MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

Vol. IV October-December 1976 No. 2

CONTENTS

[MYCOTAXON for July-September 1976 (4: 1-328) was issued September 9, 1976]

ISSN 0093-4666 *MYXNAE 4(2) 329-562 (1976)*

Library of Congress Catalogue Card Number 74-7903

Published quarterly by MYCOTAXON, Ltd., P.O. Box 264, Ithaca, NY 14850
For subscription details, see back cover

MYCOTAXON

VOLUME IV, 1976

COMPLETE IN TWO QUARTERLY ISSUES

CONSISTING OF vi + 562 PAGES

INCLUDING FIGURES

AND ONE COLORED PLATE

WITHOUT PAGE NUMBER

Published by

MYCOTAXON, LTD., P.O. BOX 264, ITHACA, NY 14850, USA

Printed in the United States of America

TABLE OF CONTENTS, VOLUME FOUR

ERRATA (Vol. 3): p.303, 1.22, *for* IPN 54 *read* Garcia 54 ENCB; 1.24, *for* IPN 6801 *read* Guzmán 6801 ENCB; 1.27, *for* IPN 262 *read* Mendiola 262 ENCB; 1.31, *for* IPN 1513 *read* Ventura 1513 ENCB; 1.35, *for* IPN 7967 *read* Guzmán 7967 ENCB; p.305, 1.11, *for* IPN 6585 *read* Guzmán 6585 ENCB; 1.14, *for* IPN 6230 *read* Guzmán 6230 ENCB; p.306, 1.33, *for* IPN 8052 *read* Guzmán 8052 ENCB; p.309, 1.24, *for* IPN 12 *read* Huerta 12 ENCB; p.310, 1.6, *for* IPN 10051 *read* Guzmán 10051 ENCB; 1.24, *for* IPN 89 *read* Romero 89 ENCB; 1.32, *for* IPN 13 *read* Araiza 13 ENCB; p.313, 1.35, *for* IPN 93 *read* Romero 93 ENCB; p.315, 1.25, *for* IPN 68-A *read* Uribe 68-A ENCB; p.316, 1.20, *for* IPN 198 *read* Mendiola 198 ENCB.

ERRATA (Vol. 4): p.283, 1.37, for *Diciseda* read *Disciceda;* p.291, 1.14, for *Octaviana* read *Octaviania.*

MYCOTAXON

Vol. IV, No. 2, pp. 329-330 October-December 1976

NOTES CONCERNING A NEW DISTRIBUTION RECORD FOR GEOPORA (PEZIZALES) FROM ALASKAN TUNDRA

GARY A. LAURSEN

Department of Biology
Virginia Polytechnic Institute and State University
Blacksburg, Virginia 24061

and

HAROLD H. BURDSALL, JR.

Center for Forest Mycology Research
Forest Products Laboratory, Forest Service
United States Department of Agriculture
Madison, Wisconsin 53705

It has been documented (Trappe, 1976) that certain mammals, particularly Sciuridae and Cricetidae (Rodentia), and Talpidae and Soricidae (Insectivora), are important in the dispersal of spores of certain hypogeous ascomycetes for they use these fungi as a food source. During the 1973 Alaskan summer field season, Mr. Herbert Melchoir brought in for identification a fungus collection that had been excavated by a sciurid rodent. The fungus, Geopora cooperi Harkness forma gilkeyae Burdsall (1968, p. 518), occasionally encountered by Melchoir, was found partially eaten at burrow entrances of the "Parka" or "Arctic Ground Squirrel," Citellus undulatus Poll. The retrieving of ascocarps from below ground level and opening them to the air above may be responsible for the maintaining of the forcible ascospore discharge mechanism found in this hypogeous species.

Geopora cooperi f. gilkeyae has been collected in Idaho, Colorado, California, and Alaska, usually in association with conifers (Pinus sp., Abies sp., Picea sp.) and occasionally with aspen (Populus sp.). The only reported Alaskan collection (V. Wells 310) is from a spruce stand 180 miles east of Anchorage. Our collection (OKM/GAL 11292, VPI) comes from a sand dune area at the base of Mt. Angmakrok and along the Kukpuk River. This collection site

is 685 miles northwest of Anchorage, 150 miles north of the arctic circle at 68° 16'N Lat., 165° 36'W Long, and at an elevation of 150 feet. The collection represents a new Alaskan Arctic tundra record and is particularly interesting because of its association with Salix alaxensis (Anderss.) Cov., the feltleaf willow with which it is most likely ectomycorrhizal. Salix alaxensis is scrubby, reaching only 50-150 cm in height, but it is the only woody species with which the fungus could be associated.

Our collection fits the description of Burdsall (1968, p. 518), except that we found: (1) a slightly larger globose to subglobose ascospore having a size range of (17-)19-27(-30) X 17-19 μ; and (2) poorly developed ectal excipular hairs, arranged not in conspicuous tufts, but rather into a very loosely interwoven mantal up to 250 μ thick.

This range extension indicates that G. cooperi and its varieties may be important mycorrhizal associates over a much wider distribution and with more tree species than previously considered.

1. Burdsall, H. H., Jr. 1968. A revision of the genus Hydnocystis (Tuberales) and of the hypogeous species of Geopora (Pezizales). Mycol. 60 (3): 496-525.

2. Trappe, J. M. 1976. Spore dispersal of hypogeous fungi, 27th Annual AIBS, Tulane University, New Orleans, Louisiana.

MYCOTAXON

Vol. IV, No. 2, pp. 331-334 October-December 1976

CONTRIBUTION TO THE LICHEN FLORA OF ARGENTINA.

IX. Some Lichens from the Provinces of Santa Fe and Santiago del Estero

HECTOR S. OSORIO (1) and LIDIA I. FERRARO (2)

Among the specimens recently collected by members of the Departamento de Botánica, Facultad de Agronomía, Universidad del Nordeste, Corrientes, Argentina (CTES), we have identified some from the Provinces of Santa Fe and Santiago del Estero.

Although the number of samples is rather small, we consider it a matter of interest to make them known, inasmuch as neither province has been studied from the point of view of their lichen flora.

All of the species mentioned are corticolous and have been preserved in CTES and MVM (Departamento de Botánica, Museo Nacional de Historia Natural, Montevideo, Uruguay).

Caloplaca holocarpa (Hoffm.) Wade

SANTA FE: Depto. de San Jerónimo: Arroyo Colastiné (Highway 11, 15 km S from Coronda). *Krapovickas & Irigoyen* 27 Jan. 1971. First report for North Argentina. Previously reported from Tierra del Fuego (Cengia Sambo, 1926), Islas Malvinas (Dumont D'Urville, 1826) and Rio Negro Province (Müll. Arg., 1889).

Candelaria fibrosa (Fr.) Müll. Arg.

---

(1) Departamento de Botánica, Museo Nacional de Historia Natural, Casilla de Correo 399, Montevideo, Uruguay

(2) Departamento de Botánica, Facultad de Ciencias Agrarias, Casilla de Correo 209, Corrientes, Argentina

SANTA FE: Depto. San Jerónimo, Arroyo Colastiné (Highway 11, 15 km S from Coronda). *Krapovickas & Irigoyen* 27 Jan. 1971.

Parmelia microsticta Müll. Arg.

SANTA FE: Depto. Gral. Obligado, Villa Ana. *Quarín* 26 Dec. 1972.
SANTIAGO DEL ESTERO: Depto. Copo, 6 km SE of Los Pirpintos. On *Aspidosperma quebracho-blanco*. *Ferraro & Schinini* 600.

Parmotrema austrosinense (Zahlbr.) Hale

SANTIAGO DEL ESTERO: Depto. Moreno, Highway 6, 40 km W of Quimilí. On *Prosopis*. *Krapovickas & Cristobal* 24 Dec. 1971. Its distribution area, known at present in Argentina, is primarily in the northeastern region: Chaco (Hale, 1965) and Corrientes (Osorio & Ferraro, 1975).

Parmotrema praesorediosum (Nyl.) Hale

SANTIAGO DEL ESTERO: Depto. Copo, 6 km SE of Los Pirpintos. On *Aspidosperma quebracho-blanco*. *Ferraro & Schinini* 598. Previously known from Tucumán (Hale, 1965).

Parmotrema reticulatum (Tayl.) Choisy

SANTIAGO DEL ESTERO: Depto. Copo, 6 km SE of Los Pirpintos. On *Aspidosperma quebracho-blanco*. *Ferraro & Schinini* 594. New to North Argentina. The northernmost previously known locality was Mendoza (Räsänen, 1941).

Parmotrema subcaperatum (Kremp.) Hale

SANTIAGO DEL ESTERO: Depto. Copo, 6 km SE of Los Pirpintos. On *Aspidosperma quebracho-blanco*. *Ferraro & Schinini* 599.

Parmotrema uruguense (Kremp.) Hale

SANTIAGO DEL ESTERO: Depto. Moreno, Highway 6, 40 km W of Quimilí. On *Prosopis*. *Krapovickas & Cristobal* 24 Dec. 1971.

Ramalina ecklonii (Spreng.) Mey. & Flot.

SANTIAGO DEL ESTERO: Depto. Moreno, Highway 6, 40 km W of Quimilí. On *Prosopis*. *Krapovickas & Cristobal* 24 Dec. 1971.

SANTA FE: Depto. Gral. Obligado, Villa Ana. *Quarín* 26 Dec. 1972.

Ramalina usnea (L.) Howe

SANTA FE: Depto. Gral. Obligado, Villa Ana. *Quarín* 26 Dec. 1972. Previously known from Corrientes (Osorio, 1970).

Teloschistes chrysophthalmus (L.) Th. Fr. var. *cinereus* Müll. Arg.

SANTA FE: Depto. San Jerónimo, Arroyo Colastiné (Highway 11, 15 km S from Coronda). *Krapovickas & Irigoyen* 27 Jan. 1971.

Teloschistes exilis (Michx.) Vain.

SANTA FE: Depto. San Jerónimo, Arroyo Colastiné (Highway 11, 15 km S from Coronda). *Krapovickas & Irigoyen* 27 Jan. 1971.

Teloschistes flavicans (Sw.) Norm. var. *acromelas* (Pers.) Müll. Arg.

SANTA FE: Depto. Gral. Obligado, Villa Ana. *Quarín* 26 Dec. 1972. Previously known from Corrientes (Osorio & Ferraro, 1975).

Usnea sulcata Mot.

SANTA FE: Depto. Gral. Obligado, Villa Ana. *Quarín* 26 Dec. 1972.

The authors thank Dr. Mason E. Hale, Jr. for help in many ways.

LITERATURE CITED

Cengia Sambo, M. 1926. I licheni della Terra del Fuoco raccolti dai Missionari Salesiani. *Contr. Scient. Miss. Salesiani Ven. Don Bosco*. No. 4:1-53.

Dumont D'Urville, J. 1836. Flore des Malouines. *Mém. Soc. Linne. Paris.* IV:572-621.

Hale, M. E., Jr. 1965. A monograph of *Parmelia* subgenus *Amphigymnia*. *Contr. U. S. Natl. Herb.* 36(5):193-358.

Müller Arg., J. 1889. Lichenes argentinenses a cl. Dr. Lorentz in Argentinia australis patagonica et prope Conceptionen lecti, additis nonnulis in Paraguay prope Assumpcion ab eodem lecti. *Flora* LXII:508-512.

Osorio, H. 1970. Contribution to the lichen flora of Argentina IV. New or additional records. *The Bryologist* 73:392-394.

Osorio, H. & Ferraro, L. 1975. Contribution to the lichen flora of Argentina VII. New or noteworthy records from the Province of Corrientes. *Comunic. Bot. Mus. Hist. Nat. Montevideo.* 4(57):1-4.

Räsänen, V. 1941. La flora liquenológica de Mendoza. *An. Soc. Cient. Argentina.* CXXXI:97-110.

MYCOTAXON

Vol. IV, No. 2, pp. 335-339 October-December 1976

STUDIES ON THE SPORES OF MYXOMYCETES. II. PHYSARUM STRAMINIPES[1,2]

RAYMOND W. SCHEETZ

Department of Biology
University of Southern Mississippi
Hattiesburg, Mississippi 39401

and

CONSTANTINE J. ALEXOPOULOS
Cell Research Institute and Department of Botany
University of Texas at Austin
Austin, Texas 78712 U.S.A.

INTRODUCTION

Physarum straminipes A. Lister is one of the less common species of Myxomycetes which, in North America, is known only from Oregon (Hagelstein, 1944; Martin, 1949; Martin and Alexopoulos, 1969). In the original description A. Lister (1898) states: "...the spores as seen with moderate magnification, are dark purple-brown, with a mottled appearance; high magnification shows the spore-wall to be olive-brown beset with crowded dark warts occupying broad irregular patches; these are separated from each other by nearly smooth intervening spaces, having the effect of pale bands." Macbride (1922), Macbride and Martin (1934) and later Martin (1949) all say "spores...warted, the papillae in definite patches." Hagelstein (1944), in his monograph patterned after Lister's The Mycetozoa (1925), describes the spores as "marked with broad patches of warts separated by smoother tracts..." Finally, Martin and Alexopoulos (1969) describe the spores of Physarum straminipes as "...prominently warted with larger warts grouped in clusters..." The illustrations of the spores in Lister's original description (1898); in the third edition (1925) of the Lister monograph; and in Martin and Alexopoulos (1969) all show prominent, smooth, wide bands separating the groups of warts, giving the spores a reticulate appearance.

---

[1]The first article of this series in Trans. Am. Microsc. Soc. 90: 473-475.

[2]Partially supported by NSF grant #DMR-7504020 to R. W. Scheetz.

In view of our results (Scheetz and Alexopoulos, 1971) with the spores of Badhamia gracilis (Macbr.) Macbride and Reticularia lycoperdon Bull. both of which exhibit ridgelike areas on their surfaces, we thought it interesting to elucidate the nature of the "bands" separating the wart groupings on the spores of P. straminipes, despite the fact that neither the original description, nor any of the later monographs describes them as ridges.

MATERIALS AND METHODS

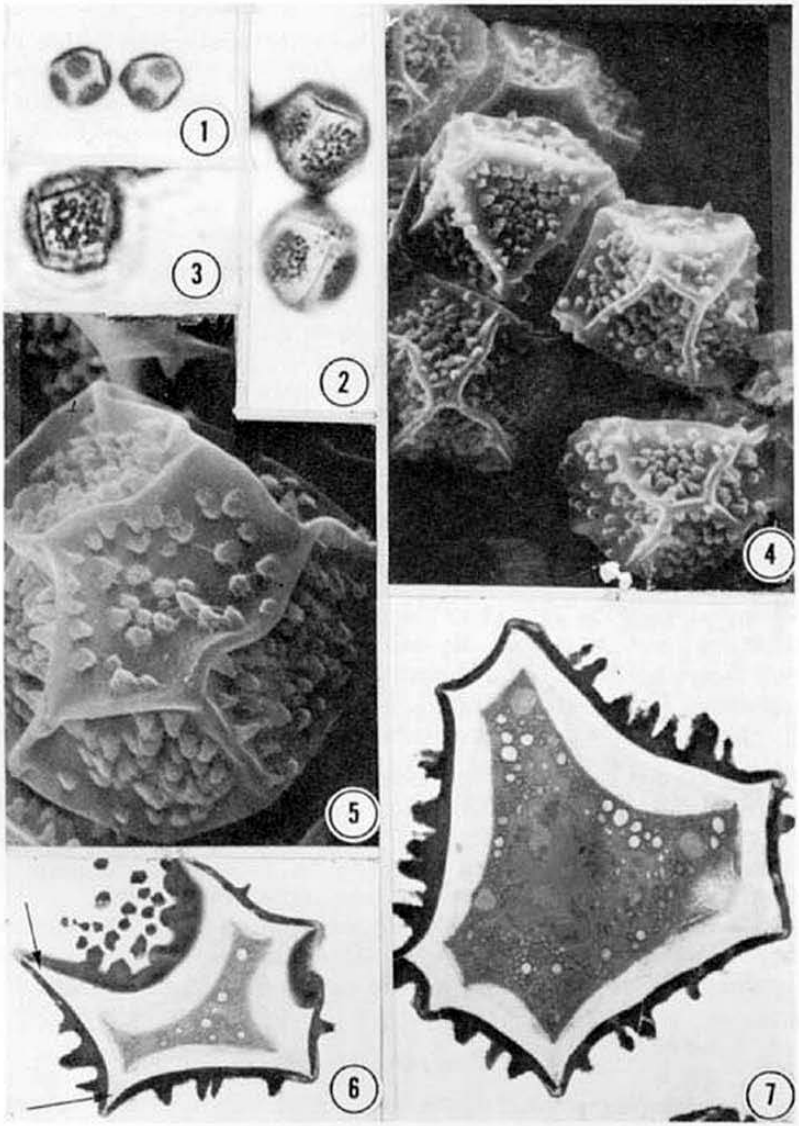
New York Botanical Garden specimen No. 10931 of P. straminipes marked type material, was borrowed through the courtesy of Dr. Clark Rogerson. Another specimen, was borrowed from the University of Iowa through the courtesy of Dr. R. L. Hulbary. Both specimens were collected in England.

For both bright field and phase contrast light microscopy, spores were mounted in Amman's medium (Martin and Alexopoulos, 1969, p. 15), on a slide, covered with a #0 square cover slip, and heated gently over a small flame for examination with the high dry (40X) and the oil immersion (100X) objectives. For scanning electron microscopy (SEM), spores were fixed in 2% glutaraldehyde, 0.1 M cacodylate, pH 7.2, dehydrated, and dried in a critical point drying apparatus. They were then coated with carbon followed by palladium (40%) and gold (60%) prior to examination in an AMR 1000A scanning electron microscope.

For transmission electron microscopy (TEM), spores were coated with 2% agar and fixed at room temperature in 2% glutaraldehyde, 0.1 M cacodylate, pH 7.2. They were then post fixed in 2% osmium tetroxide in the same buffer and then bulk stained with 0.5% uranyl acetate. Following dehydration, spores were embedded in a hard formulation of Spurr's low viscosity plastic. Sections were cut with a diamond knife using a Porter Blum MT 2-B ultramicrotome. Thin sections were stained with uranyl acetate followed by lead citrate and viewed in a Siemens Elmiscope 1A electron microscope.

RESULTS AND DISCUSSION

Examination of the spores of P. straminipes with a bright field, high dry (40X) objective shows (Fig. 1) the wide smooth bands between the groups of warts as described by all previous investigators. The 100X oil immersion objective, however, both with bright field and phase contrast optics shows them to be reticulately ridged (Figs. 2, 3). SEM micrographs (Figs. 4, 5) confirm the presence of ridges between the warted areas of the spores and show them to be virtually devoid of warts. As in Badhamia gracilis, however, these ridges do not appear to be homologous with what might be called true ridges like those of Reticularia lycoperdon spores, but rather pointed



Figs. 1-7. Spores of Physarum straminipes A. Lister N.Y.B.G. #10931 (Type material). Figs. 1-2. Bright field. Fig. 1. 40X objective, X1000. Fig. 2, oil immersion, X1500. Fig. 3. Phase contrast, oil immersion, X1500. Figs. 4-5. SEM X3500 and 8700 respectively. Figs. 6-7. TEM X6400 and 8000 respectively. (Magnifications approximate).

extensions of the entire spore wall which are duplicated inside the spore by the protoplast itself (Figs. 6, 7). True ridges are ornamentations which are an integral part of the outer, electron dense wall layer (See Scheetz and Alexopoulos, 1971). The study of both specimens cited above, yielded identical results.

Thus, we have another myxomycete spore which appears to be reticulately ridged but in which the ridges are not formed in the same way as warts or spines, but rather represent a permanent wrinkling of the spore itself. This is not due to loss of turgidity but is an inherent character of the mature spore as shown by the presence of the ridges on spores mounted in Amman's medium and expanded by heating, as well as in critically dried specimens. The spores of P. straminipes then should be described as "bearing clusters of prominent warts separated by nearly smooth ridges."

The results described above once more illustrate the value of the SEM in examining the surface markings of myxomycete spores. Direct observations with the high power, bright field objective of the light microscope sometimes fail to reveal the true nature of spore markings (Fig. 1). Even phase contrast optics are sometimes inadequate, but are admittedly much better than bright field (Fig. 3), as shown by the failure of careful observers (Lister, 1898; Hagelstein, 1944; Martin, 1949) to detect the ridges on the spores of P. straminipes, so clearly illustrated by SEM.

We do not know whether good quality oil immersion objectives were available to Arthur Lister and Hagelstein. We do know that Martin did use an apochromatic oil immersion lens for observing surface markings and for drawing them, as reported on the page just preceding the illustrations in Macbride and Martin (1934). Unfortunately, P. straminipes is not among the species illustrated in that monograph. We are at a loss, consequently to understand how a careful observer like Martin failed to see the ridges on these spores.

ACKNOWLEDGMENTS

We express our gratitude to Drs. Clark Rogerson and Robert Hulbary for the loan of specimens as cited, and to Drs. Meredith Blackwell, Marie L. Farr, and Don T. Kowalski for their critical reviews of the manuscript before submittal to MYCOTAXON.

LITERATURE CITED

HAGELSTEIN, R. 1944. The Mycetozoa of North America. 289 p. Publ. by the author. Mineola, New York.

LISTER, A. 1898. Notes on Mycetozoa. Jour. Bot. 36 (May): 161-166.

LISTER, A. and G. LISTER. (1925). Mycetozoa (3rd. ed.), 296 p. British Museum (Nat. Hist.). London.

MACBRIDE, T. 1922. The North American Slime Moulds (2nd ed.) 299 p. The Macmillan Company. New York.

MACBRIDE, T. and G. W. MARTIN. 1934. The Myxomycetes. 339 p. The Macmillan Company, New York.

MARTIN, G. W. 1949. Myxomycetes. In N. Am. Fl. Vol. 1, Pt. 1, 189 p. New York Bot. Gard., New York.

MARTIN, G. W. and C. J. ALEXOPOULOS. 1969. The Myxomycetes. 561 p. University of Iowa Press, Iowa City.

SCHEETZ, R. W. and C. J. ALEXOPOULOS. 1971. The spores of Badhamia gracilis (Myxomycetes). Trans. Am. Microsc. Soc. 90: 473-475.

MYCOTAXON

Vol. IV, No. 2, pp. 340-346 October-December 1976

CALLORIOPSIS AND MICROPYXIS: TWO DISCOMYCETE GENERA IN THE CALLORIOPSIDEAE TRIB. NOV.

DONALD H. PFISTER

Department of Biology and Farlow Reference Library and Herbarium of Cryptogamic Botany, Harvard University, Cambridge, MA 02138

A study of two monotypic genera of Discomycetes, *Calloriopsis* Sydow and *Micropyxis* Seeler, has led me to conclude that the two genera are closely related and deserve to be placed together in a new tribe of the Leotiaceae. The Discomycetes referred to these genera are parasitic on other fungi, have gelatinous, relatively simply constructed sessile apothecia, and have small iodine negative, inoperculate asci. Coincidently, both species either have been described as members of the Hypocreales or have been confused with Hypocrealean fungi.

Calloriopsis Sydow

The genus *Calloriopsis* is based upon a parasitic inoperculate discomycete which occurs on *Meliola* and related black mildews. First collected and described from Florida as *Peziza gelatinosa* Ellis and Martin, it is known throughout the tropical regions.

There has been a great deal of nomenclatural and taxonomic confusion over this fungus. The name *Peziza gelatinosa* Ellis and Martin is a later homonym of *P. gelatinosa* Bull. ex Merât. According to Article 72 of the *International Code of Botanical Nomenclature* the Ellis and Martin name has no status. Saccardo (1899) first combined this epithet under another genus, *Orbilia*. In so doing he became the publishing author. The first valid name for this species is *Orbilia gelatinosa* Sacc. By reason of its parasitism of *Meliola* it has often been confused with

Peziza leucorrhodina Mont. which is properly placed in the genus *Nectria* (Samuels 1976). Although this had been stated earlier by von Hohnel (1909) and others, Seaver (1951) nonetheless used the name *Trichobelonium leucorrhodinum* for this discomycete. Earlier the Montagne name had been used by Spegazzini (1888) under *Scutula* for this fungus. *Belonidium leucorrhodinum* (Mont.) Sacc. was used by Seymour (1929) and Seaver (1925).

I have examined several collections of *Calloriopsis gelatinosa*, including the type. The description below is based upon these collections. I consider *Calloria meliolicola* P. Hennings a synonym.

Calloriopsis gelatinosa (Sacc.) Sydow, Ann. Mycol. 15: 254. 1917. FIG. 1

≡[*Peziza gelatinosa* Ell. & Mart., Amer. Nat. 17: 1283. 1883, later homonym, non *Peziza gelatinosa* Bull. ex Merât, nec *Peziza gelatinosa* Haller].

≡*Orbilia gelatinosa* Sacc., Syll. Fung. 8: 624. 1889, (attributed to Ellis & Martin) first valid publication of epithet, Art. 72.

≡*Coryne gelatinosa* (Sacc.) Rehm, Ann. Mycol. 5: 518. 1907.

=*Calloria meliolicola* P. Henn., Botanisch. Jahrb. 25: 509. 1898.

≡*Coryne meliolicola* (P. Henn.) v. Höhnel, Sitzungsber. Kaiserl. Akad. Wiss., Math.-Naturwiss. Kl., Abt. 1. 118: 106. 1909.

Ascocarps 0.4-0.6 mm in diam, with a free margin, when dried translucent yellowish to orange to pinkish, sometimes situated upon an inconspicuous subiculum. The gelatinous material in the sterile tissue is found throughout the subhymenium, ectal excipulum and medullary excipulum. The subhymenium is composed of small tightly interwoven hyphae. The cortical layer is composed of parallel hyphae which are imbedded in gel. Lactophenol cotton-blue stains only the cytoplasm, in what appear to be thin lumenal cavities. When mounted in congo red in ammonia, the gel appears to dissolve and the cortical layer, composed of septate, thin-walled hyphae which are swollen at the tip, can be seen. The medullary zone is composed of interwoven hyphae with occasional swollen cells. These swollen cells may represent

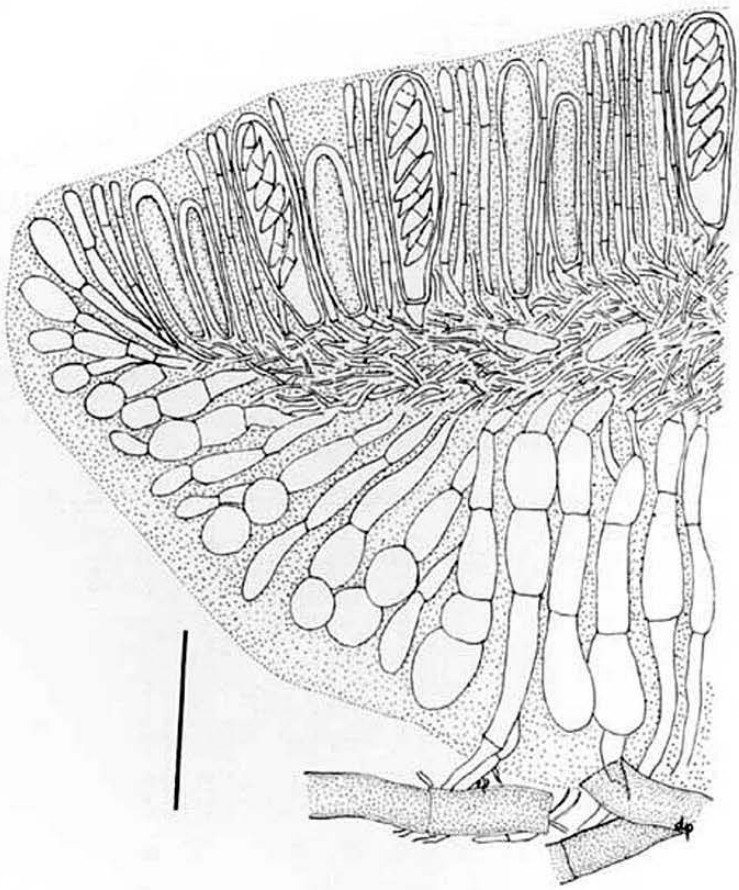


FIG. 1. Median section through an apothecium of *Calloriopsis gelatinosa* situated on mycelium of a *Meliola*. The scale is equivalent to 25 µm. (Drawn from the J. R. Bartholomew collection in FH from Florida cited in the text.)

remnants of the ascogonial system. Asci are short clavate, thick-walled (particularly in young asci), 8-spored, 40-52 x 11-15 µm. Paraphyses are filamentous, unbranched 1.5-2.5 µm in diam, sometimes swollen at the tip to 3.5 µm. The paraphyses sometimes arch over the asci but do not form a true epithecium. The hymenium is filled with gel which extends well above the hymenium. The ascopores are ellipsoid to almost fusoid, sometimes curved, one or two septate, (10-)12-16 x 3-6 µm. The asci and apothecial tissues are J-. The subiculum, when present, is composed of interwoven hyphae which are sometimes swollen to produce occasional moniliform hyphae.

Occurring in groups on the mycelium of *Meliola* spp. and related foliicolous ascomycetes.

Specimens examined - Java: auf *Phragmites* sp. an *Meliola substenospora* v. H., Buitenzorg, von Höhnel, 1907-08, FH. This collection was also issued in Rehm, Ascomyceten as number 1851 and was identified as *Calloria meliolicola*. Puerto Rico: [on *Meliola*] on leaves of herbs, Mayaguez, Fink number 938, Dec. 17, 1915, FH. Guadeloupe: sur les feuilles, citromier vivant, Camp Jacob, Duss 766, Mai 1903, Patouillard Herbarium, FH. U.S.A.: Florida, on *Meliolina*?, on black gum (*Nyssa*), Winter Park, 1939, Jas. R. Bartholomew, FH; Holotype: on living leaves of *Persea palustris*, on patches of sterile mycelium of some *Meliola*, Ellis coll., NY.

Micropyxis Seeler

Seeler (1943) very precisely described the only species placed in *Micropyxis*, *M. geoglossi* (Ell. & Ev.) Seeler. Seeler's description of it is quoted below. He considered it as a very reduced member of the Helotiaceae, with which opinion I agree. I have reexamined his material on deposit at the Farlow Herbarium. *Micropyxis* has been treated by Korf (1973) in the tribe Mniaecieae. Save for their small sessile apothecia, few traits are shared by *Micropyxis* and the other, primarily bryophilous, members of the Mniaecieae.

Micropyxis geoglossi (Ell. & Ev.) Seeler, Farlowia 1: 126. 1943.

≡*Hypomyces geoglossi* Ell. & Ev., J. Mycol. 23: 73. 1972.

≡*Peckiella geoglossi* (Ell. & Ev.) Sacc., Syll. Fung. 9: 944. 1891.
≡*Eleutheromyces geoglossi* (Ell. & Ev.) Seaver Mycologia 1: 48. 1909.

"Ascocarps superficial, parasitic on hymenial surface of members of the Geoglossaceae, growing close together, mostly distinct, rarely anastomosing, pale yellow-brown, translucent and gelatinous when wet, shrunken and brittle when dry, resembling microscopic droplets of dark resin, at first spherical, finally up to three times as broad as high, 60-150 μ diam x 60-70 μ high, ascus layer 25-45 μ deep; base (hypothecium) short, of thick-walled gelatinous hyphae, pseudoparenchymatous, lower part composed of hyphae which spread out, surrounding the tops of host paraphyses and asci and wedging between them and connecting to the bases of neighboring apothecia; excipulum formed of a single layer of branching filaments in an amber-colored gelatinous substance; these arch over the tops of the asci in young apothecia almost completely covering them; no true epithecium of fused tips of paraphyses; pale amber gelatinous material covers the tops of the asci. Asci eight-spored, clavate, short-stiped, stipes mostly broad, thickened, obtuse apex, 28-45 x 6.4-8.3 μ rarely a little longer. Paraphyses hyaline, filamentous, simple or once-branched near base, 1.2-1.6 μ diam, tips never branched, swollen, 1.9-3.2 μ diam, slightly overtopping the asci and about as numerous as they. Spores one-celled, hyaline, long elliptical or tapering toward base, ends rounded, irregularly distichous, 7.7-10.5 x 2.5-3.2 μ. No parts blue with iodine.

Besides the collections on *Trichoglossum farlowii*, *T. Walteri*, and *Geoglossum* spp. mentioned by Seeler from Massachusetts, New Jersey, Tennessee, and North Carolina, I have also seen a collection from Jamaica (CUP-MJ-311) on *Trichoglossum rasum* gathered and determined by Dr. R. P. Korf. No doubt the fungus is widely distributed through temperate and tropical regions. Its diminutive stature and near disappearance upon drying make it a particularly difficult fungus to discern.

DISCUSSION

The Tribe Calloriopsideae

Calloriopsideae trib. nov., family Leotiaceae, subfamily Leotioideae.

Apothecia parva vel minuta, sessilia, composita hypharum comparate simplicium. Hyphae in gelatina inclusae. Ascosporae hyalinae, 1-3 septatae, asci J-. Parasitici in fungis. Typus: Calloriopsis *Syd.*

The two genera included, *Calloriopsis* and *Micropyxis*, should pose no problems for identifications. The obvious differences in host preferences aside, the amber gel, simpler apothecial construction, one-celled ascospores and smaller asci of *Micropyxis* easily distinguish it from *Calloriopsis*.

Calloriopsis gelatinosa has certain similarities to some of the species now placed in the genus *Scutula* Tul. of the Patellariaceae. These lichen parasites, as a group, agree in apothecial construction with *C. gelatinosa*. Species placed in *Scutula* should be examined in light of their possible alliance with *C. gelatinosa*.

The presence of gelatinous material in the apothecia of these fungi and their parasitic habit are major features which distinguish them from most other members of the Leotioideae. Possession of gel is not unique to these fungi, but the dependence upon gel for apothecial integrity is of importance. Gel is found in the apothecia of both *Calloriopsis gelatinosa* and *Micropyxis geoglossi* in all zones, including the hymenium. Such abundance of gel has probably served a twofold function. On the one hand it may serve as a water storage material and on the other hand, it must serve as a protective barrier against excessive water loss. By virtue of the position of these fungi on their substrates they are exposed in their entirety, including their superficial mycelium, to the desiccating effects of wind and excessive light and heat. The gel which surrounds all of the thin-walled hyphal elements of the apothecium undoubtedly retards the inevitable evaporation.

ACKNOWLEDGEMENT

The author wishes to acknowledge financial support from the American Philosophical Society (grant no. 7316, Penrose Fund) for this project.

346

LITERATURE CITED

Höhnel F. von. 1909. Fragmente zur Mykologie. Sitzungsber. Kaiserl. Akad. Wiss., Math-Naturwiss. Kl., Abt. 1. *118*: 106-107.

Korf, R. P. 1973. Discomycetes and Tuberales, Chap. 9 *in* Ainsworth, G. C., F. K. Sparrow, and A. S. Sussman, eds. "The Fungi: An Advanced Treatise," 4A: 249-319.

Samuels, G. J. 1976. A revision of the fungi formerly classified as *Nectria* subgenus *Hyphonectria*. Mem. New York Bot. Gard. *(26)3*: 1-126.

Seaver, F. J. 1925. Studies in Tropical Ascomycetes - III. Porto Rican Cup-Fungi. Mycologia *17*: 45-50.

_____. 1951. "The North American Cup-Fungi (Inoperculates)." Published by the author, New York.

Seeler, E. V., Jr. 1943. Several fungicolous fungi. Farlowia *1*: 119-133.

Seymour, A. B. 1929. Host Index of Fungi of North America. Harvard University Press. Cambridge, Massachusetts.

Spegazzini, C. 1888. Fungi Guaranitici. Anales Soc. Ci. Argent. *26*: 58. 1888.

MYCOTAXON

Vol. IV, No. 2, pp. 347-348 October-December 1976

AN AUTHOR/TITLE INDEX TO BOOK REVIEWS, MYCOTAXON VOLS. 1-3

G. L. HENNEBERT

Book Review Editor, Huttelaan 38, B-3030 Heverlee, Belgium

VOLUME ONE

VOLUME TWO

VOLUME THREE

MYCOTAXON

Vol. IV, No. 2, pp. 349-488 October-December 1976

TAXONOMY OF *MALBRANCHEA* AND SOME OTHER HYPHOMYCETES WITH ARTHROCONIDIA

LYNNE SIGLER AND J.W. CARMICHAEL

University of Alberta Mold Herbarium
and Culture Collection
Edmonton, Alberta, T6G 2H7

ABSTRACT

The relationship of *Malbranchea* to other Hyphomycete form-genera is discussed and a tabular key to morphologically related genera is provided.

In Part I, generic names which are linked in some way to *Malbranchea* are treated in alphabetical order. They are *Arcuadendron* (new genus), *Arthrographis* (newly validated), *Bahusakala*, arthroconidial states of Basidiomycotina (without form-generic names), *Briosia*, *Chrysosporium*, *Coccidioides*, *Coremiella*, *Geomyces* (lectotype chosen, 1 new species, 1 new combination), *Geotrichum*, *Mauginiella*, *Oidiodendron*, *Oidium*, *Oospora* (rejected), *Ovadendron* (new, for *Oospora sulphureo-ochracea*), *Ptychogaster*, *Scytalidium* (key to species, 1 new combination) and *Sporendonema*. In the treatment of *Oidiodendron*, *Myxotrichum striatosporum* is proposed as a new combination for *Arachniotus striatosporus* and *M. setosum* is described as having an *Oidiodendron* conidial state.

In Part II, the species of *Malbranchea* are described and illustrated. The type species, *M. pulchella* Saccardo & Penzig, is redefined and *M. pulchella* var *sulfurea* (Miehe) Cooney & Emerson is raised to specific rank. Eleven new species are described and illustrated: *M. albolutea*, *M. arcuata*, *M. aurantiaca*, *M. chrysosporoidea*, *M. circinata*, *M. dendritica*, *M. flava*, *M. flavorosea*, *M. flocciformis*, *M. fulva* and *M. gypsea*. A new heterothallic genus of the Gymnoascaceae (Ascomycotina) is proposed for a single species, *Uncinocarpus reesii*, having a *Malbranchea* conidial state. The perfect states of some species of *Malbranchea* belong in the genera *Auxarthron* and *Myxotrichum* of the Gymnoascaceae.

INTRODUCTION

In our studies of keratinolytic and other soil fungi, we accumulated many cultures forming arthroconidia. These were at first filed in our collection under Geotrichum sp. or Malbranchea sp. This paper is a result of our attempts to identify or classify these strains.

It has long been known that a variety of fungi can form spores by fragmentation of their hyphae into segments. Now often called arthroconidia, these segments were formerly called oidia or arthrospores. The fungi which produced them were usually assigned to the form-genera Oidium or Oospora, both of which became dumping grounds for a wide variety of arthroconidial and other fungi. The relatively undifferentiated structure of the hyphae which produce arthroconidia, and the simple cylindrical form of the conidia have hindered attempts to sort them out.

In 1953, Hughes drew attention to the ontogeny of meristem arthroconidia, which are formed in basipetal succession on a continuously elongating conidiogenous cell. This allowed a clear separation of the conidial states of the Erysiphaceae from the rest of the 'Oidiums', and the genus name Oidium has now been conserved for this group (see Taxon 24:534, 1975). The fungi with slimy, fission arthroconidia (arthroconidia which separate from each other by fission of their common septum) were clearly established in Trichosporon by Lodder and Kreger van Rij (1952) and in Geotrichum by Carmichael (1957). In 1957, Pesante created Scytalidium for dematiaceous fungi with fission arthroconidia. However, fungi with hyaline, dry, fission arthroconidia are still not well provided with form-genera. We will validate Arthrographis for one group of them (vide infra), but the arthroconidial states of Basidiomycotina need further work.

The fungi with alternate arthoconidia (arthroconidia which are spaced apart from each other by separating cells) are also not well sorted into form-genera. Barron (1962) redescribed Oidiodendron in modern terms, but Sporendonema and Coremiella are poorly known to most mycologists. We will describe and illustrate some of their species. Saccardo created Malbranchea in 1882 for fungi with alternate arthroconidia formed on curved branches, but the genus was seldom mentioned until Cooney and Emerson described a thermophilic variety in 1964. We found that most of our previously undescribed species could be accommodated in Malbranchea by slightly revising its circumscription to include fungi with small, alternate arthroconidia borne on either straight or curved branches. For similar-appearing fungi whose conidiogenous hyphae continue to grow after the initiation of each conidium, we describe the new genus Arcuadendron. For a species similar

to Malbranchea, but having swollen arthroconidia, we describe the new genus Ovadendron.

Part I of this paper starts with a key to the genera, followed by a treatment (in alphabetical order), of the generic names which are linked to arthroconidial fungi. New species and some classical species are described and illustrated for many of the genera. Part II is a treatment of Malbranchea, with descriptions and illustrations of all the species. We include in the form-genus Malbranchea both cellulolytic and keratinolytic species. These are probably not closely related phylogenetically. Indeed, some cellulolytic species are known to have Myxotrichum perfect states, whereas some keratinolytic species have Auxarthron perfect states. For one species, we describe the new Gymnoascaceous genus Uncinocarpus.

MATERIALS AND METHODS

SPECIMENS AND CULTURES: At the beginning of this study, the University of Alberta Mold Herbarium and Culture Collection contained approximately 100 strains of Malbranchea that had been collected over a period of 10-12 years. Many of these were originally isolated by Dr. G. F. Orr (Deseret Test Center, Dugway, Utah) during his studies on Gymnoascaceae. Additional cultures were obtained from Dr. Z. Hubalek (Institute for Parasitology, Prague) who sent some isolates collected during his studies of birds (Hubalek, Balat, Touskova and Vik, 1973; Hubalek and Balat, 1974; Hubalek, 1974a, 1974b), and from Dr. K. Tubaki (Institute for Fermentation, Osaka) (IFO) who exchanged a number of cultures. Mrs. C. A. Johansen (Western Forest Products Laboratory Culture Collection of Wood Inhabiting Fungi, Vancouver) (WFPL) kindly sent several cultures of Ptychogaster. Further reference cultures were obtained from the Centraalbureau voor Schimmelcultures (CBS), Baarn; the Commonwealth Mycological Institute (CMI), Kew; and the Department of Agriculture (DAOM), Ottawa. Herbarium specimens were received from the New York Botanical Garden Cryptogamic Herbarium (NYBG), and the Herbarium of the Commonwealth Mycological Institute (IMI), Kew.

Abbreviations for other culture collections or herbaria cited in the text are:

ATCC -American Type Culture Collection, Rockville, Maryland
CDC -Center for Disease Control, Atlanta, Georgia
NRRL -Northern Utilization Research Development Division, Peoria, Illinois
RSABG -Rancho Santa Ana Botanic Garden, Claremont, California
UAMH -University of Alberta Mold Herbarium and Culture Collection, Edmonton, Alberta

Dried colonies of the type strain of each new species are maintained in the UAMH as holotype. Subcultures of the type strain are deposited in the CMI, CBS and ATCC.

CULTURE METHODS: Media used in the study consisted of phytone yeast extract agar (PYE) (Carmichael, 1962), pablum mixed cereal agar (Carmichael, 1962), dextrose-salts agar (DSA) (Carmichael, 1962), and oatmeal-salts agar (medium E) (Weitzman and Silva-Hutner, 1967; Padhye, Sekhon and Carmichael, 1973). PYE is available in dehydrated form from Baltimore Biological Laboratories, Cockeysville, Md. Pablum mixed cereal is marketed as baby food by Mead Johnson Nutritionals, Evansville, Ill.

Cellophane plates were prepared by laying a single sterile (62 x 62 mm) cellophane membrane designated 300 PT (plain, transparent) over the surface of an agar plate prepared in a 90 mm plastic disposable petri dish (Carmichael, 1962). The cellulolytic ability of the fungus was determined by its capacity to digest this membrane either partially or completely.

Cellophane plates were inoculated from the periphery of two week old colonies on cereal slants which were then maintained at 8 C as stock cultures. Each strain was inoculated in triplicate to PYE, cereal and oatmeal agar plates. The effects of temperature were recorded by incubation of a single PYE and cereal plate at each temperature of 25 C, 37 C and 45 C for a maximum of 21 days. A single oatmeal agar plate was incubated at 18 C, 25 C and 30 C for 35 days. Cultures at 25 C were exposed to fluorescent room light on an irregular basis, usually 8-10 hours per day, 5 days per week. Cultures at other temperatures were incubated in darkness with exposure to light only during examination.

Each colony on PYE and cereal was examined weekly to measure the diameter and record colony characters and presence of a diffusible pigment. The diameter recorded was the average of two measurements taken at right angles to each other. Cultures on PYE and cereal were incubated for 21 days before being photographed and dried. Colonies were dried by removing the cellophane membrane to a press (Carmichael, 1963). Colonies on oatmeal agar were examined at 35 days. If cleistothecial initials appeared or cleistothecia were not mature, oatmeal plates were kept 2-4 weeks longer.

The keratinolytic activity of a fungus <u>in vitro</u> was determined by the amount of digestion of the hair when the fungus was grown on a nutritionally minimal medium (DSA) sprinkled with hair (Carmichael, 1962). After two weeks growth, hairs were examined microscopically to record the extent of visible digestion and the degree of penetration

of the hyphae with or without the aid of penetrating bodies.

TECHNIQUES FOR SEXUAL CROSSES: Procedures for mating heterothallic species of the Gymnoascaceae, especially of the genera Arthroderma and Nannizzia, are well established (Dawson and Gentles, 1961; Padhye, 1969; Padhye and Carmichael, 1969, 1971, 1972, 1973). Early reports indicated that soil sprinkled with a keratin source such as feathers, hair, nail, hoof, etc. was superior to an agar medium (Dawson and Gentles, 1961; Dawson, Gentles and Brown, 1964; Stockdale, 1963). However, more recent studies (Weitzman, Kozma, and Silva-Hutner, 1969; Padhye et. al., 1973) indicate that a non-keratinous agar such as the oatmeal-salts agar (medium E) of Weitzman and Silva-Hutner (1967) stimulates excellent production of ascocarps.

Conidial suspensions were prepared by transferring a small inoculum from the periphery of a 14 day old culture grown at 25 C on cereal agar to 1 ml of sterile distilled water in a test tube. Two methods of inoculation to oatmeal-salts agar were used: A) mixed conidial suspensions, and B) parallel inoculation of separate conidial suspensions. If the organism was known to utilize keratin some sterile hairs from an adult blonde woman were sprinkled over the agar. Crosses were observed weekly to six weeks when gymnothecia were reported. Plates were retained up to 56 days before being discarded as negative.

Single ascospore isolations were made from gymnothecial strains with the aid of a de Fonbrune micromanipulator. After 24-48 hours incubation at 25 C, single germinating ascospores were transferred to PYE or oatmeal plates.

TERMINOLOGY FOR CONIDIA AND CONIDIOPHORES: The terms used in this report are primarily those recommended by the proceedings of the Kananaskis Conference on Fungi Imperfecti (Kendrick, 1971). However, aleurioconidium is retained here, in Vuillemin's (1911) original sense, for a conidium borne laterally or terminally on an undifferentiated hypha or on short pedicels and released by lysis of the supporting cell. Although aleurioconidium was rejected as a confused term, no other was proposed to replace it. The term specifies a particular method of conidium dehiscence (see Carmichael in Kendrick, 1971, p. 245).

Aleurioconidia are similar to alternate arthroconidia and often intergrade. We prefer the term 'alternate arthroconidia' over the older 'endoarthroconidia' for arthroconidia separated by one or more relatively empty segments, and released by lysis of the outer wall of the intervening segment. Another suitable term is

arthroaleurie defined by Orr (1963b).

The term conidiophore is used here for a differentiated hyphal structure which supports the conidia or conidiogenous cells away from the vegetative mycelium (see Carmichael, in Kendrick, 1971, p. 47). The definition accepted by the Conference (see Kendrick, 1971, p. 227) was "a conidiophore is a system of conidiogenous cells, or a single conidiogenous cell, with or without differentiated supporting structures." A conidiophore without a differentiated supporting structure is called micronematous by Ellis (1971). A micronematous conidiophore cannot be distinguished from the vegetative hypha before the process of conidium formation begins. According to the definition used in this report, fungi developing conidia on undifferentiated hyphae lack conidiophores.

TAXONOMIC NAMES AND CROSS-REFERENCE NAMES: The genera of the Hyphomycetes are form-genera, based on the asexual reproductive part of the life-cycle of fungi. Many form-genera contain species that are known to have perfect states in the Basidiomycotina or Ascomycotina. Unfortunately, the conidial form-genera do not correlate exactly with the classification of the perfect states, since morphologically similar conidial states may have distantly related perfect states, and vice versa.

When the perfect state of a fungus is known, the Linnaean binomial (binary combination of genus name and specific epithet) applied to it is the taxonomic name for the species. Since the main advantage of taxonomic names is that they provide unique and exclusive indexing terms for species, it seems undesirable to create or maintain additional binomials for conidial states of species. In order to refer to conidial states for purposes of identification or indexing, it is more appropriate to have a system of cross-reference names that indicate the connection between the conidial form-genus and the Linnaean name for the species (see Carmichael, 1962; Hennebert, 1971; Kendrick and Carmichael, 1973; Weresub, Malloch and Pirozynski, 1974; Nag Raj and Kendrick, 1976). The conidial state may be cross-referenced by referring to it as the (form-genus name) state of (Linnaean binomial). The use of cross-reference names does not contravene any of the provisions of the International Code of Botanical Nomenclature, but does provide an additional system of names. For uniform international indexing of cross-reference names, it would be better to use the Latin abbreviation for the connection, i.e., (form-genus name) stat. (Linnaean binomial). The reverse order, (Linnaean binomial) stat. (form-genus name), is appropriate to indicate the conidial state, but index it under the species name. Previously published Linnaean binomials for conidial

states can be reduced to synonymy under the appropriate cross-reference name when the perfect state connection has been established.

When the perfect state is not known, and a fungus is polymorphic, having conidial states belonging to more than one form-genus, then a Linnaean binomial can be proposed for the most prominent or most frequently encountered state (see Hughes, 1953, p. 650, 651; Carmichael, 1962, p. 1138; Hennebert, 1971, p. 215). The other conidial states can be referred to by cross-reference names. In this way, the creation of form-genera based on more than one type of conidium can be avoided. When a polymorphic imperfect fungus has already received one or more Linnaean names, then the oldest valid one would be given priority, and the later ones reduced to synonymy under the appropriate cross-reference names.

Following Hughes (1959), 1801 is taken as the starting point date for nomenclature of Hyphomycetes. This action contravenes Article 13f of the current Code. In this paper, two pre-1821 names are accepted by us for current use and attributed to their original author. These names are Geotrichum Link 1809, and Chrysosporium merdarium (Link 1818) Carmichael 1962.

PART I THE GENERA

KEY TO THE GENERA ..... Table I

Arcuadendron Sigler & Carmichael gen. nov.

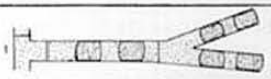
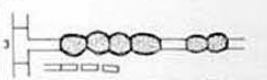
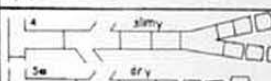
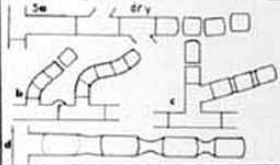
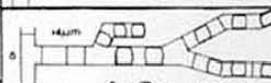
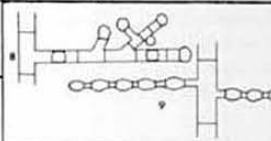
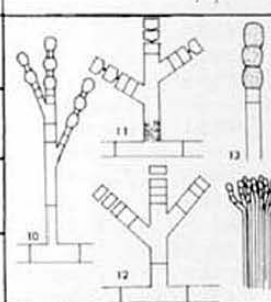
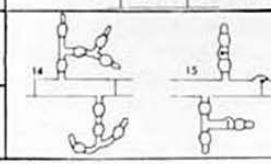
Diagnosis
Deuteromycotina, Hyphomycetes.
Hyphae hyalinae vel clarae, septatae. Conidiophorae absunt. Cellulae conidiogenae hyalinae, initio laterales, dein ex apicibus conidiorum apicalium in ordinem excrescunt, frequenter arcuatae, aliquando ramosae, demum deliquescunt. Conidia hyalina vel flava, 0-septata, in catenulatis brevibus, per cellulas vacuas disjuncta. Per deliquescere cellularum vacuarum dehiscunt.
Typus: Arcuadendron ovatum Sigler & Carmichael sp. nov.

Vegetative hyphae hyaline or yellowish green, septate; differentiated conidiophores lacking. Conidiogenous cells are integrated, serial, indeterminate, progressive, growing from the apical conidium. Conidia formed in acropetal succession, are serial, alternate, separated by short, branched or unbranched hyphal segments which dissolve to release the conidia. Conidia broadly ellipsoidal or triangular with truncate ends, hyaline or yellowish, smooth or verrucose.

TABLE I KEY TO THE

Elongation of Conidiogenous Hyphae	Septation of Conidiogenous Hyphae	Maturation of Conidia	Separation Between Mature Conidia	Width of Conidium Compared to Fertile Hypha	Color of Conidia
Determinate – Hyphal Elongation Ceases After First Conidium Initial Is Differentiated	Random or Simultaneous	Random or Simultaneous	Separating Cell	Same Width	Dark
			None	Broader	
			Connective	Same Width	Light
			Separating Cell	Broader	
	Random	Retrogressive – From Apex to Base (Basipetal)	Connective	Same Width	
			None	Broader	Dark
	Retrogressive – From Apex to Base				
Indeterminate – Elongation Continues	Progressive – Behind Growing Apex (Acropetal)	Simultaneous	Separating Cell		Light

FORM - GENERA

Erect Conidiophores	Form-Genera	Figure	Sexual States
Coremia▼	1 Coremiella		
Absent	2 Bahusakala		2 Aulographina
	3 Scytalidium		
	4 Geotrichum		4 Endomyces
	▽5a ?Mauginiella b ?Mauginiella c Not named d Not named		5▽ a ?Hymenomycetes b Phlebia c ?Hymenomycetes d Collybia
	6 Sporendonema		
	7 Malbranchea		7 Various Gymnoascaceae
	8 Chrysosporium		8 Various Gymnoascaceae
	9 Ovadendron		
Unpigmented	10 Geomyces		10 Pseudogymnoascus
Mostly Pigmented	11 Oidiodendron		11 Myxotrichum
Unpigmented	12 Arthrographis		
Coremia▼	13 Briosia		
Absent	14 Arcuadendron		
Sporodochia▼	15 Ptychogaster		15 Tyromyces

▼On natural substrate but not usually found in culture
▽Described after Bahusakala in alphabetical treatment of genera

Discussion

Arcuadendron differs from Malbranchea in that the fertile hypha continues to grow while forming conidia endogenously. In Malbranchea the hypha ceases growth before conversion to alternate arthroconidia occurs. In both, however, conidium dehiscence occurs by dissolution of the intervening segments.

Arcuadendron ovatum Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25 C velutinae, violascens, extensae. Cellulae conidiogenae in modo generis. Conidia ovoidea, truncata, flavo-viridia, verrucosa, 3-4.5 x 4-7(9)um. Typus: UAMH 2737, ex solo, India, H.C. Gugnani, S252

Colonies on PYE (Figs. 1A,1B) at 25-30 C (optimum range) are 37-39 mm in diam. in 21 days, drab violet with white or pinkish-violet center, reverse dark purple. The surface is suede-like, flat with raised center and sharp outward radiating folds developing cracks near the center (Fig. 1A); or floccose, flat near the periphery, but rising to a central plateau, smooth (Fig. 1B). Growth at 37 C is similar, 25-36 mm diam. in 21 days, drab violet, dark violet reverse, downy with few folds at the center or entirely cerebriform (Figs. 1C,1D). Colonies (Figs. 1E,1F) on cereal (diam. as on PYE) are violet, reverse dark violet, aerial growth pale buff, floccose, slightly raised with flat central plateau and glabrous margin (Fig. 1E), or yellow, powdery and flat, sectoring near the margin (Fig. 1F). The violet surface pigment does not diffuse into the agar. Colonies at 37 C grow somewhat slower (18-32 mm at 21 days) and show less luxuriant aerial growth.

Vegetative hyphae are hyaline or greenish-yellow, septate. The fertile hypha is curved (Figs. 1G-1I), narrow, 1.0-1.5um wide, arising as a lateral branch from the broader vegetative hypha; conidiogenous cells are undifferentiated. Conidia are alternate and develop serially in acropetal succession on the fertile hypha (Fig. 1G). The hypha continues to grow from the apical part of the conidium (Fig. 1J), often branching, and the conidium is delimited by an apical septum. Mature conidia (Fig. 1K), released by dissolution of the intervening hyphal segments are truncate, broadly ellipsoidal, verrucose at maturity, hyaline at first, later greenish-yellow, 3-4.5 x 4-7(9)um. The development of conidia in A. ovatum appears to be thallic, i.e., enlargement of the conidium initial occurs after delimitation by a septum. However, septum formation is not always discernible before enlargement occurs.

No other spore state was observed and an attempt to cross the isolates was unsuccessful. A. ovatum is

cellulolytic but not keratinolytic.

Material Examined
UAMH 2737, soil, India, from Gugnani, National Institute of Communicable Diseases, New Delhi as S252; UAMH 2746, from ulcer in a monkey, India, from Gugnani as M5259.

Arcuadendron triangularis Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25 C cremeae, densae, durae, pulveraceae, lente crescunt.
Cellulae conidiogenae in modo generis. Conidia triangularia, equilateralia, hyalina, laevia, in altitudine, 6-7um.
Typus: UAMH 3433, ex pilis, Clethrionomys glareolus, Yugoslavia, 1970, Hubalek BH 68 (Orr-3351)

The colony (Fig. 1L) on PYE is 20 mm diam. in 21 days, creamy white, reverse light brown. The surface is raised and convoluted, dense, tough, powdery with tiny cracks, and pale yellow exudate droplets. On cereal (Fig. 1M) the colony is flatter, 25 mm diam. in 21 days, with deep folds running parallel across the diameter of the colony, white, reverse buff, powdery. Optimum temperature 25 C; no growth at 37 C. A. triangularis digests cellophane but not keratin.

The vegetative hyphae are hyaline, septate, broad, 2.5-4um wide, often forming prominent racquet hyphae. Conidia are thallic, developing serially within an undifferentiated hypha; each conidium initial at first cylindrical, then expanding on one side to become triangular (Fig. 1N). Meristematic growth continues until the conidium is delimited by a septum (Fig. 1,O). The curved fertile hypha grows from the apex of the triangular conidium, forming conidia at regular intervals (Fig. 1,O). Conidia (Fig. 1P), released by disintegration of the intervening hyphal segments, are hyaline, smooth, triangular, more or less equilateral in shape, measuring 6-7um along the perpendicular from the apex to the base.

Arthrographis Cochet 1939 ex Sigler & Carmichael gen. nov.

Diagnosis
Deuteromycotina, Hyphomycetes.
Hyphae hyalinae, septatae, angustae, 1-3um. Conidiophora hyalina, arboroidea, brevia. Hyphae fertiles ramosae, per fissiones in septis ad arthrosporas disarticulant. Conidia hyalina vel clara, cylindrica, laevia, sicca. Geotrichi simile, sed conidia non mucosa et conidiophora adsunt. Oidiodendronis simile sed disjunctores absunt.
Typus: Arthrographis kalrai (Tewari & Macpherson) Sigler & Carmichael comb. nov.

Vegetative hyphae septate, branched, hyaline. Conidiophores simple, hyaline, branched at the apex, appearing arborescent. Fission arthroconidia formed by disjunction and segmentation of hyaline fertile branches borne at the apex of the conidiophore, or by fragmentation of undifferentiated hyphae. Arthroconidia hyaline or yellow, smooth, cylindrical, appearing discoid in end view.

Discussion

The genus Arthrographis was proposed by Cochet (1939) for a single species, A. langeroni. Although adequately described and illustrated, it was not validly published since Cochet did not include a Latin diagnosis. Arthrographis resembles both Geotrichum and Oidiodendron. It differs from Geotrichum in forming dry fission arthroconidia on conidiophores. The conidiophores of Arthrographis lack the characteristic pigmentation of Oidiodendron. Furthermore, the arthroconidia of Arthrographis are smooth-walled and lack the connectives between maturing conidia that are prominent in Oidiodendron (Barron, 1961, 1962; Cole and Kendrick, 1969).

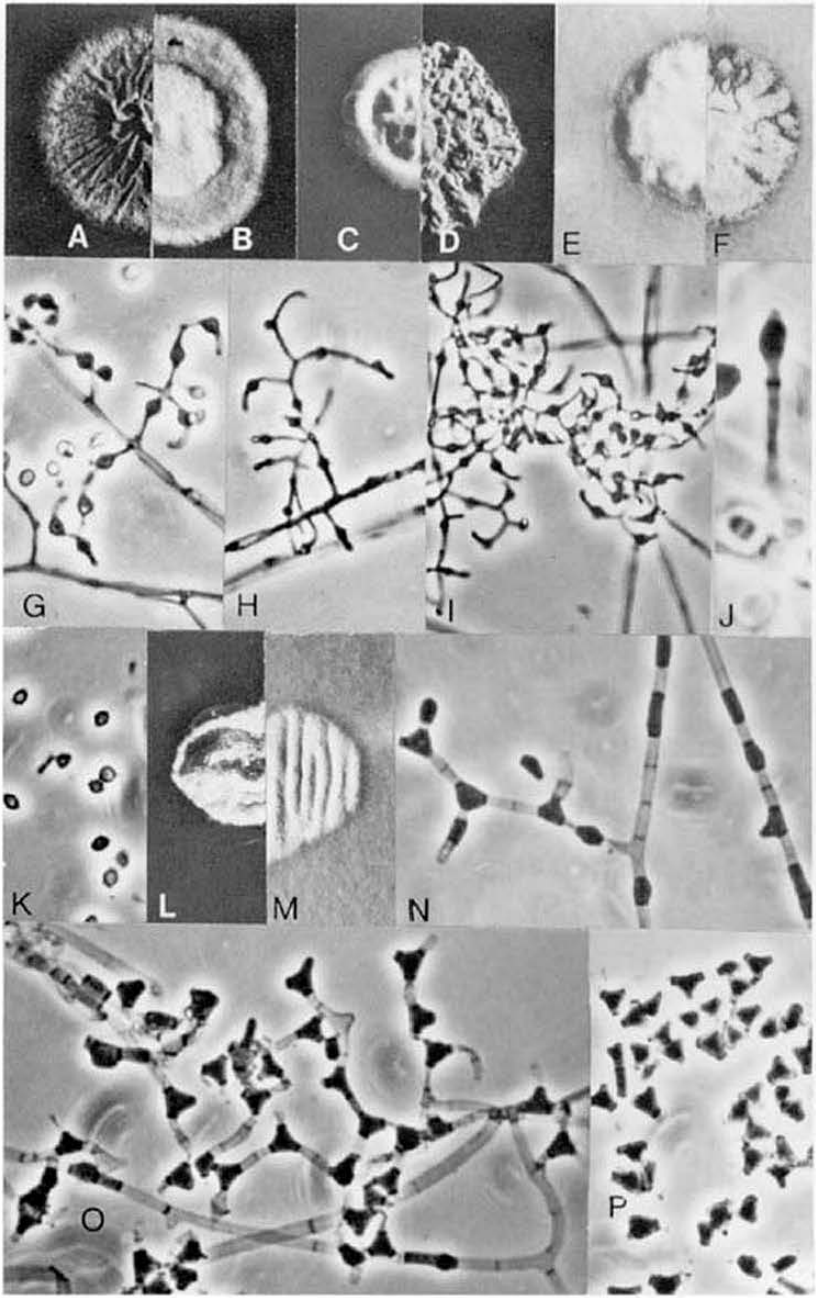
Arthrographis kalrai (Tewari & Macpherson) Sigler & Carmichael comb. nov.
= Oidiodendron kalrai Tewari & Macpherson 1971, Mycologia 63:602-611 (basionym)
= Arthrographis langeroni Cochet 1939, Ann. Parasit. Hum. Comp. 17:98-101 and pl. 3 (no Latin diagnosis)

Description

Colonies on PYE (Fig. 2A) are 22-28 mm diam. in 21 days, yellow becoming buff or tan with tan reverse, slightly raised, dome-shaped, downy or tufted becoming velvety and tough, or powdery. The surface remains smooth or develops radial ridges or folds which may crack. On cereal agar (Fig. 2B) colonies are 36-44 mm diam. in 21 days, flat, creamy white or buff, powdery, occasionally

---

Figure 1. A-K. Arcuadendron ovatum (A,D,F,G,J-UAMH 2737; B,C,E,H,I,K-2746). L-P. Arcuadendron triangularis (3433). Figs. 1A-1F. Colonial morphology after 21 days. A-D on PYE, E and F on cereal. C and D at 37 C, rest at 25 C. Figs. 1G-1I. Conidia developing serially on curved fertile hyphae. Fig. 1J. Conidium delimited by basal septum. Fig. 1K. Mature verrucose conidia. Figs. 1L-1M. Colonial morphology after 21 days at 25C. L on PYE, M on cereal. Figs. 1N-1O. Chains of triangular conidia developing serially on undifferentiated hyphae. Fig. 1P. Mature triangular conidia. Colonies x 0.7, others x 600, except J, x 1680.


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P

downy or woolly with tufts of upright hyphae. Growth at 37 C is slower.

Vegetative hyphae narrow, 1-3um wide. Arthroconidia, borne on short, branched conidiophores (Figs. 2C-2E), are cylindrical, hyaline, R.P. Southby, CMI 34813. smooth, thin-walled, 1.5-2 x 2.5-4.5(5)um. Longer, narrower arthroconidia also develop by fragmentation of young undifferentiated hyphae (Fig. 2F). In degenerate strains, this form may predominate.

Habitat and activity: Worldwide from soil, air, skin lesions and sputum. Keratinolytic with penetration of the hair shaft by single hyphae.

Pathogenicity: The pathogenicity of this species has been studied by Cochet (1939) and by Tewari and Macpherson (1968b, 1971). Experimental inoculation into mice (Tewari and Macpherson, 1968b; Swenberg, Koestner and Tewari, 1969) resulted in severe neurological disorder, more severe in mice inoculated intravenously than intraperitoneally. The organism was recovered from the spleen, kidney, liver, lung and brain. Tewari and Macpherson (1971) also discussed the dimorphic nature of the fungus. However, we have been unable to convert the type strain of O. kalrai and Cochet's strain, a somewhat degenerate isolate, to the yeast phase by the in vitro method outlined by them. Three morphological variants were isolated from sectors in Y-4, (ATCC 18434, UAMH 3616), the type of O. kalrai. All three formed mucoid colonies at 37 C, but only one (UAMH 3616c) formed a few yeast-like budding cells after multiple transfers in brain heart infusion broth (Difco). The predominant growth throughout was hyphae and arthroconidia. Arthroconidia were often seen to be germinating.

Antigenicity: Tewari and Macpherson (1968a) observed significant protection in mice challenged with Histoplasma capsulatum after vaccination with formalinized O. kalrai vaccine. Later, Tewari, Macpherson and Maitra (1969) demonstrated cross-reactive hypersensitivity between Histoplasma capsulatum and Oidiodendron kalrai.

Material Examined
From human sources: UAMH 3464, from chronic digital lesions, France, by Cochet, circa 1938, CBS strain Cochet 112.38; UAMH 3616, TYPE strain of Oidiodendron kalrai, from sputum of man with ill-defined respiratory ailment, India, Tewari (Y-4), ATCC 18434; UAMH 2298, also rec. as strain Y-4, listed as soil isolate, New Delhi, by Mohapatra, from Campbell, Harvard Univ.; UAMH 2610 & UAMH 2617, isolates from mixed culture also containing Ctenomyces serratus, rec. as Y-4, New Delhi, by Mohapatra, from Tewari, Columbus, Ohio; UAMH 2546, gastric wash specimen, Edmonton, 1965; UAMH 3380, skin of right foot (isolated on 3

occasions), from Friedman, New Orleans as 192; UAMH 3715, human source, Calif., from Orr as O-2556; From other sources: UAMH 3279, air sampling, Rabat, Morocco, by Chabert, from Nicot, Paris as 5216; UAMH 2578, CBS strain von Arx (CBS 344.49?) of Ramularia gei, possible contaminant in culture

Arthrographis cuboidea (Sacc. & Ellis) Sigler comb. nov.
= Oospora cuboidea Saccardo & Ellis 1882, Michelia 2:576 (Basionym)
= Geotrichum cuboideum (Sacc. & Ellis) Sumstine 1913, Mycologia 5:56 and pl. 83
= Coremiella cuboidea (Sacc. & Ellis) Ciferri & Caretta 1960, Mycopath. et Mycol. Appl. 12(3):249 and Tab. 3
= Geotrichum microsporum Smith 1962, Trans. Brit. mycol. Soc. 45(3):388-389 and Tab. 8, fig. 4
= Briosia microspora (Smith) von Arx 1972, Ant. v. Leeuw. 38(3):293
Excluded species: Coremiella ulmariae (McWeeney) Mason ap. Hughes = Coremiella cubispora q.v.

History

In 1882 Saccardo and Ellis discovered Oospora cuboidea growing on rotting oak in Newfield, New Jersey and provided a brief description but no figures. In 1913, Sumstine examined the presumed isotype specimen and transferred the species to Geotrichum with a brief description and illustration.

