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John S. Karling

The Chytrids of India with a Supplement of other Zoosporic Fungi

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VERLAG VON FERDINAND BERGER & SÖHNE OHG.,
HORN, NÖ., AUSTRIA

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Introduction.

The higher and more complex zoosporic fungi of India are fairly well known from the studies of several Indian mycologists. Many of these species were recorded by Butler and Bisby in 1931, and their monograph "Fungi of India" has been supplemented by Mundkur (1938), Mundkur and Ahmad (1946), Subramanian and Ramakrishnan (1956), Vasudeva (1960), Tandon and Chandra (1963—1964), and Subramanian and Tyagi (1965). Additional studies by Chaudhuri and Sachhar (1934), Mitra (1935), Chaudhuri, Kochar, Lotus and Bannerjii (1935, 1936, 1942), Chaudhuri (1942), Iyengar (1935) *et al* (1956), Hamid (1942), Balarkrishnan (1948 a, 1948 b), Das Gupta and John (1953, 1955), Lacy (1955), John (1959 a, 1959 b), Thangamani (1961), Rajagopalan (1961), and Srivastava and Bhargave (1963) have greatly extended the knowledge of the higher Indian water moulds and other aquatic Phycomycetes. Thus, by 1965, the occurrence of more than 200 Phycomycetes was recorded in India. Since that time a large number of species has been added to this list by other Indian mycologists.

The aquatic chytrids, on the other hand, are less known, and until recently few species had been reported in the literature. Butler described one species in 1907; Lacy reported four species as parasites of algae in 1949 and 1955; Das Gupta and John (1955) listed two parasites of *Spirogyra;* Thirumalacher (1942), Patil (1960) and Shukla (1962) reported a parasite of uredospores; Thangamani (1961) described two saprophytic chytrids, and in 1962 Ghosh and Dutta listed two other parasites, presumably on diatoms. The terrestrial chytrids, however, are better known, and as will become evident below numerous papers have been published on the Indian species of *Synchytrium* and *Physoderma.*

During the author's participation as marine mycologist with the UNESCO-sponsored International Indian Ocean Expedition in 1963 and later (1965) as the Sir C. V. Raman Visiting Professor at the University of Madras he isolated numerous aquatic chytrids and anisochytrids from soil, water and algae in various parts of India, and some of these were described and recorded in several publications (1964 a, b, c, d, e, f, g; 1965). At the same time, the type specimens of the terrestrial species in the Herbarium Cryptogramiae Indiae Orien-

talis, New Delhi, and elsewhere were examined and studied, and part of the descriptions of such species presented below are based on these studies.

Many of the publications relating to the chytrids of India are widely scattered in numerous journals, and inasmuch as these might not be readily available to students of the zoosporic fungi in India the author is bringing together in one publication the present-day information about these chytrids. At the same time emphasis is placed on the paucity of information on the chytrid flora of India, and it is hoped that this will stimulate more interest in and research on these fungi. Doubtless, this flora is as abundant and rich as that of other countries, but at the present time relatively few species are known. Certainly, many more genera and species exist and await discovery. Nevertheless, all chytrid families except the *Achlyogetonaceae* or *Septolpidiaceae* are represented in India by the known species.

A simple key to the families of known Indian species is presented below. Obviously, it will have to be modified as more genera and species are discovered. In this key the criteria of thallus organization, monocentricity, polycentricity, holocarpy, eucarpy, development and morphology are given prime recognition, and the occurrence of operculate or inoperculate sporangial dehiscence is not recognized as a taxonomic criterion above the level of genera. The separation of the chytrids into distinct, parallel operculate and inoperculate series and families as S p a r r o w (1943, 1960) has done relegates the more basic and striking similarities of thallus organization, sexuality, structure, morphology and development to a secondary position and attaches undue significance to operculate sporangial dehiscence beyond the generic level, as W h i f f e n (1944) pointed out so well. Under this system of classification *Cladochytrium* and *Nowakowskiella,* for example, are placed in different series and families although the thalli or rhizomycelia with their tenuous portions, rhizoids, intercalary enlargements, zoosporangia, zoospores and resting spores may be so similar that it is often difficult to tell the two genera apart except for the presence of an operculum in the latter genus. Furthermore, to cite another of numerous examples, sexuality in *Rhizophydium ovatum* Couch (1935) is basically similar to that of *Chytridium sexuale* Koch (1951) irrespective of the position of the zygote relative to the host, but these species are placed in separate series and families because the sporangia of *Chytridium* are operculate. In this connection it is significant to note that S p a r r o w (1960) apparently does not consider the presence of an operculum to be equally important in the Catenariaceae inasmuch as he includes both operculate *(Catenomyces)* and inoperculate *(Catenaria)* genera in the same family.

Thallus developing into one center of organization, growth an reproduction; monocentric, rarely polycentric

Thallus holocarpic, lacking vegetative structures; transformed directly into a reproductive organ.

Sporangia dehiscing by deliquescence of tips of one or more exit papillae or tubes, or by rupture of wall.

Thallus transformed directly into one sporangium, or usually one resting spore. Family *Olpidiaceae*

Thallus transformed directly or indirectly into a sorus of sporangia. Family *Synchytriaceae*

Thallus eucarpic, differentiated into vegetative and reproductive organs; epi- and endobiotic, or epibiotic, or endobiotic.

Sporangial dehiscence operculate or inoperculate.

Sporangium usually formed from enlargement of zoospore cyst. Family *Rhizidiaceae*

Sporangium usually formed from enlargement on germ tube. Family *Entophlyctaceae*

Thallus developing several centers of organization, replication, growth and reproduction; polycentric, rhizomycelioid.

Sporangial dehiscence operculate or inoperculate. Family *Cladochytriaceae*

Thallus alternating from monocentric to polycentric in organisation; monocentric, epi- and endobiotic thallus which bears primary epibiotic sporangia alternating with endobiotic rhizomycelioid thallus which bears resting sporangia.

Primary sporangium dehiscing by deliquescence of papillae; resting sporangium forming an endosporangium in germination which pushes off a lid or cracks the wall. Family *Physodermataceae*

Olpidiaceae

So far, only two genera, *Olpidium* and *Rozella,* and eleven species of this family have been reported in India. Species of *Rozella* are quite common as parasites of chytrids and larger zoosporic fungi which occur in soil and water, and one of these species has been found in most of the soil collections in this country. The dimensions of the species given below relate to the Indian collections, and these differ somewhat from those reported elsewhere in the literature.

Olpidium (Braun) Rabenhorst, 1968

Flora Europaea Algarum 3: 288 (sensu recent Schroeter, 1885. Kryptogamenfl. Schlesien 3: 180).

Chytridium subgen. *Olpidium* Braun, 1856. Abhandl. Berlin Acad. 1855: 75.

Cyphidium Magnus, 1875. Wissensch, Meeresunters. Abt. Kiel 2—3: 77.

Olpidiella Lagerheim, 1888. Jour. de Botan. 2: 438.

Endolpidium de Wildeman, 1894. Ann. Soc. Belge Micro. (Mem.) 18: 153.

Thallus monocentric, holocarpic, transformed into a sporangium or resting spore at maturity, endobiotic, filling host cell completely or only partly. Sporangia variable in size and shape, predominantly spherical, subspherical or ovoid, inoperculate, with one to several exit papillae or tubes of variable lengths. Zoospores formed within sporan-

gium and discharged after deliquescence of the tip of exit papillae or tubes; usually containing a refractive globule. Resting spores thick-walled and usually formed like the sporangia; occasionally formed by contraction of thallus content and its investment by a thick wall; in some species developing from a motile zygote produced by the fusion of isogametes; functioning as a sporangium in germination and producing zoospores directly.

Olpidium entophytum (Braun) Rabenhorst Flora Europeae Algarum 3 : 283.

Chytridium entophytum Braun, 1856, Monatsber., Berlin Acad. 1865 : 589.

Sporangia almost spherical, 5—28 μ diam., ovoid, or slightly pyriform, hyaline, smooth, with one, rarely 2, exit tubes, 3—6 μ diam., and up to 15 μ long. Zoospores spherical, 2—5 μ diam., with a small hyaline refractive globule; forming a quiescent globular mass at exit orifice before dispersing. Resting spores spherical, 10—26 μ diam., ovoid, 11—22.5×18—29.67, with a thick, smooth wall and coarsely globular or granular content; germination unknown.

Parasitic in *Spirogyra* sp., at Patna (Lacy, 1955), and 4 klm. west of Uchippuli, Madras State (Karling, 1964 e).

Olpidium gregarum (Nowakowski) Schroeter, 1885. Cohn, Krypt.-Fl. Schlesiens (3) 1 : 182.

Chytridium entophytum Braun, 1856, Monatsber., Berlin Acad. 1856 : 589.

Sporangia, single to numerous in a host cell, hyaline, smooth, spherical, 28—70 μ diam., ovoid, ellipsoidal, 15—32 μ diam., by 16—38 μ diam., with one short exit papilla which protrudes through wall of host cell. Zoospores spherical 2.5—3.8 μ diam., with a hyaline, eccentric refractive globule, forming a temporary mass at the mouth of exit papilla, or swimming directly away. Resting spores spherical 14—21 μ diam., with a brown, smooth or faintly striated wall, up to 6 μ thick, and containing one or more large globules; occasionally lying loose in a vesicle; germination unknown.

Parasitic in rotifer eggs, from watered brackish soil, Mandapam Camp, Rhamnad District (Karling, 1964 e).

Olpidium luxurians (Tomaschek) Fischer, 1892. Rabenhorst Kryptgamen-Fl., 1 (4) : 29.

Chytridium luxurians Tomaschek, 1879. Sitzungsber. Acad. Wiss. Wien (Math. Nat. Cl.) 78: 204, figs. 1, 3—4, 6—11.
Diplochytrium sp. ibid., p. 198.
Chytridium pollinis-typhae forma *latifoliae*, ibid., p. 203.
Olpidium diplochytrium (Tomaschek) Schroeter, 1885. Kryptogamenfl. Schlesiens 3 (1): 181.
Olpidiella diplochytrium Lagerheim, 1888. Jour de Bot. 2: 439.

Thalli usually numerous up to 30, in pollen grains, transformed directly into sporangia at maturity. Sporangia variable in size, usually spherical, 18—40 μ diam., with a thin, smooth, hyaline wall. Exit tubes usually narrow, 3—5 μ diam., and extending considerably beyond the surface of the pollen grain. Zoospore ovoid to elongate, 2—2.5×2.8—3 μ, with a rounded apex and a tapering posterior end; flagellum 9—12 μ long. Resting spores formed by contraction of thallus content and its investment by a wall, partly filling a hyaline vesicle; spherical, 16—22 μ diam., ovoid, with a hyline, smooth wall and usually containing a large refractive globule.

Parasitic in pollen of *Pinus* sp., from soil in the Ooty Botanical Garden, Ootacamund, Madras State.

Olpidium uredinis (Lagerh.) Fischer, 1892. Rabenhorst Kryptogamen-Fl., 1 (4) : 30.

Olpidiella uredinis Lagerheim, 1888. Jour. de Bot. 2 : 438 Pl. 10. figs. 1—15.

Sporangia up to 9 per host cell, spherical, 26 μ diam., when single, but polyhedral when several are present, with a smooth hyaline wall; dehiscing through a short exit tube or papilla. Zoospores ellipsoid, 3—4 μ diam., with a small globule. Resting spores globose, 16 μ diam., with a thick hyaline wall; contents hyaline with a large refractive globule.

Parasitic in the uredospores of *Hemileia canthii,* Mysore State (Thirumalachar, 1942), *Uromyces leptodermus* (Patil, 1960), Poona, Maharashtra State, and *Phakospora grewiae* (Shukla, 1962), Varanasi, U. P. Tandom and Chandra (1963—64) listed it as occurring on *Uredo airae, Puccinia rahmni, P. violae, P. rubrum,* and *P. coronata* in addition to the hosts given above.

Lagerheim reported that this species infected only uredospores of *Puccinia airae, P. violae,* and *P. rhamni* and not those of certain other rusts. In light of this it is possible that Thirumalacher's, Patil's, Shukla's, Tandon and Chandra's fungus may be a different species.

O. rotiferum Karling, 1946 c. Lloydia 9 : 6.

Sporangia up to 8 in a cell, hyaline, smooth, predominantly pyriform, 10—35×14—38 μ, ovoid, 8—17×18—28 μ, subspherical 12—32 μ, with one short, 4—6×5—12 μ, or fairly long, 3—7×10—18 μ, exit tube. Zoospores swarming in sporangia before emerging, oblong 3—3.5×6—7 μ, with one or more small elongate refractive globules; flagellum 12—15 μ long. Resting spores hyaline to light-amber and light golden-brown, ovoid, 12—14×15—18 μ, subspherical to spherical 8—16 μ, with 8 to 27 refractive globules; lying in and partly filling hyaline vesicles; germination unknown.

Parasitic in rotifer eggs and adults from soil, Kotah, Rajasthan State.

This Indian species is slightly smaller than the Brazilian *O. rotiferum,* and its resting spores are frequently light-amber to light golden-brown in color instead of hyaline. Otherwise, the two fungi are quite similar and appear to be identical.

Olpidium allomycetos Karling, 1948. Amer. J. Bot. 35 : 508.

Sporangia single to numerous in a host cell, hyaline, smooth, spherical, 8—38 μ diam., ovoid, 10—16×20—38 μ diam., pyriform, 8—15×24—33 μ diam., with one short or long exit tube, 5—10 μ broad by 9—22 μ long. Zoospores ovoid, 4×5.5 μ, elongate, 3.6—6.4 μ, and slightly curved, with 4—9 small refringent globules; flagellum 14—16 μ long. Resting spores partly or completely filling a hyaline vesicle, hyaline, smooth, spherical, 6—30 μ diam., ovoid, 10—14×18—27 μ, or slightly angular, with numerous refractive granules or globules; forming zoospores directly upon germination.

Parasitic in the resting sporangia of *Allomyces arbuscula* from soil near Valantaravai, along the Rhamnad Road, Rhamnad District, (Karling, 1964 e).

Olpidium indum Karling, 1964 e, Sydowia 17 : 303, 11 figs.

Sporangia 1 to 18 in a host cell and filling it partly or completely, hyaline, smooth, spherical, 30—150 μ diam., ovoid, 22—40×38—60 μ diam., oblong, 20—30×40—52 μ, hemispherical, polyhedral when two and a large number, respectively, fill a host cell. Exit tube solitary, rarely 2 per sporangium, 5—12 μ diam., by 8—48 μ long, cracking the host cell wall locally. Zoospores spherical, 3—4 μ diam., with a small brilliantly refractive globule and an 18—22 μ long flagellum; remaining spherical throughout motile period. Resting spores 1 to 25 in a host cell, spherical, 12—18 μ diam., ovoid, 8—12×15—20 μ diam., with a hyaline to light-amber, smooth, wall, 1.8 to 3 μ thick; formed by contraction of thallus content and its investment by a wall and lying in a hyaline vesicle; forming zoospores directly in germination.

Parasitic in the thalli and thick-walled sporangia of *Catenophlyctis variabilis* and *Rhizophlyctis fusca;* the hyphae, zoosporangia and resting spores of *Allomyces arbuscula;* and resting sporangia of *Physoderma pluriannulata* from a brackish pool at Mandapam Camp and non-brackish soil 10 and 51 klm. south of Madurai along the Rhamnad Road, Madras State, (Karling, 1964 e).

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*) The name *indicum* previously proposed for this species is preempted by Turner's (Bih, Kgl. Svensk Vetensk-Ak. Handl. 25, Afd. 5, no. 10: 164, 1892). *O. indicum,* which apparently is not a chytrid.

Rozella Cornu, 1872
Ann. Sci. Nat. Bot. V, 15: 148

Rozia Cornu, 1872. Bull. Soc. Bot. France 19: 71. Non *Rozea* Bescherelle, 1871—1872. Mem. Soc. Nation. Sci. Cherbourg 16: 241.
Pleolpidium Fischer, 1892. Rabenhorst Kryptogamen-Fl. 1 (4): 43.

Thallus monocentric, holocarpic, endobiotic, apparently naked at first and indistinguishable from contents of host cell, later usually filling host cell so completely that its wall is not distinguishable from that of the host. Sporangia usually of same size and shape as those of host cell, usually with several short exit papillae. Zoospores developed in the sporangium and usually swarming within before discharge, minute, often with a small refractive globule. Resting spores 1 to several and lying loosely in host cell, thick-walled, smooth or spiny; functioning as a sporangium and forming zoospores directly in germination.

Rozella allomycis Foust, 1937. J. Elisha Mitchell Sci. Soc. 53 : 198.

Sporangia developing usually in basipetal succession in the distal portions of the host hyphae, 1 to 8 in number, filling host segments completely and conforming to their sizes and shapes, usually barrel-shaped, 15—40 μ long by 9—22 μ diam., usually with 1 exit papilla, 1—2 μ high. Zoospores ovoid, 3×4—4.3 μ, with a minute globule and a 14—16 μ long flagellum; swarming in sporangia before emerging. Resting spores 1 to 20 in a host segment, spherical, 10—22 μ diam., with a reddish-brown, spiny wall, 1.5—2 μ thick; spines 1.5—2 μ long; containing usually one large hyaline globule; forming zoospores directly in germination.

Parasitic in the hyphae of *Allomyces arbuscula* from a brackish pond 8 klm. north of Mandapam Camp along the Rhamnad Road, Rhamnad District, (K a r l i n g, 1964 e).

The zoosporangial phase of the parasite occasionally causes septatation of the hyphae and incipient sporangia of the host but only rarely does it induce slight cell enlargement. The resting spore phase, however, causes considerable cell enlargement, particularly when numerous spores are present in a segment.

Rozella cladochytrii Karling, 1941. Torreya 41 : 105; 1942, Amer. J. Bot. 29 : 25.

Sporangia solitary in a host cell and filling it only partly, hyaline, smoth, spherical, 10—40 μ diam., ovoid, 10—15×15—35 μ diam., pyriform and obclavate, with 1 to 3 exit papillae; wall usually indistinguishable from that of host cell. Zoospores obclavate, 3.5—5×1.8—2 μ diam., aguttulate; flagellum 14 μ long; emerging fully formed in a stream and becoming actively motile in a few seconds. Resting spores faintly yellow, ovoid, spherical, 8—22 μ diam., with a large central

vacuole and coarsely granular cytoplasm, wall 1—1.8 μ thick, smooth or spiny; spines 1.5—3 μ long; forming zoospores directly in germination.

Parasitic in *Nowakowskiella ramosa* and *N. elegans* from a freshwater lake about 4 klms. west of Uchippuli, Rhamnad District, (K a r l i n g, 1964 e).

R o z e l l a r h i z o p h l y c t i i Karling, 1942 a. Amer. J. Bot. 29—32.

Sporangia solitary, filling host cell and conforming with the latter's size and shape, spherical, 20—110 μ, ovoid and slightly irregular, with 1—4 exit papillae which usually project out of the short necks of the host; wall usually indistinguishable from that of the host. Zoospores broadly pyriform, 2.5—3×1.5—2 μ diam., tapering slightly at anterior end with a minute globule near the posterior end; flagellum 18 μ long; swirling in the sporangium before emerging and swimming directly away. Resting spores faintly yellow, ovoid or spherical, 14—18 μ diam., with a large central vacuole and coarsely granular cytoplasm; wall spiny, 1.8 μ thick, spines 1.5—2 μ long; forming zoospores directly in germination.

Parasitic in *Karlingia rosea,* from brackish soil, Mandapam Camp, Rhamnad District, (Ka r l i n g, 1964 e).

R o z e l l a l a e v i s Karling, 1942 b. Mycologia 34 : 201; 1944, Mycologia 36 : 368, figs. 1—19.

Sporangia solitary, partly or completely filling hypertrophied portions of host hyphae, variable in size and shape, spherical, 20—52 μ diam., clavate, 10—20×30—112 μ diam., broadly and elongately pyriform with 1—3 exit papillae, 3—4 μ diam., by 2—3 μ high. Zoospores obclavate to pyriform 1.5—1.8×2.9—3.3 μ diam., with a globular spot which is not markedly refractive; flagellum 10—20 μ long. Resting spores spherical, 11—18 μ diam., ovoid, elongate or obpyriform with a large central vacuole and coarsely granular cytoplasm; wall smooth and hyaline, 1.5—2 μ thick; forming zoospores directly in germination.

Parasitic in *Pythium* sp, from brackish soil, Mandapam Camp, Rhammnad District, (K a r l i n g, 1964 e), and non-brackish soil at Munnar, Madras, Jodhpur, New Delhi and Calcutta.

The *Rozella* parasite reported by the author (1947) on *Catenophlyctis variabilis (Phlyctorhiza variabilis)* was found to parasitize the same host isolated from soil at Mudumalai, Madras State.

Synchytriaceae

Species of this family are unusually abundant and widely distributed in India, according to the records in the literature, and up to the present time over 59 species have been reported from this country. These represent all of the known subgenera except *Exosynchytrium.*

Synchytrium DeBary and Woronin, 1863
Ber. Naturf. Gesell. Freiburg 3: 22

Micromyces Dangeard, 1889. Le Bot. 1: 52.
Chrysophlyctis Schilberszky, 1896. Ber. deut. Bot. Gesell. 14: 36.
Pycnochytrium (de Bary) Schroeter, 1897. Engler and Prantl, Die Natur. Pflanzenf. I (1): 73.
Woroninella Raciborski, 1898. Zeitschr. Pflanzenkr. 8: 195.
Miyabella Ito and Homma, 1926. Bot. Mag. (Tokyo) 40: 110.

Thallus developing into either a group of zoosporangia or a resting spore; initial thallus functioning as a sorus and segmenting directly into a number of zoosporangia or gametangia, or as an evanescent prosorus from which the contents emerge through a pore and form an attached vesicular sporangial or gametangial sorus outside of the initial thallus but within the infected host-cell, or developing into a resting spore. Zoosporangia and gametangia variously shaped but predominantly polyhedral with a hyaline wall, and red, orange, yellow, reddish-yellow, lemon-colored, gray, or hyaline granular content; dehiscing by a tear, cleft, or papilla. Zoospores and gametes ovoid, ellipsoid, oblong, spherical, or pyriform, usually with 1 and sometimes 2 conspicuous refringent globules, and a single posterior whiplash flagellum. Resting spores formed parthenogenetically (?) by encystment of the initial thallus, or by fusion of isogametes, with the resulting zygotes infecting the host and developing into diploid resting-spores. Exospore thick, smooth, rough or ridged, hyaline, amber-colored, reddish-brown, or light- to dark-brown; endospore relatively thin and hyaline; content variously colored with a few to numerous refringent globules; functioning as a sporangium, or a prosorus in germination.

This genus was classified by the author (1961), (1964 a) into 6 subgenera as is shown below.

A. Long-cycled. Life cycle including sporangial sori, sporangia, zoospores, and resting spore in sequence.
   1. Mature initial cell or thallus functioning as a prosorus; contents emerging to form a thin-walled vesicle which cleaves into sporangia and becomes a sorus within the infected cell.
      a) Resting spore functioning as a prosorus in germination; contents emerging to form a thin-walled superficial sorus which cleaves into sporangia. Subgenus *Microsynchytrium*
      b) Resting spore functioning as a sporangium in germination and giving rise directly to zoospores. Subgenus *Mesochytrium*
   2. Mature initial cell or thallus developing directly into a sorus of thin-walled sporangia; sporangia delimited by cleavage within the sorus wall and freed by its rupture.
      a) Resting spore functioning as a sporangium in germination and giving rise directly to zoospores. Subgenus *Synchytrium (Eusynchytrium)*
      b) Resting spore functioning as a prosorus in germination; content emerging to form a superficial vesicle or incipient sorus which cleaves into sporangia. Subgenus *Exosynchytrium*

B. Short-cycled. Life cycle including only sporangial sori, or resting spores.

1. Only resting spores known.
   a) Resting spores functioning as a prosorus in germination. Subgenus *Pycnochytrium*

2. Only sporangial sori known.
   a) Mature thallus functioning directly as a sorus of thin-walled sporangia; sporangia delimited by cleavage within the sorus wall; freed by its rupture and appearing as powdery masses in open accidium-like pustules. Subgenus *Woroninella*

Subgenus *Microsynchytrium*

Key to Known Species

Digallic

Compositely dihomeogallic

Sorus usually formed beneath prosorus

Sorus usually relatively small

Sporangia 40—70 per sorus, 18—21 μ diam., zoospores ovoid, 3×5 μ diam., Resting spore spherical, 60—115 μ, or oblong. Parasitic on *Indigofera*. S. *crustaceum*

Sporangia 70—310 per sorus, polyhedral, 20—32 μ diam., zoospores unkown. Resting spores spherical, 72—132 μ diam. Parasitic on *Stereospermum*. S. *stereospermi*

Number of sporangia per sorus and size unkown, zoospores unknown. Resting spores spherical, 42—90 μ diam., ovoid, 72—98×80—110 μ diam. Parasitic on *Veronica*. S. *veronicae*

Sorus usually formed above prosorus

Sorus usually relatively small

Sporangia usually less than 100 per sorus

Sporangia 30—40 per sorus; 16—18 μ diam., zoospores large, ovoid, 3—5×4—8 μ diam. Resting spores 48—150 μ diam. Parasitic on *Solanum*. S. *akshaiberi*

Sporangia 40—60 per sorus, 14—18 μ diam. Zoospores ovoid, 3×4 diam. Resting spores 100—180 μ diam. Parasitic on *Biophytum*. S. *biophytii*

Sporangia 40—70 per sorus, 33 μ diam. Zoospores oblong, 3×7 μ diam. Resting spores 66—160 μ diam. Parasitic on *Phyllanthus*. S. *phyllanthi*

Sporangia 40—70 per sorus, 20 μ diam. Zoospores elongate, 3—5×3—7 μ diam. Resting spores 50—140 μ diam. Parasitic on *Launea*. S. *launae*

Sporangia 50—70 per sorus, 20—26 μ diam. Zoospores unknown. Resting spores 50—120 μ diam. Parasitic on *Alysicarpus*. S. *cookii*

Sporangia 60 or more per sorus, 19—24 μ diam. Zoospores ovoid, 3.5—5.7 diam. Resting spores 70—180 μ diam. Parasitic on *Sesamum*. S. *sesamicola*

Sporangia 3—5 (?) per sorus, 35—48 μ diam. Zoospores ovoid, 2.6—3×3—4.2 μ. Resting spores 24—88×44—150 μ. Parasitic on *Dipsacus*. S. *kumaonense*

Sorus usually relatively large

Sporangia frequently more than 100 per sorus Sporangia 56—139

per sorus, 14—24 μ diam. Zoospores unknown. Resting spores 45—128 μ diam. Parasitic on *Emilia*. *S. fuscum*

Sporangia 35—220 per sorus, 18—34 μ diam. Zoospores elongate 2.5—3.5×3—6 μ diam. Resting spores 50—160 μ diam. Parasitic on *Cucurbitaceae*. *S. trichosanthidis*

Sporangia 60—220 per sorus, 16—32 μ diam. Zoospores elongate, 3.5×5 μ diam. Resting spores 50—220 μ diam. Parasitic on *Acanthaceae*. *S. rytzii*

Sporangia 60—280 per sorus, 16—20 μ diam. Zoospores ovoid, 3—4×4.5—6 μ diam. Resting spores 42—170 μ diam. Parasitic on *Cucurbitaceae*. *S. lagenariae*

Sporangia 100—230 per sorus, polyhedral 20—38 μ diam. Zoospores unknown. Resting spores subspherical, 53—158 μ, ovoid, 67—72× 83—120 μ diam. Parasitic on *Micranthus*. *S. micranthum*

Sporangia 100 or more per sorus, pyriform 23—34 μ diam. Zoospores unknown. Resting spores spherical, 85—150 μ diam. Parasitic on *Oldenlandia*. *S. oldenlandiae*

Sporangia 110—280 per sorus, polyhedral, 20—30 μ diam. Zoospores unknown. Resting spores subspherical, 54—72 μ, ovoid 60—80× 72—96 μ diam. Parasitic on *Impatiens*. *S. travancoricum*

Simply dihomeogallic

Sorus usually formed beneath prosorus

Sorus usually small

Sporangia 50 or more sorus, 24 μ diam. Zoospores elongate, 3×6 μ diam. Resting spores 82—125 μ diam. Parasitic on *Sida*. *S. maculans*

Diheterogallic-

Sorus usually formed beneath prosorus

Sorus usually small

Sporangia 20 or more per sorus, 15—21 μ diam. Zoospores ovoid, 3—4×4—6 μ diam. Resting spores small, 45—80 μ diam. Parasitic on *Cassia*. *S. cassiae*

Sporangia 3—100 per sorus, 30 μ diam. Zoospores elongate, 3×6 μ diam. Resting spores large, 100—150 μ diam. Parasitic on *Oroxylon*. *S. oroxyli*

Sporangia 60—90 per sorus, 20 μ diam. Zoospores ovoid, 3—4× 4—6 μ diam. Resting spores 80—190 μ diam. Parasitic on *Zornia*. *S. zorniae*

Sorus usually formed above prosorus.

Sorus usually small

Sporangia 40—60 or more per sorus, 15—78 μ diam. Zoospores large, 3—4.5×4—7 μ diam. Resting spores 80—120 μ diam. Parasitic on *Clereodendron*. *S. collapsum*

Sporangia 40—70 per sorus, 20—30 diam. Zoospores 3—4×5—6 μ diam. Resting spores 50—180 μ diam. Parasitic on *Acanthaceae*. *S. lepidagathidis*

Sporangia 40—70 per sorus, 20—30 diam. Zoospores 3—4×5—6 μ Resting spores 50—120 μ diam. Parasitic on *Trichodesma*. *S. trichodesmatis*

S. crustaceum Lingappa, 1955 a, p. 132, figs. 9—11.

Prosori 1 or more in a cell, spherical, thin-walled, yellow; lying in apex of host cell when empty. Sori thin-walled, spherical, yellow.

Sporangia 40—70 per sorus, spherical, pyriform, 18—21 μ diam., content bright-orange. Zoospores ovoid, 3×5 μ diam.; flagellum 15 μ long. Resting spores 1 or more in a cell, spherical or oblong, 50—115 μ diam., contents globular and yellow, exospore brown, 8 μ thick, enveloped by a thick layer of residue; functioning as prosori in germination.

Compositely dihomeogallic. Galls usually crowded, confluent and crustaceous. Sporangial galls yellow, hemispherical, 400—600 μ diam., cupulate after dehiscence. Resting-spore galls subspherical, 200—400 μ diam., brown, rarely scattered.

Type spec. 25567, HCIO.

Parasitic on all aerial parts of *Indigofera enneaphylla* and *I. liniola* in Banares (Lingappa, 1955 a, b), causing thickened patches on stems and petioles and hypertrophy of stem and roots.

The symptoms produced on *I. liniola* are less severe than those on *I. enneaphylla*. Although several other leguminous plants were present in the immediate vicinity of parasitized *Indigofera* plants and conditions were favorable for their infection, none of them were infected, according to Lingappa. This suggests that *S. crustaceum* may be limited in host range to *Indigofera* species.

