E. planchoniana* as discussed in Thaxter's (1888) monograph was a misidentification of *Conidiobolus obscurus* (Hall & Dunn) Remaudière & Keller. Despite his several years of collecting at many locations in the eastern US, Thaxter apparently found no entomophthoralean pathogen of aphids with conidia resembling those of *E. muscae.*

***Culturability* in vivo:** The first culture of an *Entomophthora* from aphids was identified as *E. planchoniana* by Holdom (1983) although this fungus had conidia whose small size is comparable to that of *E. chromaphidis* and the fungus from Idaho and Washington (see Table 1). The Australian fungus was isolated easily and repeatably by dispersing hyphal bodies from surface-sterilized aphids into a liquid medium containing neopeptone (2%), glucose (5%), and fetal bovine serum (10%); sporulation was induced by spreading hyphal bodies on SEMA (Sabouraud dextrose agar + egg yolk + milk) (Holdom, 1983,1984).

An *in vivo* colony of the Idaho fungus was established by adding sporulating field-collected cadavers of *M. dirhodum* and *S. avenae* to a cage of healthy aphids; this laboratory colony was the source of infected cadavers for attempts to establish axenic cultures. Cadavers from which the fungus had not yet emerged were surface-sterilized in 1% NaOCl, rinsed in sterile distilled water, and placed individually into drops of Grace's insect tissue culture medium supplemented by 10% fetal bovine serum in a 60 mm Petri dish; cadavers were crushed with a glass needle to release fungal contents into the medium. Coarse hyphal bodies appeared in the liquid (Fig. 1h) after 24-40 hr of incubation at 20°C in a 16:8 light:dark cycle and were transferred to 5 ml of the same medium in tissue culture flasks for further incubation under the same conditions of temperature and light. Unfortunately, all cultures so obtained were overcome by bacterial contamination during shipment to Ithaca, NY, and lost before they could be purified and accessioned into the USDA-ARS Collection of Entomopathogenic Fungal Cultures (ARSEF; Ithaca, NY).

In sharp contrast to the successful attempts to isolate cultures from the small-spored *Entomophthora* species, periodic attempts (by RAH) to culture the British material of the large-spored *E. planchoniana* from N. Wilding's *in vivo* laboratory colony of this fungus on *Aphis fabae* using virtually identical materials and culture techniques have consistently failed to yield cultures.

The widely accepted concept of *E. planchoniana* given by MacLeod *et al.* (1976) must be questioned in view of the evidence supporting the restoration from synonymy of *E. chromaphidis* and the identifications of *E. planchoniana* from non-aphid hosts. Byford and Reeve (1969) noted a species of *Bradysia* (Diptera: Mycetophilidae) to be infected by *E. planchoniana.*[2] Ben-Ze'ev *et al.* (1981) reported Israeli collections identified as *E. planchoniana* (but without supporting morphological data) from unidentified insects belonging to the Cercopidae, Cicadellidae, and Membracidae, three families of the Homoptera that are quite distinct from the Aphididae. No morphological data about these non-aphid hosts was published. Such unexpected identifications of *E. planchoniana,* however tentative, coupled with continuing effort to resolve the *Entomophthora muscae* species complex (Humber, 1990) suggest that the species of *Entomophthora* deserve continued and serious taxonomic study in the future.

All available data suggest that the small-spored *Entomophthora* species from aphids in California, Idaho, Washington, and Australia are more accurately identified as *E. chromaphidis* than as *E. planchoniana* and that the former species must be restored from its status as a synonym of the latter species. Such a decision treats *E. chromaphidis* and *E. planchoniana* as members of a globally distributed complex of *Entomophthora* species attacking aphids and insects from other

[2] This fly pathogen is probably more properly referred to the unresolved species complex centering on *E. muscae* (Cohn) Fres. (Keller, 1984; Eilenberg *et al.*, 1987).

families and orders.

We regard the evidence presented here for accepting *E. chromaphidis* as distinct from *E. planchoniana* to be substantial enough to require the taxonomically conservative course of recognizing both of these distinctive forms. Future reports of these species should be careful to report primary conidial dimensions and the number and size of the conidial nuclei as well as the dates, ambient temperatures, and other climatic parameters prevailing during outbreaks of aphid-pathogenic *Entomophthora* species. Concerted attempts should be made to obtain *in vitro* cultures of both large- and small-spored forms using the tissue culture media and hyphal body inocula that have proven so successful with many other fastidiously pathogenic species of the Entomophthorales.