In 1960, Caretta examined the isotype of O. cuboidea of Ellis (from NYBG) and proposed a new combination Coremiella cuboidea (Sacc. & Ellis) Cif. & Caretta. Included in his concept of this species were four isolates from human feces, one of which (UAMH 829), received from Caretta in 1960 as Coremiella cuboidea, has been identified as a Trichosporon, possibly T. cutaneum. Indeed, Caretta's figures strongly suggest differences between the four human isolates and O. cuboidea. In placing Coremiella ulmariae in synonymy with O. cuboidea, Caretta misinterpreted arthroconidium formation in the latter as endogenous (see also Coremiella). The isotype specimen of Oospora cuboidea (Fig. 2G) is conspecific with Geotrichum microsporum Smith. However, this species belongs neither in Geotrichum nor Coremiella; therefore, a new combination is proposed in Arthrographis.

Von Arx (1972) transferred G. microsporum to Briosia while simultaneously suggesting that Coremiella cuboidea (Sacc. & Ellis) Cif. & Car. and C. ulmariae (McWeeney) Mason apud Hughes could be conspecific with Briosia ampelophaga Cavara, the type of which he examined. However, Briosia differs from both in forming thallic

meristem conidia (Kendrick, 1971, p. 168 & 251) in contrast to the fission arthroconidia of Arthrographis and the alternate arthroconidia of Coremiella (see also Briosia, Coremiella).

Description

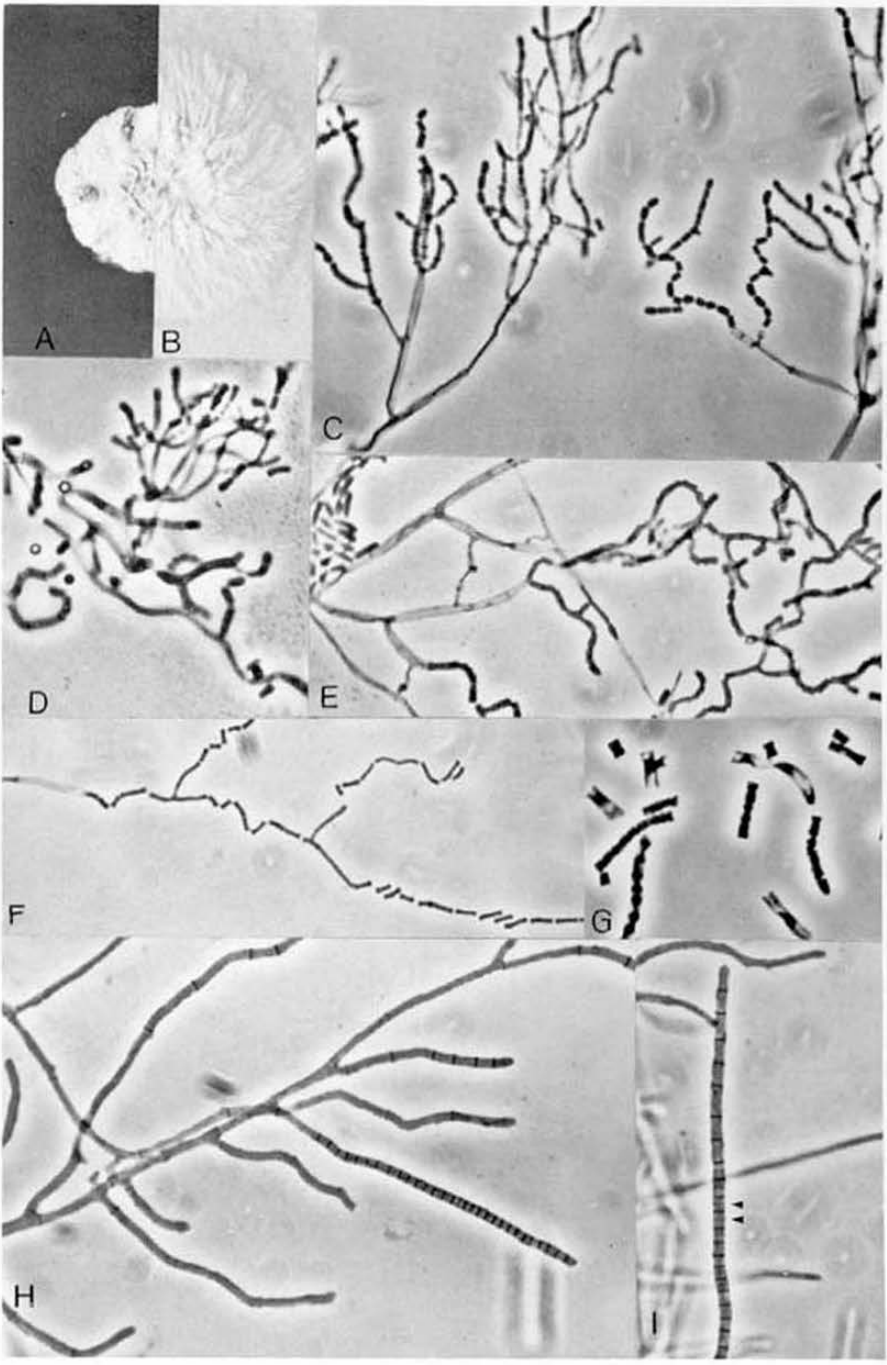
Colonies on PYE, 50-60 mm diam. in 7 days, are pale yellow, reverse yellow, flocculent and powdery with tufts of conidiogenous hyphae over the cellophane membrane. Growth at 37 C is rapid and similar in appearance except that the reverse becomes pink or violet by 14 days. On cereal agar at 7 days, colonies are 60-70 mm diam., yellow, dense with flocculent tufts of hyphae. The reverse, at first yellow, later stains dark blue. A pink pigment diffuses into the agar. At 37 C, the colony is 25-30 mm diam. in 7 days.

Hyphae septate, hyaline, 2-5um diam. Conidiophores are scarcely differentiated, simple, hyaline, branching near the apex to form a tuft of conidiogenous hyphae. The conidiogenous hypha, delimited by a basal septum (Fig. 2H), is 80-150um long, unbranched, at first sparingly, then more regularly septate (Fig. 2H), in more or less basipetal succession. The conidiogenous hypha forms septa at regular intervals, each interval 3.5-5um wide, which further subdivide into uniform, 2-2.5um, segments (Fig. 2I). The intervening septa, appearing at first less dense, begin to form before initial septation of the conidiogenous hypha is complete (Fig. 3A), and develop randomly. Fission arthroconidia (Fig. 3B), formed in more or less basipetal succession by disjunction of the hypha, appear square or rectangular, often wider than long, discoid in end view, smooth, hyaline at first, later yellow, 1.5-2.5 x 2-3.5um.

Habitat and activities: Reported from mine timber (Smith, 1962; Fassatiova, 1971) and southern yellow pine (Pinus australis Michx.) timber (Chidester, 1940). Causes pink stain in heartwood and sapwood of pine, birch, cyprus, hemlock, spruce, fir, oak and Douglas fir (Chidester,

---

Figure 2. A-F. Arthrographis kalrai (A,B-UAMH 3616; C-2617; D-3380; E-2610; F-2578). G-I. Arthrographis cuboidea (G-3760; H,I-676). Figs. 2A-2B. Colonial morphology after 21 days at 25 C. A on PYE, B on cereal. Figs. 2C-2E. Fission arthroconidia borne on branched conidiophores. Fig. 2F. Arthroconidia formed by fission of undifferentiated hyphae. Fig. 2G. Fertile hyphae and arthroconidia of isotype specimen of Oospora cuboidea. Fig. 2H. Regular septation of conidiogenous hyphae. Fig. 2I. Subdivision of intervals by septa (arrows). Colonies x 0.7, others x 600.


A
B
C
D
E
F
G
H
I

1940). A. cuboidea is strongly cellulolytic.

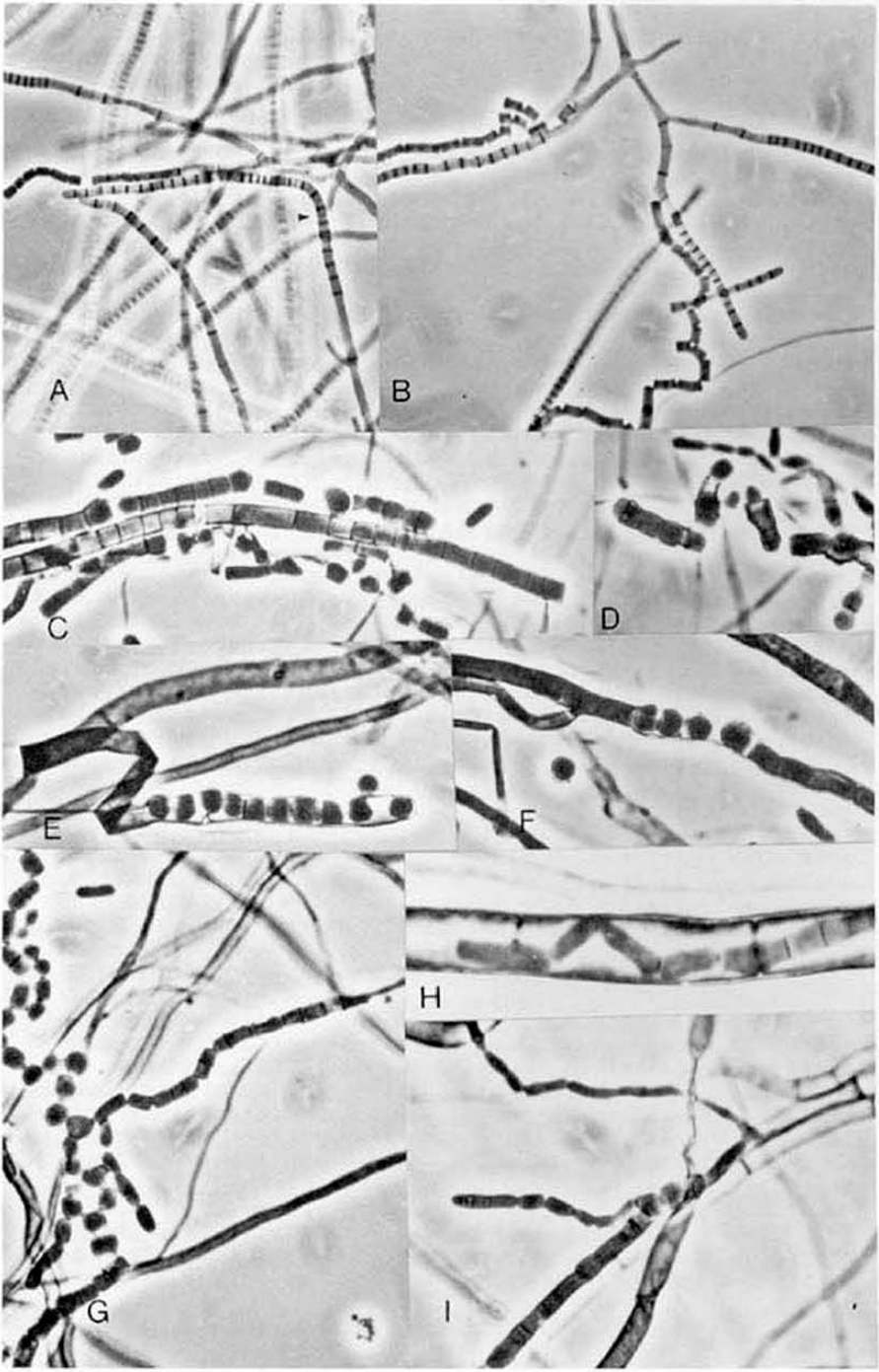
Material Examined
Oospora cuboidea, ISOTYPE, Quercus, Newfield, N.J., 1881, by Ellis (3536) from NYBG; UAMH 676, birch post, Chalk River, Ontario by Shields, 1956, DAOM 64066; UAMH 3101, TYPE strain of Geotrichum microsporum, rotten mine timber, Johannesburg, S. Africa, 1955, CMI 94091; UAMH 3792, mushroom bed, by Komatsu, 1964, from Tubaki, IFO 9190.

Bahusakala Subramanian 1958

Type Species
Bahusakala olivaceonigra (Berk. & Br.) Subramanian 1958, J. Indian Bot. Soc. 37:61-63
= Septonema olivaceo-nigrum Berk. & Br. 1873, J. Linn. Soc. 14:90

The following description is based mainly on CBS strain 499.66 (UAMH 3812), the only available culture of this species. Arthroconidia develop on more or less undifferentiated hyphae either terminally or in an intercalary position. Hyphae are pale brown at first, later becoming thick-walled and yellow-brown in the fertile segments. The hyphae are broad and sparingly septate, and some segments appear to have lost their cytoplasmic contents. Arthroconidia usually develop endogenously, like those of Sporendonema casei, but without separating cells. The fertile segments of the hyphae, at first sparingly septate, cleave into smaller segments (Fig. 3C) and mature arthroconidia are released by dissolution or fracture of the outer wall (Figs. 3E,3F). Remnants of the outer wall are often visible around the released conidia, and conidia occasionally remain connected by the outer wall (Fig. 3D) in groups of 2 or 3. These arthroconidia often appear somewhat verrucose. Mature arthroconidia are pale brown, smooth to verrucose, cylindrical with rounded corners, 0-1 septate, 3-6 x 5-12(16)um.

Figure 3. A-B. Arthrographis cuboidea (A-UAMH 3101; B-676). C-I. Bahusakala olivaceonigra (3812). Fig. 3A. Random development of intervening septa. Fig. 3B. Mature fission arthroconidia. Fig. 3C. Septation of undifferentiated fertile hypha. Fig. 3D. Mature conidia, remaining connected in groups of 2 or 3 by sections of the outer hyphal wall. Figs. 3E-3F. Mature arthroconidia released by dissolution or fracture of the outer hyphal wall. Fig. 3G. Fission arthroconidia formed by segmentation of undifferentiated hypha. Fig. 3H. Intra-hyphal hypha fragmenting to form arthroconidia. Fig. 3I. Fragmentation of new hyphal branch after fracture of the outer hyphal wall. All x 600, except H, x 1680.


A
B
C
D
E
F
G
H
I

In addition to the endogenous conidia, arthroconidia also form directly by the segmentation and disjunction of segments of the fertile hypha (Fig. 3G), just as in Scytalidium. There appears to be no outer wall surrounding these arthroconidia. Rarely, within a broad hypha in which the cytoplasmic contents are less granular, an intra-hyphal hypha (Buller, 1933) can be observed breaking into arthroconidia (Fig. 3H). It is possible that all the endogenous arthroconidia are actually formed by fission of intra-hyphal hyphae growing within segments of the original outer wall. As arthroconidia are released from the outer wall, new branches also emerge (Fig. 3I) and this new growth is probably an extension of the intra-hyphal hypha. The extruded endohypha also divides to form arthroconidia (Fig. 3I). No other spore state was observed.

In the two herbarium specimens on plant material, the arthroconidia often remain connected by portions of the outer wall, and generally agree with the culture described above. The drawing labelled B. olivaceonigra by Ellis (1971, Fig. 3) shows prominent septa and other features which suggest Scytalidium flavo-brunneum (q.v).

Muller, Harr and Sulmont (1969) described the Bahusakala state of Aulographina pinorum (Desm.) Arx & Muller which differed from the type species in forming a sexual state and in growing on Pinus maritima. They described and illustrated (their Fig. 1) endogenous arthroconidium development and noted that the wall of the maturing conidium was difficult to differentiate from the outer wall of the original hypha. From their figures, the Bahusakala state of A. pinorum is very similar to our culture of B. olivaceonigra.

Material examined: UAMH 3812, Mangifera indica, CBS 499.66; UAMH 3959, photos from Herb. IMI 135080, ex type collection, Septonema olivaceo-nigrum, Herb. Berk. 1879, on 'Agave', Ceylon; UAMH 3974, slides from MUBL 1750 on Yucca gloriosa, Madras, India, C.V. Subramanian, 1956.

Arthroconidial states of Basidiomycotina

In 1889, Brefeld illustrated the conidial states of a number of Hymenomycetes, in which the hyphae divided into short segments called 'oidia'. Hughes (1953) in his experimental classification of the Hyphomycetes discussed the formation of 'oidia' by Basidiomycotina in his Section VII. This group included fungi in which the development of conidia occurred by septation and disjunction of simple or branched hyphae.

Brodie (1936) studied 'oidial' development in Collybia velutipes and some other Hymenomycetes. He found that the 'oidia' of Collybia velutipes occurred on both dikaryon and

monokaryon mycelia but that clamp connections rarely occurred on the fertile branches of the dikaryon mycelium. He concluded that the 'oidia' of the dikaryon mycelium were haploid.

Nobles (1948) studying 126 species of wood rotting fungi growing in agar culture, described the 'oidia' of 13 species. Maxwell (1954) in a study of Thelephoraceae observed that 'oidia' were the most common form of asexual reproduction in the Agaricaceae and Polyporaceae of the Hymenomycetes.

In the UAMH, a number of strains, at first filed as '*Geotrichum* sp.', appear to be arthroconidial states of Basidiomycotina. They do not fit our current concept of *Geotrichum*, since they have dry rather than slimy arthroconidia. These strains are characterized by rapid growth, woolly or felt-like texture, strong odor, and cellulolytic activity. Although they have not been identified, we suspect that these strains are mostly Hymenomycete monocaryons. We provide a brief description of them here to alert the user of this monograph to the existence of arthroconidial fungi which do not fit well into existing form-genera of the Hyphomycetes. Their colonial morphology is rather uniform and a combined description is provided for the colonies. However, they showed sufficient variation in the manner of arthroconidium formation to describe four different groups of strains. Although we have separated these groups in the key (as 5a to d), and have tentatively assigned the first two to *Mauginiella*, we have not studied them sufficiently to assign them definitely, or to propose names for the other groups. The distinctive conidial state of *Tyromyces ptychogaster* (Polyporaceae) is described under the form-genus *Ptychogaster*. When the arthroconidial states of Basidiomycotina have been more thoroughly studied, some additional form-genera will likely be required.

Description

Colonies on PYE (Figs. 4A,4B) grow rapidly (35-62 mm in 7 days and almost filling the petri dish by 14 days) and are white or pale tan, reverse white or yellow. Aerial growth is dry, dense, patchy, matted, woolly or downy, raised, and often more dense on cellophane than on the exposed medium. When dried, the aerial growth flattens becoming felt-like and mottled yellow or tan in color. Most strains produce a diffusing yellow pigment and occasionally copious yellow exudate. A distinct sweet odor is often apparent. Growth on cereal is slightly more rapid (60-90 mm in 7 days) but otherwise similar. The diffusing pigment turns the medium tan. Most strains do not grow at 37 C, but some show slight growth. Most are strongly cellulolytic.

a) Group 1 (Strains 448, 507, 511, 1535, 1537, 2098, 2536, 2705, 2769, 2871, 3251, 3436, 3657)

Developmentally, these strains resemble Geotrichum, but differ in having dry arthroconidia. Arthroconidia (Fig. 4D), formed by septation and disjunction of undifferentiated fertile lateral branches, are hyaline, barrel-shaped or cylindrical, single-celled, measuring 2-4(5.5) x (2)3-10(15)um. They tend to lie in zig-zag chains (Fig. 4F), and collapse easily when exposed to air. Thick-walled intercalary or terminal chlamydospores (Fig. 4C) are produced by many strains. One isolate (UAMH 2769) formed clamp connections. In most respects, these strains resemble the type species of Mauginiella, M. scaettae Cavara. However in M. scaettae, the fertile hyphae are wider than the vegetative mycelium and break up reluctantly.

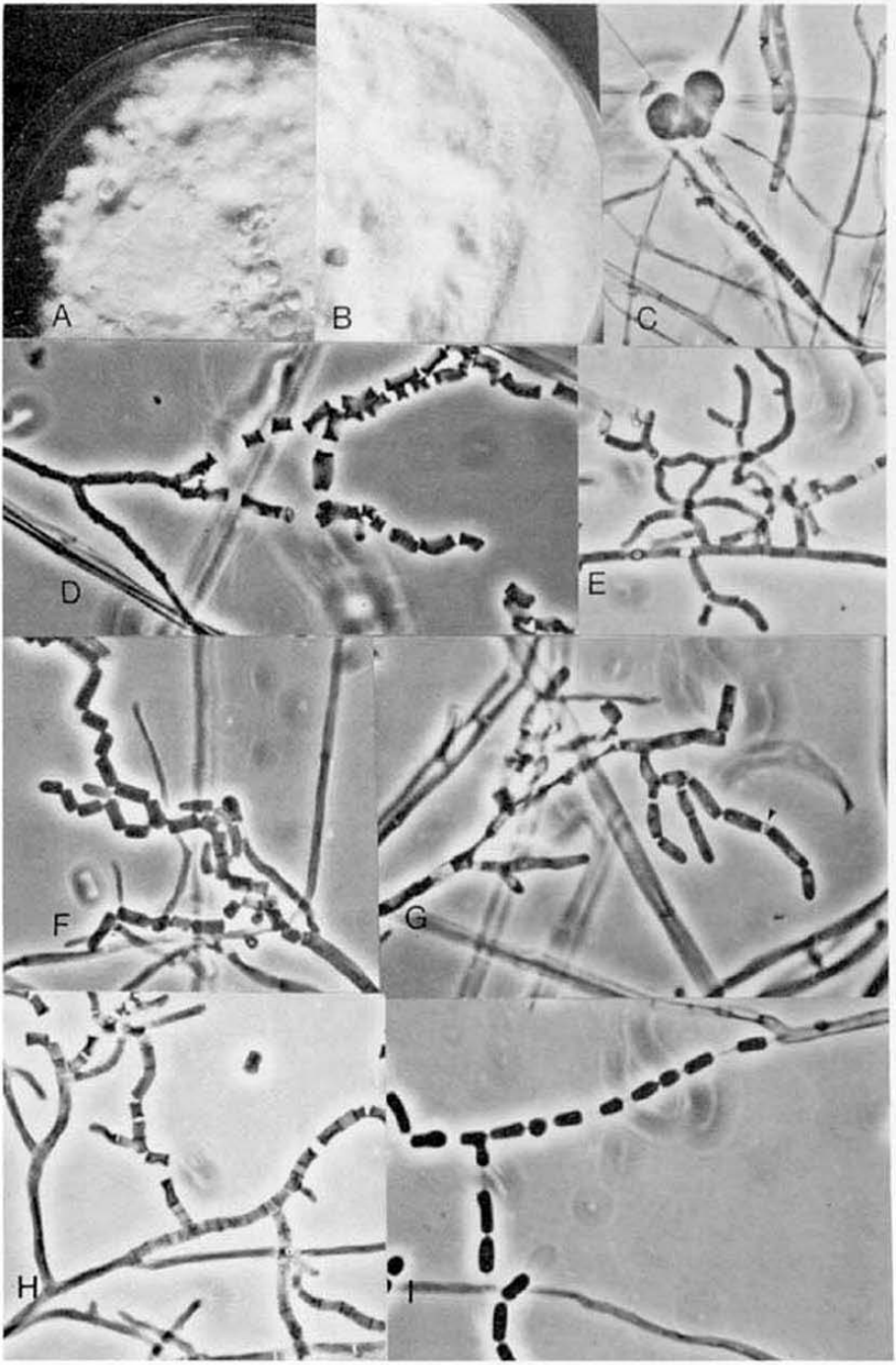
b) Group 2 (Strains 3776, 3787)

Both isolates were received as Phlebia radiata Fr. Colonies grow less luxuriantly. Arthroconidia are borne in chains on undifferentiated, often curved, lateral branches (Fig. 4E). Fission arthroconidia are hyaline, cylindrical, 2.5-4 x 4-9um. Clamp connections are present on some of the hyphae which do not break up into arthroconidia. This group differs from group 1 mainly in having curved fertile hyphae.

c) Group 3 (Strains 645, 2772, 3412)

Narrow separating cells develop between maturing arthroconidia (Fig. 4G) after septation of the fertile hypha (Fig. 4H). The connecting cell is often difficult to detect suggesting that it could be a gelatinous secretion of the maturing arthroconidia similar to that described for Oidiodendron (q.v.).

Figure 4. Arthroconidial states of Basidomycotina. A-B. Colonial morphology (A-UAMH 3251; B-511). C,D,F. Group 1 (C-1537; D-2536; F-1535). E. Group 2 (3776). G-H. Group 3 (G-3412; H-645). I. Group 4 (3796). Figs. 4A-4B. Colonial morphology on PYE after 21 days at 25 C. Fig. 4C. Thick-walled chlamydospores. Fig. 4D. Fission arthroconidia borne on undifferentiated hyphae. Fig. 4E. Fission arthroconidia borne on curved lateral branches. Fig. 4F. Mature fission arthroconidia in zig-zag chains. Figs. 4G-4H. Disjunctor cells developing between arthroconidia. Fig. 4I. Mature arthroconidia separated by collapsed disjunctor cells. Colonies x 0.7, others x 600.


A
B
C
D
E
F
G
H
I

d) Group 4 (Strains 514, 3796, 3837)

Of the two strains received as Collybia conigena (Pers. ex Fr.) Bres., one (UAMH 3837) failed to sporulate. The oidium development described by Brodie (1936) for Collybia velutipes (Curt. ex Fr.) Quel. is identical with this group. After growth of the fertile hypha ceases, the protoplasm of the hypha becomes condensed in segments separated by vacuoles. Then the condensed portions develop a septum at each end to become conidia. Brodie (1936) reported that transverse septa were rarely formed in the fertile hypha before condensation occurred.

This process differs from that found in Oidiodendron and Sporendonema where concentration of the protoplasm is preceded by septation of the fertile hypha. However, the partly mature arthroconidia of group 4 (Fig. 4I) resemble the alternate arthroconidia of Sporendonema, until the walls of the separating cells collapse. At this stage the chains of arthroconidia resemble strings of sausages (Fig. 4I). Conidia are cylindrical or rounded at the corners, or dumb-bell shaped, 2.5-4 x 5.5-13um.

Habitat: Probable contaminants in clinical material from human and animal sources; soil of sheep and horse corrals; feathers of sparrow; in Alberta, Kentucky, S. Carolina, Ohio, Kansas, Georgia, California and Czechoslovakia.

Material Examined
Collybia conigena: UAMH 3796 (CBS 146.29) and UAMH 3837 (CBS 108.13); Phlebia radiata: UAMH 3776 (CBS 278.29) and UAMH 3787 (CBS 285.73);
Alberta isolates from clinical specimens: UAMH 448, skin from perianal region, 1955; UAMH 507, sputum, 1956; UAMH 511, toenail, 1956; UAMH 514, blood, 1956; UAMH 645, toes, 1959; UAMH 2536, skin scrapings, canine, 1965; UAMH 3251, urine, 1969; From clinical specimens: UAMH 1535, sputum, (Orr KCFS 62-5241); UAMH 1537, sputum, (Orr KCFS 62-5706); UAMH 2705, vitreous humor of eye, Ohio, from Schwarz, Univ. of Cincinnati, Ohio; UAMH 3657, Orr-1209; From other substrates: UAMH 2098, Calif., Martin, 1961, as 840; UAMH 2769, sheep pen, Alberta, D. Remington, 1967; UAMH 2772, horse corral, Alberta, D. Remington, 1967; UAMH 2871, soil of broomsedge field, S. Carolina, 1967, from Coleman, Savannah Ecology Laboratory, S. C. as G80209; UAMH 3436, feather of house sparrow, Valtice, Czech., 1970, Z. Hubalek, (Orr 0-3279)

Briosia Cavara 1888

Type Species
Briosia ampelophaga Cavara 1888, Atti Ist. Bot. Univ. Pavia, ser 2, 1:321-322, Tab. 5

In the development of thallic meristem conidia of Briosia (Kendrick 1971, p. 168 & 251), septation occurs successively from the apex of the hypha followed by enlargement or expansion of the apical and subsequent segments. Expansion occurs only after delimitation by a septum. Mature conidia (Fig. 5A) are brown, thick-walled, globose or sub-globose or cylindrical and disarticulate by fission, at maturity, 5-7.5 x 6-11um (5-8um in diameter, fide Sutton, 1973).

In describing B. ampelophaga, Morris (1963) illustrated expansion occurring before delimitation by a septum in the manner described for Basipetospora rubra (Cole and Kendrick 1969; Kendrick 1971, p. 168). Von Arx (1972) placed Coremiella in synonymy with Briosia but Coremiella differs in forming alternate arthroconidia. (See also Arthrographis.)

Sutton (1973) noted the similarity of conidium development in Briosia and Ojibwaya Sutton. The latter differs in forming conidiophores from the basal cells of the erect funnel-like wall of the immersed stroma. The conidiophores are not borne on a synnema as in Briosia. Sutton (1973) considered Briosia ampelophaga similar to Coremium luteolum Camara apud Serafim collected from Vitis in Portugal. However he was unable to obtain type material of C. luteolum.

Habitat: Primarily on leaves of Vitis and Platonia causing leaf spot, and sometimes on fruits of Vitis vinifera Michx. Collected in Brazil, Italy, Wisconsin and Illinois.

Material examined: UAMH 3822, ex DAOM 137503, on leaves of Vitis riparia, Daneville, Illinois, by Solheim.

Other Species

Briosia azaleae (Peck) Dearness 1941, Mycologia 33:360
= Periconia azaleae Peck 1833, Ann. Rep. N.Y. State Mus. 25:93
= Sporocybe azaleae (Peck) Saccardo 1886, Syll. Fung. 4:608

According to Dearness, the arthroconidia of B. azaleae are smaller, measuring 3-7.5 x 2.75-4.5um. Furthermore, B. ampelophaga occurs commonly on grape leaves, whereas B. azaleae has been recovered from bud and twig blight of azalea (Davis, 1939).

Excluded Species

Briosia cubispora (Berk. & Curt.) v. Arx 1972
= Coremiella cubispora q.v.
Briosia cystopoides (Bubak & Krieger) v. Arx 1972
= Coremiella cubispora q.v.
Briosia microspora (Smith) v. Arx 1972

= Arthrographis cuboidea q.v.

Chrysosporium Corda 1833

Type Species
Chrysosporium merdarium (Link) Carmichael 1962, Can. J. Bot. 40:1160 and figs. 30-34
= Sporotrichum merdarium Link 1818, Jahrb. Gewachsk. 1:176
= Chrysosporium corii Corda 1833, Sturm's Deutschl. Flora III (Pilze), Bd. 3, Heft. 13:85

For further synonymy and descriptions of other species of Chrysosporium, refer to Carmichael (1962). Chrysosporia form aleurioconidia terminally, at the ends of short or long lateral branches, or directly on the sides of the hyphae. Intercalary aleurioconidia occur in some species, and these intergrade with alternate arthroconidia. The aleurioconidia of Chrysosporium are broader than the diameter of the fertile hypha. Malbranchea differs in having non-swollen arthroconidia. Geomyces has distinctive, acutely branched fertile hyphae borne on erect conidiophores.

Excluded species: Chrysosporium pannorum (Link) Hughes 1958, Can. J. Bot. 36:749 = Geomyces pannorus q.v.

Coccidioides Stiles 1896

Type Species
Coccidioides immitis Stiles in Rixford and Gilchrist 1896, Johns Hopkins Hospital Report 1:209-269

C. immitis is a human pathogen that occurs in tissue in the form of globose cells which divide internally to produce a few to many endospores. These structures were at one time interpreted as asci and ascospores (see Dodge, 1935, p. 147) but no one has demonstrated karyogamy or meiosis in connection with their formation. Currently, the endosporulating cells are referred to as 'spherules'.

It seems likely that the spherules represent an unusual adaptation to parasitic growth, with multiplication by endosporulation instead of budding (as in most human pathogens) or fission arthroconidia (as in the dermatophytes). Other characters of C. immitis suggest that it may be a heterothallic member of the Gymnoascaceae, whose sexual state has not yet been observed (Kwon-Chung, 1969).

In culture, C. immitis grows as a mold and produces arthroconidia typical of the form-genus Malbranchea. A description of the conidial state and further discussion

are given under the Malbranchea state of Coccidioides immitis.

Coremiella Bubak & Krieger 1912

Type Species
Coremiella cubispora (Berk. & Curt.) Ellis 1971, in Dematiaceous Hyphomycetes p. 33, fig. 6
= Cladosporium cubisporum Berk. & Curt. apud Berk. 1875, in Grevillea 3:107
= Briosia cubispora (Berk. & Curt.) v. Arx 1972, Ant. v. Leeuw. 38:293
= Coremiella cystopoides Bubak & Krieger 1912, Annal. Mycol. 10:52-53
= Briosia cystopoides (Bubak & Krieger) v. Arx 1972
= Coremiella ulmariae (MacWeeney) Mason apud Hughes 1953, Can. J. Bot. 31:640, fig. 94
= Stysanus ulmariae MacWeeney 1895, Irish Naturalist 4:277
Excluded species: Coremiella cuboidea (Sacc. & Ell.) Cif. & Car. 1960 = Arthrographis cuboidea q.v.

Because of the detailed account provided by Ellis (1971) only a brief description is given here. Arthroconidia (Fig. 6A) are alternate, separated by one or more empty cells, smooth, thick-walled, oblong or cubical with a small papilla at each end, brown, 3.5-7 x 4-9(14)um. Mature conidia are liberated by fracture or lysis of the outer hyphal wall of the adjacent empty cell, often leaving a frill of outer wall material attached to the conidium. The fertile hyphae often show characteristic dichotomous branching (Bubak, 1912; Hughes, 1953). Conidiophores are loosely aggregated to form a coremium, hemispherical at the tip, rarely observed in culture.

Arnaud (1954) described and illustrated Geotrichella alternata without a Latin diagnosis. Though Kendrick and Carmichael (1973) suggest possible synonymy with Coremiella the status of Geotrichella is not clear. Tubaki (in Kobayashi et. al., 1967) described Geotrichella arctica, a fungus bearing considerable resemblance to Coremiella, but did not validate Geotrichella. We requested Tubaki's type specimen of G. arctica from the Institute for Fermentation, Osaka, but did not receive it.

The alternate arthroconidia of Coremiella distinguish this form-genus from dematiaceous fungi forming conidia by fission such as Scytalidium, Briosia and Bahusakala. Developmentally, Coremiella resembles Sporendonema and Malbranchea but differs from both in having darkly pigmented cell walls. Furthermore, the hyphae and arthroconidia of Coremiella are 3.5-7um wide whereas those of Malbranchea rarely exceed 3.5um.

Habitat and activities: Recorded worldwide on senescent and living plant material; may cause soft rot in pears (Lucas, Carvalho and Barreiro, 1974). Digests cellophane but not keratin. Grows vigorously at 30 C, but not at 37 C. On agar, releases a pigment which appears grey or brown on cereal or yellow on PYE.

Material Examined
UAMH 1165, photomicrograph, ex DAOM 35160, from Ranunculus leaf, England, det. E.W. Mason; UAMH 1513, from Picea abies, Denmark, E.W. Mason, 1949, CMI 36938; UAMH 3793, from stump of Lindera umbellata Japan, M. Ichinoe, 1966, rec. Tubaki, IFO, Japan as 8862 (NHL 4583).

Geomyces Traaen 1914

Lectotype species
Geomyces auratus Traaen 1914, Nyt. Mag. Naturvidensk. 52:28-31 and pl. IV

History

In 1914, Traaen included four species in his description of Geomyces, but failed to designate a type species. Carmichael (1962) placed all four species into synonymy with Chrysosporium pannorum (Link) Hughes. The four species of Geomyces differ primarily in color, but Carmichael (1962) noted that the color of C. pannorum can be extremely variable.

Since Traaen's culture of Geomyces auratus is still available, this species is chosen as lectotype. Geomyces differs from Chrysosporium in forming chains of conidia on acutely branched hyphae on erect conidiophores. In Chrysosporium, aleurioconidia form directly on the sides of the hypha or on short pedicels and rarely develop in chains of two or three conidia.

Generic Description

Vegetative hyphae narrow, hyaline, septate. Conidiophores narrow, hyaline, branched acutely at the apex, sometimes verticillately. Fertile branches narrow, at first sparingly, then more regularly septate. Aleurioconidia, formed terminally or laterally on short pedicels, intergrade with alternate arthroconidia. Alternate arthroconidia, broader than the fertile hypha, develop in short or long chains and may predominate. Mature conidia, released by lysis of intervening segments, are smooth or roughened, hyaline or yellow, barrel-shaped, cuneiform, subglobose or pyriform.

Geomyces asperulatus Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25 C moderatim rapide crescunt, initio roseae, posterius flavae.
Conidiophora angusta, 0.5-1.0um in diametro, ad 150um in longitudine, aliquando ramosa. Arthroconidia in catenis longis, subasperata, doliiformia, 1.5-2.5(3) x 2.5-4.5(5)um.
Typus: UAMH 183, ex solo, Harvard Forest, Waltham, Massachusetts, F. Raymond II-1-9

Colonies on PYE (Fig. 5B) are 35-39 mm in diam. in 21 days, first pale pink, flat and cottony, becoming vivid mustard-yellow, with pink and white patches at the periphery, powdery, reverse tan. The colony lifts in the center with few radial folds, and curls up at the margin with new growth appearing below. Poorly sporulating colonies (Fig. 5C) are flatter, pale yellow, hairy or bristly. On cereal, colonies (Fig. 5D) are 55 mm in 21 days, flat, with outward radiating folds, at first white then mustard-yellow, reverse the same, powdery. During sporulation, the center flattens (Fig. 5D). Brown pigment diffuses from the colony by 14 days. Poor growth at 30 C and no growth at 37 C.

The vegetative hyphae are hyaline or yellow, narrow, septate. Conidiophores are narrow, 0.5-1.0um wide, 20-150um long, hyaline, sometimes branching along the length, mostly near the apex (Figs. 5E-5G) at an acute angle. Fertile branches are narrow, 0.5-1.0um wide, at first sparingly then more regularly septate, with concentration of cytoplasm in alternate segments. Arthroconidia (Figs. 5F,5G) become thick-walled, increase in volume, and mature in long chains in more or less basipetal succession. Arthroconidia, released by lysis of the intervening empty cell, are yellow, slightly roughened, barrel-shaped or cuneiform if terminal, 1.5-2.5(3) x 2.5-4.5(5)um.

Habitat and activities: Soil, Massachusetts, Ontario and Costa Rica. Strongly cellulolytic but not keratinolytic.

Material Examined
UAMH 182, soil, Harvard Forest, Mass., F. Raymond, Farlow Herbarium as III-4-1; UAMH 183, TYPE, soil, Harvard Forest, Mass., F. Raymond, as II-1-9; UAMH 2169, Puerto Vieho, Costa Rica, from Barron, Univ. of Guelph as 10258; UAMH 2815, soil under Pinus strobus, St. Williams, Ont., G.C. Bhatt, 1967, as UW 316.

Geomyces pannorus (Link) Sigler & Carmichael comb. nov.
= Sporotrichum pannorum Link 1824, Linn. Spec. Plant. IV, 6(1):13 (Basionym)
= Chrysosporium pannorum (Link) Hughes 1958, Can. J. Bot. 36:749
= Geomyces auratus Traaen 1914, Nyt. Mag. Naturvidensk. 52:30

= Geomyces vulgaris Traaen 1914, ibid. p. 29
= Geomyces sulphureus Traaen 1914, ibid. p. 30
= Geomyces cretaceus Traaen 1914, ibid. p. 31

For full synonymy and description of G. pannorus refer to Carmichael (1962). G. pannorus is distinguished by narrow, hyaline conidiophores (Figs. 5H,5I), 0.5-1.0um wide and 10-100um long, which branch acutely near the apex sometimes verticillately. Aleurioconidia formed terminally or laterally on short pedicels intergrade with intercalary arthroconidia (Fig. 5H). Mature conidia are cuneiform, subglobose or pyriform or barrel-shaped if intercalary, hyaline, smooth or roughened, 2-4 x 2-5um, mostly 2 x 3um.

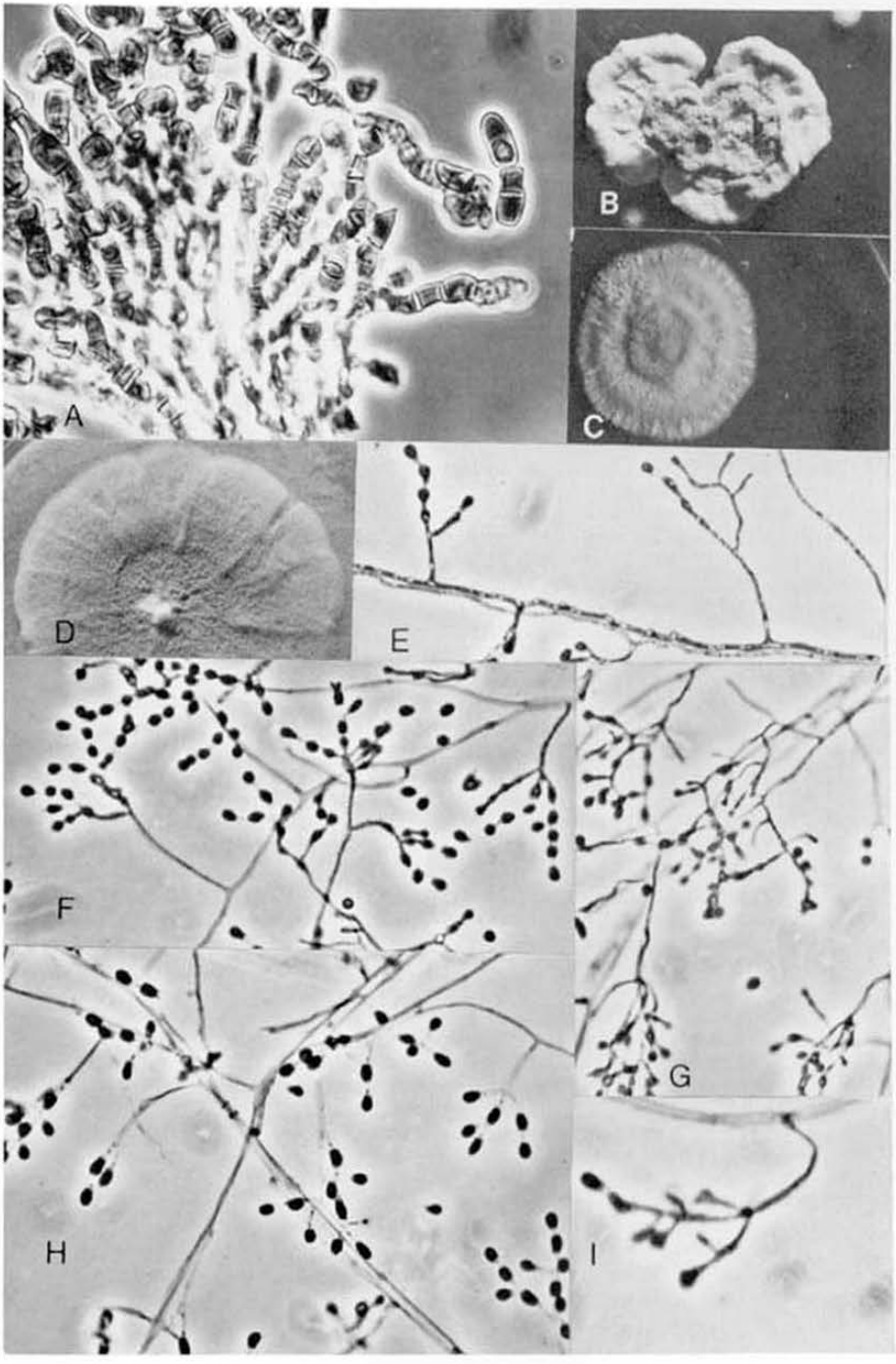
Discussion

G. pannorus differs from G. asperulatus in forming conidia in shorter chains of 2 to 4, and in forming aleurioconidia laterally on the hypha.

One of the strains examined (UAMH 3775, CBS 298.49) was received from the CBS as Onygena piligena, isolated from woollen slipper by R. Heim. The microscopic (Fig. 5I) and colonial morpaology of this strain conforms with that of G. pannorus. Whether G. pannorus is the imperfect state of Onygena piligena is uncertain, although this strain was presumably isolated from ascocarps found on the natural substrate. However, no ascocarps have been produced by this strain in culture. The ascocarps of Onygena are notoriously difficult to obtain on artificial media, though Tubaki (1960) induced ascocarp formation in O. corvina by growing it on a medium enriched with owl's claw or human fingernail. Furthermore, the cellulolytic activity of this strain (UAMH 3775) suggests that it was probably a contaminant because most species of Onygena are strongly keratinolytic (Tubaki, 1960).

Habitat and activities: ubiquitous, growing well at 5-20 C (Carmichael, 1962; Williams and Pugh, 1974). Cellulolytic but not keratinolytic. Some strains penetrate the hair by single hyphae.

Figure 5. A. Briosia ampelophaga (UAMH 3822). B-G. Geomyces asperulatus (B-D,F,G-183; E-2815). H-I. Geomyces pannorus (H-2883; I-3775). Fig. 5A. Thallic meristem conidia borne on a synnema. Figs. 5B-5D. Colonial morphology after 21 days at 25 C. B and C on PYE, D on cereal. Fig. 5E. Branched conidiophores bearing chains of arthroconidia. Figs. 5F-5G. Chains of arthroconidia. Figs. 5H-5I. Aleurioconidia and arthroconidia borne on acutely branched conidiophores. Colonies x 0.7, others x 600, except I, x 1680.


A
B
C
D
E
F
G
H
I

Material Examined
UAMH 650, plate contaminant, 1959; UAMH 723, Geomyces auratus, CBS strain Traaen, TYPE or AUTHENTIC strain (CDC B-326); UAMH 1173, Sporotrichum pannorum, photomicrograph of TYPE specimen, ex DAOM 43320; UAMH 1561, blood transfusion flask, 1962, CBS 117; UAMH 1860, soil, Dugway, (Orr 10 DM); UAMH 2883, 2884, 2885, soil, Matador, Sask., G.C. Bhatt, 1967; UAMH 3775, woollen slipper, R. Heim, CBS 298.49 (Onygena piligena);

Geomyces state of Pseudogymnoascus roseus Raillo 1929, Zentralbl. Bakt. Parasit., Abt. 2, 78:520, fig. 2
= Geomyces vinaceus Dal Vesco 1957, Allionia 3:14

For a full description and synonymy of P. roseus, refer to Samson (1972).

Although considerable variation in colonial morphology is apparent among strains of G. pannorus, the sexual state, P. roseus, is associated only with isolates having purplish-red colonies. The Geomyces state of P. roseus is indistinguishable from G. pannorus microscopically. However, the purplish-red colony and presence of the sexual state, which forms readily on oatmeal agar at 18 C, distinguishes this species.

Material Examined
UAMH 1644, Larix, Torino, Italy, Dal Vesco, from Kuehn, Medford, N.J. as 2; UAMH 1736, same strain as 1644 from Orr as 'P.g. Dal Vesco'; UAMH 1990, soil, Wisc., (Orr QM 6969); UAMH 2005, soil, Japan, (Orr NHL 2284); UAMH 2879, soil under Pinus contorta, Kananaskis, Alta., P. Widden, 1967, from Bhatt, U. Calgary, Alta., as 70 (=CBS 387.69); UAMH 3001 and 3002, from Morrall, Univ. Sask., as RM 2509 (SSF176) and RM 2169 respectively; UAMH 3166, mouse dung, Claremount, Calif., R.K. Benjamin, 1965, as 1558; UAMH 3337, TYPE of Gymnoascus rhousiogongylinus, forest soil, Parry Sound, Ontario, H.M. Wener, 1970, from Cain, U. Toronto Herbarium, as TRTC 45536 (CBS 722.69) UAMH 3875, G.F. Orr (O-3729);

Geotrichum Link 1809

Type Species
Geotrichum state of Endomyces geotrichum Butler & Petersen 1972, Mycologia 64:367
= Geotrichum candidum Link 1809, Mag. Ges. Naturf. Freunde, Berlin 3:17
(For full description and additional synonyms, refer to Carmichael, 1957.)

The form-genus Geotrichum is distinguished by formation of chains of hyaline, slimy arthroconidia by segmentation of undifferentiated hyphae. Arthroconidia

develop by more or less random septation and disjunction at a double septum of lateral branches or the broader vegetative hyphae which may branch dichotomously. Arthroconidia are thin-walled, smooth, cylindrical or ellipsoidal or oblong, sometimes becoming subglobose.

The developmental sequence of arthroconidium formation in G. candidum and the Geotrichum state of Endomyces magnusii has been recorded by time lapse photography (Cole and Kendrick, 1969). Cole (1975) described some of the ultrastructural aspects of arthroconidium formation.

Numerous species have been described in Geotrichum, making the taxonomy of the genus complicated and confused. For Geotrichum candidum alone, a species demonstrating considerable variation in culture, Carmichael (1957) lists over 50 synonyms. Furthermore, characters of many species included in Geotrichum are contrary to those attributed to the type species. For this reason, the following should be excluded from Geotrichum: dematiaceous species (see Scytalidium); fungi with differentiated conidiophores (see Arthrographis and Oidiodendron); species lacking fission arthroconidia (see Coremiella, Sporendonema, Malbranchea and Oidiodendron), and fungi forming blastoconidia as well as fission arthroconidia (Trichosporon, Moniliella).

However, a number of difficult problems remain. In culture, the type species, G. candidum, appears dry, hairy or powdery, but when disturbed the texture is slimy. This yeast-like texture is also characteristic of some other species of Geotrichum. If this yeast-like form of growth is a valid generic character, then fungi having dry-spored fission arthroconidia should be excluded. However, in order to exclude morphologically similar fungi (such as those described as arthroconidial states of Basidiomycotina) from Geotrichum, a suitable form-genus must be available for their admission. As yet, no other form-genus has been proposed to accommodate non yeast-like fungi developing hyaline fission arthroconidia on undifferentiated hyphae.

An additional problem, in assigning fungi to Geotrichum is defining the degree of specialization of the conidiophore. According to the definition accepted by the Kananaskis Conference on Fungi Imperfecti (Kendrick, 1971, p. 224-228), the hypha of Geotrichum which fragments to form arthroconidia is a simple conidiophore, 'micronematous' of Ellis (1971). However, this fertile hypha is indistinguishable from the vegetative hypha before the process of conversion begins (Cole and Kendrick, 1969). In addition, intercalary arthroconidia form in the broader vegetative hyphae (Carmichael, 1957). It is often difficult, therefore, to differentiate between an undifferentiated fertile hypha, i.e., 'micronematous'

conidiophore and a slightly differentiated, i.e., 'semi-macronematous' (Ellis, 1971) conidiophore. Species with differentiated conidiophores are excluded from Geotrichum (see Arthrographis).

Some species that have been transferred into or out of Geotrichum since 1957 are listed together here for convenience.

Geotrichum fragrans (Berkhout) Morenz 1960, Taxonomie und medizinische Bedeutung der zur Gattung Geotrichum Link gehorenden Arten p. 178 [= Oospora fragrans Berkh.]

Geotrichum klebahnii (Stautz) Morenz [as 'klebhani'], ibid, p. 180 [= Oospora klebahni Stautz]

Geotrichum gracile (Weigmann & Wolff) Windisch 1952, Beitr. Biol. Pflanzen 29:157 ?= Trichosporon fide von Arx (1972)

Geotrichum ludwigii (Hansen) Sin-Pang, Tzu-cheng & Jing-chu 1966, Acta Microbiol. Sin. 12:69 [= Oospora ludwigii Hansen]

Geotrichum robustum Sin-Pang, Tzu-cheng & Jing-chu 1966, Acta Microbiol. Sin. 12:73

Geotrichum state of Endomyces magnusii Ludwig 1886, Ber. Deut. Bot. Ges. 4:17
For a description, refer to von Arx (1972).

Excluded Species

Geotrichum amycelicum Redaelli & Ciferri 1935, Arch. fur Mikrobiol. 6:60 = Trichosporon cutaneum fide Lodder (1970)

Geotrichum cinnamomeum (Libert) Saccardo 1886, Michelia 2:636
Saccardo's description and the study of Quinta (1968) suggest that this species may be identical to Wallemia sebi (Fr.) von Arx.

Geotrichum cuboideum (Sacc. & Ellis) Sumstine
= Arthrographis cuboidea q.v.

Geotrichum dulcitum (Berkh.) Windisch 1952, Beitr. Biol. Pflanz. 29:156 = Protendomycopsis domschii Windisch 1965, Beitr. Biol. Pflanz. 41:337 = Protendomycopsis dulcita (Berkh.) Gams & Domsch 1969, Nova Hedwigia 18:20
Although proposing a new combination, Gams and Domsch treat this species under Trichosporon cutaneum. Lodder (1970) lists P. domschii as a synonym of Trichosporon cutaneum.

Geotrichum flavo-brunneum Miller et al. 1957
= Scytalidium flavo-brunneum q.v.

Geotrichum hirtum Windisch 1952, Beitr. Biol. Pfanzen 29:157 = Trichosporon cutaneum fide Lodder (1970)

Geotrichum microsporum Smith 1962 = Arthrographis cuboidea q.v.

Geotrichum purpurascens (Bon.) Sacc. 1886 = Sporendonema purpurascens q.v.

Geotrichum roseum Grove 1886 ?= Sporendonema purpurascens q.v.

Geotrichum rotundatum (Cast.) Cif. & Red. 1929 = Trichosporon cutaneum fide Lodder (1970)

Geotrichum rugosum (Cast.) Dodge 1935, Medical Mycology p. 219 = Trichosporon cutaneum fide Lodder (1970).

Geotrichum suaveolens (Lindner) Cif. apud Diddens & Lodder 1942, in Die anaskosporogen Hefen II:271 = Moniliella suaveolens (Lindner) von Arx 1972

Geotrichum vanrijii Saez 1964, Bull. mens. Soc. linn. Lyon 33(7):266 = Trichosporon cutaneum fide Lodder (1970)

Malbranchea Saccardo 1882 See Part II

Mauginiella Cavara 1925

Type Species
Mauginiella scaettae Cavara 1925, Atti della R. Acc. dei Lincei 322, ser. 6, p. 67
= Geotrichum scaettae (Cavara) Maire 1937, in Maire & Werner, Mem. Soc. Sc. Nat. Maroc 45, p. 133

A single strain was examined. The colony on PYE is 60 mm diam. in 14 days, creamy, flat, dense and downy or felt-like when dried. The reverse is yellowish-tan, with some areas of darker pigment. Growth is slightly slower at 30 C and considerably slower at 18 C (40 mm in 21 days). Colonies on cereal are similar, but with distinct yellow pigment in the aerial growth at 18 C.

The vegetative mycelium consists of a few straight regular hyphae, 3-5um wide, and many narrow, curved, irregular branches 2-3um wide. The fertile hyphae are regular, branched and 4-7um wide. They quickly become filled with dense cytoplasm and closely septate, but break up only slowly into fragments (sometimes branched) with

zero to many septa. The individual cells are 6-15um long. We received this strain too late to include it in the plates, but drawings of the arthroconidia are provided by Nicot (1972).

The colonies of M. scaettae resemble those described under Arthroconidial states of Basidiomycotina. Microscopically, M. scaettae is close to group 1, but differs in its wider fertile hyphae and incomplete disarticulation.

Habitat and activities: Causes a rot of date palm inflorescences (Nicot, 1972). Cellulolytic, not keratinolytic.

Material examined: UAMH 3098, from Phoenix dactylifera, Iraq, 1949, CMI 34813

Oidiodendron Robak 1932

Perfect States: Myxotrichum Kunze, Byssoascus von Arx

Lectotype Species
Oidiodendron tenuissimum (Peck) Hughes 1958, Can. J. Bot. 36:790
= Periconia tenuissima Peck 1893, N. Y. State Museum Report 46:113 (Basionym)
= Oidiodendron fuscum Robak 1932, Saetryk av. Nyt. Mag. Naturvidensk 71:251

This wood- and soil-inhabiting fungus forms arthroconidia on branched or unbranched, hyaline fertile hyphae borne at the apex of a pigmented conidiophore. Occasionally, conidiophore production is suppressed and arthroconidia form directly on undifferentiated fertile hyphae.

The exact mode of development of its arthroconidia is not completely understood. Barron (1962), in his monograph of nine species, reported that arthroconidia were formed either endogenously, remaining connected within the original outer hyphal wall until maturity, or more commonly, by segmentation of the hypha with each developing conidium drawing slightly apart from its neighbors, but remaining connected to them by a gelatinous secretion.

Cole and Kendrick (1969), in a time-lapse study of O. truncatum, concurred with the latter view. They found that initial septation, possibly by double septa, was followed by rounding up and drawing apart of the immature arthroconidia leaving a clear area between adjacent conidia. The clear areas, termed connectives, were often traversed by a septum. Cole and Kendrick (1969) agreed

with Barron (1962) that the connectives were either remnants of the outer hyphal wall left after endogenous formation of conidia, or more probably, that they were gelatinous secretions from the maturing conidia. The presence of a septum within the connectives suggested that new terminal end walls distinct from the original septum were formed by the maturing arthroconidium. In a further discussion, Kendrick (1971, p. 162) designated this type of arthroconidium development as type 2. Recently, Cole (1975) suggested that the connectives between conidia may be deposits of new wall material formed around the septum.

Arthroconidia of Oidiodendron, separated from each other by gelatinous connectives, are distinct from the fission arthroconidia of Geotrichum and Arthrographis and the alternate arthroconidia of Malbranchea and Ovadendron. Oidiodendron is further distinguished by its pigmented conidiophores.

For discussions of the species of Oidiodendron, the reader is referred to Barron (1961, 1962), Morrall (1968), Cole and Kendrick (1969), Kobayasi et. al. (1969), Kiffer, Mangenot and Reisinger (1969) and Tokumasu (1973). In addition, Oidiodendron conidial states have been described for Myxotrichum cancellatum [= Toxotrichum cancellatum] (Orr and Kuehn, 1964a; Apinis, 1964), Arachniotus flavoluteus (Muller and Pacha-Aue, 1968) and Byssoascus striatosporus [= Arachniotus striatosporus] (Barron and Booth, 1966; von Arx, 1971). However, in our examination of the type strain of A. flavoluteus (UAMH 3531, CBS 627.71, NRRL 1243), we were unable to confirm the presence of an Oidiodendron conidial state. Nor have Kuehn and Orr (1959), Udagawa (1963), or von Arx (1971) reported an asexual state for this species.

Oidiodendron state of Myxotrichum striatosporum

Perfect State:
Myxotrichum striatosporum (Barron & Booth) Sigler comb. nov.
= Arachniotus striatosporus Barron & Booth 1966, Can. J. Bot. 44:1060 (Basionym)
= Byssoascus striatisporus (Barron & Booth) von Arx 1971, Persoonia 6(3):377

Barron and Booth (1966) described this species in Arachniotus as having white confluent gymnothecia composed of narrow, hyaline peridial hyphae and fusiform, striate yellow ascospores. In their preliminary discussion, however, they noted that darkly pigmented hyphae occurred in association with the gymnothecia, but did not include their description in the Latin diagnosis. Von Arx (1971) removed the species from Arachniotus and proposed a new genus, Byssoascus, because of the fusiform, striate

ascospores.

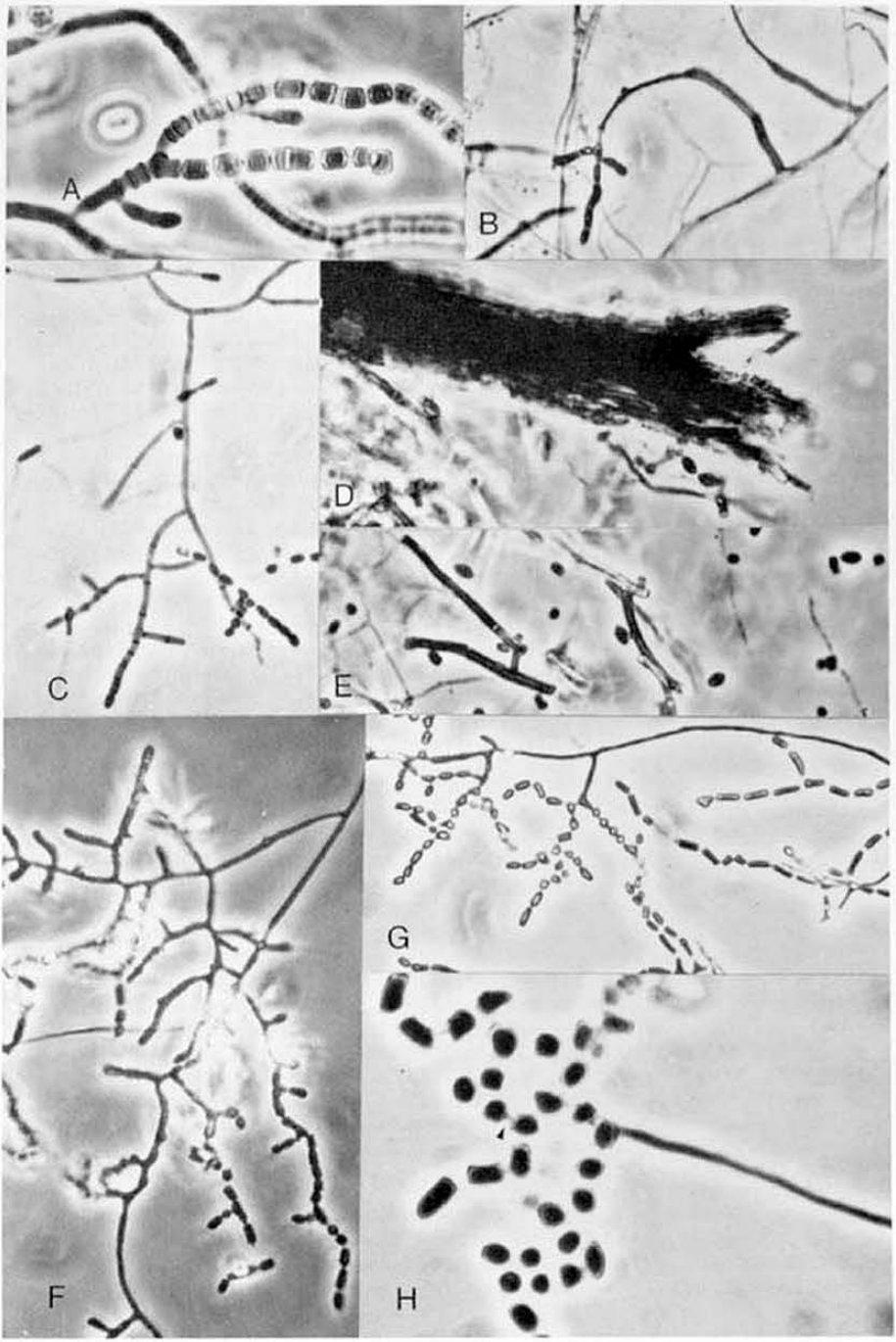
There appears to be little justification for the creation of a new genus for this fungus. On the basis of ascospore morphology alone, this species does not differ from species of Myxotrichum which have ellipsoidal or fusiform ascospores. Ascospores of some species, such as M. deflexum and M. chartarum (Orr, Kuehn and Plunkett, 1963b; Apinis, 1964; Visset, 1974) also have longitudinal furrows which are clearly visible when the ascospore is seen in polar view at high magnification. The ascospores of M. striatosporum are more definitely striate but this character would not exclude the species from Myxotrichum.

The primary reason for the removal to Byssoascus would seem to have been the nature of the gymnothecium, which is composed of thin-walled, narrow hyphae. Examination of the type strain (UAMH 3572 and 3758, CBS 642.66, CMI 115998) revealed that production of ascospores was consistently associated with the formation of dark brown, thick-walled, smooth hyphae, often aggregated into ropes (Fig. 6D). On cereal agar, ascospores are produced beneath the surface of the colony among the thick-walled hyphae. No discrete gymnothecium or peridial wall was seen. Species of Myxotrichum have been described in which the gymnothecia coalesce and do not detach readily from the vegetative hyphae (see Malbranchea circinata, Myxotrichum setosum).

The transfer to Myxotrichum is proposed for several reasons. First, the ascospore shape and surface, the Oidiodendron conidial state and the cellulolytic activity of the fungus are consistent with those of other species of Myxotrichum. In addition, the dark brown, thick-walled, coalescing hyphae (Fig. 6D) are branched and often have blunt tips where the terminal portion has broken off (Fig. 5E). This severance of the tip of branches is seen frequently in species of Myxotrichum. Finally, the similarity of M. striatosporum to M. setosum suggests that

---

Figure 6. A. Coremiella cubispora (UAMH 3793). B-E. Oidiodendron state of Myxotrichum striatosporum (B,D,E,-3572; C-3578). F-H. Oidiodendron state of Myxotrichum setosum (3835). Fig. 6A. Alternate arthroconidia borne on dichotomously branched hyphae. Fig. 6B. Arthroconidia borne on pigmented conidiophore. Fig. 6C. Arthroconidia borne on hyaline conidiophore. Fig. 6D. Dark brown 'peridial' hyphae aggregated into ropes, and fusiform ascospores. Fig. 6E. Ascospores and segments of peridial hyphae showing blunt tipped branches. Figs. 6F-5G. Arthroconidia borne on hyaline conidiophores. Fig. 6H. Septum (arrow) traversing connective between adjacent arthroconidia. All x 600, except H, x 1680.


A
B
C
D
E
F
G
H

these two species should be placed in the same genus.

The Oidiodendron state of M. striatosporum is similar to the Oidiodendron state of M. setosum. On cereal agar, the conidiophores of M. striatosporum are narrow, mostly hyaline (Fig. 6C), rarely becoming pigmented at the base (Fig. 6B). Arthroconidia are often formed directly on undifferentiated hyphae. Arthroconidia are smooth or slightly rough-walled, olive-green, barrel-shaped 1.5-2.5 x 1.5-3.5um. Barron and Booth (1966) noted that the barrel-shaped arthroconidia differed from those of other species which were mostly ovoid, globose or cylindric.

The colonial morphology of M. striatosporum also resembles that of M. setosum. M. striatosporum grows slowly on both PYE and cereal. On cereal, the colony is 22 mm in diam. at 14 days, flat, slightly zonate, velvety, dark olive-green with characteristic bright yellow margin, reverse brown. On PYE, the colony is pale olive, adhering poorly to the cellophane and lifting up at the margin.

Oidiodendron state of Myxotrichum setosum (Eidam) Orr & Plunkett, in Orr et. al. 1963b, Can. J. Bot. 41:1457-1480

?= Oidium microspermum Berkeley & Broome 1873, in Ann. Mag. Nat. Hist. 4, ser. II, 346

= Oospora microsperma (Berk. & Br.) Saccardo & Voglino 1886, Syll. Fung. 4:22

History

Berkeley and Broome (1873) described Oidium microspermum from bark of Scotch fir (Abies) with a brief description but no illustration. Saccardo and Voglino (in Saccardo, 1886) transferred O. microspermum to Oospora. Lindau (1907) described the fungus from an exsiccatum, No. 1577 of Rabenhorst's Fungi europae, from Lonicera xylosteum. Since we have seen neither illustrations nor the type specimen of Oidium microspermum no new combination is proposed for the conidial state. However, both specimens that were examined had been identified as Oidium microspermum by Hughes (DAOM 37243) and Pirozynski (DAOM 144716). One of these (DAOM 144716) formed a perfect state in culture which agreed with previous descriptions of M. setosum. Therefore, Oidium microspermum is listed as a probable synonym of the Oidiodendron state of M. setosum.

Eidam first reported Gymnoascus setosus in 1882 from an isolate on a wasp's nest, with a brief description and no illustration. In 1902, Massee and Salmon found G. setosus on a bee's nest in England. They noted the distinctive white centrum of the ascocarp, and provided an excellent illustration (See Figs. 7D,7E). Dale (1903) reported germinating the ascospores from Massee and

Salmon's specimen, but she observed only a few hyphae and masses of blastoconidia in culture on a variety of media. Perhaps she was dealing with a contaminant.

DeLamater (1937), comparing G. setosus with Eidamella spinosa [= Myxotrichum deflexum], concluded that the two species were distinct, disagreeing with Dodge's (1935) placement of E. spinosa into synonymy with G. setosus. Apinis (1964) concurred with DeLamater.

Orr and Plunkett (in Orr et. al., 1963b) proposed a new combination, Myxotrichum setosum (Eidam), based on the description and figures of Massee and Salmon (1902) and Dale (1903) and the original description of Eidam (1882). Orr and Plunkett were unable to find a type specimen or any recent isolates of G. setosus. Despite Dale's detailed account of the conidial state, they reported the asexual state to be unknown. Apinis (1964) examined Massee's original drawings (NY) of M. setosum as well as two specimens from bee hives. He described the conidial state as 'oidia', 2 - 3um wide.

The conidial state of M. setosum has not previously been referred to Oidiodendron, probably because conidiophore development is weak and conidiophores remain unpigmented. Arthroconidia often develop on undifferentiated hyphae. These are probably the 'oidia' described by Apinis (1964). The conidial state of M. setosum described by Dale (1903) is more difficult to interpret.

Description

The colony on PYE at 25 C is 17 mm in diam. at 21 days, pale olive, reverse tan, velvety, adhering poorly to the cellophane. The margin becomes undulate and the center lifts. On cereal, the colony is flatter, stretching to 22 mm at 21 days with slightly raised center, powdery, dry and cracked, olive-green with 1-2 mm wide pale yellow margin, buff reverse. Psychrophilic, producing the sexual state at 8 C.