S. stereospermi Lacy, 1950, p. 155, figs. 1—4.

Prosori spherical to subspherical, 80—190 μ diam., with a light-amber wall, 2—2.6 μ thick; lying in apex of host cell when empty. Sori subspherical, 90—210 μ diam., ovoid, 110—120×130—165 μ diam., or slightly flattened on lower surface. Sporangia 70—310 per sorus; polyhedral, 20—32 μ in greatest diameter. Zoospores unknown. Resting spores usually solitary and filling host cell, spherical, 72—132 μ diam., or ovoid; with an amber-brown wall, 3.8—4.6 μ thick; enveloping residue scarce or fairly abundant; germination unknown.

Compositely dihomeogallic. Sporangial galls orange-yellow, separate and scattered, or aggregated and confluent, protruding conspicuously, 260—380 μ high by 310—450 μ broad; sheath, 3—6 cells thick, upper sheath cells conical and hair-like, sheath cells frequently infected by resting spores. Resting-spore galls isolated, protruding, 110—180 μ high by 150—236 μ broad, sheath 3—5 cells thick.

Type. spec. 19897 in HCIO.

Parasitic on leaves of *Stereospermum suaveolens*, Bihar.

This diagnosis is based on Lacy's description and the author's study of Lacy's type material in which the empty prosorus is quite conspicuous in the base of the dehisced sporangial galls.

S. veronicae Gupta and Sinha, 1951, p. 9, fig. 5.

Prosori solitary, spherical, 60—85 μ diam., or ovoid, 58—72×70—90 μ diam., with a light-amber wall, 1.5—2 μ thick; lying in apex of cell when empty. Sori subspherical, 75—115 μ diam., or flattened on the

lower surface; plug between prosorus and sorus, 9—12 μ diam. Zoospores unknown. Resting spores solitary or up to 3 in a cell, spherical, 42—90 μ diam., or slightly ovoid, 72—79×80—110 μ diam., dark brown with an amber wall, 4—5.6 μ thick; enveloped by a layer of residue; germination unknown.

Predominantly compositely dihomeogallic, often diheterogallic. Galls scattered or aggregated, confluent and compound. Sporangial galls 132—160 μ high by 140—190 μ broad; sheath, 2—3 cells thick. Resting-spore galls low and broad, 54—60 μ high by 106—125 μ broad, or almost hemispherical, 90—104 μ high by 130—168 μ broad, with a sheath, 1—3 cells thick; often unicellular and simple in areas of dense infection.

Type specimen in Agra Coll., Agra, and Spec. 20026, in HCIO.

Found on leaves and stems of *Veronica patula,* Agra, *V. patula* and *V. cinera.* Gwalior.

This diagnosis is based on Gupta and Sinha's description and the author's study (1962) of Spec. 20026, HCIO and infected specimens of *V. cinera* and *V. patula* kindly sent to him by B. G. Nikam from Gwalior. Gupta and Sinha described only resting spores, but in Spec. 20026, HCIO, the author found a few cupulate galls which looked like empty sporangial galls. Similar empty galls were found on *V. cinera,* and on specimens of *V. patula* collected Sept. 10, 1958, at Gwalior, prosori, sori, and sporangia were present as well as resting spores. Accordingly, the author (1964 a) transferred this species to the subgenus *Microsynchytrium.* Jain, Nikam, Kulkarni and Sharma (1960) reported *S. launeae* on *Veronica patula* at Gwalior, but it is quite likely that their fungus is *S. veronicae.*

The resting spores and their galls vary markedly in relation to the intensity of local infection. In areas where nearly every epidermal cell is infected, the galls are usually unicellular and simple and bear small resting-spores.

S. akshaiberi Lingappa, 1953, p. 292, figs. 10, 11.

Prosori solitary, yellow, thin-walled, lying in base of host cell when empty. Sporangia 30—40 per sorus, ovoid, 16—180 μ diam., content yellow. Zoospores ovoid, 3—5×4—7 μ diam., flagellum 15 μ long. Resting spores solitary, spherical, 48—50 μ diam., rarely oblong, with a dark-brown wall, 6—9 μ thick and yellow granular content; functioning as prosori in germination.

Compositely dihomeogallic. Galls separate and scattered, or crowded. Sporangial galls spherical (?) 90—250 μ diam., glistening, at first yellow, later brown, becoming cupulate after dehiscence. Resting-spore galls generally smaller, up to 200 μ diam.

Type spec. 20479 in HCIO.

Parasitic on leaves and petioles of *Solanum melongena,* Banaras (Lingappa, 1953, 1955 d).

Another species. *S. melongenae,* was described on this host by Gupta and Sinha (1951) as follows: „Galls on leaves, minute, abundant along the veins, occurring singly or coalescing, usually spherical, rarely oval 0.2—0.3 mm. in diameter. Resting sporangia solitary in epidermal cells, spherical, smooth, measuring 56—76 μ (mean value 66 μ) in diameter with an epispore 8—10 μ thick." The size of the resting spores reported by them fall within the range of those of *S. akshaiberi,* but are usually smaller. However, it is quite possible that the sori and sporangia of *S. akshaiberi* relate to *S. melongenae,* and in that event the latter species would have priority.

S. biophyti Lingappa, 1955 a, p. 140, figs. 33—36.

Prosori spherical, pale-orange, thin-walled, lying in base of host cell when empty. Sori spherical, thin-walled. Sporangia 40—60 per sorus, yellow, spherical, 14—18 μ diam. Zoospores pyriform or ovoid, 3×4 μ, flagellum 12 μ long. Resting spores spherical, 100—180 μ diam., with yellow globular content, exospore 8 μ thick and enveloped by a layer of residue; functioning as prosori in germination.

Compositely dihomeogallic. Galls usually separate, rarely crowded. Sporangial galls ovoid, 400—600 μ diam. Resting-spore galls hemispherical, 150—330 μ diam., yellow to brown glistening.

Type spec. 25569, HCIO.

Parasitic on *Biophytum reinwardtii,* Banares (Lingappa, 1955, a, b), causing distortion of leaflets.

Mishra (1953 b) described another species, *S. biophytum,* on *B. sensitivum* as follows: "Galls orange-yellow to brown, minute, distinct, usually on the veinlets. Summer sporangia not observed. Resting spores yellowish-brown, ovate to spherical, thick-walled, 93.0 μ to 155.0 μ, average 123.5 μ in diameter, surrounded by 2 to 3 layers of elongated host cells on the sides, and a single layer at the top, not inciting excess cell multiplication". Whether or not this species is identical with *S. biophyti* remains to be seen inasmuch as Mishra found only resting spores, but it is not unlikely that the sori and sporangia of the latter species relate to *S. biophytum.*

S. phyllanthi Lingappa, 1955 a, p. 131, figs. 6—8.

Prosori solitary, spherical, thin-walled, light-brown, lying in the base of the host cell when empty. Sori thin-walled, spherical. Sporangia 40—70 per sorus, ovoid or spherical, 33 μ diam., with greenish-yellow content. Zoospores ovoid, 3×7 μ, with a flagellum 14 μ long. Resting spores spherical, 66—260 μ diam., with yellow globular content and a 7 μ thick, dark-brown exospore, enveloped by a crust of residue, functioning as prosori in germination.

Compositely dihomeogallic. Galls single and scattered or aggregated and confluent. Sporangial galls glistening yellow, subspherical, 300—500 μ diam., cupulate after dehiscing. Resting-spore galls brown, subspherical, 160—200 μ diam.

Type spec. 25562, HCIO.

Parasitic on leaves and stems of *Phyllanthus simplex* and *P. urinaria,* Banares (Lingappa, 1955 a, b).

This species affects its two hosts quite differently. The long, infected rachis of *P. simplex* becomes only slightly thickened by the crustaceous galls, but *P. uriaria* becomes completely defoliated. Also, the infected stems and petioles become 3—4 times thicker than normal. Furthermore, the resting spores formed on *P. simplex* (120—160 μ diam.) are larger than those on *P. urinaria* (66—120 μ diam.)

S. launae Lingappa, 1955 a, p. 130, figs. 1—5.

Prosori 1 or more in a cell, spherical, deep-yellow, thin-walled, lying in the base of the host cell when empty. Sori spherical, thin-walled. Sporangia 40—70 per sorus, ovoid, 20 μ diam., with orange-yellow content. Zoospores elongate, 3—5×3—7 μ, flagellum 18 μ long. Resting spores 1 or more in a cell, spherical, 50—140 μ diam., content orange-yellow and globular, exospore 6 μ thick; functioning as prosori in germination.

Compositely dihomeogallic. Galls single and scattered or crowded, crustaceous, and confluent. Sporangial galls yellow, subspherical, 300—700 μ diam., cupulate after dehiscence. Resting spore galls brown with or without a pink halo, subspherical, 150—200 μ diam.

Type spec. 25561, HCIO.

Parasitic of the foliage of *Launea asplenifolia,* Banaras, Bihar and Poona (Mhatre and Mundkar, 1945; Lingappa, 1955 a, b), causing thickening, disfiguration and yellow-to-brown discoloration.

Mhatre and Mundkur (1945) were the first to describe this species from Butler's collection at New Delhi and named it *S. vulgatum,* a short-cycled species which forms only resting spores. Lingappa, however, found prosori in addition to resting spores in Kahn's herbarium material which was collected in 1932, and later in living material. Karling (1961) studied Kahn's and Lingappa's material and confirmed the latter's observation.

S. cookii Lingappa, 1953, p. 291, figs. 1—9.

Prosori usually solitary, occasionally 2—3 in a host cell, with a thin yellow exospore and a hyaline endospore; lying in the base of the host cell when empty. Sporangia 50—70 per sorus, spherical to pyriform, 20—26 μ diam., with yellow content. Resting spores solitary, deep-yellow, spherical to ellipsoidal, 50—120 μ diam., exospore 5 μ thick, content yellow and granular; functioning as prosori in germination.

Compositely dihomeogallic. Galls separate and scattered or crowded and confluent. Sporangial galls subspherical, 200—300 μ diam., becoming cupulate after dehiscence. Resting-spore galls smaller and producing less distortion of host than sporangials galls.

Type spec. 20480, HCIO.

Parasitic on leaves, petioles, axillary buds, stems and fruits of *Alysicarpus monilifer,* Banaras (Lingappa, 1953).

This species causes marked proliferation and malformation of the infected organs. On young axillary buds and young parts of the stem, conspicuous, warty outgrowths, 2 cm. or more in diameter, are formed. The reaction of the host is somewhat similar to that of potato varieties infected by *S. endobioticum,* according to Lingappa. Apparently, the parasite stimulates the infected and adjacent health cells to divide, by which the resting spores may become deeply buried in the host tissue.

Ramakrishnan and Sundaram (1954 a) created a new species, *S. alysicarpi,* for a parasite on *Alysicarpus vaginalis,* which had been collected at Walayer by Sundaram and Rao (Sept. 9, 1953). They described it as fallows: "Galls numerous, on stems and leaves, reddish-orange in color, galls on stem swollen, sometimes irregularly lobed; on leaf amphigenous, becoming cupulate and whitish with age; hypnospores numerous, embedded within hypertropied cells and surrounded by proliferating tissue, subglobuse or oval, orange-brown, thick-walled, wall differentiated into a thickened endospore surrounded by a laminated thicker exospore, with granular contents, 53—130×50—98 μ; sorus subglobuse or elliptical made up of several sporangia, orange-yellow in contents, 25×22 μ (19—43×19—37), round or polygonal due to pressure". The fleshy outgrowths induced by this fungus on the stem, as shown in their fig. 1, resemble very closely those caused by *S. cookii* on *Alysicarpus monilifer.* They did not report the presence of a prosorus, but one of their figures suggests its presence in the upper part of the infected cell. The author examined a portion of their material (No. 20560, HCIO), but it was a very poor sample, which yielded no additional information.

What appears to be a different species was collected by Nikam and Kulkarni, Aug. 10, 1959, at Gwalior, on *Alysicarpus* sp. The resting spores are spherical, 156—180 μ diam., subspherical, 180—206 μ diam., or ovoid, 160—190×175—210 μ diam., with a dark-amber wall, 4—5.2 μ thick, and hyaline contents. The galls occur in abundance on the lower surface of the leaves and on the stems and are large, produding, light-yellow to slightly reddish in color. In shape, they are subspherical to ovoid, 200—276 μ high by 208—280 μ broad, with a sheath 2—4 μ cells thick.

As the author pointed out (1961), the resting spores of this fungus

are considerably larger than those of *S. cookii* and *S. alysicarpi* and have hyaline instead of yellow contents. Furthermore, it does not induce outgrowths or malformations on the host. On these grounds, this fungus may prove to be a different species.

S. sesamicola Lacy, 1951, p. 8.

Prosori spherical; orange-yellow; thin-walled. Sporangia 50 or more per sorus; light-orange; spherical, subspherical, or ovoid, 19—24 μ diam. Zoospores 3.5×5 μ; with a flagellum 14 μ long. Resting spores dark; spherical or ovoid, 78—180 μ diam., exospore, 6 μ thick; functioning as prosori in germination.

Compositely dihomeogallic. Sporangial galls usually crowded and crustaceous, 100—300 μ diam., cupulate after dehiscence. Resting-spore galls brown, hemispherical, 100 μ diam.

Type spec. 198; in HCIO.

Parasitic on leaves, petioles, and stems of *Sesamum indicum,* in Bihar and Banaras, India (Lacy, 1950; Lingappa, 1955 a, b), and at Agra (Gupta and Sinha, 1951).

Lacy found only resting spores, and most of the above diagnosis is taken from Lingappa's (1955 a, b), descriptions. According to Lacy, infection is confined largely to young axillary shoots at the base of the plants or close to the ground. The parasitized shoots are markedly malformed and appear spindly and curled. Due to imperfect leaf expansion, the young leaflets are puckered and curled into various shapes. Severely infected shoots do not bear flowers or capsules and wither away prematurely.

Gupta and Sinha (1951) described a new species, *S. sesami,* on the same host from Agra which forms large single, or scarlet crusts of coalescing galls on the young shoots, leaves, and stems. These vary from 300—430 μ diam., on the leaves to 600—700 μ diam. on the stems, and contain only solitary spherical, 172—201 μ diam., smooth, olive-brown resting spores with an epispore 10—13 μ thick. However, in a collection of this species by Gupta in August 1954 (Spec. 22115, HCIO) the author (1961) found sporangial galls with empty prosori, sori, and sporangia in addition to resting-spore galls and resting spores. The prosori are subspherical, 80—96 μ diam., or ovoid, 75—87×90—98 μ diam., with an amber-brown wall, 1.8—2 μ thick. The sori are subspherical, 90—102 μ diam., ovoid, 72—96×102—116 μ diam., or flattened on one surface, and contain 50—92 sporangia which are polyhedral, golden-yellow and 19—28 μ in greatest diameter. The resting spores are dark amber-brown, ovoid to spherical, 55—186 μ diam., with a smooth wall, 3.4—4.6 μ thick. Sinha and Gupta reported that the epispore is 10—13 μ thick, but possibly they included the adhering layer of residue in their measurement. If Gupta's collection is representative, *S. sesami* is a long-cycled species like *S. sesamicola* and

seems to be identical with it. Accordingly, the author will list it here as a synonym of *S. sesamicola.*

S. kumaonense Gupta and Sah, 1963, Indian Phytopath. 16 : 377, 1 fig.

Prosori ovoid to subspherical, 65—108 μ diam., with a hyaline wall; lying in base of host cell. Sori formed above prosorus, ovoid, 51—72× 73—96 μ, with a thin hyaline wall. Sporangia 3 to 5 (?) per sorus, polyhedral, 35—48 μ in greatest diameter, with thin hyaline walls and orange to golden-red contents. Zoospores ovoid, 2.6—3×3—4.2 μ, with a conspicuous orange globule and several minute granules; flagellum 13—15 μ long. Resting spores subspherical, oblong, ovoid, 24—88× 44—150 μ, with an amber wall, 3—4.5 μ thick; enveloped by a brownish layer of residue; functioning as prosori in germination.

Compositely dihomeogallic. Sporangial galls yellowish green, usually separate and solitary, subspherical, 230—400 μ diam.; sheath 2—4 cells thick; sheath cells frequently infected by resting spores to form large, heaped-up compound galls. Isolated resting-spore galls small, 106—108 μ highly 128—150 μ broad with a sheath 1 to 3 cells thick.

On leaves, stems and inflorescence of *Dipsacus inermis,* Naini Tal, at altitudes of 7,000 to 8,500 ft.

Type spec. no. 28364, HCIO, New Delhi.

The above diagnosis is based primarily on Gupta and Sah's description and supplemented by the author's study of their as well as type material. Gupta kindly sent the author a generous supply of infected leaves and stems, and a study of stained sections of sporangial galls showed that the initial cell functions as a prosorus, forming a superficial sorus above it. The resting spores, also, were found to function as prosori in germinating, giving rise to a superficial sorus of orange-red sporangia. Such sori were ovoid to subspherical, varied from 63—98 μ in diameter and bore 13 to 24 sporangia which measured 18 to 54 μ in greatest diameter. This number of sporangia per sorus is considerably higher than that, 3 to 5 per sorus, reported by Gupta and Sah. No sporangia were found by the author in stained sections of sporangia galls, but the size of the empty sori present suggests that they bore more than 3 to 5 sporangia. During sporogenesis cleavage in the sporangia may be unequal, resulting in large bi- and multiflagellate zoospores in addition to normal-sized ones.

The life cycle of *S. kumaonense* indicates clearly that it belongs in the subgenus *Microsynchytrium,* but its identity as a distinct species is not certain, in the author's opinion. In the material received from Gupta as well as in the type specimen, a large number of the sporangial galls were compound in the sense that their sheath cells were infected with resting spores as in *S. succisae.* Occasionally, as

many as 40 small resting spores were present on such galls. In other characteristics, also, *S. kumaonense* is similar to *S. succisae* and the species described by the author (1946 a) on *Knautia sylvantica*. The principle known differences are the size of the sporangia and number per sorus reported by Gupta and Sah, differences which may not prove to be very great with further study. Both species occur on members of the family Dipsaceae, and host range studies must be made to determine whether *S. kumaonensis* will infect *Succisa pratensis* and exhibit the same characteristics as *S. succisae*. Possibly, *S. kumaonensis* may prove to be a race or variety of the former species.

S. fuscum Petch, 1926. P. 134.

S. emiliae Ramakrishnan and Sundaram, 1953, p. 187, fig. 1.

Prosori usually solitary, spherical to subspherical, 60—110 μ diam., or slightly ovoid, with an amber to dark-brown, encrusted wall, 2—2.6 μ thick, lying in base of host cell, collapsing and becoming cup-shaped when empty. Sori subspherical, 64—130 μ diam., or ovoid, 52—67×80—96 μ diam., with a light-amber wall, 2—2.4 μ thick, bearing 56—139 sporangia. Sporangia polyhedral and 14—24 μ in greatest diameter, with light-yellow contents. Zoospores unknown. Resting spores solitary or up to 3 in a cell, spherical to subspherical, 45—128 μ diam., or ovoid; with a smooth, dark amber-brown wall, 3.8—5.2 μ thick, and yellowish-brown contents; encrusted with an enveloping layer of residue; functioning as prosori in germination.

Compositely dihomeogallic. Galls scattered, or aggregated to form crusts or heaped up masses. Sporangial galls large, 220—280 μ broad by 190—210 μ high, with a sheath 3—5 cells thick; becoming cupulate after dehiscing. Resting-spore galls dark brown, 110—140 μ high by 120—180 μ broad, sheath, 1—3 cells thick, frequently confluent.

Type specimen in PDA.

Parasitic on leaves, petioles and lamina of *Emilia sonchifolia*, Galboda, Ceylon (Petch, 1926) and Madras, India (Ramakrishnan and Sundaram, 1953).

This diagnosis is based on a study of the type material at Paradeniya, Ceylon, and at Kew, Gt. Brit. (Spec. 3367) as well as Spec. 20421, HCIO, collected by T. S. Ramakrishnan Aug. 27, 1952, at Bantawal, S. Kanara, India. Petch reported only resting spores and described their content as dividing into hyaline globose zoospores, 3—4 μ diam. If this is correct, the spores obviously function as sporangia, and his fungus would not be a species of *Synchytrium*. However, in his type material, the author found a few large cupulate and empty galls with collapsed prosori-like vesicles in them, which led him to suspect that Petch's species is long cycled. This was confirmed by a study of his material at Kew in which prosori, sori, sporangia, and resting spores were present. Ramakrishnan and Sundaram

reported only resting spores in their *S. emiliae* which function as prosori in germination, but in T. S. Ramakrishnan's collection the author found sporangial galls, prosori, sori, sporangia, and resting spores which were very similar to those found in *S. fuscum*. Accordingly, the author believes the 2 species are identical, long-cycled, and belong in the subgenus *Microsynchytrium*.

S. trichosanthidis Mhatre and Mundkur, 1945, p. 136.

Prosori spherical, subspherical, 60—87 μ diam., or ovoid, 70—90×95—110 μ diam., with a dark-brown wall, 2.6—2.8 μ thick, collapsing and becoming saucer-shaped, and lying in the base of the host cell when empty. Sori spherical, 84—116 μ diam., or slightly flattened on lower surface, with a hyaline wall. Sporangia 35—220 per sorus, polyhedral, 18—34 μ in greatest diameter. Zoospores elongated when actively motile, 2.5—3.5×3—6 μ; with a flagellum, 16—18 μ long. Resting spores solitary or 2 in a cell, spherical or subspherical, 50—160 μ or ovoid, 60—98×80—150 μ diam., with a dark-brown wall, 3.8—5.2 μ thick, enveloping residue sparse or abundant; functioning as prosori in germination.

Compositely dihomeogallic. Sporangial galls usually separate and scattered, cinnamon brown when dry, large and protruding, 220—302 μ high by 180—220 μ broad, asymmetrical; sheath, 4—6 cells thick, filled with brown residue. Resting spore galls brown, hemi- to subspherical, 140—176 μ broad by 135—168 μ high; sheath, 3—5 cells thick.

Type spec. 10365 in HCIO.

Parasitic on leaves, petioles, fruits, and stems of *Trichosanthis dioica, Citrullus vulgaris, Cephalandra* sp. (Mhatre and Mundkur, 1945), *Cucumis melo* var, *monmordica,* and *C. melo* var. *ultissimus* (Gupta and Sinha, 1951).

The fungus on *T. dioica* appears to be different from the one on the other hosts, and with more intensive study it may prove to be a different species. The fungi on the other hosts look very much like *S. lagenaria.*

S. rytzii H. Sydow, P. Sydow, and E. J. Butler, 1907, p. 510.

Prosori solitary, subspherical to ovoid, 84—96×110—125 μ diam., with an amber-colored wall, 2—2.6 μ thick, collapsing and lying in base of the host cell when empty. Sori subspherical, 80—130 μ diam., ovoid, 94—114×104—136 μ diam., or slightly flattened on lower surface. Sporangia 60—220 per sorus, orange-yellow, polyhedral, 16—32 μ in greatest diameter. Zoospores ovoid to elongated when actively motile, 3.5—5 μ; flagellum, 14 μ long. Resting spores usually solitary, sometimes 2 or 3 in a cell, partly filling host cells, subspherical to spherical, 50—220 μ diam., or ovoid, 62—110×106—180 μ diam., with

a smooth amber-brown wall, 3.6—5.2 μ thick; enveloping residue lacking or scarce or abundant; functioning as prosori in germination.

Compositely dihomeogallic. Sporangial galls scattered on leaves, or usually crowded to form crusts on petioles and stems, large, 180—420 μ diam. and protruding conspicuously; sheath, 3—6 cells thick and consisting mostly of outwardly elongated septate cells; galls becoming cupulate when empty. Resting-spore galls separate, or forming crusts, smaller but protruding, 80—220 μ diam.

Specimens 2035 and 20476, in HCIO.

Parasitic on leaves, petioles, and stems of *Anisomelis ovata* (Sydow et al., 1907; Mhatre and Mundkur, 1945), *Peristrophe* sp., *Justicia* sp., and *Leucas aspera* (Sydow et al., 1912), *Leucas* sp. and *L. aspera* (Mhatre and Mundkur, 1945), *Anisomeles ovata, Leucas aspera,* and *Orthosiphon pallidus,* (Lingappa, 1955 d).

The above diagnosis is based primarily on the author's study of Butler's spec. 653, 1382, 1379; Nos. 2035 and 20476, HCIO, and Lingappa's specimens on *Orthosiphon pallidus, Leucas aspera,* and *Anisomeles ovata.* In all of these specimens Lingappa found prosori, sori, sporangia, and resting spores. In his opinion, *S. rytzii* is a long-cycled species which belongs in the subgenus *Microsynchytrium.* Sydow and Butler (1912) established 3 forms this species; form *a* on *Peristrophe* sp., form *b* on *Justicia* sp., and form *c* on *Leucas* sp. on the basis of the size, appearance and structure of the galls, germination of the resting spores, and size of the sporangia. According to them, the resting spores of forms *b* and *c* germinated as prosori in the infected cell without a dormant period while the host was still alive. In form *b* the sporangia were 18—30 μ in diam., while those of form *c* were only 12—24 μ in diam. From the author's observations of the specimens noted above, he interprets these so-called germinating resting spores as evanescent initial cells which function as prosori and give rise to sori of sporangia. In the material studied their walls are amber-colored and only 2—2.6 μ thick in contrast to those of the resting spores which are 3.6—5.2 μ thick and brown in color. Furthermore, these initial prosori were collapsed when empty. This does not occur generally in germinated thick-walled resting spores, as Lingappa (1955 d, figs. 54 and 57) showed for this species.

The differences in size and structure of the galls and spores noted by Sydow et al. (1912) fall within the range of variations a species might exhibit on different hosts, in the author's opinion. The differences in sizes of sporangia, however, may be more significant and should be studied more intensively in living material. Host-range studies may possibly reveal biological races within this species.

Mhatre and Mundkur overlooked prosori, sori, and spor-

angia and described only resting spores. Also, without giving any reasons for doing so, they created a new species, *S. lepidagathidis,* for the fungus on *Peristrophe* sp., *Justicia* sp., and *J. procumbens,* as well as the one they studied on *Dicliptera* sp., *Lepidagathis* sp., and *L. cristata.* This species may prove to be identical with *S. rytzii* when both species have been studied intensively and compared.

S. lagenariae Mhatre and Mundkur, 1945, p. 135.

S. luffae Sinha, in Herbarium, Specs. 25449 and 25450, HCIO.

S. cucumis-sativa Sinha, in Herbarium, Spec. 25451, HCIO.

S. fistulosus Sinha, in Herbarium, Spec. 25452, HCIO.

Prosori solitary, spherical to subspherical, 74—128 μ diam., with an encrusted amber-colored wall, 2—2.4 μ thick, collapsing and lying in the base of host cell when empty. Sori bright orange, spherical to subspherical, 80—130 μ diam., ovoid, 54—66×78—110 μ diam., or flattened on the lower surface, with an amber-colored wall, 1.8—2.2 μ thick. Sporangi 60—280 per sorus, polyhedral, 16—20 μ in greatest diameter. Zoospores ovoid to elongate when actively motile, 3—4× 4.5—6 μ; flagellum, 14—16 μ long. Resting spores usually solitary, sometimes 2—3 in a cell, usually spherical, 42—170 μ diam., or ovoid with a 3.4—4.5 μ thick, smooth brown wall; enveloping residue sparse or fairly abundant; functioning as prosori in germination.

Compositely dihomeogallic, occasionally diheterogallic. Sporangial galls separate and scattered or crowded, protruding conspicuously, 300—480 μ high by 280—430 μ broad; sheath, 3—6 cells thick, sheath cells inflated at apex, and frequently infected by resting spores; galls becoming cupulate when empty. Resting-spore galls scattered or crowded; 120—150 μ high by 132—170 μ broad, sheath, 1—2 cells thick; sometimes simple, 60—78 μ high by 70—90 μ broad.

Type spec. 2019, in HCIO.

Parasitic on leaves, petioles, and stems of *Lagenaria vulgaris, Luffa aegyptica, L. acutangula, Cucumis sativa, Citrullus vulgaris* var. *fistulosus,* and *Curcurbita pepo.*

In the event the fungus which Lingappa (1955 a, d) called *S. wurthii* is identical with this species its host range includes *Bryonopsis laciniosa, Coccinia indica, Curcurbita maxima, Momordica charantia,* and *Trichosanthis dioica.* The above diagnosis is based primarily on a study of Specs. 2019, 25449, 25450, 25451, and 25452, HCIO, and Lingappa's description. Mhatre and Mundkur (1945). reported only resting spores, but in all except the type specimen the author found prosori, sori, sporangia, and resting spores. However, empty collapsed prosori were found in the sporangial galls of the type material, which, indicates that the initial cell had functioned as a prosorus.

Lingappa regarded this species and *S. trichosanthidis* as identical with *S. wurthii,* and he may prove to be right. However,

until more is known about *S. wurthii* it will be described separately. Nevertheless, the author believes *S. lagenariae* and *S. trichisanthidis* will prove to be identical when more intensive developmental, cytological, and host range studies have been made.

A specimen of *Synchytrium* sp. collected on *Cucumis trigonis* at Pusa, in December, 1920 which is deposited in PDA is similar in most respects to *S. lagenariae,* and the author (1964 a) has identified it as such.

S. micranthum Singh, 1954, p. 369.

Prosori subspherical, 120—170 μ diam., with an amber wall, 3.2—4 μ thick, cup-shaped and lying in base of host cell when empty. Sori orange-yellow, ovoid, 102—114×120—180 μ diam., subspherical, 68.5—150 μ diam., containing 100—230 sporangia. Sporangia polygonal, 20—38 μ in greatest diameter, with yellow content and a thin hyaline wall. Zoospores unknown. Resting spores solitary or rarely 2—3 in a cell, spherical to subspherical, 53—158 μ diam., ovoid, 67—72×83—120 μ diam., with an amber-brown wall, 4.2—4.8 μ thick; germination unknown.

Compositely dihomeogallic. Sporangial galls separate or confluent, large and protruding, with a sheath, 3—6 cells thick, sheath cells often infected by resting spores. Resting-spore galls smaller, separate, or occurring in conjunction with sporangial galls.

Type spec. 22123 in HCIO.

Parasitic on leaves and stems of *Micranthus oppositifolius,* Bihar.

Singh overlooked the prosori, but the author found them in most of the sporangial galls of the type material. Their presence indicates that *S. micranthum* may be a member of the subgenus *Microsynchytrium.* Except for the composite resting-spore galls which it induces, it is very similar to *S. lepidagathidis* which occurs on a large number of acanthaceous hosts in India.

S. oldenlandiae Lingappa, 1955 a, p. 139, figs. 29—32.

Prosori solitary, spherical, thin-walled; brown, lying in base of host cell when empty. Sporangia 100 or more per sorus, pyriform, 23—34 μ diam., with orange content. Zoospores unknown. Resting spores solitary, spherical, 85—150 μ, with yellow granular content, a smooth, dark-brown, exospore, 9 μ thick; germination unknown.