The definitive resolution of the species complex including *E. planchoniana* and *E. chromaphidis* will require thorough morphological, developmental, and molecular characterizations of collections from a wider range of hosts and geographical sites than have yet been available.

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MYCOTAXON

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A redescription of Peziza bananicola and comments on some similar tropical species[1]

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This brief note reports on *Peziza bananicola* (Rehm) Saccardo, a tropical species, first described from a collection made by C. F. Baker in the Philippines in 1913. My examination of the pertinent literature has failed to uncover any additional reports of the species. I discussed *P. bananicola* briefly in my type studies of taxa assigned to *Peziza* (Pfister 1979). Subsequently Vincent Demoulin collected an unusual *Peziza* in Papua New Guinea that ultimately was sent to me. It has proven to be *P. bananicola*. Demoulin's large collection, both dried and in alcohol, has allowed for a more complete description of the species. *Peziza bananicola* can now be compared more closely with similar fungi known from Africa.

Species assigned to the genus *Peziza* are often poorly known. Because certain ephemeral characters, such as color and reaction of the ascomata when damaged, are used in identifying species, knowledge of species is often fragmentary, particularly if descriptions are based on dried specimens. Species such as *P. bananicola*, known only from brief descriptions prepared from dried material, prove to be problematic. Moreover, there is no workable infrageneric taxonomic framework in which to place species. *Peziza bananicola* and two taxa described by Le Gal, mentioned in the notes, are similar morphologically and should, when disposition of taxa is possible, be placed in close proximity.

Peziza bananicola (Rehm) Saccardo, Syll. Fung. 24: 1160. 1928.
= *Plicaria bananicola* Rehm, Leafl. Philip. Bot. 6: 2234. 1914.

Ascomata concave, cupulate but becoming convoluted in some examples, gregarious, sessile or with very short stipes, 5 to 7 cm in diam, situated on a whitish subiculum. Hymenium whitish or rose or yellowish, outer surface concolourous. Subiculum composed of broad, thin-walled, sparingly-branched hyphae, no conidiogenous cells noted. Excipulum of several layers, as follows (listed in order from the subhymenium): I. a distinct subhymenium composed of interwoven hyphae; II. a layer of globose, pyriform cells from 40-80 μm in diam; III. a layer of interwoven hyphae 15-25 μm in diam; IV. a layer of globose and pyriform cells similar to those described in II, above; V. the outer layer of the apothecium composed of densely interwoven hyphae 14-18 μm in diam, which give rise to loose

[1] Publication no. 234 from the Laing Island Biological Station.

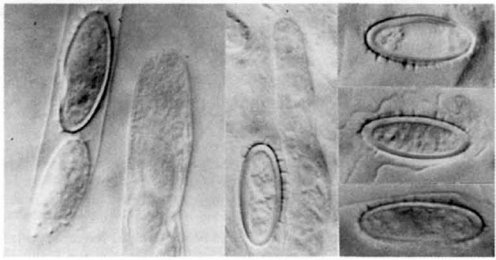

Figure 1. *Peziza bananicola.* Left, ascospores and asci; center, ascospore with a paraphysis; and right, ascospores. x 1000.

hyphal tips that cover the outer surface. The asci are cylindrical and diffusely J+, 100-330 x 13-14 μm, 8-spored, with crozers at the base. Ascospores narrow elliptical, often with walls up to 2 μm thick particularly when young, 20-24 x 8.8-12μm, covered with sparse, irregularly spaced spines what are particularly prominent at the poles. Paraphyses straight, septate, 8-9 μm broad at the apex.

Associated with debris from banana plants.

Specimens examined: Holotype. *Ad bananam emortuam*, Luzon, Prov. Laguna, Los Baños, 7/1913, leg. M. B. Raimundo, comm. C. F. Baker. (S). New Guinea: Extrémité NW des Monts Finistèrre piste Madang-Lae, un peu au S. de la vallée du Gogol, Lat./Long. env. 5° 20' S/145° 30' E. Base d'un tronc de bananier vivant, 16.12.1979. V. Demoulin (5529) and L. Smeets. (LG and portion FH, LAE).