Vegetative hyphae are hyaline, septate, narrow. Conidiophores (Figs. 6F,6G) are hyaline, narrow, 1-1.5um wide and 30-140um long, branching at the apex to form fertile hyphae. Arthroconidia develop in more or less basipetal succession on the fertile branches (Fig. 6F) or on undifferentiated hyphae. Arthroconidia, becoming slightly rounded, remain linked by connectives often traversed by a septum (Fig. 6H). Arthroconidia are olive with thickened walls (Fig. 6H), smooth, mostly cylindrical, sometimes subglobose or ovoid, 1.5-2 x 3-5um.

Homothallic. Gymnothecia confluent, not discrete.

Peridial hyphae (Fig. 7A) not anastomosed, composed of dense, dark brown, septate, thick-walled hyphae terminating in long spines (Fis. 7A,7D) bearing two or three short lateral spines, often opposite to each other (Fig. 7D). Ascomatal initials are coiled (Fig. 7B); asci are hyaline, evanescent, subglobose, 6-7um in diameter. Ascospores (Figs. 7C,7E,7F) are pale green, smooth, fusiform or navicular, with one face flattened, 1.5-2 x 3.5-6.0um.

Discussion

Massee and Salmon's description (1902) and figures (reproduced here as Figs. 7D,7E) correspond well with the fungus described here. These authors noted that the centrum containing asci remained permanently white. In young cultures, this is true, but as the ascospores mature, the centrum becomes greenish-yellow in color.

The characteristic feature of M. setosum noted by Dale (1903) was the sharply pointed, branched spines of the peridial hyphae, which did not anastomose to form a discrete gymnothecium. The dark brown peridial hyphae and fusiform ascospores suggest that this species is correctly placed in Myxotrichum.

Placement of the conidial state in Oidiodendron is most suitable for the present. Although the conidiophores are hyaline, the development of arthroconidia resembles that of other species of Oidiodendron, especially the Oidiodendron state of M. striatosporus. If similar conidial fungi are discovered which lack the pigmented conidiophores of Oidiodendron then erection of a new form genus could be justified. Indeed, Paden (1975) reported that the conidial state of the ascomycete, Cookeina sulcipes (Berk.) Kuntze, formed arthroconidia separated by connectives similar to the type described for Oidiodendron truncatum by Kendrick (1971, p. 162). However, Paden did not describe the nature of the conidiophore.

Habitat and activities: Wood of Picea glauca, soil of Alpine regosol, Alberta, nests of wasps and bees, and honey-comb of bees, England and Germany. Neither keratinolytic nor cellulolytic.

Material Examined
UAMH 1174, photomicrograph ex DAOM 37243, from Picea glauca det. Hughes; UAMH 3835, washed soil particles from Alpine regosol, Kananaskis, Alta., 1968-1972, det. Pirozynski, DAOM 144716 (Bissett, JB 922); UAMH 3939, ex IMI 471, beehive comb, Kew, 1945, H.A. Dade.

Oidium Link 1824 nom. cons. 1975

The complicated and controversial history of the use of the name Oidium was reviewed by Weresub (1973) who made two proposals for its conservation. Her first proposal (371), to conserve the name Oidium for the conidial states of Erysiphaceae, was approved by the Special Committee for Fungi and Lichens (Taxon 24:534, 1975) reporting to the XII International Botanical Congress, Leningrad. The conidia of Oidium are meristem arthroconidia, formed in basipetal succession on a continuously elongating conidiogenous cell (see Kendrick, 1971, p. 168).

Excluded species: Oidium microspermum Berkeley & Broome 1873, in Ann. Mag. Nat. Hist., ser. II, 4:346 ?= Oidiodendron state of Myxotrichum setosum q.v.

Oospora Wallroth 1833

Eleven original species, including the type species of four other genera, were included in Oospora by Wallroth (Fl. Crypt. Germ. 2:182, 1833). Numerous species have since been added to Oospora, a nomen illegitimum (Hughes, 1958). Correct identification of many species of Oospora is impeded by inadequate descriptions which often lack illustrations. Examination of type specimens would be the only way of determining the correct placement for many names in Oospora.

Oospora crustacea Saccardo 1882, Michelia 2:545 ?= Sporendonema casei q.v.

Oospora cuboidea Saccardo & Ellis 1882, Michelia 2:576 = Arthrographis cuboidea q.v.

Oospora microsperma (Berk. & Br.) Saccardo & Voglino 1886, Syll. Fung. 4:22 ?= Oidiodendron state of Myxotrichum setosum q.v.

Oospora sulphureo-ochracea van Beyma 1933, Zentralbl. Bakter. Parasit. 88:134 = Ovadendron sulphureo-ochraceum q.v.

Ovadendron Sigler & Carmichael gen. nov.

Diagnosis
Deuteromycotina, Hyphomycetes. Hyphae hyalinae, septatae, angustae. Conidiophora absunt. Arthroconidia pluria, alternata, conspicue crassiora quam hyphas conidiogenas, 0-septata, in catenis longis, hyalina, laevia. Per dissolutiones cellularum separantium liberantur.
Ab Malbranchea per arthroconidia crassiora quam hyphas differat.
Typus: Ovadendron sulphureo-ochraceum (van Beyma) Sigler et Carmichael comb. nov.

Vegetative hyphae narrow, hyaline, septate. Fertile branches narrow, at first sparingly, then more regularly septate in more or less basipetal succession. Alternate arthroconidia are broader than the fertile hypha and develop in long chains. Mature conidia, released by lysis of intervening segments, are smooth, hyaline, barrel-shaped.

Developmentally, Ovadendron resembles Malbranchea. However, the species of Malbranchea compose a rather homogeneous group in which the width of the arthroconidium rarely exceeds that of the fertile hypha. In contrast, the arthroconidia of Ovadendron show a definite increase in volume, reaching a diameter of 2 or 2.5 times that of the fertile hypha. The swelling of the arthroconidium as it matures distinguishes the genus from Malbranchea.

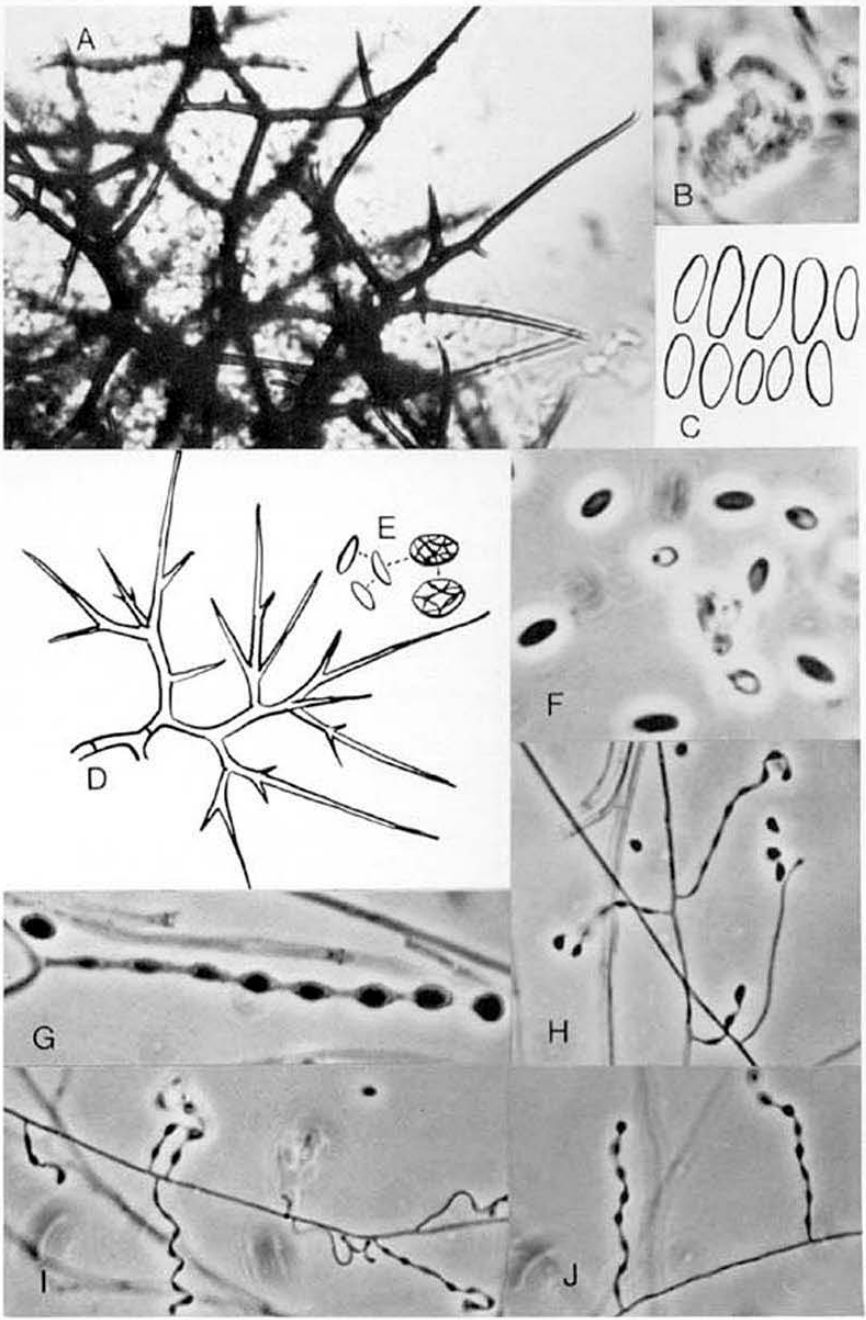
Ovadendron sulphureo-ochraceum (v. Beyma) Sigler & Carmichael comb. nov.
= Oospora sulphureo-ochracea van Beyma thoe Kingma 1933, Zentralbl. f. Bakt. u. Parasit., 2 Abt., 88:134 (Basionym)

The colony on PYE is 30 mm in diam. in 14 days, white, reverse tan, center downy and slightly raised, margin flat, glabrous. On cereal, flat (35 mm diam. in 14 days), white, floccose, reverse tan.

Vegetative hyphae are hyaline, septate, narrow. Fertile hyphae are narrow, 0.5-1.0um wide, short, coiled, lateral branches (Figs. 7G-7J) which become regularly septate, with concentration of cytoplasm in alternate segments. The arthroconidia mature in more or less basipetal succession, becoming thick-walled, and enlarging in volume. The mature, barrel-shaped arthroconidia (Fig. 7G), released by dissolution of the alternate empty segments, are hyaline, smooth 2-2.5 x 2.5-4um. No arthroconidia develop by segmentation of the vegetative hyphae.

The single strain examined (UAMH 181) corresponds to

Figure 7. A-F. Myxotrichum setosum (A-C,F-UAMH 3835). G-J. Ovadendron sulphureo-ochraceum (181a). Fig. 7A. Coalescing dark brown sharply pointed spines of peridial hyphae, x 600 BF. Fig. 7B. Coiled ascomatal initials, x 1680. Fig. 7C. Ascospores, x 1970. Fig. 7D-7E. Illustration of Massee and Salmon (1902) showing peridial hyphae (x 300) and ascospores (x 730). Fig. 7F. Ascospores, x 1680. Fig. 7G. Developing arthroconidia showing marked increase in volume, x 1680. Figs. 7H-7J. Arthroconidia in chains on coiled lateral branches, x 600.


A
B
C
D
E
F
G
H
I
J

van Beyma's original description, except that UAMH 181 remains white, whereas van Beyma noted that the colony became yellowish in age.

Activity: keratinolytic, penetrating hairs by single hyphae.

Material examined: UAMH 181, ? TYPE strain, ex CBS strain van Beyma, rec. 1954, and CBS 233.32 rec. 1975.

Ptychogaster Corda 1838

Type Species
Ptychogaster state of Tyromyces ptychogaster (Ludwig) Donk 1933, Meded. Bot. Mus. Herb. Rijks Univ. 22:153
= Ptychogaster fuliginoides (Pers. ex Steudel) Donk 1972, Proc. K. Ned. Akad. Wet. C 75:165-177
= Trichoderma fuliginoides Pers. 1801, Syn. Meth. Fung., p. 231
= Ptychogaster albus Corda 1838, Icon. Fung. II:23-24, Taf. XII, fig. 90
= Ceriomyces albus (Corda) Saccardo 1888, Syll. Fung. 6:388

Perfect State:
Tyromyces ptychogaster (Ludwig) Donk 1933, Meded. Bot. Mus. Herb. Rijks Univ. 222:153
= Polyporus ptychogaster Ludwig 1880, Zeitschr. ges. Naturwiss. III, 5:424-431
= Oligoporus ustilaginoides Brefeld 1889, Untersuch. aus dem Gesammtgeb. der Mykol., Heft 8:114-142, Taf. VII, fig. 23-25 and Taf. VIII, fig. 26-33

According to von Arx (1973), the fungus described by Corda as Ptychogaster albus was transferred by Saccardo (1888) to Ceriomyces. Brefeld (1889), including it in Oligoporus as O. ustilaginoides, provided excellent illustrations of the Ptychogaster state. These illustrations appear identical to an isolate (UAMH 3813, WFPL 170AD) received as Ptychogaster albus, from Picea, Nova Scotia.

Development of conidia in the Ptychogaster state of T. ptychogaster resembles that of Arcuadendron. Conidia are formed in chains, with the conidiogenous cells occurring serially, developing from the apex of the newly formed conidium (Figs. 8A,8B). The former differs, however, in forming clamp connections between the developing conidia (Fig. 8B). Mature conidia are yellow, smooth, ellipsoidal, ovoidal or barrel-shaped, 4-5 x 6-9um, released by lysis of the intervening hypha.

Conidia of Ptychogaster rubescens Boudier develop in

the same manner. For a description of P. rubescens, refer to Fidalgo (1958) and von Arx (1973).

Ptychogaster species are conidial states of species of the Polyporaceae. In nature, the Ptychogaster stage grows as cushion shaped sporodochia, or small pads, composed of hyphae and powdery masses of conidia, or grows within the basidiocarp (Corda, 1838; Brefeld, 1889; Rea, 1922 p. 660; Donk, 1933; Davidson, Campbell and Weber, 1942; Davidson, Christensen and Darley, 1945; Fidalgo, 1958; Singh, Singh and Bakshi, 1961).

Habitat: On wood of various types including Pinus, Abies, Picea, and mine timber wood, South Africa, Germany, Canada, India and the USA.

Scytalidium Pesante 1957

The form-genus Scytalidium is characterized by dematiaceous intercalary or terminal arthroconidia formed by fragmentation of undifferentiated hyphae. The arthroconidia are thick-walled, smooth, occasionally verrucose in age, 0-1 septate, pale to mid-brown, or yellowish brown, cylindrical, oblong or broadly ellipsoidal, and if septate, often constricted at the septum. Fission arthroconidia of a second type are hyaline, thin-walled, smooth, cylindrical, single-celled. (Also refer to Ellis, 1971.) In its thallic ontogeny, Scytalidium resembles Geotrichum and Mauginiella but differs in being dematiaceous.

KEY TO THE SPECIES OF Scytalidium

1. Both hyaline and dematiaceous arthroconidia present .. 2
1. Only dematiaceous arthroconidia present 4
2. Colonies tan, grey or black ..... S. lignicola
2. Colonies paler 3
3. Colonies white, turning grey ..... S. album
3. Colonies yellowish ..... S. aurantiacum
4. Colonies slow-growing, dark grey-brown S. acidophilum
4. Colonies growing rapidly 5
5. Colonies peach-brown or pale grey; arthroconidia brown with refractile hyaline apices; pycnidia absent ..... S. flavobrunneum
5. Colonies grey-black; arthroconidia brown; pycnidia sometimes present .....S. state of Hendersonula toruloidea

Recently, Kuhlman, Carmichael and Miller (1976) described Scytalidium uredinicola which differs from other species of Scytalidium in growing in aecia of Cronartium fusiforme and in the regular swelling of its arthroconidia in culture.

Type Species
Scytalidium lignicola Pesante 1957, Ann. sper. Agr. (Roma) 11, suppl. CCLXI-CCLXV

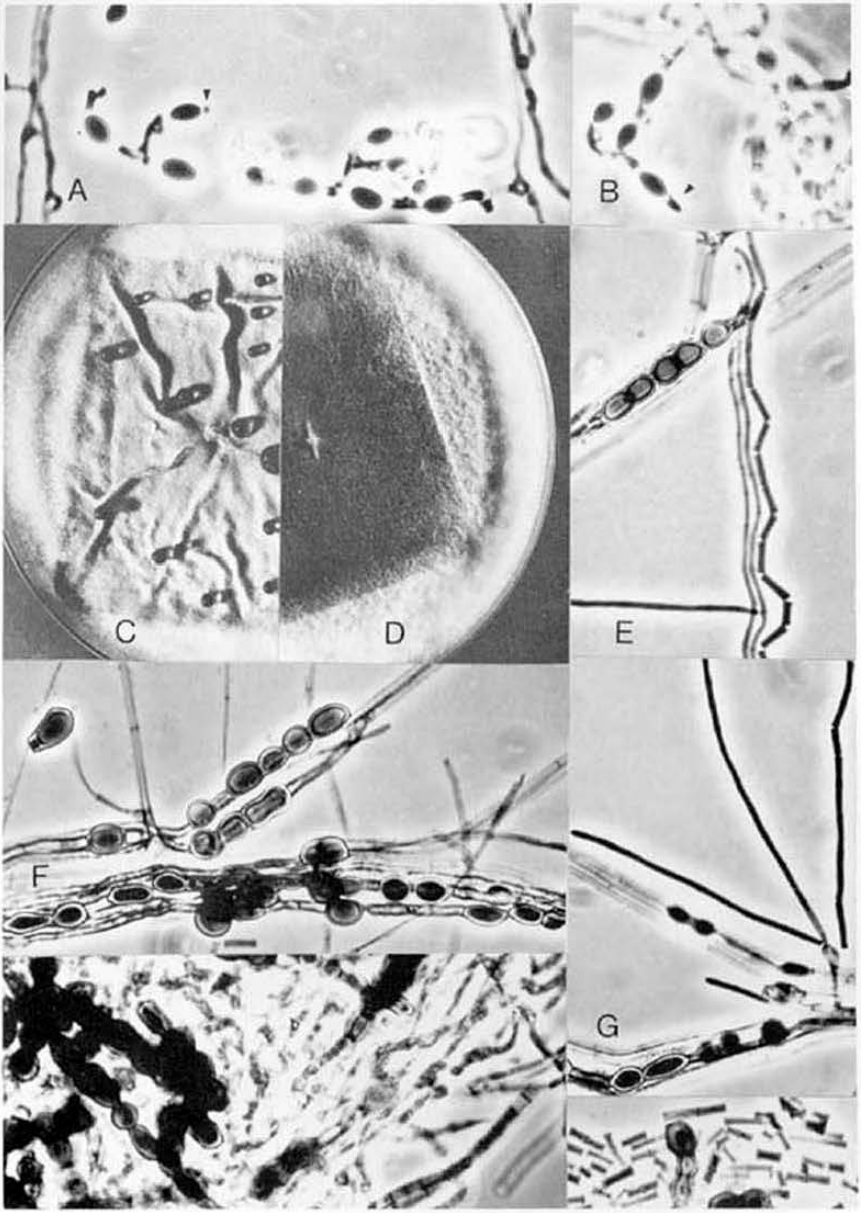
Growth on PYE (Fig. 8C) is rapid, 70-90 mm diam. in 14 days, at first white, then dark tan, pale or dark grey, front and reverse; flat with raised radial folds, downy or woolly, dense, matted. Brown or black pigment is excreted into the agar. The type culture (UAMH 1506) forms large dark brown exudate droplets. On cereal agar (Fig. 8D), colonies are 80-90 mm in 14 days, flat, at first glabrous with reddish-tan surface growth, gradually turning black as sporulation commences and forming a loose weft of white cottony aerial growth. Aerial growth is scant. The diffused pigment is plum or grey. UAMH 2816 grows faster than the type culture (UAMH 1506) and forms dense black colonies resembling a coating of thick tar on the cellophane membrane. No growth at 37 C.

Hyphae septate, hyaline, becoming brown. Arthroconidia of one type, formed by fragmentation of hyaline hyphae (Figs. 8E,8G) are cylindrical, thin-walled 2 x 4.5-8um. Arthroconidia of the second type (Figs. 8F,8G) arising in chains in an intercalary or terminal position on short, lateral branches, become thick-walled, yellowish-brown, broadly ellipsoidal, oblong, or barrel-shaped, 0-1-septate, constricted at the septum, and show an increase in volume. Arthroconidia measure 4-7 x 7.5-12um if 0-septate, and 12-17um long if 1-septate. Arthroconidia are not readily detached and may appear surrounded by a brown slime. (See also Ellis, 1971).

Habitat and activities: Isolated from blue stain of wood of Platanus, Pinus, Picea, Abies, Betula, Populus and Arachis, and from soil and roots of Vitis, in Italy, Sweden, southern USA, Canada, Japan, Cyprus, England, India, Rhodesia (Shields, 1969; Ellis, 1971; Murao, Oda and Matsushita, 1973; Klingstrom and Johanssen, 1973) and also from rhizosphere of Trifolium alexandrinum, Pakistan (Hussain and Malik, 1972). Slightly cellulolytic, not

---

Figure 8. A-B. Ptychogaster state of Tyromyces ptychogaster (UAMH 3813). C-G. Scytalidium lignicola (1502). H-I. Scytalidium album (H-3611; I-3620). Figs. 8A-8B. Chains of conidia developing serially (arrow) and forming clamp connections between each conidium. Figs. 8C-8D. Colonial morphology after 21 days at 25 C. C on PYE, D on cereal. Fig. 8E. Hyaline arthroconidia formed by fragmentation of undifferentiated hypha. Fig. 8F. Chains of thick-walled brown arthroconidia. Figs. 8G-8I. Mature arthroconidia of both types. Colonies x 0.7, others x 600.


A
B
C
D
E
F
G

keratinolytic.

Klingstrom and Johanssen (1973), testing the antagonistic properties of several isolates of S. lignicola against Fomes annosus, Polyporus versicolor, Lentinus lepideus, and Coniophora puteana, found that S. lignicola overgrew all isolates, killing the decay fungi in the process.

Material Examined
UAMH 385, photomicrographs ex DAOM 59090, from presumed type; UAMH 1502, TYPE, from Platanus wood, Italy, by Pesante and Peyronel, 1956, CMI 62532 (CBS 233.57); UAMH 2816, from cornfield soil, Bright, Ontario, G.C. Bhatt, 1967, as UW. 655.

Scytalidium album Beyer & Klingstrom 1965, Sv. Bot. Tidskr. 59(1):35

Colonies grow rapidly (50 mm on PYE and 70 mm on cereal at 14 days) and are white, flat, downy or glabrous. During sporulation, surface growth on cereal turns grey, grey pigment diffuses into the medium, and orange pigment forms near the center. On DSA, the diffused pigment is bright lemon-yellow. The arthroconidia (Figs. 8H,8I) are difficult to distinguish from those of S. lignicola (Figs. 8E-8G) and S. aurantiacum.

Klingstrom and Beyer (1965) and Klingstrom and Johanssen (1973) distinguish S. album from S. lignicola by its moderate growth at 25 C, and its inability to grow at 35 C, by its whitish colored colonies and pale yellow pigmentation on malt agar, and its antagonistic properties.

Habitat and activity: Isolated from blue stain of wood of Betula, Acer, Populus, Pinus, Abies, Picea, and Pseudotsuga (Douglas fir) utility poles, in Sweden, Finland, eastern Canada and western USA (Klingstrom and Beyer, 1965; Ricard and Bollen, 1968; Klingstrom and Johanssen, 1973). Moderately cellulolytic, not keratinolytic.

Antibiotic activity and metabolites: Klingstrom and Johanssen (1973), studying the action of S. album against four decay fungi, found that inhibition resulted from a soluble substance excreted into the medium. Production of a yellow pigment was associated with antagonistic ability, but the pigment itself had no antibiotic activity. The active agent was extracted from culture filtrates of S. album and found to be inhibitory to Fomes annosus.

One of the S. album strains studied by Klingstrom and Johanssen (1973) was the FY strain (UAMH 3620) of Ricard and Bollen (1968). Considerable interest has been generated in the metabolites produced by this strain.

Ricard and Bollen (1968) reported inhibition of the wood decay fungus Poria carbonica and some bacteria by culture filtrates. Stillwell, Wall and Strunz (1973) isolated and defined the structure of scytalidin, a second antiobiotic compound active against a wide variety of fungi. In addition to scytalidin, other antibiotic agents were present in culture filtrates, active against some fungi where scytalidin was not.

Findlay and Kwan (1973 a,b) defined another major metabolite, scytalone (3,6,8 -trihydroxytetralone) and a minor one (6,4,8 -dihydroxytetralone), neither of which were inhibitory to any significant degree. Similarly, Geigert, Stermitz and Schroeder (1973) isolated two other compounds, hexenophenones, neither inhibitory to Poria carbonica.

Material Examined
UAMH 3611, TYPE, from Norway spruce, Garpenberg, Sweden by Klingstrom and Beyer, 1963 (FF28), CBS 372.65; UAMH 3620, from heartwood of Pseudotsuga utility poles, western Oregon, by Ricard and Bollen (FY), from Wang, N.Y. State Univ., Syracuse as 1041.

Scytalidium aurantiacum Klingstrom & Beyer 1965, Sv. Bot. Tidskr. 59(1):35

Colonies grow moderately rapidly (40 mm on PYE and 65 mm on cereal at 14 days). On PYE, colonies are pale yellow, flat, woolly, coarsely matted or bristly. A lemon yellow pigment diffuses into the agar on PYE and DSA. Microscopically similar to S. lignicola and S. album.

Klingstrom and Beyer (1965) and Klingstrom and Johanssen (1973) distinguish S. aurantiacum from S. lignicola by its slower growth at 25 C and its inability to grow at 35 C. S. aurantiacum differs from S. album in the yellow-red color of the colonies and visible spots apparent on malt agar. S. aurantiacum is antagonistic to some human pathogenic bacteria (Klingstrom and Beyer, 1965), and to a number of wood decay fungi (Klingstrom and Johanssen, 1973).

Habitat and activities: pulpwood of Pinus, Betula, Picea, Sweden (Klingstrom and Johanssen, 1973). Cellulolytic but not keratinolytic. Penetrates hairs by single hyphae.

Material examined: UAMH 3612, TYPE, from pulpwood of Pinus silvestris at Skinnskatteberg, Sweden, by Klingstrom and Beyer (FF21), 1962, CBS 374.65.

Scytalidium acidophilum Sigler & Carmichael 1974, Can. J. Microbiol. 20(2):267-268

Sporulation and growth is enhanced on acid media. Colonies grow slowly (21-26 mm in 21 days on cereal agar) and are dark grey-brown, reverse dark grey, furrowed, cracked with a thin velvety nap. Scant growth at 37 C.

Arthroconidia formed in extended chains (Fig. 9A), not easily detached, brown, thick-walled, smooth or verrucose in age, 0-1-septate, measuring 4.5-6.5(8) x 7-13(16)um if single-celled and 4.5-6.5(8) x (10)11.5-23um if two-celled. Arthroconidia are broadly ellipsoidal, cylindrical or irregularly shaped, and if septate, constricted at the septum.

Habitat and activities: Isolated from acid soil near sulfur stockpiles, uranium mine drainage water, and acid solutions containing 4% copper sulfate from an industrial plant, Canada and U.S.A. (Sigler and Carmichael, 1974; Starkey and Waksman, 1943). Tolerant to extreme acidity and high concentrations of copper (Starkey and Waksman, 1943; Starkey, 1973; Gould, Fujikawa and Cook, 1974). Sensitivity to copper increases as the pH approaches neutrality (Starkey, 1973). Neither cellulolytic or keratinolytic.

Scytalidium flavo-brunneum (Miller, Giddens & Foster) Sigler comb. nov.
= Geotrichum flavo-brunneum Miller, Giddens, & Foster 1957, Mycologia 49:792, figs. 5-7 (Basionym)

Colonies on PYE, growing rapidly (70 mm in 14 days), are effuse, velvety, peach or salmon becoming brown, reverse dark yellow, adhering poorly to the cellophane developing radial folds, or lifting at the periphery. No growth at 37 C. On cereal agar, colonies fill the petri dish by 14 days and are flat with small central umbo and few outward radiating folds, effuse, velvety, with dark grey aerial hyphae, yellow surface growth and droplets of yellow exudate. The medium turns yellow or orange from diffusing pigment. On DSA, the pigment is bright yellow.

Arthroconidia form in chains on lateral branches (Figs. 9B,9C); conidiophores are absent. Fertile branches formed on hyaline vegetative hyphae, become regularly septate with a concentration of cytoplasm. The septa are strongly refractile. At disjunction, the conidia (Fig. 9D) are cylindrical, truncate or oblong, swollen, brown with prominent refractile apices (Figs. 9D,9E), predominately single-celled and measure 3.5-5 x 5.5-12(22)um. Ellis' (1971) Figure 3, labelled Bahusakala olivaceonigra, appears to be S. flavo-brunneum or a similar species.

In old cultures, Monochaetia-like conidia were occasionally formed on small compact masses of hyphae. These conidia are fusiform-curved, smooth, 3- to 5-septate,

5-6 x 15-20(25)um (Fig. 9F). The center cells are brown; the apical and basal cells are pale, each with a single hyaline appendage 0.5 x 7-8um. It is interesting that the other species of Scytalidium with prominent, refractile septa (the Scytalidium state of H. toruloidea) also has a second conidial state with fusiform phragmoconidia.

Habitat and activity: soil, Georgia and Wyoming (Miller et. al., 1957; Boeck et. al., 1975). Moderately cellulolytic but not keratinolytic.

Antibiotic activity: Boeck et. al. (1975) reported antifungal activity of culture filtrates from an organism which they called Geotrichum flavo-brunneum. In assessing the antibiotic activity of the fungus, the authors observed that no other Geotrichum was known to produce antifungal agents. Because of its dematiaceous nature, G. flavo-brunneum has been transferred to Scytalidium, a genus having several other species which also produce antibiotics.

The antibiotic agent, isolated and characterized as an azasteroid (Michel et. al., 1975) was found to have one major and six minor components. The major component was active against several pathogenic fungi, including Candida albicans and Trichophyton mentagrophytes, but minimally inhibitory to bacteria (Gordee and Butler, 1975).

Material Examined
UAMH 617, from Pfizer and Co., 1958, (? same strain as UAMH 3487); UAMH 3487, TYPE, from forest soil, Clarke Co., Ga., J.H. Miller, 1956, CMI 100715.

Scytalidium state of Hendersonula toruloidea Nattrass 1933, Trans. Brit. mycol. Soc. 18:197
= Exosporina fawcettii Wilson 1947, Hilgardia 17(12):427, fig. 2

The arthroconidial state of Hendersonula toruloidea is frequently recovered from moribund tissues of fruit and trees in warm climates. Nattrass (1933) isolated the arthroconidial state from die-back disease of stone fruit trees in Egypt and reported development of pycnidia only after prolonged growth on wood. He described the arthroconidial state as characteristic of Torula.

Wilson (1947), comparing a fungus isolated from branch wilt disease of Persian walnut with two others from damaged citrus trees in California, noted the similarity of his isolate to H. toruloidea but failed to find pycnidia. He described a new species, Exosporina fawcettii. Later Wilson (1949) induced pycnidial formation in wood experimentally inoculated with E. fawcettii, and concluded that E. fawcettii was the conidial state of H. toruloidea.

Oudemans (1904) created the genus Exosporina for a single species, E. laricis, which he found on twigs and needles of Larix decidua. He described conidia developing in chains from a stroma. Immature conidia at the base of the chain were cubical, whereas mature conidia at the apex were more rounded. His description and illustrations suggest that the conidia may be thallic meristem conidia. Exosporina resembles Ojibwaya (Sutton, 1973), reported on stems of juniper. The Scytalidium state has been previously described but not named by Hughes (1952, 1953).

Recently, H. toruloidea has been recovered from infections of the skin and nails in humans (Gentles and Evans, 1970; Campbell, Kurwa, Abdel-Aziz and Hodgson, 1973; Campbell, 1974). Most infections were reported in former natives of tropical countries now residing in Great Britain. Pycnidia have rarely been observed in isolates from human infections (Gentles and Evans, 1970; Campbell, 1974) although Campbell et. al. (1973) reported that 5 of 8 isolates eventually developed pycnidia. Campbell (1974) induced pycnidial formation in 2 of 25 isolates by exposing them to ultra-violet irradiation.

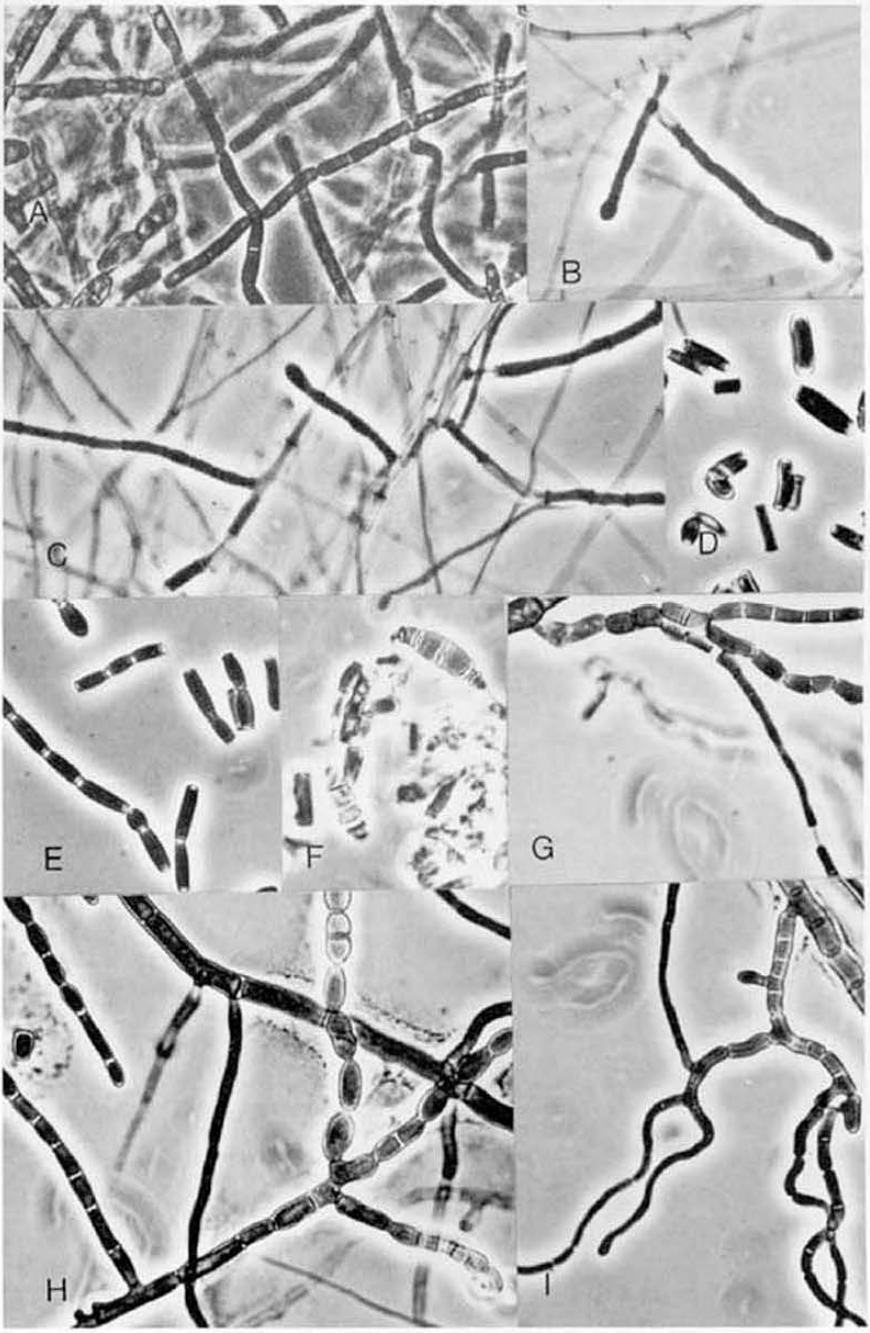
Description

The Scytalidium state is characterized by dark grey-black, effuse, rapidly growing colonies often forming thin, upright ropes of hyphae. Chains of arthroconidia develop on undifferentiated, broad (4-7um), brown hyphae (Fig. 9H), often surrounded by a brown slime, or narrower (3-4um) lateral branches (Figs. 9G,9I). The septa are almost as strongly refractile as those of S. flavo-brunneum. Arthroconidia (Fig. 9H) are 0-1-septate, smooth-walled, brown, at first cylindrical-truncate, rapidly rounding up and becoming barrel-shaped or subglobose, 3.5-5 x 6.5-15um (2.5-7 x 2.5-10(15)um of Campbell, 1974). For a more detailed description, refer to Campbell (1974).

The pycnidial state has been described by Nattrass (1933), Wilson (1949) and Hughes (1952). The single isolate examined by us (UAMH 3770) first formed pycnidia after exposure to ultra-violet light. During the process

---

Figure 9. A. Scytalidium acidophilum (UAMH 3460). B-F. Scytalidium flavo-brunneum (B,C-3487; D,F-617). G-I. Scytalidium state of Hendersonula toruloidea (3770). Fig. 9A. Chains of thick-walled arthroconidia. Figs. 9B-9C. Fission arthroconidia forming on lateral branches. Figs. 9D-9E. Mature brown arthroconidia with hyaline apices. Fig. 9F. Multi-septate conidia. Figs. 9G-9I. Chains of arthroconidia forming on broad hyphae or narrower lateral branches. All x 600.


A
B
C
D
E
F
G
H
I

of drying, colonies (see Materials and Methods) are exposed overnight to a General Electric germicidal 15 w lamp, and when dried are placed in plastic bags for storage. However, the agar was not completely dry and the colony eventually formed pycnidia within the plastic bag. Subsequently, pycnidia developed on straw agar (chopped decomposing straw, 3%; agar 1.5%) after 49 days incubation at 25 C.

Habitat and activities: Reported from fruit trees of many types principally citrus and stone fruits (Nattrass, 1933; Wilson, 1947, 1949; Hughes, 1952; Calavan and Wallace, 1954) and Persian walnut, black walnut, European chestnut (Wilson, 1949; Calavan and Wallace, 1954). Cellulolytic. Moderately keratinolytic (Campbell, 1974; Evans and Hose, 1975).

Material examined: UAMH 3770, from fingernail of Jamaican-born resident of England, at Univ. of Birmingham, C.K. Campbell (M40)

Sporendonema Desmazieres 1827

History

In 1827 Desmazieres described and illustrated Sporendonema casei which he found growing on outer crusts of cheese. He noted the affinity of S. casei to Mucor crustaceus Bulliard, Aegerita crustacea De Candolle, and Oidium rubens Link and suggested that none of these authors had correctly interpreted the manner of spore formation. Desmazieres recognized two different forms of spore dissemination, one through release from the tip of the fertile hypha and the other by destruction of the outer hyphal wall. Disagreement among mycologists on the exact nature of spore formation and dehiscence has resulted in considerable confusion over the placement of this species. At our request, Mme. J. Nicot searched for type material of S. casei in the exsiccati of Desmazieres located at the Museum of Natural History, Paris, but was unable to find any.

S. casei was transferred to Torula Persoon as T. casei by Corda (1838) and later as T. sporendonema by Berkeley and Broome (1850). Berkeley and Broome disagreed with Desmazieres' interpretation of spore formation and noted "Corda's Torula Casei appears to be very different". Bonorden (1851) followed Fries (1832) in accepting Desmazieres' Sporendonema casei as the correct name for this fungus, and later Bainier (1907) reviewed S. casei and described two new species.

However, Saccardo in 1882 referred Torula sporendonema Berk. & Br. to Oospora Wallr., a nomen illegitimum, as O.

crustacea (Bulliard) [= Mucor crustaceus Bull.]. In 1886 Saccardo placed Sporendonema casei in synonymy with O. crustacea. Lindau (1907) accepted this transfer.

Sumstine (1913) complicated the taxonomy of this fungus by stating that O. crustacea was congeneric with Oospora lactis (Fres.) Saccardo (now Geotrichum candidum). Sumstine also considered Chalara mycoderma Bonorden, another species referred to G. candidum (Carmichael, 1957), as a possible synonym of S. casei.

Oudemans in 1886, according to Lindau (1907), emended Sporendonema to include a new species, S. terrestre, whose status is now uncertain. Arnaud (1952), in describing Nyctalina lignicola, stated that it resembled S. terrestre.

In classifying a fungus isolated from curing blue cheese, Hammer and Gilman (1944) outlined the problems in naming the fungus. After reviewing the literature, they recommended retention of the name Sporendonema casei agreeing with Desmazieres' original interpretation. In addition, the authors accurately and precisely recorded the conidium development of S. casei. More recently, von Arx (1970) also accepted Sporendonema casei Desmazieres.

Generic Description

Hyphae septate, broad, hyaline; conidiophores lacking. The fertile hyphae are branched, often dichotomously; at first sparingly then more regularly septate, with septa forming first near the apex of the hypha. Arthroconidia are formed by condensation of the cytoplasm in adjacent or more often alternate segments separated by one or more empty cells. Maturing arthroconidia, retained within the original outer hyphal wall, become thick-walled and are released by fracture or lysis of the intervening empty cell. Arthroconidia are hyaline or pink or yellow, mostly more than 4um broad, smooth, thick-walled.

Sporendonema is distinguished from Coremiella by its light colored hypnae and arthroconidia. Furthermore, Coremiella may develop coremia on natural substrates, though rarely in culture. Coremium formation has not been reported in Sporendonema. Malbranchea differs from Sporendonema in the width of the hyphae and arthroconidia, which in Malbranchea rarely exceeds 4um.

Type Species

Sporendonema casei Desmazieres 1827, Ann. Sci. Nat. XI:247; Desmazieres 1827, Rec. Trav. Soc. Sci. Agric. Arts, Lille p. 185-187, pl. 3
= Torula casei (Desm.) Corda 1838, Icon. Fung. 4:8, fig. 36
?= Mucor crustaceus Bulliard 1782, Bull. Champ. Tab. 100

= Oospora crustacea (Bull.) Saccardo 1882, Michelia 2:545
?= Aegerita crustacea DeCandolle 1805, Fl. France 2:72
= Torula sporendonema Berkeley & Broome 1850, Ann. Mag. Nat. Hist. ser. 2, 5:460
?= Oidium rubens Link 1815, in Mag. Ges. Naturf. Freunde, Berlin 7:37

If Desmazieres' assertion that Aegerita crustacea DeCandolle is the same species as S. casei can be corroborated then this earlier specific epithet would take precedence. Similarly, Link's brief description of Oidium rubens is difficult to interpret with certainty, but it may also be an earlier specific epithet for S. casei.

Description

S. casei is psychrophilic, growing and sporulating well at 8 C. Colonies grow slowly at 25 C with scant sporulation, and fail to grow at 30 C. At 18 C, colonies on PYE agar are 30 mm in diam., flat, downy, creamy white front and reverse. On cereal agar, growth is slower but more luxuriant, at first creamy white, then cinnamon yellow as sporulation commences. The reverse is pink and a pink pigment diffuses into the medium. In microscopic preparations numerous large dark brown rod-shaped crystals may be found.

Characteristically the fertile hyphae, arising as lateral branches from the vegetative mycelium, are slightly broader, mostly curved or loosely coiled, or straight (Figs. 10A,10B) and the cytoplasm is more dense. Septa, forming in more or less regular segments, are thick suggesting double septa (Fig. 10C). Concentration of cytoplasm occurs in alternate or adjacent segments (Fig. 10B) and the internally developing arthroconidia synthesize new wall material. Maturing arthroconidia often become rounded at the corners and the original outer hyphal wall remains visible. Mature arthroconidia (Fig. 10D), released by fracture, sometimes remaining connected in a chain of 2 or 3, are yellow or hyaline, oblong, smooth (3)4-5 x 4-8(10)um. In old cultures, cinnamon colored arthroconidia are released not only by fracture of the hypha, but also by extrusion from the apex of the outer hyphal tube (Figs. 10E,10F), leaving a section of empty hypha, exactly as described by Desmazieres (1827).

Habitat and activities: Reported mostly from cheese; other records should probably be referred to Scopulariopsis, according to Wakefield and Bisby (1941). Neither cellulolytic nor keratinolytic.

Material Examined
UAMH 1506, from cheese, England by Galloway, 1949, CMI

37084; UAMH 1508, from wooden cheese drum, London, England by Worthington, 1957, CMI 68748; UAMH 3790, isolated at Hokkaido Univ., Japan by Sasaki (AHU 9107), 1963, from Tubaki, IFO, Japan as 7656.

Sporendonema purpurascens (Bonorden) Mason & Hughes 1953 apud Wood 1957, Nature 179:328
= Coprotrichum purpurascens Bonorden 1851, Handbuch allgemeinen Mycologie p. 76, fig. 32 (Basionym)
= Geotrichum purpurascens (Bonorden) Saccardo 1886, Syll. Fung. 4:40
?= Geotrichum roseum Grove 1886, Syll. Fung. 4:40 fide Caretta 1959
= Allonema roseum (Grove) Sydow 1934, Ann. Mycol. 32:283
?= Sporendonema roseum Grove var. album Arnaud 1952, Bull. Soc. Mycol. France 68:192, fig. 3,C,D

History

In 1851, Bonorden described and illustrated Coprotrichum with two species, C. purpurascens and C. cinereum. The hyphae and spores of C. purpurascens were described as purple whereas those of C. cinereum were greyish. In 1886, Saccardo transferred both species to Geotrichum. Later, Windisch (1951) listed both species as synonyms of Endomyces lactis and subsequently Carmichael (1957), in emending Geotrichum, included all three as synonyms of G. candidum Link.

At about the same time, Wood (1957) in a brief report on a disease of cultivated mushrooms caused by a so-called 'red Geotrichum' or 'lipstick mold' cited Mason and Hughes' identification of the causal agent as Sporendonema purpurascens (Bonorden) [= Coprotrichum purpurascens]. According to Wood, the fungus Bonorden described as Coprotrichum purpurascens was not identifiable with G. candidum and should be removed from Geotrichum. Certainly Bonorden's description of the hyphae and spores as purple would indicate a difference from G. candidum. Although Sporendonema purpurascens is the name commonly applied to the fungus known as the 'lipstick mold' (Cole and Kendrick, 1969; von Arx, 1970; Kendrick, 1971, p. 164), Kendrick and Carmichael (1973), in a review of Hyphomycete genera, list Coprotrichum as a synonym of Geotrichum.

Caretta (1959), following Redaelli and Ciferri (1934) and Ciferri (1958) in accepting Oudemans' (1886, in Lindau 1907) emended description of Sporendonema Desmazieres, retained Coprotrichum purpurascens for the neotype culture of Wood (1957). However, Redaelli and Ciferri (1934) included in Sporendonema unrelated fungi (Dodge, 1935) and the fungus they called Sporendonema epizoum has been transferred to Wallemia as W. sebi (Fries) von Arx (1970)

(see excluded species).

Caretta (1959) listed a number of synonyms for C. purpurascens including Monilia miniata Wallr. (?= S. casei, see Saccardo, 1886, p. 20), Oospora crustacea Sacc. [?= S. casei Desm.], Endoconidium luteolum Delacr., Oidium rubrum Proks., Scopulariopsis casei Loubiere, ? Oidium aurantiacum Henneberg, Coprotrichum crustaceum Cif. & Red. and Coprotrichum lutescens Cif. & Red. We have not seen the original descriptions of these species.

Description

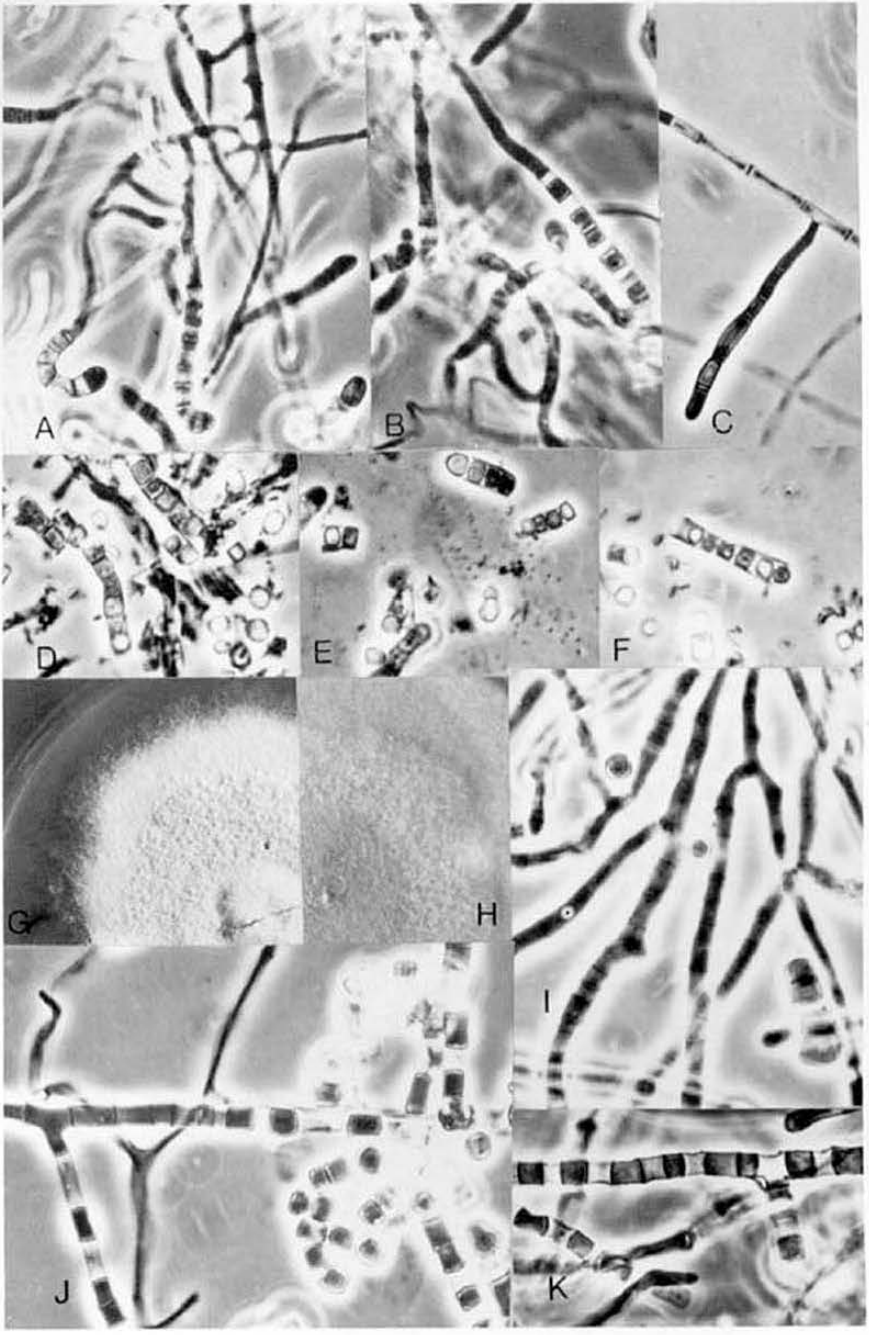
Colonies on PYE (Fig. 10G) are 55-68 mm in diam. in 21 days. Aerial growth at first scant, cottony, white, then rose-pink with white margin, dense, cottony or more often powdery, flat with central plateau, dry, cracked. The reverse is burnt orange in culture but burgundy when dried. Growth on cereal agar (Fig. 10H) is less luxuriant (45-60 mm diam. in 21 days), cottony, at first white then peach or pale pink, reverse white with tan or pink diffusing pigment. No growth at 37 C; optimum 25-30 C.

Alternate arthroconidia form on undifferentiated hyphae which may branch dichotomously (Fig. 10I). Arthroconidia (Figs. 10J,10K) are cylindrical or oblong, discoid in end view, hyaline at first, later pink, thick-walled, smooth, 4-7 x 4-12(15)um. The formation of arthroconidia has been recorded by time-lapse photography (Cole and Kendrick, 1969).

Habitat and activities: Commonly associated with cultivated mushrooms. S. purpurascens, one of several fungi tested by Komatsu (1969) inhibited Pholiota nameko in vitro at 25 C but failed to do so at 12 C. Weakly cellulolytic after prolonged growth, not keratinolytic.

Material Examined
From mushroom beds: UAMH 432 and 433, rec. from Kneebone, Penn. State Univ., as isolates A and B respectively; UAMH 1497, NEOTYPE, Chesham, England, F.C. Wood, 1951, CMI

Figure 10. A-F. Sporendonema casei (A,B,D-F-UAMH 3790; C-1506). G-K. Sporendonema purpurascens (G-I,K-432; J-3791). Figs. 10A-10C. Alternate arthroconidia developing on straight or curved fertile hyphae. Fig. 10D. Mature arthroconidia. Figs. 10E-10F. Extrusion of arthroconidia from the apex of the outer hyphal wall. Figs. 10G-10H. Colonial morphology after 21 days at 25 C. G on PYE, H on cereal. Fig. 10I. Dichotomously branched fertile hyphae. Fig. 10J-10K. Alternate arthroconidia. Colonies x 0.7, others x 600.


A
B
C
D
E
F
G
H
I
J
K

45638; UAMH 3791, same strain as UAMH 1497, rec. from Tubaki, IFO as 7659 (ex CMI 45638).

Species of Uncertain Status

Sporendonema salicis Bainier 1907, Bull. Soc. Mycol. France 23:24, pl. VI, fig. 7-9; Saccardo and Trotter 1913, Syll. Fung. 22:1240

No authentic material of S. salicis could be located (Nicot, pers. comm.).

Sporendonema artemisiae Bainier 1907, ibid, pl. VI, fig. 10-12; Saccardo and Trotter 1913, Syll. Fung. 22:1240

Bainier reported this species on dead stems of the mugwort, Artemisia, forming well developed yellowish-white or grey tufts (coremia?). It could be Coremiella cubispora (Berk. & Curt.) Ellis. Bainier lists the size of the conidia as "1um12 - 1um25" and Saccardo and Trotter interpret these measurements as "1,12 - 1,25" u. However, according to the illustrations (all at the same magnification), the diameter of the conidia of Sporendonema artemisiae exceeds that of S. salicis which was given by Bainier as "4um2". These measurements of Bainier appear to be in error. No authentic material of S. artemisiae could be located (Nicot, pers. comm.).

Sporendonema terrestre Oudemans 1886, Versl. en. Med. Konink. Ak. Wetensch. Amsterdam Afd. Natuurk. 3, ser. 2:115, pl. 1

The description and drawing in Lindau (1907, pp. 22-23) vaguely suggest Scytalidium flavo-brunneum, but no one since Oudemans seems to have examined the type.

Sporendonema roseum v. album Arnaud 1952, Bull. Soc. Mycol. France 68:192, fig. 3,C,D

Perhaps Sporendonema purpurascens, but there is no specimen preserved with Arnaud's material (Nicot and Charpentie, 1971).

Excluded Species

Sporendonema sebi Fries 1849 = Wallemia sebi (Fr.) von Arx 1970

Sporendonema epizoum (Corda) Ciferri and Redaelli 1934 = Wallemia sebi fide von Arx 1972

PART II MALBRANCHEA SACCARDO 1882

Type Species
Malbranchea pulchella Saccardo & Penzig 1882, Michelia 2:638

History

In 1882 Saccardo established the form-genus Malbranchea for a single species, M. pulchella Saccardo and Penzig, found growing on damp cardboard in Rouen, France. Although providing no illustrations, Saccardo described the characteristic branched, arcuate, or curved fertile hyphae. In reporting the extrusion of conidia from the apex of the fertile hyphal branch, "ex apice ramulorum continuo exsilientibus", he failed to recognize the arthric nature of conidium dehiscence. Later repeating his original description, he (1886) referred to the affinity of Malbranchea with Oospora Wallroth and Glycophila Mont. He did not describe the cultural characteristics of the organism.

Since its original description, Malbranchea has been largely ignored by mycologists. Two other species, M. bolognesii-chiurcoi Vuill., Poll. & Nann. and M. kambayashii Kamb., were described in the period 1925-1935, but later reduced to synonymy with M. pulchella. Miehe (1907) described in detail, Thermoideum sulfureum, a thermophilic fungus, but Saccardo (1908) and Saccardo and Trotter (1913) considered it a synonym of M. pulchella. More recently, attention focused on thermophilic isolates of Malbranchea, when Cooney and Emerson (1964) reviewed the history of the genus and provided an excellent description. The history of the mesophilic and thermophilic species are discussed under M. pulchella and M. sulfurea (Miehe) Sigler & Carmichael respectively.

Generic Description

Hyphae hyaline, septate; conidiophores absent. Primary hyphae straight, branched, mostly the same diameter, or slightly broader than the fertile hyphae, rarely exceeding 4um in diameter. Fertile hyphae, arising as branches from the primary hyphae, characteristically arcuate, in some species straight, branched, narrow, 1.5-3um, rarely exceeding 4um in width. Hyphae at first sparingly septate, then regularly so, with concentration of cytoplasm in alternate segments, separated by 1 or more empty cells; arthroconidia released by lysis or fracture of outer hyphal walls of intervening empty cells. Alternate arthroconidia smooth-walled, cylindrical-truncate, curved or straight, hyaline, later becoming yellow, tan, orange, or greenish-yellow, not wider in diameter than the hypha which bears them.

In brief, the form-genus Malbranchea is characterized by regular, narrow, alternate arthroconidia. It resembles Coremiella and Sporendonema, but both of the latter have wider hyphae and arthroconidia. In addition, Coremiella is dematiaceous. Ovadendron differs from Malbranchea in having swollen arthroconidia.

Comments on the Key and Descriptions

Species of Malbranchea can be divided into two groups: those having arcuate or curved fertile hyphae and those having more or less straight fertile hyphae. In the descriptions of the species, the ones with arcuate fertile hyphae are given in alphabetic order in Part A, and the ones with straight fertile hyphae in Part B. In some species, arthroconidia may also form in the wider, straight primary hayphae. These are referred to in the key as accessory conidia. The size range of arthroconidia varies little among the species of Malbranchea. For this reason, the colonial morphology and color are important characters in distinguishing among the species. For color photographs of colonies, see Fig. 22.

KEY TO THE SPECIES OF Malbranchea

Conidiophores absent 1
Conidiophores hyaline ..... Try Geomyces
Conidiophores pigmented ..... Try Oidiodendron
1. Fertile hyphae mostly more than 4um wide ..... Try Sporendonema
1. Fertile hyphae mostly narrower 2
2. Fertile hyphae arcuate or curved (Part A) 3
2. Fertile hyphae straight, branched (Part B) 11
3. Fertile hyphae tightly coiled, accessory conidia lacking 4
3. Fertile hyphae curved, arcuate, accessory conidia present 6
4. Colonies thermophilic; conidia 2.5-4.5um wide ..... M. sulfurea
4. Colonies not thermophilic; conidia mostly narrower .. 5
5. Colonies dark gold; sexual state Myxotrichum ..... M. circinata
5. Colonies tan, white or pale brown ..... M. pulchella
6. Colonies orange 7
6. Colonies pale colored 9
7. Homothallic; sexual state Auxarthron ....A. conjugatum
7. Not homothallic; sexual state absent 8
8. Arthroconidia intergrade with aleurioconidia formed laterally or terminally ..... M. chrysosporoidea
8. Aleurioconidia absent ..... M. aurantiaca
9. Colonies restricted, pinkish-buff; sexual state Myxotrichum ..... M. flavorosea
9. Colonies some other color 10
10. Colonies ivory yellow, spreading, zonate; Auxarthron

sexual state .....M. albolutea
10. Colonies buff or tan, rarely white, restricted or spreading .....M. arcuata
11. Branching of fertile hyphae regularly acute, arborescent .....M. dendritica
11. Branching of fertile hyphae otherwise 12
12. Arthroconidia mostly narrow, 1.5-3um 13
12. Arthroconidia mostly broader, 2.5-5um 17
13. Fertile hyphae, repeatedly branched, in dense tufts .....M. flocciformis
13. Branching of fertile hyphae more restricted 14
14. Colonies buff, tan or white 15
14. Colonies lemon-yellow ..... M. flava
15. Colonies white, restricted ..... M. gypsea
15. Colonies buff or tan 16
16. Arthroconidia with refractile terminal walls, mostly 2-3 x 3.5-8(11)um .....M. fulva
16. Arthroconidia broader, 2.5-3.5 x 3.5-6um; uncinate appendages mostly present ..... Uncinocarpus reesii
17. Arthroconidia broad, 3-5um, closely spaced ..... M. state of Coccidioides immitis
17. Arthroconidia narrower, 2.5-3.5um, irregularly spaced; uncinate appendages mostly present Uncinocarpus reesii

Perfect States

The perfect states of Malbranchea, where known, belong in the Gmnoascaceae (Kuehn, Orr and Ghosh, 1964; Hubalek, 1974a). This family of the Eurotiales is also reported to have conidial states in the form-genera Trichophyton and Microsporum (Rebell and Taplin, 1970), Chrysosporium (Carmichael, 1962; Apinis, 1970; Varsavsky and Orr, 1971; von Arx, 1971; Samson, 1972; Orr and Kuehn, 1972; Fennell, 1973), Oidiodendron (Orr and Kuehn, 1964a; Barron and Booth, 1966; Morrall, 1968; Muller and Pacha-Aue, 1968; von Arx, 1971; Fennell, 1973; Tokumasu, 1973), and Geotrichum (von Arx, 1971).

A closely related family, the Onygenaceae, is also known to have arthroconidial and aleurioconidial states (Tubaki, 1960; Malloch and Cain, 1971; Samson and van der Aa, 1973; Fennell, 1973). The lack of a phialoconidial state distinguishes the Gymnoascaceae from the Eurotiaceae (Stolk and Samson, 1972; Fennell, 1973).

Arthroconidial states have been described for a number of species of Gymnoascaceae, although they have been frequently referred to in earlier reports as 'oidia', or chlamydospores, or arthrospores (Kuehn, 1955b, 1959; Benjamin, 1956; Apinis, 1964). Orr et al. (1963b) introduced the term 'arthroaleuriospore' or 'arthroaleurie' to differentiate alternate arthroconidia from the 'true',

i.e., fission arthroconidia of Geotrichum. However, Orr et al. (1963a,b) considered the arthroaleuries to be variable and therefore of little value in distinguishing among species.

Some Malbranchea species described here were found to have sexual states in Myxotrichum, Auxarthron and Uncinocarpus. For the species we have described, the Malbranchea state is the one usually produced in culture, and thus would be used for identification. It should be noted that there are a number of homothallic Gymnoascaceae, not described here, which produce a Malbranchea state in culture along with the gymnothecia. Since the perfect state would normally be used for identification, and since we have not made a thorough study of this group, these species are not described or included in the key.

Gymnothecium production in the Gymnoascaceae is stimulated by growth on oatmeal-salts agar (Weitzman and Silva-Hutner, 1967; Padhye et al., 1973) and by incubation at different temperatures such as 18 C, 25 C and 30 C. Strains failing to form gymnothecia at 25 C may do so readily at 18 C or 30 C, although the lower temperature more often stimulates development. In addition, keratinophilic isolates form gymnothecia when grown on dextrose-salts agar, a minimal nutrient medium, sprinkled with a keratinous substrate such as hair. Gymnothecium production is enhanced in cellulolytic fungi by growth on a cellophane membrane on the surface of the agar (see Materials and Methods) although the membrane tends to limit gymnothecium formation in keratinophilic isolates. Some, especially degenerate strains or ones maintained for long periods in culture, require an additional stimulus, usually prolonged growth, 6-10 weeks or more, or multiple transfers on oatmeal-salts agar.

Ecology and Distribution

Malbranchea is a common soil fungus having a worldwide distribution. Species are mesophilic, thermotolerant or thermophilic and may be keratinolytic or cellulolytic.

Thermophilic isolates of Malbranchea sulfurea are cellulolytic, and commonly associated with self-heating decomposing matter, or dung. Since its description by Cooney and Emerson (1964), this species has been frequently reported (see M. sulfurea).

However, other records of Malbranchea are rare. Few reports of Malbranchea have occurred in surveys of keratinophilic fungi (Rebell and Taplin, 1970; Orr and Kuehn, 1972; Hubalek, 1974a; Hubalek and Balat, 1974; Rippon, 1974; Ajello and Padhye, 1974). Malbranchea is a little known genus, and isolates may well have been listed

as unidentified Chrysosporium species or more probably as unidentified Gymnoascaceae or as asexual states of Gymnoascaceae (Emmons, 1954; Rees, 1967a,b; De Vroey, 1970; Hubalek, 1974a; Caretta and Piontelli, 1975). A number of species of Malbranchea have their sexual states in the Gymnoascaceae. Some keratinolytic thermotolerant species are asexual states of Auxarthron whereas some mesophilic cellulolytic species are asexual states of Myxotrichum.

With the exception of the Malbranchea state of Coccidioides immitis, a human pathogen, there is little evidence to suggest that species of Malbranchea are pathogenic. However, arthroconidia of nonpathogenic species may be transient inhabitants of man and animals, recoverable from tissues of animals such as rodents, and surviving passage through animals (Emmons, 1954; Kuehn et al., 1964; Orr, 1968; Rippon, 1974). Some species of Malbranchea have been previously reported as fungi which resemble C. immitis (Emmons, 1954, 1967; Plunkett, Walker and Huppert, 1963; Huppert, Sun and Bailey, 1967; Orr, 1968; Orr and Kuehn, 1972).

Temperature relationships and activity of isolates are important in differentiating species of Malbranchea. Incubation at 18 C or 30 C often stimulates formation of the sexual state. Since arthroconidium morphology in many species of Malbranchea is rather uniform, colony appearance becomes an important character. The morphology and growth rate of colonies at different temperatures are valuable taxonomic characters for differentiation among species.

A) Malbranchea species with arcuate fertile hyphae

Malbranchea albolutea Sigler & Carmichael sp. nov.

Sexual state: Auxarthron Orr, Kuehn & Plunkett 1963a

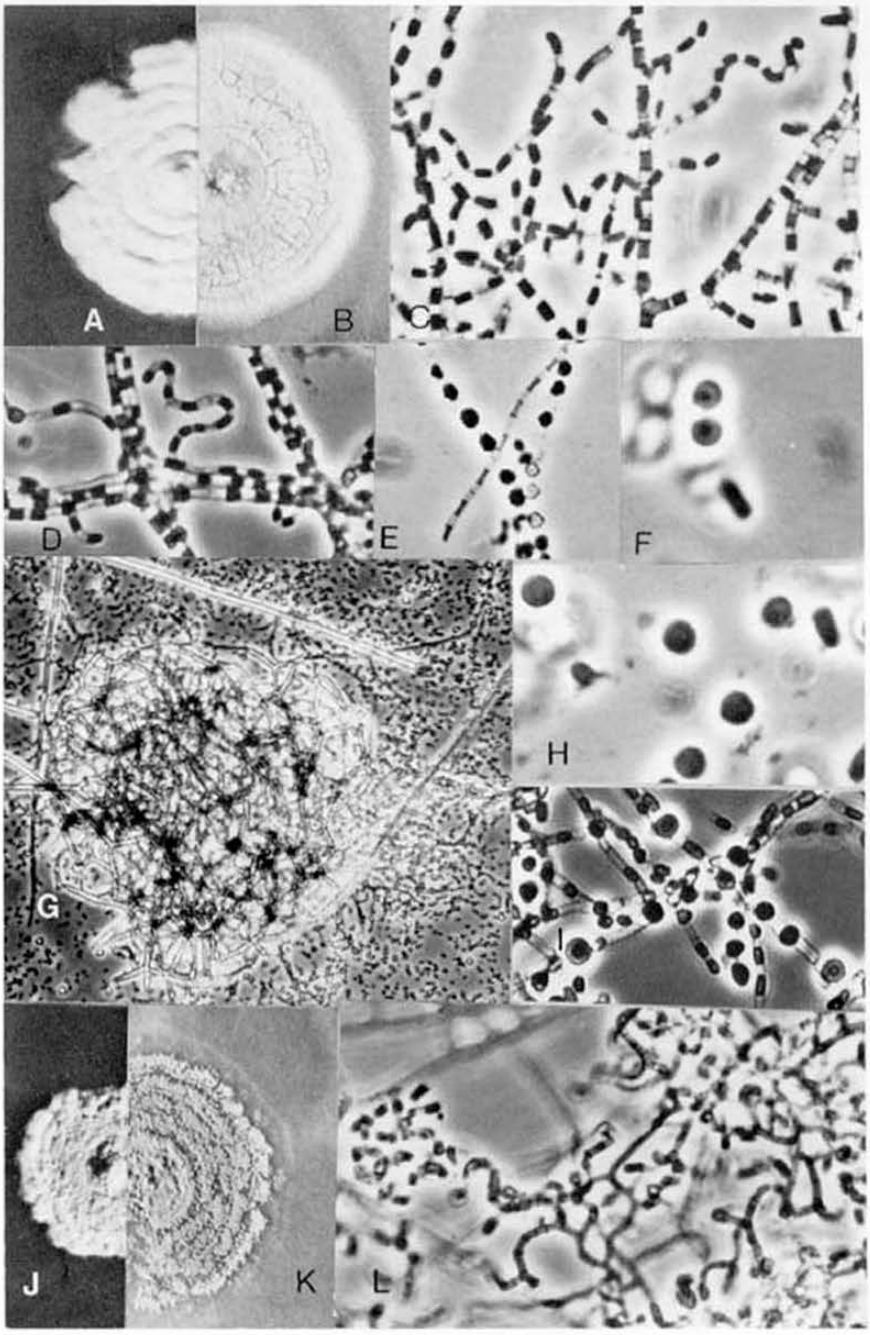
Coloniae in agaro ad 25-30 C rapide crescunt, alboluteae, pulveraceae, rimosae. Incrementum nullum ad 37 C. Arthroconidia cylindrica, aliquando curva, laevia, hyalina vel flava, 1.5-2 x (2.5)3-5(6)um. Arthroconidia ex hyphis principalibus crassiora, aliquando inflata, 2.5-3(4) x (1.5)2-5(6.5)um.
Status perfectus: Auxarthron, sed species incerta est.
Typus: UAMH 2846, ex solo, Utah, 1967, G.F. Orr, 0-3508

Colonies on PYE (Fig. 11A) at 25-30 C (optimum range) are 50-57 mm diam. in 21 days, pale ivory-yellow, reverse yellow, powdery, dry and cracked. The surface is slightly raised with central umbo, two or three powdery zones and downy periphery. The periphery develops broad, flat sectors, having scant aerial growth, identical to the margin. The zonate pattern and sectoring is less evident on downy colonies. On cereal, colonies (Fig. 11B) are 42-53 mm diam. in 21 days, pale ivory-yellow or creamy buff, reverse yellow, powdery, dry, cracked by numerous tiny fissures, periphery downy, rarely sectoring. The surface is flat, with tiny central umbo or zone of scant aerial growth at center. No growth at 37 C except scant growth by UAMH 1846.