Compositely dihomeogallic. Sporangial galls usually confluent, elongated, 200—300 μ diam., cupulate after dehiscence. Resting-spore galls usually separate; punctiform, 200 μ diam., brown.

Type spec. 25568, in HCIO.

Parasitic on all aerial parts of *Oldenlandia corymbosa,* at Banaras, causing death of infected organs but no hypertrophy.

S. travancoricum Ramakrishnan, 1956. Proc. Ind. Acad. Sci., sect. B, 44:114.

Prosori solitary, subspherical, 60—114 μ diam., with an amber-colored wall, 8—2.8 μ thick, lying in base of infected cell, collapsing and becoming saucer-shaped when empty. Sorus spherical to subspherical, 72—130 μ diam., ovoid, or flattened on the lower surface. Sporangia 110—280 per sorus, polyhedral, 20—30 μ in greatest diameter. Zoospores unknown. Resting spores usually solitary, subspherical, 54—72 μ diam., to ovoid, 60—80×72—96 μ diam., with a dark amber-brown wall, 3.6—4.2 μ thick; enveloping residue sparse, usually lacking; germination unknown.

Compositely dihomeogallic. Galls scattered on leaves or aggregated along the midrib, and forming crusts on the stem. Sporangial galls low and mound-shaped, 220—260 μ broad by 80—150 μ high, with a sheath, 1—3 cells thick. Resting-spore galls small, low, 170—208 μ broad by 78—130 μ high; with a sheath, 1—2 cells thick.

Type spec. 23860, in HCIO.

Parasitic on leaves, petioles, and stems of *Impatiens chinesis,* Kohayan, T. C. State.

This species is generally smaller than *S. impatientis* Cook (1951) so far as it is known, but further study may possibly prove it to be identical with or closely related to Cook's species. Ramakrishnan (1956) reported only resting spores, but in the type material the author (1961, 1964 a) found an abundance of sporangial galls, prosori, sori and sporangia in addition to resting spores. Apparently, Ramakrishnan had sporangia at hand in his material because he was able to obtain infection of your healthy leaves from older infected ones within 11 days. Ordinarily, reinfection from resting spores takes a much longer time.

The author (1961) was unaware of Ramakrishnan's description and name of this species and described it (1964) in relation to *S. impatientis* Cook.

S. maculans Lingappa, 1955 a, p. 138, Figs. 25—28.

Prosori 1 or more in a cell, spherical, thin-walled, dull-brown, lying in apex of host cell when empty. Sori spherical, thin-walled. Sporangia 50 or more per sorus, yellow, spherical to ovoid, 24 μ diam. Zoospores ovoid to solid oblong, 3×6 μ, with a flagellum 15 μ long. Resting spores 1 or more in a cell, spherical, 82—125 μ diam., with yellow globular content, with a smoke-colored or dark-brown exospore, 6 μ thick; functioning as prosori in germination.

Simply dihomeogallic. Galls usually single and scattered. Sporangial galls punctiform, subspherical, 200—400 μ diam., cupulate after dehiscence. Resting-spore galls hard, hemispherical, 200 μ diam., crateriform, brown.

Type spec. 25566, in HCIO.

Parasitic on leaves, petioles, and stems of *Sida rhombifolia*, Banaras (Lingappa, 1955 a, b).

All galls induced by this species are simple and unicellular, according to Lingappa, and in this respect it differs from *Synchytrium australe* and *Synchytrium* M 1 (Karling, 1964 a) on *Modiola caroliniana* and *Sphaeralcea bonaerensis*, respectively, which also develop prosori. Malvaceous species such as *Sida cordifolia*, *Sida* sp., and *Abutelon* sp. were present in the vicinity of the parasitized *S. rhombifolia* plants, but they were not infected, according to Lingappa.

S. cassiae Lingappa, 1955 a, p. 139, Figs. 44—46.

Prosori spherical, light brown; thin-walled, lying in the apex of the host cell when empty. Sori spherical, thin-walled. Sporangia 20 or more per sorus, dark-yellow; spherical, 15—21 μ diam. Zoospores ovoid, 3—4 × 4—6 μ, with a flagellum, 15 μ long. Resting spores ovoid, angular, oblong or spherical, 45—80 μ diam., with yellow globular content and an exospore 6 μ thick; enveloped by a thick crust of residue; functioning as prosori in germination.

Diheterogallic. Galls single and scattered, or aggregated. Sporangial galls composite, pinkish in color, ovoid, 400 μ diam. Resting-spore galls abundant, inconspicuous, minute, simple.

Type spec. 25573, in HCIO.

Parasitic on all aerial parts of *Cassia pumila*, Banaras, (Lingappa, 1955 a, b); sporangial galls causing conspicuous hypertrophy and pinkish coloration of infected shoots.

According to Lingappa, the resting spores generally do not induce gall formation (!), but occur in almost every epidermal cell on the older leaflets, which appear dirty brown and granular. However, in Lingappa's type material the author found distinct, simple galls.

S. oroxyli Lingappa, 1955 a, p. 136, figs. 16—20.

Prosori yellow, thin-walled; lying in the apex or slightly to one side in the host cell when empty. Sori, spherical, thin-walled. Sporangia 3—100 per sorus, spherical or ovoid, 30 μ diam., yellow. Zoospores ovoid or elongated, 3 × 6 μ, with a flagellum, 15 μ long. Resting spores spherical, 100—150 μ diam., with bright yellow content, exospore 5 μ thick; functioning as prosori in germination.

Diheterogallic. Galls single and scattered or aggregated. Sporangial galls composite, spherical, 500 μ diam., light yellow, becoming cupulate after dehiscence. Resting-spore galls simple, papillate, hard, brown, subspherical, 300 to rarely 3000 μ diam. (?).

Type spec. 25574, in HCIO.

Parasitic on tender aerial parts of *Oroxylon indicum*, in Banaras,

(Lingappa, 1955 a, b), causing hypertrophy, distortion, browning and death of infected parts.

S. zorniae Lingappa, 1955 a, p. 134, figs. 12—15.

Prosori solitary, spherical, greenish-yellow, thin-walled lying above or at one side of sorus when empty. Sori spherical, thin-walled. Sporangia 60—90 per sorus; spherical to ovoid, 20 μ diam., with yellow content. Zoospores ovoid, 3—4×4—6 μ, with a flagellum, 15 μ long. Resting spores solitary, ovoid to oblong, 95—190 μ diam., with yellow globular content, and a dark-brown exospore, 5 μ thick; functioning as prosori in germination.

Diheterogallic (?). Sporangial galls single and scattered, or aggregated and confluent, composite, crateriform, subspherical, 200—400 μ diam., yellow, with or without a pink halo; cupulate and brown after dehiscence. Restingspore galls usually scattered and less crowded, usually on under surface of leaves, simple, rarely composite (?), subspherical, 100—150 μ diam.

Type spec. 25564 in HCIO.

Parasitic on all aerial parts of *Zornia diphylla,* Banaras, (Lingappa 1955 a, b) causing only slight distortion.

As noted above, this species is characterized by a difference in its type of galls. The resting-spore galls are reported to be simple and unicellular while the sporangial galls are composite and multicellular. As the latter mature, the mucilagenous content of the sourrounding sheath cells become pink in color with the result that a distinct pink halo is usually present around the yellow prosori.

S. collapsum Sydow, and Sydow, and Butler, 1907, p. 510.

Prosori solitary, spherical, thin-walled, dark yellow; empty prosoral vesicle usually lying in base of infected cell. Sori spherical, thin-walled. Sporangia 40—60 or more per sorus, ovoid to pyriform, 15—18 μ diam., with thin hyaline walls, and bright yellow content. Zoospores elongated, 3—4.5 μ 4—7 μ with a flagellum, 15 μ long. Resting spores solitary, partly filling host cell, spherical to globose or ellipsoidal, 50—150 μ diam., with a 3—6 μ thick, smooth brown epispore, and a thin hyaline endospore; content coarsely granular, yellow or golden, surrounded by a thick layer of brown residue; functioning as a prosori in germination.

Diheterogallic. Sporangial galls usually aggregated in crusts, frequently embedded in host tissue, whitish and later becoming brown, composite and multicellular, ovoid, pyriform, or subspherical, 300—500 μ diam. Resting-spore galls separate and scattered or aggregated, simple and unicellular, light brown and minute.

Type spec. 654, in HCIO.

Parasitic on all aerial parts of *Clerodendron* sp. and *C. infortunatum* (Sydow et al., 1907, 1912; Butler and Bisby, 1931;

Mhatre and Mundkur, 1945; Lingappa, 1955 a, b; Prasad and Sinha, 1962), causing thickening of stems and discoloration and distortion of leaves and tender stems.

This species was collected first by Butler and named by Sydow who first regarded it as a form of *S. aureum* and later described it as a separate species. Mhatre and Mundkur (1945) found only resting spores in the herbarium material and, thus, concurred with Sydow on the morphology of this species. Lingappa (1955 a), however, found prosori, sori, and sporangia in addition to resting spores in Khan's collection from Pusa, and later found abundant prosori in living material. He (1955 b) also observed that the resting spores function as prosori in germination and proved that this species is a member of *Microsynchytrium.*

S. lepidagathidis Mundkur and Mhatre, 1945, p. 135.

Prosori solitary, subspherical to spherical, 70—160 μ diam., or ovoid, 80—97×120—142 μ diam., with an amber-colored wall, 2—2.5 μ thick; collapsing and lying in the base of the host cell when empty. Sori subspherical to spherical, 80—170 μ diam., ovoid, or slightly flattened on lower surface, lemon to orange-yellow, bearing 85—290 sporangia. Sporangia polyhedral, 20—30 μ in greatest diameter, lemon-yellow. Zoospores ovoid to elongated when actively motile, 3—4×5—6μ, with a flagellum 14—16 μ long. Resting spores usually solitary, rarely 2—3 in a cell, spherical, 50—180 μ diam., subspherical to ovoid with a brown wall, 3.8—5.4 μ thick; enveloping residue lacking, or sparse; functioning as prosori in germination.

Diheterogallic (?). Sporangial galls separate or crowded and forming crusts; large, 280—470 μ diam., protruding conspicuously; sheath, 3—6 cells thick, commonly infected by resting spores; becoming cupulate when empty. Resting-spore galls simple (?), smaller.

Type spec. 10355, in HCIO.

Parasitic on leaves, petioles, and stems of *Lepidigathis* sp., *L. cristata, Dicliptera* sp., (Mhatre and Mundkur, 1945), *Lepidagathis trinervis* (Payak, 1953), *Rungia parviflora* var *pectinata, Justicia diffusa, J. quinquiangularis, Peristrophe bicalyculata, Dicliptera roxburghiana,* and *Andrographis paniculata* (Lingappa, 1955 a).

Mhatre and Mundkur overlooked the prosori, sori, and sporangia and described only resting spores. All of these developmental phases were present in the specimes studied. Whether or not this species is distinct from *S. rytzii,* is open to question, in the author's opinion. He has found both simple and composite resting-spore galls, and it is doubtful that *S. lepidagathidis* is always diheterogallic. Obviously, more intensive study of living material is needed, as well as extensive host-range studies.

S. trichodesmatis Lingappa, 1955 a, p. 136, Figs. 21—24.

Prosori 1 or more in a cell, spherical, yellow, thin-walled, lying in the base of host cell when empty. Sori spherical, thin-walled. Sporangia 40—70 per sorus, pyriform, 19—24 μ diam., with light-orange content. Zoospores oblong, 3×6 μ, with a flagellum 18 μ long. Resting spores 1 or more in a cell, spherical, 50—120 μ diam., with yellow globular content, and a smooth, dark-brown exospore, 5 μ thick; functioning as prosori in germination.

Diheterogallic (?). Galls single and scattered, or aggregated, confluent, and crustaceous. Sporangial galls composite, subspherical, 300—500 μ diam., light-yellow, cupulate after dehiscence. Resting-spore galls inconspicuous, simple, brown, subspherical, 100—200 μ diam.

Type spec. 25565, in HCIO.

Parasitic on all aerial parts of *Trichodesma indicum,* in Banaras (Lingappa, 1955 a, b).

According to Lingappa, the infected plants may be readily recognized by their yellow discoloration and moribund appearance. Upon dying, the plants become black. As a result, the herbarium specimens show none of the characteristic color symptoms.

Subgenus *Mesochytrium*

This subgenus includes only two species, *S. endobioticum* and *S. desmodiae* at present, according to the author (1964 a). The former species was reported in India for the first time by Ganguly and Paul in 1953. It is not improbable that *S. desmodicolum* Mishra is identical with *S. desmodiae* Munasinghe from Ceylon, and in that event two species of *Mesochytrium* occur in India. *Synchytrium desmodiae* is described here in the event this proves to be so, although it has been reported only from Ceylon.

Key to Fully Known Species

Digallic
- Compositely dihomeogallic
  - Sorus usually formed above prosorus
    - Sorus small
      - Sporangia 1—9 per sorus, 25—39×62—78 μ diam. Zoospores small, 1.5—2.27 diam. Resting spores 40—70 μ diam. Parasitic on Solanaceae. *S. endobioticum*
  - Sorus usually formed beneath prosorus.
    - Sorus relatively small.
      - Sporangia 40—50 per sorus, 16—25 μ diam. Zoospores spherical, 1.6—6 μ diam. (?). Resing spores 57—176 μ diam. Parasitic on *Desmodium.* *S. desmodii*

S. endobioticum (Schilberzky) Percival, 1910, p. 445, Plates 1—3.
Chyrsophlyctis endobiotica Schilberzky, 1896, p. 36.
Synchytrium solani Masse, 1910.

Prosori solitary or up to 4 in a host cell, spherical, ovoid, 40—50 μ diam., with a fairly thick, light golden-brown outer wall, a thin hyaline inner membrane, hyaline contents; lying in the base of the host cell when empty. Contents emerging through a pore in the outer wall of the initial cell into the upper part of the host cell to form an ovoid, flattened or almost spherical sorus of sporangia, 47×100 μ to 72—81 μ diam.; plug between empty prosorus and sorus, fairly conspicuous, 7—9×10—14 μ diam. Sporangia or gametangia 1—9 per sorus, polyhedral, ovoid, or almost spherical, 25—38 μ to 62—87 μ diam., with thin hyaline walls; single sporangia and gametangia sometimes present, 41—64×47—75 μ diam. Zoospores and facultative gametes ovoid, pyriform, 1.5—2.2 μ diam., with a large hyaline refringent globule. Gametes isogamous and fusing to form biflagellate zygotes which penetrate the host cell and develop into resting spores. Resting spores usually deeply embedded in the host tissue, due to the repeated division of the infected cell; filling the host cell almost completely; spherical, ovoid, slightly elongated, and angular, 40—70 μ diam., with a fairly thin hyaline endospore, a smooth golden-brown, 1.8—2.5 μ thick, mesospore, an outer, chitinous, furrowed, ridged, and irregularly thick exospore, which appears to be derived partly from the degenerated protoplasm of the host cell; functioning as sporangia in germination and giving rise directly to zoospores *).

Compositely dihomeogallic. Sporangial galls highly variable, depending on their occurrence on under- or above-ground parts of the host and the relative susceptability of the host; rosette-like, almost hemispherical, radiate or circumvallated, stalked, sessile, or sunken; with or without vascular elements. Resting-spore galls usually aggregated and confluent; forming large warts, excrescences, or cancer-like outgrowths.

Parasitic in *Solanum tuberosum,* Darjeeling District, West Bengal (Ganguly and Paul, 1953; Lal. 1958), causing warts and excrescences on the tubers.

S. desmodii Munasinghe, 1955, p. 36, figs. 1—11.

Prosori ovoid to subspherical, with two-layered walls. Sori formed beneath prosori, subspherical, ovoid or almost hemispherical, yellow. Sporangia 40—50 per sorus, polyhedral to almost spherical, 16—25 μ

*) Since this paper went to press Kole (1965, Neth. J. Plant Path. 71: 72—78, 7 figs) has shown that the resting spores of this species function as prosori in germination and form only one large sporangium. Accordingly, it has the same developmental cycle as species of the subgenus *Microsynchytrium.* See Kole's paper for the author's comments interpretation and significance of this recent discovery.

diam., with thin hyaline walls, and bright yellow content. Zoospores spherical, 1.4—6 μ diam., with a 2—6 μ long flagellum (?). Resting spores ovoid, 57—96 × 64—176 μ diam., with a smooth brown wall, 6.5—15 μ thick and yellowish oily content; functioning as a sporangium in germination.

Compositely dihomeogallic (?). Galls usually crowded and confluent, or separate and scattered, highly variable in size and shape, hemispherical to almost spherical, 1000—5000 μ diam. Sporangial galls dull-yellow. Resting-spore galls light-to darkbrown.

Type specimen in Mycological Dept. Rubber Research Inst., Agalawatta, Ceylon.

Parasitic on the growing apex, leaves, petioles, and stems of *Desmodium ovalifolium* in Ceylon, causing distortion, malformation of the infected organs.

This species causes a wart disease of its host, which is used as a cover crop on rubber plantations, and in the very wet districts of Ceylon it may lead to considerable damage, according to Van Emden (1953). Munasinghe reported that the resting spore of the causative agent functions as a sporangium in germination and gives rise directly to zoospores which reinfect the host. For this reason he placed *S. desmodiae* in the subgenus *Mesochytrium.* The author has made several attempts to secure specimens of this species without success. However, from excellent photographs of sections kindly sent to him by Dr. I. A. P. Kole, he has confirmed the presence of an empty prosorus lying above the flattened sorus of sporangia.

Subgenus *Synchytrium (Eusynchytrium)*

So far only one doubtful species has been reported from India, which may be tentatively assigned to this subgenus.

S. desmodicolum Mishra, 1953, p. 59, figs. 305.

Sporangia numerous, orange-yellow, subglobose to polygonal, 59—93 μ diam., smooth and thin-walled. Zoospores unknown. Resting spores yellowish-brown, thick-walled, ovoid or spherical, 84—124 μ diam., buried in the host tissue; germination unknown.

Compositely dihomeogallic (?). Sporangial and resting-spore galls forming crustose to warty growths on leaves, stems, and pods.

Parasitic on *Desmodium gangeticum,* Bihar.

Although Mishra uses the term prosorus in his description of this species, it is not yet certain that one is present. His fig. 5 of what he calls a prosorus appears to be a sorus of sporangia. Therefore, until this point is settled *S. desmodicolum* is included temporarily in the subgenus *Synchytrium.* The author has been unable to secure herbarium material for study. In the event an evanescent prosorus is present, it may prove to be closely related or identical with *S. desmodiae*

Munasinghe (1955) on *D. ovalifolium* in Ceylon, although at present it appears to be a larger species.

Subgenus *Exosynchytrium*

So far no representative species of this subgenus have been reported from India.

Subgenus *Pycnochytrium*

Section *Pycnochytrium* (Chrysochytrium)

Key To Fully Known Species

Compositely monogallic
- Resting spores usually large
  - Sorus usually large
    - Resting spores 114—226 μ diam., contents yellow
      - Sporangia 150—300 per sorus, small, 17—21 μ diam. Zoospores 3—4×3.5—5 μ diam. Parasitic on *Phaseolus*.

S. ajrekari

Resting spores somewhat smaller
- Sorus usually smaller
  - Resting spores 66—166 μ diam., contents golden-red.
    - Sporangia 60—120 per sorus, 18—36 μ diam. Zoospores unknown. Parasitic on various hosts.

S. wurthii

  - Resting spores 90—170 μ diam., contents yellow.
    - Sporangia 80—220 per sorus, small, 16—20 μ diam. Zoospores ovoid, 3—4×5—6 μ diam. Parasitic on *Millingtonia*.

S. millingtonicola

  - Resting spores 115—180 μ diam., contents orange.
    - Sporangia 100—500 (?) per sorus, small, 6—20 μ diam. Zoospores ovoid, 3—4×5—6 μ diam. Parasitic on *Rhynchosia*.

S. rhynchosiae

  - Resting spores 120—210 μ diam., contents yellow.
    - Sporangia 300—500 (?) per sorus, 14—28 μ diam. Zoospores ovoid, 3×5 diam. Parasitic on *Vitis*.

S. viticola

  - Resting spores 132—181 μ diam., contents yellow.
    - Sporangia 150—450 per sorus, 14—21 μ diam. Zoospores ovoid, 3×5 μ diam. Parasitic on *Atylosia*.

S. thirumalachari

  - Resting spores 85—165 μ diam., light-brown.
    - Sporangia 150—350 per sorus, spherical, or polyhedral, 15—24 μ diam., ovoid, 15—20×20—24 μ. Zoospores ovoid, 3—4×4—5 μ diam. Parasitic on *Melilotus*.

S. meliloti

S. ajrekari Payak and Thirumalacher, 1951, p. 103—104.

Resting spores solitary, filling host cell, spherical, 114—226 μ diam., golden-brown, with a wall, 8—11.5 μ thick, and yellow content; functioning as prosori in germiniation. Sori lemon-yellow, 180—300 μ diam. Sporangia 150—500 per sorus, spherical, 17×21 μ diam., and

yellow. Zoospores ovoid, 3—4×3.5—5 μ diam., with a 14 μ long flagellum.

Compositely monogallic. Resting-spore galls usually separate and scattered, rarely confluent and compound, hemispherical with a sheath of thin-walled cells.

Specimens nos. 20017, 19810, 20114, in HCIO.

Parasitic on leaves of *Phaseolus mungo* in Poona, (P a y a k, 1951, 1953), *P. mungo,* and *P. radiatus* in Banaras (L i n g a p p a, 1952, 1955 b).

In connection with this species, see *Synchytrium phaseoli- radiati.*

S. w u r t h i i Rytz, 1907, p. 807.

Resting spores (?) partly filling host cell, usually solitary, spherical 66—126 μ diam., seldom ellipsoidal, with a smooth dark-brown, 3 μ thick exospore, a hyaline, 2—5 μ thick endospore, and intensely golden-red finely granular content, which includes numerous golden oil droplets; enveloped by crumbly residue which may fill the remainder of the host cell; functioning as prosori in germination. Sori 75—140 μ diam., cleaving into 60—120 globular sporangia. Sporangia 18—36 μ diam., with a golden-red granular content. Zoospores unknown.

Compositely monogallic. Resting-spore galls single and scattered or aggregated and confluent, hemispherical, 180—200 μ high by 250—300 μ diam., at the base; sheath, 3—6 cells thick, derived largely from enlarged and divided epidermal cells.

Parasitic on leaves, petioles, and stems of *Gymnopetalum cochinchinense,* Salatiga, Java, and various hosts in India(?)

R y t z's study of this species was based on alcohol-preserved material which he received from Dr. T. W u r t h, and so far as the author has been able to ascertain, herbarium specimens are not available. It is significant to note that the resting spores germinated in the living host without a definite dormant period like that reported by S y d o w and B u t l e r (1912) for forms b and c of *S. rytzii.* This appears to be an unusual occurrence in species of *Synchytrium,* and the question has been raised whether the bodies reported by Rytz are resting spores or unusually thick-walled initial cells which function as prosori. Whether or not this species occurs in India remains to be proven. L i n g a p p a (1955 a) reported the occurrence of prosori in what he believes to be *S. wurthii* on *Bryonopsis laciniosa, Coccinia indica, Cucumis sativus, Cucurbita maxima, Lagenaria vulgaris, Luffa aegyptiaca, Momordica charantia,* and *Trichosantes dioica* in India. According to him, M h a t r e and M u n d k u r's (1945) *Synchytrium lagenariae* and *S. trichosanthidis* are synonyms of *S. wurthii,* which he believes is a long-cycled member of the subgenus *Microsynchytrium* instead of *Pycnochytrium.* The author believes L i n g a p p a's interpretation will prove to be correct, but this remains to be shown by additional collections, the study of *S. wurthii* on its original host in

Java, and by cross inoculations involving the hosts reported from India. The author is including *S. wurthii* in *Pycnochytrium* temporarily until such studies have been made.

S. millingtonicola Safeula and Govindu, 1952, p. 319, fig. 1.

Resting spores solitary; globose to spherical, 90—170 μ diam., bright yellowish-brown, with a smooth brittle, 6—7 μ thick exospore, and yellowish granular content, functioning as prosori in germination. Sori 120—170 μ diam. Sporangia 80—220 per sorus, spherical, or polyhedral, 16—20 μ diam., with orange contents. Zoospores ovoid, 3—4×5—6 μ diam., with a 12 μ long flagellum.

Compositely monogallic. Resting-spore galls protruding conspicuously, greenish to light-yellow or dark-pink when young, becoming dark-brown cylindrical to subspherical and constricted at the base, 200—350 μ broad by 200—270 μ high; sheath, 3—4 cells thick.

Parasitic on leaves, petioles, and lower parts of stems of *Millingtonia hortensis,* Bangalore (Safeula and Govindu, 1952) and Banaras (Lingappa, 1955 d).

Lingappa reported the resting spores to be 120—170 μ diam. as compared with 90—140 μ in Safeula and Govindu's specimens. He succeeded in germinating the resting spores under laboratory and greenhouse conditions.

S. rhynchosiae Lingappa, 1955 a, p. 140, figs. 37—39.

Resting spores solitary, spherical, 115—180 μ diam., with yellow globular content, and a 10 μ thick exospore; enveloped by a thick layer of residue; functioning as prosori in germination. Sori 90—175 μ diam., bright-orange. Sporangia 100—500 per sorus, orange, spherical, or polyhedral 16—20 μ diam. Zoospores ovoid, 3—4×5—6 μ diam., with a 12 μ long flagellum.

Compositely monogallic. Resting-spore galls crowded, yellow; hemispherical, 300—700 μ diam.

Type spec. 25570, in HCIO.

Parasitic on all aerial parts of *Rhynchosia aurea,* Banaras.

The resting spore of this species occupies the outer portion of the large and protruding galls, and when a slight friction is applied to the surface of the leaf the infected host cells rupture, releasing the spores and leaving cupulate galls.

S. viticola Lingappa, 1955 a, p. 141, figs. 40, 41.

Resting spores solitary, spherical, 120—210 μ diam., with yellow granular content, and a smooth, 6—8 μ thick, brown exospore; functioning as prosori in germination. Sori 120—210 μ diam., lemon-yellow. Sporangia 300—500 per sorus, orange-yellow, spherical or angular, 14—28 μ diam. Zoospores 3×5 μ diam., with a 12 μ long flagellum.

Compositely monogallic. Resting-spore galls mostly single and

separate on leaves, aggregated on stems, glistening, pink to dark-red, subspherical, 300—1000 μ diam.

Type spec. 25571, in HCIO.

Parasitic on leaves, petioles, and stems of *Vitis trifolia,* Banaras, causing typertrophy of stems and petioles.

It is possible that this species as well as Mishra's (1953 a) *S. ampelocissi* on *Ampleocissus latifolia* may be identical with Cook's (1953) *S. parthenocissi* which occurs on *Parthenocissum quinquefolia, Ampelopsis arborae,* and *Vitis* sp. All of these are short-cycled species whose resting spores show a wide range in size. Obviously, extensive cross-inoculations are necessary to determine the exact indentity of these species.

S. thirumalachari Lingappa, 1955 a, p. 141, figs. 42 and 43.

Resting spores solitary, spherical, 132—181 μ diam., dark-brown with yellow globular content, and a 7 μ thick, blackish-brown exospore; enveloped by a thick layer of residue; functioning as prosori in germination. Sori 80—200 μ diam., lemon-yellow. Sporangia 150—450 per sorus, light-yellow, spherical, 14—21 μ diam. Zoospores ovoid or elongated, 3×5 μ diam., with a 10 μ long flagellum.

Compositely monogallic. Resting-spore galls single and scattered or aggregated, hard, pink, red, or dark-brown, subspherical, 300—600 μ diam.

Type spec. 25572, in HCIO.

Parasitic on all aerial parts of *Atylosia scarabeoides,* Banaras, (Lingappa, 1955 a, b), causing slight thickening or deformation of infected organs.

S. melilloti Lingappa, 1953, p. 293, figs. 12 and 13.

Resting spores solitary, spherical, 85—165 μ diam., lightbrown with finely granular content; functioning as prosori in germination. Sori 85—160 μ diam., bright-orange. Sporangia 150—350 per sorus, spherical, or polyhedral, 15—24 μ diam., ovoid, 15—20×20—24 μ diam., orange-yellow. Zoospores ovoid, 3—4×4—5 μ diam., with a 15 μ long flagellum.

Compositely monogallic. Resting-spore galls largely superficial, protruding and prominent, 200—400 μ diam., light-yellow but becoming dark-brown with age; sheath, 3—4 cells thick.

Type spec. 20478, in HCIO.

Parasitic on all parts of *Melilotus indica,* Banaras, (Lingappa, 1953, 1955 d), causing marked distortion, yellowing of leaves, and extensive defoliation.

The following species are incompletely known because resting spore gemination has not been observed. Accordingly, the sori, sporangia and zoospores are unknown. *Synchytrium cyperi* and *S. physalidis* are so poorly known that it is difficult to classify them. Two of

the species *S. gei* and *S. phaseoli-radiati* are simply monogallic. Two unidentified species occur on *Corchorus* and *Ipomoea,* respectively. All of these species are presented below in the chronological order of their discovery and diagnosis.

S. gei Padwick, 1945, p. 1.

Resting spores solitary, globose, or subglobuse, 51—94 μ diam., not filling host cell completely, enveloped by a small amount of residue, wall smooth, amber to amber-brown, 3.8—4.5 μ thick, content pale-yellow to sepia; gemination unknown.

Simply monogallic. Galls sparse, reddish-brown, sessile and subsperical, 80—109 μ diam., ovoid, 90—108×114—150 μ diam., clavate 60—110×80—160 μ diam., or stalked, 60—70×78—96 μ diam., with an amber wall, 2—2.5 μ thick; shriveling and invaginating to become almost cup-shaped after drying out.

Type spec. 10504 in HCIO.

Parasitic on leaves of *Geum elatum,* Aru, Kashmir.

This description is based on Padwick's diagnosis and the author's study of Padwick's type collection from Aru, Kashmir. This species occurs at an elevation of 11,000 ft. and differs from *S. aureum* on the same host by its generally smaller spores and simple galls.

S. cyperi Mundkur and Mhatre, 1945, p. 134.

Resting spores solitary, smooth, dark-brown; spherical, 210—240 μ diam., with an olive-colored, thick epispore. All else unknown.

Galls numerous, large, 200—300 μ diam., stone-gray.

Type specimen in HCIO.

Found on stems of *Cyperus flavidus,* Birganj, Nepal.

The author has not been able to secure type material of this species for study. Type slides were received from New Delhi, but these were so badly shattered in the mail that nothing could be determined from them.

S. physalidis Mhatre and Mundkur, 1945, p. 135.

Resting spores solitary or up to 4 in a cell, spherical, 43—82 μ diam., smooth, pale to dark brown, with a thick dark-brown wall. All else unknown.

Galls solitary or in groups, covering entire host surface, light-brown, cupulate, 2.25 mm diam.