Demoulin's collection has allowed for a much more complete picture of the anatomy of this species. Two distinctive characteristics mark this species -- the extensive whitish subiculum and the peculiar ornamentation of the ascospores. The subiculum is prominent; it covers and binds the substrate. An extensive subiculum such as this does not often occur in the genus *Peziza*. Among tropical taxa the only mention of a subiculum known to me is that of *Galactinia tapesioides* Le Gal (1959). *Galactinia tapesioides* was described from Africa from woody and other debris. It has spore ornamentations and hymenial colors that are similar to *Peziza bananicola* but the spore ornamentations seem to lack the acutely pointed apices found in *P. bananaicola*. In addition to *G. tapesioides* there is another African species, *G. luteorosella* Le Gal (1959), which is similar to *P. bananicola*. In this species long thin spines develop irregularly over the spore surface but are aggregated particularly at the spore poles. Additionally, all three species, *P. bananicola*, *G. tapesioides*, and *G.*

luteorosella, have eguttulate ascospores that have refractive inclusions. Le Gal's somewhat abbreviated description of the excipular construction of *G. tapesioides* does not allow a complete comparision of its anatomy with that of *P. bananicola*. On the other hand, Le Gal did show the excipulum of *G. luteorosella* to be composed of a single more or less uniform layer rather than stratified as in *P. bananicola*. The excipulum in *G. luteorosella* is composed of a layer of elonglated cells. A collection from Gaudeloupe, F. W. I. (on mosses, rock and soil, Manceau above Capesterre along Riv. des Peres about 200 m, D. H. Pfister 598 FH) is identical to Le Gal's *G. luteorosella*. The excipulum is unstratified and the spores have the same distinctive type of ornamentation. I believe *G. luteorosella* should be accepted in the genus *Peziza*. The new combination is thus made: **Peziza luteorosella** (Le Gal) Pfister, **comb. nov.** ■ *G. luteorosella* Le Gal, Bull. Jard. Bot. Etat. 29: 82. 1959. A deposition of *G. tapesioides* in *Peziza* would be logical but its identity will not be completely known until further studies are undertaken. Both of these taxa from Africa clearly require futher study from fresh or well-preserved collections. Rehm's name, *Plicaria bananicola*, is the oldest among those discussed above and can thus be used confidently at least for the Asian material.

I wish to thank V. Demoulin for providing the specimens for study. His work in New Guinea is supported by the Belgian FRFC, contract number 2.9001.90.

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Pfister, D. H. 1979. Type studies in the genus *Peziza*. V. Species described by Rehm. Mycotaxon 8: 187-192.

MYCOTAXON

Volume XLI, no. 2, pp. 509-512 July-September 1991

BOOK REVIEWS

L. M. Kohn, Book Review Editor

A Bibliography of Taxonomic Mycological Literature 1753-1821, by D. H. Pfister, J. R. Boise & M. A. Eifler. Mycologia Memoir No. 17, published for The New York Botanical Garden in collaboration with The Mycological Society of America. 161 pp., cloth hardcover, 143x233 mm, 1990. J. Cramer in der Gebrüder Borntraeger Verlagsbuchhandlung, Johannesstr. 3 A, D-7000 Stuttgart 1, F.R.G. (U.S. Agent: Lubrecht & Cramer, R.D. 1, Box 244, Forestburgh, NY 12777) ISBN 3-443-76007-4. DM 76.-- US$55.--