Arthroconidia, borne on narrow, arcuate or curved lateral branches (Figs. 11C,11D), are cylindrical sometimes curved, hyaline, in age yellow, 1.5-2 x (2.5)3-5(6)um. Arthroconidia formed by segmentation of the broader primary hyphae (Fig. 11D) are hyaline, cylindrical, 2.5-3(4) x (1.5)2-5(6.5)um. In age, racket hyphae, and enlarged, subglobose, or irregularly shaped arthroconidia (Fig. 11E) are

---

Figure 11. A-H. Malbranchea albolutea (A,B,F,G-UAMH 2846; C-1846; D-2861; E-2848; H-3651). I-L. Malbranchea arcuata (I-1861; J-L-2519). Figs. 11A. Colonial morphology after 21 days at 25 C, x 0.7. A on PYE, B on cereal. Figs. 11C-11D. Alternate arthroconidia of arcuate branches and straight primary hyphae, x 600. Fig. 11E. Chains of enlarged arthroconidia, x 600. Fig. 11F. Globose ascospores, x 1680. Fig. 11G. Gymnothecium with elongate appendages, x 150. Fig. 11H. Finely asperulate ascospores, x 1680. Fig. 11I. Chains of enlarged arthroconidia, x 600. Figs. 11J-11K. Colonial morphology after 21 days at 25 C, x 0.7. J on PYE, K on cereal. Fig. 11L. Alternate arthroconidia borne on arcuate branches, x 600.


A
B
C
D
E
F
G
H
I
J
K
L

formed.

Gymnothecia (Fig. 11G) are spherical, discrete, 280-400um in diameter (excluding elongate appendages), brown, composed of a branched network of thick-walled, delicately asperulate, septate, 3-5um wide, yellow-brown hyphae, with free apices terminating in bluntly pointed spines. Elongate appendages (Fig. 11G) arising from a bifurcate base are 400-800um long, smooth, thick-walled and yellow-brown over half the length, tapering to a hyaline apex, straight, rarely uncinate. The hyaline portion is often broken off, leaving the tip blunt. Asci are evanescent, hyaline, 6.5-8um in diameter, 8-spored. Ascospores (Figs. 11F,11H) are globose, delicately roughened, yellow (2.2)2.5-3.5um. The ascospores appear smooth at low magnification and the rough surface is often difficult to detect even at high magnification (x2700)(Figs. 11F,11H).

Discussion

Malbranchea albolutea differs from other Malbranchea species having arcuate fertile hyphae, such as M. aurantiaca and M. arcuata, in its creamy white to pale ivory-yellow colored colonies. Moreover, it forms a sexual state in culture.

Most isolates developed gymnothecia only after prolonged growth on oatmeal agar without cellophane. Even when gymnothecia are produced, the colony remains creamy white in color, never orange or brown. The gymnothecia mature slowly, requiring 6-8 weeks or longer before ascospores are produced. In some strains, even apparently mature gymnothecia often contain no ascospores. However, ascospores can be induced by repeated transfers on oatmeal agar and growth at 25 C or 30 C.

The sexual state of M. albolutea is assigned to Auxarthron, a genus distinguished from other genera of the Gymnoascaceae by its net-like anastomosed peridial hyphae bearing prominent enlarged septa, described as 'knuckle-joints', and by its ascospore morphology (Orr et al., 1963a). These generic characters have not been accepted by some others. Apinis (1964) noted that enlarged septa also occurred in some species of Gymnoascus and in Myxotrichum herbariense [= Tripedotrichum herbariensis Orr & Kuehn, 1964b]. Therefore, he retained Auxarthron and Pseudogymnoascus Raillo as subgenera of Gymnoascus. He included in the subgenus Auxarthron, species having uncinate or straight, elongate peridial appendages. Udagawa (1966) followed Apinis in retaining Gymnoascus.

Historically, the character of the peridial hyphae and appendages has received emphasis in classification of genera of the Gymnoascaceae. However, Samson (1972) in a

study of Pseudogymnoascus, Gymnoascus and Auxarthron pointed to the variability of these characters during different stages and cultural conditions of growth, and suggested that more reliable characters for differentiation were morphology of the ascomatal initials, asci and ascospores. Samson (1972) retained all three genera and distinguished Auxarthron from Gymnoascus and Pseudogymnoascus on the basis of its globose or subglobose, roughened or echinulate ascospores and arthroconidial or aleurioconidial asexual state.

Eight species have been described in Auxarthron (Orr et al., 1963a; Orr and Kuehn, 1971, 1972). Samson (1972) suggested that a review of the number of species of Auxarthron should be considered. Species of Auxarthron, which have a rather uniform ascospore size and morphology, are difficult to differentiate by the morphology of the peridial hyphae and their appendages.

The sexual state of M. albolutea most closely resembles Auxarthron thaxteri (Kuehn) Orr & Kuehn [= Myxotrichum thaxteri Kuehn, 1955b]. Orr et al. (1963a) described Auxarthron brunneum based on Rostrup's description of Myxotrichum brunneum and placed M. thaxteri Kuehn in synonymy. Apinis (1964) compared Rostrup's type specimen of M. brunneum with the type material of Gymnoascus umbrinus Boudier and found the two to be identical. Apinis placed M. brunneum in synonymy with G. umbrinus v. umbrinus and retained Kuehn's M. thaxteri as a variety, G. umbrinus var thaxteri. After evaluating the type materials of Rostrup and Boudier, Orr and Kuehn (1971) disagreed with Apinis' (1964) placement of M. thaxteri and they proposed to retain it as a separate species, Auxarthron thaxteri. Myxotrichum brunneum Rostrup was placed in synonymy with A. umbrinum (Boudier) Orr & Plunkett, but Auxarthron brunneum sensu Orr & Kuehn (1963a) was placed in synonymy with A. thaxteri since the description of this species was based on the type culture of M. thaxteri.

The sexual state of M. albolutea appears to fit the description of Orr et al. (1963a) of A. thaxteri [= A. brunneum sensu Orr & Kuehn]. Indeed, the sexual state of one of the strains examined by them (0-1024, UAMH 1117) is identical with that described here. However, our examination of the type strain of A. thaxteri (UAMH 3912, NRRL 1714, ATCC 15598, 0-532) revealed that ascospores are ovoid, delicately roughened, 2-2.2 x 2.8-3.2um, compared to the ascospores of M. albolutea which are globose, delicately roughened (2.2)2.5-3um in diameter. Secondly, the gymnothecia of both are similar in size and shape but the elongate appendages of A. thaxteri are shorter, 300-400um in length, and mostly uncinate. Finally, the arthroconidial state, M. albolutea, is prominent in early

stages of growth, permitting recognition of this species, whereas the Malbranchea state of A. thaxteri is associated with the appearance of ascomatal initials in culture.

At present, the primary reason for not including the sexual state of M. albolutea in A. thaxteri is the difference in size and shape of the ascospores. Obviously, this difference in size is small and would normally be part of the range of variation for this species, but the shape of ascospores within a species should be uniform. Indeed, the ascospores of all isolates of M. albolutea are uniformly globose. The ascospores of Auxarthron species are not only globose or subglobose as suggested by Samson (1972) but also oblate and may be delicately roughened to spiny or echinulate-reticulate. For the present, the sexual state of M. albolutea has not been assigned to A. thaxteri nor has it been described as a new species, because the already named species of Auxarthron need reevaluation before additional ones are added.

Habitat and activities: Recovered from soil or dung, in the USA, from Utah, Colorado, California and Wyoming and in Hungary. Moderately keratinolytic, no penetrating bodies; not cellulolytic.

Material Examined
From soil: UAMH 1117, Oildale, Calif., (Orr 0-1024); UAMH 2632, soil?, Cache la Poudre River, Col., W.B. Cooke, 1965, from Barron, Ont. Agric. College as 10527; UAMH 2846, TYPE, Utah, G.F. Orr, 1967, (0-3508); UAMH 2848, fabric bait technique, Hungary, G.F. Orr, 1967, (0-3515); UAMH 2861, Utah, G.F. Orr, 1967, (0-3509); UAMH 3651, Wendover, Utah, (Orr PO-0062); UAMH 3911, grasslands, Laramie, Wy., M. Christensen (TC-22), (Orr 0-1030); From dung: UAMH 1846, rat, Mercur, Utah, (Orr 'Merc'; ?0-1089); Material of Auxarthron thaxteri: UAMH 3912, TYPE, dung of opossum shrew (Selenodon), Haiti, R. Thaxter, (Orr 0-532; NRRL 1714; ATCC 15598)

Malbranchea arcuata Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25-30 C moderatim vel lente crescunt, alutaceae, pulveraceae, rimosae, aliquando plicatae. Incrementum nullum vel paulum ad 37 C.
Arthroconidia cylindrica, frequenter curva, laevia, hyalina vel alutacea, (1.5)2-3 x 3-6um, in senectute aliquando amplificata, subglobosa vel irregularia.
Typus: UAMH 1861, ex solo, Utah, G.F. Orr, 0-1094 (DPG 105)

Colonies on PYE (Fig. 11J) are 13-30 mm diam. in 14 days) slightly raised with small central umbo, or smoother with few folds. The center is tan, powdery, dry and cracked and the margin downy, creamy white and flatter,

reverse yellow or yellowish tan. Colonies of some strains, growing more rapidly (45 mm in 14 days) are flatter, downy, creamy-white with pale tan center, reverse yellow, smooth or with few outward radiating folds. Growth at 37 C is variable. Of five strains tested, four (UAMH 1861, 2519, 2570 and 3910) failed to grow, but the other (UAMH 2983) showed scant growth. On cereal, colonies (Fig. 11K) are 23-40 mm diam. in 14 days, tan, reverse buff, flat, powdery, either slightly zonate, or patchy. Scant brown pigment diffuses into the medium on cereal and oatmeal.

Arthroconidia borne on narrow arcuate or curved lateral branches (Fig. 11L), are cylindrical, often curved, smooth, hyaline at first, later tan, (1.5)2-3 x 3-6um. Arthroconidia, formed by segmentation of the straight primary hyphae are hyaline, cylindrical, slightly broader, mostly 3um wide, and predominate in young cultures. In age, some arthroconidia become enlarged, subglobose or irregularly shaped (Fig. 11I). No other spore state was observed.

Discussion

The tan powdery colonies and arthroconidia borne on arcuate hyphae are characteristic of M. arcuata. Some variation in colonial morphology and growth rates is evident among strains included in this species. However, there appears to be little justification for removing any to separate species since the microscopic morphology is uniform.

M. arcuata is distinguished from other Malbranchea species having buff or tan colored colonies, such as the Malbranchea state of Uncinocarpus reesii and Malbranchea fulva, by its arcuate hyphae. M. aurantiaca and M. albolutea differ in having orange, and pale ivory-yellow colonies respectively.

Habitat and activities: Recorded from soil, dung of dog and birds, hair of rodents, USA and Yugoslavia (Hubalek, 1974a,b). Scarcely to moderately keratinolytic, no penetrating bodies; not cellulolytic.

Material Examined
From soil: UAMH 1861, TYPE, Dugway, Utah, G.F. Orr (DPG 105; 0-1094); UAMH 2519, Austin, Texas, C.J. Alexopoulas, 1965, (Orr as Alex(50); UAMH 3877, ?dog dung, C.J. Alexopoulas (50), (Orr 0-3263); ?UAMH 2570, plant debris, from Columbia, S. Am., A. Rostrepo, from Emmons, Dept. Health, Bethesda, Md., as B 27-40; From pellets of Merops apiaster in nest, Pesirevo, Yug., Z. Hubalek, 1968: UAMH 3844, as 232B; ?UAMH 3845, as 236A; From hair of small rodents, Yug., Z. Hubalek, 1968: UAMH 3847, as JU 1623 2;

UAMH 3902, Apodemos sp. (BH 14), (Orr 0-3411); From other sources: UAMH 3842, feathers of Corvus monedula, Furka, Yug., Z. Hubalek, 1968, as 153A; UAMH 2983, from R.S. Pore, W. Virginia Univ. Medical Center, Morgantown as 704; UAMH 3910, from Ellis, NRRL 6089.

Malbranchea aurantiaca Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25-30 C moderatim rapide crescunt, frequenter cum zonis spiralibus vel concentricis, centraliter atro-aureae, aurantiae vel aurantio-brunneae, in peripheria cremeae. Incrementum bonum ad 37 C, nullum ad 45 C.
Arthroconidia cylindrica, frequenter curva, laevia, initio hyalina, dein aurantia vel fulva, 1.5-2 x (2)3-5.5(6)um.
Arthroconidia ex hyphis principalibus crassiora, 3-4 x (2)3-7(7.5)um.
Status perfectus: probaliter Auxarthron, sed species incerta est. Ascosporae semel visae sunt.
Typus: UAMH 3599, ex aere laboratorii? (cultura contaminata), Utah, G.F. Orr, 0-1526

Colonies on PYE are 64-70 mm diam. in 21 days, spirally zonate (Fig. 12A), at center umbonate, dark yellow-gold or orange-brown, velvety or powdery; outer zones varying from dark gold or yellow-orange to creamy white and floccose at the periphery, reverse dark orange. The margin gradually extends in a spiral pattern around the colony, at first white with scant aerial growth eventually creamy white, floccose and dense. Sometimes the zonate pattern is not as distinct but the characteristic color remains. At 37 C growth on PYE (Fig. 12C) is almost as rapid (44-62 mm, rarely up to 72 mm in 21 days), flat with irregular folds, pale orange or tan, dark orange reverse, downy with droplets of yellow or brown exudate. No growth at 45 C; optimum range 25-30 C.

On cereal, colonies (Fig. 12B) are 53-62 mm diam. in 21 days, at first, domed, floccose and white; as sporulation commences, becoming flattened, dark yellow-gold, orange-brown or tan, powdery or granular, and sharply demarcated from a floccose, creamy white, raised peripheral ridge (Fig. 12B). Two gradations can occur around the center with an inner region, pale tan or creamy white and floccose, slightly raised above the flat center. The reverse is yellow and yellow pigment occasionally diffuses into the agar. At 37 C, the colony (Fig. 12D) is characteristically slower growing (42-56 mm in 21 days) flat, dark tan or brown, powdery or granular, dense or patchy, with orange surface growth forming a distinct orange glabrous margin, 5-8 mm wide, and light or dark orange reverse.

Arthroconidia borne on narrow arcuate or curved

lateral branches (Figs. 12E,12F) are cylindrical, often curved (Fig. 12H) hyaline, later orange or tan in mass, smooth, 1.5-2 x (2)3-5.5(6)um. Arthroconidia formed on the straight primary hyphae (Fig. 12G) are hyaline, broader, cylindrical, 3-4 x (2)3-7(7.5)um and predominate in young cultures. The development of racket hyphae is common in the primary hyphae with swelling at the septum up to 9um in diameter. Rarely, intercalary chlamydospores are seen.

a) Atypical strains (UAMH 1569, 1853, 1709, 2844)

Four strains differ in several characters from those summarized in the description above. All four are indistinguishable microscopically (Figs. 12I,12J) from M. aurantiaca and they are retained here until similar isolates are found which show the differences to be constant.

Two strains (UAMH 1569 and 1853) are identical to each other, and differ from typical strains in having paler yellow-orange colonies, and in lacking the distinct spiral zonate pattern. At 37 C growth is more restricted (22-33 mm on PYE and 7-14 mm on cereal in 21 days.

UAMH 2844 is similar to strains UAMH 1569 and 1853 in the color of its colonies. On PYE the colony is smooth, not zonate, domed with a central umbo; on cereal, it is almost flat with sparse aerial growth at periphery and denser, raised center. This strain differs from all others in growing more robustly and rapidly at 37 C (75 mm on PYE and 63 mm on cereal in 21 days).

Strain 1709 differs in having slower growing (46 mm on PYE and 42 mm on cereal after 21 days), dark orange, velvety or downy colonies. On cereal, the colony is zonate with a central umbo and on PYE it is flat with broad white margin and central orange umbo. There is no growth at 37 C after 21 days. The arthroconidia are slighter broader, 2-3um in diameter. Late in the study we received another isolate (UAMH 3878) which greatly resembled UAMH 1709. These two strains may eventually require transfer to a separate species, but it seems preferable to retain them here until a larger number of isolates has been studied.

Discussion

The orange colonies of M. aurantiaca resemble those of the M. state of Auxarthron conjugatum. However, A. conjugatum is homothallic and regularly forms the sexual state in culture. Furthermore, the M. state of A. conjugatum lacks the spiral zonate pattern on PYE, and growth at 37 C is much more restricted. M. chrysosporoidea also forms orange colonies but lacks arcuate fertile hyphae. The color of the colony distinguishes M.

aurantiaca from M. arcuata and M. albolutea.

Habitat and activities: Isolated from soil or dung, India, Central America, Australia, USA and Belgium. Moderately or markedly keratinolytic, not cellulolytic.

Mating tests: Crosses were performed in duplicate by preparing mixed conidial suspensions (method A) and by parallel inoculation of separate conidial suspensions (method B) (see Materials and Methods), with the addition of autoclaved human hair.

With a single exception, no gymnothecia were seen in any cross after 42 days (Table II). In the mixed conidial suspension of UAMH 1707 x 3705, a single gymnothecium of the 'Auxarthron' type (Orr, 1963a) bearing elongate uncinate appendages and few spiny oblate ascospores was seen. After a further two weeks growth no other gymnothecia were found nor were any discovered on the parallel streak plate. Incompatibility between strains was frequently indicated by a narrow or wide zone of inhibition between strains inoculated in parallel (Fig. 12K, Table II).

Failure to obtain the sexual state in this species was surprising considering the close resemblance to some species of Auxarthron, especially A. conjugatum. Indeed, several single ascospore isolates were attempted from a number of strains of A. conjugatum in the belief that M. aurantiaca might be the asexual state of this species. However, all single ascospore isolates proved to be homothallic (see Auxarthron conjugatum).

The occurrence of a single fertile gymnothecium suggests either latent homothallism in one of the two strains tested or heterothallic incompatibility of the type frequently observed in some Gymnoascaceae. Incompatibility results in infertile crosses between F1 progeny and parent strains and between wild-type isolates crossed with each other or with tester strains of the opposite mating type. In the latter case, wild type isolates may only cross with the more fertile progeny of the parent strains (Kwon-Chung, 1971, 1972; Padhye and Carmichael, 1971, 1973).

Figure 12. Malbranchea aurantiaca (A,B-UAMH 3704; C,D,H-1707; E,G-3599; F-3705; I,J-2844; K-1707x3599). Figs. 12A-12D. Colonial morphology after 21 days. A and C on PYE, B and D on cereal; C,D at 37 C, others at 25 C. Figs. 12E-12J. Alternate arthroconidia of curved branches and straight primary hyphae. Fig. 12K. Zone of inhibition in cross of 1707x3599 inoculated in separate parallel streaks. Colonies x 0.7, others x 600.

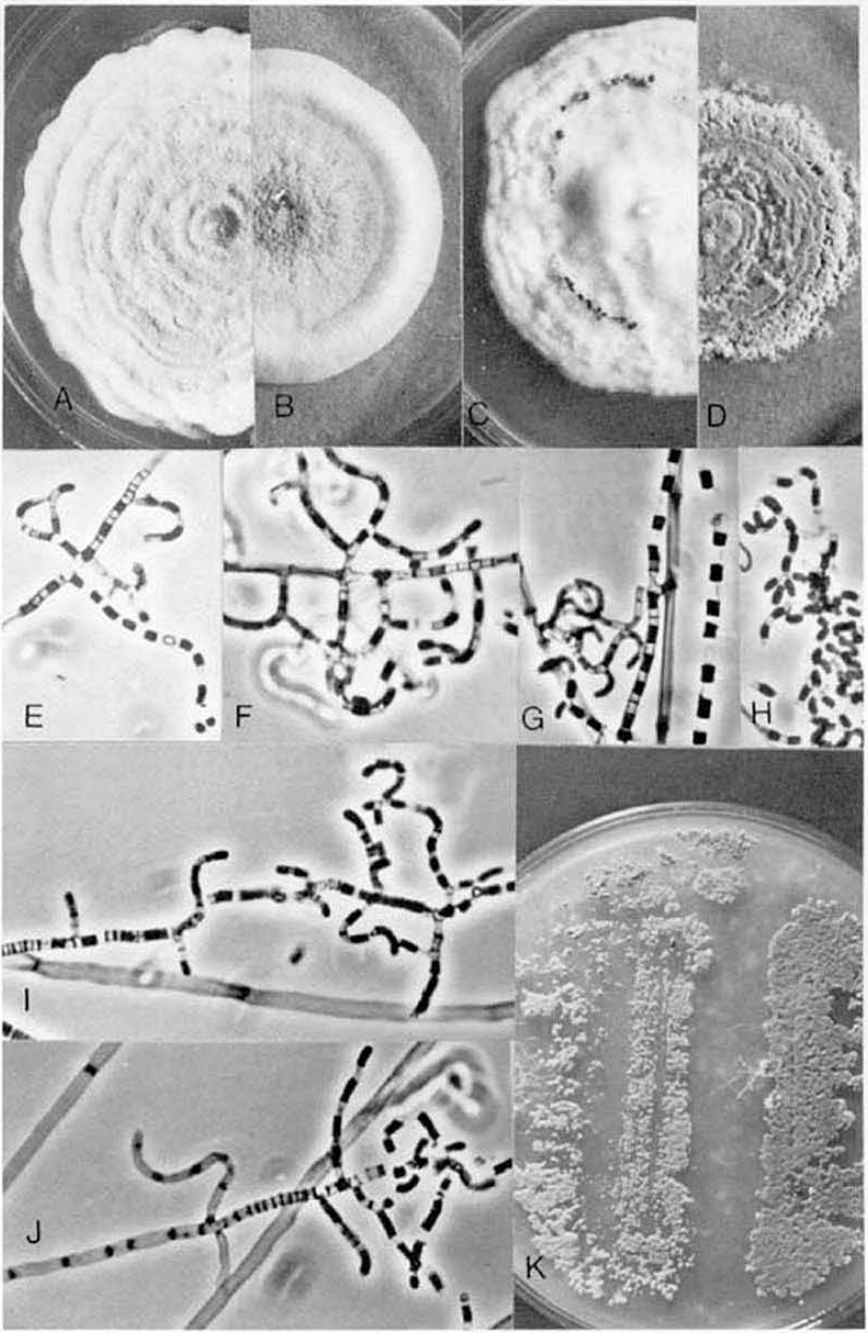

A
B
C
D
E
F
G
H
I
J
K

TABLE II
INCOMPATIBILITY AMONG CROSSES OF MALBRANCHEA AURANTIACA

STRAIN	1707	1709	1778	1853	2844	3524	3599	3660	3704	3705
1569	I	I	-	NI	-	-	NI	NI	-	-
1707		I	-	I	-	NI	I	NI	-	+
1709			NI	-	-	-	NI	I	-	-
1778				-	-	-	-	-	-	-
1853					-	-	NI	-	-	NI
2844						S	-	-	-	-
3524							NI	-	S	NI
3599								I	S	NI
3660									I	NI
3704										NI

Legend:
- \- No gymnothecia formed on duplicate crosses
- \+ Single fertile gymnothecium formed on mixed suspension plate
- NI Narrow zone of inhibition (<3 mm) and no gymnothecia
- I Moderate zone of inhibition (>3 mm) and no gymnothecia
- S Zone of stimulation at interface of mating strains

Material Examined
From soil: UAMH 1569, chicken feeding ground, Tonasi, Panama, coll. H.P. Puri, isol. G.P. Orr (0-2505); UAMH 1705, garden, Tonasi, Panama, G.F. Orr (0-2535); UAMH 1707, chicken feeding ground, Tonasi, Panama, G.F. Orr (0-2531); UAMH 1709, Calif., G.P. Orr (0-584); UAMH 1710, pig yard, Tonasi, Panama, G.F. Orr (0-2534); UAMH 1778, from mixed culture rec. as 288c (soil, Guatemala) from Orr; UAMH 1853, Aust., Warcup, (Orr 0-3598; A 270 1); UAMH 2844, Belgium, C. De Vroey, 1966, (Orr 0-3178); UAMH 3660, Ellice Island, Alaska, (Orr 0-3035); UAMH 3818, Italy, E. Varsavsky (I36) from Orr (0-3437); UAMH 3878, Inogmar area, Calif., (Orr 0-683); 0-3482, Somalia, C. DeVroey (RV 20443) from Orr; 0-2592, Panama, from Orr; From dung: UAMH 3483, mouse, India, (Orr 0-3150); UAMH 3524, rat, India, (Orr 0-3733; NRRL A-19283); UAMH 3704, rat, India, (Orr 0-1163); UAMH 3053, lizard, Chihauhua, Mexico, R.K. Benjamin, 1964, RSABG, as 1468; From other sources: UAMH 3599, TYPE, air? (plate contaminant), Dugway, Utah, G.F. Orr (0-1526); UAMH 3705, plate contaminant, Dugway, Utah, G.F. Orr (0-3214); UAMH 3879, hair from ringworm lesion on horse, Riverton, Utah, (Orr 0-3710)

Malbranchea chrysosporoidea Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25 C rapide crescunt, tangerinae, densae, pulveraceae vel velutinae, cum zonis concentricis. Incrementum restrictum ad 37 C.
Aleurioconidia copiosa, truncata in basibus, paula crassiora quam hyphae, 2-3 x (2.5)3-3.5(6.5)um.
Arthroconidia cylindrico-truncata, hyalina, laevia denique aurantia, (1.5)2-4 x (2)3-9(13)um.
Typus: UAMH 1032, ex solo, Arizona, C.W. Emmons, E5003

Colonies on PYE (Fig. 13A) are 66-83 mm diam. in 21 days, characteristically bright tangerine orange, center and periphery often white or pale yellow, reverse orange. The surface is dense, powdery or velvety, with a downy or floccose central umbo, slightly raised, scarcely zonate, showing color changes from dark orange center to light periphery, or distinctly zonate with 6 or 7 concentric zones, and thin, floccose, white or pale orange margin. No pigment is apparent but most strains formed yellow, orange or white exudate droplets. At 37 C, growth on PYE is more restricted (Fig. 13C) (25-31 mm diam. in 21 days) adhering poorly to the cellophane, center lifting up, becoming convoluted or folded, dark tan, brown, or tawny, powdery, and new surface growth downy, orange. Colonies remaining firmly attached to the cellophane are orange-buff, 44 mm in diam.

Colonies on cereal (Fig. 13B) are 61-68 mm diam. in 21 days, flat, ± small central umbo, powdery or granular, patchy or dense, often sectoring, scarcely zonate, dark

orange center, tawny to yellow at periphery, reverse orange. At 37 C, growth is slower (18-36 mm diam. in 21 days), orange or buff, rarely white, granular or downy, flat, with a brown diffusing pigment (Fig. 13D).

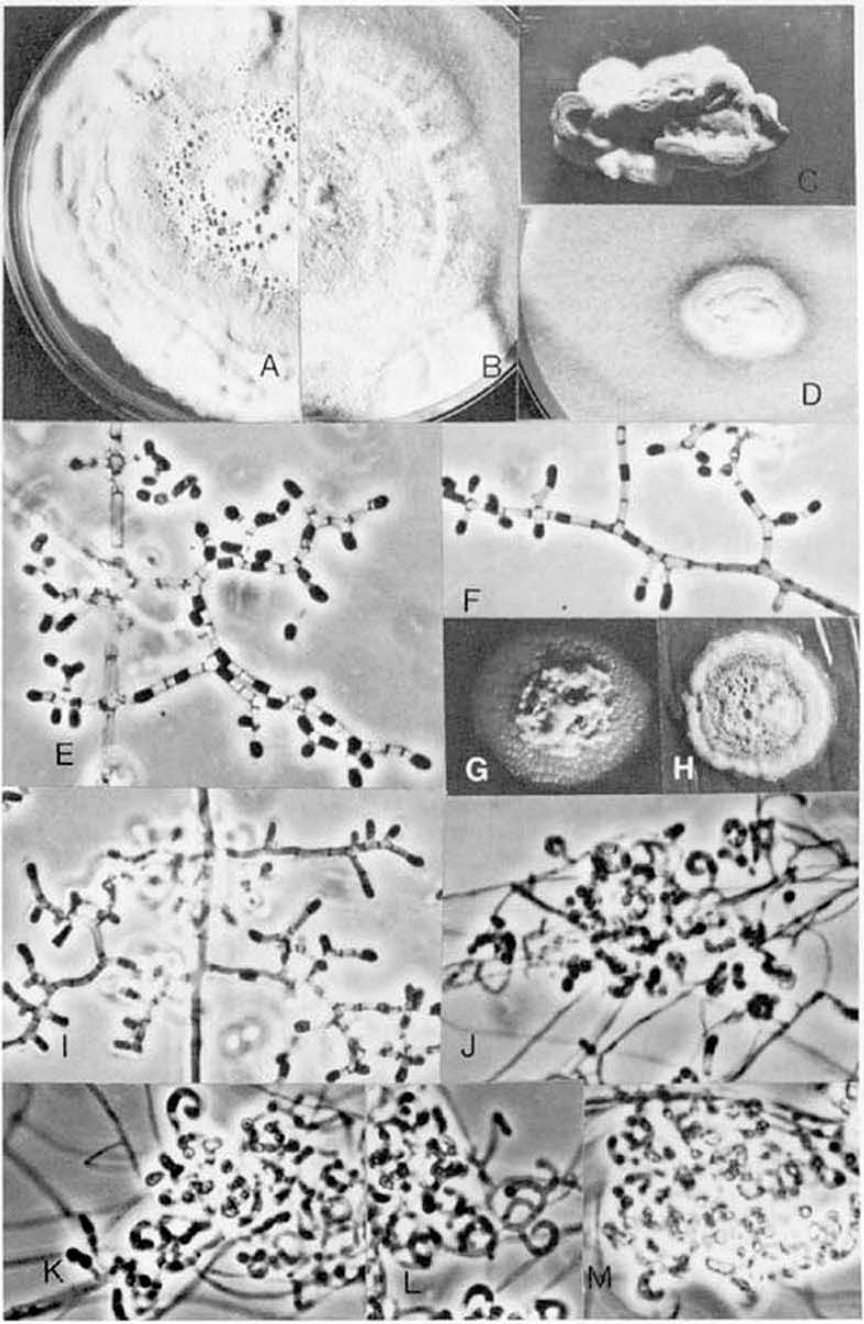
Fertile hyphae bearing arthroconidia are of two types. Straight, slightly broader, branched primary hyphae, 2-4um wide, develop intercalary arthroconidia (Figs. 13E,13F), and later form multiple straight or curved, deflected lateral branches. The fertile branches (Fig 13E,13I) bear intercalary arthroconidia which intergrade with aleurioconidia formed terminally or directly on the sides of the hypha. The width of the arthroconidia and aleurioconidia forming on a hypha is identical with that of the hypha. Intercalary arthroconidia are cylindrical-truncate, hyaline, later pale orange, orange in mass, (1.5)2-4 x (2)3-9(13)um. Aleurioconidia are smooth, hyaline, later pale orange, orange in mass, cuneiform 2-3 x (2.5)3-5.5(6.5)um. No other spore state was observed.

Discussion

This species is intermediate between Malbranchea and Chrysosporium. Though formation of aleurioconidia is characteristic of Chrysosporium, arthroconidia may predominate in degenerate strains. The aleurioconidia of Chrysosporium are mostly subglobose, pyriform or clavate, and wider than the diameter of the supporting hypha. Though this distinction appears somewhat arbitrary, it is difficult to assign this species with assurance to either Malbranchea or Chrysosporium. Several characters favor its placement in Malbranchea: the width of the aleurioconidia and intercalary arthroconidia does not exceed that of the supporting hypha; intercalary arthroconidia predominate in the primary hyphae, consistent with other species of Malbranchea; the diameter of the fertile hyphae fits well within the rather narrow range for Malbranchea. Interestingly, vivid orange colonies occur in at least three other species of Malbranchea, whereas most Chrysosporium colonies are white or light colored, green,

---

Figure 13. A-F, I. Malbranchea chrysosporoidea (A-D-UAMH 1032; E,F,I-1031). G,H,J-M. Malbranchea circinata (G-H,J,M-1890; K,L-3589). Figs. 13A-13D. Colonial morphology after 21 days. A and C on PYE, B and D on cereal. C and D at 37 C, others at 25 C. Figs. 13E-13F. Aleurioconidia and intercalary arthroconidia. Figs. 13G-13H. Colonial morphology after 21 days at 25 C. G on PYE, H on cereal. Fig. 13I. Lateral or terminal aleurioconidia and intercalary arthroconidia. Figs. 13J-13M. Coiled conidiogenous hyphae. Colonies x 0.65, others x 600.


A
B
C
D
E
F
G
H
I
J
K
L
M

brown, grey, buff, occasionally pale orange or orange-buff.

Habitat and activities: Recorded from soil, dung or air samples, Maryland, Utah, Hawaii, Arizona, South Carolina, California (Orr, 1970, 1972), Japan and India. One strain was recovered from omental abscesses and the spleen after experimental intra-peritoneal inoculation of soil into mice. Slight or no digestion of keratin, not cellulolytic.

Material Examined
From soil: UAMH 1031, Ariz., C.W. Emmons (E5002), (Orr 0-1524; same strain as UAMH 2786?); UAMH 2786, omental abscesses in mice inoculated with soil, Bethesda, Md., C.W. Emmons (E5002), 1958, from Kwon-Chung, N.I.H., Bethesda; UAMH 1032, TYPE, Ariz., C.W. Emmons (E5003), from Orr (0-1525); UAMH 2288, bean garden, Shokuku, Japan, G.F. Orr; UAMH 2740, India, from H.C. Gugnani, National Institute of Communicable Disease, New Delhi, as S536; UAMH 3570, S. Carolina, from Orr (0-3517); UAMH 3876, Oahu, Hawaii, E. Varsavsky (9), from Orr (0-3295); Soil isolates from Orr: 0-3224, Maui, Hawaii, E. Varsavsky (7); 0-3377, Calif.? E. Varsavsky (20); 0-3381, Kauai, Hawaii, E. Varsavsky (18); 0-3398, Oahu, Hawaii, E. Varsavsky (21); 0-3399, Maui, Hawaii, E. Varsavsky (25); From other sources: UAMH 1060, coyote dung, Kern Co., Calif., G.F. Orr (0-837; NRRL A-10663); UAMH 1241, plate contaminant, Edmonton, 1962; UAMH 2051, Hawaiian Islands, soil?, from Varsavsky, CDC, as KAVAI-18; UAMH 2850, wind tunnel contaminant, Utah, G.F. Orr, 1967, (9BR5); UAMH 3856, spore mass, Dugway, Utah, from Orr (0-3077); NRRL 6087, from Ellis

Malbranchea circinata Sigler & Carmichael sp. nov.
Perfect State: Myxotrichum Kunze

Coloniae in agaro ad 25 C lente crescunt, cremeae vel aurantiae, floccosae vel velutinae, ad marginem mucosae. Incrementum minus ad 18 C vel 30 C, nullum ad 37 C. Arthroconidia cylindrica, curva, laevia, initio hyalina, dein flava, flavo-brunnea, chlorina vel purpurea, 2-3 x 3-5um.
Status perfectus: Myxotrichum, sed species incerta est. Ascosporae non visae sunt.
Typus: UAMH 1890, ex solo, Dugway, Utah, G.F. Orr, 0-1103 (DPG 111)

Colonies on PYE (Fig. 13G) are 29 mm diam. in 21 days, pale creamy yellow, reverse yellow, floccose tufts of hyphae at center, and wide (4-8 mm) margin of slimy tufted surface growth. On cereal, colonies (Fig. 13H) (diam. as on PYE) are more luxuriant, dense, velvety, smooth with a narrow slimy margin, dark gold, reverse yellow. Brown exudate droplets on surface dry and leave surface pitted; reddish brown pigment diffuses into the medium. No growth

at 37 C; optimum 25 C.

The conidiogenous hyphae (Figs. 13J-12L), arising as lateral branches wider than the narrow vegetative hypha, are tightly coiled or curved, closely spaced, eventually forming a dense cluster (Fig. 13M). Arthroconidia are smooth, cylindrical, curved, kidney-shaped or ovate, almost discoid in end view, pale yellow, or yellowish-brown, in age purple or dark yellow-green, 2-3 x 3-5um. No arthroconidia develop on the primary hyphae.

Gymnothecia (Fig. 14A) are dark brown, almost black, discrete, 350-450um in diameter, excluding appendages, spherical but tending to coalesce, not easily dislodged from the conidiogenous hyphae. Peridial hyphae are dark brown, thick-walled, smooth, continuously branched, terminating in 'antler-like' appendages (Figs. 14A,14C-14E) with narrow delicate branchlets (Figs. 14C,14D), pointed toward the perimeter. Appendages of a second type are uncinate (Figs. 14A,14C), sparingly septate, thick, smooth walled, 100-200um long, 5-7um wide at the tip and the same diameter or slightly narrower at the base. The uncinate appendages arise at the center or near the periphery from a bifurcate base with the other branch terminating in the 'antler-like' appendage (Fig. 14C). No ascospores were found. When the gymnothecium is crushed, yellow-green or purple, coiled conidiogenous hyphae in the centrum give the impression of asci, and the mature kidney-shaped or ovate conidia can be mistaken initially for ascospores.

Discussion

The formation of gymnothecia corresponded to sectoring of the colonies on oatmeal agar at 25 C (Fig. 14B). Indeed, gymnothecia consistently formed along the interface of the sector, which was white with sparse aerial growth and glabrous margin, compared to the remainder of the colony which was yellowish-brown, powdery and dense with abundant conidial formation. Transfers from the sector to fresh oatmeal agar produced a degenerate colony with scant aerial growth, pale color, and scant sporulation. Transfers from the powdery yellow-brown portion yielded similar, profusely sporulating colonies which eventually sectored. A transfer of a single gymnothecium yielded again a sectoring colony developing gymnothecia along the interface. Formation of gymnothecia in sectors has also been recorded for atypical colonies of M. stipitatum (Orr et al., 1963b). Attempts to stimulate ascospore production by mating were unsuccessful, only two isolates being available. Gymnothecia occurred only when colonies were grown on a cellophane membrane, not on oatmeal agar alone.

In the absence of ascospores, it is difficult to relate this species to any described Myxotrichum species.

Although our cultures of M. carminoparum Robak (Orr et al., 1963b) (UAMH 1597 and 1906) also have failed to produce ascospores, this species differs in its conidial state, which lacks the coiled conidiogenous hyphae of M. circinata and in its colonial morphology. At 25 C, the colony of the type strain (UAMH 1597, CBS 224.31) is sparse and restricted and the observation of Orr et al. (1963b) of growth at 7 C ± 2 C suggests a lower optimum temperature for growth. The peridial hyphae of M. chartarum, 'witches-broom-like' (Orr et al., 1963b) are somewhat similar but the terminal branchlets are more spiny and less delicate. Although M. chartarum has an arthroconidial asexual state, the conidiogenous hyphae are not coiled.

Habitat and activities: Recorded only from soil, Utah (Orr and Kuehn, 1972). Cellulolytic, not keratinolytic. Hairs on DSA become purple in color after three weeks from the diffused pigment.

Material examined: UAMH 1890, TYPE, soil, Dugway, Utah, G.F. Orr (0-1103; DPG 111); UAMH 3589, soil, Terra, Utah, from Orr (0-3225; DPG 118)

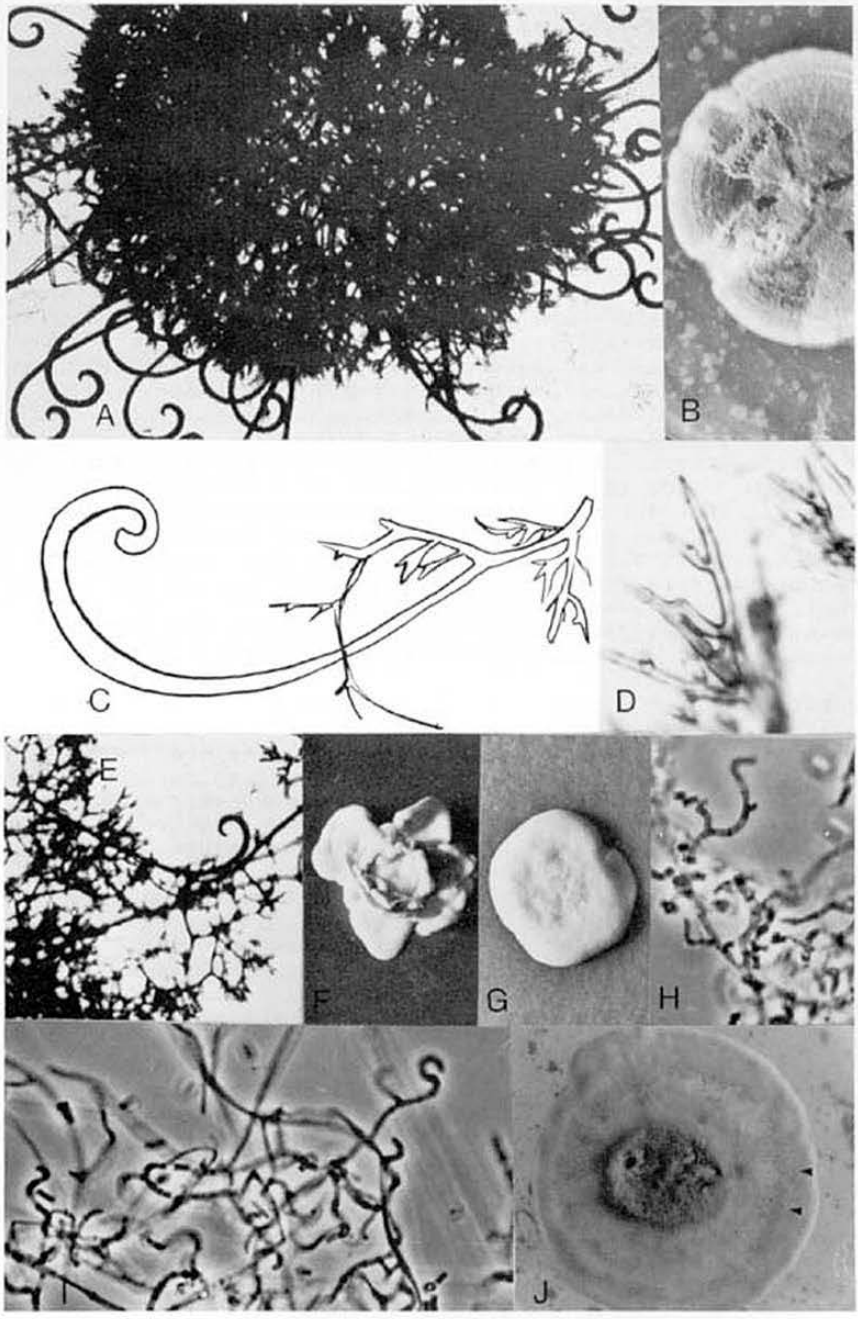
Malbranchea flavorosea Sigler & Carmichael sp. nov.
Perfect state: Myxotrichum Kunze

Coloniae in agaro ad 25-30 C moderatim lente crescunt, cremeae, in centro fulvae vel roseo-fulvae, floccosae vel velutinae. Incrementum nullum ad 37 C.
Arthroconidia cylindrica, frequenter curva, laevia, hyalina, 1.5-2 x 3-5um, in senectute inflata, subglobosa.
Status perfectus: Myxotrichum, sed species incerta est.
Ascosporae non visae sunt.
Typus: UAMH 1051, ex solo, Riverside County, California, G.F. Orr, 0-643

Colonies on PYE are 29-32 mm diam. in 21 days, adhering poorly to the cellophane, lifting up at the margin

---

Figure 14. A-E. Malbranchea circinata (A-UAMH 3589; B-E-1890). F-J. Malbranchea flavorosea (F-H-1051; I,J-1065). Fig. 14A. Gymnothecium bearing uncinate appendages, x 150 BF. Fig. 14B. Sectoring on oatmeal agar after 35 days at 30 C, x 0.7. Fig. 13 C. 'Antler-like' and uncinate appendages, x 480. Fig. 14D. 'Antler-like' appendages, x 960 BF. Fig. 14E. Coalescing peridial hyphal appendages of both types, x 150 BF. Figs. 14F-14G. Colonial morphology after 21 days at 25 C, x 0.65. F on PYE, G on cereal. Figs. 14H-14I. Curved fertile hyphae bearing alternate arthroconidia, x 600. Fig. 14J. Gymnothecia (minute black specks) formed at the center and near the periphery after 42 days at 25 C on oatmeal agar, x 0.65.


A
B
C
D
E
F
G
H
I
J

and curling toward the center to form a distinct petaloid pattern (Fig. 14F). New growth extends unevenly below margin. The surface is creamy white, buff in center, reverse dark tan in center, yellow at the periphery, velvety. On cereal, colonies (Fig. 14G) (diam. as on PYE) are flatter, pinkish-buff, floccose, with diffusing dark brown pigment. No growth at 37 C; optimum range 25-30 C.

On oatmeal agar, colonies (Fig. 14J) (optimum 25 C) become deep rose pink in center with paler margin, floccose, crateriform. Gymnothecia form most abundantly at 18 C, developing at the center and close to the periphery (Fig. 14J).

Arthroconidia developing on short, loosely curved or arcuate lateral branches (Figs. 14H,14I) are cylindrical, often curved, hyaline, smooth, 1.5-2 x 3-5um. In age, arthroconidia become swollen, rounded or subglobose.

Gymnothecia are spherical, approximately 400-600um, discrete, black (Fig. 15A), composed of a network of smooth, thick-walled, septate, dark-brown peridial hyphae, 5-6um wide, having blunt tips and lateral bluntly pointed spines along the length reflexed at an acute angle toward the center (Fig. 15B). The blunt tipped ends of the peridial appendages extend 120-200um beyond the densely branched center (Fig. 15A). No other appendages are formed. Asci and ascospores were not observed.

Discussion

Neither of the two strains studied developed ascospores even after prolonged growth and multiple transfers. Attempts to cross the two isolates were unsuccessful. A third strain (UAMH 3909, NRRL 6088) received late in the study also failed to develop ascospores. No isolation data was provided with this strain. Since it was deposited by G.F. Orr in NRRL, it could be the same strain as either UAMH 1051 or 1065.

The sexual state of this species is assigned to Myxotrichum primarily on the morphology of its dark brown peridial hyphae. In the absence of ascospores, a specific epithet has not been chosen, nor can the isolates be assigned with certainty to any known species. Although superficially resembling Myxotrichum deflexum Berkeley (Ann. Nat. Hist. 1:260, 1838), this species differs in several respects. First, the gymnothecia are much larger, 400-600um, compared to 100-400um for M. deflexum (Orr et al., 1963b; Apinis, 1964); the appendages of M. deflexum are narrow, 1.4-1.8um (Orr et al., 1963b) or up to 3um (Apinis, 1964), with lateral branches, deflected either upward or downward, having hyaline blunt apices, whereas those of this species are wider, 5-6um in diameter, with

lateral bluntly pointed spines, brown, branched consistently downwards (Fig. 15B); finally, a conidial state has not been observed for M. deflexum (Orr et al., 1963b; Apinis, 1964).

Other characters of this species are also common to Myxotrichum. Orr et al. (1963b) reported cessation of growth at 37 C for all Myxotrichum species, characteristic reddish-brown diffusing pigments, and pink or reddish colonies in species such as M. aeruginosum, M. deflexum and M. stipitatum. In addition, this species is cellulolytic, as are other species of Myxotrichum.

Material examined: UAMH 1051, TYPE, soil, Riverside Co., Calif., G.F. Orr (0-643); UAMH 1065, lung, kangaroo rat, Palo Verde, Calif., from Orr (0-647); UAMH 3909 (NRRL 6088)

Malbranchea pulchella Saccardo & Penzig 1882
Michelia 2:638

Synonyms
= Malbranchea bolognesii-chiurcoi Vuillemin, Pollacci & Nannizzi 1925, in Bolognesi & Chiurco, Archivi di Biologia 1:255-276
= Actinomyces bolognesii-chiurcoi (Vuill. et al.) Dodge 1935, Medical Mycology p. 766
= Malbranchea kambayashii Kambayashi 1934, Archiv fur Dermatologie u. Syphilis 170:97-106

History

Saccardo (1882) described Malbranchea with a single species M. pulchella Sacc. & Penz., reiterating his description in 1886. Saccardo (1908) and Saccardo and Trotter (1913) reduced Miehe's (1907) thermophilic Thermoideum sulfureum to synonymy with M. pulchella.

Two other species were described, M. bolognesii-chiurcoi Vuill., Poll. & Nann. in Bolognesi and Chiurco (1925) and M. kambayashii Kamb. (1934). Baldacci, Ciferri and Vaccari (1939) reviewed both and reduced them to synonymy with M. pulchella after comparing the cultural and microscopic characteristics of four isolates: M. pulchella from Buisman, M. bolognesii-chiurcoi from Bolognesi and Chiurco (1925) and Rivelloni (1938), and M. kambayashii from Kambayashi (1934). With the exception of the Rivelloni strain which showed scant growth, all failed to grow at 37 C. Furthermore, the authors could find no reason to justify Dodge's (1935) transfer of M. bolognesii-chiurcoi to Actinomyces.

Elisei (1940a), in a similar examination of Malbranchea, reviewed the literature and studied the same four isolates. He revised the genus, concurring with

Saccardo (1908) in placing T. sulfureum in synonymy with M. pulchella. Elisei also observed a number of microscopic features not previously recorded, including nodular organs, spiral hyphae, and pectinate bodies. These were later reviewed (Elisei, 1940b) in comparison to some dermatophytes.

Few reports of other Malbranchea species are cited in the literature. In 1913, Sumstine transferred Rhinotrichum pulveraceum Ellis to Malbranchea as M. pulveracea. Linder (1942) disagreed and proposed the combination Oidium pulveraceum because the conidia were borne in chains on short denticles. Clamp connections on the hyphae indicate that this species is a conidial state of a Basidiomycete genus.

Cooney and Emerson (1964), studying a thermophilic isolate of Malbranchea, proposed a new variety M. pulchella var sulfurea. However a number of characters differentiate the mesophilic M. pulchella from the thermophilic isolates, suggesting that the latter should be distinguished as a separate species.

More recently, Wang (1965) again described and illustrated a mesophilic Malbranchea pulchella isolate from a pulp sample. Von Arx (1970) stated that Malbranchea included 3 or 4 species, but named only M. pulchella.

Description

Colonies on PYE (Fig. 15C) are 26-33 mm diam. in 21 days, either flat, margin entire, or convoluted, lifting at the center or at the margin with new growth below, lobate and undulate. Colonies are tan or pale brown, occasionally white, reverse tan or yellow, downy or velvety, occasionally with white exudate droplets. On cereal, colonies (Fig. 15D) (diam. as on PYE) are downy or velvety, tan, buff or white, reverse pale or dark tan or yellow, and adhere more firmly to the cellophane, remaining flat with central umbo and few outward radiating folds, or dome-shaped. Droplets of white or brown exudate sometimes form on the surface, and a brown pigment diffuses into the agar. Good growth occurs at 30 C; no growth at 37 C.

Fertile hyphae, arising as short lateral branches from the narrow (1-2um wide) vegetative hyphae, form multiple branches which are tightly coiled, arched, or curved (Figs. 15E-15H). Arthroconidia are cylindrical, curved, hyaline, in mass tan, smooth 1.5-3 x 2-6.5um, mostly 1.5-2.5 x 2.5-5um. Accessory arthroconidia are rarely formed by segmentation of the primary hyphae.

Typical strain: from pulp sample at paper towel mill, N. Y. State, 1959, C.J.K. Wang, UAMH 1560

Discussion

Considerable variation was initially evident among isolates received as M. pulchella. A comparison of Saccardo's description with photomicrographs from a slide (ex DAOM 41374) of the type, indicated to us that some of these isolates should be excluded (see Malbranchea flocciformis and M. flavorosea). Arthroconidia of DAOM 41374 measure 1.5 x 2-4um. Of the remaining isolates, UAMH 3794 (strain Kambayashi) differs from the others in forming larger arthroconidia (2.5-3 x 4.5-6um) and wider primary hyphae (3um) which fragment to form accessory arthroconidia. However, this strain resembles the others in colonial morphology and inability to grow at 37 C.

UAMH 3783 (strain Rivelloni) failed to grow at 37 C although Baldacci et al. (1939) reported slight growth. Also the size of the arthroconidia, 2.5-3 x 3.5-6.5um differs slightly from the measurements given by them (3-4 x 6.5-7.5um), but variations could be expected in view of the prolonged maintenance of this isolate. Indeed, Cooney and Emerson (1964) reported no sporulation at all. In UAMH 3907 (strain M. bolognesii-chiurcoi), production of arcuate fertile hyphae was weak. However, this strain was initially contaminated with bacteria and failed to sporulate. When it was freed from contamination, it sporulated after prolonged growth on cereal agar. However, the culture appears to be somewhat degenerate. Baldacci et al. (1939) reported arcuate hyphae in the type strain of M. bolognesii-chiurcoi. None of these three strains corresponds exactly with the typical strain. However, all three more closely resemble M. pulchella than any other species described herein.

In general, the following characters distinguish M. pulchella from other species: buff or tan slow growing colonies, no growth at 37 C, lack of accessory arthroconidia and presence of cellulolytic activity.

Habitat and activities: Reported from cardboard (Saccardo, 1882), France; pulp (Wang, 1965), USA; wallpaper; human sources in Italy, China, Sardinia (Baldacci et al., 1939; Cooney and Emerson, 1964); nests and feathers of birds, Czechoslovakia and Yugoslavia (Hubalek, Balat, Touskova and Vik, 1973; Hubalek, 1974a,b). Slightly cellulolytic. A single strain (UAMH 3189) also digested keratin slightly with single hyphae penetrating the hair.

Pathogenicity: Cooney and Emerson (1964) noted that experimental inoculation by Vuillemin, Pollacci and Nannizzi into white rats, and by Kambayashi into guinea pigs, reaffirmed the pathogenicity of their isolates from human sources. However, similar experiments by Rivelloni were unsuccessful in demonstrating pathogenicity.

Material Examined
UAMH 643 & 1191, photomicrographs of slide (ex DAOM 41374) of TYPE, wet cardboard, Rouen, Fr.; UAMH 1560, from pulp sample at a paper towel mill, N.Y. State, 1959, C.J.K. Wang, State Univ. of N.Y., Syracuse; UAMH 3189, card, Gravesend, England, P. Russell (BS421), 1954, (CMI 57206); UAMH 3783, CBS 204.38, from Ciferri as 'ceppo Rivelloni'; UAMH 3794, CBS 203.38, from Ciferri as M. kambayashii, 1938; UAMH 3909, CBS 202.38, from Ciferri as M. bolognesii-chiurcoi, 1938

Malbranchea state of Auxarthron conjugatum
(Kuehn) Orr & Kuehn in Orr, Kuehn & Plunkett 1963a, Can. J. Bot. 41:1452

History

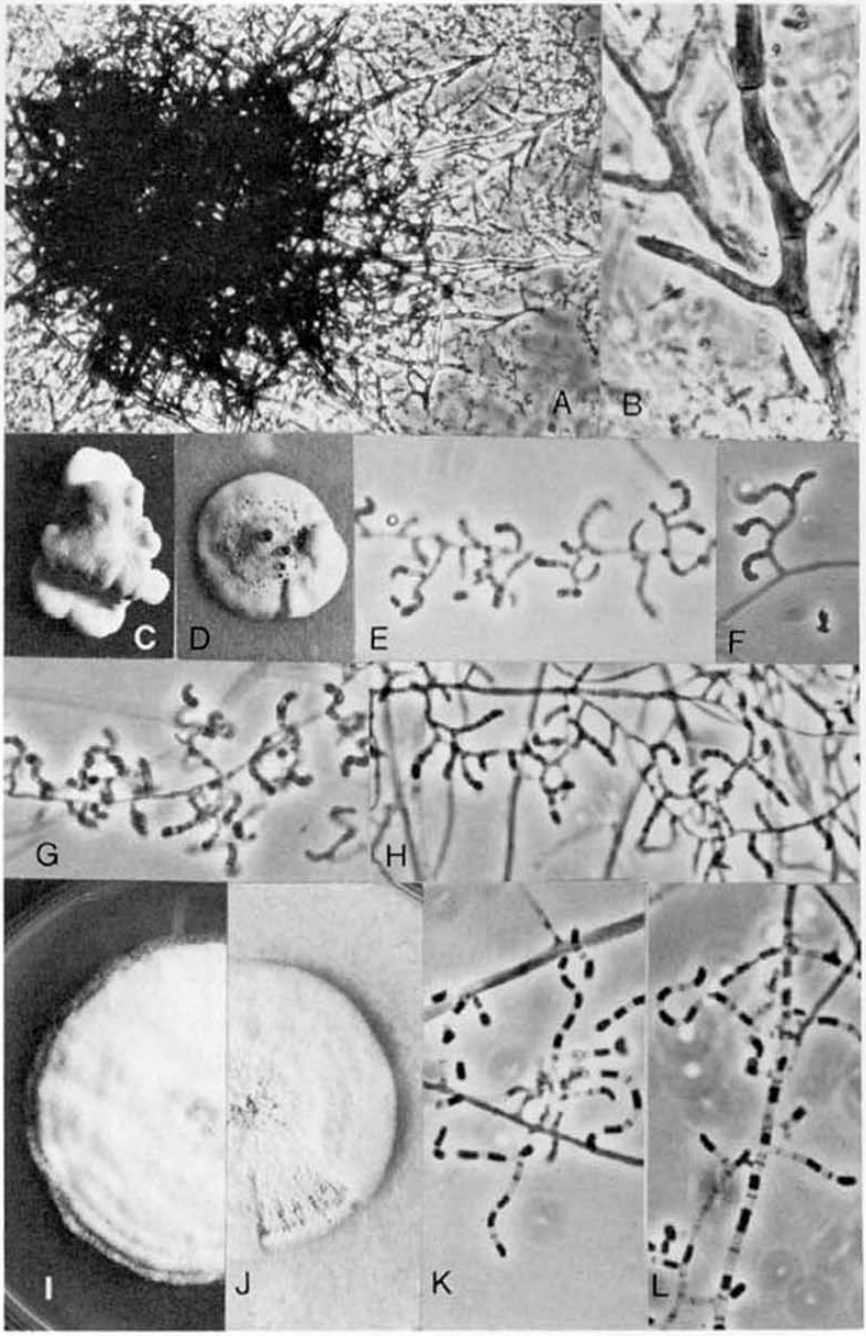
Orr et al. (1963a) transferred Myxotrichum conjugatum Kuehn (1955b) to Auxarthron. De Vroey (1970) referred to an undescribed species of Auxarthron isolated from soil in Burundi and his fig. 39 indicates a resemblance to A. conjugatum.

Description

Colonies on PYE (Fig. 15I) are 46-59 mm diam. in 21 days, pale yellow-orange or orange-buff, reverse dark orange, dry, powdery, cracked or powdery near the center with downy, creamy white overgrowth and periphery. If mostly powdery, the colony is flat with central downy umbo, otherwise zonate with 7-8 outer zones including the margin. On cereal, colonies (Fig. 15J) are orange-buff, flat, powdery or with downy creamy white to pale orange pleomorphic overgowth, reverse light to dark orange. Gymnothecia form near the center of the colony. Growth at 37 C is slow (7-9 mm at 14 days); colonies are pale orange, heaped up, downy, or velvety, reverse tan or orange.

Arthroconidia borne on narrow, lateral, arcuate

Figure 15. A-B. Malbranchea flavorosea (UAMH 1051). C-H. Malbranchea pulchella (C,D,F,G,-1560; E,H-3189). I-L. Malbranchea state of Auxarthron conjugatum (I,J-3817; K,L-3156). Fig. 15A. Gymnothecium composed of dark brown peridial hyphae. Fig. 15B. Peridial hypha with deflected lateral spines. Fig. 15C-15D. Colonial morphology after 21 days at 25 C. C on PYE, D on cereal. Fig. 15E-15H. Coiled or curved conidiogenous hyphae. Fig. 15I-15J. Colonial morphology after 21 days at 25 C. I on PYE, J on cereal. Fig. 15K-15L. Alternate arthroconidia of curved branched and straight primary hyphae. Colonies x 0.7, others x 600, except A, x 150.


A
B
C
D
E
F
G
H
I
J
K
L

branches (Figs. 15K,15L) are cylindrical, curved or straight, smooth, hyaline, in age pale orange, 1.5-2 x 2.5-5um. Arthroconidia formed by segmentation of the broader, straight hyphae (Fig. 15L) are 3 x 3-5um in diameter, often becoming swollen, rounded or subglobose in age (Fig. 16A).

This species is homothallic, and the sexual state has been described in detail by Orr and Kuehn (in Orr et al., 1963a).

Discussion

In early stages of growth, the Malbranchea state of Auxarthron conjugatum closely resembles M. aurantiaca. Both have orange colonies, arcuate fertile hyphae and arthroconidia of a similar size range. Indeed, in order to determine the relationship between the two species, strains of M. aurantiaca were crossed, and single ascospore isolations of several A. conjugatum strains were attempted. However, single ascospore isolates from five strains (UAMH 3130, 3156, 3516, 3517, and 3519) of A. conjugatum were consistently self-fertile. The sexual crosses of M. aurantiaca were negative with the exception of one cross, UAMH 1707 x 3705 (Table II), which formed a single gymnothecium having elongate appendages and containing few spiny, oblate ascospores (see Malbranchea aurantiaca).

In describing Auxarthron conjugatum, Orr and Kuehn (1963a) noted that elongate appendages were straight, hooked or coiled, rarely branched. However, we observed that apical branching of elongate appendages (Fig. 16B) occurred frequently in all strains of A. conjugatum when cultured on a variety of media, including cereal, oatmeal and DSA agar. A single gymnothecium, in addition to branched elongate appendages, also bore some which were unbranched, straight or hooked at the apex.

Orr and Kuehn (1963a) reported that ascospores of A. conjugatum were spherical or ovoid, asperulate, smooth when young but becoming asperulate in age. Our examination indicates that the ascospores are oblate (Figs. 16C,16D), 1.5-2.2 x 2.5-3.2um and very finely roughened. In all strains examined, the asperulate nature of the ascospores is almost beyond the resolution of the phase contrast light microscope. Even at high magnification (x2700), the finely roughened edge of the ascospore is barely discernible (Figs. 16C,16D). Scanning electron microscopy would be required to resolve the exact nature of the ascospore surface.

Habitat and activities: Recovered from soil, dung, feathers and lungs of rodents, USA, Australia, Mexico, India and the Sudan (Orr et al., 1963a). Moderately keratinolytic, with no penetrating bodies, not cellulolytic.

Material Examined
From soil: UAMH 3156, TYPE, Ariz., C.W. Emmons (47), from Benjamin, RSABG as 1530 (NRRL 1244; 0-520); UAMH 3516, Sudan, rec. from Ajello, CDC 32 b; UAMH 3517, Sudan, from Ajello, CDC 32 a; UAMH 3519, Sudan, from Ajello, CDC 28 a; UAMH 3817, India, G. Ghosh, from Orr (0-1236); UAMH 3874, Kansas, from Orr (0-3750); From other substrates: UAMH 3130, lizard dung, Chihuahua, Mexico, R.K. Benjamin, 1964, RSABG as 1474; UAMH 3841, feathers (domestic fowl), Australia, R.G. Rees (F91), from Orr (0-3153)

Malbranchea sulfurea (Miehe) Sigler & Carmichael comb. nov.

Synonyms
= Thermoideum sulfureum Miehe 1907, Deutsche Botanische Gesellschaft 25:515 (Basionym)
= Malbranchea pulchella var sulfurea (Miehe) Cooney & Emerson 1964, Thermophilic Fungi p. 102

History

In 1907, Miehe created a new genus and species Thermoideum sulfureum for a fungus he found growing on spontaneously heated compost heaps. By studying the fungus in culture, he not only established the thermophilic nature of the organism but also accurately illustrated and described the formation of conidia. According to Miehe, the curved fertile hypha divided itself into short segments, which later developed an internal thickened membrane to form the spore. In the process, not all the cells became spores, but only alternate ones. Saccardo (1908) and Saccardo and Trotter (1913) reduced Thermoideum sulfureum to synonymy with M. pulchella without regard for the thermophilic nature of the organism. Elisei (1940a) examining four mesophilic strains, followed Saccardo (1908) in placing T. sulfureum in synonymy with M. pulchella.

In 1964, Cooney and Emerson reviewed the history of Malbranchea and provided an excellent account of the morphology of a thermophilic strain isolated by Emerson in 1945. Their fungus corresponded in appearance to the description of the thermophilic Thermoideum sulfureum of Miehe (1907). A comparison with the study of Baldacci et al. (1939) of four mesophilic isolates indicated that these organisms differed at least in temperature relations. Cooney and Emerson examined a single mesophilic strain (strain Rivelloni) which failed to sporulate and they were unable to make a definite distinction between the thermophilic and mesophilic isolates. Therefore they proposed a new variety for the thermophilic isolates, Malbranchea pulchella var sulfurea (Miehe) until a more comprehensive comparison of the mesophilic and thermophilic strains could be made.

An examination of a number of isolates indicated that the thermophilic strains are specifically distinct from the mesophilic M. pulchella and therefore a new combination is proposed here.

Description

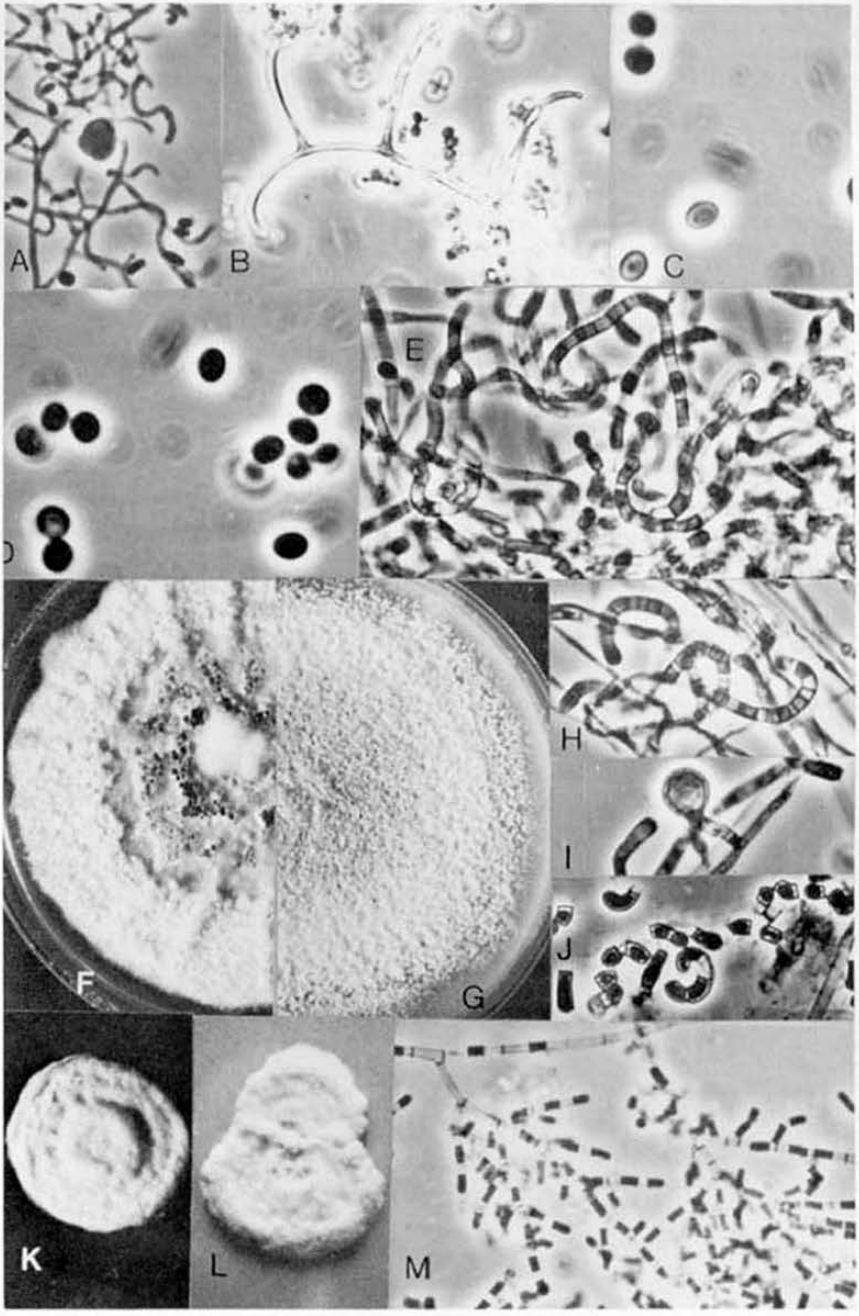
At 45 C, colonies (Fig. 16F) on PYE are robust, almost or completely filling the petri dish by 7 days, dense, thick, smooth or with few outward radiating folds, velvety with coarse, creamy yellow tufts of hyphae. The color is sulfur-yellow or yellowish-tan, with yellow or pink margin, by 21 days dark gold, buff-brown or deep reddish-brown. Large droplets of dark brown exudate, which appear on the surface by 7 days (Fig. 16F), gradually dry and leave the surface pitted and mealy. The medium turns dark brown or black from diffused pigment. At 37 C, growth is slightly slower (70-78 mm in 7 days), sulfur-yellow with darker tan center, otherwise similar to colonies at 45 C. Pigment production is slightly reduced.