Type specimen in HCIO.

Found on leaves and stems of *Physalis* sp.

Type slides of this species were received from New Delhi, but they were so shattered in the mail that nothing could be determined from them.

S. phaseoli-radiati Sinha and Gupta, 1951, p. 7.

Resting spores solitary, spherical, 165—200 μ diam., with a smooth, amber-brown wall, 3—5.2 μ thick; germination unknown.

Simply monogallic, rarely compositely monogallic. Resting-spore galls singly and uniformly scattered, rarely confluent; 400—600 μ diam. (?).

Type specimen in Agra Coll., Agra, and Spec. 253266, IMI.

Parasitic on leaves and stems of *Phaseolus radiatus, P. mungo, Cajanus cajan,* and *Crotalaria juncea,* Agra.

It is impossible to determine from Sinha and Gupta's description whether the galls are simple or composite. However, in their material on *P. mungo* (IMI, No. 253266) the author found the galls to be unicellular or simple and rarely composite. Safeula and Govindu (1952) maintained that this species is identical with *S. ajrekari* Payak and Thirum., which also occurs on *P. mungo.* However, in *S. ajrekari* the galls are composite as Lingappa (1952) showed, and the author has confirmed his observations. Obviously, more intensive study of living as well as fixed and stained sections of these two species is essential before their exact identity and relationship are fully known.

S. melongenae Gupta and Sinha, 1951, p. 8.

Resting spores solitary, ovoid to spherical, 40—92 μ diam., contents yellow, amber-brown wall, 4.8—6.2 μ thick; germination unknown.

Compositely monogallic (?). Resting-spore galls abundant along veins of leaves, separate and scattered, or aggregated and confluent, rarely ovoid, usually subspherical, 200—300 μ diam.

Type specimen in the Herbarium, Agra Coll., Agra, and HCIO.

Parasitic on leaves of *Solanum melongena,* Agra.

In material collected by Gupta, Sept. 26, 1949, the author (1961) found several cupulate galls which looked like empty sporangial galls, but no sori and sporangia were present. However, in the apex of some of the galls occurred a collapsed, dark-amber vesicle which looked like an empty prosorus. For this reason, he believes that *S. melongenae* will prove to be a long-cycled species when it has been studied intensively at different seasons of the year. In that event, Lingappa's (1953) *S. akshaiberi* on the same host from Banaras may prove to be identical with it, and the author is including it only tentatively in the subgenus *Pycnochytrium* at present.

S. ampelocissi Mishra, 1953 a, p. 152.

Resting spores globoid to subspherical, 110—280 μ diam., reddish- or golden-brown, thick-walled and filled with oil globules; germination unknown.

Compositely monogallic. Resting-spore galls usually aggregated

and imparting a scabby and warty appearance on the host, minute, and golden-yellow.

Type specimen in HCIO.

Parasitic on leaves and stems of *Ampelocissus latifolia*, Bihar.

The author has not been able to secure the type material for study.

In connection with this species, see Cook's (1953) *S. parthenocissi* and Lingappa's *S. viticola*.

S. biophytum Mishra, 1953 b, p. 58, figs. 1 and 2.

Resting spores yellowish-brown, ovate to spherical, 93—115 μ diam., thick-walled; germination unknown.

Compositely monogallic (?). Resting-spore galls largely superficial, orange-yellow to brown, small and inconspicuous, usually on veinlets of leaves; sheath, 2—3 cells thick.

Parasitic on leaves and stems of *Biophytum sensitivum*, Bihar.

It is possible that this species is the resting spore stage of *S. biophytii* Lingappa. Mishra apparently did not deposit type specimens of this and the following species; at least, the author has not been able to find them.

S. cissampeli Singh, 1954, p. 369.

Resting spores spherical, 16.3—68.8 μ diam., with a dark-amber wall, 3.8—4.2 μ thick, contents hyaline and oily; germination unknown.

Compositely (?) monogallic. Galls minute, inconspicuous; separate or aggregated on the veins, pale-yellow and turning brownish.

Type spec. 22122, HCIO.

Parasitic on leaves and stems of *Cissampelos* pareira, Bihar.

This is a very minute species which causes inconspicuous dots on the leaves. The author studied a portion of the type specimen and found only a few resting spores which were spherical, 52—66 μ diam. However, the appearance of some of the empty galls suggest that this might be a long-cycled species.

S. phyllanthicola Mishra, 1953 b, p. 59, figs. 6 and 7.

Resting spores several in a gall, yellowish-brown thick-walled, ovate to spherical, 103.5—207 μ diam., with orange-yellow droplets; germination unknown.

Compositely monogallic Resting-spore galls minute, elongate to globoid, cushion-shaped, scattered and indistinct or crowded together, presenting a warty appearance; sheath cells, thick-walled, hyaline, parallelepiped to prismatic in shape, and uniform in size.

Parasitic on leaves and stems of *Phyllanthus viruri*, Bihar, without causing malformation of host.

Whether or not this species may be the resting spore stage of *S. phyllanthi* which Lingappa reported on *Phyllanthus simplex* and

P. urinari, is not certain. The resting spores described by Mishra are generally larger than those of *S. phyllanthi* Lingappa.

S. celosiae Gupta and Sinha, 1955, p. 78.

Resting spores usually solitary, dark-brown; spherical, 90—120 μ diam., with a smooth epispore, 9—11.6 μ thick; germination unknown.

Compositely monogallic (?). Resting-spore galls, scattered and separate, spherical, 200—380 μ diam.

Type specimen, Agra Coll., Agra, and No. 22124, in HCIO.

Parasitic on leaves of *Celosia argentea,* Agra.

This was the first species to be reported on a member of the family Amarantaceae, but whether or not it is different and distinct from other similar short-cycled species is not evident from Gupta and Sinha's description. Its occurrence on a new host is not sufficient reason, in the author's opinion, for establishing it as a new species.

S. cyamopsidis Gupta and Sinha, 1955, p. 78.

Resting spores solitary or up to 2—3 in a cell, predominantly spherical, 68—120 μ diam., with a smooth, dark-amber wall, 4.7—6.6 μ thick; enveloped by a sparse to fairly abundant amount of reddish-brown residue; germination unknown.

Compositely monogallic. Galls usually scattered on leaves and stems, fairly large and protruding conspicuously, 136—230 μ high by 182—480 μ broad at base; sheath, 2—5 cells thik.

Type specimen Agra Coll., Agra, and No. 22125, HCIO.

Parasitic on stems and leaves of *Cyamopsis psoroliodes,* Agra.

In the diagnosis above, the author supplemented Gupta and Sinha's description from his study of the type material at Agra and New Delhi. It may be noted here that several short-cycled species which induce composite galls have been reported on the Leguminosae in India, and it is possible that *S. cyamopsidis* may be identical with one of these species.

Synchytrium on *Corchorus* sp. (Karling, 1961, p. 33).

Resting spores subspherical, 140—168 μ diam, or ovoid, 152—165 × 170 —178 μ diam., with a smooth amber-brown wall, 4.6—5.3 μ thick, and light-yellow contents; enveloping residue thick and reddish-brown; germination unknown.

Compositely monogallic. Resing-spore galls dark-brown, protruding, large, 208—312 μ high by 208—468 μ broad; sheath, 3—5 cells thick, sheath cells greatly enlarged and elongated outward.

Specimen at Gwalior.

Parasitic on leaves, petioles, and stems, Gwalior.

This is the only species known to occur on a species of the Tiliaceae in India, but the author has not found any sharply-defined characteristics which distinguish it clearly from other similar species.

Synchytrium on *Ipomoea* sp. (Karling, 1961, p. 33).

Resting spores filling host cell almost completely, spherical, subspherical, 144—168 μ diam., ovoid, 64—90×70—120 μ diam., with a smooth dark-amber wall, 4.8—6 μ thick, and lemon-yellow content; enveloping residue scarce or lacking; germination unknown.

Compositely monogallic. Resting-spore galls embedded largely in the leaf tissue, small, 98—274 μ high by 70—168 μ broad at base, with a sheath, 1—2 cells thick.

Specimen at Gwalior.

Parasitic on the underside of leaves of *Ipomoea,* Gwalior.

This is the only species known to occur on *Ipomoea* in nature, but the author (1960 a) has infected several species of this genus with *S. macrosporum* under greenhouse conditions.

Section *Leucochytrium*

Only two species of this section have been reported from India so far; both are incompletely known, and one of these is undentified.

S. anemones (De Candolle) Woronin, 1868, Figs. 31—36

Dothidea anemones De Candolle, 1815, p. 143.
Sphaeronema anemones Sibert, 1830, p. 167.
Septoria anemones Fries, 1946, p. 426.
Chytridium anemones De Bary and Woronin, 1863, p. 48, (Plate 2, figs. 8—10).
Pycnochytrium anemones (De Candolle) Schroeter, 1897, p. 74.
S. anemones var. *ranunculi* Patouillard, 1897, p. 68.

Resting spores usually solitary, occasionally up to 3 in a cell, usually spherical, 60—170 μ diam., with a thick, smooth or slightly warty and transversely ridged, gloden-brown epispore, a hyaline thin endospore; hyaline contents; usually surrounded by the degenerated host protoplasm which forms a thick brown crust; germination unknown.

Compositely monogallic. Resing-spore galls single and scattered, or aggregated and confluent and forming calluses on, and deformations of the host, blackish and hard at maturity, broadly crateriform, subhemispherical, 250—500 μ diam.; infected cell with a 12 μ-thick wall; filled with a bluish-red or dark-violet pigment; protruding and surrounded at base by enlarging sheath cells.

Parasitic on leaves of *Anemone,* Kashmir (Mhatre and Mundkur, 1945).

Synchytrium on *Alysycarpus* sp. (Karling, 1961, p. 32)

Resting spores spherical, 156—180 μ diam., subspherical, 180—206 μ diam., or ovoid, 160—190×175—200 μ diam., with a dark-amber

wall, 4—5.2 μ thick, and hyaline contents; enveloped by a thick layer of residue which fills remainder of host cell; germination unknown.

Compositely monogallic. Resting-spore galls subspherical to ovoid in shape, 200—276 μ high by 208—280 μ broad; sheath, 2—4 cells thick, sheath cells greatly enlarged.

Specimen at Gwalior.

Found on leaves, causing no malformation of host.

The resting spores of this fungus are considerably larger than those of *S. alysycarpi* and *S. cookii* with hyaline instead of yellow contents, and it may prove to be a different species.

Subgenus *Woroninella*

Key to species

Compositely monogallic
- Sorus often unusually large
  - Sorus 100—1250 μ diam., contents brilliantly orange.
    Sporangia up to more than 1000 per sorus, 19—34 μ diam. Zoospores large, ovoid, 6×10 μ diam.
    Parasitic on *Pueraria*. — *S. minutum*
  - Sorus 90—700 μ diam., contents orange or yellowish-red.
    Sporangia 60—600 per sorus, 17—33 μ diam. Zoospores unknown.
    Parasitic on *Dolichos*. — *S. dolichi*
  - Sorus up to 500 μ diam., contents orange.
    Sporangia numerous, 17—34 μ diam. Zoospores unknown.
    Parasitic on *Crotalaria*. — *S. crotalariae*
- Sorus relatively smaller
  - Sorus 120—300 μ, contents yellow.
    Sporangia 100—250 or more per sorus, small, 12—18 μ diam. Zoospores ovoid, 3×4.5 μ diam.
    Parasitic on *Amphicarpaea*. — *S. decipiens*
  - Sorus 170—220 μ diam., contents orange-yellow.
    Sporangia numerous, 23—32 μ diam. Zoospores size and shape unknown.
    Parasitic on *Atylosia*. — *S. atylosiae*
  - Sorus 230—250 μ diam., contents bright orange.
    Sporangia numerous, small, 12—25 μ diam. Zoospores unknown.
    Parasitic on numerous legumes. — *S. umbilicatum*

S. minutum (Patouillard) Gäumann, 1927, p. 172.

Caeoma minutum Patouillard, 1890, p. 59.
Uredo minuta (Patouillard) Saccardo, 1891, p. 334
Aecidium puerariae P. Henning, 1893, p. 6
Uromyces puerariae (P. Henning) Dietel, 1900, p. 282
Synchytrium puerariae (P. Henning) Miyabe, 1905, p. 199
Woroninella puerariae (P. Henning) H. Sydow, 1914, p. 486
W. minuta Sydow, 1924, p. 379
Miyabella puerariae (P. Henning) Ito and Homma, 1926, p. 112

Sori solitary, globose, or subglobose and beaked, 100—1250 μ diam., with a thin hyaline wall. Sporangia up to several hundred per large sorus, polyhedral when compressed, globose, 19—34 μ diam., with smooth hyaline walls; brilliant orange content. Zoospores ovoid, 6×10 μ diam., with numerous yellowish-orange refringent globules, and a 9—13 μ-long flagellum.

Compositely monogallic. Galls scattered or aggregated, protruding or largely embedded in leaf, sometimes protruding on both sides of leaf, 240—280 μ high by 275—470 μ broad, embedded galls on stems up to 1400×1280 μ diam.; sheath, 4—8 cells thick.

Parasitic on the leaves and stems of *Pueraria* sp., *P hirsuta* and *P. tuberosa in India* (Butler and Bisby, 1931; Mhatre and Mundkur, 1945; Lingappa, 1955 c).

S. dolichi (Cooke) Gäumann, 1927, p. 172

Uromyces dolichi Cooke, 1882, p. 127.

Woroninella dolichi (Cooke) H. Sydow, 1914, p. 485.

Sori usually solitary in a cell, ovoid, 80—250×115—300 μ diam., spherical, 90—700 μ diam., or ellipsoidal; giving rise to 100—600 or more sporangia which are liberated an disseminated when the galls mature and open. Sporangia polyhedral, 17—30 μ diam., globose, 20—33×15—25 μ diam., with hyaline smooth walls and orange or yellowish-red contents. Zoospores unknown.

Compositely monogallic. Sporangial galls very similar to those of *S. decipiens*, 300—700 μ diam., opening and becoming aecidium-like at maturity.

Parasitic on the leaves and stems of *Dolichos gibbosus, Glycine javanica* and *Dunbaria ferruginea* in Mysore and Madras (Sydow, 1914; Butler and Bisby, 1931; Mhatre and Mundkur, 1945).

S. crotalariae Ramakrishnan and Ramakrishnan 1950, p. 67.

Sori up to 500 μ diam. Sporangia globose or angular, 17—34× 20—34 μ diam., orange, smooth, thin-walled. Zoospores unknown.

Compositely monogallic. Sporangial galls numerous, single or in groups, bright orange when young, cupulate after dehiscence, 1—2 mm diam.; amphigenous, but more abundant on lower surface.

Specimen no. 18764 in HCIO.

Found on leaves and stems of *Crotalaria semperflorens,* Madras.

Petch and Bisby (1950) reported that *S. (Woroninella) umbilicata* occurs on *Crotolaria walkeri* in Ceylon, but whether or not their and Ramakrishnan's species are identical remains to be seen. Also, the sori of *S. crotalariae* are reported to attain a greater diameter than those of *S. atylosiae,* but otherwise the species appear to be similar, so far as they are known.

S. decipiens Farlow, 1885, p. 240, plate IV, figs. 4—6.

Uredo leguminosarum and *U. fabae* Curtis (in Herbarium).

U. aecidiodes Peck (non *U. aecidioides* DeCandolle, 1815), 1872, p. 88.

U. peckii Thümen, 1879.

S. fuglens var. *decipiens* Farlow, 1878, p. 229.

S. peckii (Thümen) Pound, 1894, p. 35.

Woroninella aecidioides (Peck) H. Sydow, 1914, p. 485.

Miyabella aecidioides (Peck) Ito and Homma, 1926, p. 111.

Sori bright yellow to light-orange, usually solitary, globose to spherical, 120—200 μ diam. Sporangia numerous, often more than 500 in a sorus, forming powdery masses as the sorus membrane and gall rupture, predominantly polyhedral, 12—18 μ in greatest diameter, with thin hyaline walls, and orange-yellow content. Zoospores ovate or globose 3×4.5 μ diam., with a whiplash flagellum, 9.5—14.5 μ long.

Compositely monogallic. Sporangial galls numerous on both surfaces of leaves and on petioles, pods, and stems, separate and scattered, or aggregated and confluent, bright yellow, subhemispherical or mound-shaped; scattered galls on leaves, 108—175 μ high by 132—300 μ broad, and usually protruding on opposite side of leaf; sheath, 3—8 cells thick.

Parasitic on leaves, petioles, stems, flowers and fruits of *Amphicarpaea monoica* (Sydow, 1914; Butler and Bisby, 1931), and *A. edgworthii* (Mhatre and Mundkur, 1945) Simla, Punjab.

S. atylosiae (Petch) Gäumann, 1927, p. 174.

Aecidium atylosiae Petch, 1909, p. 302.

Sori smooth, globose to spherical, 170—200 μ diam., hyaline to orange with a thin wall, and orange-yellow contents. Sporangia subglobose, 25—32×23—28 μ diam., or spherical, 17—21 μ diam., forming 32—48 zoospores.

Compositely monogallic. Sporangial galls hypophyllous, globose, 200—500 μ diam., orange-red, cupulate after dehiscing, deeply sunken in host tissue, covered by epidermal hairs.

Parasitic on the leaves of *Atylosia* sp. in Mysore (Mhatre and Mundkur, 1945), and *Rhynchosia minima* (Ramakrishnan and Sundaram, 1954 a) in Madurai District.

Sydow and Sydow (1924) examined the original material of Petch and came to the conclusion that the fungus in question should be called a species of *Woroninella*. Gäumann (1927) used the sporangia from *A. scarabaeoides* as an inoculum and attempted to infect *Desmodium dependens, Psophocarpus tetragonobolus, Vigna sinensis, Phaseolus* sp., and *A. scarabaeoides*. Only the last named species became infected, and Gäumann concluded that his fungus is the same as Petch's and that its host range is limited to species

of *Atylosia.* Mhatre and Mundkur reported that Thirumalachar succeeded in germinating the sporangia and secured uniflagellate zoospores.

S. umbilicatum (Berk. and Broome) Karling, 1964 a, p. 338.

Aecidium umbilicata Berkeley and Broome, 1875, p. 95.

A. cajan Petch, 1909, p. 302.

Woroninella umbilicata (Berkeley and Broome) Petch, 1918, p. 162.

S. cajani (Petch) Ramakrishnan and Sundaram (HCIO, 20889).

Sori bright reddish-orange, 230—250 μ diam. Sporangia ovoid, 12—22×15—25 μ diam., with thin walls, bright orange content. Zoospores unknown.

Compositely monogallic. Galls reddish-orange, scattered and separate or crowded and confluent, becoming cupulate after dehiscing.

Parasitic on leaves, stems, and pods in *Cajanus cajan* in Cinchona (Anamalais) (Ramakrishnan and Sundaram, 1954).

The above diagnosis is taken largely from Ramakrishnan and Sundaram's description. Whether or not the fungi reported on other hosts are one and the same species remains to be proven from intensive cross-inoculations involving numerous leguminous hosts. The fungi which Petch (1909) and Petch and Bisby (1950) reported on *Atylosia condollei* and *A. ruosa* relate apparently to *S. atylosiae* as Gäumann (1927) has indicated. In this connection, see *S. phaseoli* and *S. crotalariae* in regard to their hosts.

Excluded Species of Synchytrium

S. piperi Mhatre and Mundkur, 1945, p. 136.

This species was created for what was believed to be a *Synchytrium* species in the leaves of *Piper betle,* collected by Topany at Alibog, Bombay. Mhatre and Mundkur described the galls as minute white dots, somewhat deep-seated in the leaves, which bear a single, spherical, 30—38 μ diam., smooth, thin-walled, light-brown resting spore. The author (1961) observed these dots in a portion of the type (HCIO 10366) and other material (HCIO, 23681) but found nothing that resembled the resting spores of *Synchytrium.* Deep-seated and fairly uniformly distributed, amber, thin-walled bodies are present in the mesophyll and palisade of the leaves, but they do not relate to *Synchytrium.* In fixed and stained sections of infected *Piper betle* collected by M. I. Thirumalachar at Bangalore (Jan. 26, 1946) and sent to the herbarium of the University of Wisconsin, the author found similar bodies throughout the leaves. If the specimens which he has studied are representative, the author does not believe the organism present is a species of *Synchytrium.*

S. indicum (Patel et al.) Karling, 1953, p. 282.

This fungus was first described as a short-cycled species, *S. phaseoli,* on *Phaseolus mungo* at Poona, but inasmuch as its specific name was preempted by Weston's (1930) *S. phaseoli,* the author renamed it *S. indicum.* Patel et al. described the resting spores as unusually small, spherical, 18—26.6 μ diam., to slightly ellipsoidal with a smooth, thick, brown wall. No galls *per se* were present on the host, but both sides of the leaves were covered with quadrilateral to polygonal crusts, 1×2—2 mm diam. Payak (1951) examined the material collected by Patel et al. and found that so-called sporangia in the intercellular spaces of the mesophyll were similar to the spores of downy mildews. Lingappa (1952) also examined the herbarium specimens at the Agricultural College at Poona and found no trace of the fungus. In view of the small size of the resting spores reported by Patel *et al.* and the observations of Payak and Lingappa, the author does not think this is a species of *Synchytrium.*

S. borreriae Lacy, 1950, p. 159.

Resting spores solitary, subglobose to spherical, 112—154 μ diam., reddish-brown, with oily granular content, and a 11—28 μ thick, three-layered wall. All else unknown.

Galls hypophyllous, appearing as orange-yellow specks, 154—210 μ diam., primarily epidermal in origin, later innate and subepidermal; parasite not causing proliferation or thickening of leaves, protruding very little or not at all.

Parasitic on leaves of *Borreria hispida,* Bihar.

Lingappa (1956) found that the thick-walled spores are cysts of an endophytic alga; the author has confirmed these observations.

S. khandalensis Payak and Thirumalchar, 1956, p. 38.

Resting spores globose, ovate to spherical, 110—175 μ diam., with a reticulate or areolate exospore, 7.5—15 μ thick; germination unknown.

Compositely monogallic. Galls on leaves amphigenous, glistening, lemon-yellow when fresh, becoming brownish with age.

Type spec. 26540, HCIO.

Found on leaves of *Blepharis asperrima* and *Asystasia dalzelliana,* Khandala, Bombay.

Payak (1953) listed two species, *S. asystasiae* and *S. khandalensis,* for this organism in his first report, but later he and Thirumalchar merged them. The author (1961) studied the type material on *B. asperrima* and the specimens on *A. dalzelliana* and found that the reticulate or areolate bodies described are not resting spores of *Synchytrium.* These bodies occur singly in small galls or in groups in large protruding galls, and each lies in a hyaline envelope. They are predominently pyriform with a blunt peg, but may be ovoid

to elongate, also. The wall ist unusually thick and sculptured with the points of convergence of the polygons extending out as blunt spines over the periphery. Their content is markedly different from that of *Synchytrium* resting spores, and the author believes they may be eggs or cysts of an insect, or possible cysts of an alga.

Rhizidiaceae

This family is represented at present by relatively few of the numerous well-known genera and species of eucarpic monocentric chytrids, and most of the reported ones occur as saprophytes in the soil of India.

Rhizophydium Schenk, 1958

Verhandl. Phys.-Med. Gesell. Würzburg 8:245.

Chytridium subgen. *Sphaerostylidium* Braun, 1856, Abhandl. Berlin Aakad. 1855:75.

Rhizophyton Zopf, 1888. Nova Acta Leop.-Carol. 52(7):343.

Thallus monocentric, eucarpic, endo- and epibiotic. Sporangium epibiotic, sessile or stalked, inoperculate with one to several exit papillae or tubes. Rhizoids endobiotic, usually branched. Zoospores usually containing a single refractive globule. Resting spores epibiotic, thick-walled, with one or more fairly large globules; developing like the sporangia and formed asexually, or sexually by fusion of the contents of an adnate and a receptive thallus; functioning usually as a sporangium and giving rise directly to zoospores in germination.

Rhizophydium sphaerotheca Zopf, 1887. Abhandl. Naturf. Gesell. Halle 17:92, pl. 2, figs. 33—41.

Sporangia sessile, hyaline, smooth, subspherical to spherical, 6—24 μ diam., with up to 5 protruding exit papillae and subtended by a branched rhizoidal system. Zoospores spherical to ovoid, 2.5—3 μ diam., with a hyaline refractive globule and a 10—12 μ long flagellum. Resting spores unknown.

On dead pollen of *Pinus sylvestris* from brackish soil, Mandapam Camp, Rhamnad District, Madras State (Karling, 1964 d).

Rhizophydium minutum Atkinson, 1909. Bot. Gaz. 48 : 328, fig. 4.

Sporangia sessile hyaline, smooth obpyriform or flask-shaped, broadly papillate, 5—6 μ diam., with a few rhizoidal filaments at the base. Zoospores 2—4 per sporangium, ovoid, 2.5 μ diam., with a minute refractive globule. Resting spores unknown.

Parasitic on *Spirogyra* sp. at Patna (Lacy, 1955).

Rhizophydium keratinophilum Karling, 1946 a. Amer. J. Bot. 33:753, 43 figs.

Sporangia sessile, hyaline, predominently spherical, 7—50 μ diam., with 2—5 prominent exit papillae, 3—4 μ high by 4—6 μ broad; wall ornamented with short simple bifurcate, 2—6 μ high, or dichotomously branched, 15—45 μ long, spines, or simple or branched threads. Rhizoids fairly extensive, up to 120 μ and richly branched, main axis up to 5 μ diam. Zoospores spherical, 2.5—3 μ diam., with a minute spherical refractive globule; flagellum 10—13 μ long. Resting spores spherical, 7—15 μ diam., ovoid, 5—6×7—14 μ diam., with a 2—3.5 μ thick, brown warted wall; contents coarsely but evenly granular; functioning as prosporangia in germination and forming a superficial zoosporangium.

On human hair from soil of a dry rice paddy near Uttarakosamanga, Rhamnad District, Madras State (Karling, 1964 d).

Rhizophydium collapsum Karling, 1964 d. Sydowia 17:285, 15 figs.

Sporangia usually sessile, hyaline, smooth, slightly subspherical to spherical, 14—27 μ diam., or broadly obpyriform, 14—16×18—20 μ diam., with a thin, 0.8—1.2 μ, wall which collapses and partially dissolves as zoospores emerge, basal, portion of wall slightly thickened and persistent; visible exit papillae lacking. Rhizoids arising from a narrow axis and finely branched. Zoospores spherical, 2.3—3 μ diam., with a small hyaline refractive globule and a 12—14 μ long flagellum. Resting spores subspherical to spherical, 5.2—9.5 μ diam., or slightly ovoid, 5—6.3×6—7.8 μ diam., with a light-brown wall which is usually smooth but rarely slightly rough or verrucose; functioning as prosporangia in germination.

On dead pollen of *Pinus sylvestris,* from brackish soil at Mandapam Camp, and near Valantarvai along the Rhamnad Road, Madras State (Karling, 1964 d).

Rhizophydium sp. Karling, 1964 d. Sydowia 17:290.

Sporangia sessile, hyaline, smooth, spherical, 25—60 μ diam., with 5 to 8 almost equally distributed exit papillae, 3—4 μ diam., which are filled with broadly conical, protruding, 4 μ high by 5 μ diam. at base, plugs of slightly opaque, homogeneous material. Main rhizoidal axis 3.5—4 μ diam., occasionally slightly inflated and almost apophysis-like. Zoospores spherical, 3—3.8 μ diam., with a small refringent globule, emerging simultaneously and singly from several exit papillae. Resting spores unknown.

On bleached corn leaves from soil, Panakudi and Virudunagar, Madras State (Karling, 1964 d).

Rhizophydium sp.

Sporangia sessile, hyaline, smooth, subspherical to slightly polyhedral with up to 7 low, inconspicuous exit papillae; exit orifices up

to 6 μ diam. Rhizoids arising from base of sporangium, bushy, richly-branched. Zoospores spherical, 2.4—3 μ diam., with a small hyaline refractive globule; flagellum 10—12 μ long. Resting spores unknown.

Parasitic on the resting sporangia of *Physoderma pluriannulatum*, from brackish soil, Mandapam Camp, Madras State.

This species appeared as a parasite of the resting sporangia of *Physoderma pluriannulatum* when they were added to a watered brackish soil culture in a test to determine the host range of *Olpidium indianum*, noted previously, and sometimes as many as 9 thalli occurred on 1 host sporangium. Resting spores were not observed, and it is impossible to identify the species on the information available.

Phlyctochytrium Schroeter, 1897

Engler and Prantl, Die. Naturl. Pflanzenf. *T* (1):78

Phlyctidium (Braun) Rabenhorst, 1868. Flora Europaea Algarum 3:278.

Rhizidium sensu Fischer, 1892. Rabenhorst's Kryptogamen — Fl. 1(4):106. non Braun, 1856, Monatsb. Berlin Akad. 1856:591.

Thallus monocentric, eucarpic, epi-and endobiotic. Sporangium epibiotic, inoperculate with one or more exit papillae or exit tubes. Subsporangial apophysis and branched rhizoids endobiotic. Zoospores fully formed in the sporangium, usually with a refractive globule. Resting spores epibiotic and developed like the sporangium, apparently formed asexually; usually functioning as a sporangium and forming zoospores directly in germination.

Phlytochytrium planicorne Atkinson, 1909. Bot. Gaz. 48:337, fig. 7.

Sporangia usually sessile, sometimes stalked, variable in size and shape, broadly ovoid, 8—18 μ high by 6—20 μ in diam., pyriform, ellipsoid with a thin hyaline wall, bearing 4 to 6 solid highly refractive, slightly converging teeth up to 4—5 μ long, at the apex and around the exit papilla. Rhizoids variable in extent and degree of branching, arising from an ovoid or subspherical, 4—10 μ diam., endobiotic subsporangial apophysis. Zoospores spherical, 3.5—4.8 μ diam., with a conspicuous hyaline refractive globule and 22—26 μ long flagellum. Resting spores unknown.

Weakly parasitic on *Spirogyra* sp., Poondi, Madras State.

Phlyctochytrium chaetiferum Karling, 1937. Mycologia 29:179, 3 figs.

Sporangia sessile, ovoid, subspherical, 15—47 μ diam., or broadly pyriform, 12—30 μ high by 18—45 μ in diam., with a broad protruding apical papilla; wall bearing 3—30 or more delicate, flexible branched hairs up to or exceeding 200 μ in length. Rhizoids one to several, arising from a spherical, 8—11 μ diam., elongate, fusiform or irregular apophysis. Zoospores spherical, 2.5—3.2 μ diam., with a hyaline refractive

globule. Resting spore subspherical or ovoid, 9—14×10—17 μ diam., spherical, 10—17 μ diam., with a smooth, hyaline, moderately thick wall; germination unknonwn.

On dead pollen of *Pinus sylvestris* from brackish soil at Mandapam Camp, Madras State (K a r l i n g, 1964 d).

P h l y c t o c h y t r i u m i n d i c u m Karling 1964 d, Sydowia 17:287, 15 figs.