Efficient access to the mycological taxonomic literature for 1753-1821 has become critical following the revisions of Article 13.1(d) of the *International Code of Botanical Nomenclature* adopted at the Sydney and Berlin Botanical Congresses. This period brackets the newly designated designated starting point, Linnaeus' *Species plantarum*, ed. 1 (1753) and the former starting point, Fries' *Systema mycologicum*, Vol. 1 (1821). The compilations of R. H. Petersen, Pritzel, Lindau & Sidow, and Streinz have provided workers with an entry to the literature of this period, and indeed served as a preliminary entry for the authors of this volume. This new bibliography will be a central source for access to this literature in several respects. First, the new bibliography is comprehensive, including not only general references, but also a wide range of books and journal articles in which nomenclatorally significant names were published; the use of binomials or polynomials is indicated in entries. Second, each entry contains both descriptive information, such as citation of alternative printings and pagination, as well as several types of "locators" for acquisition of the cited material. These locators include references to other bibliographies, including Stafleu & Cowan's *Taxonomic Literature*, Second Edition, microfiche editions, libraries, and the *Union List of Serials in Libraries of the United States and Canada*. The Farlow Reference Library of Cryptogamic Botany at Harvard University is the central library resource (call numbers provided), although other Harvard Libraries, as well as those of the British Museum, Carnegie-Mellon University, Royal Botanical Gardens (Kew), Botanische Staatssammlung, and Missouri Botanical Garden are also cited. Coding is used for some types of data, but it is relatively simple and is fully described in the Introduction. Last among the resources offered in this volume is an appendix providing full names of periodicals cited, with information on availability in Harvard Libraries, microfiche editions, and cross references to the *Union List*. Tables provide publication information on Bulliard's *Herbier de la France*, *Flora Danica* , *Svensk Botanik*, *Deutschlands Flora*,

Smith's *English Botany* , and Wulfen's *Plantae Rariores Carinthiacae*. This comprehensive compilation has been conscientiously designed for use by contemporary fungal taxonomists and will become an immediate standard reference through this, and subsequent editions. *L. M. Kohn, Erindale College, Univ. of Toronto, Canada.*

Fungi of Switzerland, Volume 3, Boletes and agarics 1st part, by J. Breitenbach and F. Kränzlin. 359 pp., laminated hard-cover, 216x288 mm, 1991. Edition Mycologia Lucerne, P. O. Box 165, CH-6000 Lucerne 9, Switzerland. English Edition, ISBN 3-85604-230-X; French Edition (Champignon de Suisse, Tome 3) ISBN 3-85604-130-3; German Edition (Pilze der Schweiz, Band 3) ISBN 3-85604-030-7. Sfr. 148.--

This third volume in the series, **Fungi of Switzerland**, under the aegis of the Mycological Society of Lucerne, is dedicated to Dr. R. A. Maas Geesteranus on the occasion of his 80th birthday. In this volume, 450 species are described, mainly from central Switzerland, with drawings of microscopic features and color photographs, following the format of the previous volumes (Ascomycetes, Vol. 1, and Heterobasidiomycetes, Aphllophorales, and Gasteromycetes, Vol. 2). This volume treats the Strobilomycetaceae, Boletaceae, Paxillaceae, Gomphidiaceae, Hygrophoraceae, Tricholomataceae, and lamellate Polyporaceae. Volume 4, in preparation for publication in 1995, will treat the Entolomataceae, Pluteaceae, Amanitaceae, Agaricaceae, Coprinaceae, Bolbitiaceae, Strophariaceae, and Crepitodaceae. Volume 5, still in the planning stages, will treat the Cortinariaceae and Russulaceae.

Like the previous volumes, this is an attractive book whose main strength is in providing high quality photographs (with descriptions of specimens) of a broad survey of species representing a wide range of genera, some of which are relatively obscure and rarely photographed. As H. Clémençon astutely suggests in the Preface, this first foray into the Agaricales takes the authors on a new, and challenging adventure. Floras and field guides on large fleshy fungi abound, replete with lavish, though not always useful, photography. In this crowded field, criticism can be severe, if not carping. The authors have taken this challenge very seriously. Methods of study are carefully explained; I was especially impressed by the care given to methods for spore rehydration and statistical applications for reporting spore dimensions. In this volume the normal distribution of spore measurements is the basis for the range reported in descriptions and the mean length/width ratios and volumes are also reported. Line drawings of macroscopic and microscopic features, a glossary and lists of abbreviations and plant names (Latin and common English names) are provided in the Introduction. As in the other volumes, keys to species in the text are provided. I (as well as my students) have found the keys in this series to be frustratingly artificial. The addition of keys to families and genera would have made organizational sense in this volume since species are arranged in the text by families and genera. Keys to families and genera would be more of a resource for those not

working strictly with the Swiss/European mycobiota, as well as a less a purely functional (and artificial) access to the text.