At 45 C, colonies (Fig. 16G) on cereal are 79-81 mm diam. in 7 days, sulfur-yellow, flat, coarse, and mealy with tufts of yellow hyphae, and yellow to dark brown exudate droplets which dry and leave the colony pitted. By 21 days, the colony is dark tan or reddish-brown, with diffusing dark brown pigment, dense, velvety, thick, smooth often with few irregular folds. Growth at 37 C is slightly slower, but otherwise similar.

Degenerate or less robust strains (UAMH 2481, 2486, and CBS 423.54) are greenish-grey or drab-grey, glabrous, hairy or leathery with scant aerial growth. Diffusing pigment is scant.

The arthroconidia are borne on curved or loosely

Figure 16. A-D. Auxarthron conjugatum (A,B,D-UAMH 3156; C-3817). E-J. Malbranchea sulfurea (E,I,J-2485; F,G-3748; H-2486). K-M. Malbranchea dendritica (2731). Fig. 16A. Enlarged arthroconidia and curved conidiogenous hyphae. Fig. 16B. Apical branching of elongate peridial appendage. Figs. 16C-16D. Oblate, finely asperulate ascospores. Fig. 16E. Alternate arthroconidia borne on curved or coiled branches. Figs. 16F-16G. Colonial morphology after 7 days at 45C. F on PYE, G on cereal. Fig. 16H. Curved conidiogenous hyphae. Fig. 16I. Thick-walled chlamydospore. Fig. 16J. Thick-walled mature arthroconidia. Figs. 16K-16L. Colonial morphology after 21 days at 25 C. K on PYE, L on cereal. Fig. 16M. Branching at an acute angle of fertile hyphae. Colonies x 0.7, others x 600, except C and D, x 1680.


A
B
C
D
E
F
G
H
I
J
K
L
M

coiled lateral branches (Figs. 16E,16H) arising from broader vegetative hyphae (3-6um in diameter). The vegetative hyphae are hyaline, later yellowish-brown with prominent racket hyphae, swelling at the septum to a diameter of 9um or more. In some strains, thick-walled intercalary or terminal chlamydospores (Fig. 16I) occur, especially at 45 C. Arthroconidia (Fig. 16J) are cylindrical, often curved, thick-walled, often with attached hyaline frill from the outer hyphal wall of the separating empty cell, hyaline at first, later yellow, tan or yellowish-green (2)2.5-4(4.5) x (3)3.5-7.5(8.5)um, mostly 3-4 x 4-7um.

Discussion

Cooney and Emerson (1964) and Awao and Otsuka (1973) also describe the morphology of this species.

M. sulfurea differs from M. pulchella in its thermophilic nature, its colonial morphology, its broader vegetative hyphae and its thick-walled, broader arthroconidia. In its capacity to grow at high temperature, M. sulfurea is distinct from all other species of Malbranchea. Furthermore, chlamydospores are formed regularly. No other spore state was observed and attempts to mate the isolates by pairing them on oatmeal agar at 37 C in 3% CO2 were unsuccessful.

Occurrence: Reported from plant heaps and rotting plant material: guayale rets, California (Cooney and Emerson, 1964); composting heaps, Germany, Texas (Miehe, 1907; Rode, Foster and Schuhardt, 1947); wheat straw compost, England (Chang and Hudson, 1967) and stacked tobacco leaves, South Africa (Eicker, 1972). It has been isolated from soil in Japan (Awao and Otsuka, 1973; Tubaki, Ito, Matsuda and Yano, 1975); peanut kernals and associated soil, Texas (Taber and Pettit, 1975); coal spoil tips, England (Evans, 1971); faeces of Cape sparrow, South Africa (Eicker, 1972); dung of deer, Japan (Minoura, Yokoe, Kizima, and Nehira, 1973) and cattle, Alberta; hen-house litter, Netherlands; snuff, USA, (Tansey, 1975) and from air sample surveys, England (Hudson, 1973). M. sulfurea is notably absent from self-heating wood chip piles (Shields, 1969; Tansey, 1970 (Abstract), 1971b; Smith and Ofosu-Asiedu, 1972).

Growth rates: Table III compares maximum diameters of colonies of M. sulfurea tested at five temperatures. Growth occurred at 25 C, albeit slowly, and at 55 C for all isolates tested. The minimum temperature is close to 25 C, the maximum 55-57 C (Cooney and Emerson, 1964). Chapman (1974), studying the effects of temperature on growth rates of several thermophiles, concluded the optimum for M. sulfurea was 40-45 C, with no growth at 30 C or 55 C after 8 days.

TABLE III
DIAMETER (MM) OF AGAR PLATE COLONIES OF MALBRANCHEA SULFUREA AFTER GROWTH AT DIFFERENT TEMPERATURES

Temperature (°C)	25[1]	30[1]	37[2]	45[2]	55[2]
Time (days)	28	35	7	7	7
2481	+	75	78	90	N
2485	+	30	73	90	42
2486	+	66	72	90	N
3747	+	23	74	80	26
3748	+	16	77	80	10
3761	N	N	N	N	32
3788	N	N	N	N	42
3789	N	N	N	N	25

Legend: + Scant growth (diameter of colony < 5 mm)
N Not tested
1 Growth tested on oatmeal agar only
2 Growth tested on PYE agar

Cellulolytic Activity: M. sulfurea attacks cellophane vigorously, markedly weakening the membrane by 21 days.

Chang (1967) reported growth on xylan, the major hemicellulose of straw, when provided as the sole carbon source, but no utilization of cellulose in the form of filter paper, an observation confirmed by Fergus (1969). Fergus (1969) demonstrated the use of carboxymethyl cellulose. Tansey (1971a) measured the zone of clearing of acid swollen cellulose in an agar medium. Although M. sulfurea produced a definite clearing, indicating cellulolytic activity, the zonal front was indistinct and difficult to measure. Tansey suggested that a portion of the system of enzymes required for digestion of cellulose could be lacking, thereby rendering the organism incapable of attacking insoluble cellulose.

Metabolites: Rode et al. (1947) identified an antibiotic

from M. sulfurea as comparable in activity to authentic penicillin. Ong and Gaucher (1973), examining a number of thermophiles, characterized intracellular and extracellular proteases, one of which, the extracellular alkaline protease of M. sulfurea, has been defined by Voordouw, Gaucher and Roche (1974) as thermomycolase, a thermostable protein protease.

Lipids: Mumma, Fergus and Sekura (1970), studying the lipid composition of some thermophilic and mesophilic fungi, revealed a difference in the degree of saturation of fatty acids, measured by the number of double bonds per mole of fatty acid. The thermophiles, in comparison to mesophiles of the same genus, were found to be more saturated, i.e., have fewer double bonds per mole. Crisan (1973) pointed to the higher melting point of the saturated fatty acids as a factor in the thermostability of these organisms, and discussed lipid stability as one of four hypotheses explaining thermophilism in fungi. However, he considered the best explanation of thermostability resided in the basic ultrastructure of the organism, possibly in the integral genetic make-up, the cell structure or the ribosomes. Mumma et al. (1970), finding a higher lipid composition for M. sulfurea than some other thermophiles, suggested the difference may be due to extraction of soluble pigment.

Material Examined
UAMH 3761, NEOTYPE, from retting Parthenium argentatum, Salinas, Calif., R. Emerson (27), 1945, CMI 126327; From ensiling alfalfa hay forage: UAMH 2481, isol. 1953, rec. from Semeniuk, S. Dakota State Univ., Brookings as 401; UAMH 2485, 1953, from Semeniuk as 422; UAMH 2486, 1953, from Semeniuk as 459; From dung: UAMH 3747, manure in cattle feedlot, Lethbridge, Alta., R.G. Bell, 1974, Research Station, Lethbridge as 1; UAMH 3748, manure in cattle feedlot, Lethbridge, R.G. Bell, 1974, as 2; UAMH 3789, deer dung, Hiroshima, Japan, K. Minoura, 1970, from Tubaki, IFO 9739; From other substrates: UAMH 3827, soil, hen-house litter, A.H.M. Grimbergen, CBS 343.55; UAMH 3857, seed of Oryza sativa, China, CBS 115.68; UAMH 3858, CBS 960.72; CBS 423.54

B) Malbranchea species with straight fertile hyphae

Malbranchea dendritica Sigler & Carmichael sp. nov.

History

During a search for Coccidioides immitis in California soil, Plunkett, Walker and Huppert (1963) isolated three fungi which produced arthroconidia from acutely branched hyphae, giving a "pine-tree appearance" to the sporulation

in slide culture. They inoculated three mice intraperitoneally with each strain and killed them after 10, 15 and 20 days. Small nodules were found in all mice, but no endosporulating spherules were seen. "When planted on media, these nodules yielded colonies that were identical to the original culture. Isolates from tissue were prepared for inoculation into a second group of five mice. On the 7th day after inoculation all mice revealed endosporulating spherules at autopsy and established the identification as C. immitis. The cultures recovered from the mice were again identical to the original one." Despite the discrepancy between the results of the first and second sets of mouse inoculations, they identified their isolates as atypical Coccioides immitis.

Huppert, Sun and Bailey (1967) studied a collection of 301 strains of fungi which would grow on media containing cyclohexamide. They stated that for each strain endosporulating spherules had been demonstrated in mice inoculated intraperitoneally, and the fungus recovered in culture. Thus, they identified all their strains as C. immitis, regardless of their colonial and microscopic morphology. Details of the animal inoculations were not given. Some of their isolates (strain numbers not given) had acutely branched fertile hyphae and their Figure 6 shows the microscopic morphology which we now consider to be characteristic of M. dendritica. Their Figure 7 shows a Malbranchea similar to M. gypsea (q.v.). (See also discussion under Malbranchea state of Coccidioides immitis).

Orr (1968) isolated a dendroid Malbranchea from soil. Later (Orr, 1972), he compared the pathogenicity of this isolate (UAMH 2731, DPG-141) with several other isolates of Malbranchea, including strains of M. gypsea, and with Coccidioides immitis. Passage of each organism though mice produced lesions in the spleen and liver but no endosporulating spherules were observed in mice other than the ones inoculated with C. immitis. In addition, histopathological examination revealed no fungal elements, although the arthroaleuriospore-formers could be recovered in culture from the tissue. Malbranchea dendritica was recovered from the lungs in addition to the spleen and liver and survived four serial passages though mice. Control mice inoculated with physiological saline were negative.

It appears probable that the three isolates of Plunkett et al. (1963) and some of the atypical Coccidioides immitis strains of Huppert et al. (1967) should be included in Malbranchea dendritica.

Coloniae in agaro ad 25 C moderatim lente crescunt, cremeofulvae, velutinae. Incrementum lentum ad 37 C.

Hyphae fertiles in angulo acuti ramosae, dendroideae. Arthroconidia cylindrica, non curva, hyalina, laevia, 1.5-2(3) x 3-5um.
Typus: UAMH 2731, ex solo, Dugway, Utah, 1967, G.F. Orr, DPG 141

The colony on PYE (Fig. 16K) is 31 mm diam. in 21 days, creamy buff, reverse buff, rising to a central plateau, velvety. On cereal (Fig. 16L), the colony is 37 mm diam. in 21 days, white, reverse white, slightly raised, scarcely zonate, velvety. At 37 C, the colony on PYE is 23 mm diam. in 21 days, white, heaped up and convoluted, velvety, detaching from the cellophane at periphery; on cereal (diam. as on PYE), flat at periphery, cerebriform in center, waxy, pale buff.

The fertile hypha, branched at an acute angle from the primary hypha (Fig. 16M) is straight, bearing multiple short or long lateral branches. Branching is consistently acute, giving the fertile hypha a tree-like appearance (Fig. 17A). At first, arthroconidia develop apically on the main axis of the fertile hypha and on the lateral branches (Fig. 17B). Later, the base of the hypha and the primary hypha become regularly septate, followed by separation into arthroconidia. Arthroconidia are separated by one or more empty segments, a single segment often shorter than the length of an arthroconidium. Arthroconidia are hyaline, smooth, cylindrical 1.5-2(3) x 3-5um.

The regularly acute angle of branching of the fertile hyphae distinguishes M. dendritica from all other species of Malbranchea.

Habitat and activities: Recovered from soil, Utah, cave floor, Malayasia (Emmons, 1967). Moderately keratinolytic, no penetrating bodies.

Material examined: UAMH 2731, TYPE, soil, Dugway, Utah, G.F. Orr, 1967 (DPG 141); UAMH 3953, soil, Dugway, (Orr 0-3230; NRRL 5131; ?same strain as UAMH 2731); UAMH 3956, cave floor, Kuala Lumpur, Malayasia, from Kwon-Chung, N.I.H., Bethesda (B-3056; I-752B)

Malbranchea flava Sigler & Carmichael sp. nov.
?= Malbranchea state of Oncocladium flavum Wallroth 1833, Flor. Crypt. German. p. 289

History

In 1900, A. L. Smith described Gymnoascus verticillatus, as having brown, thick-walled verticillately branched peridial hyphae and globose (2.5um diam.) ascospores, occurring separately, or in ascus-like groups.

In 1963, Orr and Kuehn transferred this species to a new genus, Actinodendron, redescribing it from Smith's description and information supplied by Stockdale and Balfour-Browne, who examined Smith's type specimen, HERB BM. Because of its verticillately branched peridial hyphae, the fungus was considered distinct from Gymnoascus Baranetzky. Smith (1900, 1901) apparently did not attempt pure cultures, but Orr and Kuehn (1963) reported several recent isolations of the fungus, by Szathmary in Hungary, Plunkett in California, and Stockdale in Wales. However, the verticillately branched hyphae observed in the original specimens could not be reproduced in culture. Also, neither asci nor ascospores were observed in the specimens of Szathmary and Plunkett. Several fungi were isolated from Plunkett's hair bait sample (all designated OAP- 19-317), two of which had arthroaleuriospore states. Orr and Kuehn (1963) suggested that a keratin source such as hair may be required for gymnothecial development.

Apinis (1964) examined several specimens of Actinodendron verticillatum, including Smith's type material, Stockdale's specimen from sheep's wool (HERB IMI 100,300), his own isolate from a dead bird, and one from feathers placed in a damp chamber (HERB K). In the latter material, Apinis observed asci and ascospores as well as the characteristic appendages in older brown clusters formed on the feathers. In addition, he reported aleurioconidia resembling those of Chrysosporium merdarium, arthroconidia resembling those of Geotrichum, and endogenous microconidia. Apparently, Apinis did not attempt to make pure cultures from the feathers.

Hughes (1968), comparing the type specimen of Oncocladium flavum Wallroth, a Hyphomycete, with the type specimen, HERB BM, of Actinodendron verticillatum, concluded that the verticillately branched hyphae in both were identical. In the specimen of O. flavum, Hughes observed neither asci nor ascospores, nor any conidia of the Chrysosporium type, but reported an arthroconidial state resembling Oidiodendron. Hughes considered the verticillately branched hyphae to be characteristic of Oncocladium. Since Wallroth's original description did not refer to ascospores, Hughes suggested Oncocladium flavum may be the conidial state of Actinodendron verticillatum. He also noted that Oncocladium could be an earlier name for Oidiodendron.

The taxonomic position of Actinodendron verticillatum was complicated by Orr and Kuehn (1971), who agreed with Hughes, and rejected their own transfer of the fungus to a perfect state genus, since ascospores had not been observed in any but Smith's type specimen. They concluded that the ascospores present in Smith's type material were not part of the same fungus. Apparently, they failed to examine the

two specimens reported by Apinis (1964) to have ascospores.

From these conflicting reports, it is difficult to assess the true nature of Oncocladium. On the one hand, there is Apinis' observation of ascospores and on the other, there is Orr and Kuehn's (1971) rejection of Actinodendron. While both Orr and Kuehn (1963) and Szathmary (1967b) reported verticillately branched hyphae in keratin-baited samples, to our knowledge, neither has induced their formation in culture. However, the list of cultures of Oncocladium flavum examined by Orr and Kuehn (1971) includes isolates from Plunkett's hair bait sample (OAP-19-317, incorrectly cited as OAP-19-1317) (Orr and Kuehn, 1963), as well as several arthroaleuriospore-formers corresponding in appearance to isolates described as Gymnoascus verticillatus by Szathmary (1967a,b).

In specimens we have examined, HERB IMI 100,300 of Stockdale, and HERB IMI 100,445, a few spiny, oblate ascospores were observed in the latter. The label on the specimen indicated Anixiopsis stercoraria [= Aphanoascus fulvescens] to be present. Conidia of the Chrysosporium type and the appearance of the ascospores agree with A. stercoraria, although no cleistothecia were observed. In any case, the ascospore appearance does not agree with the descriptions of Smith (1900) and Apinis (1964). No ascospores were observed in two slides of IMI 100,300.

In both specimens, however, an arthroconidial state is present within clusters bearing verticillately branched hyphae (Figs. 17C,17D). Pseudogymnothecia or peridial appendages have been observed in culture in some heterothallic Gymnoascaceae, notably Ctenomyces serratus (Benjamin, 1956), Uncinocarpus reesii, and some Myxotrichum and Arthroderma species (Varsavsky and Ajello, 1964; Padhye and Carmichael, 1973; Sekhon, Padhye and Carmichael, 1973). The peridial hyphae of the pseudogymnothecium resemble those of the fertile gymnothecium, but the structure contains only conidia. The presence of infertile gymnothecia confused the taxonomy of Ctenomyces serratus Eidam until Benjamin (1956) showed that Eidam's specimen actually contained two different fungi. Eidam had originally described Ctenomyces as having two stages, a fertile gymnothecial state and a sclerotial or resting state. Although no ascospores were reported by Eidam for the sclerotial state, Benjamin (1956) retained the name Ctenomyces serratus for the fungus distinguished by the characteristic comb-like appendages.

The infrequent occurrence of ascospores in Oncocladium suggests that the fungus may be heterothallic. It seems probable that the verticillately branched hyphae arise as thick-walled extensions of the vegetative hyphae, forming clusters on the natural substrate, but remaining infertile

unless compatible mating types are present. In the Malbranchea state of Uncinocarpus reesii, uncinate appendages occur in the conidial state as extensions of the vegetative hyphae, but only intertwine to form a gymnothecium when compatible strains are mated.

The verticillately branched hypha of Oncocladium flavum is narrow at the base, becoming wider at the apical or distal end, terminating in a blunt tip and occasionally extending into a hyaline, septate hyphal appendage, which gradually narrows to a diameter of 2-3um (Fig. 17C). The branchlets forming the verticils are pointed at first, becoming blunt-tipped as the apical segment detaches. In this respect, the hyphae resemble the peridial hyphae of some Myxotrichum species which often terminate in blunt spines, the terminal portion having broken off.

We have not yet been able to determine the true nature of the association of the appendages with the arthroconidial state. It appears probable to us that the verticillately branched hyphae are peridial appendages. If so, the name Oncocladium could be retained for the sexual state since the key feature of Oncocladium, as Hughes (1968) noted, is the verticillately branched hyphae. The arthroconidial state, clearly distinct from Oidiodendron is assigned to Malbranchea.

Coloniae in agaro ad 20-25 C moderatim rapide crescunt, sulphureae, citreae vel alboluteae, pulveraceae vel floccosae, densae, siccae, planae vel undatae, rimosae. Incremuntum paulum ad 30 C, nullum ad 37 C. Arthroconidia cylindrica, directa, laevia, hyalina, posteriorus chlorina, 2-3 x 2-6um, plerumque 2-3 x 2.5-5.5um.
Typus: UAMH 1589, ex solo, California, 1962, O.A. Plunkett, OAP 19-317

Colonies on PYE (Fig. 17F) are 39-61 mm diam. in 21 days, lemon-yellow with darker gold center, sulfur-yellow, greenish-yellow, rarely creamy white. The surface is powdery, rarely woolly, dense, dry, separating from the cellophane and lifting in the center, undulate, often cracked or split with folds extending to the margin, scarcely zonate (Fig. 17E). Growth on cereal (Fig. 17G) is 26-39 mm diam. in 21 days, flat, straw-yellow, with darker gold center, rarely white, coarse, powdery or woolly, with scant diffusing yellow pigment. In some strains, a wrinkled, waxy small umbo with tiny cracked furrows, develops at center. The optimum temperature is 18-25 C; 30 C is close to the maximum. One strain (UAMH 1879) showed scant growth at 5 weeks (10 mm).

Arthroconidia developing on straight, branched fertile

hyphae (Figs. 17H-17J), separated from each other by one or more empty segments (Fig. 17H), are divided by

Habitat and activities: Recorded from soil, California, Hungary and France (Szathmary, 1967a,b; Orr and Kuehn, 1963, 1971). Most isolates were only slightly keratinolytic. Two strains (UAMH 1879 and 1956) did not attack hair at all. This limited capacity to digest hair *in vitro* is interesting since most isolations were made from keratin-bait techniques. In addition, it has been suggested that development of gymnothecia of *Actinodendron verticillatum* may depend upon a source of keratin (Orr and Kuehn, 1963).

Material Examined
Soil isolates from Orr: UAMH 1589, TYPE, Calif., O.A. Plunkett, 1962, (OAP-19-317); UAMH 1879, Calif., O.A. Plunkett, (OAP-19-317(6)); UAMH 1956, Arg., E. Varsavsky, (EV 5V;0-3596); UAMH 2859, Tunis, C. De Vroey, (RV 19535a; 0-3496); UAMH 2860, sector of RV 19535a, G.F. Orr, (RV 19535b); UAMH 2864, fabric-bait, Hungary, Szathmary, 1967, (0-3512); UAMH 2865, fabric-bait, Hungary, Szathmary, 1967, (0-3514); Material of *Oncocladium flavum*: HERB IMI 100,300, sheep's wool on dung, Wales, P.M. Stockdale, 1962 (UAMH 3920); HERB IMI 100,445, wool, associated with *Anixiopsis stercoraria* (UAMH 3921)

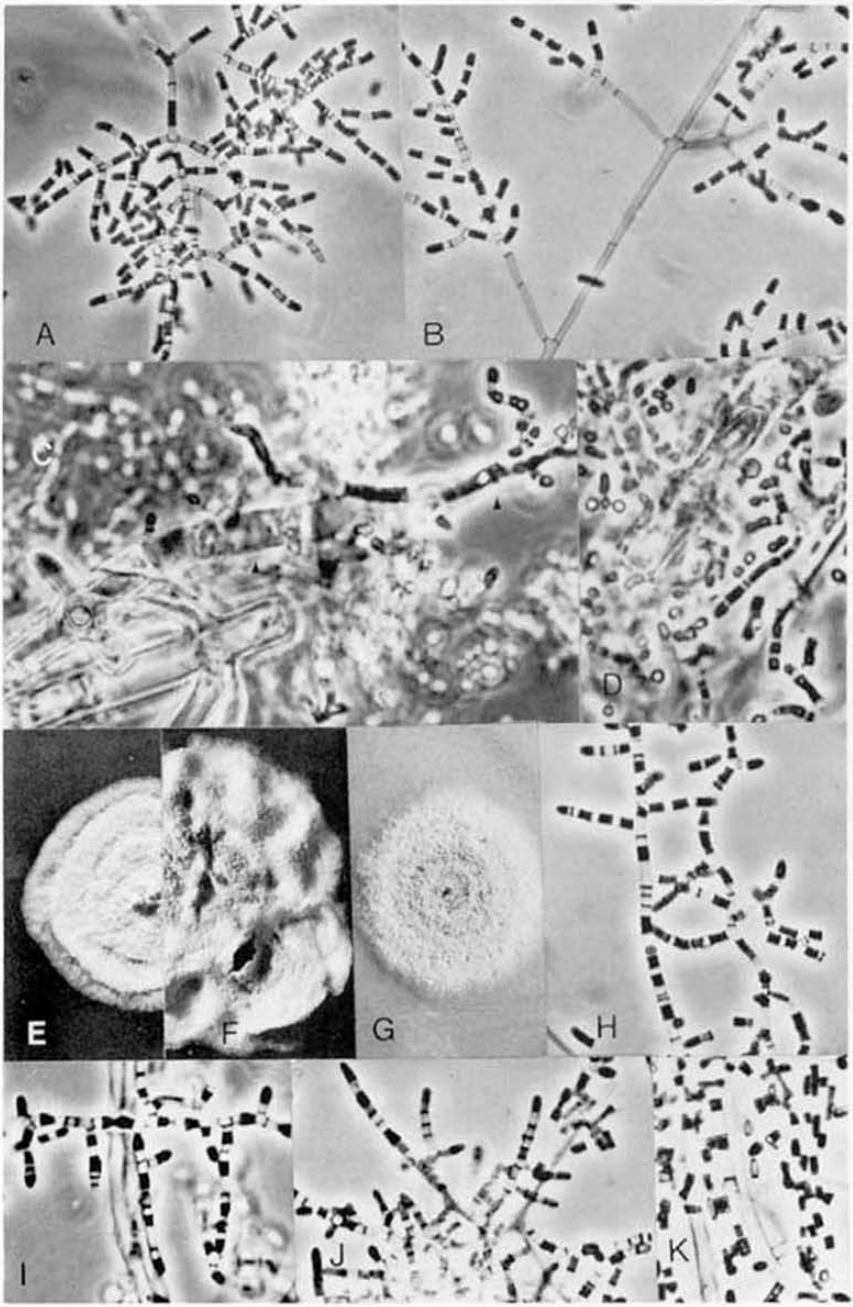
Malbranchea flocciformis Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25 C moderatim lente crescunt, tangerinae vel flava, cumulae, convolutae, lanuginosae vel velutinae. Incrementum nullum vel exiguum ad 37 C. Arthroconidia cylindrica, directa, in fascicula densa, hyalina vel lutea, laevia, (1.5)2-2.5 x 2-5.5um.
Typus: UAMH 3273, ex solo salino, Chateau-Saline, Lorraine, France

Colonies on PYE (Fig. 18A) are 22-42 mm diam. in 21 days, adhering poorly to the cellophane, lifting at margin,

---

Figure 17. A-B. *Malbranchea dendritica* (UAMH 2731). C-D. *Oncocladium flavum* (IMI 100300). F-K. *Malbranchea flava* (E,J,K-2864; F,G-1589; H-1956; I-1879). Figs. 17A-17B. Tree-like appearance of branched fertile hypha. Fig. 17C. Blunt tipped verticillately branched hypha with hyaline terminal appendage (arrows). Fig. 17D. Verticillately branched appendage and associated arthroconidial state. Figs. 17E-17G. Colonial morphology at 25 C. E and F on PYE, G on cereal. E at 14 days, F and G at 21 days. Figs. 17H-17J. Alternate arthroconidia of branched fertile hyphae. Fig. 17K. Arthroconidia with refractile end walls. Colonies x 0.7, others x 600.


A
B
C
D
E
F
G
H
I
J
K

or at center with margin depressing the medium. Colonies are domed with deep folds or convolutions, or petaloid, pale or tangerine orange, reverse tan, downy or velvety, sometimes with exudate droplets at center. On cereal agar, colonies (Fig. 18B) are flatter (24-38 mm diam. in 21 days), either downy, dome-shaped with margin depressing the medium, or crateriform, zonate and powdery, pale or tangerine orange or pale yellow. One strain (UAMH 675) formed yellow exudate droplets and brown diffusing pigment. No growth at 37 C, except scant growth by UAMH 3273 (5 mm in 21 days on PYE).

Arthroconidia are borne on the primary hyphae (Fig. 18C) and on short or long lateral branches (Figs. 18C,18D) which often branch repeatedly to form a dense tuft (Fig. 18E) The fertile hyphae are characteristically straight, occasionally curved (Fig. 18F). Arthroconidia are cylindrical, hyaline or pale yellow, orange in mass, smooth (1.5)2-2.5 x 2-5.5um.

M. flocciformis digests cellophane after prolonged growth and is slightly keratinolytic.

Discussion

Two of the strains included here were initially determined to be M. pulchella. Of the two, UAMH 675 resembles M. pulchella in its curved fertile hyphae (Fig. 18F) but differs in forming accessory arthroconidia on the primary hyphae and in having orange colonies. Although UAMH 675 may not be suitably placed in this species, it is retained here until further isolates have been examined.

Material Examined
UAMH 675, wooden lemon storage bin, Calif., P.R. Harding, 1959, ex DAOM 64000 (CMI 96741); UAMH 3273, TYPE, briny soil, Chateau-Saline, Lorraine, France, from J. Nicot, Laboratoire de Guffbogaurie, Paris; UAMH 3785, salty soil, France, J. Villoutreix, CBS 361.69

Malbranchea fulva Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25-30 C moderatim rapide crescunt, cum zonis concentricis, alataceae vel brunneae vel flavae, pulveraceae vel granulatae. Incrementum nullum vel paulum ad 37 C.
Arthroconidia cylindrica vel doliformia, subflava, laevia, 2-3(3.5) x 3.5-8(11)um.
Typus: UAMH 2851, ex aere, Dugway, Utah, 1967, G.P. Orr, 0-3042 (DPG 167; NRRL 5160)

Colonies on PYE (Fig. 18G) are 38-44 mm diam. in 21 days, powdery, occasionally downy at center. The surface

is zonate, slightly raised with central tan or yellow umbo, tan or pale brown or yellow near center, and white or hyaline at periphery, reverse dark tan or reddish-brown with diffusing tan pigment. The zonate pattern is more distinct on half of the colony, with umbo often positioned slightly off center. On cereal agar (Fig. 18H), colonies (diam. as on PYE) are flatter, with a small ridge surrounding a zone of less dense aerial growth at center, tan or buff-brown, reverse tan, powdery or granular, with diffusing tan or brown pigment. Optimum range 25-30 C; growth at 37 C variable (scant growth by some strains, 2-8 mm in 21 days).

Hyphae bearing arthroconidia are straight, branched (Figs. 18I,18J), septate, 2-4um wide. Racket hyphae appear during early growth, swelling to 5-6um in diameter. Septa formed in the fertile hyphae are thick (Figs. 18I,18J) suggesting double septa, and at maturity arthroconidia develop refractile terminal walls (Fig. 18K). Arthroconidia are cylindrical or barrel-shaped, hyaline, pale yellow, in mass yellow, smooth, 2-3(3.5) x 3.5-8(11)um, sometimes remaining connected in pairs. Orange-brown slime occasionally surrounds some hyphae (Fig. 18L). No other spore state was observed and an attempt to cross the isolates was unsuccessful.

Discussion

M. fulva lacks the uncinate appendages of the Malbranchea state of Uncinocarpus reesii and has slower growing tan colonies and restricted growth at 37 C. M. fulva lacks the arcuate fertile hyphae of M. arcuata.

Habitat and activities: Recovered from air (Orr and Kuehn, 1972), soil and dung, California, Utah and Colorado. Strongly keratinolytic, producing marked digestion of hairs with penetration of hair by single hyphae; not cellulolytic.

Material Examined
From soil: UAMH 1050, Riverside Co., Calif., G.F. Orr, (0-759); UAMH 1708, Palo Verde, Calif., G.F. Orr, 1957, (0-630); From air sample: UAMH 2849, wind tunnel contaminant, Utah, G.F. Orr, 1967, (4TL3); UAMH 2851, TYPE, Dugway, Utah, G.F. Orr, 1967, (DPG-167; 0-3042; NRRL 5160); From dung: UAMH 3889, mouse, Fruita, Color., (Orr 0-1508); UAMH 3901, lizard, Palo Verde, Calif., (Orr 0-1319); From unknown source: UAMH 3729, (Orr DPG-45).

Malbranchea gypsea Sigler & Carmichael sp. nov.

Coloniae in agaro ad 25-30 C lente vel moderatim crescunt, gypseae vel cremeae, cumulae, convolutae, velutinae vel floccosae. Incrementum nullum vel paulum ad 37 C.

Arthroconidia cylindrica vel subdoliformia, hyalina, laevia, 2-2.5 x (2.5)3-6(9)um.
Typus: UAMH 1975, ex solo, Bakersfield, California, 1964, G.F. Orr, 0-2565

Growth on PYE variable, 17-39 mm diam. in 21 days, mostly 27-30 mm diam. Colonies (Fig. 19A) are chalky-white or creamy white, reverse buff, downy or velvety, slightly raised, domed with folded or convoluted surface, sometimes with prominent central umbo. The colony (Fig. 19B) of two strains (UAMH 1942 and 1943) was smoother with hairy or coarsely woolly matted texture and glabrous margin. On cereal, colonies (Fig. 19C) are 15-42 mm diam. in 21 days (mostly 27-32 mm), white, reverse white or tan, powdery, downy, or floccose, almost flat or domed with small central umbo and small irregular folds. One strain (UAMH 1975) excreted tan pigment by 21 days. Optimum range 25-30 C; growth at 37 C variable (scant growth by UAMH 1941 and 1943). One strain (UAMH 1734) grew poorly at 30 C.

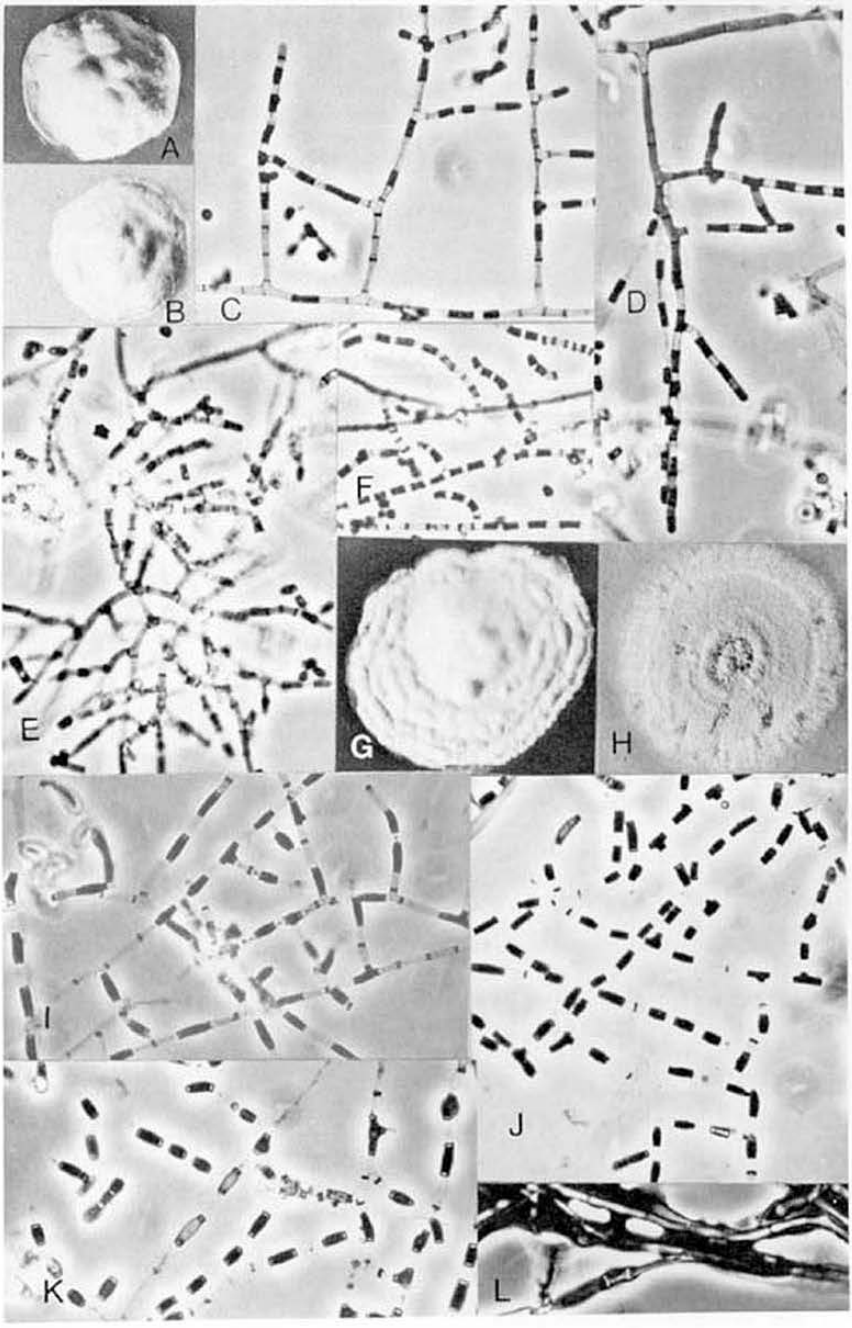
Arthroconidia (Figs. 19D,19F), borne in an intercalary or terminal position on the straight primary hyphae or on short or long lateral branches, are separated by one or more alternate empty cells, or rarely, formed immediately adjacent to each other (Fig. 19E). Arthroconidia are cylindrical or slightly barrel-shaped, slightly broader than the width of the interconnecting hypha (Figs. 19E,19F), hyaline, smooth, 2-2.5 x (2.5)3-6(9)um. No other spore state was observed. An attempt to cross three isolates (UAMH 1841, 1943 and 1975) with each other was unsuccessful.

Discussion

The white colonies and lack of arcuate fertile hyphae distinguish M. gypsea from most other species of Malbranchea. During early development, M. gypsea may be confused with the Malbranchea state of Uncinocarpus reesii,

---

Figure 18. A-F. Malbranchea flocciformis (A-E-3273; F-675). G-L. Malbranchea fulva (G,H-2851; I-1708; J-2849; K,L-3729). Figs. 18A-18B. Colonial morphology after 21 days at 25 C. A on PYE, B on cereal. Figs. 18C-18D. Alternate arthroconidia borne on straight primary hyphae and lateral branches. Fig. 18E. Repeated branching of fertile hyphae. Fig. 18F. Slightly curved conidiogenous branches. Figs. 18G-18H. Colonial morphology at 21 days at 25 C. G on PYE, H on cereal. Figs. 18I-18J. Intercalary arthroconidia of straight, branched fertile hypha. Fig. 18K. Mature arthroconidia with refractile terminal walls. Fig. 18L. Orange-brown slime surrounding vegetative hyphae. Colonies x 0.7, others x 600.


A
B
C
D
E
F
G
H
I
J
K
L

especially if the characteristic uncinate appendages of the latter are lacking. However, the M. state of U. reesii differs in forming arthroconidia which are slightly broader, 2.5-3um in diameter compared to 2-2.5um for M. gypsea; in growing more vigorously at both 25 C and 37 C; and in being markedly keratinolytic in contrast to M. gypsea which is cellulolytic.

Habitat and activities: Can be recovered from lesions on the spleen and liver after passage through experimental animals (Orr, 1972). (See discussion under Malbranchea state of Coccidioides immitis). Cellulolytic after prolonged growth; not keratinolytic.

Material Examined
Isolates from soil passaged through experimental animals (from Orr): UAMH 1941, Calif., Huppert (SFVH 129), (Orr 0-3226); UAMH 1942, Calif., Huppert (SFVH 130), (Orr 0-3283); UAMH 1943, Calif., Huppert (SFVH 149), (Orr ?0-1088); From other substrates: UAMH 1734, cat hair, C.W. Emmons, (Orr 'cat hair PBSF'); UAMH 1975, TYPE, soil, Bakersfield, Calif., G.F. Orr, 1964, (VJC 4; 0-2565)

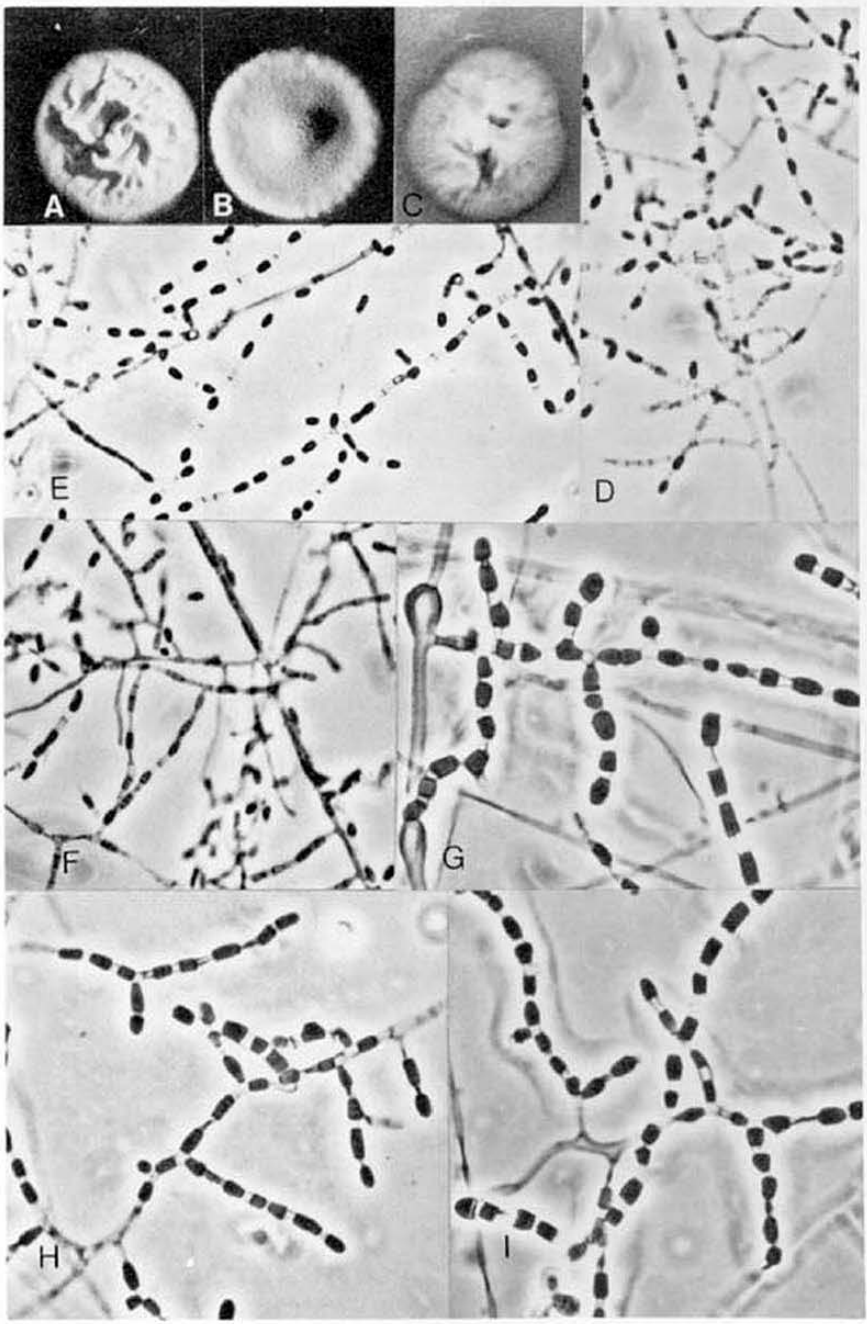
Malbranchea state of Coccidioides immitis Stiles in Rixford & Gilchrist 1996, Johns Hopkins Hospital Report 1:209-269

The cultural morphology and pathology of C. immitis are described in medical mycology textbooks (see Rippon, 1974). Since Alberta is not an endemic zone, the following description is based on two locally isolated strains (UAMH 3624 and 3667) from infected travellers. Slide cultures of these strains were kindly supplied by Dr. A. S. Sekhon (Provincial Laboratory of Public Health, Edmonton).

The arthroconidia are borne in an intercalary or terminal position on short or long, straight, lateral branches, arising at right angles from the vegetative hypha (Fig. 19G). The vegetative hyphae are narrower than the fertile branches, septate, hyaline, 2-4.5um wide, often swelling at the septa to 9um, and do not divide into arthroconidia. Arthroconidia (Figs. 19H,19I) are closely spaced, separated by short segments, hyaline, barrel-

---

Figure 19. A-F. Malbranchea gypsea (A,C-UAMH 1975; B-1843; D-F-1841). G-I. Malbranchea state of Coccidioides immitis (3624). Figs. 19A-19C. Colonial morphology after 21 days at 25 C. A and B on PYE, C on cereal. Figs. 19D-19F. Arthroconidia borne on primary hyphae and straight lateral branches. Figs. 19G-19I. Closely spaced, barrel-shaped arthroconidia borne on straight lateral branches. Colonies x 0.7, others x 600.


A
B
C
D
E
F
G
H
I

shaped, cuneiform if terminal, 3-5(6) x 3-8um, mostly 3.5-4.5 x 3-8um. In width, arthroconidia are the same or only slightly larger than the width of the fertile hypha.

Discussion

In its arthroconidium formation, C. immitis is close to the borderline between Malbranchea (conidia mostly less than 4um in diameter) and Sporendonema (conidia mostly more than 4um in diameter). However, the general appearance of the fertile hyphae and arthroconidia most closely resembles the other species of Malbranchea. Indeed, Huppert et al. (1967) apparently confused some isolates of other Malbranchea species with C. immitis and described them as variants of C. immitis. They reported that these unusual isolates produced coccidioidomycosis in mice, but made no mention of controls to rule out the possibility of accidental infection of their mice with C. immitis. Their figure 6 displays the distinctive arthroconidial morphology of Malbranchea dendritica. The type strain of M. dendritica (UAMH 2731) studied by Orr (1972) survived for long periods in mice and could be recovered from the spleen, liver and lung. However, no endosporulating spherules or other fungal elements were found in any tissue by Orr.

In the same study, Orr (1972) included three other arthroaleuriospore-forming isolates (UAMH 1941, SFVH 129; UAMH 1942, SFVH 130; UAMH 1943, SFVH 149), none of which produced coccidioidomycosis in mice. These three strains, which have been included in the species Malbranchea gypsea, are not so distinctive in their microscopic morphology. However, Figure 7 of Huppert et al. (1967) suggests M. gypsea and may be a photomicrograph of one of the above strains having SFVH numbers.

Three isolates were received from the CDC as C. immitis from Russia (UAMH 3595, 40-73-48553; UAMH 3596, 40-73-48555; UAMH 3602, 40-73-48554). They form chains of budding conidia and have been assigned to the form-genus Fusidium (Lechevalier, Lechevalier, Handley, Ghosh and Carmichael, 1976).

The arthroconidia of the Malbranchea state of C. immitis are broader than all other species of Malbranchea which are mostly less than 4um in diameter. Arthroconidia of M. sulfurea measure 2.5-4um but this species is thermophilic and forms arcuate fertile hyphae. The arthroconidia of the Malbranchea state of U. reesii are slightly narrower, 2.5-3.5um occasionally 4um in diameter and are separated by intervals of irregular length. In addition, this species regularly forms uncinate appendages in culture.

Malbranchea state of Uncinocarpus reesii Sigler & Orr sp. nov.

Perfect State: Uncinocarpus Sigler & Orr gen. nov.

Ascomycotina, Gymnoascaceae. Gymnothecia eperidiata. Asci inter appendices. Appendices laeves, aseptatae, brunneae, intertextae, uncinatae. Asci subglobosi, evanescens, octospori. Ascosporae oblatae, laeves, flavo-brunneae vel rufo-brunneae.
Typus: Uncinocarpus reesii Sigler et Orr sp. nov.

Gymnothecia more or less spherical, reddish brown. Ascomatal initials on short stalks, bulbous. Peridial hyphae, smooth, aseptate, consisting of elongate appendages loosely intertwined. Free ends extending beyond the core of the ascocarp, uncinate, sometimes spiral. Asci subglobose, evanescent, 8-spored. Ascospores oblate, smooth, yellow to reddish-brown. Malbranchea conidial state.

History

This fungus has been frequently isolated during surveys of soil and keratinous substrates. The conidial state, most often encountered, has been ascribed to Chrysosporium, Malbranchea or various conidial forms of Gymnoascaceae. The perfect state has been reported by various workers as a probable new genus of the Gymnoascaceae, but not given a name (see below).

Attention focused on the conidial state because of its resemblance to the pathogenic Coccidioides immitis. Emmons (1954) studied several Gymnoascaceae isolated from organs of rodents and other animals. Some of these, which he called Myxotrichum, formed the sexual state, whereas others, seemingly degenerate, produced only peridial appendages. The loss of fertility appeared to be related to a change in colony color from orange to white.

Examining two of Emmons' ascosporic isolates, Kuehn (1955a) described Myxotrichum emmonsii, later reduced to synonymy with Auxarthron umbrinum (Boudier) by Orr & Plunkett (in Orr et al., 1963a). Both Kuehn, and Orr and Plunkett described an arthroconidial state, though neither reported the persistence of peridial appendages in degenerate strains.

However, Kuehn et al. (1964) reported persistence of appendages but no ascocarps in isolates believed to be similar to Auxarthron brunneum. In a later report, Emmons (1967) confirmed that his ascocarpic isolates earlier designated Myxotrichum were M. emmonsii Kuehn and again reiterated his observations of peridial appendages

persisting in infertile strains. Emmons discerned little difference between Auxarthron umbrinum and A. brunneum and noted that arthroconidia of both resembled Coccidioides immitis. Furthermore, he found no evidence to suggest that appendages persisted in any other Gymnoascaceae maintained in culture.

Rees (1967a), surveying keratinophilic fungi from Australia isolated the conidial state of "? Gymnoascus uncinatus" from Rattus rattus. Later, he (1967b) isolated "Genus A" and noted its similarity to the previously reported "? G. uncinatus" which formed only arthroconidia and trichomes in culture. He concluded that the relationship of "Genus A" and "? G. uncinatus" to Gymnoascus uncinatus appeared doubtful. The type specimen of U. reesii was derived from one of Rees' strains (F143).

De Vroey (1970) reported the fungus from soil in Sulawesi, Celebes Islands. Caretta and Piontelli (1975) illustrated the conidia and appendages of a strain they isolated from soil in Italy. Hubalek (1974a) reported several isolates of the conidial state as a probable new species of Auxarthron from birds in Yugoslavia and Czechoslovakia.

Uncinocarpus reesii Sigler & Orr sp. nov.

Heterothallicus. Gymnothecia, et cetera in modo generis. Ascosporae 2.5-3 x 4-5um, plerumque 2.5-2.8 x 4-4.5um. Coloniae in agaro ad 25-30 C moderatim rapide crescunt, cremeae, vel fulva, numquam aurantiae, cumulae, convolutae, rimosae, lanuginosae vel pulveraceae. Incrementum tardum ad 37 C.
Arthroconidia (Malbranchea) copiosa, cylindrica vel doliformia, hyalina, posteriorus fulva, laevia, 2-4 x 3-6(8)um, plerumque 2.5-3.5 x 3.5-6um.
Typus: UAMH 3882, ex cruce UAMH 3880 x UAMH 3881.
Hi ex UAMH 2845 lecto.
UAMH 2845, ex pennis, Australia, 1967, Rees, F.143

Colonies on PYE (Fig. 20A) are 51-64 mm diam. in 21 days, creamy white or buff, never orange, reverse dirty yellow, domed and convoluted, or flatter with outward radiating folds, sometimes umbonate, downy or powdery. If powdery, cracks appear near center and along folds. At 37 C, colonies grow slowly (6-24 mm diam. at 21 days), adhering poorly to the cellophane, heaped up, convoluted, downy, waxy or glabrous, or grow more rapidly (Fig. 20B) (28-46 mm diam. at 21 days) slightly raised, with numerous folds, downy, white or tan, with dark brown exudate droplets, and yellow diffusing pigment. This pigment can be detected only with difficulty in some strains at 25 C, since it is usually obscured by the yellow color of the PYE.

Colonies on cereal (Fig. 20C) are 39-53 mm diam. in 21 days, creamy white, buff or tan, never orange, white periphery, reverse the same. The surface is powdery or granular, rarely downy, dense or patchy, appearing mottled, occasionally zonate, flat with small central umbo and numerous tiny cracks or fissures. At 37 C, growth at 21 days is scant (5-10 mm) or restricted (14-26 mm). Colonies of the latter (Fig. 20D) are downy, floccose and white, or tan and granular, with a brown diffusing pigment (Fig. 20D). This brown pigment is difficult to detect at 25 C.

Heterothallic. Gymnothecia (Figs. 20E,20H) discrete, reddish-brown, globose, compacted in the center, 200-1000um, with appendages extending beyond 100-250um. Ascomatal initials, hyaline, arising as short branches, septate at first, with a bulbous enlarged tip, often completely inrolled (Figs. 20F,20G). Gymnothecium composed of a loose association of intertwined appendages, uncinate at each end, often forming one or more lateral uncinate branches (Fig. 20I), smooth, thick-walled, aseptate, reddish-brown. Appendages mostly uncinate, occasionally spiral, wide at the tip, 5-8um, narrowing at center. No differentiated peridial hyphae but immature gymnothecia often surrounded by a loose weft of hyaline hyphae bearing arthroconidia. Asci evanescent, hyaline, on short stalks, subglobose, 7-9um in diameter (Figs. 20J,20K), 8-spored. Ascospores yellow-brown, reddish-brown in mass, smooth, oblate, sometimes with depression in one face (Figs. 21A,21B), 2.5-3 x 4-5um, mostly 2.5-2.8 x 4-4.5um.

Arthroconidia (Figs. 21D,21E), borne in an intercalary position along the broader (2-5um) primary hyphae, or intercalarly or terminally on short or long lateral branches, are cylindrical, sometimes barrel-shaped or cuneiform if terminal (Figs. 21F,21I). Separated by one or more segments of irregular length, arthroconidia are hyaline, later tan, smooth, 2-4 x 3-6(8)um, mostly 2.5-3.5 x 3.5-6um. Enlarged subglobose or broadly barrel-shaped arthroconidia (Fig. 21C), found in old cultures and near fertile gymnothecia, are 5-8um wide, hyaline, mostly single-celled. Racket hyphae sometimes present.

Characteristic uncinate appendages (Fig. 21G) of the conidial state appear after 7-14 days. The appendage, arising mostly as a thick-walled, more dense extension from the primary hypha (Fig. 21H), or from a thick-walled segment of the hypha resembling a foot cell, becomes uncinate at each end, often forming one or more lateral branches (Fig. 21J). The hypha bearing appendages continues to extend forming arthroconidia along its length. Appendages are uncinate, occasionally spiral, aseptate, pale brown, paler and slightly narrower (3-5um at the tip)

than the appendages forming the gymnothecium.

Holotype: UAMH 3882, dried colonies of cross of single ascospore isolates UAMH 3880x3881
Mating types: UAMH 3880 '-', single ascospore isolate 'A' of UAMH 2845
UAMH 3881 '+', single ascospore isolate 'B' of UAMH 2845

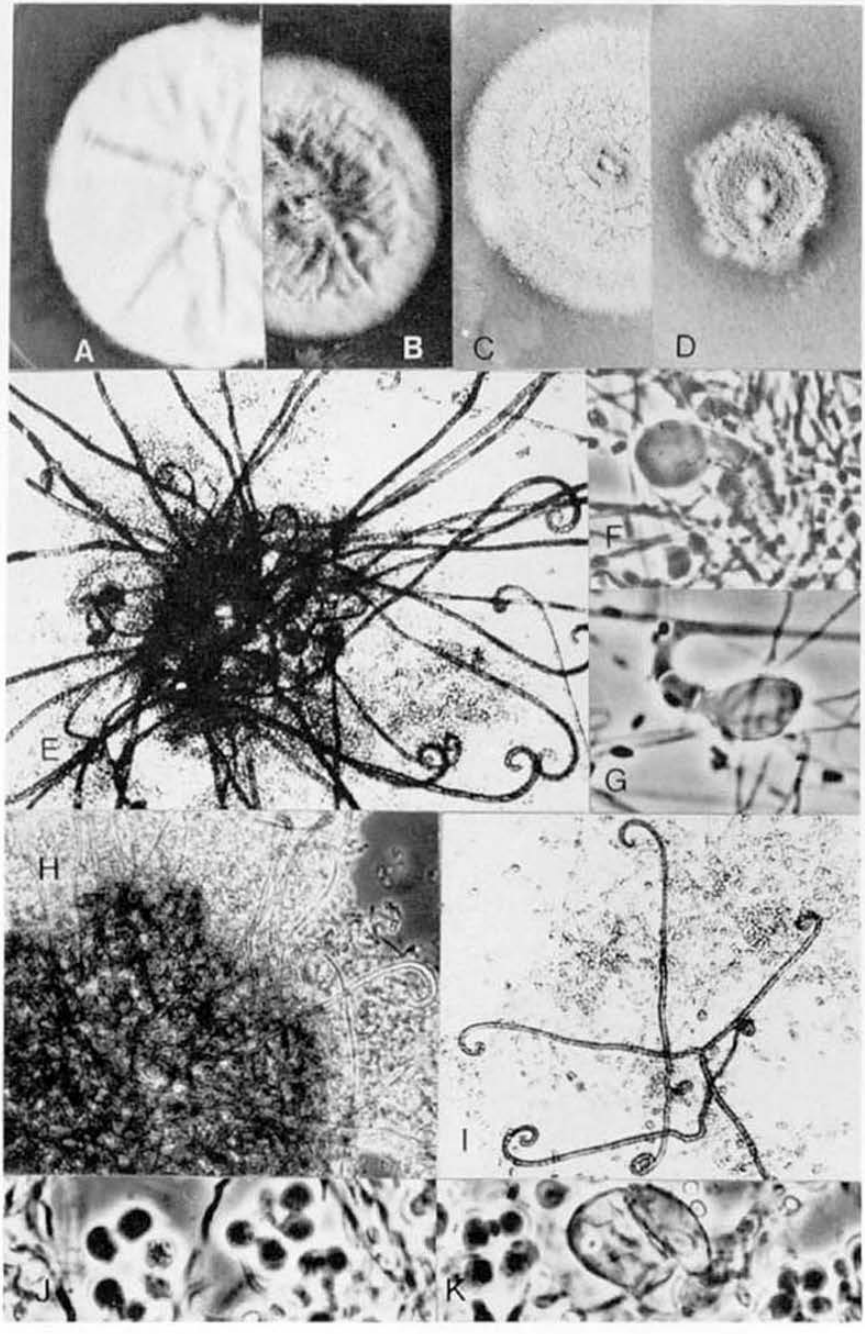
Discussion

The Malbranchea state of Uncinocarpus reesii is easily identified by its uncinate appendages. These appendages have not been seen in any other conidial state of Gymnoascaceae examined by us. Some strains lack appendages (UAMH 3257 and 3258), but nevertheless can be recognized by their arthroconidia and white or buff colonies. M. arcuata differs in forming arcuate fertile hyphae. M. fulva grows more slowly at both 25 C and 37 C; its arthroconidia are slightly narrower and often have refractile ends; and arthroconidia are separated by shorter segments, equivalent to or less than the length of an arthroconidium, compared to the intervals between arthroconidia in U. reesii which are longer and more irregular.

The genera of Gymnoascaceae are differentiated by the peridial hyphae, the shape and surface ornamentation of the ascospores and the ascomatal initials (Samson, 1972). On this basis, Uncinocarpus is similar to Gymnoascus Baranetzky, which also has oblate, smooth ascospores. Gymnoascus differs in the net-like structure of its peridial hyphae, in its ascomatal initials which are coiled, and in its Chrysosporium conidial state (Orr et al., 1963c; Samson, 1972). The peridial hyphae and reticulate or spiny, globose or oblate ascospores distinguish the genus Auxarthron. Auxarthron is similar to Uncinocarpus in its keratinolytic activity, its formation of elongate uncinate appendages, and its Malbranchea conidial states. Petalosporus (Ghosh, Orr and Kuehn, 1963) and Shanorella (Benjamin, 1956), two closely related genera, also form

---

Figure 20. Uncinocarpus reesii (A-D-2847; E-2002x2847; F-3484; G-3573; H-2845; I-2855x3257; J,K-3881x2002). Figs. 20A-20D. Colonial morphology after 21 days, x 0.7. A and B on PYE, C and D on cereal. B and D at 37 C, others at 25 C. Fig. 20E. Fertile gymnothecium composed of loose association of uncinate appendages. x 150 BF. Figs. 20F-20G. Ascomatal initials, x 600. Fig. 20H. Gymnothecium, x 150. Fig. 20I. Intertwined branched uncinate appendages from a fertile gymnothecium, x 150 BF. Fig. 20J. Asci, x 600. Fig. 20K. Asci and ascomatal initial, x 600.


A
B
C
D
E
F
G
H
I
J
K

oblate ascospores, but differ from Uncinocarpus in their rudimentary peridial hyphae and coiled ascomatal initials. In addition, species of both genera are cellulolytic.

Furthermore, although heterothallic species are common in Nannizzia, Arthroderma and Ctenomyces, none has been reported so far in the other genera of Gymnoascaceae. However, there are several reports of loss of fertility in some species (Orr et al., 1963b; Apinis, 1964; von Arx, 1971; Samson, 1972). The Myxotrichum states of Malbranchea flavorosea and M. circinata reported herein lacked ascospores, suggesting possible heterothallism.

Pathogenicity: Though the pathogenicity of U. reesii has not been firmly established, it appears to be a transient inhabitant of man and animals, and can survive for extended periods in tissue. Emmons (1954) recovered the organism from organs of rodents and other animals and from small omental abscesses at the site of intraperitoneal inoculation into mice.

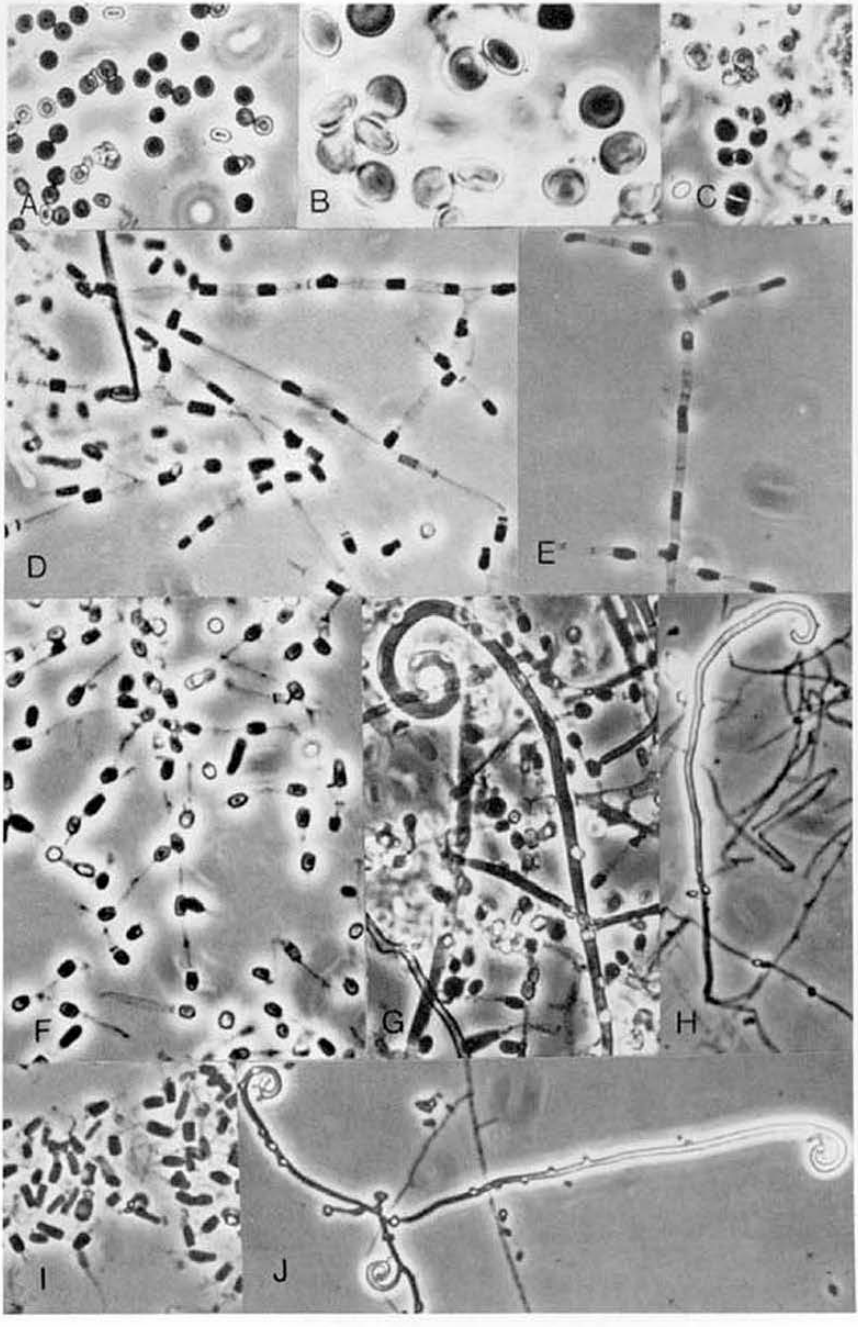
Species of Malbranchea considered to resemble C. immitis have been recovered from animal tissues, human sources and the spleen and liver of mice after intraperitoneal inoculation (Kuehn et al., 1964; Emmons, 1967; Orr, 1968, 1970). Orr (1972) reported that species of Malbranchea could be recovered from tissues of mice even when no gross lesions were apparent, and that fungal elements were not observed in any lesion.

Habitat and activities: Recorded worldwide from soil of desert and wooded area, bat guano, keratinous substrates such as feathers of wild birds and domestic fowl, organs of rodents and human sources. Strongly keratinolytic, digesting hair with the aid of penetrating bodies; not cellulolytic.

Results of Mating Tests

A. Notes on techniques

Figure 21. Uncinocarpus reesii (A-C-1704x2050; D-2845; E-2991; F-3257; G-1704; H-3485; I-3703; J-2847). Figs. 21A-21B. Smooth oblate ascospores with a depression in one face. Fig. 21C. Ascospores and enlarged, 0- or 1-septate arthroconidia. Figs. 21D-21F. Arthroconidia borne on the primary hyphae or on straight lateral branches. Fig. 21G. Uncinate appendage of the Malbranchea state. Fig. 21H. Uncinate appendage arising as a thick-walled extension from the vegetative hypha. Fig. 21I. Mature arthroconidia. Fig. 21J. Branched uncinate appendage of the Malbranchea state. B x 1680, H and J x 240, others x 600.


A
B
C
D
E
F
G
H
I
J

The presence of fertile gymnothecia in two isolates (UAMH 2845 and 3484) of ? Gymnoascus species, associated with a Malbranchea conidial state, prompted initial investigation of compatibility among several similar Malbranchea strains. Fertile crosses confirmed the sexual state to be Uncinocarpus reesii.

The two methods of inoculations used were mixed conidial suspensions (method A) and parallel inoculations of separate conidial suspensions (method B). Parallel inoculation of separate conidial suspensions (B) had the advantage that fertile gymnothecia could be easily located in the region between the tester strains, which had less dense vegetative growth. One of the problems associated with sexual crosses of Gymnoascaceae is the formation of profuse pleomorphic overgrowth which obscures gymnothecia. This degeneration occurred less rapidly in the streak-plate cultures. Gymnothecia were never formed in great abundance and when small were difficult to differentiate from clumps of conidia. Furthermore, if strains were in fact inhibitory, a readily apparent demarcation zone could be observed between the tester strains.

B. Results of crosses

The compatibility among isolates of the Malbranchea state of U. reesii is summarized in Table IV. Of the 19 wild type isolates tested, six were found to be incompatible with all other strains and with each other. The incompatible strains, UAMH 160, 1273, 1706, 1955, 2992 and 3573, resembled the others in microscopic morphology although UAMH 3573 also formed ascomatal initials in abundance. All wild type isolates were self-sterile.

C. F1 progeny

Two single ascospore progeny of the self-fertile UAMH 2845, determined to be opposite mating types by back crossing with each other, were designated + (UAMH 3881) and - (UAMH 3880) mating types. All F1 progeny were self-sterile. These tester strains when back crossed with four wild conidial isolates known to be fertile, resulted in two fertile crosses, UAMH 2002 x 3881 and UAMH 2847 x 3880 (Table IV). UAMH 2854 and 3485 failed to cross with either mating type (Table IV).