Sporangia sessile, hyaline, smooth, broadly pyriform with a slightly flattened base, 18—28 μ broad by 24—38 μ high, occasionally broadly citriform, or almost spherical, 22—29 μ diam., with one broad, 14—17 μ diam., apical exit papilla. Rhizoids arising from a subspherical, 8—12 μ diam., ovoid, slightly elongate, or irregular apophysis. Zoospores spherical, 2.5—3 μ diam., with a minute refractive globule and a 11—13 μ long flagellum. Resting spores hyaline, smooth, subspherical, to spherical, 16—20 μ diam., with a large, somewhat angular refractive body and several smaller ones; functioning as a prosporangium in germination.

On dead pollen of *Pinus sylvestris*, from brackish soil, at Mandapam Camp, Madras State (K a r l i n g, 1964 d).

P h l y c t o c h y t r i u m sp. Karling, 1964 d. Sydowia 17:291.

Sporangia sessile, hyaline, smooth, spherical, 20—24 μ diam., with 5—12 barely discernable exit papillae which are fairly evenly distributed. Apophysis small, occasionally lacking, 3.2—5 μ diam., from which arise 1—3 branched rhizoids. Zoospores small, spherical, 2—2.5 μ diam., with a minute droplet which appears dark to black in transmitted light. Resting spores unknown.

On bleached corn leaves from brackish soil at Mandapam Camp, Madras State (K a r l i n g, 1964 d).

This species resembles somewhat *Phlyctochytrium spectabile* Uebelmesser (1956), but its sporangia, zoospores and apophysis are markedly smaller.

Podochytrium Pfitzer, 1870

Sitzungsber. Niederrhein. Gesell. Natur-Heilkunde, 1869:62

Septocarpus Zopf. 1888. Nova Acta Acad. Leop.-Carol. 52:248.
Rhizidiopsis Sparrow. 1933. Trans. Brit. Mycol. Soc. 18:216; 1936. J. Linn. Soc. London (Bot.) 50:450.

Thallus monocentric, eucarpic, endo- and epibiotic. Sporangium epibiotic, formed from the apical prolongation of the sterile epibiotic zoospore cyst and separated from it by a cross wall, elongate, ovoid to fusiform, inoperculate. Rhizoids endobiotic usually arising from the tip of the fine narrow penetration tube, branched or continuous. Zoospores with a hyaline refractive globule. Resting spores where known

epibiotic, thick-walled, flattened; functioning as a prosporangium in germination.

So far only two species of this genus have been reported from India, and these are incompletely known.

Podochytrium clavatum Pfitzer, 1870. Sitzungsber. Niederrhein. Gesell. Natur- und Heilkunde 1869:62.

Septocarpus corynephorus Zopf, 1888. Nova Acta Acad. Leop.-Carol. 52:348, pl. 20, figs. 21—28.

Sporangia proper resting on a knob-like, sterile basal cell which varies from 2 to 4 μ diam.; usually sessile but sometimes standing off from the host cell on a narrow part of the germination tube, sporangia proper obpyriform to clavate, 8—20 μ high by 5—9 μ in greatest diam., with a smooth, hyaline and fairly thick wall. Rhizoids unusually delicate, branched and usually arising at the tip of the germination tube. Zoospores spherical, 3 μ diam., with a hyaline refractive globule, emerging through a broad apical exit papilla. Resting spores doubtful.

Isolated from soil in paddy fields of Orissa (Ghosh and Dutta, 1962).

Podochytrium lanceolatum Sparrow, 1936. Trans. Brit. Mycol. Soc. 18 : 216; 1936, J. Linn, Soc. London (Bot.) 50 : 450, fig. 4 c—f.

Sporangia resting on a sterile cup-like or knob-like basal cell which varies from 4—5 μ in diam., lanceolate or slightly fusiform in shape, occasionally slightly tilted, 20—25 μ high by 8—10 μ in greatest diam., with a small apical exit papilla. Rhizoids sparsely branched and arising from tip of needle-like germination tube. Zoospores spherical, 3—4 μ diam., with a hyaline refractive globule. Resting spores unknown.

Isolated from soil in paddy fields of Orissa (Ghosh and Dutta, 1962).

Ghosh and Dutta did not record the hosts of these two species but only stated that they had isolated them from soil. Species of *Podochytrium* are limited to diatoms as host so far as they are known and it is presumed that Gosh and Dutta found the two species on such hosts.

Rhizidium Braun, 1856

Monatsber. Berlin Akad. 1856:591; Flora 14:599

Thallus moncentric, eucarpic, usually lying free of the substratum or host; composed of a sporangium or resting spore and a main, broader rhizoidal axis with secondary branches. Sporangium inoperculate, with one or more exit papillae or tubes. Zoospores usually with a refractive globule; surrounded by slime at the exit orifice; separating and

swimming away, or swarming in a vesicle before dispersing. Resting spores thick-walled; smooth, verrucose or hairy, formed as the sporangium, asexually, or sexually by fusion of contents of 2 thalli through anastomosing of rhizoids; functioning as a prosporangium in germination.

Rhizidium verrucosum Karling, 1944 b. Amer. J. Bot. 31:255, figs. 34—63.

Sporangia spherical, 6—60 μ, ovoid, 15—20×30—40 μ, oblong, 20×35 μ diam., pyriform, or egg-shaped with a verrucose light or reddish-brown crusty outer wall and a thinner hyaline inner wall; both up to 3.5 μ thick; dehiscing by a relatively large exit papilla which breaks through the wall; exit orifice 7—10 μ diam. Rhizoidal system intra- and extramatrical, usually arising from a main axis, up to 10 μ diam., and extending for distances up to 300 μ. Zoospores ovoid, 3—3.5×5—3.5 μ, with a small reddish-brown refractive globule; emerging in a globular mass which becomes enveloped by a vesicular membrane in which they swarm before breaking out and swimming away. Resting spores (?) similar to sporangia but becoming dormant, spherical, 8—22 μ, ovoid, 6—9×12—16 μ diam., with a brown warty, 4—6 μ thick wall; functioning directly as a sporangium in germination.

On snake skin from brackish soil at Mandapam Camp, Madras State, and non-brackish soil in Calcutta, Bengal State (Karling, 1964 d).

Rhizophlyctis A. Fischer, 1892

Rabenhorst Kryptogamen-Fl. 1(4):119 (sensu recent. Minden 1911, Kryptogamenfl. Mark Brandenburg 5:374)

Thallus monocentric eucarpic, epibiotic, partly endo- and epibiotic, composed of a sporangium or resting spore, and several main branched rhizoidal axes. Sporangia with one or more exit papillae or tubes. Zoospores formed within the sporangium; usually containing a refractive globule or several granules; frequently embedded in a gelatinous matrix after discharge from which they escape. Resting spores thick-walled, formed like the sporangium; functioning as a prosporangium in germination.

Rhizophlyctis petersenii Sparrow, 1937. Proc. Amer. Phil. Soc. 78:48, pl. 3, fig. 1—7, text, figs. 3—4.

Sporangia smooth-walled, spherical, 42—80 μ, or irregular in shape, containing numerous orange-brown globules, with a long, 26—30 μ, fairly broad, 15—18 μ diam., exit tube. Rhizoids arising from several points on periphery of sporangium, coarse, 12—16 μ diam., richly-branched and extending for distances up to 620 μ. Zoospores subspherical to spherical, 4.6—5.4 μ diam., with a small orange-brown globules and a few refractive granules; forming a globular mass at

exit orifice before dispersing. Resting spores ovoid to spherical or slightly angular, thick-walled with orange-brown, densely granular content; germination unknown.

Saprophytic in bleached corn leaves from a watered soil sample, Jodhpur, Rajasthan State.

Thangamani (1961) reported the occurrence of this species on cellophane from baited soil cultures at Coimbatore, but the accompanying drawings of it suggest that might be *Karlingia rosea*.

Rhizophlyctis lovetti Karling, 1964 f. Mycophat, et Mycol. Appl. 23:216, figs. 1—11.

Sporangia hyaline to faintly pink or orange, smooth, spherical, 40—190 μ diam., ovoid, 60—140×80—180 μ, obpyriform or clavate when crowded and sometimes stalked; dehiscing by one or more short, 5—7 μ high by 10—15 μ broad, tapering exit papillae, or long, 20—130 μ exit tubes which may become curved, coiled, contorted, hypha-like and branched. Rhizoids arising from a few to numerous points on surface of sporangium, usually coarse, up to 15 μ diam., frequently coiled, richly-branched and sometimes extending for a distance of 2 mm. Zoospores small, ovoid, to elongate, 2.8×3.5—4 μ with a conspicuous nuclear cap and a 14—17 μ long flagellum. Resting spores unknown.

Saprophytic on human fibrin film from soil near Rhamnad and Vallison, Madras State (Karling, 1964 f).

Although no resting spores have been found in this species, they probably occur in the soil and debris and function as an inoculum for suitable substrata. When sandy soil, which was dry when collected and has been kept in this state in an open dish in the laboratory for 2 years, is flooded with water and baited with fibrin film young thalli begin to develop on this substratum within 16 hours.

Rhizophlyctis fusca Karling, 1964 f. Mycopath, et Mycol. Appl. 23:217, figs. 12—21.

Sporangia subspherical to spherical, 56—195 μ, ovoid, 65—80×78—92 μ diam., or obpyriform, hyaline, thin-walled, smooth; dehiscing by an exit tube, 16—20 μ long by 8—12 μ diam., which breaks through the wall and protrudes to the outside. Rhizoids numerous, arising from several points on the periphery of sporangium, usually coarse, up to 14 μ diam., and extending for distances up to 400 μ; constricted conspicuously. Zoospores ovoid to elongate, 2—2.5×3.8—4.5 μ, with a conspicuous nuclear cap and a 12—14 μ long flagellum. Resting spores *per se* doubtful, dormant sporangia similar in size and shape to the evanescent ones but with a smooth, reddish-brown, 5—8 μ thick, wall; germinating after several weeks by the development of a broad tapering exit tube which cracks the thick wall and protrudes to the outside.

Saprophytic in bleached corn leaves, snake skin, fibrin film and bits of hemp seed from brackish soil at Mandapam Camp, and non-brackish soil at 7 locations along the Rhamnad Road between Madurai and Rhamnad, Madras State; Calcutta, Bengal State; Jodhpur, Rajasthan State.

Rhizophlyctis hirsuta Karling, 1964 f. Mycopath et Myco. Appl. 23:221, figs. 22—26.

Thalli completely, or partly extramatrical, or extramatrical. Sporangia spherical, 15—220 μ diam., hyaline, filled with numerous large refractive globules; wall bearing 20—80 radial hairs or rhizoids, 1.5—3 μ diam., which branch sparingly at their tips and extend for distances up to 350 μ. Sporangia lying free and near, or attached to substratum by a stout, 7—20 μ diam., richly branched rhizoid; dehiscing by a broad exit papilla or a long tapering tube. Zoospores narrowly ovoid or spindle-shaped, 3.8—4.2×6—8 μ, with an unusually large globular or slightly angular refractive body which occupies most of the zoospore.

Saprophytic on or near bits of hemp seed, bleached corn leaves and fibrin film from soil in a dry rice paddy 2 kms. north of Rhamnad along the Rhamnad Road to Madurai, Madras State (Karling, 1964 f).

The thallus of this species varies markedly in relation to the substrata. Free lying thalli near bits of hemp seed are usually small and bear numerous radially oriented hairs or rhizoids. Other extramatrical sporangia may be anchored to bits of hemp seed by a stout, 7—20 μ diam., richly branched rhizoid which ramifies the substratum. Such sporangia bear numerous hairs on their periphery, In fibrin film the thalli grow prolifically and attain their largest size. Instead of hairs, the sporangia bear up to 8 coarse rhizoidal axes which are attacked at various points on their periphery. Such sporangia are usually appendiculate as the result of the persistence of the zoospore cyst and germ tube which become enlarged and thik walled.

Polyphagus *)

Nowakowski, 1876 Cohn's Beitr. Biol. Pflanzen 2:203

Thallus, monocentric, eucarpic and lying free in the surrounding water composed of a central expanded portion, the primordium of the

*) The present report of *Polyphagus* in India is based primarily on notes and camera lucida sketches left in the University Botany Laboratories, Madras by the late M. O. P. Iyengar, the eminent Indian algologist. In his studies of the algae he found *Euglena, Chlamydomonas* and *Nautococcus* to be parasitized by species of *Polyphagus,* and he made careful studies of their life histories as well as numerous camera lucida sketches of the successive developmental stage. Unfortunately, he did not publish the results of

prosporangium, from which arise two to several rhizoidal axes that bear numerous branches. Tips of rhizoid branches polyphagus and endobiotic. Sporangium developed as an outgrowth of central portion or prosporangium and delimited from it by a cross wall, inoperculate. Zoospores variable in shape with a conspicuous refractive globule, discharged through a pore at the tip of the sporangium. Resting spores formed by the fusion of two anisogamous aplanogametes in the distal portion of a conjugation tube which is usually formed by the smaller of the thallus-like gametangia; wall thick, smooth or echinulate, content densely ganular with a large globule; functioning as a prosporangium in germination.

Polyphagus euglenae Nowakowski 1876., Cohn's Beitr. Biol. Pflanzen 2:203, pl. 8, figs. 1—7, 12; pl. 9, figs. 1—6, 14—15 (sensu recent. Bartsch, 1945, Mycologia 37:566, figs. 9—18).

Polyphagus euglenae Nowakowski proparte (loc. cit.)

Sporangia usually elongate, tubular and tapering towards the apex, sometimes narrowly pyriform, ovoid, 6—28 μ in diam. by 18—160 μ long with a thin hyaline smooth wall and apical exit papilla. Zoospores elongate almost cylindrical to ellipsoid 4.5—5×9—11 μ with a posteriorly pale yellow to light orange refractive globule and an 18—22 μ long flagellum. Zygospores or resting spores subspherical 11—28 in diam. ovoid or broadly fusiform, 10—25×18—26 μ, with a bright yellow to amber-brown spiny exospore, and a smooth hyaline endospore, content coarsely granular with a large globule; functioning as a prosporangium in germination.

Parasitic on *Euglena* sp., *E. basichloris* and *Chlamydomonas* behind Elliott's Beach, Madras.

Polyphagus laevis Bartsch, 1945. Mycologia 37 : 567, fig. 1—8. 19—23.

Polyphagus euglenae Nowakowski 1876, proparte. Cohn's Beitr. Biol. Pflanzen 2:203, pl. 8, figs. 8—11; pl. 9, figs. 7—13, 16.

Polyphagus euglenae var. *minor* Nowakowski, 1878. Akad. umiejetnosci. Krakowie. Wydziat mat.- przyrod., Pamietnik 4:174, pl. 10, figs. 97—100.

Sporangia usually ovoid, 16—34 μ in diam., by 22—46 μ long, with an apical or subapical exit papilla. Zoospores ovoid to elongate, 3.8—4.5 μ in diam., by 4.8—7 μ long, with a pale bluish- green droplet or body located at the posterior end. Zygospores or resting spores variable in size and shape, ovoid, truncate, spheroid to elongate,

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his studies, but through the courtesy of Professor T. V. Desikachary his notes and drawings were made available to the author, and thanks are herewith expressed for the permission to use them here. Collections were made by the author in the localities noted by Iyengar, and *P. euglenae* was found to occur in abundance on *Euglena*.

15—18 μ in diam., by 20—40 μ long with a smooth hyaline to pale yellow exospore and a smooth hyaline endospore; functioning as a prosporangium in germination.

Parasitic on *Euglena* sp. in a pool behind Elliott's Beach, Madras.

Polyphagus nowakowskii Raciborski, 1900. Parasitische Algen and Pilze Java's p. 6, Batavia.

Sporangia broadly obpyriform, ovoid with a broad base 12—22 μ diam. by 16—35 μ high with apical exit papilla. Zoospores subspherical to spherical, 4.5—6.5 μ diam., with a 16—18 μ long flagellum. Zygospores or resting spores spherical, 10—14 μ diam. ovoid to elongate, as 9—14 μ broad by 15—21 μ long with a smooth, yellowish wall; germination unknown.

Parasitic on *Chlamydomonas maderaspatensis* in a pond behind Elliott's Beach, Madras.

Iyengar's notes and drawings of this species are sparse and incomplete, but the dimensions given indicate that they relate to Raciborski's fungus.

In addition to the species note above Iyengar also left some sketches of a *Polyphagus* species which attacked the germlings of *Nautococcus terrestris* when they formed a film in the culture vessel. However, it is impossible to determine from his sketches whether or not this is a different species.

Chytridium Braun, 1851

Betrachtung über die Erscheinungen der Verjüngung in der Natur p. 198, Leipzig; 1855, Monatsber. Berlin Akad. 1855:378

Thallus monocentric eucarpic, epi- and endobiotic, composed of an epibiotic sporangium, endobiotic, apophysis or rhizoid axis, branched or unbranched rhizoids, and resting spore. Sporangium sessile, apophysate or non-apophysate, operculate, formed as a part of or all of the encysted zoospore. Zoospores fully formed in the sporangium, containing a single refractive globule. Resting spores thick-walled, smooth or varrucose, formed asexually or sexually; functioning as a prosporangium in germination.

Chytridium olla Braun, 1851. Betrachtungen über die Erscheinung der Verjüngung in der Natur ., p. 198, Leipzig.

Euchytridium olla (Braun) Sorokin, 1883. Arch. Bot. Nord France 2:21, fig. 19.

Sporangia epibiotic, hyaline, smooth, sessile, rarely stalked, operculate, ovoid to urceolate, 11.9—100 μ high by 7—14 μ diam., with a umbonate or smooth operculum. Rhizoids endobiotic, tenuous, branched, arising from an expanded tubular stalk or axis at the base of the sporangium. Zoospores spherical, 3.3—5 μ diam., with a hyaline, refrac-

tive globule and a 15—20 μ long flagellum. Resting spores endobiotic, formed in the expanded stalk or axis, subspherical, spherical to pyriform, 24—33 μ diam., with a smooth thick wall and a single large globule; producing an epibiotic operculate sporangium in germination.

Parasitic on *Oedogonium* sp., Patna (Lacy, 1949).

Chytridium schenkii (Schenk) Scherffel, 1926. Arch. protistenk. 54:237, pl. 10, figs. 125—129; pl. 11, figs. 130—132.

Rhizidium intestinum Schenk, 1858, pro parte, Über das Vorkommen contractiler Zellen im Pflanzenreich, p. 5. Würzburg.

Rhizidium schenkii Dangeard, 1886. Ann. Sci. Nat. Bot. VII, 4:297, pl. 13, figs. 24—30.

Phlyctochytrium schenkii (Dang.) de Wildeman, 1896. Ann. Soc. Belge Micro. (Mem.) 24:48.

Sporangia ovoid, pyriform, or ellipsoid, 10 μ diam. by 15 μ high, erect or procumbent, with a prominent apical papilla surmounted by a convex operculum, 3 μ diam.; persistent zoospore case thick-walled hemispherical, and attached to the side or base of sporangium. Rhizoids branched and well developed in one or more cells of substratum, arising from base of a 8—10 μ diam., apophysis; occasionally becoming extramatrical. Zoospores spherical, 2—4 μ diam., with a hyaline refringent globule and a 10 μ long flagellum: emerging from sporangium and forming a motionless mass at exit orifice before becoming motile. Resting spores endobiotic spherical, 10 μ diam., with a thick smooth hyaline wall and refractive, oily content; functioning as a prosporangium in germination and forming an epibiotic sporangium.

On *Spirogyra* sp., Lucknow, U. P. (Das Gupta and John, 1955.

Chytridium lagenaria Schenk, pro parte, 1858. Über das Vorkommen contractiler Zellen m Pflanzenreich, p. 5, figs. 11—13. Würzburg. Non *C. lagenaria* Schenk, 1858. Verhandl. Phys.-Med. Gesell. Würzburg, A. F. 8:241.

Rhizidium lagenaria (Schenk) Dangeard, 1889. Le Bot. 1:64, pl. 3, fig. 23.

Rhizidium westii Massee, 1891. British Fungi, p. 155, pl. 2, fig. 36, 37. London.

Phlyctochytrium westii (Massee) de Wildeman, 1896. Bull. Soc. Roy. Bot. Belg. (Mem.) 35:48.

Sporangia epibiotic, sessile, variable in size and shape, spherical, subspherical, broadly pyriform, ovoid, with a smooth hyaline wall. Rhizoids endobiotic, fairly stout, branched; arising from base of spherical, 8—28 μ diam., ovoid, 7.5—15×13—26 μ, subspherical, or broad tubular apophysis. Zoospores ovoid to spherical, 3—5.5 μ diam.,

with a hyaline refractive globule and a 20 μ long flagellum. Resting spores endobiotic, ovoid to spherical, 18—30 μ diam., with a smooth hyaline, 2—3 μ thick wall; contents with a large hyaline globule; functioning as a prosporangium in germination and forming an epibiotic sporangium.

On *Spirogyra* sp., Lucknow, U. P. (Das Gupta and John, 1955).

(?) *Chytridium oedogonii* Couch, 1938. Jour Elisha Mitchell Sci. Soc 54:256, pl. 24.

Sporangia epibiotic, sessile, usually procumbent, sometimes erect, broadly fusiform and tapering at both ends, 12—22 μ in greatest diameter and 20—42 μ long, occasionally endo-operculate; operculum shallow, saucer-shaped, 5—8 μ diam. Apophysis endobiotic subspherical to spherical, 12—21 μ diam. Rhizoids arising from periphery of apophysis, branched, main axes up to 4.5 μ diam., extending for distances of 140 μ or more into adjacent host cells and sometimes to the outside of the host. Zoospores spherical 3—4 μ diam., with a hyaline refractive globule. Flagellum 25—28 μ long. Resting spores endobiotic, subspherical to spherical, 12—20 μ diam., with a smooth hyaline wall and containing a large refractive globule; germination unknown.

Weakly parasitic on *Oedogonium* sp., Madras, Madras State.

This species is tentatively identified as *C. oedogonii* Couch, but it differs principally from the description given by Couch (1938) and Canter (1950) by its smaller zoospores and occasionally endo-operculate sporangia. Furthermore, its rhizoids branch more often and do not end bluntly as in those of *C. oedogonii*. Apparently, it is weakly parasitic inasmuch as it was found only in moribund cells of *Oedogonium*.

Chytridium parasiticum Willoughby, 1956. Trans. Bit. Mycol. Soc. 39:135, figs. 5—7.

Sporangia epibiotic, sessile or on a 10 μ long stalk, pyriform, 8—27 μ long by 6—22 μ diam., with a narrow base, 2—3 μ diam.' which is the unexpandel portion of the zoospore cyst; operculum not sharply defined, up to 12 μ diam. Rhizoids delicate, branched. Zoospores spherical 2.2—3 μ diam. Resting spores unknown.

Parasitic on *Karlingia rosea,* from brackish soil 14 kms. north of Mandapam Camp along the Rhamnad Road, Madras State (Karling, 1964 d).

It is not certain that the Indian fungus is identical with Willoughby's species, but it resembles it quite closely. For this reason it is identified as such for the time being.

Chytriomyces Karling, 1945 b
Amer. Jour. Bot. 32:363

Thallus monocentric, eucarpic, composed of an epibiotic or extramatrical sporangium, or resting spore, an endobiotic apophysis or rhizoidal axis, and branched rhizoids. Sporangium sessile, operculate, formed from the encysted zoospore. Zoospores usually containing a single refractive globule; swarming, usually in a hyaline vesicle after emerging and before escaping. Resting spores borne like the sporangium, thick-walled, apophysate or non-apophysate, formed asexually, or sexually; functioning as a prosporangium in germination.

Chytriomyces hyalinus Karling, 1945 b. Amer. J. Bot. 32:363, figs. 46—61.

Chytriomyces nodulatus Haskins, 1946. Trans. Brit. Mycol. Soc. 29—137, figs. 1—8.

Sporangia hyaline, smooth, usually spherical, 10—60 μ diam., operculum apical or subapical, shallow saucer-shaped, 8—16 μ diam. Zoospores ovoid, 3—3.5×5—5.5 μ, with a small, 1—1.5 μ diam. hyaline refractive globule; zoospores emerging and swarming in a vesicle for 1—16 minutes before breaking out and swimming away; vesicle continuous with interior of sporangium. Apophysis when present spherical, subspherical, fusiform or elongate, 3—7 μ diam. Rhizoidal system well developed, main axis up to 7 μ diam., extending for a distance of up to 300 μ. Resting spores spherical, 10—20 μ diam., ovoid, 6—8×10—14 μ, elongate, clavate, pyriform, or slightly irregular, with a smooth, 2 μ thick, light-brown wall and a large central refractive globule surrounded by several smaller ones; functioning as prosporangia in germination.

On shrimp chitin, from the Pulviar River at the Ghat Road crossing, Madras State (K a r l i n g, 1964 d).

Chytriomyces verrucosus Karling, 1960. Bull. Torry Bot. Club 87:327, figs. 1—19.

Sporangia epibiotic, unusually sessile, hyaline, smooth, obpyriform, 20—46 μ high by 14—32 μ broad, subspherical, 24—42 μ diam., spherical, 18—38 μ diam., urceolate, subclavate and somewhat anatropus with an apical, subapical or lateral operculum, 12—20 μ diam., occasionally with two opercula. Rhizoids sparse, branched, bushy, sometimes extending to a distance of 22 μ, arising from tip of the main axis or base of the sporangium. Zoospores spherical, 2—2.8 μ diam., with a minute refractive globule; flagellum 9—12 μ long. Resting spores epibiotic, light- brown, subspherical to spherical, 14—22 μ diam., with a tuberculate or verrucose wall, 2—3.5 μ thick; functioning as a prosporangia in germination.

Parasitic on *Karlingia rosea,* from brackish soil at Mandapam Camp, Madras State (K a r l i n g, 1964 d).

Nephrochytrium Karling, 1938

Amer. J. Bot. 25:211

Thallus monocentric, eucarpic, endobiotic, composed of an apophysate sporangium, or resting spore, and extensive, branched rhizoids. Sporangium usually formed as an outgrowth from the apophysis, operculate, with one or more exit tubes. Zoospores fully formed in the sporangium, usually with a single refractive globule; zoospore case and germ tube often persistent. Resting spore developed like the sporangium, thick-walled; germination unknown.

Nephrochytrium appendiculatum Karling, 1938. Amer. J. Bot. 25:507, 509, 34 figs.

Sporangia hyaline, smooth, subspherical, flattened, depressed and somewhat kidney-shaped, 8—18×14—30 μ diam., with 1—3 operculate exit papillae or tubes or varying length. Zoospores spherical, 3.5—4.5 μ diam., with a large hyaline refractive globule and a 40 μ long flagellum; zoospore case becoming thick-walled, amber and persisting with the germ tube on the surface of host cell after germination. Apophysis elongate, transverse, usually fusiform and medianly constricted. Rhizoids arising at ends of apophysis, main axes, 5—6 μ diam., extending occasionally over a radius of 600 μ; intercalary swellings 4—8 μ diam. Resting spores smooth, light- to dark-amber, somewhat kidney-shaped, flattened, depressed, pyriform, 10—17×18—26 μ, thick-walled with one or more refractive globules.

In bleached grass leaves, from soil in a tea estate, 39 klms. west of Munnar, Kerala State. (Karling, 1964 d).

Nephrochytrium aurantium Whiffen, 1941. Amer. J. Bot. 28:41 26 figs.

Sporangia spherical, cylindrical or lobed, 12—17×54—62 μ diam., with one or more operculate exit papillae. Apophysis spherical, 6—7×23—30 μ, developing as an enlargement of germ tube; with an orange-brown zoospore case attached to it by the germ tube; rhizoids richly branched and extensive. Zoospores spherical, 4—4.8 μ, with an orange-colored refractive globule. Resting spore unknown.

Saprophytic in bleached corn leaves, from soil in a tea estate 39 klms. west of Munnar, Kerale State (Karling, 1964 d).

Karlingia Johanson, 1944

Amer. J. Bot. 31:399

Karlingiomyces Sparrow, 1960. Aquatic Phycomycetes, 2nd revised ed., p. 559.

Thallus predominantly monocentric, occasionally polycentric, eucarpic, composed of a sporangium, or resting spore with one to several radiating, branched rhizoidal axes. Sporangia endo- or exo-operculate, with one to several exit papillae. Zoospore fully formed

within sporangium, containing a refractive globule or several granules. Resting spores developed like the sporangia, thick-walled; functioning as a prosporangium in germination.

Karlingia rosea (De Bary and Woronin) Johanson, 1944. Amer. J. Bot. 31:399, 37 figs.

Chytridium roseum De Bary and Woronin, 1865, Ber. Verhandl. Naturf. Gesell. Freiburg 3(2):52, pl. 2, figs. 17—20.

Rhizophlyctis rosea (De Bary and Woronin) Fischer, 1892. Rabenhorst Kryptogam -Fl. 1(4):122.

Sporangia highly variable in size and shape, spherical, 3.5—450 μ diam., ovoid, pyriform, 7—180×15—260 μ, broadly clavate to angular, endo-operculate; content colorless in small sporangia, rosy red, golden to reddish-brown; exit tubes 1 to 28 in number, short, broad, filled with plugs of hyaline gelatinous material under which lies the operculum. Operculum shallow saucer-shaped or bowl-shaped, 3—8 μ diam., pushed out quickly and instantaneously in dehiscence. Zoospores spherical to ovoid, 3.5—5.3 μ diam., faintly rose-colored, usually with several small globules; flagellum 19—21 μ long. Rhizoids 1—15 per sporangium, attached at the base when single or at numerous points on the periphery, main axes up to 22 μ diam., richly branched, extending for distances up to 650 μ or more and frequently curved and coiled in the surrounding water. Resting spores spherical, 10—22 μ, ovoid to angular, 17—25×55—60 μ, with a thick wall and numerous globules; functioning as prosporangia in germination.

Saprophytic in bleached corn leaves, onion skin and cellophane from all soil collections in Madras State, Kerala State, Bengal State, Rajasthan State and Punjab State (Karling, 1964 d).

This is the most common and widely distributed of all chytrids, and has been reported from all continents and most countries throughout the world. In view of this it might be regarded as the universal chytrid. In addition to its occurrence in India, the author found it in all soil collections in Ceylon, Thailand, Hong Kong and Japan in brackish soil at sea level and non-brackish soil at altitudes up to and over 9000 ft.

Variations in size, structure and pigmentation were observed in the various Indian collections, and these variations suggest that more than one strain of *K. rosea* occurs in India.

Some workers (Haskins, 1950; Haskins and Weston, 1950) have contended that dehiscence in this species is inoperculate and maintained that the presence of endo-opercula does not indicate that a species is operculate. Willoughby (1958) made an intensive study of this species in England and found that dehiscence was always operculate as described by Johanson (1944) and the author 1947 a). Careful observations over long periods of time on the development

of the sporangia, exit papillae and tubes, and dehiscence were made on the Indian collections, and in no cases was inoperculate dehiscence observed. Obviously, *K. rosea* is operculate and does not belong in the genus *Rhizophlyctis* as some writers claim.