The systematic basis is Moser's 1983 "Die Röhrlinge und Blätterpilze", although the current European taxonomic literature is widely treated. For example, species concepts in the Armillaria mellea complex are based on recent treatments (and are represented beautifully in the photographs). One of the great strengths of this volume is that it presents an excellent overview of the taxonomic status quo in a floristic context that will be uniquely valuable to professionals, students, and amateurs. The authors have used the strict guidelines of the Association of The Official Mushroom Control Officers of Switzerland (VAPKO) in reporting on edibility. I found the photographs to be of very high quality with excellent color, although they are limited in size due to the number of species included in a volume of fixed size and format. Especially when compared to Volume I on ascomycetes, the descriptions (and distributional data) are quite thorough for a floristic treatment. There are typographical errors; spellings of author's names (e.g., Müller and Mueller, Rose and Roze) can be slippery. This is, however a floristic treatment of the highest standards, one that will excite both experienced and novice mushroom hunters. Anyone interested in the European mushroom flora will want to own this, and forthcoming contributions in this series. *L. M. Kohn, Erindale College, Univ. of Toronto, Canada.*

Indentification Manual For Fungi From Utility Poles, I. The Eastern United States, by C. J. K. Wang and R. A. Zabel (eds.). 356 pp. + viii, paper, 280x215 mm, 1990. American Type Culture Collection, 12301 Parklawn Dr. Rockville, Maryland 20852. ISBN 0-93-0009-31-2.

This publication is the result of approximately 10 years of research on the fungi decaying utility poles in New York State. It arose from an earlier manual included as an appendix of a final report to the Empire State Electric Energy Research Corporation, but has obviously gone far beyond its humble beginning.

The manual is divided into four chapers: 1) a short introduction by the editors including an historical review of studies on utility pole decay, a characterization of decay types, a brief outline of fungal classification and an overview of the manual itself, 2) a brief discussion by R. A. Zabel and F. C. Terracina of sampling and isolation methods, 3) an examination by F. F. Lombard and G. P. Chamuris of methods for isolating basidiomycetes from utility poles followed by detailed descriptions and illustrations of 32 species in culture, distinguished by a tabular synoptic key, and 4) a treatment of microfungi by C. J. K. Wang similar in format to chaper 3 but including a dichotomous key. Each chapter includes its own bibliography. There are two appendices: Appendix A outlines test procedures used for decay and soft-rot determinations, while Appendix B covers procedures used for anatomical study of decaying wood.

The two chapters dealing with basidiomycetes and microfungi take up about 330 of the 360 pages of the text and are the reason most people would want the book. Both of these chapters are conventional in approach and place everything where users will expect them.

The basidiomycete chapter provides an outline of the Davidson and Nobles systems for coding cultures and includes both codes with each description. Growth and hyphal characteristics as well as distinguishing features are provided in separate paragraphs. Photographs of colonies of one or more (usually two) strains of each species are on a separate, usually facing page along with line drawings of taxonomically useful structures.

The chapter on microfungi includes a few zygomycetes, ascomycetes and coelomycetes as well as numerous hyphomycetes. One basidiomycete, *Pachnocybe ferruginea* (Sow.:Fr.) Berk., is included because its basidiomata and basidia are likely to be mistaken for synnemata and conidiophores. The keys to genera of microfungi are not strictly dichotomous but are indented and easy to use. The genera of hyphomycetes are separated according to a modified Hughes system and appear to be quite workable. Accompanying each group of keys are clear photographs of the genera involved. The species descriptions include both cultural and microscopic characteristics and are accompanied by a paragraph of relevant remarks. Illustrations are on a page facing each description and are composed of a photograph of a typical colony and several photomicrographs of taxonomically important structures.