Six wild type isolates incompatible with all other conidial isolates (see Results of crosses) failed to cross with either of these two tester strains. In addition, two F1 progeny from the cross of UAMH 2002 x 2847, found to be + (UAMH 3915) and - (UAMH 3916) mating types by back crossing with the parent strains, were also incompatible with all six wild type isolates.

TABLE IV
SUMMARY OF THE FERTILE CROSSES OF UNCINOCARPUS REESII

	+ Plus mating strains						
- Minus Strains	1704	2847	2854	2855	2991	3703	3881
2002	+++	+++	+++	++	++	+++	+++
2050	++	+++	-	+++	-	-	N
2852	+	-	-	+++	-	-	N
2862	-	-	-	++	-	-	N
3257	-	-	-	+++	-	-	N
3258	+	-	-	+++	-	-	N
3485	+	+++	++	+	-	-	-
3880	N	+++	-	N	N	N	+++

\+ < 10 gymnothecia
++ 10-20 gymnothecia
+++ > 20 gymnothecia
N Not tested

Increased fertility of mating strains from the progeny of fertile crosses has been reported for other Gymnoascaceae (Kwon-Chung, 1971, 1972; Padhye and Carmichael, 1971, 1973). More work is required to determine if the failure of the six wild type isolates to cross is due to incompatibility or whether the Malbranchea state is a complex similar to that of Microsporum gypseum (Stockdale, 1963) or Trichophyton terrestre (Padhye and Carmichael, 1973).

Material Examined

Single ascospore isolates, Alberta, L. Sigler, 1975: UAMH 3882, TYPE, dried colonies of cross of UAMH 3880 x 3881; UAMH 3880, - mating type, isolate 'A' of UAMH 2845; UAMH 3881, + mating type, isolate 'E' of UAMH 2845; UAMH 3883, - mating type, ('B' of UAMH 2845); UAMH 3884, - mating type, ('C' of UAMH 2845); UAMH 3915, + mating type, ('E' of cross of UAMH 2002x2847); UAMH 3916, - mating type, ('A' of cross of UAMH 2002x2847); From keratinous material (self-fertile isolates): UAMH 2845, feathers, Aust., R.G. Rees (F143), 1967, (Orr 0-3406; NRRL A-14871; QM 9335); UAMH 3484, feathers, Aust., R.G. Rees (F122), (Orr 0-3144; NRRL A-14870); From keratinous material: UAMH 2862, feathers, Aust., R.G. Rees (F122), ?1965, from Orr; UAMH 3485, feathers, Aust., (Orr 0-3047); UAMH 3843, feathers of Corvus monedula, Krivogastani, Yug., Z. Hubalek, 1968, as 193D (0-1296); UAMH 3846, nest of Carduelis cannabina, Valtice, Czech., Z. Hubalek, 1970, as 539A (0-1304); 0-3367, feather of Jackdaw, Yug., Z. Hubalek, (766A), from Orr; From rodent lung: UAMH 160, Sylvilagus auduboni, Texas, C.E. Emmons, 1949 (C 3716); From unknown sources: UAMH 2991, from R.S. Pore, W. Virginia Medical Center, Morgantown as 707; UAMH 2992, from Pore as 718; From human sources (from Orr): 0-2559, sputum, Mo., Bransberg (118); 0-3222, child's hair, Arg., Negroni (274); 0-3718, child's hair, Arg., Negroni (276); 0-782, child's hair, Arg., Negroni (255), from Orr; From soil, California isolates: UAMH 1704, G.P. Orr, 1960, (0-2080); UAMH 1706, G.F. Orr, 1957, (0-482a); 0-216, G.P. Orr; 0-2569, G.P. Orr; Hungarian isolates, Szathmary, 1967 (from Orr): UAMH 2847, fabric bait (0-3513); UAMH 2854, fabric bait (SZ 284); UAMH 2855, fabric bait (SZ 303); Italian isolates: UAMH 2002, E. Varsavsky, 1964, from Orr, (EV 1-14); UAMH 2050, from Varsavsky (I-79); UAMH 2852, E. Varsavsky, 1964, (Orr I-26); UAMH 3573, E. Varsavsky, (Orr 0-3407); UAMH 3819, E. Varsavsky (I-5), (Orr 0-3344); UAMH 3820, E. Varsavsky (I-15), (Orr 0-3233); UAMH 3918, Pavia, G. Caretta (E 21 +), (Orr 0-1322); 0-1323, Pavia, G. Caretta (E 25), from Orr; 0-1324, Pavia, G. Caretta, (E 9 I+), from Orr; South American isolates: UAMH 1955, Arg., E. Varsavsky, (Orr EV-50; 0-3597); 0-3451, Arg., Negroni (408), from Orr; UAMH 1273, Venez., Pollak (5770) from Ajello, CDC 45-36-62; 0-2558, Mexico, Plunkett (707), from Orr; Indian isolates: UAMH 3257, from H.C. Gugnani, National Institute of

Communicable Diseases, Delhi, as S673; UAMH 3258, from Gugnani as S1038; 0-2081, Garg (1045), from Orr.

ACKNOWLEDGMENTS

As is indicated in Materials and Methods and in the lists of material studied, this work would have been very incomplete without the cultures and specimens sent to us by many mycologists around the world. We are particularly indebted to Dr. G.F. Orr, whose frequent gifts of *Malbranchea* cultures prompted this study.

We also offer special thanks to Mme. J. Nicot, who searched for type specimens of species described by Bainier and Desmazieres; to Dr. A.S. Sekhon who lent us a de Fronbrune micromanipulator; and to Drs. L.K. Weresub and W.B. Kendrick who read the draft manuscript and made many suggestions for improving it.

REFERENCES

Ainsworth, G. C. 1973. Introduction and keys to higher taxa. Chpt. 1. In The Fungi Vol. IVA. (Ainsworth et al., eds.) Academic Press, N.Y.

Ajello, L. and A. Padhye. 1974. Keratinophilic fungi of the Galapagos Islands. Mykosen 17(10):239-243.

Apinis, A. E. 1964. Revision of British Gymnoascaceae. Mycol. Papers CMI 96:1-56.

Apinis, A. E. 1970. Concerning *Rollandina*. Trans. Brit. mycol. Soc. 55(3):499-502.

Arnaud, G. 1952. Mycologie concrète: genera I. Bull. Soc. Mycol. Fr. 68:181-223.

Arnaud, G. 1954. Mycologie concrète: genera II. Bull. Soc. Mycol. Fr. 69:265-306.

Arx, J. A. von. 1970. The Genera of Fungi Sporulating in Pure Culture. Verlag-Cramer, Lehre.

Arx, J. A. von. 1971. On *Arachniotus* and related genera of the Gymnoascaceae. Persoonia 6(3):371-380.

Arx, J. A. von. 1972. On *Endomyces*, *Endomycopsis* and related yeast-like fungi. Ant. van Leeuw. 38(3):289-309.

Arx, J. A. von. 1973. Further observations on *Sporotrichum* and some similar fungi. Persoonia 7(2):127-130.

Awao, T. and S.-I. Otsuka. 1973. Notes on thermophilic fungi in Japan(2). Trans. mycol. Soc. Japan 14:221-236.

Bainier, M. G. 1907. Mycothèque de l'école de pharmacie. X. *Sporendonema casei*. Bull. Soc. Mycol. Fr. 23:23-25 and pl. vi.

Baldacci, E., R. Ciferri and E. Vaccari. 1939. Revisione sistematica del genre *Malbranchea* Sacc. Atti Ist. Bot. Critt. Ital. Univ. Pavia ser. 4; 11:75-103.

Barron, G. L. 1961. Studies on species of *Oidiodendron*, *Helicodendron* and *Stachybotrys* from soil. Can. J. Bot.

39:1563-1571.
Barron, G. L. 1962. New species and new records of Oidiodendron. Can. J. Bot. 40:589-607.
Barron, G. L. and C. Booth. 1966. A new species of Arachniotus with an Oidiodendron conidial state. Can. J. Bot. 44:1057-1061.
Benjamin, R. K. 1956. A new genus of the Gymnoascaceae with a review of other genera. El Aliso 3(3):301-328.
Berkeley, M. J. and C. E. Broome. 1850. Notices of British fungi. Ann. Mag. Nat. Hist., Ser. 2, 5:455-466.
Berkeley, M. J. and C. E. Broome. 1873. Notices of British fungi. Ann. Mag. Nat. Hist. Ser. 4, 11:339-349.
Beyma thoe Kingma, F. H. van 1933. Beschreibung einiger neuer Pilzarten usw. Zentralbl. Bakter. Parasitkende 2, Abt. 88:134.
Boeck, L. D., M. M. Hoehn, J. E. Westhead, R. K. Wolter, D. N. Thomas. 1975. New azasteroidal antifungal antibiotics from Geotrichum flavo-brunneum. 1. Discovery and fermentation studies. J. Antibiot. 28(2):95-101.
Bolognesi, G. and G. A. Chiurco. 1925. Sopr una nuova micosi del torace ("Malbranchea Bolognesii-Chiurcoi" Vuillemin, Pollacci et Nannizzi) Arch. Biol. (Genoa) Nuova Ser., 1:255-276.
Bonorden, H. F. 1851. Handbuch der Allgemeinen Mykologie. Stuttgart.
Brefeld, O. 1889. Basidiomyceten III. Untersuchungen aus dem Gesammtgebiete der Mykologie. VIII Heft. Verlag von Arthur Felix, Leipzig.
Brodie, H. J. 1936. The occurrence and function of oidia in the Hymenomycetes. Am. J. Bot. 23(5):309-327.
Bubak, F. 1912. Ein Beitrag zur Pilzflora von Sachsen. Ann. Mycol. 10:51-53
Buller, A. H. R. 1933. Researches on Fungi. Vol. 5. Longmans, Green and Co., London.
Butler, E. E. and L. J. Petersen. 1972. Endomyces geotrichum a perfect state of Geotrichum candidum. Mycologia 64(2):365-374.
Calavan, E. C. and J. M. Wallace. 1954. Hendersonula toruloidea Nattrass on citrus in California. Phytopathology 44:635-639.
Campbell, C. K. 1974. Studies on Hendersonula toruloidea isolated from human skin and nail. Sabouraudia 12:150-156.
Campbell, C. K., A. Kurwa, A.-H. M. Abdel-Aziz and C. Hodgson. 1973. Fungal infection of skin and nails by Hendersonula toruloidea. Brit. J. Dermat. 89:45-52.
Caretta, G. 1959. Caratteristiche ed affinita del genere Coprotrichum. Atti Ist. Bot. Critt. Univ. Pavia, ser. 5, 17:2-12.
Caretta, G. 1960. Coremiella cuboidea (Sacc. et Ell.) Cif. et Car. n. comb. isolata da feci umane. Mycopath. et Mycol. Appl. 12(3):233-250.
Caretta, G. and E. Piontelli. 1975. Isolation of

keratinophilic fungi from soil in Pavia, Italy. Sabouraudia 13:33-37.
Carmichael, J. W. 1955. Lacto-fuchsin: a new medium for mounting fungi. Mycologia 47(4):611.
Carmichael, J. W. 1957. Geotrichum candidum. Mycologia 49(6):820-830.
Carmichael, J. W. 1962. Chrysosporium and some other aleuriosporic Hyphomycetes. Can. J. Bot. 40:1137-1173.
Carmichael, J. W. 1963. Dried mold colonies on cellophane. Mycologia 55(3):283-288.
Chang, Y. 1967. The fungi of wheat straw compost. II. Biochemical and physiological studies. Trans. Brit. mycol. Soc. 50(4):667-677.
Chang, Y. and H. J. Hudson. 1967. The fungi of wheat straw compost. I. Ecological studies. Trans. Brit. mycol. Soc. 50(4):649-666.
Chapman, E. S. 1974. Effect of temperature on growth of seven thermophilic fungi. Mycologia 66(3):542-546.
Chidester, M. S. 1940. A pink stain of wood caused by a species of Geotrichum. Phytopathology 30:530-536.
Ciferri, R. 1958. Manuale di Micologia Medica. Tomo I. Renzo, Cortino, Pavia 370pp.
Cochet, G. 1939. Sur un nouveau champignon arthrosporé (Arthrographis langeroni) agent pathogène d'une onychomycose humaine. n. g., n. sp. Ann. Parasit. Hum. Comp. 17:98-101 and pl. 3.
Cole, G. T. 1975. The thallic mode of conidiogenesis in the fungi imperfecti. Can. J. Bot. 53(24):2983-3001.
Cole, G. T. and W. B. Kendrick. 1969. Conidium ontogeny in Hyphomycetes. The arthrospores of Oidiodendron and Geotrichum, and the endoarthrospores of Sporendonema. Can. J. Bot. 47:1773-1780.
Cooney, D. G. and R. Emerson. 1964. Thermophilic Fungi. W. H. Freeman and Co., San Francisco. 188 pp.
Corda, A. C. J. 1838. Icones fungorum hucusque cognitorum. Tomus II:1-43.
Crisan, E. V. 1973. Current concepts of thermophilism and the thermophilic fungi. Mycologia 65:1171-1198.
Dale, E. 1903. Observations on Gymnoascaceae. Ann. Bot. 17:571-596.
Davidson, R. W., W. A. Campbell and G. W. Weber. 1942. Ptychogaster cubensis, a wood decaying fungus of southern oaks and waxmyrtle. Mycologia 34:142-153.
Davidson, R. W., C. M. Christensen and E. F. Darley. 1946. Polyporus guttulatus and Ptychogaster rubescens. Mycologia 38:652-663.
Davis, W. H. 1939. A bud and twig blight of azalea caused by Sporocybe azaleae. Phytopathology 29:517.
Dawson, C. O. and J. C. Gentles. 1961. The perfect states of Keratinomyces ajelloi Vanbreuseghem, Trichophyton terrestre Durie and Frey and Microsporum nanum Fuentes. Sabouraudia 1:49-57.
Dawson, C. O., J. C. Gentles and E. M. Brown. 1964. Environmental conditions affecting sexual reproduction

in Arthroderma and Nannizzia. Sabouraudia 3(3):245-250.
Desmazières, M. J. B. H. J. 1827. Observations sur le Sporendonema casei; nouveau genre de Mucedinées. Ann. Sci. Nat. XI:246-249.
Deverall, B. J. 1968. Psychropniles In The Fungi vol. III (Chpt. 5) (Ed. Ainsworth, G. C. and A. S. Sussman) Academic Press, N. Y.
Dodge, C. W. 1935. Medical Mycology. C. V. Mosby, St. Louis 900 pp.
Donk, M. A. 1933. Revision der niederlanischen Homobasidiomycetae Aphyllophoraceae II, 9. Mededeelingen van het Botanisch Museum en Herbarium van de Rijks Universiteit te Utrecht 22:153.
Eicker, A. 1972. Occurrence and isolation of South African thermophilic fungi. S. Afr. J. Science 68:150-155.
Eidam, E. 1882. Über Entwicklungsgeschichte der Ascomyceten. Botanische Zentralblat. 10:106-107.
Elisei, F. G. 1940a. Nuovo reperto e nuova interpretazione morfologica e sistematica di Malbranchea pulchella Sacc. et Penz. considerata come una nuova specie e un nuova genere di dermatofiti. Atti Ist. Bot. Critt. Univ. Pavia, Ser. 4; 12:141-200.
Elisei, F. G. 1940b. Le ife pettinate e i fusi di Malbranchea Sacc. Atti Ist. Bot. Critt. Pavia, Ser. 4, 12:213-219.
Ellis, M. B. 1971. Dematiaceous Hyphomycetes. Commonwealth Mycological Institute, Kew, Surrey.
Emmons, C. W. 1954. Isolation of Myxotrichum and Gymnoascus from the lungs of animals. Mycologia 46:334-338.
Emmons, C. W. 1967. Fungi which resemble Coccidioides immitis. In Coccidioidomycosis (Ed. L. Ajello) University of Arizona Press, Tucson.
Eriksson, J. and L. Ryvarden. 1973. The Corticiaceae of North Europe. Vol. 2. Fungiflora, Oslo, Norway.
Evans, H. C. 1971. Thermophilous fungi of coal spoil tips II. Trans. Brit. mycol. Soc. 57(2):255-266.
Evans, E. G. V. and H. Hose. 1975. In vitro degradation of human hair by Hendersonula toruloidea. Sabouraudia 13:323-328.
Fassatiova, O. 1971. Some new records of Hyphomycetes from Czechoslovakia. Cseka Mykologie 25(2):112-117.
Fennell, D. I. 1973. Plectomycetes; Eurotiales. Chpt. 4. In The Fungi Vol. IVA (Ainsworth, G. C., P. K. Sparrow and A. S. Sussman, eds.) Academic Press, N. Y.
Fergus, C. L. 1969. The cellulolytic activity of thermophilic fungi and actinomycetes. Mycologia 61:120-129.
Fidalgo, O. 1958. Studies on Ptychogaster rubescens Boud. the chlamydosporiferous form of Polyporus guttulatus Pk. Mycologia 50:831-836.
Findlay, J. A. and D. Kwan. 1973a. Scytalone (3,6,8-trihydroxytetralone), a metabolite from a Scytalidium species. Can. J. Chem. 51(10):1617-1619.
Findlay, J. A. and D. Kwan. 1973b. Metabolites from a

Scytalidium species. Can. J. Chem. 51(19):3299-3301.
Fries, E. M. 1832. Systema Mycologicum 3:434
Gentles, J. C. and E. G. V. Evans. 1970. Infection of the feet and nails with Hendersonula toruloidea. Sabouraudia 8:72-75.
Geigert, J., F. R. Stermitz and H. A. Schroeder. 1973. Two new natural substituted hexenophenones from the fungus Scytalidium. Tetrahedron 29:2343-2345.
Ghosh, G. R., G. P. Orr and H. H. Kuehn. 1963. A new genus of the Gymnoascaceae with a rudimentary peridium. Mycopath. et Mycol. Appl. 21(1):36-44.
Gordee, R. S. and T. P. Butler. 1975. New azasteroidal antifungal antibiotics from Geotrichum flavo-brunneum. III. Biological activity. J. Antibiot. 28(2):112-117.
Gould, W. D., J. I. Fujikawa and P. D. Cook. 1974. A soil fungus tolerant to extreme acidity and high salt concentration. Can. J. Microbiol. 20(7):1023-1027.
Hammer, B. W. and J. C. Gilman. 1944. Red mold on blue cheese. J. Dairy Science 27:413-418.
Hennebert, G. L. 1971. Pleomorphism in fungi imperfecti. In Taxonomy of Fungi Imperfecti (Kendrick, W. B., ed.) Univ. of Toronto Press, Toronto.
Heslop-Harrison, J. 1962. Purposes and procedures in the taxonomic treatment of higher organisms. In Microbial Classification (Ainsworth, G. C. and P. H. A. Sneath, eds.) University of Cambridge Press, Cambridge.
Holubová-Jechová, V. 1969. New species of the genus Oidium Link ex. Fr. emend. Linder. Česká Mykologie 23(4):209-221.
Hubalek, Z. 1974a. Fungi associated with free-living birds in Czechoslovakia and Yugoslavia. Acta Scientiarum naturalium, Brno 8(3):1-62.
Hubalek, Z. 1974b. The distribution patterns of fungi in free-living birds. Acta Scientiarum naturalium, Brno 8(9):1-51.
Hubalek, Z., F. Balat, I. Touskova and J. Vik. 1973. Mycoflora of birds' nests in nest-boxes. Mycopath. et Mycol. Appl. 49(1):1-12.
Hubalek, A. and F. Balat. 1974. The survival of microfungi in the nests of tree sparrow [Passer montanus L.] in the nest-boxes over the winter season. Mycopath. et Mycol. Appl. 54:517-530.
Hudson, H. J. 1973. Thermophilous and thermotolerant fungi in the air-spora at Cambridge. Trans. Brit. mycol. Soc. 60(3):596-599.
Hughes, S. J. 1952. Fungi from the gold coast. I. Mycol. Papers CMI 48:40.
Hughes, S. J. 1953. Conidiophores, conidia and classification. Can. J. Bot. 31:577-659.
Hughes, S. J. 1958. Revisiones hyphomycetum aliquot cum appendice de nominibus rejiciendis. Can. J. Bot. 36:727-836.
Hughes, S. J. 1959. Starting point of nomenclature of Hyphomycetes. Taxon 8(3):96-103.

Hughes, S. J. 1968. Some Gymnoascaceae. Can. J. Bot. 46:939-943.

Huppert, M., S. H. Sun and J. W. Bailey. 1967. Natural variability in Coccidioides immitis. In Coccidioidomycosis (Ed. L. Ajello) Univ. Arizona Press, Tucson.

Hussain, A. and M. A. B. Malik. 1972. Three new records of fungi from Pakistan. Pak. J. Sci. Ind. Res. 15:88.

Kambayashi, T. 1934. Über ein von einer Spezies der Malbranchea hervorgerufenes Hautleiden in Chine. Arch. Dermatol. Syph. 170:97-106.

Kendrick, W. B. (ed.) 1971. Taxonomy of Fungi Imperfecti. Univ. Toronto Press, Toronto.

Kendrick, W. B. and J. W. Carmichael. 1973. Hyphomycetes. Chpt. 10. In The Fungi Vol. IVA. (Ainsworth et al., eds) Academic Press, N. Y.

Kiffer, E., P. Mangenot, and O. Reisinger. 1969. Sur la position taxinomique de quelques Hyphomycètes isolés des sols de la R. C. P. 40. Rev. Ecol. Biol. Sol, 6(2):181-194.

Klingstrom, A. and L. Beyer. 1965. Two new species of Scytalidium with antagonistic properties to Fomes annosus (Fr.) Cke. Sv. Bot. Tidskr. 59(1):30-36.

Klingstrom, A. E. and S. M. Johansson. 1973. Antagonism of Scytalidium isolates against decay fungi. Phytopathology 63(4):473-479.

Kobayashi, Y., N. Hiratsuka, R. P. Korf, K. Tubaki, K. Aoshima, M. Soneda, and J. Sugiyama. 1967. Mycological studies of the Alaskan arctic. Ann. Rep. Inst. Ferm. Osaka 3(1):202.

Kobayashi, Y., N. Hiratsuka, Y. Otani, K. Tubaki, S.-I. Udagawa and M. Soneda. 1969. The second report on the mycological flora of the Alaskan arctic. Bull. Nat. Sci. Mus. 12(2):311-430.

Komatsu, M. 1969. Notes on the hyphomycetous fungi isolated from sawdust-ricebean media of Pholiota nameko (Ito) Ito et Imai. Rep. Tottori Mycol. Inst. 7:78-89.

Kuehn, H. H. 1955a. Observations on Gymnoascaceae I. Myxotrichum uncinatum and a new species of Myxotrichum. Mycologia 47:533-545.

Kuehn, H. H. 1955b. Observations of Gymnoascaceae II. Two new species of Myxotrichum. Mycologia 47:878-889.

Kuehn, H. H. 1959. A preliminary survey of the Gymnoascaceae II. Mycologia 51:665-692.

Kuehn, H. H. and G. F. Orr. 1959. Observations on Gymnoascaceae VI. A new species of Arachniotus. Mycologia 51:864-870.

Kuehn, H. H., G. F. Orr and G. R. Ghosh. 1964. Pathological implications of the Gymnoascaceae. Mycopath. et Mycol. Appl. 24(1):35-46.

Kuhlman, E. G., J. W. Carmichael and T. Miller. 1976. Scytalidium uredinicola, a new mycoparasite of Cronartium fusiforme on Pinus. Mycologia (in press).

Kwon-Chung, K. J. 1969. Coccidioides immitis : cytological

study on the formation of the arthrospores. Can. J. Gen. Cytol. 11:43-52.
Kwon-Chung, K. J. 1971. Genetic analysis on the incompatibility system of Ajellomyces dermatitidis. Sabouraudia 9:231-238.
Kwon-Chung, K. J. 1972. Genetic study on the incompatibility system in Arthroderma simii. Sabouraudia 10:74-78.
Lamater, E. D. de. 1937. Eidamella spinosa Matruchot and Dassonville refound. Mycologia 29:572-582.
Lechevalier, H., M. P. Lechevalier, D. A. Handley, B. K. Ghosh and J. W. Carmichael. 1976. Strains of fusidia which can be mistaken for actinomycetes. Mycologia (in press).
Lindau, G. 1907. Hyphomycetes (erste Hälfte). In Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. 2 ed. Vol. 1, Sect. VIII, E. Kummer, Leipzig.
Lindau, G. 1910. Hyphomycetes (zweite Hälfte). In Rabenhorst's Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz. 2 ed., Vol. 1, Sect. IX, E. Kummer, Leipzig.
Linder, D. H. 1942. A contribution towards a monograph of the genus Oidium (Fungi Imperfecti). Lloydia 5:165-207.
Lodder, J. 1970. The Yeasts. North-Holland Publ. Co., Amsterdam.
Lodder, J. and N. J. W. Kreger van Rij. 1952. The Yeasts, a Taxonomic Study. North-Holland Publ. Co., Amsterdam.
Lucas, M. T., A. B. Carvalho and M. C. Barreiro. 1974. Pear fruit rot caused by Coremiella cubispora. Trans. Brit. mycol. Soc. 62:206-208.
Malloch, D. and R. F. Cain. 1971. New genera of Onygenaceae. Can. J. Bot. 49(6):838-846.
Massee, G. and E. S. Salmon. 1902. Researches on coprophilous fungi. II. Annals Botany, London 16:57-93.
Maxwell, M. B. 1954. Studies of Canadian Thelephoraceae. XI. Conidium production in the Thelephoraceae. Can. J. Bot. 32:259-280.
Michel, K. H., R. L. Hamill, S. H. Larsen and R. H. Williams. 1975. New azasteroidal antifungal antibiotics from Geotrichum flavo-brunneum. II. Isolation and characterization. J. Antibiot. 28(2):102-111.
Miehe, H. 1907. Thermoideum sulfureum n. g., n. sp., ein neuer Wärmepilz. Deutsche Botanische Gesellschaft 25:510-515.
Miller, J. H., J. E. Giddens and A. A. Foster. 1957. A survey of the fungi of forest and cultivated soils of Georgia. Mycologia 49:779-808.
Minoura, K., M. Yokoe, T. Kizima and T. Nehira. 1973. Thermophilic filamentous fungi in Japan. Trans. mycol. Soc. Japan 14(4):352-361.
Morrall, R. A. A. 1966. Two new species of Oidiodendron from boreal forest soils. Can. J. Bot. 46:203-206.
Morris, E. F. 1963. The synnematous genera of the Fungi

Imperfecti. West. Ill. Univ. Ser. Biol. Sci. 3:32-33.
Müller, E., J. Harr and P. Sulmont. 1969. Deux Ascomycètes dont le stade conidien présente des conidies phaeophragmiées endogènes. Rev. Mycol. 33(5):369-378.
Muller, E. and R. Pacha-Aue. 1968. Untersuchungen an drei Arten von Arachniotus Schroeter. Nova Hedwigia 15:551-558 and Taf. 76-78.
Mumma, R. O., C. L. Fergus and R. D. Sekura. 1970. The lipids of thermophilic fungi: lipid composition comparisons between thermophilic and mesophilic fungi. Lipids 5:100-103.
Murao, S., K. Oda and Y. Matsushita. 1973. Isolation and identification of a microorganism which produces non Streptomyces pepsin inhibitor and N-diazoacetyl-DL-norleucine methylester senstitive acid proteases. Agr. Biol. Chem. 37:1417-1421.
Nag Raj, T. R. and B. Kendrick. 1976 (in press). A Monograph of Chalara and Allied Genera. Wilfred Laurier Univ. Press, Waterloo.
Nattrass, R. M. 1933. A new species of Hendersonula (H. toruloidea) on deciduous trees in Egypt. Tran. Brit. mycol. Soc. 18:189-198.
Nicot, J. 1972. Mauginiella scaettae Cav. Pourriture de l'inflorescence du palmier-dattier. Rev. Mycol. 37(3):Fiche de Phytopath. Trop. no. 24, 5 pp. (published 1973)
Nicot, J. and M.-J. Charpentie. 1971. Index des fungi imperfecti décrits par G. Arnaud (Mycologie Concrète. Genera I et II). Bull. Soc. Mycol. France 87:25-38.
Nobles, M. K. 1948. Studies in forest pathology. VI. Identification of cultures of wood rotting fungi. Can. J. Research, C, 26:281-431.
Ong, P. S. and G. M. Gaucher. 1973. Protease production by thermophilic fungi. Can. J. Microbiol. 19:129-133.
Orr, G. F. 1968. Some fungi isolated with Coccidioides immitis from soils in endemic areas in California. Bull. Torrey Bot. Club 95(5):424-431.
Orr, G. F. 1970. Neogymnomyces, a new genus of the Gymnoascaceae. Can. J. Bot. 48(6):1061-1066.
Orr, G. F. 1972. Recovery of several arthroaleuriosporous fungi from mice following intraperitoneal inoculation. Mimeographed Technical Report, Desert Test Center, Dugway, DTC project number TN-72-542 (RDTE number I-T-O-61101-A-91A, USATECOM number 9-CO-043-000-002).
Orr, G. F. and H. H. Kuehn. 1963. Gymnoascus verticillatus Smith. Mycopath. et Mycol. Appl. 21(3-4):211-216.
Orr, G. F. and H. H. Kuehn. 1964a. A reevaluation of Myxotrichum spinosum and M. cancellatum. Mycologia 56(4):473-481.
Orr, G. F. and H. H. Kuehn. 1964b. A new genus of the Gymnoascaceae with dark ascocarps. Mycologia 54(4):482-487.
Orr, G. F. and H. H. Kuehn. 1971. Notes on Gymnoascaceae. I. A review of eight species. Mycologia 63(2):191-203.

Orr, G. F. and H. H. Kuehn. 1972. Notes on Gymnoascaceae. II. Some Gymnoascaceae and keratinophilic fungi from Utah. Mycologia 64:55-72.
Orr, G. F., H. H. Kuehn and O. A. Plunkett. 1963a. A new genus of the Gymnoascaceae with swollen peridial hyphae. Can. J. Bot. 41:1439-1456.
Orr, G. F., H. H. Kuehn and O. A. Plunkett. 1963b. The genus Myxotrichum Kunze. Can. J. Bot. 41:1457-1480.
Orr, G. F., H. H. Kuehn and O. A. Plunkett. 1963c. The genus Gymnoascus Baranetzky. Mycopath. et Mycol. Appl. 21(1):1-18.
Oudemans, C. A. J. A. 1904. Exosporina Laricis Oud. A new microscopic fungus occurring on the larch and very injurious to this tree. Proc. K. Akad. Wetensch. Amersterdam 6:498-501 and fig. A-C.
Paden, J. W. 1975. Ascospore germination, growth in culture, and imperfect spore formation in Cookeina sulcipes and Phillipsia crispata. Can. J. Bot. 53(1):56-61.
Padhye, A. A. 1969. Behavior of non-pigment forming isolates of Keratinomyces ajelloi mated with Arthroderma uncinatum. Mycologia 61:1175-1177.
Padhye, A. A. and J. W. Carmichael. 1969. Mating behavior of Trichophyton mentagrophytes varieties paired with Arthroderma benhamiae mating types. Sabouraudia 7(3):178-181.
Padhye, A. A. and J. W. Carmichael. 1971. Incompatibility in Microsporum cookei. Sabouraudia 9:27-29.
Padhye, A. A. and J. W. Carmichael. 1972. Arthroderma insingulare sp. nov., another gymnoascaceous state of the Trichophyton terrestre complex. Sabouraudia 10:47-51.
Padhye, A. A. and J. W. Carmichael. 1973. Mating reactions in the Trichophyton terrestre complex. Sabouraudia 11:64-69.
Padhye, A. A., A. S. Sekhon and J. W. Carmichael. 1973. Ascocarp production by Nannizzia and Arthroderma on keratinous and non-keratinous media. Sabouraudia 11:109-114.
Pesante, A. 1957. Osservazioni su una carie del platano. Ann. Sper. Agr. (Roma) 11, suppl. CCLXI-CCLXV.
Plunkett, O. A., L. Walker and M. Huppert. 1963. An unusual isolate of Coccidioides immitis from the Los Banos area of California. Sabouraudia 3(1):16-20.
Pouzar, Z. and V. Jechová. 1967. Botryobasidium robustior spec. nov., a perfect state of Oidium rubiginosum (Fr.) Linder. Česká Mykologie 21(2):69-73.
Quinta, M. L. 1968. Natural destruction of the mycological flora of sea salt. Food Technology 22(12):103-105.
Rea, C. 1922. British Basidiomycetae. Cambridge Univ. Press
Rebell, G. and D. Taplin. 1970. Dermatophytes. Their Recognition and Identification. U. Miami Press, Coral Gables, Florida.
Redaelli, P. and R. Ciferri. 1934. Studio comparativo di

ventum ceppi di Sporendonema epizoum (Corda) Nobis (= Hemispora stellata Vuillemin; = Oospora d'Agatae Saccardo; ecc.). Atti Ist. Bot. Critt. Univ. Pavia, ser. 4, 5:145-198.
Rees, R. G. 1967a. Keratinophilic fungi from Queensland. I. Isolations from animal hair and scales. Sabouraudia 5(3):165-172.
Rees, R. G. 1967b. Keratinophilic fungi from Queensland. III. Isolations from feathers of domestic fowls. Sabouraudia 6(1):19-28.
Ricard, J. L. and W. B. Bollen. 1968. Inhibition of Poria carbonica by Scytalidium sp., an imperfect fungus from Douglas-fir poles. Can. J. Bot. 46:643-647.
Rippon, J. W. 1974. Medical Mycology. W. B. Saunders and Co., Philadelphia.
Rivelloni, G. 1938. Isolamento di un raro micete (Malbranchea Bolognesii-Chiurcoi) da una micosi umana. Boll. Sez. Reg. Suppl. Giorn. Ital. Derm. Sif. 16:384.
Rode, L. J., J. W. Foster and T. V. Schuhardt. 1947. Penicillin production by a thermophilic fungus. J. Bact. 53:565-566.
Saccardo, P. A. 1882. Michelia commentarium mycologicum fungos in primis Italicos 2:638
Saccardo, P. A. 1886. Sylloge fungorum omnium hucusque cognitorum IV: 1-807.
Saccardo, P. A. 1888. Sylloge fungorum omnium hucusque cognitorum 6:388.
Saccardo, P. A. 1908. Notae mycologicae. Ser. X. Ann. Mycol. 6:553-569.
Saccardo, P. A. and A. Trotter. 1913. Sylloge fungorum omnium hucusque cognitorum 22:1240.
Saez, H. 1964. Geotrichum vanrijn nouvelle espèce de champignon arthrosporé isolé chez une sarcelle d'été (Anas querquedula L.). Bull. Mens. Soc. Linn. Lyon 33(7):263-267.
Samson, R. A. 1972. Notes on Pseudogymnoascus, Gymnoascus and related genera. Acta Bot. Neerl. 21(5):517-527.
Samson, R. A. and H. A. van der Aa. 1973. Het ascomycet engeslacht Onygena. Coolia 16(12):30-35.
Sekhon, A. S., A. A. Padhye and J. W. Carmichael. 1973. Mating reactions in Arthroderma tuberculatum. Sabouraudia 11:283-286.
Shields, J. K. 1969. Microflora of eastern Canadian wood chip piles. Mycologia 61:1165-1168.
Sigler, L. and J. W. Carmichael. 1974. A new acidophilic Scytalidium. Can. J. Microbiol. 20(2):267-268.
Singh, S., B. Singh, and R. K. Baksni. 1961. Merulius tremellosus (Schrad.) Fr. and its Ptychogaster stage. Can. J. Bot. 39:1845-1847.
Smith, A. L. 1900. Some new microscopic fungi. VII. Journal Royal Microscopic Society 1900:422-424.
Smith, A. L. 1901. Fungi new to Britain. Trans. Brit. mycol. Soc. 1:150-158.
Smith, G. 1962. Some new and interesting species of micro-

fungi. III. Trans. Brit. mycol. Soc. 45(3):387-394 and pl. 8, fig. 4.
Smith, R. S. and A. Ofosu-Asiedu. 1972. Distribution of thermophilic and thermotolerant fungi in a spruce-pine chip pile. Can. J. Forest Res. 2(1):16-26.
Stalpers, J. A. 1975. Revision of the genus Oedoceophalum (Fungi Imperfecti). Proc. Koninkl. Nederl. Akad. van Wetenschappen, Amsterdam. Ser. C, 77(4):383-401.
Starkey, R. L. 1973. Effect of pH on toxicity of copper to Scytalidium sp., a copper tolerant fungus, and some other fungi. J. Gen. Microbiol. 78:217-225.
Starkey, R. L. and S. A. Waksman. 1943. Fungi tolerant to extreme acidity and high concentrations of copper sulfate. J. Bact. 45(5):509-519.
Stillwell, M. A., R. E. Wall and G. M. Strunz. 1973. Production, isolation, and antifungal activity of scytalidin, a metabolite of Scytalidium species. Can. J. Microbiol. 19(5):597-602.
Stockdale, P. M. 1963. The Microsporum gypseum complex (Nannizzia incurvata Stockd., N. gypsea (Nann.) comb. nov., N. fulva sp. nov.). Sabouraudia 3(1):114-126.
Stolk, A. C. and R. A. Samson. 1972. The genus Talaromyces. Studies on Talaromyces and related genera II. Studies in Mycology 2:1-65.
Sumstine, D. R. 1913. Studies on North American hyphomycetes. II. The tribe Oosporeae. Mycologia 5:45-61.
Sutton, B. C. 1973. Hyphomycetes from Manitoba and Saskatchewan, Canada. Mycol. Papers CMI 132:1-143.
Swenberg, J. A., A. Koestner and R. P. Tewari. 1969. Experimental mycotic encephalitis. Acta neuropath. (Berl.) 13:75-90.
Szathmary, S. 1967a. Verfahren zur Zuchtung krankheitserregender Fadenpilze aus verfaulenden Stroh und Maisstengeln. Mykosen 10(4):153-162.
Szathmary, S. 1967b. Pseudomakrokonidiumbildung bei der ungarischen Variation von Gymnoascus verticillatus. Mykosen 10(7):271-280.
Taber, R. A. and R. E. Pettit. 1975. Occurrence of thermophilic microorganisms in peanuts and peanut soil. Mycologia 67(1):157-161.
Tansey, M. R. 1970. Experimental studies of thermophilic and thermotolerant fungi, with emphasis on their occurrence in wood chip piles, cellulolytic ability, nutrition and physiology. Ph.D. thesis, unpublished. Univ. California Berkeley.
Tansey, M. R. 1971a. Agar-diffusion assay of cellulolytic ability of thermophilic fungi. Arch. Mikrobiol. 77:1-11.
Tansey, M. R. 1971b. Isolation of thermophilic fungi from self-heated, industrial wood chip piles. Mycologia 63:537-547.
Tansey, M. R. 1975. Isolation of thermophilic fungi from snuff. Appl. Microbiol. 29(1):128-129.

Tewari, R. P. and C. R. Macpherson. 1968a. Cross-protection between Histoplasma capsulatum and Oidiodendron kalrai in mice. Mycopath. et Mycol. Appl. 37(1):97-103.
Tewari, R. P. and C. R. Macpherson. 1968b. Pathogenicity and neurological effects of Oidiodendron kalrai for mice. J. Bact. 95(3):1130-1139.
Tewari, R. P. and C. R. Macpherson. 1971. A new dimorphic fungus, Oidiodendron kalrai: morphological and biochemical characterisitics. Mycologia 63:602-611.
Tewari, R. P., C. R. Macpherson and T. K. Maitra. 1969. Serological and skin test cross-reactivity between Histoplasma capsulatum and Oidiodendron kalrai. Mycopath. et Mycol. Appl. 39(2):113-120.
Tokumasu, S. 1973. Notes on Japanese Oidiodendron. Trans. mycol. Soc. Japan 14:246-255.
Tubaki, K. 1960. Imperfect stage of Onygena corvina and its perithecial formation under culture. Bull. Nat. Sci. Mus. (Tokyo) 5(1):36-43.
Tubaki, K., T. Ito, Y. Matsuda and H. Yano. 1975. Fungus flora of lake sediment. IFO Res. Comm. 7:37-52.
Udagawa, S.-I. 1963. Notes on some Japanese Ascomycetes. I. Trans. mycol. Soc. Japan 4(4):94-100.
Udagawa, S.-I. 1966. Notes on some Japanese Ascomycetes. III. Trans. mycol. Soc. Japan 7(2-3):91-97.
Varsavsky, E. and L. Ajello. 1964. The perfect and imperfect forms of a new keratinophilic fungus Arthroderma ciferrii sp. nov.: Trichophyton georgii sp. nov. Revista di Patologia vegetale, Ser. 3, 4:351-363.
Varsavsky, E. and G. F. Orr. 1971. A new genus of the Gymnoascaceae. Mycopath. et Mycol. Appl. 43(2):229-234.
Vesco, G. dal. 1957. Geomyces vinaceus n. sp. forma conidica di Pseudogymnoascus vinaceus Raillo. Allionia 3(2):1-15.
Visset, M.-F. 1974. Quelques Gymnoascaceae observées au microscope electronique a balayage. Mycopath. et Mycol. Appl. 54(3):377-383.
Voordouw, G., G. M. Gaucher and R. S. Roche. 1974. Physiochemical properties of thermomycolase, the thermostable, extracellular serine protease of the fungus Malbranchea pulchella. Can. J. Chem. 52(11):981-990.
Vroey, C. H. de 1970. Contribution à l'étude des dermatophytes et d'autres Gymnoascacées. Ann. Soc. belge Méd. trop. 50:1-174.
Vuillemin, P. 1911. Les Aleuriosporés. Bull. Soc. Sci. Nancey. III, 12:151-175.
Wakefield, E. M. and G. R. Bisby. 1941. List of hyphomycetes recorded for Britain. Trans. Brit. mycol. Soc. 25:49-126.
Wang, C. J. K. 1965. Fungi of Pulp and Paper in New York. State Univ. College of Forestry, New York.
Weitzman, I., I. Kozma and M. Silva-Hutner. 1969. Some observations on Arthroderma uncinatum. Sabouraudia 7:216-218.

Weitzman, I. and M. Silva-Hutner. 1967. Non-keratinous agar media as substrates for the ascigerous state in certain members of the Gymnoascaceae pathogenic for man and animals. Sabouraudia 5:335-340.
Weresub, L. K. 1973. Oidium (Fungi) nom. cons. prop. Taxon 22:696-701.
Weresub, L. K., D. Malloch, and K. A. Pirozynski. 1974. Response to Hawksworth and Sutton's proposal for Art. 59. Taxon 23(4):569-578.
Williams, J. I. and G. J. F. Pugh. 1974. Fungal biological flora: Chrysosporium pannorum (Link) Hughes 1958. International Biodeterioation Bulletin 10(3):75-80.
Wilson, E. E. 1947. The branch wilt of Persian walnut trees and its cause. Hilgardia 17(12):413-430.
Wilson, E. E. 1949. The pycnidial state of the walnut branch wilt fungus, Exosporina fawcetti. Phytopathology 39:340-346.
Windisch, S. 1951. Zur Biologie und Systematik des Milchschimmels und einiger ähnlicher Formen. I. Der Milchschimmel (Endomyces lactis) und Endomyces Magnusii. Beiträge zur Biologie der Pflanzen 28:69-130.
Wood, F. C. 1957. Diseases of cultivated mushrooms. Nature 179:328.

INDEX OF GENERA AND SPECIES

A page number followed by an asterisk (*) indicates an illustration.

Figure 22. Colonies of Malbranchea species and Auxarthron conjugatum after 21 days at 25 C, except K at 37 C. Fig. 21A. M.albolutea (UAMH 1846 on PYE). Fig. 21B. M.arcuata (2983 on PYE). Fig. 21C. M.arcuata (3877 on cereal). Fig. 21D. M.circinata (3589 on cereal). Fig. 21E. M.aurantiaca (3705 on PYE). Fig. 21F. M.aurantiaca (3660 on cereal). Fig. 21G. M.fulva (2849 on PYE). Fig. 21H. M. chrysosporoidea (2288 on PYE). Fig. 21I. M.chrysosporoidea (2288 on cereal). Fig. 21J. Auxarthron conjugatum (3817 on PYE). Fig. 21K. M.sulfurea (3747 on PYE). Fig. 21L. M.flava (2865 on PYE). Fig. 21M. M. state of Uncinocarpus reesii (2847 on PYE). Fig. 21N. M.flavorosea (1051 on cereal). Fig. 21O. M.pulchella (1560 on cereal). Fig. 21P. M. flocciformis (3273 on PYE). Fig. 21Q. M.gypsea (1841 on cereal). All x 0.55.

MYCOTAXON

Vol. IV, No. 2, pp. 489-492 October-December 1976

NOTES ON HYPHOMYCETES. XII. A NEW SPECIES OF *CHALARA*.

G. Morgan-Jones and Edwin G. Ingram

Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, Alabama 36830, U.S.A.

ABSTRACT

Chalara alabamensis Morgan-Jones and Ingram is described and illustrated from leaves of *Quercus nigra* in Alabama. It is compared with *C. hughesii* Nag Raj and Kendrick.

INTRODUCTION

A survey of microfungi associated with leaf litter of *Quercus nigra* L., in Alabama, has yielded a number of interesting and novel dematiaceous hyphomycetes. Among these is a fungus belonging to the genus *Chalara* (Corda) Rabenh. A comparison of two collections of it with species described by Nag Raj and Kendrick (1975) in their recent monograph of the genus indicates a broadly similar morphology to *Chalara hughesii*. It cannot, however, be considered to be conspecific with it.

TAXONOMIC PART

Chalara alabamensis sp. nov. (Fig. 1).

Coloniae hypophyllae, effusae, pallide brunneae, velutinae. Mycelium partim superficiale, partim in substrato immersae. Conidiophora macronemata, mononemata, solitaria, simplicia, recta, laevia, 46 - 87µm longa. Phialides lageniformes, 40 - 82 X 3 - 7µm, pallide brunneae, laeves, venter subcylindraceus, 14 - 17 X 6 - 7µm, collum cylindraceum, 30 - 53 X 3 - 4µm. Phialospora endogena in catenis sporidiis maturis apice, cylindracea, 1-septata, hyalina, laevia, 15 - 18 X 2 - 2.5µm.

In foliis emortuis *Quercus nigrae*, Chewacla State Park, Lee County, Alabama, April 1976, E. G. Ingram, BPI, holotypus.

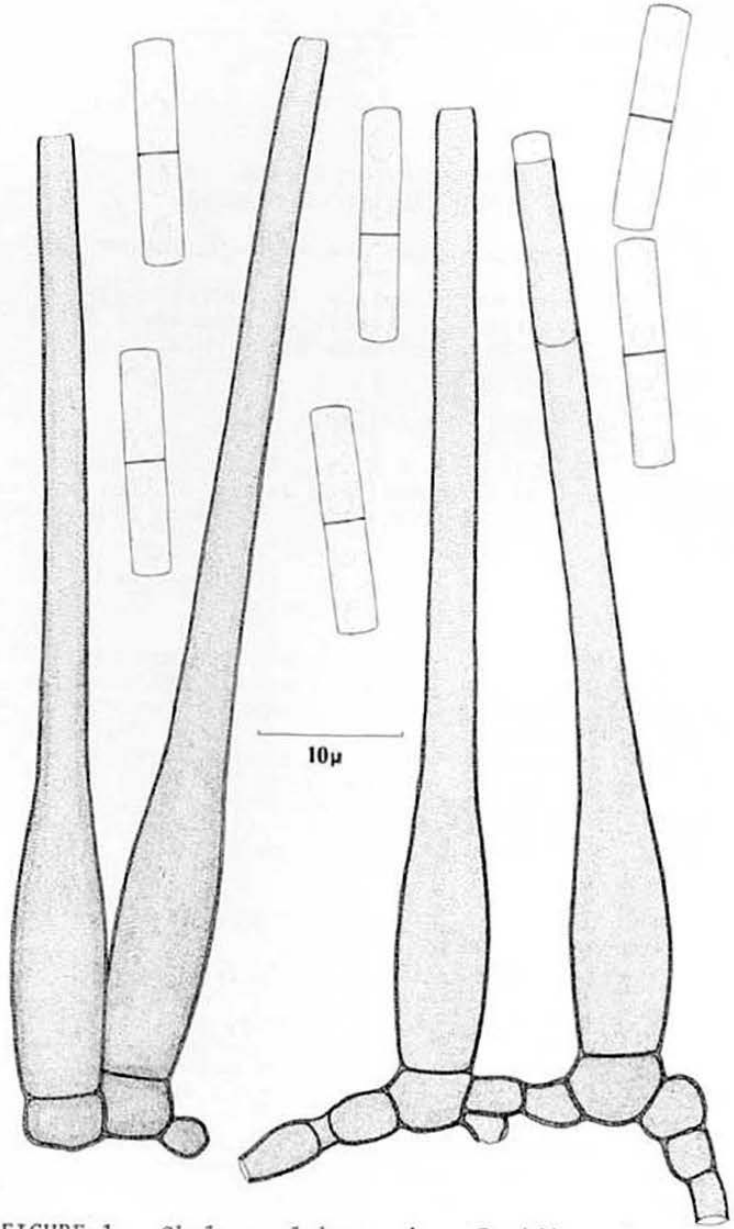


FIGURE 1. *Chalara alabamensis*. Conidia and conidiophores.

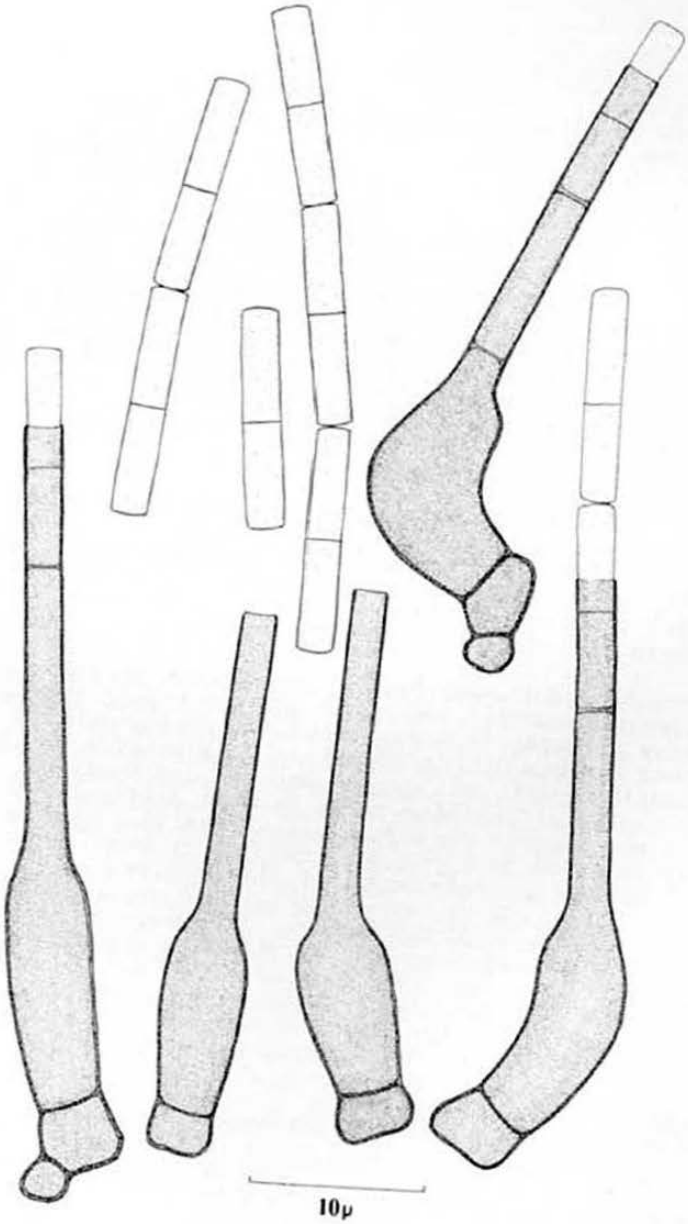


FIGURE 2. *Chalara hughesii*. Conidia and conidiophores.

Colonies hypophyllous, effused, dark brown, velutinous. Mycelium partly superficial, partly immersed in the substratum. Immersed mycelium composed of branched, septate, subhyaline hyphae, 1.5 - 2µm wide, superficial mycelium composed of swollen, pale brown, somewhat thick-walled hyphal cells. Conidiophores macronematous, mononematous, phialidic, solitary, scattered or gregarious, simple, erect, smooth, arising directly from cells of the superficial mycelium or from short basal cells, 46 - 87µm long. Phialides lageniform, 40 - 82 X 3 - 7µm, pale brown, with a subcylindric venter, 14 - 17 X 6 - 7µm, and a long cylindric collarette which attenuates very gradually towards the apex, 30 - 53 X 3 - 4µm, transition from venter to collarette gradual. Phialoconidia endogenous, produced in basipetal chains, cylindrical, 1-septate, hyaline, smooth, truncate at each end, lacking a basal marginal frill, 15 - 18 X 2 - 2.5µm.

On dead leaves of *Quercus nigra*; North America.

Collections examined: on *Q. nigra*, Chewacla State Park, Lee Co., Alabama, April 1976, E. G. Ingram, BPI, AUA, type; on *Q. nigra*, Auburn University Forestry Plots, Auburn, Lee Co., Alabama, April 1976, E. G. Ingram, AUA.

C. alabamensis belongs to a group of species possessing 1-septate conidia and conidiophores consisting of phialides borne directly from superficial mycelium or from a single short stalk cell. It resembles *C. agathidis* Nag Raj and Kendrick and *C. angionacea* Nag Raj and Kendrick, as well as *C. hughesii*, in these respects. It differs from the former two species, as does *C. hughesii*, in the absence of a basal circumjacent frill on the conidia, as well as in conidium dimensions and coloration of the phialides. Its conidia are closely similar to those of *C. hughesii* but are consistently slightly longer. Moreover the phialides are much longer than those of *C. hughesii* (Fig. 2, on wood, Lloyd-Cornell Preserve, Ringwood, New York, September 5, 1952, S. J. Hughes, DAOM 29354, type), and in that species the transition from venter to collarette is regularly abrupt and the phialides are frequently distinctly curved.

ACKNOWLEDGMENT

We thank Miss Mary E. Elliott for kindly making available for examination the type collection housed at the Biosystematics Research Institute, Ottawa, Canada, and Dr. J. Leland Crane for his review of the manuscript.

REFERENCE

NAG RAJ, T. R. and B. KENDRICK. 1975. A monograph of *Chalara* and allied genera. Wilfrid Laurier Univ. Press, Waterloo, 1-200.

MYCOTAXON

Vol. IV, No. 2, pp. 493-497 October-December 1976

NOTES ON HYPHOMYCETES. XIII. CONCERNING TWO SPECIES OF *PHAEOISARIOPSIS*.

G. Morgan-Jones and Lawrence G. Brown

Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, Alabama 36830, U.S.A.

ABSTRACT

Cercospora liriodendri is reclassified in *Phaeoisariopsis* and together with *Phaeoisariopsis magnoliae* is redescribed and illustrated.

INTRODUCTION

Study of a fresh collection of *Cercospora liriodendri* Ell. and Harkn., made in Alabama on leaves of *Liriodendron tulipifera* L., and of its type specimen has indicated that this species has closer affinity with *Phaeoisariopsis* Ferraris than with *Cercospora* Fresenius. *Cercospora magnoliae* Ell. and Harkn., a closely related fungus considered by Chupp (1953) to be conspecific with *C. liriodendri*, was transferred by Jong and Morris (1968) to *Phaeoisariopsis*. Hodges and Hassis (1962) had previously correctly recognized *C. magnoliae* to be distinct from *C. liriodendri* and to be congeneric with *Isariopsis griseola* Sacc., the type species of *Phaeoisariopsis*.

C. liriodendri and *P. magnoliae*, the cause of leaf spot diseases of their respective magnoliaceous hosts, produce conidia which differ but slightly in shape, dimension and septation and both produce fasciculate conidiophores characteristic of the genus *Phaeoisariopsis*. *P. magnoliae* is herein redescribed and illustrated from its type; *C. liriodendri* is illustrated, redescribed and reclassified in *Phaeoisariopsis*.

TAXONOMIC PART

Phaeoisariopsis liriodendri (Ell. and Harkn.) comb. nov. (Fig. 1).

≡ *Cercospora liriodendri* Ellis and Harkness, Bull. Torrey Bot. Club 8:27, 1881.

Leaf spots mostly angular, bordered by leaf veins, olive green, 2 - 3mm in diameter. Colonies limited, brown. Mycelium immersed in the substratum, composed of branched, septate, pale brown hyphae, 3 - 5µm wide. Stromata prosenchymatous, immersed, occasionally partially exposed, up to 70µm wide. Conidiophores hypophyllous, macronematous, mononematous, densely fasciculate, arising from the upper cells of the stromata, straight to somewhat flexuous, smooth-walled, simple, cylindrical, slightly wider distally, geniculate above, scars thin but distinct, pale brown, paler towards the tip, 3 - 5-septate, 55 - 150 X 3 - 4µm. Conidiogenous cells polyblastic, indeterminate, terminal, integrated. Conidia holoblastic, solitary, dry, acrogenous, straight, pyriform to broadly fusiform, pale brown, delicately verruculose, 1 - 3-septate, mostly 1-septate, apex obtuse, base subtruncate, scars thin, 20 - 29 X 6µm at widest part.

On leaves of *Liriodendron tulipifera* L.; N. America. Specimens examined: on *L. tulipifera*, Vineland, New Jersey, U.S.A., October 1880, J. B. Ellis and H. W. Harkness, North American Fungi No. 645, type, NY; on *L. tulipifera*, Auburn, Lee County, Alabama, U.S.A., April 1976, L. G. Brown, AUA.

Phaeoisariopsis magnoliae (Ell. and Harkn.) Jong and Morris, Mycopathol. et Mycol. Appl. 34:271, 1968 (Fig. 2).

≡ *Cercospora magnoliae* Ellis and Harkness, Bull. Torrey Bot. Club 8:27, 1881.

≡ *Isariopsis magnoliae* Plakidas, Mycologia 52:258, 1960.

Leaf spots suborbicular to angular, sometimes bordered by leaf veins, center grayish with raised dark brown to black margin, up to 3mm in diameter. Colonies limited, evenly spaced, deep olivaceous to dark brown. Mycelium immersed in the substratum, composed of branched, septate, pale brown, 3 - 5µm wide hyphae. Stromata largely immersed, prosenchymatous to pseudoparenchymatous, disc-shaped, up to 70µm wide. Conidiophores hypophyllous, macronematous, mononematous, densely fasciculate, arising from the upper cells of the stromata, simple, straight or flexuous, somewhat geniculate distally, smooth-walled, pale brown, relatively thick-walled, multiseptate, scars distinct but thin, 100 - 225 X 2.5 - 4µm. Conidiogenous cells polyblastic, cylindrical, integrated, terminal or intercalary, sympodial. Conidia holoblastic, solitary, dry, acropleurogenous, straight to slightly curved, verruculose, obclavate, 1 to 3-septate, mostly 2-septate, apex obtuse, base conico-truncate, scars thin, 23 - 42.5 X 5 - 6.5µm.

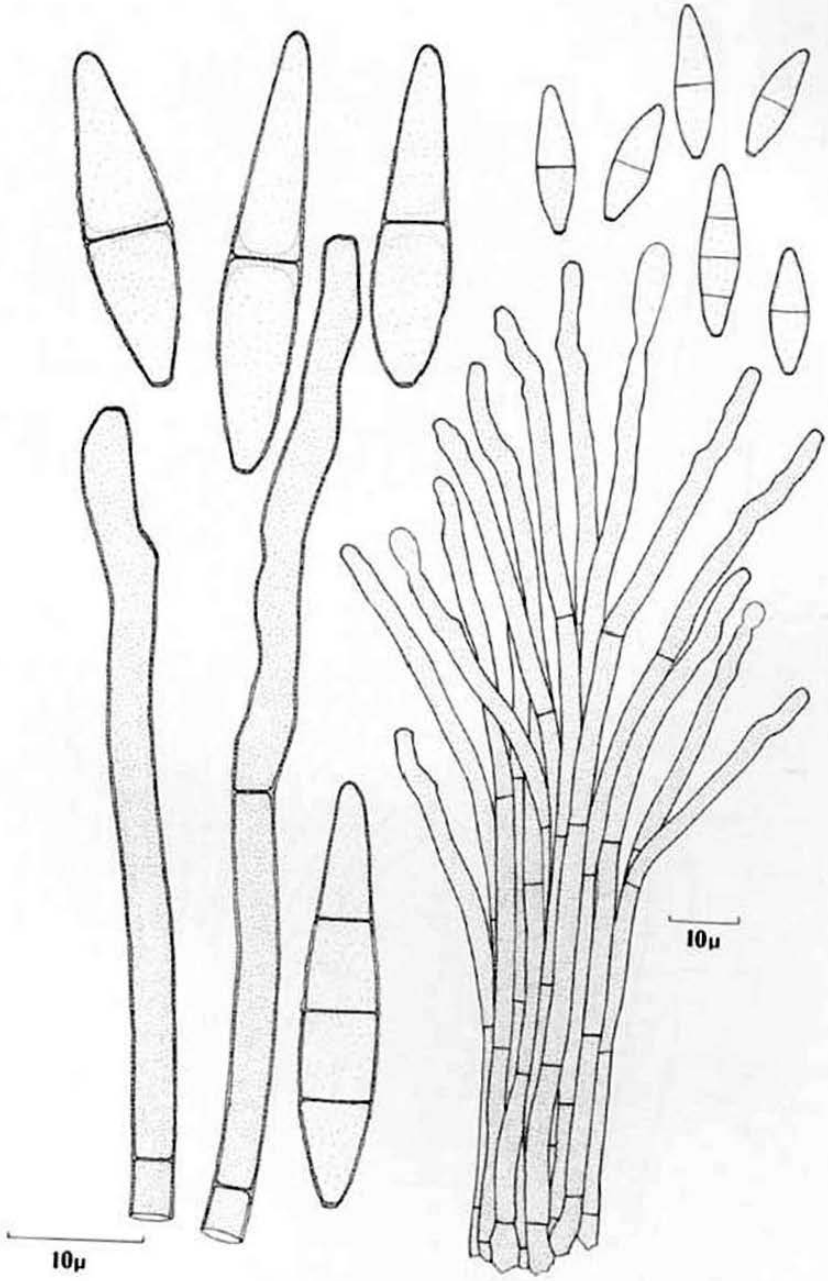


FIGURE 1. *Phaeoisariopsis liriodendri*. Conidia and conidiophores.

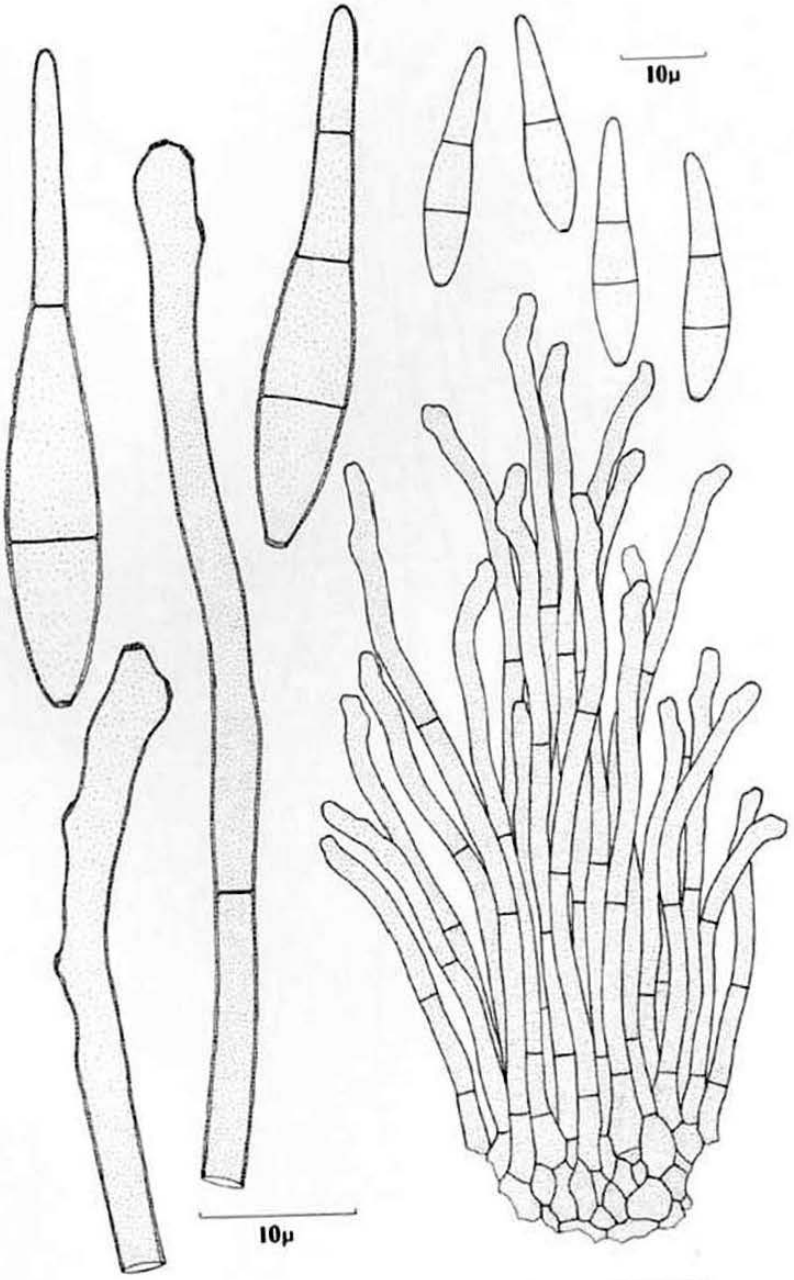


FIGURE 2. *Phaeoisariopsis magnoliae*. Conidia and conidiophores.

On leaves of *Magnolia* species; N. America. Specimens examined: on *M. virginiana* L. (*M. glauca* L.), Newfield, New Jersey, U.S.A., November 1880, J. B. Ellis and H. W. Harkness, North American Fungi No. 643 type, NY; on *M. virginiana*, Newfield, New Jersey, U.S.A., September 23, 1883, J. B. Ellis, NY (Ellis placed the name *Cercospora glauca* Ell. and Everh., on this collection but the name was never published.).

In some respects these two fungi bear resemblance to species of *Fusicladium* Bonorden. The shape of the conidia and the minutely verruculose nature of the conidium wall are similarities.

ACKNOWLEDGEMENTS

We thank Dr. Clark T. Rogerson, New York Botanical Garden, for making available for examination the two type specimens. Dr. Roger D. Goos, University of Rhode Island, kindly reviewed the manuscript.

REFERENCES

Chupp, C. 1953. A monograph of the fungus genus *Cercospora*. Ithaca, New York, 1-667.

Ferraris, T. 1909. Osservazioni Mycologiche su specie del gruppo Hyphales. Ann. Mycol. 7:273-286.

Hodges, C. S. and F. A. Haasis. 1962. Etiology of *Cercospora* leaf spot of *Magnolia*. Mycologia 54:448-454.

Jong, S. C. and E. F. Morris. 1968. Studies on the synnematous Fungi Imperfecti. III. *Phaeoisariopsis*. Mycopathol. et Mycol. Appl. 34:263-272.

MYCOTAXON

Vol. IV, No. 2, pp. 498-503 October-December 1976

NOTES ON HYPHOMYCETES. XIV. THE GENUS *HETEROCONIUM*.

G. Morgan-Jones

Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, Alabama 36830, U.S.A.

ABSTRACT

Helminthosporium solaninum Saccardo and Sydow is transferred to the genus *Heteroconium* Petrak and, together with *Heteroconium citharexyli* Petrak, the type species of this genus, is redescribed and illustrated.

INTRODUCTION

The genus *Heteroconium* was established by Petrak (1949) to accommodate a dematiaceous hyphomycete possessing cylindrical, septate conidia borne in unbranched chains on well differentiated but short conidiophores formed from a largely superficial mycelium. The fungus occurred on living leaves of *Citharexylum ilicifolium* in Ecuador. Petrak considered *Heteroconium* in relation to *Dendryphion* Wallroth noting the very short, simple conidiophores of the former to be a point of difference. A more fundamental distinction between these two genera lies in the fact that the conidiogenous cells of *Dendryphion* are tretic whereas those of *Heteroconium* are blastic, a relatively wide wall area at the conidiophore and conidium apex being involved in conidiogenesis.

Morgan-Jones (1975), in a discussion of the affinities of *Lylea catenulata* Morgan-Jones restated the unique characteristics of *Heteroconium*.

Examination of the type collection of *Helminthosporium solaninum* Saccardo and Sydow made on living leaves of *Solanum argenteum* in Brazil has revealed it to be a second species of *Heteroconium*. Since its establishment this species has been reclassified in *Sporohelminthium* Spegazzini and *Septonema* Corda but neither of these genera provide a fully satisfactory disposition for it.

Sporohelminthium is now recognized as a synonym of *Clasterosporium* Schweinitz, its type species *S. anomalum* (Speg.) Speg., which had originally been classified in *Napicladium* Thümen, being clearly congeneric with *Clasterosporium caricinum* Schweinitz on which the latter genus is based. The catenate nature of the conidia and the absence of hyphopodia precludes the classification of *H. solaninum* in *Clasterosporium*.