Karlingia marilandica Karling, 1949. Mycologia. 41:51, figs. 70—78.

Karlingiomyces marilandicus (Karling) Sparrow, 1960. Aquatic Phycomycetes, 2nd ed., p. 562.

Sporangia hyaline, smooth, wall 1.8—2.6 μ thick, spherical, 20—60 μ diam., ovoid, 20—72×30—80 μ, pyriform, 20—28×40—60 μ, elongate to irregular, with 1—2 exit papillae or long tubes, 10—26×15—204 μ; exo- or endooperculate, operculum, bowl-shaped, thick-walled, up to 17 μ diam. Zoospores spherical, 5.5—6 μ diam., with a large hyaline refractive globule, 2.3—2.8 μ diam. Resting spores unknown.

Saprophytic in bleached corn leaves and cellophane from soil 39 kmls. west of Mannar, Kerala State, at an altitude of 3500 ft. and at Madras, and at sea level in brackish soil 14 klms. north of Mandapam Camp along the Rhamnad Road, Madras State (Karling, 1964 d).

The majority of the sporangia observed in the Indian collections were exo-operculate, but endo-operculate ones occurred fairly often as the author described them from Maryland, U. S. A. Careful and continuous observations of the development and dehiscence of endo-operculate sporangia were made to determine whether or not they dehisce without the extrusion of an operculum, and in no cases did this occur. As in the Maryland material (fig. 72) the thalli were occasionally monorhizoidal, and the exit canal extended for distances up to 228 μ. No resting spores developed in the Indian collections.

Cylindrochytridium Karling, 1941 b

Bull. Torrey Bot. Club 68:382

Siphonochytrium Couch, 1939, nom. nud. J. Elisha Mitchell Sci. Soc. 55:208.

Thallus monocentric, eucarpic, intramatrical. Sporangium usually stalked and cylindrical, operculate. Zoospores fully formed in sporangium and lying quiescent in a globular mass at the exit orifice before dispersing. Rhizoids extensive, branched, with numerous catenulate fusiform swellings. Resting spores doubtful (?).

Cylindrochytridium johnstonii Karling, 1941 b. Bull. Torrey Bot. Club 68:383, 16 figs.

Sporangia hyaline, smooth, thin-walled, usually tubular, cylindrical, or slightly clavate, 12—25×30—800 μ, occasionally ovoid, pyriform and sessile, stalk or basal portion usually of same shape and diameter as sporangium, sometimes inflated, vesicular, irregular and

apophysis-like. Operculum oval, ellipsoidal, 4—6×8—10 μ, circular, 4—17 μ diam. Zoospores spherical, 5.6—7 μ diam., with a large hyaline refractive globule and a 22—26 μ long flagellum. Rhizoidal system arising from 1 to several points at the base of the stalk, extending over a radius of 100—1200 μ; spindle- shaped swellings when present 8—20×12—30 μ. Resting spores (?) subspherical, smooth thick-walled, light-brown to amber, with a large yellow-globule; germination unknown (Shanor, 1944).

Saprophytic in bleached corn leaves, from soil in a tea estate 45 klms. west of Munnar, Kerala State (Karling, 1964 d).

Entophlyctaceae

So far as is known this family is represented only by two genera and three species in India.

Entophlyctis Fischer, 1892

Rabenhorst Kryptogamen-Fl. 1(4):114

Thallus monocentric, eucarpic, endobiotic, composed of the epibiotic zoospore cyst, endobiotic sporangium or resting spore and branched rhizoids. Sporangium inoperculate with one or more exit tubes. Zoospores usually with a refractive globule, fully formed in the sporangium and emerging after deliquescence of tips of the exit tube. Resting spores thick- walled, borne like the sporangiua and formed asexually; functioning as a prosporangium in germination.

Entophlyctis bulligera (Zopf.) Fischer, 1892. Rabenhorst Kryptgamenfl. 1 (4):116.

Rhizidium bulligera Zopf, 1884. Nova Acta Acad. Leop.-Carol. 47:195, pl. 18, figs. 5—8.

Sporangia smooth, hyaline, appendiculate, variable in size, subspherical, 14—20 μ, ovoid, 7—10×10—15 μ; dehiscing through a pore in the appendiculum or extramatrical encysted zoospore case. Size and structure of zoospores and resting spores unknown.

Parasitic in *Spirogyra* sp., Patna (Lacy, 1949).

Entophlyctis texana Karling, 1941 a. Torreya 41:106.

Sporangia highly variable in size and shape, subspherical, 18—45 μ diam., pyriform 10—22×20—40 μ, elongate, truncate, 15—25×35—60 μ, lobed or irregular, with one to several exit tubes of variable length and diameter. Zoospores spherical, 4—4.5 μ diam., with a conspicuous golden-red refractive globule and a 20—40 μ long flagellum; forming a globular mass at exit orifice before becoming motile. Rhizoidal axis arising usually at base of sporangium, coarse, 3—7 μ diam., greatly branched and extending for distances up to 600 μ. Resting spores spherical, 18—24 μ diam., oblong, 10—13×15—18 μ,

elongate and truncate, 10—22 μ, with 1 to 3 large centric globules, 8—15 μ diam; wall rust-colored, smooth, 1.5—2 μ thick; functioning as a prosporangium in germination.

Saprophytic in bleached corn leaves, from soil in a tea estate 39 klms. west of Munnar, Kerala State, at an altitude of about 3500 ft. (K a r l i n g, 1964 d).

E n t o p h l y c t i s h e l i f o r m i s (Dang.) Ramsbottom, 1915. Trans. Brit. Mycol. Soc. 5:318.

Chytridium helioformis Dangeard, 1886. Bull. Soc. Bot. France 33:356; 1886, Ann. Sci. Nat. Bot., VII, 4:293.

Chytridium heliomorphum Dangeard, 1888. J. de Botan. 2:143, pl. 5, figs. 19—23.

Entophlyctis heliomorpha (Dang.) Fischer, 1892. Rabenhorst Kryptogamen-Fl. 1 (4):118.

Sporangia hyaline, smooth, ovoid to spherical 12—52 μ diam., with a cylindrical exit tube of variable length. Rhizoids arising from one to several points on the surface of the sporangium, sparse or fairly abundant and branched. Zoospores spherical, 3—4 μ diam., with a conspicuous hyaline refractive globule. Resting spore borne like the sporangia, ovoid, subspherical, spherical, 12—32 μ with a smooth, thick, hyaline wall, content slightly yellow with numerous oil globules; germination unknown.

In cells of *Nitella* sp., Poondi, Madras State.

Numerous large zoosporangia like those encountered by the author in 1928 and 1931 b were observed in the Indian collection.

Diplophlyctis Schroeter, 1897

Engler and Prantl, Die Naturl. Pflanzenf. 1(1):78

Thallus monocentric, eucarpic, endobiotic, composed of an apophysate sporangium, or resting, spore and extensive, branched rhizoids which arise from the apophysis. Sporangium inoperculate, usually with one exit tube. Zoospores fully formed within the sporangium, containing a refractive globule. Resting spores borne like the sporangium, thick-walled, smooth, verrucose or spiny, formed asexually, or sexually by fusion of contents of thalli through anastomosing rhizoids; functioning as prosporangia in germination.

D i p l o p h l y c t i s i n t e s t i n a (Schenk) Schroeter, 1897. Engler and Prantl. Natürlichen Pflanzenf. 1 (1):78.

Rhizidium intestinum Schenk (Pro parte) 1858. Über das Vorkommen contractiler Zellen im Pflanzenreich, p. 5, figs. 1—9, Würzburg.

Entophlyctis intestina (Schenk) Fischer, 1892. Rabenhorst Kryptogamenfl. 1 (4):116.

Sporangia hyaline, smooth, spherical to subspherical, up to 120 μ

diam., pyriform, ovoid, cylindrical, clavate or irregular with a cylindrical, tapering exit tube; basal apophysis spherical, subspherical, 3—6 μ diam., or pyriform. Rhizoids arising from a basal axis, richly branched and extending for distances up to 400 μ Zoospores ovoid, 4—6 μ diam., with a large, hyaline, refractive globule. Resting spores yellowish-brown, sphercial, 18—30 μ, subspherical, ovoid, 16—22× 20—28 μ; walled covered with minute, short and stout spines; functioning as prosporangia in germination.

In cortical cells of *Chara* sp., in a freshwater lake 4 klms. east of Uchippuli, Madras State (K a r l i n g, 1964 d).

Cladochytriaceae *)

(pro parte) Cohn, Beitr. Biol. Pflanz. 2:92

So far as it is known this family is represented in India by only three genera and nine species at the present time. Species of this family are characterized by a polycentric rhizomycelium *) which consists of fine or relatively coarse tenuous filaments, interculary swellings, rhizoids, sporangia and resting spores. In *Cladochytrium* and other genera of this family the sporangia are inoperculate, while in *Nowakowskiella* and *Septochytrium* they are operculate.

Cladochytrium Nowakowski, 1876

(pro parte) Cohn, Beitr. Biol. Pflanz. 2:92

Thallus rhizomycelioid, polycentric, eucarpic, predominantly intramatrical, composed of tenuous filaments with spindle-shaped swellings and rhizoids, sporangia and resting spores. Sporangium terminal or intercalary, inoperculate, usually with one exit tube. Zoospores fully formed in sporangium, containing a single refractive globule. Resting spore usually intercalary and borne like the sporangia with a thick, smooth or spiny wall; functioning as a prosporangium in germination.

C l a d o c h y t r i u m r e p l i c a t u m Karling, 1931. Amer. J. Bot. 18:538, pls. 42—44.

Cladochytrium nowakowskii Sparrow, 1931. Amer. J. Bot. 18:619, pl. 45, fig. H—N.

Entophlyctis aurantiaca Scherffel, in Domjan, 1936 Folio Cryptogam. 2:26, pl. 1, fig. 50, 51, 57—59, 72, 73, 75.

Rhizomycelium relatively fine and delicate, bearing numerous, broadly or narrowly fusiform, septate intercalary swellings, rhizoids, sporangia, and resting spores. Sporangia usually terminal an short lateral branches, smooth, thin-walled, spherical, 6—28 μ diam., ovoid,

*) Because the thallus is polycentric, extensive, somewhat mycelium-like and bears numerous rhizoids, the author (1932) proposed the purely descriptive name, *rhizomycelium,* for it without implying any phylogenetic significance.

or pyriform, or assuming the size and shape of the substratum cell, with one or more narrowly cylindrical, long, or short exit tubes. Zoospores spherical, 4—7.3 μ diam., with a cadmium-orange or golden-brown refractive globule and a long flagellum. Resting spores predominantly spherical, 9—21 μ diam., with a thick, hyaline, smooth or spiny wall and a large cadmium-orange or golden-brown globule; functioning usually as a prosporangium in germination.

Saprophytic in bleached corn leaves and onion skin, from soil in a tea estate 39 klms. west of Munnar, Kerala State (Karling, 1964 g), and Coimbatore and Poonde, Madras State.

Cladochytrium hyalinum Berdan, 1941. Amer. J. Bot. 28:425, figs. 1—84.

Sporangia intra- and extramatrical, terminal or intercalary, apophysate, proliferating, spherical, 15—40 μ diam., subspherical, ovoid, pyriform, irregular, branched and lobed, or greatly elongate, 4—40×12—100 μ, with a single exit tube, 2—6×2—10 μ. Tenuous portions of rhizomycelium sparse or copious, fine or coarse, 1.5—8 μ diam., richly branched and anastomosed; intercalary swellings spherical, ovoid, or fusiform, 2—10×4—14 μ. Zoospores spherical, 8—10 μ diam., with a hyaline, highly refractive and mobile globule, 4—7 μ diam., flagellum 40—50 μ long. Resting spores spherical, 12—18 μ diam., ovoid, pyriform, or elongate, 10—12×25—28 μ, and subtended by several small thin-walled cells; wall smooth, hyaline, several-layered; content containing a single eccentric globule, 8—10 μ diam.; functioning as a prosporangium in germination.

Saprophytic in bleached corn leaves and onion skin, from soil in a tea estate 39 klms. west of Munnar, Kerala State, (Karling, 1964 g).

Cladochytrium aneurae, Thirumalachar, 1948, Trans. Brit. Mycol. Soc. 31 : 8, fig. 1—3.

Rhizomycelium intramatrical, composed of tenuous filaments, septate or nonseptate spindle-shaped swellings, sporangia and resting spores. Sporangia terminal or intercalary, conforming in sizes and shapes to the host cells, 50—100 μ diam., with a constricted exit pore. Zoospores unknown. Resting spores ovoid to spherical, 30—44 μ diam., cinnamon-yellow, thick-walled; formed by the transformation of the spindle-shaped swellings; germination unknown.

Parasitic in the gametophytes of *Aneura* sp., Agumbe, Mysore State (Thirumalachar, 1948).

Nowakowskiella Schroeter, 1897

Engler and Prantl, Die Natürl. Pflanzenf. 1(1) : 82

Cladochytrium Nowakowski, 1876, pro parte. Cohn, Beitr. Biol. Pflanz. 2 : 92.

Thallus rhizomycelioid, polycentric, eucarpic, intra- and extramatrical, composed of extensive tenuous filaments which bear intercalary

swellings, rhizoids, sporangia and resting spores. Sporangium intercalary or terminal, apophysate or non-apophysate, exo- or endooperculate, usually with one exit papillae or tube. Zoospores fully formed in sporangium, usually lying quiescent in a globular mass at the exit orifice after emerging and before dispersing, containing a single refractive globule or several granules. Resting spores usually intercalary, formed by transformation of the intercalary swellings into thick-walled structures, or on outgrowths from the septate swellings; thick-walled; functioning as a prosporangium in germination.

Nowakowskiella elegans (Nowak.) Schroeter, 1897. Engler and Prantl, Natürlich. Pflanzenf. 1(1) : 82.

Cladochytrium elegans Nowakowski, 1876. (pro parte) In Cohn, Beitr. Biol. Pflanz. 2 : 95, pl. 6, fig. 14—17.

Nowakowskiella endogena Constantineanu, 1901. Rev. Gen. Bot. 18 : 387, fig. 83.

Rhizomycelium extensive, richly branched, tenous portions variable in diameter, up to 10 μ, intercalary swellings occasionally septate. Sporangia usually terminal, sometimes intercalary, hyaline, smooth, spherical, 15—50 μ diam., ovoid, pyriform, oblong, often assuming the shape of the substratum cell, apophysate or nonapophysate; dehiscing by an operculate papilla or exit tube; operculum smooth or umbonate, 5—7 μ diam. Zoospores spherical, 5—7.5 μ diam., with a large hyaline refractive globule and a 32—38 μ long flagellum. Resting spores sparse, usually spherical, 14—25 μ diam., ovoid, or oblong, with a thick hyaline, smooth wall and a large hyaline refractive globule; functioning as prosporangia in germination.

Saprophytic in bleached corn leaves, cellophane and fibrin film, from dry non-brackish soil at Satur, and 10 klms., 30 klms., 60 klm. south of Madurai along the Rhamnad Road, and at Virudunagar; also in brackish soil at Mandapam Camp, Madras State, (K a r l i n g, 1964 g). The author later isolated it from non-brackish soil from New Delhi, Jodhpur and Calcutta, which indicates that this species is widespread in India.

Nowakowskiella ramosa Butler, 1907. Mem. Dept. Agr. India, Bot. Ser. 1 : 141, pl. 10, fig. 3—10.

Rhizomycelium richly branched, sometimes septate, 1.5—8 μ diam., and anastomosing; intercalary swellings ovoid, or 4—6×6—10 μ, or broadly fusiform, 5—7×12—16 μ, or almost spherical, 6—9 μ diam., or elongate. Sporangia terminal or intercalary, apophysate or nonpophysate, apophysis when present up to 11 μ diam., spherical, 20—50 μ diam., pyriform, 15—30×25—40 μ, ovoid, 15—20×22—30 μ, elongate, or slightly irregular, with 1—3 low exit papillae or exit tubes up to 100 μ long. Operculum oval or circular in outline, 4—6 μ diam. Zoo-

spores spherical, 6.6—8.8 μ diam., with a large, 3 μ, hyaline, plastic refractive globule; flagellum, 36—40 μ long. Resting spores formed on short protuberances from multiseptate, pseudoparenchymatous intercalary swellings; spherical or slightly angular, 15—26 μ diam., with a hyaline to faintly yellow, thick wall, and numerous small or a large refractive globule; functioning usually as prosporangia in germination.

Saprophytic in bleached corn leaves, cellophane and fibrin film, from non-brackish soil and water at Satur, Uttarskosamangai, Virudunagar, and Rhamnad, Madras State, and Calcutta, Bengal State (Karling, 1964 g), and one cellophane. Colimbatore, Madras State (Thangamani, 1961).

Nowakowskiella granulata Karling, 1944 a. Bull. Torrey Bot. Club, 71 : 374, 29 figs.

Cladochytrium granulatum (Karling) Sparrow, 1960. Aquatic Phycomycetes, p. 469.

Rhizomycelium profuse, richly-branched tenous portions 1.5—7 μ diam., intercalary enlargements mostly non-septate, ovoid, 6—7 by 9—11 μ, broadly fusiform, 5—9 by 8—13 μ, subspherical, 6—10 μ diam., or irregular. Sporangia intercalary or terminal, almost spherical, 12—35 μ diam., pyriform, 12—22 by 15—30 μ, ovoid, 10—18 by 12—25 μ, or slightly irregular, with 1—3, usually 1, discharge papillae or tubes, 3 by 5 μ, which bear a plug of opaque material under which occurs an oval, discoid, bowl-, cup-, or cone-shaped endooperculum, 3—7 μ diam. Zoospores spherical, 5—6.6 μ diam., with numerous golden-brown granules; flagellum about 35 μ long. Resting spores formed from intercalary swellings, subspherical, 15—20 μ diam., ovoid, 15×22 μ, with a hyaline, smooth, 1.5—2 μ thick wall and a large, up to 12 μ diam., refractive globule surrounded by several smaller ones; germination unknown.

Saprophytic in boiled corn leaves and on cellophane from soil at Kota, Rajasthan State.

During the course of two years, dehiscence of more than 200 endo-operculate sporangia has been carefull studied, and in none of these was inoperculate discharge observed. In every case the sunken operculum was pushed out as the zoospores emerged. Accordingly, these additional studies on *N. granulata* has convinced the author that this is an operculate species which does not belong in *Cladochytrium*.

Nowakowskiella elongata Karling, 1944 a. Bull. Torrey Bot. Club 71 : 375, fig. 30—44.

Rhizomycelium hyaline, profuse, richly branched, tenous portions 1—6 μ diam., bearing non-septate, ovoid, 5—13×7—15 μ, broadly fusiform, 4—8×8—17 μ, or globose, 5—15 μ diam., intercalary swellings, rhizoids, sporangia and resting spores. Sporangia terminal or inter-

calary, hyaline, smooth, rarely apophysate, sometimes with a 1—3 septate basal, sterile portion; straight, elongate-clavate, 8—40×20—820 μ, cylindrical with swollen apex, curved or coiled, 5—20×30—900 μ, pyriform, 15—44×20—70 μ, globose, 10—70 μ diam., or irregularly ovoid, with an apical convex operculum, 4—8 μ diam. Zoospores globose, 5—6 μ diam., with a single, rarely two, hyaline, refractive globules, 2—2.5 μ diam. Resting spores formed by the transformation of the intercalary enlargements into thick-walled, hyaline, smooth, globose, 16—24 μ diam., ovoid, 14—16×18—22 μ, or citriform bodies or spores which contain a large, up to 15 μ diam., hyaline, refractive globule; functioning as prosporangia in germination.

Saprophytic in bleached corn leaves, from non-brackish soil in a dry catch basin, 5 klms. north of Rhamnad along the Rhamnad Road, Madras State. (K a r l i n g, 1964 g).

N o w a k o w s k i e l l a m u l t i s p o r a Karling, 1964 e. Sydowia 17 : 314—314, 8 figs.

Rhizomycelium profuse, richly branched, tenuous portions 2—5 μ diam., bearing numerous non-septate, narrowly ovoid, fusiform, 10—15×17—30 μ, or elongate, 8—10×17—22 μ, swellings, fine rhizoids, sporangia and resting spores. Sporangia usually terminal, sometimes intercalary, non-apophysate, hyaline, smooth, predominantly fusiform, 12—16×20—32 μ with long exit tubes; frequently elongate and almost cylindrical, ovoid, or spherical, 8—26 μ diam., endo- or exo-operculate. Zoospores small, spherical, 3—3.9 μ diam., with a minute hyaline refractive globule; flagellum 12—14 μ long. Resting spores unusually abundant, formed by transformation of intercalary swellings into fairly thick-walled structures, hyaline, smooth, almost spherical, 15—30 μ diam., broadly to narrowly ovoid, 12—15×15—30 μ, oblong or elongate, 8—10×17—22 μ, with truncate ends, containing numerous refractive globules; functioning as prosporangia in germination.

Saprophytic in bleached corn leaves and on cellophane, from non-brackish soil in a dry catch basin along the Rhamnad Road near Valantaravai and Madras, Madras State (K a r l i n g, 1964 g).

Another member af *Nowakowskiella* was isolated on corn leaves and cellophane from soil collected at Kota, Rajasthan State, which is very similar to *N. multispora* and may prove to be a variety of this species. The tenuous portions of the rhizomycelium, intercalary swellings, sporangia, and zoospores are similar to those of *N. multispora*. However, its sporangia are almost universally endo-operculate, and the tip of the exit papilla or tube is frequently filled with a conspicuous plug of opaque material. The development of the mucilaginous plug and endo-operculum is somewhat similar to that described by C a n t e r (1963) for *Pseudopileum unum* except that no refractive cap is present.

No resting spores have developed in the cultures during the course of more than a year in contrast to *N. multispora*. Until these are discovered, the identity of this species is uncertain.

Septochytrium, Berdan, 1942

Amer. J. Bot. 26 : 431

Thallus rhizomycelioid, polycentric, eucarpic, intramatrical, composed of elongate, septate, tenuous constricted filaments which bear intercalary swellings, rhizoids, sporangia and resting spores. Sporangium intercalary or terminal, operculate, with one or several exit tubes. Zoospores fully formed in the sporangium, lying quiescent in a globular mass for a few minutes after emerging, containing a single refractive globule or several minute granules. Resting spores terminal or intercalary, thick-walled, containing one large or several smaller refractive globules; functioning as a prosporangium in germination.

Septochytrium variabile Berdan, 1942. Amer. J. Bot. 29 : 641, fig. 2.

Rhizomycelium coarse, extending up to a distance of 1 cm., richly branched, with constrictions and septations or trabeculae extending partly or completely across the tenuous portions or rhizoids; intercalary swellings persisting as empty or partially empty enlargements or becoming enlarged and transformed into sporangia or resting spores. Sporangia hyaline to faintly brown, spherical, 4—150 µ diam., with a short broad papilla or neck, ovate, egg-shaped, broadly pyriform, 10×15—180×220 µ, with a neck 4—60 µ wide, obclavate to flask-shaped, 2×6—35×360 µ, bell-shaped, irregular, flattened and depressed with a broad exit papilla of varying diameter and length. Operculum circular, 1—16 µ diam., or oval in outline, 3×6—6×10 µ. Zoospores hyaline, spherical to ovoid, 4—6 µ diam., with a hyaline refractive globule, 0.7—3 µ diam.; flagellum 30—45 µ long. Resting spores light- to dark-amber, spherical, 4—60 µ diam., ovoid, 4×6—50×65 µ, or elongate, 10×35 µ, with a smooth, thick wall and a large refractive globule; functioning as a sporangium in germination.

Saprophytic in bleached corn leaves, from non-brackish soil in a dry catch basin near Valantarvai along the Rhamnad Road, Madras State (Karling, 1964 g).

Physodermataceae

This family is well represented in India, and up to the present time approximately 31 species of *Physoderma* have been reported. Unlike other polycentric chytrids, the fully known species of this family have a monocentric phase which is usually followed by a polycentric phase. Epibiotic primary zoosporangia are borne on small rhizidiaceous

eucarpic thalli and produce primary zoospores. These in turn reinfect the host and produce successive generations of monocentric thalli, or give rise to extensive endobiotic polycentric thalli which produce numerous thick-walled resting sporangia. These germinate and produce secondary zoospores which may initiate the monocentric phase again or give rise to other polycentric thalli. The zoospores from primary epibiotic sporangia have been reported by Y. Lingappa (1959) to function as gametes which fuse to form a zygote, which infects the host, and gives rise to the endobiotic thallus in *P. pulposa.* In the event this is proven to occur in all species of *Physoderma* the primary ephemeral sporangia and primary zoospores should be regarded as gametangia and gemetes, respectively. On the basis of the descriptions in the literature at that time, the author (1950) merged the genus *Urophlyctis* with *Physoderma* because the descriptions did not indicate any basic and clearcut morphological differences between the genera, symptoms produced on the host plants, and method of resting sporangium germination. However, he pointed out that if the formation of a lid or operculum in resting sporangium germination is constant and specific for certain species these might be segregated in the genus *Physoderma,* while those in which an operculum is lacking might constitute the genus *Urophlyctis.* S p a r r o w (1962) concurred with this viewpoint and stated that „this difference may in the future prove to be one of the most obvious distinctions between these two genera." However, resting sporangium germination has been observed in so few the many described species that no definite conclusions can be drawn at this time. Accordingly, the author is listing the species in *Physoderma.*

Among the numerous species described from India, *P. aeschynomenis* is the only one in which the monocentric phase has been described. Also, germination of the resting sporangia has been observed in only 9 species, i. e., *P. limnanthemi, P. commelinae, P. corchori, P. aeschynomenis, P. chrysopogonicola, P. narasimhanii, P. nelumbii, P. bothriochloae,* and *Physoderma* sp. on *Trifolium alexandrinum,* and the other species are known only by the size, shape and color of their resting sporangia, and the symptoms produced by the parasites. Accordingly, it is impossible at present to devise a workable and effective key to the known Indian species, and any system of classification of them would be temporary and inadequate. Therefore, they are merely described below in the chronological order of their discovery.

Physoderma Wallroth, 1833

Flora Crypto. Germ. 2 : 192

Urophlyctis Schroeter, 1885. Cohn's Kryptogamen-Fl. Schlesien 3(1) : 196

Monocentric eucarpic thallus consisting of an epibiotic sessile or stalked sporangium and endobiotic rhizoids which may arise from an

apophysis or at the tip of the main rhizoidal axis. Primary sporangium variously shaped, with one or more exit papillae, proliferating internally. Primary zoospores fully formed in the sporangium, containing a conspicuous refractive globule; (?) functioning as gametes which fuse to form a zygote from which the endobiotic polycentric thallus develops.

Polycentric eucarpic thallus endobiotic, extensive, consisting of tenuous filaments which bear septate turbinate enlargements, rhizoids and resting sporangia. Resting sporangia usually numerous, large, thick-walled, dark-colored, usually flattened on one surface and bearing a ring of digitate haustoria; formed from one cell of the turbinate enlargements or as an outgrowth from it; wall cracking open irregularly or dehiscing by a circumscissle lid in germination; sac-like, elongate endo-sporangium protruding out of the opening thus formed with a broad exit papilla whose tip deliquesces. Secondary zoospores sometimes larger than primary ones, with a conspicuous refractive globule.

P. maculare Wallroth, 1833. Fl. Crypt. Germ. 2 : 192.

Protomyces macularis (Wallr.) Fuckel, 1869. Jahrb. Nassau Ver. Nat. 23 : 75.

Synchytrium alismatis Cornu, 1871, Bull. Soc. Bot. France 6, ser. 15 : 288, pl. 15, figs. 4, 5.

Cladochytrium alismatis (Wallr.) Büsgen, 1877. Cohn's Beitr. Biol. Pflanz. 4 : 280.

C. maculare (Wallr.) Graff, 1928. Mycologia 20 : 166

Monocentric eucarpic thallus composed of an epibiotic primary sporangium and an endobiotic apophysis which bears reduced digitate, or extensive, up to 80 μ, richly branched rhizoids. Primary sporangia gregarious, flattened, deeply-lobed, ovoid or irregular, proliferating 1 to 6 times, dehiscing by an apical or lateral papilla. Primary zoospores nearly spherical, 4.5—5 μ diam, or ovoid to elliptical, with a conspicuous refractive globule.

Polycentric eucarpic, rhizomycelium endobiotic, tenuous and richly branched; intercalary enlargements broadly spindle-shaped, ovoid or elliptical, usually septate, and bi- to multicellular, bearing numerous short, fine rhizoids. Resting sporangia terminal or intercalary, elliptical, 17—30×20—45 μ diam., in surface view and somewhat flattened on lower surface, with a reddish-brown, smooth exospore and a thin hyaline endospore; content coarsely granular with one or more large refractive globules; germinating by the formation of an endosporangium which pushes up a circular or oval, saucer-shaped lid; secondary zoospores similar to primary ones.

Parasitic on *Alisma reniformis,* Bannaras (Thirumalachar and Pagvi, 1954), causing small spots.

The descriptions of the monocentric phases of this species as well

as those of *P. maydis* and *P. graminis* are taken from observation made elsewhere than in India.

P. graminis (Büsgen) de Wildeman, 1896. Bull. Soc. Roy. Belge (Mem.) 35 : 59.

Cladochytrium graminis Büsgen, 1887. Cohn's Beitr. Biol. Pflanz. 4 : 280.

Monocentric thallus eucarpic, composed of an epibiotic primary sporangium and bushy endobiotic rhizoids. Primary sporangium usually ovoid to ellipsoidal, and sometimes lobed, 20—55 μ long by 20—40 μ broad. Primary zoospores elongate, ellipsoidal, 2—2.5×4—6.5 μ, flagellum 10—20 μ (?) long.

Polycentric, eucarpic rhizomycelium endobiotic, tenuous portions delicate and fine; intercalary enlargements elongate, ovoid, broadly and narrowly fusiform, usually septate, bi- or multicellular. Resting sporangia reddish-rown, flattened on one surface, 20—34×20—40 μ diam., with granular contents; germinating by the formation of an endosporangium which pushes up a saucer-shaped lid and protrudes out to emit zoospores through an apical papilla, size of secondary zoospores unknown.

Parasitic in the culms and leaves of *Cynodon dactylon,* Banaras (Thirumalachar and Pagvi, 1954) causing stunting and malformation of the plants.

Infection of the host plant is systemic, starting from the base and progressing upward. Internodal elongation of the culm is reduced so that the plants become stunted and change from a creeping to an erect habit of growth. Small pale yellow striae are produced on the leaves which gradually change to stripes as numerous striae coalesce.

This species has been reported on numerous grasses in Europe and America, but Gopalkrishnan's preliminary inoculation experiments suggest that it may be limited to one host. Possibly biological races of this species occur which will infect only specific hosts.

Massee (1913) and Gopalkrishnan (1951) described thin-walled zoosporangia as occurring on the endobiotic rhizomycelium, but Thirumalachar and Pagvi maintained that they represent the under-developed stages of the resting sporangia in the underground tissues.