A book such as this might appear to be of rather limited appeal: useful only on those occasions when one is sent a decaying utility pole. However, it describes and illustrates 113 taxa occurring in an ecologically circumscribed niche and is undoubtedly useful beyond the realm it was designed to cover. In addition it contains a wealth of information on methods for cultivating and examining wood-decaying fungi. Its widest application may be in the classroom, where relatively inexpensive identification manuals are always in demand. For the student or non-mycologist this book will be an excellent and unintimidating introduction to practical mycology. The professional mycologist may find little that is new here other than a list of fungi that decay utility poles. Virtually all of the taxa have been described and illustrated before. On the other hand, I suspect that it might be the first place to look when identifying an unknown isolate from decaying conifer wood regardless of its source. Overall, I think that few purchasers will be disappointed. *D. W. Malloch, Dept. of Botany, Univ. of Toronto, Canada.*

MYCOTAXON

Volume XLI, no. 2, pp. 513 July-September 1991

NOTICE

FOND FAREWELLS AND HEARTFELT WELCOMES

Volume 40 of MYCOTAXON concluded over seventeen years of service as Managing Editor and English Language Editor for Dick Korf, and nearly as many years of service, at first uncredited, and later acknowledged as Assistant Editor, Associate Editor, and Index Editor, by Susan Gruff. Korf will continue with the journal, in charge of the Order & Subscription Department.

We leave the journal's production to the editorial skills of Dr. Jean R. Boise, in the new post of MYCOTAXON *Editor-in-Chief*. She has selected admirable helpers as Associate Editors: Dr. Grégoire L. Hennebert (continuing his service as one of the founding co-editors) is French Language Editor, Dr. Linda M. Kohn is Book Review Editor, and Mr. Robert Dirig is Index Editor. We welcome them and wish them all the best of luck.

The retiring Managing Editor, Dick Korf, wishes to apologize for the delay in publication of volume 40, the January–March 1991 issue, which was caused by his hospitalization from January 6th through April 6th. He owes a great debt to Susan Gruff, who saw volume 40 through to its final mailing in May. The good wishes conveyed by those subscribers who knew of his illness are gratefully acknowledged here.

We are now at work on producing the 20–volume Index for Volumes 21–40, which should appear later this year.

Not long ago an Editorial Advisory Board for MYCOTAXON was appointed, consisting of six eminent mycologists who have agreed to assist the new Editor-in-Chief and to insure the continued excellence of the journal. We hope our subscribers will also welcome that Board and all four Editors, and that MYCOTAXON will continue to flourish with the infusion of their new ideas.

RICHARD P. KORF
SUSAN C. GRUFF

AUTHOR INDEX, VOLUME FORTY-ONE

REVIEWERS, VOLUME FORTY-ONE

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers appearing in this volume:

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INDEX TO FUNGOUS AND LICHEN TAXA, VOLUME FORTY-ONE

This index contains the names of genera, infrageneric taxa, species, and infraspecific taxa. New names are in **boldface**, as are the page numbers on which new taxa are proposed.

ERRATA, VOLUME THIRTY-FIVE

Page 383	line 45	*for* Cetrareia	*read*	Cetraria
434	5	for nicaragense	read	nicaraguense

ERRATA, VOLUME FORTY

Page 48	line 8	for *kumaonicus*	read	*kumaonica*
87	6	*for* 264	*read*	2621
116	1	*for* A. H. Chivers, J. H. Miller, *read* J. H. Miller, A. H. Chivers,		
202	33	for *cuculata*	read	*cucullata*
315	31	*for* 2567,	*read*	2567 (UPS)
433	13	*for* Isotypes	*read*	Isoparatypes
463	36	for *Acanthophyscium*	read	*Acanthophysium*

ERRATA, VOLUME FORTY-ONE

The new Editor-in-Chief apologizes for some problems with pagination of the volume. The omission of page numbers 234 and 235 resulted in misnumbering of the article. Page 224a, following 224, and 261a, following 261, were added in proof. So, volume 41(1) does contain exactly 320 pages as indicated on the cover.

Page 460	for *Tubeufia cera*	read	*Tubeufia cerea*
464	for *Cacumisporum*	read	*Cacumisporium*

PUBLICATION DATES FOR VOLUMES 40 AND 41(1):

Mycotaxon	Volume 40	May 22, 1991
Mycotaxon	Volume 41(1)	June 12, 1991

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MYCOTAXON is a quarterly journal devoted to all phases of mycological and lichenological taxonomy and nomenclature. It seeks to publish all papers within 5 months of submission, using photo-offset lithography. All articles are reviewed by specialists prior to acceptance. Publication is open to all persons. Papers may be in French or in English. Summaries in those or in any additional languages desired by the authors are given for longer articles. KEYWORDS are provided for each article to facilitate library and computerized access. Printing is on high quality, acid-free, recycled book paper.

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