H. solaninum has more affinity with *Heteroconium* than with *Septonema*, as exemplified by its type *S. secedens* Corda, on a number of accounts particularly its superficial habit on leaves in the tropics, its monoblastic conidiogenous cells and its simple conidium chains.

Hughes (1958) listed *Dendryphion loranthi* Hansford as a synonym of *H. solaninum*. He had previously (Hughes, 1952) transferred this to *Septonema* as *Septonema loranthi* (Hansf.) Hughes. Although the type material on which this name is based has not been examined during the present study this synonymy is accepted here.

Helminthosporium solaninum is transferred to *Heteroconium* and both it and *H. citharexyli* are redescribed and illustrated.

TAXONOMIC PART

Heteroconium citharexyli Petrak, Sydowia 3:265, 1959 (Fig. 1).

Colonies effuse, olivaceous to dark brown, hypophyllous, abundant. Mycelium superficial, composed of flexuous, branched, pale olive brown to olive brown, smooth-walled, 3-5µm wide hyphae. Conidiophores macronematous, mononematous, simple, arising as lateral branches of the superficial hyphae, erect, straight or slightly curved, cylindrical, brown, smooth-walled, multiseptate, septa relatively closely spaced, sometimes somewhat bulbous at the base when arising from narrower hyphae, 10-32 X 4-7µm. Conidiogenous cells monoblastic, integrated, determinate or percurrent, terminal on the conidiophore or as an apical cell of the conidium. Conidia catenate, dry, acrogenous, simple, smooth-walled, pale brown to brown, straight, cylindrical, formed in short unbranched acropetal chains, obtuse at the apex, truncate at the base, 1 to 7-septate, slightly constricted at the septa, 10-40 X 3-7µ.

On leaves of *Citharexylum ilicifolium* H.B. and K.; South America.

Specimen examined: on *C. ilicifolium*, Pichincha, Quito, Ecuador, September 29, 1937, H. Sydow, type, S.

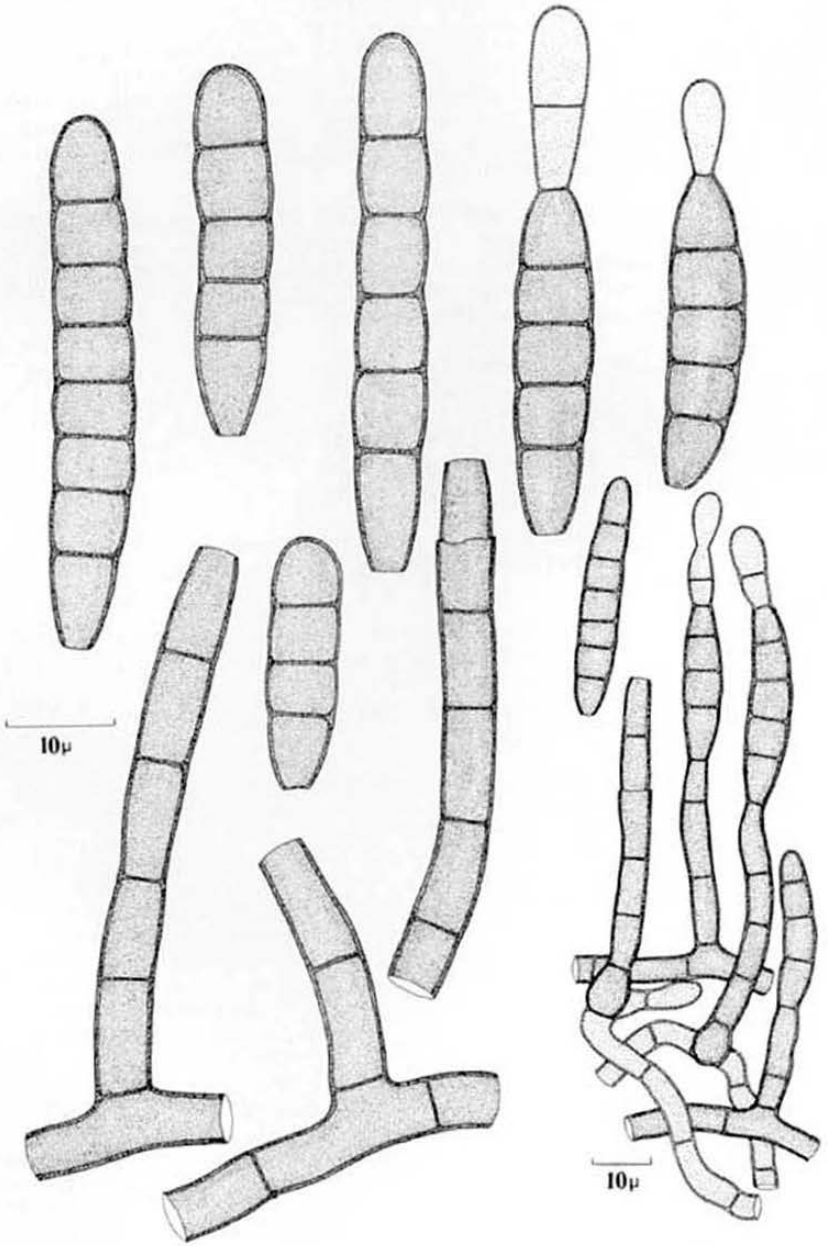


FIGURE 1. *Heteroconium citharexyli*. Conidia and conidiophores.

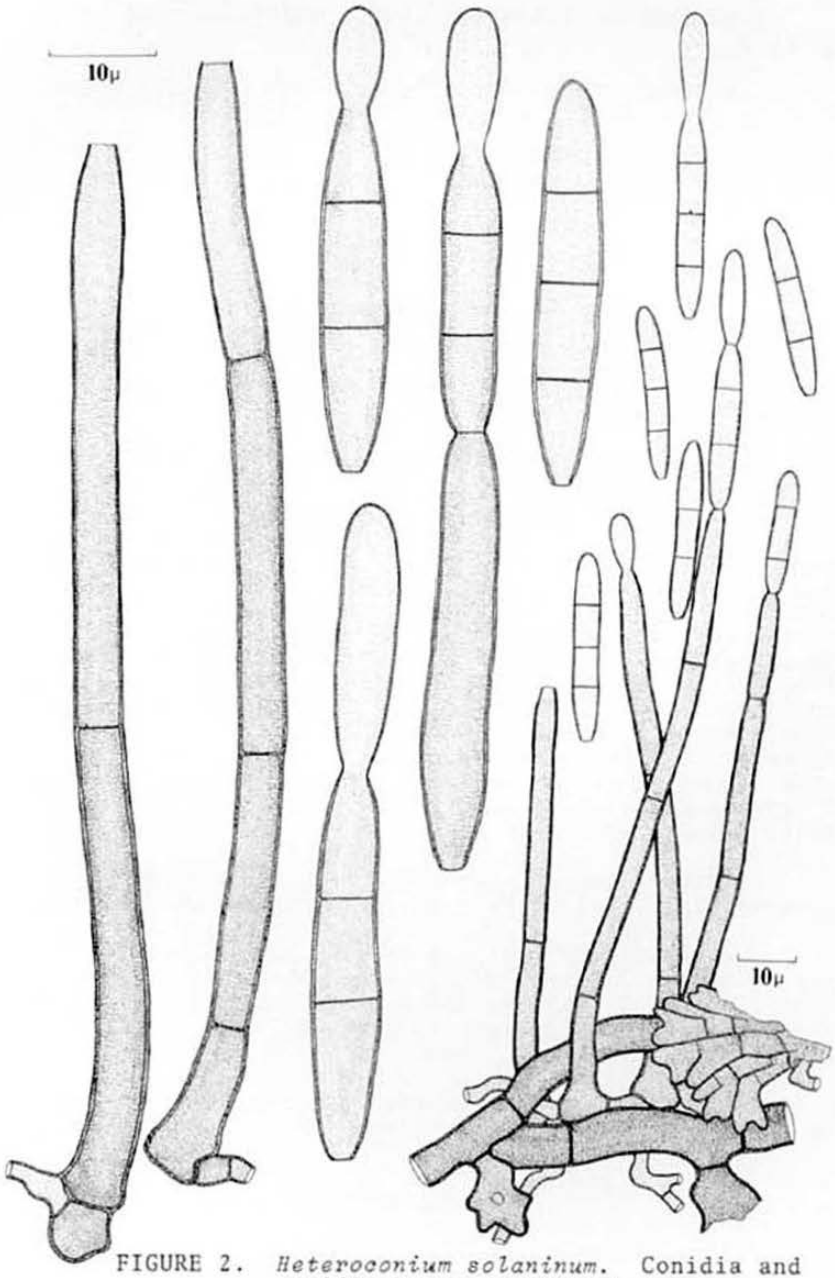


FIGURE 2. *Heteroconium solaninum*. Conidia and conidiophores (conidiophores on *Asterina* sp.).

Heteroconium solaninum (Sacc. and Syd.) comb. nov. (Fig. 2).

≡ *Helminthosporium solaninum* Saccardo and Sydow, Atti Congr. bot. Palermo 58, 1902.

≡ *Sporohelminthium solaninum* (Sacc. and Syd.) Spegazzini, Physis. 4:292, 1918.

≡ *Septonema solaninum* (Sacc. and Syd.) Hughes, Can. J. Bot. 36:804, 1958.

= *Dendryphion loranthi* Hansford, Proc. Linn. Soc. Lond., 155:46, 1943 [fide Hughes, 1958].

= *Septonema loranthi* (Hansf.) Hughes, Naturalist, Lond., 12, 1952.

Colonies effuse or somewhat orbicular, dark brown, epiphyllous. Mycelium superficial, composed of flexuous, branched, septate, pale brown to brown, smooth-walled, 3-4µm wide hyphae. Conidiophores macronematous, mononematous, simple, arising as lateral branches of the superficial hyphae, erect, straight or slightly curved, smooth-walled, 1 to 4-septate, frequently somewhat bulbous at the extreme base, brown, paler distally, 50-78 X 3-5µm. Conidiogenous cells monoblastic, integrated, determinate, terminal on the conidiophore or as an apical cell of the conidium. Conidia catenate, dry, acrogenous, simple, smooth-walled, formed in unbranched acropetal chains, seceding readily, straight, cylindrical, obtuse at the apex, truncate at the base, or truncate at each end, 0 to 3-septate, septa appreciably thinner than the periclinal wall, pale brown, 16-24 X 4-4.5µm

On living leaves associated with *Meliola* spp., *Asterina* spp., and other fungi; Africa and South America.

Specimens examined: on *Solanum argenteum* Dun. ex Poir., Rio de Janeiro, Brazil, September 1887, E. Ule (1461), type, S, PAD; on *Garcina huillensis* Welw., Kahama, Kigoma, Tanzania, February 7, 1974, K. A. Pirozynski, IMI 106494b, AUA.

Hughes (1952) reported the occurrence of this species in Uganda, Ghana and Sierra Leone (as *Septonema loranthi*).

ACKNOWLEDGEMENTS

I thank the curators of the herbaria at Padova and Stockholm for the loan of type specimens. The manuscript was kindly reviewed by Dr. Richard T. Hanlin, University of Georgia.

REFERENCES

HUGHES, S. J. 1952. Four species of *Septonema*. Naturalist, Lond., 7-12.

HUGHES, S. J. 1958. Revisiones Hyphomycetum aliquot cum appendice de nominibus rejiciendis. Can. J. Bot. 36:727-836.

MORGAN-JONES, G. 1975. Notes on Hyphomycetes. VIII. *Lylea*, a new genus. Mycotaxon 3:129-132.

PETRAK, F. 1949. Neue Hyphomyzeten-Gattungen aus Ekuador. Sydowia 3:259-266.

MYCOTAXON

Vol. IV, No. 2, pp. 504-509 October-December 1976

NOTES ON HYPHOMYCETES. XV. TWO NEW SPECIES OF *CODINAEA*.

G. Morgan-Jones and Edwin G. Ingram

Department of Botany and Microbiology
Auburn University Agriculture Experiment Station
Auburn, Alabama 36830, U.S.A.

ABSTRACT

Codinaea cylindrospora Morgan-Jones and Ingram and *Codinaea unisetula* Morgan-Jones and Ingram are described and illustrated from leaves of *Quercus nigra* in Alabama.

INTRODUCTION

Among new hyphomycetes collected from leaf litter of *Quercus nigra* L. in Alabama, in addition to *Chalara alabamensis* Morgan-Jones and Ingram described in a previous paper (Morgan-Jones and Ingram 1976), are two species of *Codinaea* Maire. Both are strikingly different in their respective morphologies from species of this genus known hitherto. Hughes and Kendrick (1968) provided a review of *Codinaea* adding nine new species, transferring to it two species from *Menispora* and describing three as states of new species of *Chaetosphaeria* Tulasne. Since the two fungi which form the subject of this paper cannot be assigned to any previously documented species, names are established for them herein.

TAXONOMIC PART

Codinaea cylindrospora sp. nov. (Fig. 1).

Coloniae hypophyllae, effusae, atro-brunneae vel atrae. Mycelium ex hyphis immersis, semimmersis vel superficialibus, subhyalinis vel brunneis, in stromata basibus setarum et conidiophorarum aggregatis, compositium. Setae erectae, rectae, leaves, usque ad 125µm longae, usque ad 6-septatae, ex cellulis basilaribus, inflatis oriundae, basi 5 - 8µm latae, atrobrunneae et crassitunicatae, superne pallidiores, apicem pallide brunneae vel subhyalinae. Setae in phialide singula terminantes. Conidiophora singulariter oriunda vel 2 - 4 aggregata, simplicia,

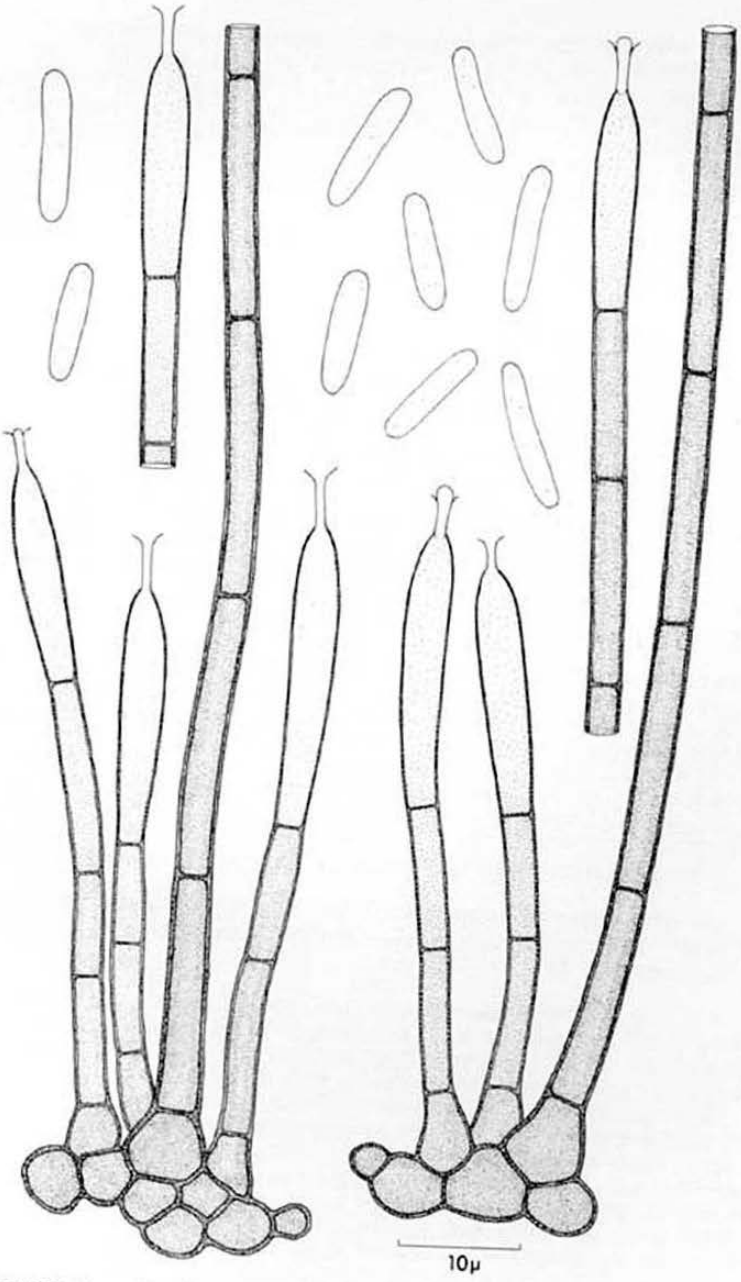


FIGURE 1. *Codinaea cylindrospora*. Conidiophores and conidia.

erecta, cylindrica vel anguste clavata, basi brunnea, apicem versus pallidiora, usque ad 3-septata, 30 - 60 X 2.5 - 4µm. Conidiophora in phialide singula terminantia. Phialides rectae, pallide brunneae vel subhyalinae, colla infundibuliformia. Conidia (phialoconidia) continua, hyalina, cylindracea, recta, 8 - 11 X 2 - 2.5µm, in capitulum mucosum incoloratum aggregata.

In foliis dejectis *Quercus nigrae*, Auburn University, Lee County, Alabama, April 1976, E. G. Ingram, BPI, holotypus.

Colonies hypophyllous, effused, dark brown to almost black. Mycelium composed of immersed, semi-immersed or superficial, branched, septate, subhyaline to pale brown hyphae, 1.5 - 2.5µm wide, aggregated to form small stromata at the bases of setae and conidiophores. Stromatic cells globose or angular, thick-walled, brown, up to 7µm wide. Setae arising from dark brown, swollen basal cells, erect, straight, smooth, up to 6-septate, dark brown and thick-walled in the lower part, paler above, fertile, terminating in a single, narrowly clavate phialide, 105 - 125 X 3 - 4µm, 6 - 7µm wide at the bulbous base. Conidiophores macronematous, mononematous, arising in groups of up to four near the base of each seta, cylindrical, with a somewhat swollen basal cell, simple, septate, smooth, 30 - 60 X 2.5 - 4µm, terminating in a single, pale brown to subhyaline, narrowly clavate phialide, each phialide bearing a single apical, funnel-shaped, stalked collarette. Conidia (phialoconidia) extruded in slimy colorless droplets, continuous, hyaline, cylindrical, straight or very slightly curved, obtuse at each end, 8 - 11 X 2 - 2.5µm.

On fallen leaves of *Quercus nigra*; N. America.

Collection examined: On *Q. nigra*, Auburn University Forestry Plots, Auburn, Lee County, Alabama, April 1976, E. G. Ingram, BPI, AUA, type.

C. cylindrospora is not entirely typical of *Codinaea* as defined by Hughes and Kendrick (1968) on account of the absence of phialidic proliferation to produce polyphialides. However, in overall morphology, it is so similar to species of this genus as to dictate its inclusion in it. Moreover the conidiophore of the type species of *Codinaea*, *C. aristata* Maire, the location of whose type specimen is unknown, was described and illustrated by Maire (1937) as monophialidic ("apex of fertile hypha forming spores"). In the absence of sympodial proliferation *C. cylindrospora* resembles *Cyphellophora* de Vries. This species cannot be accommodated in this genus for several reasons, however. In *Cyphellophora laciniata* de Vries, the type species, the hyphae have very little pigment, the collarettes are predominately sessile and the conidia, which become brown

when mature, are distinctly constricted at a central septum. None of these peculiarities are exhibited by *C. cylindrospora*.

Apart from other morphological details *C. cylindrospora* differs from *C. aristata* by the absence of conidial appendages. In this respect it resembles the *Codinaea* states of *Chaetosphaeria callimorpha* (Mont.) Sacc., and *Chaetosphaeria talbotii* Hughes, Kendrick and Shoemaker, *Codinaea botulispora* Hughes and Kendrick, *C. maharashtrensis* Pirozynski and Patil and *C. setosae* Hughes and Kendrick.

C. cylindrospora is distinguished from other species of *Codinaea* by its narrowly club-shaped phialides bearing relatively long, stalked collarettes, and by its straight or almost straight conidia.

Codinaea unisetula sp. nov. (Fig. 2).

Coloniae hypophyllae, effusae, griseo-brunneae vel atrae. Mycelium ex hyphis immersis vel semiimmersis, ramosis, subhyalinis vel brunneis, compositum. Setae desunt. Conidiophora singulariter oriunda vel 2 - 3 aggregata, simplicia, recta, cylindrica, basi brunnea, apicem versus pallidiora, usque ad 3-septata, 28 - 76 X 2 - 3µm. Conidiophora in polyphialide singula terminantia. Polyphialides rectae vel flexae, pallide brunneae vel subhyalinae, sympodialter per usque ad 3 proliferationes successivas elongascentes, usque ad 3 reliquias laterales collorum ferentes, colla infundibuliformia. Conidia (phialoconidia) continua, hyalina, fusiformia, recta vel leniter curvata, 6 - 7 X 1µm, ad apicem setula singula 13 - 15µm longa praedita, in capitulum mucosum incoloratum aggregata.

In folis dejectis *Quercus nigrae*, Chewacla State Park, Lee County, Alabama, April 1976, E. G. Ingram, BPI, holotypus.

Colonies hypophyllous, effused, gray-brown to black. Mycelium composed of immersed or semi-immersed, branched, septate, subhyaline to pale brown hyphae, 1.5 - 2µm wide. Hyphae giving rise to a few pale brown to brown, subglobose cells, up to 6µm wide associated with conidiophores. Setae absent. Conidiophores macronematous, mononematous, arising singly or in groups of up to three, cylindrical, usually attenuating slightly distally, with a swollen basal cell, simple, septate, smooth, straight or somewhat flexuous, 28 - 76 X 2 - 3µm, up to 6µm wide at the base, terminating in a single pale brown to subhyaline phialide or polyphialide bearing funnel-shaped collarettes. Conidia (phialoconidia) extruded in slimy colorless droplets, continuous, hyaline, fusiform, straight or very slightly curved, 6 - 7 X 1µm, bearing a single apical filiform appendage, 13 - 15µm long.

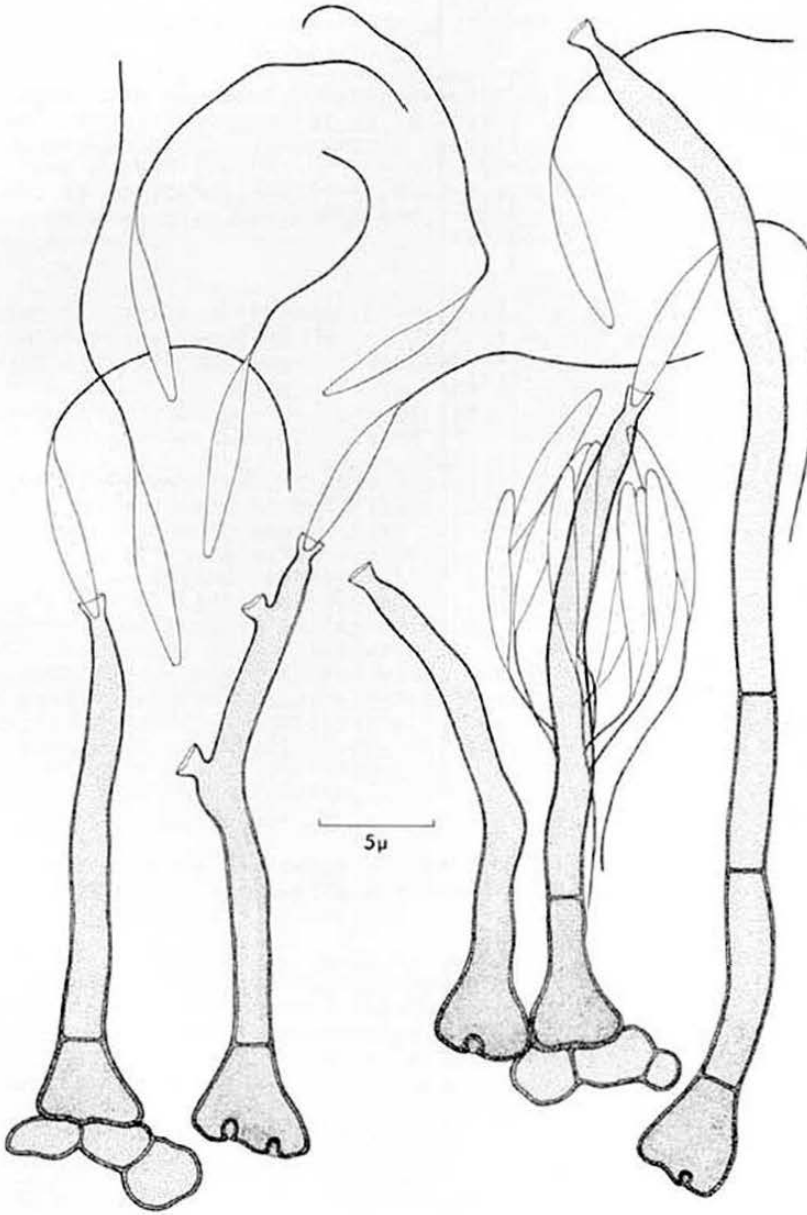


FIGURE 2. *Codinaea unisetula*. Conidiophores and conidia.

On fallen leaves of *Quercus nigra*; N. America.

Collection examined: On *Q. nigra*, Chewacla State Park, Lee County, Alabama, April, 1976, E. G. Ingram, BPI, AUA, type.

C. unisetula is distinguishable from all other species of *Codinaea* by its small fusiform conidia which bear single undulate appendages up to twice their length.

ACKNOWLEDGMENT

We thank Dr. Roger D. Goos, University of Rhode Island, for reviewing this manuscript.

REFERENCES

HUGHES, S. J. and W. B. KENDRICK. 1968. New Zealand Fungi 12. *Menispora, Codinaea, Menisporopsis*. N. Z. Jl Bot. 6:323-375.

MAIRE, R. 1937. Fungi Catalaunici, Series altera. Contribution a l'etude de la Flore Mycologique de la Catalogne. Publcions Inst. bot., Barcelona 3:1-128.

MORGAN-JONES, G. and E. G. INGRAM. 1976. Notes on Hyphomycetes. XII. A new species of *Chalara*. Mycotaxon 4:489-492.

MYCOTAXON

Vol. IV, No. 2, pp. 510-512 October-December 1976

NOTES ON HYPHOMYCETES. XVI. A NEW SPECIES OF *STACHYBOTRYS*.

G. Morgan-Jones, and G. W. Karr, Jr.

Department of Botany and Microbiology
Auburn University Agricultural Experiment Station
Auburn, Alabama 36830, U.S.A.

ABSTRACT

Stachybotrys zeae Morgan-Jones and Karr, a new species, is described and illustrated from corn in Alabama. It is compared with *Stachybotrys chartarum* (Ehrenb. ex Link) Hughes.

INTRODUCTION

A fungus tentatively identified as *Stachybotrys chartarum* during a preliminary survey of hyphomycetes occurring on corn in Alabama appears upon detailed examination to be sufficiently different in a number of key characters to be considered as an undescribed taxon.

TAXONOMIC PART

Stachybotrys zeae sp. nov. (Fig. 1).

Coloniae effusae, grisea. Mycelium in substrato immersum, ex hyphis ramosis, septatis, hyalinis, levibus, 2 - 3µm crassis compositum. Conidiophora solitaria vel laxe aggregata, erecta, recta vel flexuosa, septata, cylindrica, laevia, hyalina, 48 - 85 X 3 - 5µm. Phialides terminales, 2 - 5 in verticillo dispositae, obovatae, leviae, salmonicolores, 9 - 11 X 4 - 5µm. Phialosporae in muco accumulatae, ellipsoideae, brunneae vel atro-brunneae, verrucosae, 7 - 9 X 3.5 - 4.5µm.

In folis *Zea mays* L., Camden, Wilcox County, Alabama, VII 1975, G. W. Karr, Jr., BPI, holotypus.

Colonies effuse, gray. Mycelium immersed in the substratum, composed of branched, septate, smooth, hyaline to subhyaline hyphae, 2 - 3µm wide. Conidiophores macronematous, mononematous, solitary or aggregated in loose

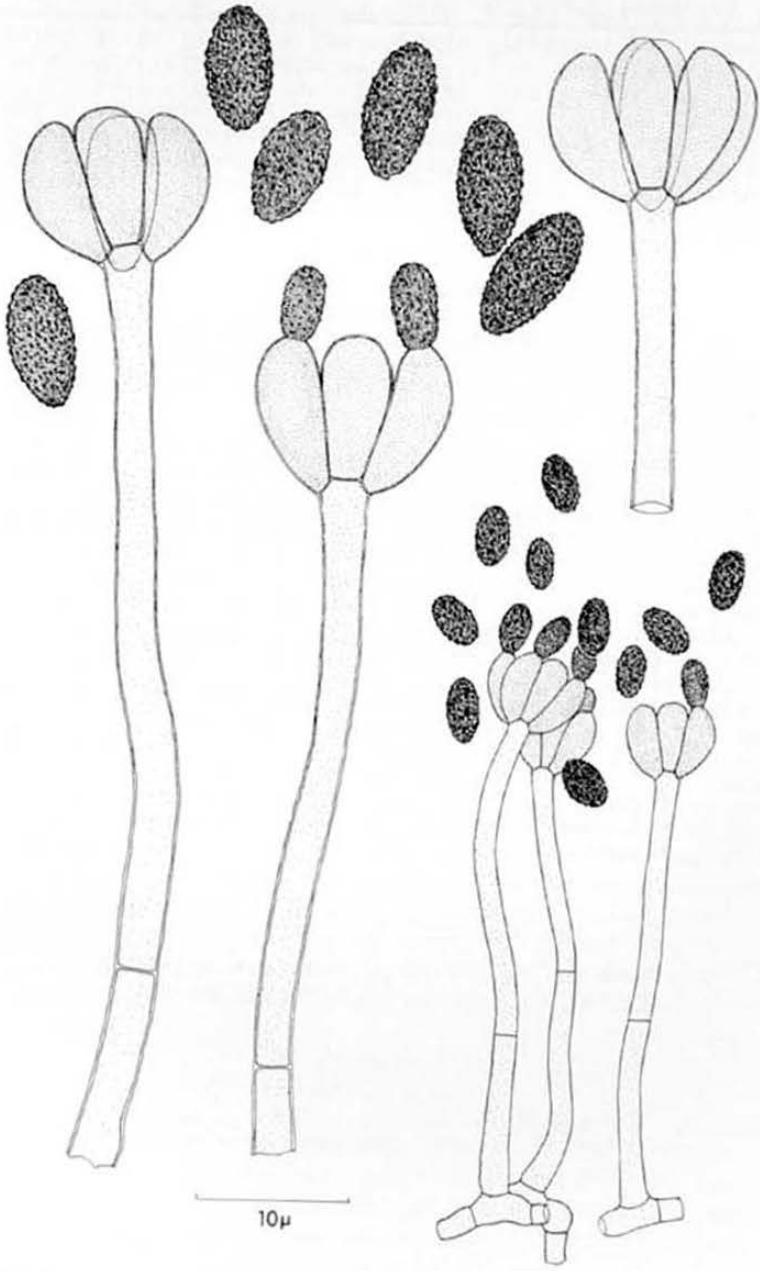


FIGURE 1. *Stachybotrys zeae*. Conidiophores and conidia.

groups of a few, erect, straight or somewhat flexuous, unbranched, cylindrical, attenuating slightly but gradually towards the upper part, septate, smooth, hyaline, 48 - 85 X 3 - 5µm, terminating in a verticil of phialides. Phialides formed in groups of up to five around the base of a central phialide, obovate, the outer ones somewhat curved, smooth, pale salmon-colored, producing conidia successively at the apex, 9 - 11 X 4 - 5µm. Phialospores ellipsoidal, unicellular, brown to dark brown, verruculose, 7 - 9 X 3.5 - 4.5µm.

On leaves of *Zea mays*; North America.

Specimen examined: On *Z. mays*, Auburn University Agricultural Experiment Station, Lower Coastal Plain Substation, Camden, Wilcox County, Alabama, July 1975, G. W. Karr, Jr., BPI, type.

Of the known species of *Stachybotrys* Corda, *S. zeae* most closely resembles *S. chartarum*. It differs from it however in a number of significant respects. The conidiophores are unbranched and their stipes are hyaline and smooth-walled whereas those of *S. chartarum* are usually branched and their stipes are dark olivaceous in color and roughened in the upper part. The phialides of *S. chartarum* are also dark olivaceous and have conspicuous collarettes. Those of *S. zeae* have no discernible collarettes and are distinctly salmon-colored. In addition the outer phialides of a whorl are generally more noticeably curved in *S. zeae* than are those occupying a similar position in *S. chartarum*. The conidia of *S. zeae* are smaller than is normal in *S. chartarum* although they fall almost within the range given for that species by Jong and Davis (1976). They do not however exhibit the very characteristic banded or ridged surface ornamentation seen in *S. chartarum*.

ACKNOWLEDGMENT

We thank Dr. S. C. Jong, American Type Culture Collection, for reviewing the manuscript.

REFERENCE

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

MYCOTAXON

Vol. IV, No. 2, pp. 513-533 October-December 1976

NOTES ON COLORADO FUNGI II. SPECIES OF *ARMILLARIA* (FR.) KUMMER. (AGARICALES)

D. H. MITCHEL

Denver Botanic Gardens, 909 York Street
Denver, Colorado 80206

and

ALEXANDER H. SMITH

The University Herbarium, University of Michigan
Ann Arbor, Michigan 48104

SUMMARY

The status of *Armillaria* and the tribe Biannulariae of the *Agaricales* is reviewed and revised. A key to the species of *Armillaria* section *Armillaria* is presented. *A. pitkinensis* sp. nov., *A. fusca* sp. nov., *A. straminea* var. *americana* f. *alba* comb. nov. are presented along with *A. albolanaripes* f. *alba* f. nov. The taxonomic value of divergent gill trama as a generic character in tribe Biannulariae and in genus *Armillaria* is questioned. The possibility that *A. straminea* var. *americana*, *A. fusca*, and *A. albolanaripes* in the central Rocky Mountain area hybridize to produce a "hybrid swarm" of variants is postulated.

INTRODUCTION

The abundant fruitings of the striking fungus known in our western states as "*Armillaria luteovirens* (Fr.) Saccardo" have attracted both the amateur and professional mycologist. The basidiocarps are conspicuous, have excellent flavor and are frequently collected for the table. In Colorado the species is clearly associated with aspen and in this habitat often occurs as a mushroom "weed." Several amateur collectors have for years been aware of variations

in this species, but since all were found edible, little attention was paid to basidiocarp anatomy, and all were simply referred to as "Shaggy Stems." Our interest was stimulated by the changing status of *Armillaria luteovirens* in Europe and the placing of *Armillaria straminea* (Krombholz) Kummer in synonymy with it. In addition to our concern over the identity of *A. luteovirens*, we soon became interested in the related species as they were found here in the state. The present report consists of the results of our studies to date.

In working with this group it was tempting to postulate that we have three basic species in Colorado--*A. albolanaripes*, *A. fusca*, and *A. straminea* var. *americana*, and that the long series of variants discovered, including *A. pitkinensis*, represent hybrids between any two of the three basic species. It is this series that requires further critical study.

We have studied about 300 collections, but these were not all made in Colorado. Smith's collections at the University of Michigan Herbarium are from the western United States generally, and Charles Barrows encountered the genus frequently in the mountains of New Mexico and Arizona.

Color terms within quotation marks in our descriptions are taken from R. Ridgway (1912). Specimens are on deposit at the Denver Botanic Gardens (DBG), and the University of Michigan Herbarium (MICH) at Ann Arbor.

THE STATUS OF *ARMILLARIA LUTEOVIRENS* (ALB. & SCHW. EX FR.) KUMMER.

Singer, in his classification of the Agaricales (1951, 1962, 1975), made an attempt to save the genus *Armillaria* from obscurity by restricting the concept to species with amyloid spores. *Agaricus luteovirens* Albertini & Schweinitz was selected as the type (1951); in later works (1962, 1975) *Armillaria straminea* Krombholz was substituted, but it was indicated as a synonym of *A. luteovirens*. The situation was complicated by Pouzar (1957) who described the genus *Floccularia* based on *A. straminea* Krombh. The genus was placed in the Amanitaceae because of the bilateral

hymenophoral trama. Singer (1975) incorporated the feature of bilateral gill trama in his tribe Biannulariae which includes, among other genera, his restricted concept of *Armillaria*. In other words, he accepted Pouzar's data of hyphal arrangement of the gill trama but did not agree with him as to the family in which the species belonged. He continued to maintain that *A. luteovirens* and *A. straminea* were synonyms. Since we first identified our Colorado collections as *Armillaria luteovirens*, and since Smith described the gill trama of North American collections as parallel (p. 355, 1949), and the same for form *alba* (1947), we were interested first in a restudy of the hyphal arrangement of the gill trama. Pilat (1969) reported f. *alba* (A. H. Smith) Pilat, and mentioned the bilateral lamellar trama. We could not be sure whether Pilat's observations were based on dried specimens of Smith's collections or on fresh material he collected. He studied both. We felt it very desirable to restudy the whole problem particularly on fresh material to clarify this feature relative to these species and their variants.

THE HYMENOPHORAL TRAMA OF *"ARMILLARIA LUTEOVIRENS"*

None of the collections we studied showed any trace of a bilateral arrangement of lamellar hyphae. Our detailed study was made on free-hand sections of fresh material mounted in water. We used lamellae from basidiocarps in all stages of development from unopened buttons in which the gills were incompletely formed to caps past maturity. Some specimens were dried and then revived and re-examined in mounts made in both Melzer's solution and in 3% KOH. Dried specimens from herbaria were similarly revived and examined. In all of these studies, the hyphae of the gill trama were parallel or practically so. We then investigated related species (all those in the key) and found the hyphal arrangement in the gill trama exactly comparable with that found for *"A. luteo-virens"*: no indication of bilaterality was observed. Fortunately, when Pouzar erected *Floccularia* he desigated as the type *Agaricus straminеus* Krombh. This then must be the species with the bilateral hymenophoral trama. It has not yet been discovered in either its typical or albino form in North America. Since Singer (1951) listed *Agaricus luteovirens* as the type of *Armillaria*, in an attempt to compare the original concept of this species with that of *A. straminea*, we

consulted the original description by Albertini & Schweinitz--which we quote in part as follows:

> "483. A. G. luteo-virens nobis
> "A. G. subcaespitosus, pileo carnoso duro subflexuosa pulverulento sordide lutescenti-viridi, lamellis confertis angustis subliberis pallentibus, stipite solido crasso brevi sursum incrassato squamuloso toto albo."

A more detailed account follows in which the habitat is stated as "Amat sylvas acerosas sicciusculus sed parum frequens occurrit."

In the North American collections the pileus was in no way pulverulent (dusted), the consistency was not hard (duro), in no way can "sordide lutescente-viridi" be considered the equivalent of lemon to chrome yellow, and lamellae up to 12 mm broad cannot be interpreted as narrow (angustis). In short, we are forced to conclude that the original description of *A. luteo-virens* cannot, within reason, apply to our Colorado mushroom. Fries' (1821) description, which validates the name, in general follows the diagnosis of Albertini & Schweinitz, but is not the concept of current authors. It seems that the only way to settle the concept of this species is by designating a type according to the procedure proposed by Smith (1976, in press).

Romagnesi (1967, pl. 243, f. 4), under the name *Tricholoma luteo-virens*, gives a good illustration of our Colorado fungus, and one which passes rather well for *Agaricus stramineus* Krombholz (see the original plate of the latter author). Romagnesi's observations are especially pertinent to our problem: "...Peu d'espèces ont provoqué autant d' erreurs, certaines méme enormes, quant à sa position dans la classification." He comments further that the bilaterality of the hymenophoral trama does not resemble that of *Amanita* but is more like that of *Catathelasma*. In regard to *Catathelasma*, we have been able to easily and regularly demonstrate a transient stage of bilaterality in the trama of some of the North American collections. We conclude from Romagnesi's comments that his concept of *"Tricholoma luteo-virens"* is that of the same species for which Pouzar used the name *Floccularia straminea*. Obviously, he did not believe the hyphal arrangement he observed in the gill trama of this species to be a valid generic character of this

group. We agree with this evaluation, and like Romagnesi, do not use it as Singer (1975) did, as the diagnostic feature of a tribe. The feature is not consistent in *Catathelasma*, and, we think, obviously an unreliable one as a unifying feature in *Armillaria*. On this basis, it is logical to cite *Agaricus stramineus* Krombholz as the type of the genus *Armillaria* and to remove *Agaricus luteovirens* from synonymy. We describe the North American collections of *A. straminea* as a variety differing from the type variety in lacking bilateral gill trama at any stage in the development of the lamellae. This may seem to be a naive solution but in our estimation is closer to reality than describing the American material as an autonomous species. If we were to follow the pattern of Singer's classification (1975), it would be necessary to describe a new genus for the North American taxa. We have not been able to study fresh material of *A. straminea* var. *straminea* and we accept the statements of those who have. We feel that the results obtained from the study of dried material would be inconclusive.

THE VEILS

In *A. straminea* var. *americana*, we found the veil to be composed of two different types of cells. On the upper canescent surface the cells were large, oval (inflated), thin-walled, and 50-70 x 25-30 μ (Fig. 1). On the inferior floccose surface they were long, slender, tubular and 80-100 x 6-10 μ (Fig. 2). Details on the other species are not as complete, but in *A. albolanaripes*, data from studies of dried material showed the bulk of the veil to be made up of tubular hyphae with little or no constriction at the septa. Clamps were regularly present, the cells were greatly elongated to over ten times as long as wide, and the walls were thin and smooth. In the other species studied to date, the hyphae were 75-200 x 4-12 μ, tubular and smooth-walled. In some variants as yet unclassified, we hazard the prediction that both single and "double" veils will be found in the North American species of *Armillaria* sect. *Armillaria*.

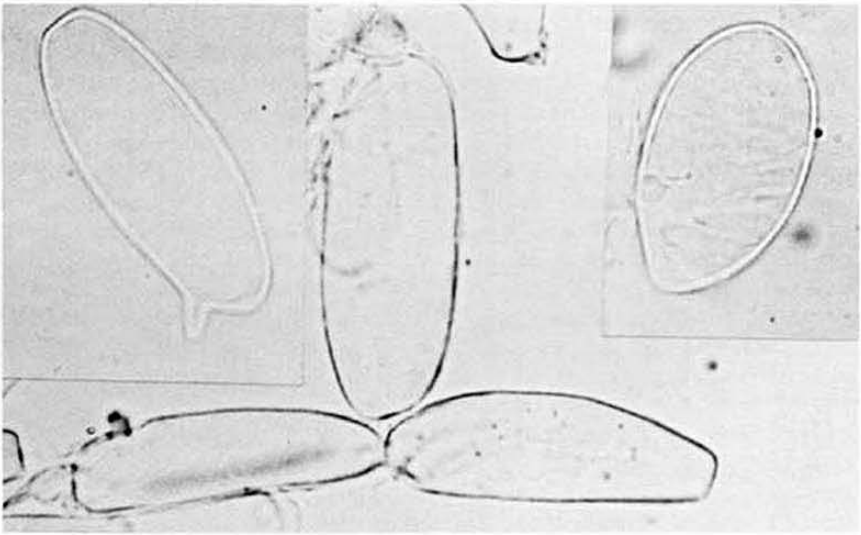


Fig. 1. Inflated cells from upper surface of veil of *A. straminea* var. *americana* x2000 Mitchel 5950

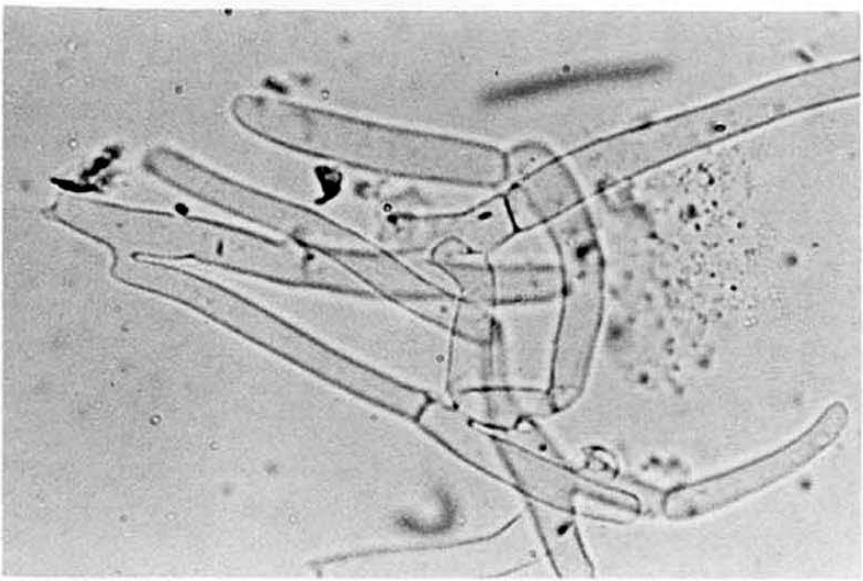


Fig. 2. Slender cells from lower surface of veil of *A. straminea* var. *americana* x2000 Mitchel 5950

PILEAR CUTICLE

In *A. straminea* var. *americana* and *A. fusca* the cuticle is of appressed ± radial hyphae which at intervals give off fascicles of similar hyphae that form the scales on the cap. In *A. fusca* a trichoderm is at first present and as it collapses a more or less glabrous surface with patches of appressed fibrils results. To say the least, the cuticle appears to be in a rather primitive stage of development. Characters of the cuticular hyphae of possible taxonomic significance are the degree to which the hyphae are narrowed at the cross-walls and the shape of the end-cells. The ratio of clamps per 100 septa (as a sample) may be found to be of limited value. The narrowing of the cells at the cross-walls, we believe, has some phylogenetic significance in reviewing the relationships of *Cystoderma* to other genera in tribe Biannulariae.

SYSTEMATIC CONSIDERATIONS

In view of our estimates of the value of some of the characters, and since these differ from the evaluations Singer employed in his system of classification, we present a tentative revision of the tribe Biannulariae and, in particular, the genus *Armillaria*.

The tribe Biannulariae: In Singer's (1975) classification this tribe is defined and keyed out primarily on the presence of bilateral gill trama. *Armillaria* is included with *A. straminea* as the type. In view of the questions we have raised relative to bilaterality of the gill trama in this group, we omit this feature as a major character. We include, in the present tentative revision of the tribe, the genera *Cystoderma*, *Catathelasma*, *Armillaria*, and marginally *Armillariella*.

For *Catathelasma* we emphasize the amyloid spores, large, heavy, persistent basidiocarps with hard white flesh at first, a distinct, usually double veil, and in most species, some divergence of hyphae near the subhymenium. The population of this genus in Colorado is relatively diverse and will be the subject of a forthcoming paper by us.

Armillaria: We define as a genus of white to whitish-spored species with stipe confluent with the pileus and

gills attached (in various ways) to the stipe. A veil leaving a double annulus, or if annulus single or arachnoid (± a cortina) the spores amyloid. The pileus is never powdery or granulose as in *Cystoderma*. This definition excludes a number, but not all, of the species once placed in *Armillaria* but now placed in *Tricholoma* by some authors.

Cystoderma: Spores amyloid or not, veil basically double, outer layer granulose to powdery from sphaerocysts, stipe typically slender (in a few 12-20 mm thick) but continuous with pileus, cuticle of pileus usually reactive in KOH (turning cinnamon or olive). This genus is now placed in the Agaricaceae by Singer but its relationships appear to us to be here.

Armillariella: We do not insist upon this genus being a member of the tribe Biannulariae, but since Smith has observed some semblance of bilaterality in the hymenophore of *Armillariella mellea* ss. lato, and since the floccose veil appears in many collections to be double, in at least a rudimentary sense, we comment on it here. Its pattern of specialization relative to habitat, production of rhizomorphs, etc., certainly indicate a trend away from the other genera.

ARMILLARIA (FR.) KUMMER

Spore deposit white to whitish; pileus and stipe confluent; stipe centrally attached, lamellae adnate, adnexed or decurrent; annulus present as a membranous ring or floccose band; spores amyloid, or if inamyloid then annulus double; typically terrestrial and assumed to be mycorrhiza formers.

Type species *Armillaria straminea* (Krombh.) Kummer.

KEY TO SECTIONS

1. Spores amyloid, veil floccose, annulus not typically membranous . . . . . .Sect. *Armillaria*

1. Spores inamyloid, annulus membranous and double. . . . . Sect. *Caligate**

SECTION *Armillaria*

KEY

1. Pileus conspicuously scaly with ± rusty brown scales; growing on hardwood logs, etc. . . . . *A. decorosa* (Pk.) Smith & Walters (extralimital)

1. Not as above. 2

2. Basidiocarps white when young. 3

2. Basidiocarps colored when young. 4

3. Pileus at first with recurved large scales. . . . . *A. straminea* var. *americana* f. *alba*

3. Pileus ± glabrous or with appressed fibrils . . . . . *A. albolanaripes* f. *alba*

4. Pileus with conspicuous recurved bright yellow scales, chrome yellow when fresh, fading to whitish, evenly colored; under aspen . . . . . *A. straminea* var. *americana* f. *americana*

4. Not as above 5

5. Pileus when fresh fuscous to gray; no yellow tints present . . . . . *A. fusca*

5. Yellow tints present on some part of basidiocarp by maturity. 6

6. Pileus margin bright yellow at maturity; cuticle of hyphae 4-10 μ wide, tubular and the cells not, or scarcely, constricted at septa; end-cells of elements tubular with blunt apices. . . . . *A. albolanaripes* f. *albolanaripes*

---

*Sect. *Caligate* sec. nov. A typo differ: annulus duplex: sporae inamyloidae. Typus: *Armillaria caligata* Viv.

6. Pileus margin weakly colored (not bright yellow); cuticular hyphae with cells constricted at the septa and end-cells cystidioid or tapered to a subacute apex. . . . . *A. pitkinensis*

1. Armillaria straminea (Krombholz) Kummer, var. *americana* var. nov. f. *americana*

Agaricus stramineus Krombholz, Naturgetreue Abbildungen und Beschreibungen der essbaren, schädlichen und verdächtigen Schwamme; pl. 25, figs. 8-14, 1836. Illustrations: Fig. 3: Smith (1949) reel 32, no. 222, (1975) p. 143.

Pileus 4-18 cm latus, demum late umbonatus vel convexus siccus, sapor mitis; lamellae latae, adnatae, confertae, vel subdistantes, pallide lutae; stipes 5-12 cm longus, 1.2-2.5 cm crassus, saepe bulbosus (3 cm latus); vellum copiosum, floccosum; sporae in cumulo albae, (5) 6-8 x (3.7) 4-5 μ leviter amyloideae; trama lamellorum hyphis parallelis. Specimen typicum in Herbarium Denver Botanic Gardens conservatum est; legit prope West Village, Aspen, Colorado, 9 August 1975, Smith 85661 (DBG--6254).

Pileus 4-18 cm broad, obtusely conic to convex, becoming broadly umbonate to plane, surface dry, with conspicuous triangular scales, appressed-fibrillose at first but scales becoming tufted and recurved in age (up to 1 cm broad with recurved tips to 0.5 cm long), imbricate, arranged in concentric circles, surface of cap glabrescent in age; ground color "straw yellow" and scales varying from "lemon chrome" to "mustard yellow" and finally at times with orange-brown tips, fading in sun to whitish; margin incurved at first, becoming straight, appendiculate with remnants of yellow floccose veil. Context white except stained bright yellow to depth of 3-4 mm under cuticle, firm, up to 3 cm thick, odor and taste mild, KOH and $FeSO_4$ both negative.

Lamellae adnate to sinuate, moderately close, broad (to 12 mm), margins crisped and soon eroded to serrate, light yellow when young becoming pale lemon yellow in age, always lighter colored than pileus, not staining.

Fig. 3. *Armillaria straminea* var. *americana* f. *americana* x1 Smith 31216

Stipe 5-12 cm long, 1.5-2.5 cm thick, equal to expanding upward but often with a bulb up to 3 cm thick; smooth and white above the thick floccose veil, soon shaggy squamulose below from veil remnants; the scales concolorous with pileus and up to 5 mm long, arranged in concentric zones below annular zone; base not discoloring, solid to loosely stuffed with a white pith; cortex stained yellow to depth of 1 mm in area below annulus.

Spore deposit white. Spores (5) 6-8 x (3.7) 4-5 µ. Cystidia none. A few dextrinoid basidioles scattered in hymenium. Lamellar trama parallel, hyphae thin-walled, tubular, the cells 30-45 x 10-15 µ and rectangular in optical section. Clamps present. Cuticle of pileus of long filamentous hyphae united in places into semi-erect fascicles, cells 80-150 x 8-15 µ, very little constriction at cross-walls, clamps infrequent. Yellow pigment soluble in alcohol, water, and KOH and soon breaking down where exposed to sunlight.

Habit, habitat and distribution: In aspen groves with scattered alder and maple, common most years at elevations of 7,000 to 9,000 feet during the summer rainy period.

Observations: No collections were found that showed any intergradation with *A. albolanaripes* but Miller's (1972) pl. 107 may be such a variant.

Material cited: COLORADO: Barrill 18; Hesler 12684; Mitchel 1307 (A), 2430, 2803, 3794, 4116, 5111, 5300, 5949, 5950, 5974, 5975, 6129, 6130; Smith 85140, 85847. WASHINGTON: Smith 31216. WYOMING: Solheim 3522, 3558.

2. *Armillaria straminea* var. *americana* f. *alba* comb. nov.

Armillaria luteovirens f. *alba* Smith, Mycologia 39:625, 1947, *Floccularia luteovirens* (Alb. & Schw. ex Fr.) Pouzar f. *alba* (A. H. Smith) Pilat.

This variant is similar to var. *americana* f. *americana* in all features with the exception that it is white throughout.

3. *Armillaria albolanaripes* Atkinson, Annales Mycol. 6:54, 1908, f. *albolanaripes*

Illustrations Fig. 4. Smith, 1975, pl. 145; and 1949, reel 15, no. 104.

Pileus 4-12 cm broad, convex to obtuse, expanded to broadly umbonate-convex, plane or the margin turned up slightly, surface slightly tacky, soon dry, disc innately fibrillose with patches of appressed fibrils or squamules toward the margin, distinctly scaly in age at times; edge decorated with loose patches from the broken veil; color at first bright yellow ("yellow chrome") over disc, margin paler to whitish, disc gradually becoming cinnamon brown to bister or blackish as do the squamules, ground color over margin becoming bright yellow in age if whitish at first. Context about 2 cm thick on disc, tapered evenly to margin, with a narrow yellow band under the cuticle, remainder white, firm; odor none, taste none.

Lamellae close, deeply depressed-adnate to nearly free, close, white, moderately broad, edges uneven to eroded, not staining where injured.

Stipe 2-8 cm long, 9-25 mm thick, equal or either enlarged or narrowed downward, stuffed by a compact white pith; lower half sheathed by the torn, somewhat fibrillose, scaly remains of an outer veil, squamules white with yellowish or brownish tips, at times squamules in concentric zones; annulus membranous to fibrillose, lax; stipe above annulus smooth and white at first, flushed yellowish in age.

Spore deposit white. Spores 6-8 x 4-5 µ, ellipsoid, smooth, thin-walled, weakly amyloid (best seen on spores from prints ± 40 years old). Basidia 4-spored, clavate, 23-34 x 5.5-8.5 µ. Pleuro- and cheilocystidia not observed. Gill trama of a central interwoven strand of cells somewhat inflated, this region flanked by bands of parallel tubular hyphae to the indistinct subhymenium (no sign of diverging hyphae). Pileus trama of intricately interwoven hyphae with cells ± enlarged and 10-18 µ in diameter, walls thin and smooth. Pileus cuticle of ± radial, tubular, long slender hyphae (150-200 x 8-10 µ), the layer colored diffusely (under microscope), the cell walls at most faintly

Fig. 4. *Armillaria albolanaripes* f. *albolanaripes* x1 Smith 17036

ochraceous, not constricted at the septa. Clamps present but infrequent.

Habit, habitat and distribution: Scattered to gregarious under conifers, western USA, summer and fall, not uncommon.

Observations: This is a variable species but the pileus cuticle is constant in its characters--the hyphae are loosely radially arranged, long, straight and tubular, 5-12 μ in diameter, with clamps at the cross-walls, and no significant pigment in the cell walls. The spores are weakly amyloid in most collections, and there is no sign of divergence in the gill trama. The species features bright yellow pigments in the pileus, especially the margin at maturity.

Material cited: COLORADO: Mitchel 6155, 6164. IDAHO: Smith 76160, 76552. NEW MEXICO: Barrows 152. WASHINGTON: Smith 2840, 17036.

4. Armillaria albolanaripes f. *alba* f. nov.

A typo differt: pileus albus tarde demum pallide argillaceus; vellum sparsum, albidum. Specimen typicum in Herbarium Denver Botanic Gardens conservatum est; legit August 1961, prope Bull Creek, New Mexico, Barrows 1299.

The status of this variant is not entirely clear as yet since the basidiocarps slowly became alutaceous as they dried and the veil is thin. We take this occasion to place the variant on record. We have an additional record from Colorado, Mitchel 6132.

5. Armillaria fusca sp. nov.

Illustration. Fig. 5.

Pileus 4-7 cm latus, obtusus, demum convexus, glaber, udus, subhygrophanus, fuscus vel pallidior, ad marginem albo-appendiculatus; odor nullus, sapor mitis; lamellae confertae, latae, anguste adnatae, sordide albae; sporae 6-8 x 4-5 μ, leves, amyloideae. Specimen typicum in Herbarium Denver Botanic Gardens; legit prope Eagle, Colorado,

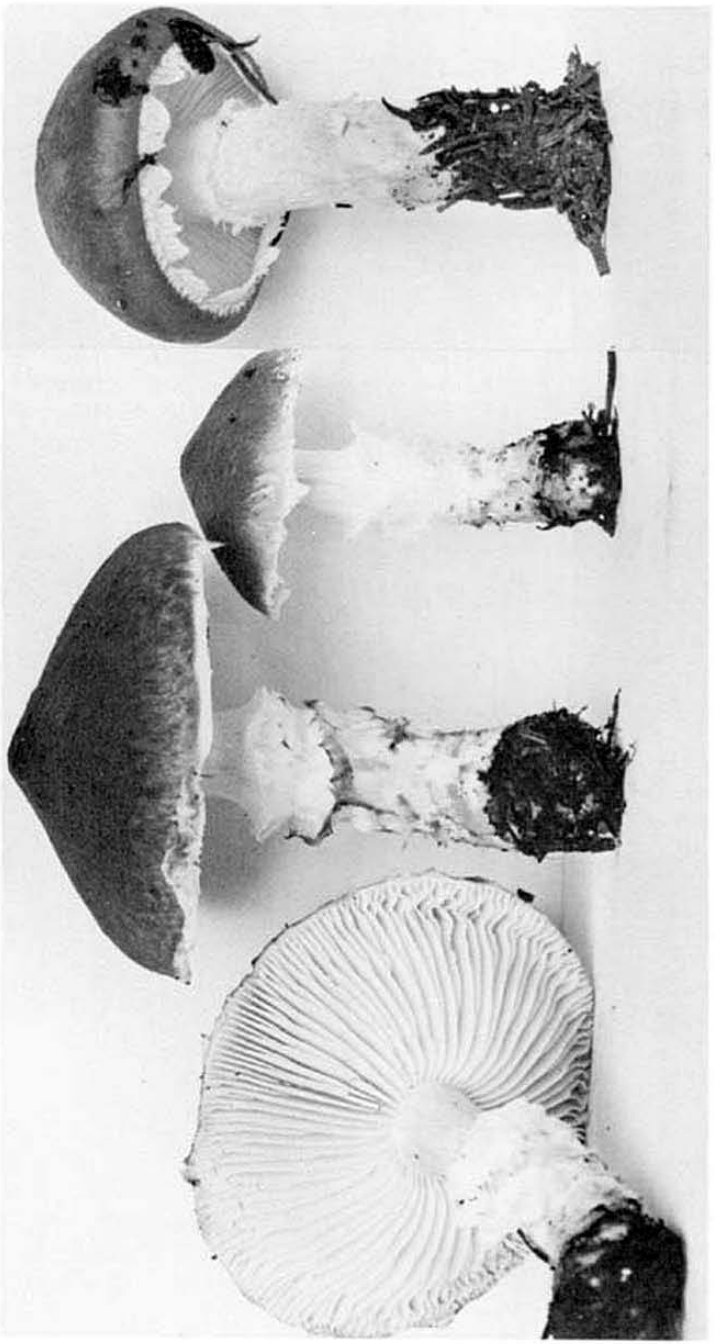


Fig. 5. *Armillaria fusca* x1 Smith 51601

2 August 1967, Mitchel 1307 B.

Pileus 4-7 cm broad, obtuse to convex becoming plane or nearly so, surface moist, subhygrophanous, glabrous when young but with streaks of appressed fibrils in age as ground color becomes paler, "olive brown" to "wood brown" (more or less fuscous over all); margin opaque at all times and usually appendiculate with white veil remnants, in age becoming slightly squamulous as the fascicles of fibrils recurve slightly at their tip. Context white, soon riddled by larvae, not darkening around tunnels, odor slight, taste mild; KOH on cuticle not distinctive; $FeSO_4$ no reaction.

Lamellae close, broad, adnexed (deeply so at times), dull white to flushed with gray in age (lacking yellow tints), edges even to serrulate, not staining where injured.

Stipe 6-7 cm long, 10-15 mm thick, equal, solid but soft within; surface floccose below the ragged annular zone, the veil remnants pallid or finally grayish buff, silky and pallid near apex.

Spore print white; spores (5.5) 6-8 (9) x (3.7) 4-5 μ, smooth, thin-walled, hyaline, ellipsoid, often with central oil drop, strongly amyloid.

Basidia 23-30 x 6-8 μ, usually 4-spored. Cystidia lacking. Dextrinoid basidioles scattered in the hymenium. Lamellar trama parallel, cells 20-30 x 8-15 μ, not inflated except in region of central core. Cuticle of pileus of tubular hyphae becoming appressed, cells of hyphae of variable length in the epicutis, mostly medium-long (100-150 x 8-12 μ), with numerous cross-walls, clamps present but rare.

Habit, habitat and distribution: Solitary to scattered under spruce, Colorado, summer rainy season.

Observations: This species features a fuscous to cinereous pileus which is glabrous to inconspicuously squamulose from appressed squamules, and a lack of yellow tints in the basidiocarps. The intensity of the color may vary from dark (in some collections the buttons are nearly black) to light (two collections are nearly white) but the

hue stays the same--a smoky gray without yellow tints. These features distinguish it from *A. pitkinensis*. Both appear to be distinctive features of the agaric flora of the central and southern Rocky Mountains.

Material cited: COLORADO: Mitchel 2101, 3972, 5777, 5966, 6133; Smith 51601, 85888, 85915, 85916.

6. Armillaria pitkinensis sp. nov.

Illustrations. Fig. 6.

Pileus 4-10 cm latus, demum subplanus, viscidulus, pallide subochraceus ad; centrum avellaneo-virgatulus, ad marginem appendiculatus; sapor mitis, odor nullus; lamellae luteolae, latae, confertae, sinuatae; stipes 3-7 cm longus, 0.5-2 cm crassus, sursum albidus deorsum squamulosus, squamulae parvae, griseoluteolae; annulus membranaceus, sursum albus, subtus squamis cinereoluteolis; sporae in cumulo albae, 6-8 x 4-5 μ, amyloideae. Specimen typicum in Herbarium Denver Botanic Gardens conservatum est; legit prope West Village, Aspen, Pitkin County, Colorado, 20 August 1975, Smith 85889.

Pileus 4-10 cm broad, obtuse to convex, finally plane, when young slightly viscid, smooth at first, shiny when dry, cuticle breaking up into appressed imbricate fibrillose squamules, ground color pale dingy yellow to ivory-yellow or brownish, squamules pinkish-gray ("avellaneous") to "wood brown" (slightly darker) on disc; margin incurved at first, becoming straight in age, typically appendiculate with ragged remnants of the veil. Context white, no discoloration around worm tunnels, odor and taste not distinctive, no color change where bruised, $FeSO_4$ more or less cinnamon; with KOH no distinct reaction.

Lamellae white, becoming dingy yellowish and drying yellowish, not staining where bruised, close, moderately broad, adnexed, edges eroded.

Stipe 3-7 cm long, 0.5-2 (2.5) cm thick, equal to slightly clavate, bulb small, loosely stuffed with a white pith; surface smooth and white above the veil, more or less covered below with dingy pale yellow to grayish-yellow squamules or zones of veil tissue, basal mycelium

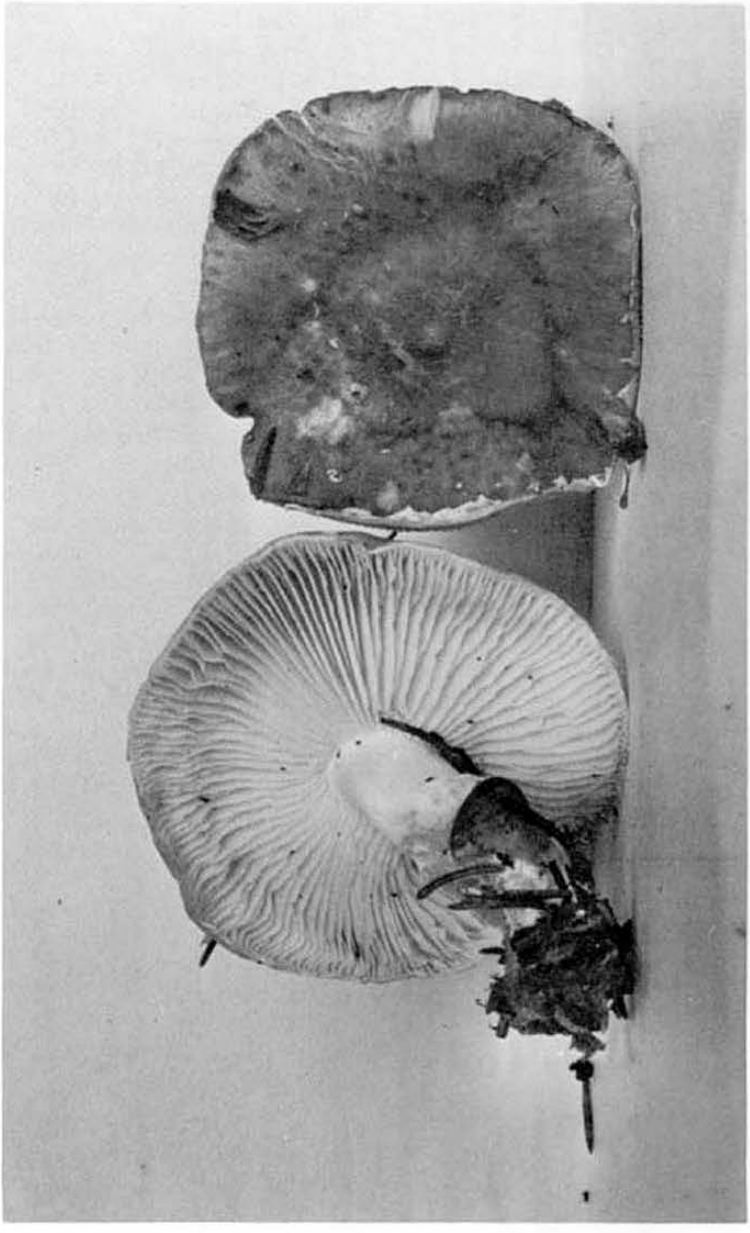


Fig. 6. *Armillaria pitkinensis* x1 Smith 52513

white.

Spore deposit white; spores 6-8 x 4-5 µ, smooth, thin-walled, hyaline, ellipsoid, amyloid.

Basidia clavate, 4-spored, (20) 23-28 x 6-8 µ. Dextrinoid basidioles scattered in hymenium. Cystidia none. Lamellar trama of parallel hyphae, the cells 40-50 x 15-20 µ, tubular. Cuticle of pileus an intermittent trichoderm, the elements of which soon become appressed to the cap surface as fibrils, the cells of the elements constricted at the septa, cells 90-125 x 12-15 µ. Clamps present.

Habit, habitat and distribution: Scattered under conifers (spruce and fir), Colorado, after summer rains, not common.

Observations: The habitat appears to be specialized. Near Ashcroft in a grove of aspen with scattered old spruce trees, this species was found only on the piles of old cones and needles. In the pileus considerable color variation was noted--olive buff, dull pale yellowish, pale buff to vinaceous buff, and often gray tones developing in age or on drying--either on cap or stipe or both. This species appears to be the nearest to *Agaricus luteo-virens*, as the latter was originally described, of any North American material seen. The manner in which the cells of the cuticular elements are constricted at the cross-walls reminds one, to a degree, of *Cystoderma*.

Material cited: COLORADO: Mitchel 2856, 5938, 6126, 6128, 6135, 6138, 6156, 6275, 6276, 6300, 6301, 6439; Smith 52513, 85772, 85839. IDAHO: McKnight F887; Weber 3414. NEW MEXICO: Barrows 241, 261, 556, 575, 1293, 1504, 1731; Isaacs 2650.