P. trifolii (Passerini) Karling, 1950. Lloydia 13 : 50.

Synchytrium trifolii Passerini, 1887. In Rabenhorst's Fungi Europ. no. 2419; Hedwigia 17 : 171.

Olpidium trifolii Schroeter, 1885 (pro parte). Cohn's Krypt. Fl. Schlesiens 3 : 181.

Urophlyctis bohemica Bubak, 1902. Centralbl. Bakt. Parasit'k. II, 8 : 819, figs. 1, 2.

Urophlyctis trifolii Magnus, 1902 a. Centralbl. Bakt. Parasit'k. II, 9 : 896.

Monocentric eucarpic thalli, ephemeral epibiotic primary zoosporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic. Resting sporangia numerous, up to 200 in a host cell, almost hemispherical, somewhat concave on one surface, 40—55 μ diam., with a ring of pits in the smooth, golden-brown wall; exospore thin, endospore relatively thick; germination unknown.

Parasitic in *Trifolium resupination,* Panjab (Sydow and Ahmad, 1939), causing 0.5—1. mm diam. warts on the leaves, petioles and stems.

This species has been reported on several species of *Trifolium* in other parts of the world as well as *Lotus corniculatus.* However, it is possible that the fungus on the latter host may be *P. potteri* Bartlett (1926). Sydow and Ahmad did not describe the Indian fungus but merely reported its occurrence.

P. limnanthemi Thirumalachar, 1950. Indian Phytopath, 2 : 128—131, 17 figs.

Monocentric thalli, ephemeral epibiotic primary zoosporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, abundant; tenuous portions richly branched, fine and delicate, 1.7—2.3 μ diam.; intercalary enlargements non-septate, polygonal, elongate, ovoid, 8—10×12—14 μ diam., or occasionally irregular. Resting sporangia pale cinnamon-brown, polygonal, ovoid, and flattened on one surface, 16—21×20—27 μ with a whorl of acicular, bifed, or antler-like haustoria; exospore 1.8—2.8 μ thick, endospore thin, content refractive with a large, 7—9.5 μ diam., spherical or ovoid globule surrounded by several small ones; germinating by the circumscissile dehiscence of a lid; secondary zoospores ovoid, size unknown.

Parasitic in *Limnanthemum indicum,* Bangalore, (Thirumalachar, 1950; Suryanarayana, 1959) causing tuberous, warty, yellowish-white and occasionally greenish, bulbil-like, 2—8 mm diam. galls on the lower submerged surface of leaves.

P. indicum Narayanaswami and Ranga Swamy, 1957. Jour. Indian Bot. Soc. 36 : 105, pl. 5.

Synchytrium marsiliae Ahmad and Lodhi, 1953, Sydowia 7 : 266—269.

Monocentric eucarpic thalli, ephemeral epibiotic primary zoosporangia, and primary zoospores unknown.

Polycentric rhizomycelium endobiotic, tenuous portions indistinct. Resting sporangia 2—4 in a cell and embedded in a matrix, yellowish-

brown, smooth, 18.3—28.3 μ long by 13.3—25 μ diam.; germination unknown.

Type spec. in HCIO.

Parasitic on leaves and petioles of *Marsilea minuta,* Delhi, causing tiny lenticular, yellow to deep reddish-brown galls.

Narayanaswami and Ranga Swamy maintained that this species differs from *P. marsiliae* Brewster (1952) by the lack of antler-like haustoria on the resting sporangia, but with further study this difference may not prove to be significant. However, in *P. marsiliae* the ensheathing thin outer wall is strongly wrinkled over the lower 1/3 of the resting sporangia, according to Brewster, a characteristic not noted in *P. indicum.* Possibly, this wrinkled sheath may be the remnants of the embedding matrix reported in *P. indicum.*

P. alfalfae (Pat. and Lagerh.) Karling, 1950. Lloydia 13 : 44.

Cladochytrium alfalfae Patouillard and Lagerheim, 1895. Bull. l'Herb. Boissier 3 : (62).

Physoderma leproides Lagerheim, 1898. Bihang K. Svensk, Vet. Akad. Hand. 24, afd. 3, no. 4 : 10 pls. 2, 3.

Urophlyctis alfalfae (Lagerh.) Magnus, 1902 b. Ber. Deut. Bot. Gesell. 20 : 296, pl. 15, figs. 1—8.

Monocentric eucarpic thalli, ephemeral epibiotic primary zoosporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenous portions richly branched, fine, 0.5—1.0 μ diam. when yong but becoming coarse, 3—5 μ diam., and thick-walled when old; intercalary enlargements predominantly turbinate, 10—15×17—19 μ diam., consisting of 2—6 somewhat disc-shaped cells which bear groups of branched, digitate and blunt haustoria at the apex. Resting sporangia almost hemispherical and flattened on one surface, with branched, blunt haustoria; wall smooth, golden-brown, exospore 1.5—2 μ thick, endospore thin, hyaline, contents coarsely granular and refractive, wall cracking irregularly in germination with the protrusion of an endosporangium; secondary zoospores unknown.

Parasitic on stems, buds, and leaf scales of *Medicago denticulata,* Panjab (Butler and Bisby, 1931; Sydow and Ahmad, 1939), causing marked malformation of the host.

This species is wide spread throughout most of the world where alfalfa is grown and causes the disease commonly known as crownwart. This disease is characterized by large conspicuous warts on the rudimentary leaves and buds which lead to stunting and abortion of the infected plants. Sydow and Ahmad merely reported its occurrence in Panjab without describing it. Their fungus might possibly be a different species inasmuch as Jones and Dreschler (1920) reported that they never found *P. alfalfae* on *M. denticulata* even when it was

growing in close association with infected alfalfa, and they were of the opinion that this species is limited in hosts to *M. sativa* and *M. falcata.*

Disagreement still persists about the developmental cycle of this species. Wilson (1920) reported that the resting spores produce large and small biflagellate isocont gametes and zoospores. The gametes may fuse and form a zygote or infect the host directly without fusion. The zygotes and zoospores both produce amoebae in the host cell and these develop into an extensive plasmodium in which numerous mitotic divisions occur. Wilson found no evidence of a rhizomycelium. On the other hand, Scott (1920) reported that the resting sporangia function as prosporangia in germination and form 1 to 15 zoosporangia which produce uniflagellate zoospores. In light of Jones and Dreschler (1920) and Line's (1921) studies on this species it is highly probable that Wilson and Scott were involved with more than one organism. Their accounts, nevertheless, make it obvious that more intensive study is necessary to clear up the problem of development and cytology of this species.

P. maydis Miyabe, 1909. In A. Idata, Nippon Shôkubutsu Byôrigaku (Handbook of plant diseases of Japan) 4th edition, Tokyo Skowabô, M. 42, pt. 1 : 114, fig. 19.

Cladochytrium sp. nov. Sengoku, 1901. In Ehime-ken Nowaihô (Jour. Agr. Soc. Ehime prefecture) no. 32 : 58, M. 34, XII. In A. Idata, Nippon Shôkubutsu Byôrigaku (Handb. Pl. Dis. Japan) 3rd ed., Tôkyô Skôwabô M. 36 : 75 (nomen nudum): Omori, J. and G. Yamada. Shôkubutsu Byôrigaku (Plant Path.) Tôkyô, Hakubunkwam. M. 37 : 202 (nomen nudum).

Physoderma zea-maydis Shaw nov. sp. In H. Sydow, P. Sydow and E. J. Butler, 1912. Ann. Mycol. 10 : 245—247, fig. 2.

Monocentric eucarpic thallus composed of an epibiotic primary sporangium and an endobiotic, small, spherical apophysis which bears rudimentary digitate once-branched rhizoids. Primary sporangium elongate, asymmetrical, slipper-shaped, 13—66 μ long by 10—15 μ broad with the long axis parallel to the surface of the host, and an apical, broad and blunt exit papilla; proliferating one or more times.

Polycentric eucarpic rhizomycelium endobiotic; tenuous portions delicate, 1—2.3 μ diam., richly-branched; intercalary enlargements elongate, ovoid, or fusiform, usually septate, bi- or multicellular. Resting sporangia terminal or intercalary, flattened on one surface, 18—24×20—30 μ diam., with a double, 3—7 μ thick, amber smooth, wall; content coarsely granular with 1 to several large refractive globules; germinating by forming a conical or pyriform, 8—13 μ long, endosporangium which pushes up a shallow saucer-shaped lid and emits zoospores through an apical papilla. Secondary zoospores ellipsoidal,

5×7 μ diam., with a large eccentric hyaline refractive globule; flagellum 20—25 μ long.

Parasitic in the leaves of *Zea mays*, Duars and Pusa (Shaw, Sydow and Butler, 1912; McRae, 1928; Mitra, 1930; Butler and Bisby, 1931; Mundkur, 1938), Bihar (Thirumalachar and Mishra, 1953); and Rajasthan (Prasad, Mathur and Kothari, 1962).

This is a widely distributed species because of the extensive cultivation of *Zea mays*, which will likely be found wherever this host is grown. Although it was first reported in Japan and India it may have originated in prehistoric times and was introduced into other countries from South and Central America or Mexico, the original habitats of its host. It has been known as *P. zea-maydis* since the time of Shaw's diagnosis in 1912, but according to Tanaka (1922) and Mundkur (1938) Sengoku's *Cladochytrium* sp. nov. on corn and Miyabe's *C. maydis* and *P. maydis* are identical with Shaw's species. Since the reported sizes, shapes and color of the resting sporangia are so similar in all of the above species which occur on the same host, it is unlikely that they are different species. Accordingly, Miyabe's binomial is given priority.

Inasmuch as the zoospores from the ephemeral zoosporangia are smaller than those produced by the resting sporangia it has been postulated that they are gametes which fuse to form a zygote from which the polycentric endobiotic rhizomycelium develops, but this has not been proven by subsequent studies.

P. corchori Lingappa, 1955 e. Mycologia 47 : 109, figs. 1—16.

Monocentric eucarpic thalli, ephemeral epibiotic, primary zoosporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, profusely branched, tenuous portions 1.5—2 μ diam., intercalary enlargements one or two-celled, spherical or spindle-shaped. Resting sporangia subspherical or globose with a circular depression on one surface, 19—30 μ diam.; exospore smooth, dark-brown, 1.5 μ thick; endospore thin and hyaline; content yellowish with one or more oily globules; germinating by the protrusion of an endosporangium which pushes aside a 14—18 μ diam., lid. Secondary zoospores ovoid, 3.5—6 μ with blunt ends, an 18 μ long flagellum, and an eccentric refractive globule near the anterior end.

Type spec. in HCIO, IMI NY, BPI.

Parasitic on *Corchoris obitorius* and *C. acutangulus*, Banaras (Lingappa, 1955e) and Mahashastra (Patil, 1962), causing hemispherical, dark-brown galls on the stems, branches, petioles and leaves.

This species invades the vasicular bundle like *P. graminis*, but does not occur in the xylem vessels.

P. commelinae Lingappa, 1955 e. Mycologia 47 : 110, figs. 17—30.

Monocentric eucarpic thalli, ephemeral zoosporangia, and primary zoospores unknown.

Polycentric rhizomycelium endobiotic, profusely branched, tenuous portions coarse, 3 μ diam., intercalary enlargements minute, spherical, non-septate. Resting sporangia hemispherical to slightly elongate, bright-brown, 24—33 μ diam., ovoid, 23×33 μ diam., with a concave side; exospore bright-brown, smooth, 3 μ thick, endospore thin, hyaline; germinating by the protrusion of an endosporangium which pushes off a convex, 20—24 μ diam. lid; secondary zoospores ovoid to elongate, 5×7 μ diam., with tapering or blunt ends, an eccentric refractive globule and a 20 μ long flagellum.

Type spec. HCIO, IMI, NY, BPI.

Parasitic on *Commelina nudiflora, Cyanotis axillaris* and *Aneilema nudiflorum*, Banaras (Lingappa, 1955 e) and *C. forskalii,* Poona (Patil, 1962), causing light-brown to dark, 1—1½ in. long patches on the leaves, nodes and internodes.

P. aeschynomenis Thirumalachar and Whitehead, 1951, Mycologia 43 : 435, figs. 1—17.

Monocentric thalli largely extramatrical, attached to host by a stalk and branched rhizoids; ephemeral, epibiotic primary sporangia slipper-shaped; primary zoospores unknown.

Polycentric eucarpic rhizomycelium tenuous, delicate and branched with intercalary spindle-shaped swellings. Resting sporangia filling host cell, reddish-brown, hemispherical, flattened on one side with a saucer-shaped lid on the depression, with 1—3 acicular haustoria on convex-side, 25—28×19—25 μ; germinating by dehiscence of the lid and protruding an endospore. Secondary zoospores, spherical, 5—7 μ diam., with a 20 μ long flagellum.

Type spec. in HCIO.

Parasitic on the submerged parts of *Aeschynomene indica,* Bangalore, Banaras, (Thirumalachar and Whitehead, 1951, Lingappa, 1955) and Poona (Thirumalachar, Bhatt, Dhand and Patel, 1956) causing cushion-shaped galls up to 10×20 mm.

Thirumalachar and Whitehead described and figured some of the resting sporangia as germinating by the development of a hypha which became septate and bore chlamydospores. This report apparently relates to sporangia which were parasitized by another fungus as Lingappa (1955 e) pointed out.

P. dichanthicola Thirumalachar and Pagvi, 1954. Bull. Torrey Bot. Club 81 : 153, figs. 2, 5.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia reddish-brown, hemispherical and flattened on one surface, 24—45×17.5—31.2 μ diam., smooth; embedded in a matrix within the host cell; germintion unknown.

Parasitic in the leaves of *Dichanthium annulatum,* Banaras, Bihar and Mahashastra (Thirumalachar and Pagvi, 1954; Patil, 1962), inciting linear reddish-brown to grey and black spots, 2—5 mm long by 1—2 mm diam.

This species resembles *P. paspali* Stevenson (1946) by the symptoms caused but differs by the size of the resting sporangia and the presence of an embedding matrix, according to Thirumalachar and Pagvi.

P. brachiariae Thirumalachar and Pagvi, 1954. Bull. Torrey Bot. Club 81:153.

Monocentric eucarpic thalli, ephemeral sporangia, and primary zoospores unknown.

Polycentric rhizomycelium endobiotic tenuous. Resting sporangia 1—3 in a cell surrounding the vascular bundles, reddish-brown, ovoid to subspherical, 17—29×11—24 μ diam., smooth; germination unknown.

Parasitic in the leaves of *Brachiaria distachya,* Bihar (Thirumalachar and Pagvi, 1954), causing a paling of the leaves and slightly raised streaks.

P. schroeteri Krieger, 1896. Hedwigia 35:144.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric rhizomycelium endobiotic, tenuous. Resting sporangia chiefly intra-epidermal and also in mesophyll cells, 1—4 in a cell, embedded in a purple pigmented matrix, ovate to spherical, 21.5—38.5×14.3—28.5 μ diam., flattened on one surface; germination unknown.

Type spec. in HCIO, IMI, BPI.

Parasitic in the parenchyma of *Scirpus supinus,* Pusa (H. and P. Sydow and Butler, 1907; Butler and Bisby, 1931) and *Cyperus compressus,* Banaras, (Pagvi and Thirumalachar, 1954) and *C. rotundus,* Mahashtra (Patil, 1962), causing black, slightly raised, purple black, subglobose to polygonal, 1—1.5 μ diam. spots on upper surface of leaves and occasionally on peduncles.

The above diagnosis is based largely on Pagvi and Thirumalachar's description of the species on *Cyperus compressus.*

P. cynodontis Pagvi and Thirumalachar, 1954, Sydowia 8 : 91, pl. 4, figs. 1, 2.

Monocentric thalli, eurcarpic, ephemeral epibiotic primary sporangia and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia 1—2 in a host cell yellowish-brown, ovoid to subglobose, flattened on one surface, smooth, thin-walled, 15.7—38.5×1.5—28.5 μ diam., germination unknown.

Type spec. in HCIO, IMI, and BPI.

Parasitic in *Cynodon dactylon,* Banaras, (Pagvi and Thirumalachar, 1954), causing subcircular to elongate, pale-brown spots, 1—3 mm long by 0.5—1.5 mm wide, often coalescing, becoming slightly raised and surrounded by a yellow halo.

Unlike *P. graminis* on the same host in India, this species does not infect its host systematically and cause stunting or witches' broom-like symptoms. Also, its resting sporangia are smaller, according to Pagvi and Thirumalachar.

P. eriochloae Pagvi and Thirumalachar, 1954, Sydowia 8 : 92, pl. 4, figs. 3, 4.

Monocentric eucarpic thalli, ephemeral epibiotic, primary sporangia, and primary zoospores unknown.

Polycentric rhizomycelium endobiotic, tenuous. Resting sporangia intra-epidermal and within mesophyll cells, pale-brown, globose to ovate and flattened on one surface, smooth, medium thick-walled, 14.5—23×11.5—17 μ diam., germination unknown.

Type spec. in HCIO, IMI, BPI.

Parasitic on *Eriochloa procera,* Banaras, causing circular to linear spots, 1—1.5 mm long, reddish-brown spots on the leaves, often coalescent and surrounded by a yellowish halo.

P. setaricola Pagvi and Thirumalachar, 1954. Sydowia 8 : 93; pl. 4, figs. 5, 6.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia 2—3 in a cell, pale yellowish-brown, globose to ovate, smooth, flattened on one surface, 17.2—33×14.3—24.3 μ diam.; germination unknown.

Type spec. HCIO, IMI, and BPI.

Parasitic in *Setaria glauca,* Banaras, (Pagvi and Thirumalachar, 1954) and Mahashtra (Patil, 1962), causing dark, olive-green to brownish, 1—1.5 mm long, coalescent, slightly raised streaks on leaf sheaths and stems.

P. digitariae Pagvi and Thirumalachar, 1954. Sydowia 8 : 94, pl. 5, figs. 9, 10.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting

sporangia yellowish-brown, thin-walled, ovate, globose to reniform, occasionally irregular, with a lateral depression, 15.7—26×11.5—24.3 μ diam., germination unknown.

Type spec. HCIO, IMI, and BPI.

Parasitic on *Digitaria royleana,* Banaras, causing minute, pale-brown roundish to fusoid, 1—2 mm diam., spots on the leaves.

P. aneilemae Pagvi and Thirumalachar. 1954. Sydowia 8 : 94, pl. 5, figs. 11, 12.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia thick-walled, smooth, cinnamon-brown, ovate-globose, 25.7—33×21.5—30 μ diam., germination unknown.

Type spec. in HCIO, IMI, and BPI.

Parasitic in *Aneilema nodiflorum,* Banaras, causing greyish-brwon, oblong, linear, 3—8 mm long by 1—2 mm broad, slightly raised spots on the leaves.

Quite probably this species is identical with *P. commelinae* which Lingappa collected on *A. nodiflorum* at Banaras and described in 1955.

P. echinochloae Thirumalachar and Whitehead, 1953. Science 118 : 693—944, 2 figs.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium, endobiotic, delicate, ramose. Resting sporangia filling mesophyll cells surrounding the vascular bundles, yellowish-brown, smooth, hemispherical, flattened on one surface, with a circumscissile lid, 18—26×10—16 μ diam., germination unknown.

Type spec. in HCIO.

Parasitic on *Echinochloa crus-galli,* Patna, (Thirumalachar and Whitehead, 1953), Banaras (Pagvi and Thirumalachar, 1954) and Poona (Thirumalachar, Bhatt, Dhande and Patel, 1956), causing numerous brownish, linear spots 1—2.5 μ long, on the leaves.

Thirumalachar and Whitehead attempted to infect *Zea mays* with this species but were unsuccessful.

P. nelumbii Thirumalachar and Mishra, 1953. Sydowia 7 : 83, pl. 4, figs. 10, 11.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentrac eucarpic rhizomycelium endobiotic, tenuous, fine and inconspicuous. Resting sporangia 1 to 3 in a cell, reddish-brown,

smooth, ovate to spherical, flattened on one surface, 16—24 μ long by 1(?)—18 μ broad.

Type spec. in HCIO, IMI, and BPI.

Parasitic on *Nelumbium speciosum,* Bihar (Thirumalachar and Mishra, 1953; Patil, 1962) and *Nymphaea stellata,* Poona (Thirum. and Pagvi, 1964) causing pale-yellow patches on the lower surface of leaves.

The symptoms caused by this species are similar to those incited by *P. maculare,* but its resting sporangia are smaller, according to Thirumalachar and Mishra. Later, Thirumalachar and Pagvi, (1964) reported that the spotting on the leaves of varieties of *Lotus* was so severe that it disfigured and caused premature dying of the leaves. They succeeded in germinating the resting sporangia in the laboratory and found that in this process the endosporangium pushes off an operculum as in other *Physoderma* species.

P. chrysopogonicola Thirumalachar and Pagvi. 1956. Sydowia 10 : 113, pl. 1, figs, 1, 2.

Monocentric eucarpic thalli, epibiotic ephemeral primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia chiefly in the epidermis in a continuous layer, occasionally in the mesophyll, 1—2 in a cell, pale-yellow, smooth, medium thin-walled, embedded in a brownish matrix, globose to subspherical, 15—32×10—27 μ diam., germinating by pushing up a lid and protrusion of an endosporangium; secondary zoospores 4—5 μ diam.

Type spec. in HCIO, IMI, and BPI.

Parasitic in *Chrysopogan* species, Poona, causing leaden-grey spots, 3—4 mm long, on the top leaves and 2—3 cm. long stripes on the lower leaves.

P. bothriochloae Thirumalachar and Pagvi, 1956. Sydowia 10 : 114, pl. 1, figs. 3, 4.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia 1—3 in the epidermal and mesophyll cells, heterosporus, having same shape as host cell embedded in a matrix, dark reddish-brown; larger sporangia 30—37×17—29 μ diam., smaller ones 13—20×10—17 μ diam.

Type spec. in HCIO, IMI, and BPI.

Parasitic in *Bothriochloa pertusa,* Poona, causing deep purple fusoid spots, 2 mm long, which coalesce to form up to 1 cm long streaks on the leaves. In 1964 Thirumalachar and Pagvi reported that the discease caused by this species is systemic and culmicolous, and when rooted stolons are surface sterilized and planted

the new leaves show the characteristic purple streaks. The systemic infection causes severe dwarfing of the internodes and deformity of the shoots. They succeeded in germinating the resting sporangia and found that the developing endosporangium pushes off an operculum in this process.

P. dicksoni Thirumalachar and Pagvi, 1956. Sydowia 10 : 114, pl. 1, figs. 5, 6.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia chiefly in the epidermis, rarely in the mesophyll, 1—2 in each cell, pale golden-yellow, smooth, ovate to subspherical, 21—37× 17—36 μ, position of lid obscure; germination unknown.

Type spec. in HCIO, IMI, and BPI.

Parasitic in *Iseilema lapum,* Poona, causing rose colored flecks or spots in the leaves.

P. paspalidii Thirumalachar and Pagvi, 1956. Sydowia 10:115, pl. 2, figs. 7—10.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhicomycelium endobiotic, tenuous. Resting sporangia 1—3 in epidermal and mesophyll cells, yellowish-brown, smooth, thick-walled, ovate to subglobose and flattened on one surface, 18.5—30×24—27 μ diam., germination unknown.

Type spec. in HCIO, IMI, and BPI.

Parasitic in *Paspalilium germinatum,* Poona, causing linear, minute, yellowish-brown to leaden-grey sori, often over the entire surface of the plant.

P. narasimhanii Thirumalachar and Pagvi, 1956. Sydowia 10:116, pl. 2, figs. 11—12.

Monoentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous. Resting sporangia 1 per epidermal and mesophyll cell, yellowish-brown, smooth, thick-walled, ovate to subglobose and flattened on one surface, 19—33×16—24 μ diam.; germinating by pushing up a lid and protrusion of an endosporngium; secondary zoospores 5 μ diam.

Parasitic in *Dactylotaenium aegypticum,* Poona, causing minute, linear, reddish-brown, 1—2 mm long, streaks on the leaves.

P. digitariae marginatae Thirumalachar and Pagvi, 1964. Sydowia 17 : 28, pl. VIII, figs. 3, 4.

Monocentric thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium, intracellular, tenuous. Resting sporangia 1 to 3 in a cell, yellowish-brown, globoid, ovoid to hemispherical, 15.7—25.2 μ diam.; germination unknown.

In leaves of *Digitaria marginata* at Pimpri, Poona, inciting conspicuous reddish-brown, fusoid to ovoid spots, 1—2×0.5 mm diam., often coalescent and covering most of the laminar surface.

According to Thirumalachar and Pagvi, this species differs from *P. digitaricola* and *P. digitariae-longiflorae* by the production of symptoms only on the leaves, whereas in the former two species the infection appears to be systematic and only submerged leaves or leaf sheaths are infected.

P. digitariae-longiflorae Thirumalachar and Pagvi, 1964. Sydowia 17 : 28, pl. 8, figs. 1, 2.

Monocentric thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric, eucarpic, rhizomycelium intracellular, tenuous. Resting sporangia 1—2 in mesophyll cells, embedded in a yellow to dark- brown matrix, pale yellow, globoid to ovoid, thin-walled, and smooth, 17.2—24.3×14.3—22.8 μ; germination unknown.

In leaves of *Digitaria longiflora* at Pimpri, Poona, inciting reddish-brown, 2—2.5 mm long, indefinite streaks, or coalescing to form large non-raised spots.

The resting spores of this species are embedded in a matrix, and when the streaks are scraped the entire host cells which contain the resting sporangia are dislodged, a characteristic not usually evident in the other two parasites on *Digitaria*.

P. kyllingiae Thirumalarchar and Pagvi, 1964. Sydowia 17 : 30.

Monocentric thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium, tenuous and intracellular. Resting sporangia 3—8, chiefly in epidermal cells, light-brown, spherical 22.9—31.5×17.2—30 μ, thick-walled, smooth, bearing 3—5 hyaline minute peg-like appendages, germination unknown.

In leaves of *Kyllingia brevifolia,* Hingne, Poona, inciting minute, inconspicuous, pale-brown adjacent raised streaks which may coalesce to form stripes, 2—3 cm long, over upper leaf surface, turning blackish-grey at maturity.

P. brachiariae-cruciformis Thirumalachar and Pagvi, 1964. Sydowia 17 : 30, pl. 9, figs. 9, 10.

Monocentric thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium intracellular, tenuous, Resting sporangia 1—2 in a cell, distributed mostly in the epidermis and meso-

phyll surrounding the vascular strands, golden-brown, mostly hemispherical to ovoid, 18.6—30×12.9—22—9 μ with a thick, smooth wall; germination unknown.

In leaves of *Brachiaria cruciformis*, at Pimpri, Poona, causing minute, olive-brown to blackish, closely adjacent streaks, 1—2 mm long, which cover entire leaf blade.

P. eragrostidis Thirumalachar and Pagvi, 1964. Sydowia 17 : 31, pl. 9, figs. 11, 12.

Monocentric thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium intracellular, tenuous. Resting sporangia 1—2 per cell, usually distributed in the mesophyll between the vascular tissue, sometimes in the epidermis, light golden-yellow, globose to ovoid, 17.2—28.5×11.5—24.3 μ, with a thin smooth wall; germination unknown.

In leaves of *Eragrostis* sp., Pimpri, Poona, causing very minute olive-brown, slightly raised streaks, up to 1 mm long., over the whole surface of lower leaves.

P. sparrowii Thirumalachar and Pagvi, 1964. Sydowia 17 : 31, pl. 9, figs. 7, 8.

Monocentric thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium intracellular, tenous. Resting sporangia usually distributed in mesophyll cells, occasionally in the epidermis, golden to pale yellow-brown, subspherical to ovoid, 15.7—25.7×12.9—22.9 μ, with a thin, smooth wall; germination unknown.

In leaves of *Setaria pallidifusca*, at Pimpri, Poona, causing dark-brown to black, very minute, slightly raised, elongate specks over the leaf surface.

Physoderma sp. on *Trifolium alexandrinum* Thind and Sharma, 1959. Indian Phytopath. 12 : 122—130, 17 figs.

Monocentric eucarpic thalli, ephemeral epibiotic primary sporangia, and primary zoospores unknown.

Polycentric eucarpic rhizomycelium endobiotic, tenuous portions narrow, about 0.5 μ diam., becoming broader, 2—6 μ diam., and thick-walled with age. Intercalary enlargements turbinate, 12—16×18—20 μ bearing a tuft of haustoria, becoming multicellular by tangential divisions. Resting sporangia orange to golden-brown, plano-convex or almost hemispherical, 30—48×38—52 μ diam. with a ring of haustoria and a smooth two-layered wall; epispore 1.5—2 μ thick, endospore thin, hyaline; contents granular and refractive with several large oily globules; germinating by cracking the sporangium wall and emitting

zoospores through a protruding apical papilla, secondary zoospores ellipsoidal, 4×7 μ diam., (?) anteriorly biflagellate, heterocont; two (?) flagella 5—7 and 13—15 μ long, respectively, fusing to form (?) „zygospores".

Parasitic on *Trifolium alexandrianum,* Punjab, causing crownwart, or severe and profuse gall development on the lower parts of the stem; galls spherical, cushion-shaped or pulvinate, 5—11 mm diam.

The gross symptoms and host tissue reactions caused by this species are fairly similar to those incited by *P. alfalfae* on *Medicago* species, and its rhizomycelium with the turbinate cells, haustoria and resting sporangia illustrated by Thind and Sharma (fig. 3—9) is strikingly similar to that of the former species. However, they pointed out that their species does not cause any distortion or stunting of the host as occurs in *Medicago* species infected with *P. alfalfae.* Furthermore, the maximum number of segments arising from a turbinate cell is 3 in contrast to 5 in *P. alfalfae.* The range in sizes of the resting sporangia in both species are the same, but those of *Physoderma* sp. are reported to differ by the number of haustorial pits in the wall and other minor characteristics also. The Indian species in reported to differ from *P. trifolii,* which Sydow and Ahmad (1939) reported from Punjab, and *P. vagabunda.*

The production of anteriorly biflagellate heterocont zoospores by the resting sporangia and the fusion of these to form zygospores needs further study. The author attempted to germinate the resting sporangia of this species but was unable to do so.

Supplement of other zoosporic Fungi

In addition to the Indian chytrids described above, many other zoosporic fungi were discovered and isolated from soil, water and debris in the manner indicated previously. These are recorded and described here primarily because most of them have not been reported before in India. They include both uniflagellate and biflagellate species which are not commonly seen and recognized unless one is familiar with them *).