LITERATURE CITED

Albertini, I. B. de et L. D. de Schweinitz. Conspectus Fungorum. Lipsiae, 1805. pp. 375, 12 plts.

Fries, Elias Magnus. Systema Mycologicum I. Lundae, 1821. pp. 520.

Miller, O. K. Jr. Mushrooms of North America. New York: E. P. Dutton & Co., 1972. p. 74.

Pilat, Albert. "Ueber *Floccularia luteovirens* (Alb. & Schw. ex Fr.) Pouzar f. *alba* (A. H. Smith) Pil. in Ungarn." Česká Mycologie 23:13-14, 1969.

Pouzar, Zdeněk. "Nova Genera Macromycetum I." Česká Mycologie 11(1):48-49, 1957.

Ridgway, R. Color Standards and Color Nomenclature. Washington, D.C., 1912.

Romagnesi, Henri. Nouvel Atlas des Champignons IV. Bordas, 1967.

Singer, Rolf. The Agaricales in Modern Taxonomy. Lilloa 22:1932, 1951.

Singer, Rolf. The Agaricales in Modern Taxonomy. Weinheim: Cramer 4, 1962.

Singer, Rolf. The Agaricales in Modern Taxonomy (third revision). Vaduz, Germany: J. Cramer, 1975. pp. 215, 289, 299.

Smith, Alexander H. Mushrooms in Their Natural Habitats. Portland, Ore: Sawyers, 1949. pp. 347, 351.

Smith, Alexander H. A Field Guide to Western Mushrooms. Ann Arbor: Univ. of Mich. Press, 1975. pp.279, color plts. 201.

Smith, Alexander H. Species Concept in Lactarius. Proceedings of the Conference on Species Concept, Lausanne, Switzerland, 1976, *(in press)*.

Smith, Alexander H. and Maurice B. Walters. "Notes on the Genus *Armillaria*," Mycologia 39:623-25, 1947.

MYCOTAXON

Vol. IV, No. 2, p. 534 October-December 1976

NOTICES

SECOND INTERNATIONAL MYCOLOGICAL CONGRESS 1977

The Second and Final Circular describing the Second International Mycological Congress has been distributed to those persons responding to the first circular. The circular describes the symposium portion of the program, the format for contributed papers, events to occur during the Congress, and accommodations at or near the University of South Florida. Anyone interested in learning more of, or participating in the Congress should write:

Dr. Melvin S. Fuller
Secretary IMC^2
Department of Botany
University of Georgia
Athens, GA 30602 USA

imc 2

AUGUST 27 to SEPTEMBER 3, 1977

UNIVERSITY OF SOUTH FLORIDA
TAMPA, FLORIDA

BELTSVILLE SYMPOSIUM II:
BIOSYSTEMATICS IN AGRICULTURE

In 5 symposium sessions leading investigators will lecture or engage in panel discussions on the role that biosystematics has in agriculture. Main topics will include new techniques, taxonomic theories, uses of taxonomic and biosystematic data, especially predictive applications, and the planning and direction of biosystematic research. In addition, a poster session and mixer is scheduled for the evening of May 9. Manned displays at the mixer should generate valuable discussion.

For further information send your name and address to:

Dr. James A. Duke
Publicity Committee, BARC Symposium II
Plant Taxonomy Laboratory
Room 117, Bldg. 001, BARC West, USDA
Beltsville, Maryland 20705 USA

MAY 9-11, 1977

MYCOTAXON

Vol. IV, No. 2, pp. 535-539 October-December 1976

A NEW SPECIES OF EMERICELLA

SHUN-ICHI UDAGAWA AND YOSHIKAZU HORIE

National Institute of Hygienic Sciences, Kamiyoga 1-chome, Setagaya-ku, Tokyo 158, Japan & Research Institute for Chemobiodynamics, Chiba University, Izumi-cho 3-chome, Narashino-shi, Chiba-ken 275, Japan

In 1974, one of us (S.U.) had the opportunity to study the natural occurrence of mycotoxin-producing fungi in various parts of Malaysia and Thailand. On this occasion we found an Emericella which differed in several microscopic characteristics from E. rugulosa (Thom & Raper) C.R. Benjamin and also from all other species of Emericella described so far (Raper & Fennell, 1965; Wiley & Simmons, 1973; Samson & Mouchacca, 1974, 1975). Therefore, it is described below as new.

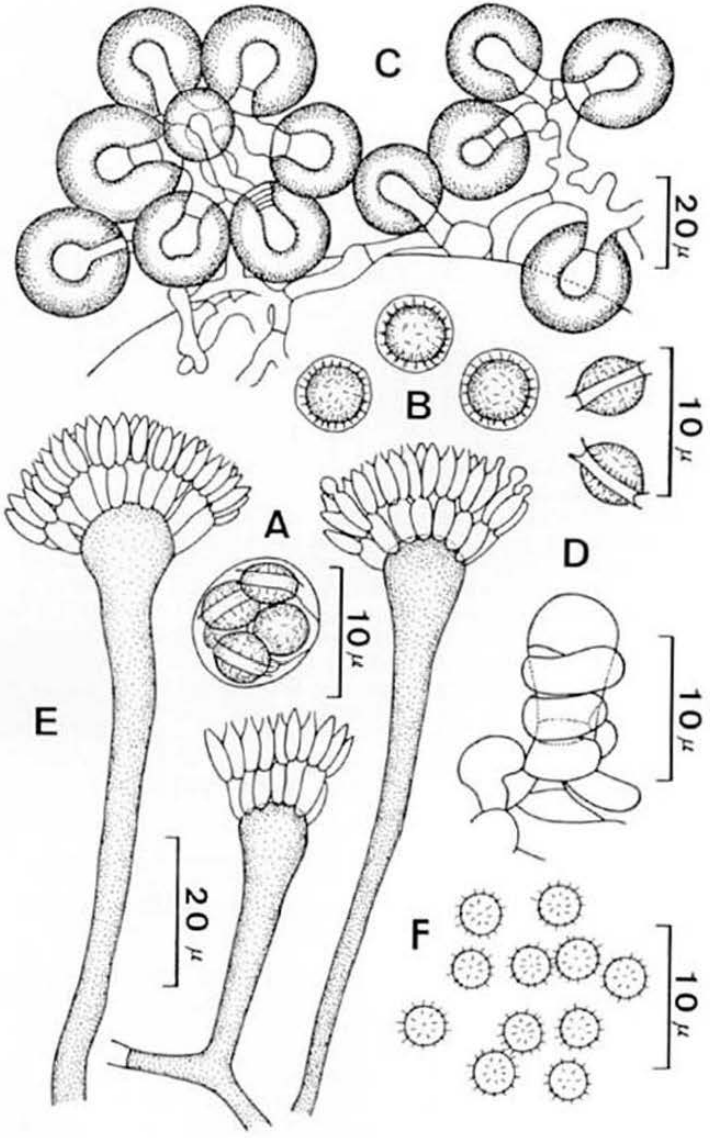
Specimens cited are deposited as follows: No. 2763 (holotype) in the Mycological Herbarium, National Institute of Hygienic Sciences (NHL), Tokyo, Japan, and No. 4522 (isotype) in the Mycological Herbarium, Research Institute for Chemobiodynamics (IFM), Chiba University, Narashino-shi, Chiba, Japan.

Emericella corrugata Udagawa & Horie sp.nov. (Figs. 1-2)

Status conidialis: Aspergillus corrugatus Udagawa & Horie st.nov.

Coloniae in agaro Czapekii fere celeriter crescentes, basi coactae, floccosae, dilute fulvae vel obscure flavo-virides; cleistothecia abundanter producentia; fructificationes conidiorum limitatae; reversum valde rubro-brunneum. Coloniae in agaro maltoso effusae, planae, obscure flavae vel olivaceae vel griseo-olivaceae, cum mycelio aerio limitatae sed cleistotheciis abundanter producentes; fructificationes conidiorum aliquantum numerosae; reversum valde flavo-aurantiacum.

Cleistothecia valde purpurea, globosa vel subglobosa, plerumque 100-240 µm diam., cum numerosis cellulis "hülle" incrustata. Asci octospori, globosi vel ovati, 9-12 x 9-9.5 µm, catenulati, evanescentes. Ascosporae purpureo-rubrae, lenticulares, duabus cristis praeditae, 3.5-4.5 x 3.5-4.0 µm (sine cristis), paginis convexis irregulariter rugosis (canaliculatis). Cellulae "hülle" hyalinae, globosae vel subglobosae, 12-30 µm diam. Capitula conidiorum


C
20 μ
B
10 μ
A
10 μ
D
10 μ
E
20 μ
F
10 μ

radiantia vel columnaria. Conidiophora vulgo e aeriis hyphis exorientia, (20-)45-140(-200) x 3.5-5.5 µm, sinuosa, interdum septata, rubro-brunnea, glabra, satis crassa. Vesiculae lageniformes, 9-12(-14) µm diam., in summa parte fertiles. Metulae 5-8 x 2.5-4 µm. Phialides ampulliformes, 6-7(-8) x 2.5-3.5 µm. Conidia globosa vel subglobosa, 2.5-3.5 µm diam., echinulata, dilute flavovirentia.

Typus No. 2763, NHL, isolatus e solo in thailandensis.

Cleistothecia dark purple, globose to subglobose, mostly 100-240 µm in diam., produced within dense masses of thick-walled hülle cells; peridium thin, consisting of several layers of yellowish encrusted hyphae, at maturity darkened and somewhat coriaceous. Asci 8-spored, globose to ovate, 9-12 x 9-9.5 µm, produced in chains from croziers, early deliquescent. Ascospores purple-red, lenticular, with two conspicuously pleated equatorial crests, 3.5-4.5 x 3.5-4.0 µm (crests 0.5-1.0 µm excluded), with convex surfaces irregularly wrinkled (with numerous grooves scattered when observed by scanning electron microscope). Hülle cells hyaline, globose to subglobose, 12-30 µm in diam. Conidial heads radiate to columnar. Conidiophores mostly arising from aerial hyphae as short side branches, (20-)45-140(-200) µm in length and 3.5-5.5 µm in diam. at middle, sinuous, sometimes septate, reddish brown, with walls smooth, fairly thick. Vesicles flask-shaped, 9-12(-14) µm in diam., fertile over the upper one-half to two-thirds. Metulae 5-8 x 2.5-4 µm. Phialides flask-shaped, 6-7(-8) x 2.5-3.5 µm, with a distinct collarette. Conidia globose to subglobose, 2.5-3.5 µm in diam., echinulate, yellowish green in masses.

At 37 C, growth better than at 25 C and with increased production of cleistothecia and conidial structures.

Holotype - No. 2763, NHL, isolated from soil sample in sugar-cane field, Nakorn Pathom, Thailand, December 15, 1974. Isotype - No. 4521, IFM.

Other material examined - No. 4522, IFM, isolated from soil from the same cultivated site, December 15, 1974.

The new species superficially resembles E. rugulosa (Thom & Raper) C.R. Benjamin (Raper & Fennell, 1965) but differs in its ascospore ornamentation. The convex walls of the ascospores are irregularly wrinkled by scattered grooves, in contrast to the closely reticulate walls in E. rugulosa (Locci, 1972; Fig. 2). E. nidulans var. echinulata Godeas (1972), the only other species of Emericella with similar ascospore color and markings, is differentiated from our species in having the convex surfaces echinulate rather than wrinkled (Fig. 2).

Figure 1. Emericella corrugata. A. Ascus. B. Ascospores. C. Hülle cells. D. Ascocarp initial. E. Conidial structures. F. Conidia.

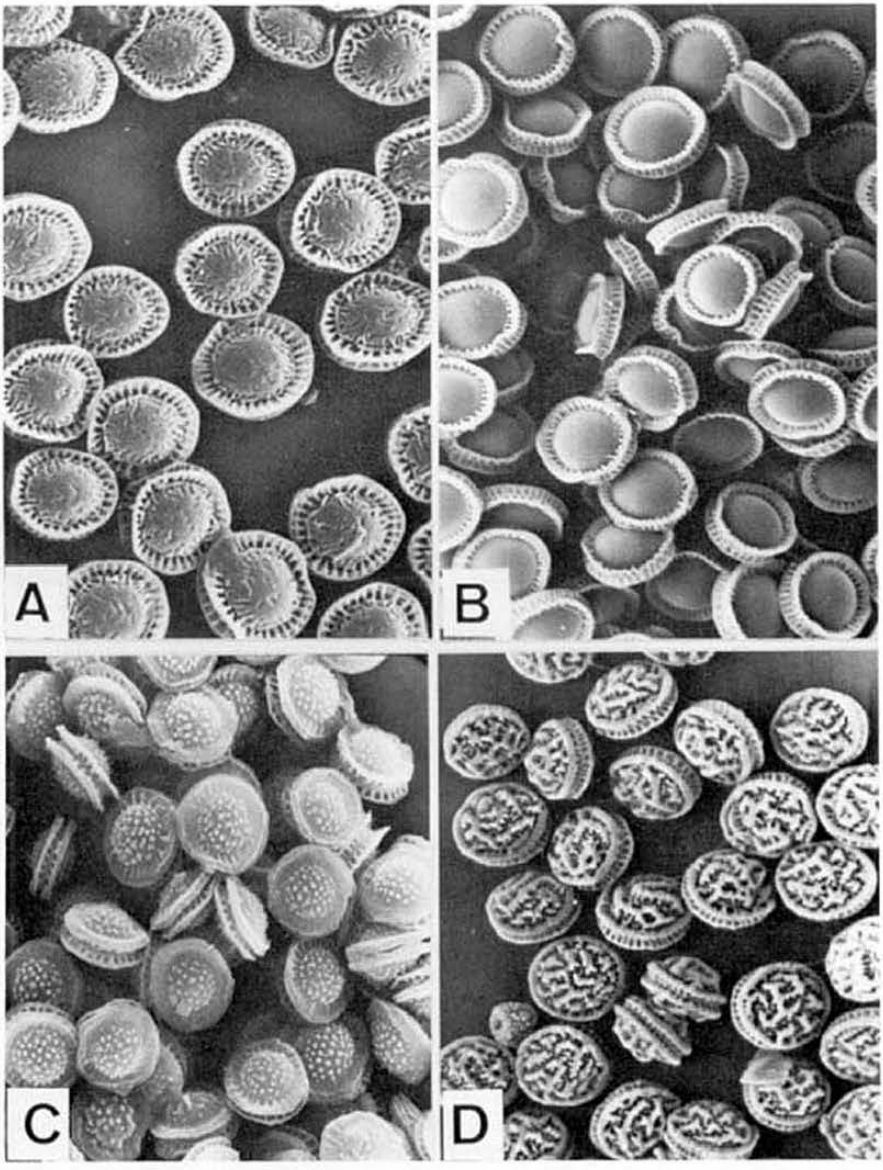


Figure 2. SEM photographs of ascospores of Emericella spp. A. E. corrugata. X 23,000. B. E. nidulans var. nidulans. X 20,000. C. E. nidulans var. echinulata. X 20,000. D. E. rugulosa. X 23,000.

ACKNOWLEDGMENTS

The authors thank Professor David Malloch, Department of Botany, University of Toronto, for reading the manuscript and making helpful suggestions.

REFERENCES

Godeas, A.M. 1972. Micoflora del suelo de la Argentina. I. Mycopathol. Mycol. appl. 46: 189-204.

Locci, R. 1972. Scanning electron microscopy of ascosporic Aspergilli. Riv. Patol. Veg. Vol. 8, Ser. IV, Suppl. 172 p.

Raper, K.B. and D.I. Fennell. 1965. The genus Aspergillus. Williams & Wilkins Co., Baltimore. 686 p.

Samson, R.A. and J. Mouchacca. 1974. Some interesting species of Emericella and Aspergillus from Egyptian desert soil. Antonie van Leeuwenhoek 40: 121-131.

Samson, R.A. and J. Mouchacca. 1975. Additional notes on species of Aspergillus, Eurotium and Emericella from Egyptian desert soil. Antonie van Leeuwenhoek 41: 343-351.

Wiley, B.J. and E.G. Simmons. 1973. New species and a new genus of Plectomycetes with Aspergillus states. Mycologia 65: 934-938.

MYCOTAXON

Vol. IV, No. 2, pp 540-544 October-December 1976

UN CORDYCEPS NOUVEAU DES PYRÉNÉES FRANÇAISES: CORDYCEPS ROUXII SP. NOV.

FRANCOISE CANDOUSSAU [1]

8 Rue François Villon, TOULOUSE - BLAGNAC 31700, France

RÉSUMÉ

Ce *Cordyceps* parasite d'*Elaphomyces variegatus* Vitt. est récolté depuis 1974 en Juin-Juillet, sous *Fagus*, à 1000 m d'altitude, dans la région de Pau (Pyrénées Atlantiques) par le Docteur Guy ROUX à qui nous dédions; il appartient aux "Directae-Valliformes-Mediae."

SUMMARY

This *Cordyceps* parasitic on *Elaphomyces variegatus* Vitt. has been collected since 1974 in the months of June and July, under *Fagus*, at 1000 m elevation, in the Pau region of France (Pyrénées Atlantiques) by Dr. Guy ROUX to whom we dedicate it; it belongs to the "Directae-Valliformes-Mediae" group.

Dans un travail précédent publié dans le Bulletin de la Société Mycologique du Béarn (Candoussau, 1975) nous avons identifié la récolte de Juillet 1974 à *Cordyceps japonica* Lloyd pensant à des carpophores mal développés, mais deux nouvelles récoltes en 1975 et 1976 nous ont fait revenir sur cette détermination ainsi que des études complémentaires, en particulier de la structure des carpophores ont confirmés qu'il s'agissait bien d'une nouvelle espèce.

CARACTÈRES MACROSCOPIQUES

Stroma solitaire ou rarement par deux, distinctement capité, s'élevant directement de l'hôte, 3 à 6 cm de hauteur. Partie fertile du carpophore ronde ou semi globuleuse brun-noir (Séguy 706) brillante et visqueuse d'un diamètre de

[1] *A cooperating scientist of the Plant Pathology Herbarium, Cornell University, Ithaca, NY 14853, USA.*

0,6 à 1,2 cm; ostioles légèrement proéminentes sous la couche gélifiée. Stipe cylindrique droit ou flexueux, sillonné longitudinalement, blanc teinté de gris vers le haut et parfois d'olivacé dans la partie inférieure, 0,2-0,8 cm de diamètre (FIGS. 1, 2).

CARACTÈRES MICROSCOPIQUES

Sous le microscope en coupe verticale (FIG. 3) le cortex laisse paraître un peridium sombre et pseudoparenchymateux couvert d'une couche superficielle de 20 µm environ d'épaisseur, de teinte plus claire et nettement différentiée: structure caractéristique du groupe "Valliformes." Perithèces ovoïdes (FIG. 4), 400-500 × 200-280 µm. Thèques (FIG. 5) 250-320 × 7-10 µm. Fragments sporaux fusoïdes (FIG. 6), (13-) 16 (-21) × 2,5-3 µm.

HABITAT

Sur *Elaphomyces variegatus* Vitt. Récoltes Guy ROUX: Juillet 1974 - 22 Juin 1975 - 3 Juillet 1976. *Station:* Bois de Haouquère près du Plas des Asphodèles, altitude 1000 m, exposition Sud. Région PAU, Pyrénées Atlantiques, France.

Il est à noter que l'apparition de ce *Cordyceps* ce situe depuis trois ans toujours à la même période et coïncide avec la croissance au même endroit sous *Fagus* des champignons

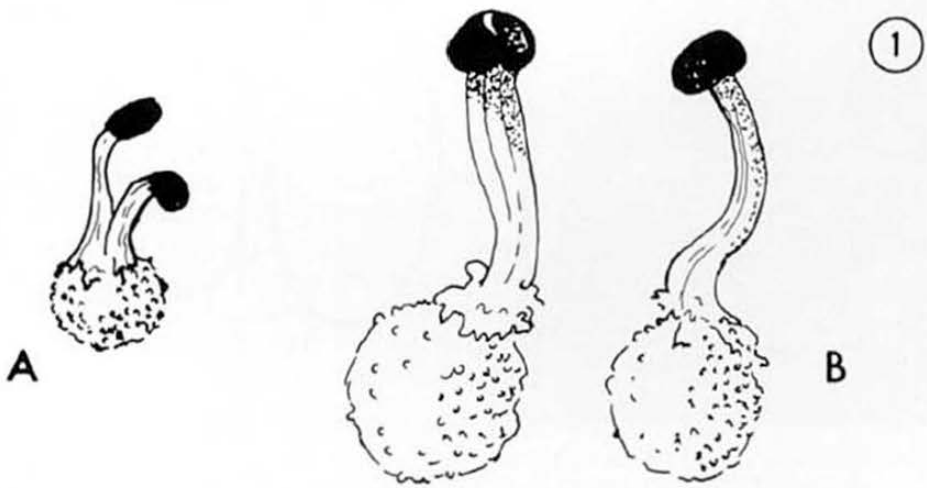


FIG. 1. *Cordyceps rouxii*. A. Récolte Dr. Guy ROUX - Juillet 1974 (Candoussau, 1975). Bois de Haouquère. (CUP 54948). B. Récolte Dr. Guy ROUX - 22 Juin 1975. Bois de Haouquère, /s *Fagus*, 1000 m alt. (CUP 54934).

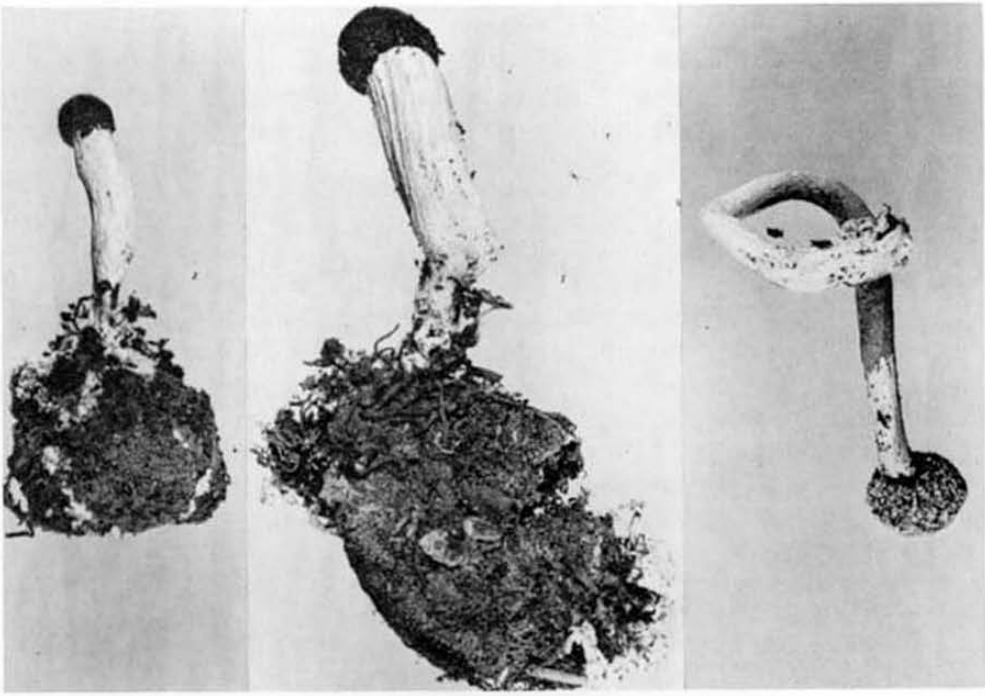


FIG. 2. *Cordyceps rouxii*. Récolte Dr. Guy ROUX - 3 Juillet 1976, même station que Fig. 1. (CUP 54937, HOLOTYPE). Photographies × 2.

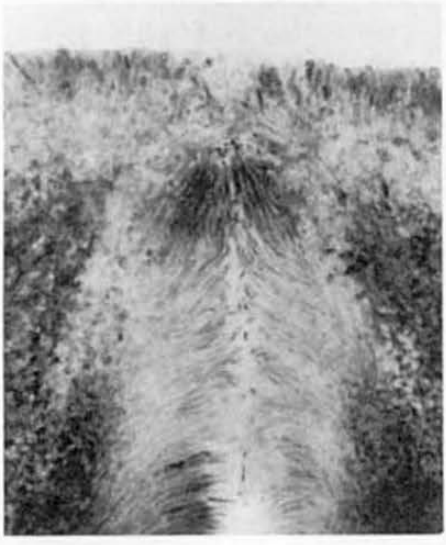


FIG. 3. *Cordyceps rouxii*. Coupe verticale du cortex de la partie fertile du carpophore, × 500. (CUP 54934).

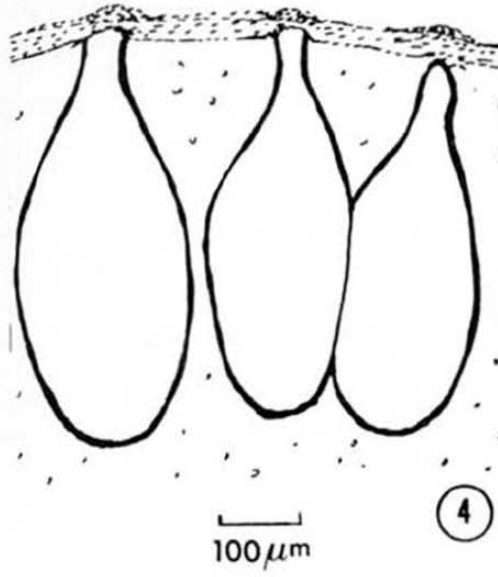
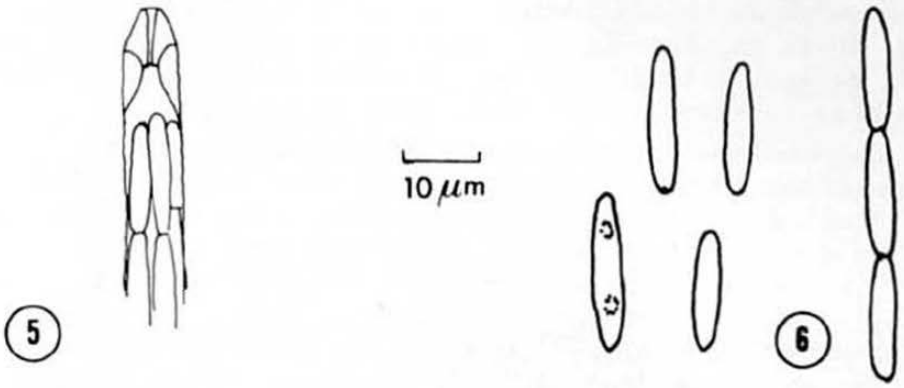


FIG. 4. *Cordyceps rouxii*. Coupe médiane de la partie fertile du carpophore (magnification indiquée). (CUP 54934).



FIGS. 5, 6. *Cordyceps rouxii*. 5. Extrémité de thèque mûre. 6. Segments sporaux. (Magnification indiquée).

suivants: *Pleurotus ostreatus* Jacq., *Russula cyanoxantha* Sch., *Marasmius aliaceus* Jacq., *Mycena alcalina* Rick, *Agrocybe praecox* Pers.

POSITION TAXONOMIQUE

Depuis que la structure des *Cordyceps* parasites d'*Elaphomyces* a été étudiée par Y. Kobayasi et D. Shimizu (1960) nous considérons qu'il éxiste deux groupes bien distincts: les Valliformes et les Evalliformes selon que la partie fertile des carpophores possède un cortex différentié ou non.

De ce fait notre récolte se situe dans *les Valliformes*. De plus les carpophores ne possédant pas de rhisomorphes abondants et superficiels tels que ceux de *C. ophioglossoïdes* par exemple, mais naissant directement de l'*Elaphomyces* notre *Cordyceps* sera classé dans les *Directae-Valliformes* et enfin considérant les mesures sporales qui se situent dans les moyennes 10-16 × 2,5-3 µm données par les auteurs Japonais, il prendra place dans les *Mediae*. Parmi les onze espèces décrites dans la monographie de Kobayasi et Shimizu aucune encore n'a été faite dans les *"Directae-Valliformes-Mediae,"* la nôtre est donc la première.

Nous pouvons cependant comparer notre récolte aux deux autres à tête capitée comme la nôtre, du groupe Valliformes:

C. intermedia Imai, spores 3-6 × 1,5-2 µm, section *Minutae*, sur *E. subvariegatus* et *E. cervinus*, Sept.

C. canadensis Ell. et Everh., spores (21-) 30-50 (-60) × 3-5 µm, section *Magnae*, sur *E. granulatus* et *E. reti-*

culatus, Juin et Sept., régions subalpines.
Si le stipe de ces deux *Cordyceps* est sensiblement plus long: 10-11 cm, la tête des carpophores est de même taille: 0,6-1 cm env. elle diffère par sa couleur soit brun rougeâtre chez *intermedia* et orangée chez *canadensis*.

C. canadensis semble avoir un habitat et une date d'apparition proches de notre espèce.

Quant à la couch gelifiée du cortex elle est d'une épaisseur de 21-27 µm chez *C. intermedia* Imai
de 8-12 µm chez *C. canadensis* Ell. & Everh.
de 20 µm chez *C. rouxii* F. Cand.

Les mesures sporales séparent les 3 nettement.

Aucune des espèces décrites par Mains (1957) ne correspond à la nôtre.

REMERCIEMENTS

Notre reconnaissance au Professeur R. P. KORF pour l'aide qu'il nous a apportée dans l'étude de ces récoltes. Tous nos remerciements à Susan C. GRUFF d'avoir fait pour nous les coupes verticales et à H. H. LYON d'avoir photographié les carpophores et les coupes verticales.

DIAGNOSE LATINE

Cordyceps rouxii Françoise Candoussau, species nova

Stromata solitaria vel caespitosa duo 2-4 cm alta directe fructificatione *Elaphomycetis variegatis*. Pars fertilis globularis 3-8(-10) mm, peridio fusco atro nitente viscoso, valliformi. Perithecia medium immersa, minuta, ovoidea collis plusve minusve elongatis 400-500 × 200-280 µm. Asci 250-320 × 7-10 µm capitibus circa 8-10 µm diam. Articuli ascosporarum cylindracei (13-) 16 (-21) × 2,5-3 µm utrinque fusiformi. HOLOTYPUS, CUP 54937; ISOTYPUS, Herbier F. Candoussau 4789-1.

BIBLIOGRAPHIE

CANDOUSSAU, FRANÇOISE. 1975. Récolte de Cordyceps japonica Lloyd dans la région de Pau. (Première fois en France et deuxième en Europe). Bull. Soc. Mycol. Béarn No. 62: 1-3.

KOBAYASI, YOSIO & DAISKE SHIMIZU. 1960. Monographic studies of Cordyceps 1. Group parasitic on Elaphomyces. Bull. Natl. Sci. Mus. 5: 69-85.

MAINS, E. B. 1957. Species of Cordyceps parasitic on Elaphomyces. Bull. Torrey Bot. Club 84: 243-251.

MYCOTAXON

Vol. IV, No. 2, 545-550 October-December 1976

COPROTIELLA, A NEW CLEISTOCARPOUS GENUS OF THE PYRONEMATACEAE WITH ASCOSPORES POSSESSING de BARY BUBBLES[1]

R.S. JENG and J.C. KRUG

Department of Botany, University of Toronto
Toronto, Canada

SUMMARY

Coprotiella gongylospora gen. et sp. nov. is described and illustrated from horse dung collected in Argentina. The genus is compared with Coprotus, its operculate counterpart. Cleistothelebolus, Eoterfezia, Lasiobolidium, Microeurotium, Orbicula, Warcupia and Xeromyces are transferred to the Pyronemataceae.

INTRODUCTION

In the course of a continuing study of coprophilous fungi, one apparently undescribed cleistocarpous genus was found growing on horse dung, collected in Argentina and maintained in moist chamber at room temperature. This taxon is characterized by possessing light coloured cleistothecia; broadly clavate asci; and hyaline, smooth, thin-walled ascospores possessing de Bary bubbles. Since no other cleistocarpous genus is known with this combination of characteristics, the taxon is described here as a new genus.

TAXONOMY

Coprotiella Jeng & Krug gen. nov.

Ascocarpia dispersa vel gregaria, sine stromate nec ostiolo, subglobosa vel globosa, primum hyalina, deinde cremea vel flavida, glabra; peridium membranaceum, pseudoparenchymatosum, cremeum vel flavidum. Asci unitunicati,

[1] Supported by grants from the National Research Council of Canada.

iodo non caerulescentes, late clavati, evanescentes, non uncinati neque apparato apicali praediti. Paraphyses nullae. Ascosporae unicellulares, leves, hyalinae, tenuitunicatae, plerumque bullulas conspicuas exhibentes, sine foramine vel fissura germinationis; vagina gelatinosa nulla. Conidia incognita.

TYPUS GENERIS: Coprotiella gongylospora Jeng et Krug.

ETYMOLOGY: Derived from the generic name Coprotus and the diminutive suffix -ellus, referring to the similarity to the genus Coprotus.

Ascocarps scattered or gregarious, non-stromatic, non-ostiolate, subglobose to globose, hyaline at first, becoming creamy or yellowish, glabrous; peridium membranaceous, pseudoparenchymatous in surface view, creamy or yellowish. Asci unitunicate, non-amyloid, broadly clavate, evanescent, without croziers or apical apparatus. Paraphyses lacking. Ascospores one-celled, smooth, hyaline, thin-walled, at maturity usually possessing a conspicuous de Bary bubble; germ pores or germ slits lacking; gelatinous sheath absent. Conidial state unknown.

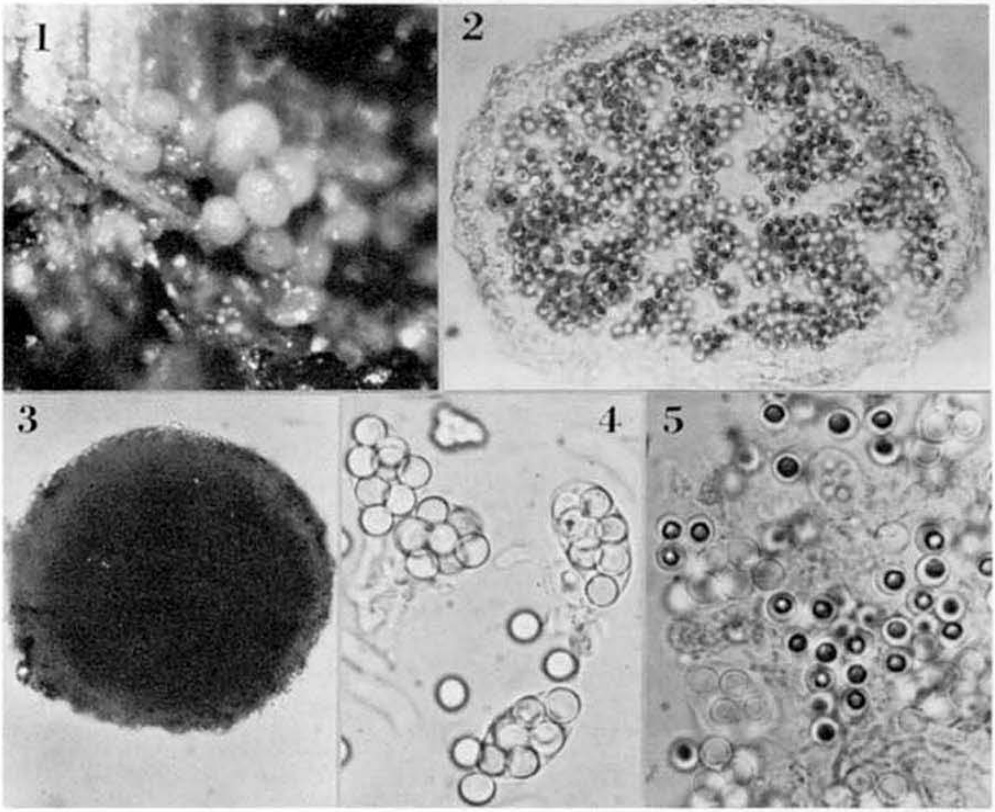
Coprotiella gongylospora Jeng & Krug sp. nov. Figs. 1-5.

Ascocarpia dispersa vel gregaria, non ostiolata, subglobosa vel globosa, 140-290µm diametro crassa, primum hyalina, deinde cremea vel flavida, glabra; peridium membranaceum, pseudoparenchymatosum, 9-12µm crassum, textura angulari vel textura globulosa in uno strato compositum, cellulis 3-14 x 3-6µm magnis. Asci unitunicati, iodo non caerulescentes, octospori, subglobosi vel late clavati, basin versus in stipitem brevem contracti, 24-31 x 13-21µm magni, evanescentes. Ascosporae unicellulares, globosae, 5.6-6.3µm diametro crassae, hyalinae, leves, tenuitunicatae, plerumque bullulas conspicuas exhibentes.

HOLOTYPUS: in equorum fimo lectus est, in loco a Cafayete 40 km meridionali remoto, in via 40 vocata, in Tucuman provincia reipublicae Argentinensis, 31 Mart. 1974, Mares C1387b. In Torontoensis universitatis Cryptogamarum herbario.

ETYMOLOGY: Greek, gongylos = ball, and spora = seed, referring to the globose shape of the ascospores.

Ascocarps scattered or gregarious, non-ostiolate, subglobose to globose, 140-290µm in diameter, hyaline at first, becoming creamy or yellowish, glabrous; peridium membra-



Figs. 1-5. Coprotiella gongylospora. 1. Habit view of the ascocarps. x36. 2. Longitudinal section of an ascocarp. x295. 3. Ascocarp in optical view. x176. 4. Young asci and ascospores. x590. 5. Mature asci and ascospores, showing the de Bary bubbles. x590.

naceous, pseudoparenchymatous in surface view, occasionally intertwined with filamentous hyphae, 9-12µm thick, creamy or yellowish, one-layered in section, consisting of textura angularis to textura globulosa, with cells measuring 3-14 x 3-6µm. Asci unitunicate, non-amyloid, 8-spored, subglobose to broadly clavate, short stipitate, 24-31 x 13-21 µm, evanescent, without croziers or apical apparatus. Paraphyses lacking. Ascospores one-celled, globose, 5.6-6.3µm in diameter, hyaline, smooth, thin-walled, at maturity usually possessing a conspicuous de Bary bubble; gelatinous sheath absent; germ pores or germ slits lacking. Conidial state unknown.

HABITAT: on horse dung.

SPECIMEN EXAMINED: ARGENTINA: Tucuman Prov.: along Hwy. 40, 40 km S of Cafayete, horse dung, 31 Mar. 1974, Mares C1387b (TRTC).

DISCUSSION

Coprotiella is similar in many ways to Coprotus Korf et Kimbrough. The ascocarps are likewise slightly coloured, the peridium is composed of textura globulosa to textura angularis like the excipulum in species of Coprotus, and the ascospores at maturity are mainly hyaline with a conspicuous de Bary bubble. On the contrary Coprotiella differs from Coprotus in possessing ascocarps which remain closed at all stages of development and asci which are subglobose to clavate, evanescent, and probably irregularly disposed. Coprotiella is also similar to Cleistothelebolus Malloch et Cain and Lasiobolidium Malloch et Cain but differs primarily from both genera in having ascospores possessing de Bary bubbles.

Malloch and Cain (1971) erected two new genera, Cleistothelebolus and Lasiobolidium, which were considered as the respective cleistothecial counterparts of the discomycetes Thelebolus Tode ex Fr. and Lasiobolus Sacc. Both Cleistothelebolus and Lasiobolidium were placed along with Eoterfezia Atkinson, Microeurotium Ghatak, Orbicula Cooke and Xeromyces Fraser in the Eoterfeziaceae. Undoubtedly Warcupia Paden et Cameron (1972) and perhaps even Monascus van Tiegham are also related, although at present it seems appropriate to retain Monascus in a separate family.

It has been accepted by a number of workers (Malloch, 1970; Lundqvist, 1972; Müller and von Arx, 1973) that closely related ostiolate and cleistothecial genera are better accommodated in one rather than in separate families as originally suggested by Cain (1956) who was followed in this respect by various other workers. Accordingly, it would seem appropriate to place Cleistothelebolus and Lasiobolidium along with Thelebolus and Lasiobolus in the same family. Similarly Coprotus and Coprotiella would belong in one family. In his recent concept of the Pezizales, Korf (1972) placed those operculate discomycetes that are fimicolous, with ascocarps reduced in size and complexity, possessing non-amyloid asci, with smooth, hyaline ascospores in the Pyronemataceae tribe Theleboleae while Eckblad (1968) would treat this taxon at the family level. We are following Korf and placing Cleistothelebolus,

Coprotiella, and Lasiobolidium along with their discomycetous counterparts in the tribe Theleboleae. Except for its terricolous habit, Warcupia also seems to possess morphological and developmental features characteristic of this taxon. Although discomycetous connections have not yet been established, the remaining genera in the Eoterfeziaceae are obviously closely related to those in this tribe. Accordingly Eoterfezia, Microeurotium, Orbicula, Warcupia and Xeromyces are transferred to the tribe Theleboleae of the Pyronemataceae.

ACKNOWLEDGMENTS

We wish to express our appreciation to Dr. D.W.Malloch (Toronto) for confirming the identity of the fungus. Dr. J. A. von Arx (Baarn) has made a number of helpful suggestions while Dr. W.Gams (Baarn) has improved the Latin diagnoses for which we are especially thankful.

LITERATURE CITED

Cain, R.F. 1956. Studies of coprophilous Ascomycetes. II. Phaeotrichum, a new cleistocarpous genus in a new family and its relationships. Can. J. Bot. 34: 675-687.

_____. 1956. Studies of coprophilous Ascomycetes. IV. Tripterospora, a new cleistocarpous genus in a new family. Can. J. Bot. 34: 699-710.

Eckblad, F.E. 1968. The genera of the Operculate Discomycetes. A Re-evaluation of their taxonomy, phylogeny and nomenclature. Norwegian J. Bot. 15(1/2): 1-191.

Korf, R.P. 1972. Synoptic key to the genera of the Pezizales. Mycologia 64: 937-994.

Lundqvist, N. 1972. Nordic Sordariaceae s. lat. Symbol. Bot. Upsal. 20(1): 1-374.

Malloch, D. 1970. New concepts in the Microascaceae illustrated by two new species. Mycologia 62: 727-740.

_____ and R.F. Cain. 1971. Four new genera of cleistothecial Ascomycetes with hyaline ascospores. Can. J. Bot. 49: 847-854.

Müller, E. and J.A. von Arx. 1973. Pyrenomycetes: Meliolales, Coronophorales, Sphaeriales. pp. 87-132. In: Ainsworth, G.C., F.K. Sparrow, and A.S. Sussman (eds.), The Fungi, an advanced Treatise, Vol. 4A. Academic Press, New York and London.

Paden, J.W. and J.V. Cameron. 1972. Morphology of Warcupia terrestris, a new ascomycete genus and species from soil. Can. J. Bot. 50: 999-1001.

MYCOTAXON

Vol. IV, No. 2, pp. 551-557 October-December 1976

REVUE DES LIVRES

G. L. HENNEBERT

Book Review Editor, Huttelaan 36, B-3030 Heverlee, Belgium

GUIDE TO AQUATIC HYPHOMYCETES. AN ILLUSTRATED GUIDE TO AQUATIC AND WATER-BORNE HYPHOMYCETES (FUNGI IMPERFECTI) WITH NOTES ON THEIR BIOLOGY, par G. I. INGOLD. Freshwater Biological Association, Scientific Publication no. 30, 96 p., 39 figs., broché, 1975. Freshwater Biological Association, The Ferry House, Ambleside nr. Windermere, Cumbria LA22 8LP, UK. Prix: £1.oo.

Ce petit livre est bien un guide. Il vous donne l'envie d'aller récolter et examiner les feuilles mortes submergées au bord des ruisseaux avant que la pollution n'en détruise la richesse de la fonge aquatique.

Dans l'introduction, on apprendra que, pour être "aquatique", un champignon doit être capable de développer l'entièreté de son cycle - croissance, reproduction, libération, dispersion - sous l'eau. La conidiogénèse des Hyphomycètes, même exogène, aura lieu sous l'eau. C'est là une capacité qui n'en exclut pas d'autres, comme celle de se développer aussi dans des situations terrestres, telles que les litières humides. Il s'agit d'un groupe "biologique" plutôt qu'un groupe "naturel" d'organismes par leurs affinités taxonomiques ou phylogénétiques. Par exemple, deux espèces d'Anguillospora seraient les stades conidiens d'ascomycètes de genres différents, Massarina et Mollisia. Il faut cependant admettre que ce groupe "biologique" d'organismes est bien naturel par la convergence de ses adaptations au milieu dans la forme et les besoins. 126 espèces, classées dans 46 genres, sont décrites et illustrées. Elles comprennent 121 Hyphomycètes, 1 levure imparfaite, 2 Spaeropsidales, 1 Basidiomycète imparfait et 1 Zoopagacée, ces cinq derniers étant donnés comme "non-hyphomycètes". Les Hyphomycètes hyalins sont répartis en trois groupes suivant leur conidiogénèse: 24 genres produisent des thalloconidies, 5 genres ont des phialoconidies et 2 des blastoconidies. Cependant les genres à conidies filiformes (2 phialosporés et 3 thallosporés) sont curieusement classés séparément de même que 5 genres d'Hyphomycètes dématiés. Dans cette classification plutôt pragmatique que taxonomique, les genres à "thalloconidies" dominent. Celles-ci sont surtout des conidies terminales à septum de base du diamètre de l'hyphe conidiogène et diffèrent certainement des blastoconidies du genre Drechslera que l'auteur (p. 9) prend en exemple pour elles.

Le fait que 19 espèces d'Hyphomycètes et 14 types despores restent sans nom, montre combien ce groupe de champignons méritent l'attention.

IMPORTANT DISEASES OF FOREST TREES. CONTRIBUTIONS TO MYCOLOGY AND PHYTOPATHOLOGY FOR BOTANISTS AND FORESTERS, par R. HARTIG.

Phytopathological Classics no. 12, traduit de l'allemand par W. MERRILL, D. H. LAMBERT et W. LIESE, 22 + 120 p., 1 photo, 160 figs. en 6 pls., 8°, relié, (1874) 1975. The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minn. 55121. Prix: US $ 4.50.

La Société Américaine de Phytopathologie a très heureusement choisi de publier, comme Classique de la Phytopathologie, la traduction de l'ouvrage de Robert Hartig, considéré comme la base de la pathologie forestière. La traduction reproduisant de près le fond et la forme du texte original et la reproduction fidèle des lithographies originales nous permettent d'aprécier toute la minutie et l'objectivité de Hartig dans son observation, il y a 100 ans, des grandes maladies de nos forêts dues à Armillaria mellea, Trametes pini, Trametes radiciperda, Aecidium pini, Caeoma pinitorquum, Caeoma laricis, Peziza willkommii, Hysterium macrosporum, Hysterium nervisequium et Melampsora salicina. Un retour aux sources qui vaut la peine.

ANNUAL REVIEW OF PHYTOPATHOLOGY, VOL. 13, édité par K. F. BAKER, G. A. ZENTMYER et E. B. COWLING, 12 + 412 p., ill., 8°, relié toilé, 1975. Annual Reviews Inc. 4139 El Camino Way, Palo Alto, California 94306. Prix: US $ 17.50.

Chacun connaît la qualité des 12 premiers volumes des Annual Reviews of Phytopathology et leur impact dans l'avancement de cette discipline. Cependant on apréciera, dans ce 13e volume, la publication de 5 articles plus mycologiques.

Dans Variation and Speciation in the Fusaria, T. A. Tousson et P. E. Nelson comparent fort objectivement les systèmes de Snyder et Hansen, de Messiaen et Cassini et de Booth, mais sans y inclure celui de Wollenweber et Reinking, la base des autres. Dans The present status of Fusarium taxonomy, C. Booth démontre la nécessité de stabiliser la nomenclature de ce genre par le choix d'un matériel type nouveau (néotypes) vivant.

La nature, la morphogénèse et le rôle des appressoria d'une part et des sclérotes d'autres part sont revues de manière intéressante par L. W. Emmet et D.G. Parbery et par J. Chet et Y. Henis.

Mais on ne peut taire la remarquable réflexion que nous propose J. Walker sur les Mutual Responsibilities of Taxonomic Mycology and Plant Pathology. Si d'une part se manifeste une sorte de retraite monastique, on constate d'autre part une apathie certaine. Dans une analyse sincère de cet état de choses, l'auteur entraine le lecteur à une prise de conscience des remèdes. Certainement l'auteur appelle à plus de coopération mutuelle. Tant de poubelles de laboratoires phytopathologiques regorgent de beaux spécimens de plantes malades porteurs du champignon pathogène tandis que l'herbier mycologique voisin n'a pas de specimen de ce champignon ou n'a que quelques spécimens obtenu en échange d'un pays étranger. Il serait cependant simple et profitable de confier ces échantillons au taxonomiste en y adjoignant les informations indispensables d'hôte, de localité de collecteur et de date. Dans d'autres cas, au contraire, le taxonomiste est mis à contribution presque sans considération, dans l'identification de nombreux "isolements" de champignons de plantes malades ou du sol. Il arrive si souvent que ces "isolements" présentent des associations étranges de caractères ou de sporulation qui en feraient de nouvelles espèces

ou sont au contraire stériles: mais ce sont des cultures mixtes de plusieurs espèces fongiques ou encore de champignons, de bactéries, et même encore d'amibes, de nématodes ou d'acariens. Ainsi cet Humicola sp., présumé mycorhizique, qui devait se révéler comme nouvelle espèce, si son mycélium blanc abondant n'avait été celui d'un Mortierella ne sporulant plus par suite de la présence de bactéries et ses chlamydospores celles d'un Phialophora dont la conidiogénèse était inhibée au sein de l'association. Si le taxonomiste doit commencer l'identification d'une souche de Penicillium par la séparation des deux taxa voisins qu'elle contient par voie de cultures monogermes, il ne faut pas s'étonner de devoir attendre le résultat. Que J. Walker soit remercié pour la sincérité de son appel à plus de considération mutuelle.

BIOLOGICAL TRANSFORMATION OF WOOD BY MICROORGANISMS, édité par Walter LIESE, 203 p., 53 figs., 8°, broché, 1975. Springer Verlag, Heidelberger Platz 3, D-4023 Berlin-West. Prix: DM 32.oo, US $ 13.8o.

Communications à la Session "Wood Products Pathology" du 2e Congrès International de Phytopathologie de Minnéapolis, les 10-12 septembre 1973 par 18 spécialistes de la biodégradation du bois. Ce rapport fait état des recherches récentes sur la colonisation du bois par les champignons, la succession des flores, leurs relations avec la nature du bois et sa résistance spécifique, la position du bois par rapport à l'inoculum (sol), la profondeur de pénétration, les antagonismes et synergies, les effets et les mécanismes physiques et chimiques de la dégradation. Corrélativement, on trouvera aussi des données critiques sur les méthodes d'investigation et de "testing" du bois en vie de sa protection.

MULTILINGUAL COMPENDIUM OF PLANT DISEASES. COMPENDIUM POLYGLOTTE DES MALADIES DES PLANTES, par Paul R. MILLER et Hazel L. POLLARD, 457 p., 325 col. figs. in 36 pls., 4° relié,1976. The American Phytopathological Society, 3340 Pilot Knob Road, St Paul, Minn. 55121.Prix: US $ 36.oo.

Ce Compendium a pour but de faciliter la communication à travers le monde dans le domaine de la protection des cultures en cataloguant et clarifiant la dénomination des maladies dans 21 langues différentes et en fournissant une description synthétique de chacune des 325 maladies en 4 langues, anglais, français, espagnol et "interlingua". L'enquête a été limitée aux maladies dues aux champignons et aux bactéries. Chaque maladie est dénommée et classée alphabétiquement par le nom latin de l'hôte principal + le nom du pathogène. Chaque maladie, sauf 43, est illustrée par photographie en couleurs de petites dimensions (5 x 5 cm) mais de bonne qualité. Des index des hôtes, des pathogènes et des maladies, sur plus de 120 pages, complètent utilement l'ouvrage.

THE CHEMOTAXONOMY OF PLANTS, par P. M. SMITH, in coll. Contemporary Biology, édité par E. J. W. BARRINGTON et A. J. WILLIS, 313 p., ill., broché, 1976. Edward Arnold, 25 Hill Street, London W1X 8LL. Prix: relié £ 13.oo, broché £ 6.5o.

L'auteur tente d'explorer l'immense champ de rencontre entre taxonomistes et chimistes, de manière à mieux servir la taxonomie des plantes (seuls quelques exemples concernent les champignons et les bactéries). Dans une première partie, l'auteur définit très bien la place de la chimiotaxonomie et analyse sa démarche: partant d'une taxonomie classique des organismes d'une part et des possibilités offertes d'analyses chimiques d'autre part, le chimiotaxonomiste accumule des données qu'il interprétera en vue d'une confirmation ou d'une modification de la taxonomie préétablie et éventuellement en vue d'une construction phylogénétique. Dans une seconde partie, les diverses sources d'information chimique sont alors évaluées, sur la base d'exemples, pour leur utilité en taxonomie: amino-acides, phénols, bétalaïnes, huiles, cires, hydrates de carbone, alkaloides, terpénoïdes, stéroides, protéines et acides nucléïques. Dans une dernière partie, les promesses et les limitations de la chimiotaxonomie sont formulées avec lucidité. Ce livre d'une lecture facide, aidera le taxonomiste et le chimiste à se rencontrer.

BIOLOGICAL IDENTIFICATION WITH COMPUTERS, édité par R.J. PANKHURST, The Systematics Association Special Volume no. 7, 333 p., 33 figs., 8°, relié, 1975. Academic Press Inc., 24-28 Oval Road, London NW1, 111 Fifth Ave, New York, NY 10003. Prix : £ 11.oo.

Ce livre publie les 16 communications offertes à la conférence organisée par la Systematics Association à Cambridge les 27-28 septembre 1973, dans le but de définir les possibilités et les limites de l'ordinateur dans l'identification des organismes vivants. Il apparaît que l'ordinateur ne se substitue pas encore au biologiste dans l'observation de départ. Son rôle se limite à reproduire et peut-être standardiser (ou "modeler") la procédure de décision. Beaucoup de travaux ont été réalisés sur l'usage de l'ordinateur pour la classification (voir taxonomie numérique), mais peu encore pour l'identification, endehors du domaine du diagnostic médical dont il n'est pas ici question. Cette synthèse des connaissances commence par une analyse conceptuelle des mécanismes essentiels de l'identification et ensuite détaille les divers procédés offerts par l'ordinateur: la construction de clés dichotomiques, de clés à entrées multiples, l'identification par approche globale, par tests multiples et dépendants, par clés binaires et coefficient de similitude, l'identification par la probabilité, par les distances euclidiennes ou les coefficients de corrélation, et même l'identification par reconnaissance des charactères des spécimens ("Pattern Recognition") et même l'identification par conversation en ligne (procédé question-réponse). Ces techniques présuppose une observation ordonnée des caractères selon un programme qui peut être élaboré par ordinateur. Ces recherches finissent par faire appel à une nouvelle forme de perfection des descriptions taxonomiques. Elles amènent aussi le taxonomiste traditionnel à repenser les principes de son activité, d'en découvrir les mécanismes profonds, de les expérimenter et les modifier en vue de les rendre communicables et reproductibles. Cet ouvrage, technique sans doute mais d'un style clair, est une heureuse réflexion sur une phase essentielle du travail taxonomique.

LICHENOLOGY: PROGRESS AND PROBLEMS, édité par D. H. BROWN, D. L. HAWKSWORTH et R. H. BAILEY. The Systematics Association Special Volume no. 8, xii + 554 p., ill., 8° relié, 1976. Academic Press, London, New York. Prix £ 19.oo.

La lichénologie fait de grand progrès durant ces récentes années, grâce aux nouvelles techniques d'approche et stimulé par les problèmes d'environnement et de pollution. Ce livre résulte du Symposium international tenu à l'Université de Bristol les 8-10 avril 1974. Ses 20 contributions reflètent bien les orientations de recherche actuelles: l'ultrastructure des lichens par SEM et TEM, l'étude morphologique du développement et de la fructification, l'étude taxonomique du phycobionte, les facteurs écologiques de la distribution des lichens, le taux de croissance des lichens et l'âge des supports, les adaptations des lichens à des milieux particuliers tels que les matériaux ou le milieu marin, l'absorption de SO2 et de minéraux dans les milieux pollués, la physiologie et le métabolisme des lichens et enfin la nature profonde de la symbiose lichénique analysée dans ses principes ou dans son entité comme écosystème. Ce livre montre combien les lichens, par les mystères de leur "vie à deux" méritent l'attention d'un très large public.

ENDOMYCORRHIZAS, édité par F. E. SANDERS, Barbara MOSSE et P.B. TINKER, xiv + 626 p., ill., 8°, relié,(1975) March 1976, Academic Press, London, New York. Prix: £ 9.6o.

Proceedings of a Symposium held at the University of Leeds, 22-25 July 1974. Cet ouvrage complète très bien cet autre édité par G. C. Marks et T. T. Kozlowski sur les "Ectomycorrhizae, their ecology and physiology" (Academic Press,1973). La plupart des 41 communications se concentrent sur les endomycrhizes vésiculaires et arbusculaires, sans négliger les autres endomycorhizes, en particulier des Orchidées et des Ericacées. On y parle de l'évolution de la classification et de la culture des endophytes, de leur physiologie, de leur ultrastructure, des relations et interactions entre le champignon, l'hôte et le milieu (carbohydrates, phosphore) et enfin de l'interférence des fertilisants et des fongicides sur la symbiose. Ce livre, le plus récent sur les endomycorhizes, sera une base de référence dans toute nouvelle investigation.

DE NEDERLANDSE MYXOMYCETEN, par N. E. NANNEGA-BREMERKAMP, Publication no. 18, 440 p., 1000 figs., relié toilé, 1974. Koninklijke Nederlandse Natuurhistorische Vereniging, B. Hoogenboomlaan 24, Hoogwoud 1743, Nederland. Prix: DFl 70.oo, US $ 21.oo.

Madame Nannega-Bremerkamp dédicace son livre à son père, son époux et ses enfants et l'adresse aux lecteurs en ces termes : "Zoekt, vindt en geniet" (cherche, trouve et jouis). L'auteur exprime là la patience de sa recherche, le dynamisme de sa découverte et l'enthousiasme de son admiration de la nature. En 25 années, elle est arrivée à découvrir au Pays-Bas 266 espèces de Myxomycètes qu'elle décrit avec soin et illustre de beaux dessins à la plume aux grossissements de 10 à 1000 X. Dans 13 planches hors texte, elle compare encore en détail (2000 X) les spores de 182 espèces.

Des notes taxonomiques fournissent la distinction d'avec les espèces qui n'ont pas été trouvées aux Pays-Bas. Elles pousseront sans doute vers de nouvelles découvertes.

Bien qu'écrit en néerlandais, ce livre aura une audience beaucoup plus large du fait de ses qualités scientifiques et de l'importance de sa contribution pour la mycoflore d'Europe. Il faut en féliciter l'auteur et venir apprendre avec elle l'art de cultiver les Myxomycètes dans son propre jardin, de les y observer chaque jour et les admirer.

INTRODUCTION TO THE HISTORY OF MYCOLOGY. par G. C. AINSWORTH, xi + 359 p., 106 figs., 8°, relié, 1976. Cambridge University Press, Trumpington Street, Cambridge CB2 1RP, or 32 East 57th Street, New York, NY 10022. Prix: £ 11.00.

Quel plaisir la lecture de ce livre raffiné par son style et le choix de son illustration ne donnera-t-elle pas à tout mycologue, à tout botaniste et à quiconque est curieux de regarder vers ceux qui furent à la source de nos connaissances. En frontispice, une planche coloriée de Bulliard (1791) et en couverture, le médaillon gravé du Selecta fungorum carpologia des frères Tulasne montrent d'emblée l'appréciation esthétique et le bon jugement scientifique et historique de l'auteur.

La mycologie a de multiples aspects, son histoire de même. L'auteur les considérera séparément. D'abord ce qu'ont été les champignons et leur statut en science naturelle, ensuite leurs formes et leurs structures telles qu'elles furent observées avec les instruments de chaque époque, puis leur nutrition et leur culture. La découverte de leur polymorphisme, de leur sexualité, de leur génétique furent des étapes passionnante. Mais aussi, depuis longtemps, l'alarme a été lancée sur leur pathogénécité, leur toxicité, leurs effets hallucinogénique et allergénique, malgé un usage plus que millénaire. L'exploration du monde eut ses époques, de même la découverte des champignons et de leur distribution. Avec l'accumulation des données, la classification aussi évolua beaucoup, marquée par les synthèses d'hommes fameux. La mycologie est enfin affaire d'hommes qui seuls ou groupés en sociétés en ont fait une science et l'activité humaine que nous connaissons.

Non seulement agréable à lire, ce livre est aussi un document scientifique, rigoureux et critique. C'est aussi un livre stimulant la réflexion sur les possibilités futures de la mycologie.

MORE DEMATIACEOUS HYPHOMYCETES, par Martin B. ELLIS, 507 p., 383 figs, 8°, relié, 1976, Commonwealth Mycological Institute, Kew. Central Sale Branch, Commonwealth Agricultural Bureaux, Farnham Royal, Slough SL2 3BN, UK. Prix: £ 18.00.

Après le premier volume "Dematiaceous Hyphomycetes" publié par l'auteur en 1971, on accueillera avec plaisir ce nouveau volume d'ailleurs aussi important puisqu'il contient la description de 732 autres espèces d'Hyphomycètes. Alors que le premier volume abondait en champignons lignicoles, on trouvera dans celui-ci une revue plus large des genres communs tels que Alternaria, Cladosporium, Cercospora, Drechslera, Phialophora, Stachybotrys, On y trouvera aussi 10 genres nouveaux, 61 nouvelles espèces et 119 noms et combinaisons nouvelles.

Une fois de plus l'auteur est à féliciter pour la technicité de ses ses descriptions et l'excellence des dessins qu'il fournit pour chaque espèce. Sans aucun doute, ce travail magistral sera consulté par tous ceux qui étudient les Hyphomycètes.

REVISION OF THE SUBSECTION FASCICULATA OF PENICILLIUM AND SOME ALLIED SPECIES, par R. A. SAMSON, Amelia C. STOLK et R. HADLOK. Studies in Mycology, no. 11, 47p., 15 figs., 1976. Centraalbureau voor Schimmelcultures, Baarn, Pays-Bas. Prix Dfl 15.oo.

L'étude d'un grand nombre de souches de Penicillium asymétriques des sous-sections Fasciculata, Lanata et Funiculosa de Thom et Raper conduit les auteurs à réévaluer les caractères diagnostiques et n'accepter comme critère fondamental que la morphologie de l'appareil conidien. Les caractères de couleur, de texture et de croissance, utilisés par Thom et Raper comme diagnostiques de séries ou de sous-sections, sont considérés ici comme variables et de valeur secondaire.

Il en résulte des modifications taxonomiques importantes. Les espèces Penicillium puberulum, martensii, aurantiovirens, crustosum, lanosocoeruleum, biforme, lanosogriseum, terrestre, aurantiocandidum et solitum deviennent synonymes de P. verrucosum var. cyclopium (P. cyclopium),
P. lanosoviride et psittacinum synonymes de P. verrucosum var. verrucosum (P. viridicatum),
P. carneolutescens synonyme de P. verrucosum var. ochraceum (P. ochraceum), et P. resticulosum synonyme de P. expansum.
P. griseofulvum reprend sa priorité sur P. urticae.
P. cyclopium var. album devient P. verrucosum var. album.
P. corymbiferum et hirsutum deviennent P. verrucosum var. corymbiferum.
Les espèces P. expansum, P. italicum, P. granulatum, P. claviforme, P. clavigerum, P. isariiforme, P. lanosum et P. commune sont maintenues, auxquelles s'ajoutent P. hordei Stolk et P. echinulatum Fassatiova et 1 espèce, P. concentricum, et 2 variétés nouvelles P. italicum var. avellaneum et P. verrucosum var. melanochlorum que décrivent les auteurs.

Il est difficile de mettre en question la précision de la méthode et la qualité de l'observation à la base de ce travail. Cependant il faut admettre que le lecteur qui, depuis 20 ou 30 ans, a reconnu avec Thom et Raper tant d'espèces proches comme distinctes par la couleur ou la fasciculation sera d'abord étonné, puis déçu parce que voulant comprendre il ne trouvera pas la démonstration convaincante de l'identité des espèces mises en synonymie. Il eut fallu plus qu'une simple affirmation d'identité, plus qu'une figure de 3 conidiophores sans indication d'origine pour prouver et faire accepter l'identité de 17 souches types d'espèces différentes à une seule, P. verrucosum var. cyclopium. Sur quels caractères trompeurs chacune de ces 17 espèces synonymes ont-elles pu être reconnues comme distinctes, pour ne plus l'être aujourd'hui. C'est cette analyse de cas particuliers que le lecteur désireux de comprendre ne trouve pas.

Il est certain que dans ce travail transparaît une optique nouvelle sur la systématique des Penicillium, qui mérite toute l'attention des mycologues et microbiologistes.

INDEX TO FUNGOUS AND LICHEN TAXA

This index includes genera, infrageneric taxa, species, and infraspecific taxa. New taxa are in CAPITALS, and the pages where they are published are in *italics*. Gilliam's monograph of *Marasmius* is separately indexed (pp. 140-144), Petersen's index to Schaeffer's "Bavarian Fungi" is itself an index (pp. 147-153), and Sigler & Carmichael's monograph of *Malbranchea* and allied genera is also separately indexed. References to these indices are indicated by the notation *"see"*. The list of epithets on pp. 191-209 is also not indexed here.

REVIEWERS

The Co-Editors express their appreciation to the following individuals who have reviewed one or more of the papers in this volume prior to their submission.

J. A. VON ARX
M. D. BERLINER
H. E. BIGELOW
M. BLACKWELL
G. H. BOEREMA
J. L. CRANE
M. B. ELLIS
J. ERIKSSON
M. L. FARR
W. L. GAUGER
R. D. GOOS
M. E. HALE, JR.
R. T. HANLIN
S. C. JONG
W. B. KENDRICK
J. W. KIMBROUGH
D. T. KOWALSKI
D. L. LARGENT
H. J. LARSEN
D. MALLOCH
D. L. MANNING
C. T. ROGERSON
A. Y. ROSSMAN
E. V. SEELER
R. L. SHAFFER
S. SHUSHAN
H. D. THIERS
J. M. TRAPPE
A. L. WELDEN
L. K. WERESUB

CO-EDITORS OF MYCOTAXON

G. L. HENNEBERT
FRENCH LANGUAGE EDITOR & BOOK REVIEW EDITOR
Huttelaan 36
B-3030 Heverlee, Belgium

RICHARD P. KORF
ENGLISH LANGUAGE EDITOR & MANAGING EDITOR
P.O. Box 264
Ithaca, NY 14850, USA

MYCOTAXON is a quarterly journal devoted to all phases of mycological and lichenological taxonomy and nomenclature. It seeks to publish all papers within 4 months of acceptance, using photo-offset lithography. All articles are reviewed by specialists prior to acceptance. Publication is open to all persons, and papers may be in French or in English.

SUBSCRIPTION INFORMATION

Each issue of MYCOTAXON may vary in number of pages. Each volume, beginning with volume 3, consists of at least 512 pages, and may consist of as few as 2 or as many as 8 quarterly issues depending upon the amount of copy received from authors. Subscriptions are on a per volume basis, *not* on an annual basis. If only one bill during each year is a requirement, please pay for two volumes, which will cover at least one year's issues. Personal subscriptions are available at a substantially reduced subscription rate for individuals who agree not to deposit their copies in another library than their private one within three years after publication. Subscription prices for each volume, beginning with volume 3, are:

	U.S. & CANADA	OTHER FOREIGN
Regular (multi-user)	$30.00	$32.00
Personal (individuals only)	$12.00	$14.00

(Vols. 1 & 2 are available at half the above rates per volume.)

MYCOTAXON may also be obtained on a journal-exchange basis. This may be arranged with journals, institutions, or individuals who have difficulty in obtaining foreign currencies. For details and exchange subscription forms write to a Co-Editor.

EDITORIAL SERVICES AND INFORMATION FOR PROSPECTIVE AUTHORS

Authors prepare their own camera-ready copy after having received comments from pre-submission reviewers. Detailed Instructions to Authors appeared in MYCOTAXON 1(1): 3-12. 1974. A copy of these instructions will be sent upon request to one of the Co-Editors.

We are able to provide prospective authors with two aids to publication. Both are sold at no profit, and are shipped postpaid from MYCOTAXON, Ltd., P.O. Box 264, Ithaca, NY 14850 USA:

SPECIAL MANUSCRIPT PAPER is available in packages of 50 sheets, and is ruled in blue, non-photoreproducing ink for each of the two sizes of typeface called for in the instructions to authors (elite and pica). It is a convenience to typists, but certainly not an essential, since the appropriate sized rectangles can be prepared on any paper using a non-photoreproducing blue pencil. Each package of 50 sheets is available at $1.25, *postpaid*.

BIOPLATE is a special sheet of transfer letters for the use of authors in the preparation of plates and graphs for publication. It is manufactured specifically for us, and is available in both black and white. Each sheet is approximately 30 × 39 cm, and has a wide assortment of numbers, letters, Greek letters, symbols, and arrows in various sizes. Our cost is $3.00 per sheet, and we will mail these to prospective authors *postpaid* (black will be sent unless white is specified).