Blastocladiales and Monoblepharidiales

Members of these two orders are characterized by posteriorly uniflagellate zoospores, isogamous, and heterogamous sexual reproduction, and both groups are generally regarded as ascending series among the uniflagellate fungi. Several species of the Blastocladiaceae, including

*) Mention is made in this connection also that the author found the soils of India to be very rich in species of the Actinoplanaceae, including members of the genera *Actinoplanes, Ampullariella* (Couch, 1963, 1964) and *Spirillospora.*

Allomyces arbuscula, A. javanicus, A. anomalus as well as *Blastocladia sparrowi, B. rostrata, B. globosa* and *B. ramosa,* have been recorded by Butler (1911), Mitra (1935), Emerson (1941), Das Gupta and John (1953), Lacy (1955), Thangamani (1961) and others. The author isolated *A. arbuscula* and *A. anomalus* from most of the soil samples collected in India in 1963. Two species of the Coelomomycetaceae, *Coelomomyces indiana* and *C. anophelesica,* have been described by Iyengar (1935). In the Monoblepharidiales and the family Gonapodiaceae, Das Gupta and John (1953), Lacy (1955) and John (1959) also recorded *Gonapodya prolifera* and *G. polymorpha.* Accordingly, these two orders are represented fairly well in India, and inasmuch as the species are well known they will not be described here.

The family Catenariaceae, on the other hand, is known only from one species, *C. sphaerocarpa* Karling in India, and since the author isolated two additional genera and three species of this family they will be described in detail.

Catenariaceae

Thallus predominantly polycentric, eucarpic, composed of cylindrical, branched, septate filaments bearing numerous rhizoids. Sporangia intercalary or terminal, formed as local enlargements in the filaments and separated by isthmuses, variable in size and shape, dehiscing by the development of exit papillae or long tubes. Zoospores posteriorly uniflagellate. Resting spores formed in enlargements in the filaments whose centent contracts and becomes enveloped by a pale-brown, thick wall; germinating as sporangia by development of a long exit tube and producing zoospores, which give rise to new asexual plants or encyst at once to become gametangia and form four posteriorly uniflagellate isogametes; gametes fusing to produce biflagellate zygotes which reestablish the sporophytic thalli.

Catenaria Sorokin, 1876.

Ann. Sci. Nat. Bot. VI, 4 : 67.

Thallus predominantly polycentric, eucarpic, occasionally monocentric, eucarpic, rarely holocarpic, endobiotic or intermatrical branched or unbranched and bearing numerous rhizoids, septate. Sporangia usually intercalary, delimited by septa; with one or more short or long exit tubes. Zoospores fully formed in the sporangium, with a conspicuous nuclear cap and several granules, or a single refractive globule. Resting spores thick-walled, usually intercalary and borne like the sporangia; functioning as sporangia in germination; zoospores giving rise to new asexual thalli; or encysting and later forming gametes which fuse in pairs to form zygotes; zygotes developing into sporophytic thalli.

Catenaria anguillulae Sorokin, 1876. Ann. Sci. Nat. Bot. VI, 4 : 67, pl. 3, figs. 6—28.

Thallus predominantly polycentric, composed of cylindrical, branched, septate filaments, 4—17 μ diam., and bearing numerous branched rhizoids; ocassionally monocentric, eucarpic and *Rhizidium*-ilke, or holocarpic and *Olpidium-like*. Sporangia usually intercalary, highly variable in size and shape, pyriform, obpyriform, 20—50×40—80 μ, subspherical, 15—130 μ, ovoid to highly irregular, with one of more exit papillae or straight, curved, coiled, contorted, single or branched tubes, up to 3 mm in length. Zoospores fully delimited in sporangia and swarming before emerging, ovoid to elongate, 3.5—5.4×6—8 μ, with several anterior granules, a conspicuous nuclear cap, and a side body; flagellum long. Resting spores in intercalary swellings whose content contracts and becomes enveloped by a fairly thick, 2—3 μ, light-amber wall, ovoid to oblong, 16—18×20—33 μ, spherical, 21—42 μ, subspherical, 18—35×40—60 μ, or irregular to lobed with a conical pip at the point of emergence of exit tube; functioning as a sporangium in germination; exit tube cracking the outer wall and protruding to the outside.

Saprophytic in bleached corn leaves, onion skin, bits of hemp seed, snake skin and pine pollen from soil in Madras State, Kerala State, Rajasthan State, Punjab State and Bengal State.

This is one the most common zoosporic fungi isolated by the author. It occurred in all 82 soil samples collected and was found in brackish and non-brackish soils at sea level and up to 8640 ft elevation. The thalli varied markedly in various substrata, and in some cases were monocentric and *Rhizidium*-like. In pollen grains, they were often monocentric, holocarpic and *Olpidium*-like as described by the author (1943) and Gartner (1962). Its growth on various agar media was identical to that of European and American collections, and the author is confident that the Indian fungus is *C. anguillulae.*

Catenaria sphaerocarpa Karling, 1938 b. Amer. Jour. Bot. 25 : 328, figs. 1—34.

Thallus predominantly polycentric, occasionally monocentric. Sporangia hyaline and smooth, usually spherical, 8—50 μ, ovoid, 8—30×15—40 μ, and sometimes fusiform, 7—15×14—25 μ, with one or more straight, curved or irregular exit tubes, 2.5—8 μ broad by 5—600 μ long, which may end flush with the outer surface of the host cell or extend 3 to 200 μ beyond it. Zoospores spherical, 4—4.8 μ diam., with a single large hyaline refractive globule, flagellum approximately 25 μ long; emerging singly in succession and after a momentary pause swimming away. Isthmuses between sporangia and resting spores of variable lengths, rarely inflated and fusiform. Resting spores usually spherical, 10—30 μ diam., or ovoid, 20—30×25—40 μ, occasionally fusi-

form and elongate, with a thick, 1.5—2.5 μ, brown wall and evenly granular content; apparently developed in the same manner as the sporangia; germination unknown.

Saprophytic in moribund cells of *Spirogyra* sp., at Lucknow, Uttar Pradesh (John, 1959).

Miss John identified the fungus which she discovered as *C. sphaerocarpa,* but the author is inclined to believe that it is *C. anguillulae* on the grounds that the resting spores of her species lie in hyaline vesicles. In *C. sphaerocarpa,* apparently, they are not formed by contraction of the content of sporangia-like swellings and its investment with a wall, and do not lie in vesicles. They appear to develop as the sporangia and differ only by the presence of a thick, brown wall around them.

Catenomyces Hanson, 1944

Torreya 44 : 30.

Thallus usually polycentric, occasionally monocentric, eucarpic, intra- and extramatrical, branched or unbranched, septate. Sporangia intercalary or terminal, endo-operculate, with one or more long exit tubes. Zoospores fully formed within the sporangium, containing numerous granules. Resting spores doubtful.

Catenomyces persicinus Hanson 1944. Torreya 44 : 30.

Thallus usually polycentric and extensive, or rarely monocentric. Sporangia terminal or intercalary, smooth, endo-operculate, variable in sizes and shapes, pyriform, 12—45×19—82 μ, spherical, 17—57 μ, or irregular, 26—67×35—193 μ, with peach to golden-colored content and 1—9 continuous or branched exit canals, 3.7—16×7.5—112 μ, only one of which is functional; tips of exit papillae or tubes filled with a plug of muscilaginous material below which occurs the operculum. Opercula thin, shallow saucer-shaped, circular or oval in outline, 2.2—2.9 μ diam. Zoospores spherical, 3.7—4.5 μ diam., with numerous golden refractive globules and a conspicuous nuclear cap; flagellum about 30 μ long. Resting spores intercalary, ovoid, elliptical or irregular, thick-walled, with one to several large golden refractive globules; germination unknown.

Saprophytic in bleached corn leaves and sparse in human fibrin film, from soil in a dry rice paddy 2 klms. north of Rhamnad, Madras State.

Hanson (1945 a) has clearly demonstrated the successive stages in the development of the endo-operculum in this species, and the author has confirmed her observations from the Indian material. In no cases was dehiscence observed to be inoperculate.

Catenophlyctis, Karling, 1965

Amer. Jour. Bot. 52 : 133.

Perirhiza Karling nom. nud. 1946. Amer. J. Bot. 33, suppl. 3 : 219.

Thallus eucarpic, monocentric or polycentric. Monocentric thalli consisting of a sporangium with one to numerous rhizoids arising from its periphery; polycentric thalli rhizomyceloid and extensive, consisting usually of tubular, frequently branched septate tenuous filaments bearing numerous rhizoids and sporangia, or resting spores in succession which are separated by long or short isthmuses. Sporangia highly variable in size and shape, inoperculate, with one or more broad, long or short exit tubes. Zoospores fully formed in the sporangium, containing a conspicuous nuclear cap and several granules. Resting spores (?) or dormant sporangia thick-walled; functioning as sporangia in germination.

Catenophlyctis variabilis Karling, 1965. Amer. Jour. Bot. 52 : 134, figs. 1—3.

Perirhiza endogena Karling nom. nud , 1946 a. Amer. Jour. Bot. 33, suppl. 3 : 219.

Phlyctorhiza variabilis Karling, 1947 b. Amer. J. Bot. 34 : 27, 43 figs., 1951. Amer. J. Bot. 38 : 772—777, 3 figs.

Thallus eucarpic, monocentric or polycentric. Monocentric thalli consisting of a sporangium with a single or numerous radiating rhizoids; polycentric thalli extensive, *Catenaria*-like and rhizomycelioid, bearing numerous rhizoids at irregular intervals and sporangia or resting spores in succession which are separated by long or short isthmuses. Sporangia highly variable in size and shape, spherical, 10—25×22×56 μ, pyriform, clavate, obpyriform irregular, polyhedral to somewhat stellate, with a smooth wall, 1.5—2.3 μ thick, and one, rarely 2—3 exit tubes, 4—10 μ wide by 10—90 μ long, which crack the outer sporangium wall and protrudes to the outside. Zoospores ovoid to oblong, 2—2.5×3.8—4.5 μ diam., with non-guttulate, finely granular cytoplasm, a conspicuous nuclear cap and a side body; flagellum 12—14 μ long. Rhizoids richly branched, usually arising from several points on the periphery of the, sporangium or along the tenuous portions of the rhizomycelium, main axes up to 15 μ diam., and extending for distances up to 5 mm on the surrounding water. Resting spores (?) or dormant sporangia yellowish, amber to light-brown, with smooth walls up to 5 μ thick, of same size and shape as thin-walled sporangia; functioning as sporangia in germination; exit tubes cracking outer thick wall.

Saprophytic in bleached corn leaves, human skin, snake skin, and fibrin film, from all soil samples collected in Bengal State, Madras State, Kerala State, Punjab State and Rajasthan State (Karling, 1964, 1965).

This species occurred as commonly as *Karlingia rosea* and *Catenaria anguillulae* in all 82 soil collections made in India. The author observed it in all soil collections in Ceylon, Thailand, Hong Kong, and Japan, also. In a previous publication the author (1947 b) described this species as a keratinophilic chytrid, but Rothwell (1956) found that it will grow readily on a variety of synthetic media. Also, it occurred quite commonly in cellulolic substrata in India, but its growth was more prolific in keratinic tissues. On human fibrin film its development, growth and structure were unusually extensive and complex (Karling, 1965).

Hyphochytriales or Anisochytridiales

Species of this order are strikingly similar in thallus structure and organization to members of the Chytridiales but differ from them by the presence of an anterior tinsel-type flagellum on the zoospores. For this reason primarily, they have been separated from the true chytrids and placed in another order. The author (1943) classified the known species into three families, Anisolpidiaceae, Rhizidiomycetaceae, and Hyphochytriaceae, on the basis of thallus structure and organization and pointed out that these families resemble to some degree, respectively, the *Olpidiaceae, Rhizidiaceae* and *Cladochytriaceae* of the true chytrids. So far only species of the *Rhizidiomycetaceae* and *Hyphochytriaceae* have been found in India, but it is quite likely that members of the *Anisolpidiaceae* are present also and will be found to occur when intensive search is made for them.

Rhizidiomycetaceae

Members of this family are characterized by a monocentric eucarpic thallus which consists of an extramatrical or epibiotic sporangium, or resting spore, and intramatrical or endobiotic rhizoids which may or may not arise from an apophysis. The spore plasm is discharged slowly as a mass and undergoes cleavage into zoospores outside of, or cleavage into zoospores within the sporangium. Where known, the resting spores are borne like the sporangia.

Rhizidiomyces Zopf, 1884

Nova Acta Acad. Leop.-Carol. 47 : 188.

Thallus monocentric, eucarpic, consisting of an extramatrical epibiotic apophysate or non-apophysate sporangium, and an intramatrical or endobiotic branched system of rhizoids. Sporangium sessile, or slightly stalked, inoperculate; forming a thin-walled exit tube at maturity through which the sporeplasms flows out and undergoes cleavage into zoospores. Zoospores ovoid to spherical, with one to several small refractive granules. Resting spores unknown.

Rhizidiomyces apophysatus Zopf, 1884. Nova Acta Acad. Leop.-Carol. 47:188, pl. 20, fig. 1—7.

Sporangium obpyriform, subspherical to spherical, 15—50 μ diam., smooth or with short, stout spines, hyaline or faintly golden; forming a short or long exit tube for dehiscence. Rhizoids richly branched, arising from one or more stout axes which are attached to a pyriform, fusiform or almost spherical, 8—20 μ diam., apophysis. Zoospores usually delimited outside of the sporangium, ovoid to oblong, 3.7×6 μ, with a few refractive granules. Resting spores unknown.

Parasitic on the oogonia of *Achlya klebsiana* (Chaudhuri and Kochar, 1935), Punjab Univ., and *Achlya* sp. (Karling, 1964 c), Bodinakayanur, Madras state.

Chaudhuri and Kochar reported the zoospores to be spherical, 3.5—3.7 μ diam., wheras other workers found them to be ovoid or oblong (Zopf, 1884; Couch, 1941; Karling, 1944 d).

Rhizidiomyces hansonii Karling, 1944 d. Amer. Jour. Bot. 31 : 396, figs. 35—64.

Sporangia smooth, spherical, 10—60 μ diam., ovoid, 8—20×12—38 μ, to oblong, 12—22×18—35 μ, non-apophysate. Zoospores ovoid to slightly elongate, 4—4.5×5.5—6.5 μ, with numerous yellowish to orange tinted granules and one or two minute globules, flagellum 8—10 μ long. Dormant sporangia with a thick, 2.3 μ, dark brown, wall dehiscing in the same manner as the thin-walled sporangia. Resting spores per se unknown.

Saprophytic on bleached corn leaves and bits of hemp seed from soil 2 klms. north of Rhamnad, Madras State (Karling, 1964 c), and soil from Ooty and Coimbatore, Madras State.

Rhizidiomyces hirsutus Karling, 1945 c. Bull. Torrey Bot. Club 72 : 47, 19 figs.

Sporangia hyaline, globose, 6—18 μ diam., ovoid, 8—20×26—60 μ, pyriform, obpyriform, oblong, or irregular; wall bearing 3—47 coarse elongate setae, 15—190 μ long by 2—3 μ diam., non-apophysate. Rhizoids arising from a single axis at base of sporangium and richly branched in substratum, single main axis lacking in free liquid media and replaced by several radiating axes which branch. Zoospores ovoid, oblong to elongate, 3—4×6—8 μ, with a single minute refractive globule; flagellum 14—18 μ long.

Saprophytic on bits of hemp seed, from brackish soil at Mandapam Camp, Madras State, (Karling 1964 c) and on snake skin from soil in New Delhi, Punjab State. In 1965 the author found this species to be quite common in soils from Ooty, Coimbatore and Kancheepurum, Madras State.

Rhizidiomyces parasiticus Karling, 1964 c. Sydowia 18 : 194, 6 figs.

Sporangia smooth, hyaline with a 2—3 μ thick wall, spherical, 20—40 μ diam., ovoid, 12—21×30—42 μ, non-apophysate. Zoospores ovoid to oblong, 3.5—4.2×5.7—7 μ, with coarsely granular refractive content; flagellum 14—16 μ long. Resting spores unknown.

Parasitic on the sporangia of *Rhizophlyctis fusca,* from brackish soil at Mandapam Camp, Madras State (Karling, 1964 c).

Hyphochytriaceae

Species of this family are characterized by a polycentric eucarpic thallus which consists of broad, tubular, branched, occasionally septate hyphae that bear intercalary or terminal inoperculate sporangia. The zoospores are delimited partly or completely on the outside at or near the exit orifice. The resting spores are usually intercalary and thick-walled.

Hyphochytrium Zopf, 1884

Nova Acta Acad. Leop.-Carol. 47 : 187.

Hyphophagus (Zopf) Minden, 1911. Kryptogamenfl. Mark Brandenburg 5 : 420.

Hyphae broad, extensive, branched, with occasional septa. Sporangia terminal or intercalary; dehiscing by a pore or one or more long exit tubes. Zoospores delimited partly or fully within the sporangium, or partly or wholly on the outside near the exit orifice. Resting spores usually intercalary and thick-walled.

Hyphochytrium catenoides Karling, 1939. Amer. J. Bot. 26 : 513; 18 figs.

Thallus predominantly polycentric and extramatrical, consisting of a linear series, up to 500 μ in extent, of intercalary and terminal swellings and sporangia connected by tubular hyphae or isthmuses, 1—138 μ in length by 2.2 to 4 μ diam.; occasionally monocentric, ovoid, elongate, spherical and *Olpidium-like.* Sporangia terminal or intercalary, delimited by septa, hyaline, smooth, spherical, 10—35 μ, ovoid, 10—18×12—22 μ, broadly fusiform, 6—10×9—18 μ, elongate and sometimes irregular, with 1—4 single or branched, straight, curved, coiled or irregular exit tubes, 5—250 μ in length by 3—6 μ diam. Content of sporangium usually emerging as a naked spherical mass to the outside and undergoing cleavage into zoospores; occasionally undergoing partial or complete cleavage within the sporangium after which the segments glide out in succession. Zoospores slightly flattened, ovoid to elongate, 1.5—2×3—3.5 μ, with several small, slightly refractive globules. Resting spores unknown.

Saprophytic in bleached corn leaves, from soil in the Thalayar Tea Estate, near Munnar, Kerala State (K a r l i n g, 1964 c).

Plasmodiophorales

Plasmodiophoraceae

Species of this order and family are characterized by cysts, primary zoospores, sporangial plasmodia, sporangiosori, sporangia, secondary zoospores, cystogenous plasmodia, and cysts in succession of development. The primary anteriorly biflagellate heterocont zoospores from germinated cysts give rise to sporangial plasmodia which cleave into segments to produce single or groups of sporangia (sporangiosori). The sporangia produce a small number of anteriorly biflagellate heterocont secondary zoospores which reinfect the host and apparently give rise to successive generations of sporangial plasmodia and sporangia. Eventually cystogenous or sporogenous plasmodia are formed which cleave into segments. These become thick-walled cysts or resting spores which may be separate and free, or united into clusters, or cystosori. The cysts germinate and usually produce a single primary zoospore, whereby the life cycle is started anew.

The Plasmodiophoraceae includes 9 genera and 38 species (K a r l i n g, 1942 c) of which only 7 species have been reported so far in India.

Plasmodiophora Woronin, 1877

Arb. St. Petersbourgh Nat. Gesell. 8 : 169.

Cystes lying free and loose, not united into cystosori, forming usually one primary zoospore in germination. Sporangial plasmodium cleaving into segments which develop into sporangia. Sporangia united loosely in sporangiosori, small, with a minute exit papillae; forming a few secondary zoospores. Cystogenous plasmodia cleaving into segments which become thick-walled cysts.

P l a s m o d i o p h o r a b r a s s i c a e Woronin 1877. Arb. St. Petersbourg Nat. Gesll. 8 : 169, pls. 1—6.

Cysts lying free, not united into cystosori, globose, subspherical to spherical, 1.6—4.3 μ diam., average 3.9 μ, ellipsoidal, ovoid, 4.6× 6 μ, sometimes constricted, elongate and irregular, 2.5—6.9 μ, with hyaline, relatively thin, minutely spiny walls; usually forming one, or sometimes more primary zoospores in germination. Primary zoospores pyriform, subspherical to ovoid, 2.5—3.5 μ, shorter flagellum with a blunt tip and longer one with a whip-lash tip. Sporangial plasmodia variable in size. Sporangia few or numerous, loose or united in compact aggregates or sporangiosori, small, ovoid to subspherical and spherical, 6—6.3 μ diam., angular or slightly elongate with thin hyaline walls;

producing 4 to 8, 1.9—3.1 μ diam., secondary zoospores; shorter flagellum 3.4 μ long with a blunt tip, longer flagellum with a whiplash tip and 11.8 μ long. Cystogenous plasmodia, 100—200 μ diam., hyaline to pale grey, amoeboid, encysting occasionally, multiplying by schizogony (?) into uni- or multinucleate meronts (?), eventually cleaving into free and loose cysts.

Parasitic on *Brassica oleracea* (M c R a e, 1928), Pusa. Dr. K. R a m a k r i s h a n reported to the author that this species occurs fairly commonly on cauliflower and cabbage in the mountain terraces around Ootacamund, Madras State, at elevations up to 7500 ft.

Spongospora Brunchorst, 1877

Bergens Mus. Aarsberet, 1886 : 225.

Clathrosorus Ferdinandsen and Winge, 1920. Ann. Bot. 34:468.

Cysts loosely or compactly associated in cystosori, variously shaped with thin or fairly thick walls; producing one or more (?) primary zoospores in germination. Primary zoospores infecting host and developing into sporangial plasmodia which cleave into sporangia and thus form sporangiosori. Sporangia small or fairly large, variously shaped, producing few to many secondary zoospores. Cystogenous plasmodia similar to sporangial plasmodia but denser and darker; cleaving into segments and forming one or more spongy or hollow cystosori.

S p o n g o s p o r a s u b t e r r a n e a (Wallr.) Lagerh. var. *s u b t e r r a n e a* Tomlinson, 1958. Trans. Brit. Mycol. Soc. 31 : 498.

S. subterranea (Wallr.) Lagerheim, 1891. Jour. Mycol. 7 : 104.

Erysibe subterranea Wallroth, 1842 a. Beitr. zur Bot. 1:118; 1842 b, Linnaea 16:332.

Protomyces tuber-solani Martius, 1842 a. Die Kartoffel-Epidemie der letzten Jahre oder die Stockfäule und Räude der Kartoffeln, München; 1942 b, Comp Rendu Acad. Sci. Paris 15:314.

Rhizosporium solani Rabenhorst, 1843. Arch. Pharm. 83 : 300.

Tubercina scabies Berkeley, 1846. J. Hort. Soc. London 1 : 33, pl. 4, fig. 39, 31.

Sorosporium scabies Waldheim, 1877. Apercu System. des ustilag., Paris, p. 33.

Spongospora solani Brunchorst, 1887. Bergens Mus. Aarberet, 1886:225.

S. scabies Massee, 1908, J. Bd. Agr. England 15 : 592, fig. 1—12.

S. subterranea radicicola Blattny, 1935. Rec. Inst. Rech. Agron. Rep. tchecosl. 137 : 21.

S. subterranea tubericola Blattny, l. c.

Cysts loosely associated, usually polyhedral, 3.5—4.5 μ diam., with smooth, yellowish to yellowish-green walls; usually forming one

primary zoospore in germination. Sporangial and cystogenous plasmodia small or large, elongated, amoeboid or irregular, up to 70 μ or more in length; forming either sporanigo- or cystosori. Sporangia single or united loosely in sporangial sori, spherical, ovoid, elongate, lobed or irregular with small exit papillae; forming few to many zoospores. Secondary zoospores ovoid to spherical, 2.5—4.6 μ diam., long and short flagella 13.7 μ and 4.35 μ long, respectively. Cystosori ovoid, elongate, irregular, 19—85 μ, usually spongy, often hollow, or with numerous irregular channels and openings.

Parasitic on *Solanum tuberosum,* Mahableshwar (Bombay) western India, Himalayas, and Nilgris (E. J. Butler, 1917; Anon. 1919; Mann, Nagpurkar, Kulkarni, Kasargode, Paranjpye and Joshi, 1921).

Sorosphaera Schroeter, 1885

Cohn's Kryptogamen-Fl. Schlesiens 3 : 155.

Cysts united in hollow, predominently spherical to ellipsoidal cystosori, variously shaped, producing usually one primary zoospore which infects host and develops into the sporangial plasmodium. Sporangiosori usually loose. Sporangia small to quite large, producing few to many zoospores. Cystogenous plasmodia one to several in a cell, cleaving into cysts at maturing and forming cystosori.

Sorosphaera veronicae Schroeter, 1886. Phytomyxini. In Cohn's Kryptogamen-Fl. von Schlesien, p. 135.

Tubercinia veronicae Schroeter, 1877. In Cohn's Beitr. Biol. Pflanz. 2:383.

Sorosporium veronicae Winter, 1884. Die Pilze Deutschlands, Österreich und der Schweiz 1:103.

Cysts ovoid, pyriform, pyramidal, urn-shaped, 2.8—5×6—9 μ, with brown, smooth or verrucose (?) outer walls, often surmounted by an apical collar; each producing usually one ovoid or subspherical, 4—4.8 μ diam., primary zoospore in germination. Sporangial plasmodia occurring in roots, dividing into relatively few large segments and forming sporangiosori. Sporangia usually united and apparently connected by common openings or short isthmuses, with large bulbous exit papillae; forming numerous ovoid to spherical, 5.6—7 μ diam., secondary zoospores; shorter flagellum 5.6—7.7 μ long; longer flagellum 16.8—22.4 μ long, both with whip-lash tips. Cystogenous plasmodia occurring in shoot tissues, usually numerous in host cells, 29—30 μ or more in diam., schizogony doubtful, dividing into segments at maturity and forming spherical, 18—32 μ diam., or elliptical, 18—21×36 μ, cystosori.

Parasitic in *Veronica agrestis,* Rohtak, Punjab State (Mundkur and Ahmad, 1946).

Sorodiscus Lagerheim and Winge, 1913

Ark. f. Bot. 12 : 23.

Cysts united in flat, ovoid, disc-shaped, two-layered and compact cystosori, variously shaped, producing usually one primary zoospore which infects the host and develops into a sporangial plasmodium. Sporangia loosely associated in sporangiosori, small, producing a few secondary zoospores. Cystogenous plasmodia similar to sporangial plasmodia but denser and darker, cleaving into cysts at maturity and forming variously-shaped cystosori.

S o r o d i s c u s r a d i c i c o l u s Cook, 1931. Ann. Mycol. 29 : 321. pls. 1, 2.

Cysts ovoid, angular, polyhedral, 2.8—4.2×3.2—3.6 μ, with hyaline walls, the outer of which may be extended into blunt spines; producing ovoid or pyriform, 2.5×3.5 μ, primary zoospores in germination. Sporangial plasmodia, sporangiosori, sporangia and secondary zoospores unknown. Cystogenous plasmodia one to several in a cell, each plasmodium dividing at maturity into cyst mother-cells which divide twice to form 4 incipient cysts. These in turn aggregate to form flat and disc-shaped cystosori which are composed of up to 50 cysts.

Parasitic in the roots of *Gynandropsis gynandra,* Jodhpur, Rajasthan State (G h e m a w a t 1964).

S o r o d i s c u s c o k e r i Goldie-Smith, 1951. J. Elisha Mitchell Sci. Soc. 67:108, pls. 1, 2.

Cysts up to 60 in a cystosorus and adhering tightly together, usually polyhedral 3.10—4.1 μ diam., with thick, pale-brown walls; germination unknown. Sporangial plasmodia variable in size, approx. 15—33 μ diam., partly or wholly filling enlarged portion of host hypha; dividing into 6—30 or more sporangia to form sporangiosori. Sporangia loosely associated, spherical to ovoid, 5.3—8.8 μ diam., with thin hyaline walls; peripheral sporangia forming short, broad exit papillae to the outside of host, inner sporangia apparently connected by isthmuses with peripheral sporangia. Secondary zoospores 4—11 per sporangium, ovoid to elongate, 3—4×4—5 μ; encysting on host hyphae and forming a broad penetration tube in germination. Cystogenous plasmodia of same size as sporangial plasmodia but denser and darker in appearance, dividing into segments and becoming cystosori which may be single or up to 7 in a hyphal swelling, predominantly circular, 15—35 μ diam., ovoid and disc-shaped with 2 layers of cysts, sometimes Y-, X- and H-shaped.

Parasitic in *Pythium* sp., from soil at Jodhpur, Rajasthan State (K a r l i n g, 1964 b) causing conspicuous swelling in the hyphae.

Woronina Cornu, 1872

Ann. Sci. Nat. Bot. V. 15 : 176.

Cysts few to more than a hundred per cystosorus, loosely associated and usually separable, usually polyhedral, producing one or (?) more primary zoospores in germination which infects the host and develops into a sporangial plasmodium which cleaves into sporangial rudiments and forms sporangiosori which vary in size and shape. Sporangia rarely single, or up to 50 per sorus, and loosely asociated, producing few to numerous secondary zoospores. Cystogenous plasmodia similar in size and shape to but denser and darker than sporangial plasmodia, cleaving into cysts at maturity. Cystosori indefinite in size and shape.

Woronina polycystis Cornu, 1872 a. Ann. Sci. Nat. Bot. V Ser. 15 : 176, pl. 7.

Cysts few to more than 100 per sorus, loosely associated and readily separable, usually polyhedral, 4—8.6 μ diam., with thick, golden-brown walls; becoming elongate to almost spherical and thin-walled at germination and forming 1 or more primary zoospores. Sporangial plasmodia 1 or more per cell and filling it almost competely or partly, dividing into sporangial rudiments and becoming sporangiosori. Sporangiosori ovoid, ellpisoidal, elongate, cylindrical, 30—60×100—476 μ diam., occasionally hollow. Sporangia rarely single, or up to 50 or more per sorus and loosely associated, spherical, subspherical, ovoid, polyheydral, 8—33 μ diam., with thin hyaline walls; some of peripheral sporangia forming short, broad, semi-globular exit tubes to outside of host; inner sporangia apparently continuous and discharging zoospores through the exit papillae of the peripheral sporangia. Secondary zoospores few to numerous per sporangium, ovoid to elongate, 2×3—4 μ; encysting on host hyphae and forming a curved, stalk-like, 1.2—2 μ long, penetration tube at germination. Cystogenous plasmodia similar in size and shape to but denser and darker than sporangial plasmodia, dividing into cysts at maturity. Cystosori one or more in a host swelling, variable in size, shape and structure, ovoid, subspherical, irregular, elongate, cylindrical, 42—140×50—308 μ diam., yellowish to golden-brown.

Parasitic in *Saprolegnia* sp., from soil in a tea estate 39 klms. west of Munnar, Kerala State (K a r l i n g, 1964 b).

Woronina pythii Goldie-Smith, 1956. J. Elisha Mitchell Sci. Soc. 72 : 348, figs. 1—7, 16—35.

Cysts usually loosely associated and readily separable, ovoid, subspherical, or polyhedral, 3.5—5.6 μ diam., with smooth and fairly thick walls; producing usually only one primary zoospore, 3.2×4.6—5.3 μ diam., in germination. Sporangial plasmodia usually filling hyphal spelling partly or almost completely, dividing into 3 to 26 or more

segments and forming sporangiosori. Sporangia ovoid to subspherical, 4.3—9 μ diam., with thin hyaline walls; peripheral sporangia forming short, broad papillae; inner sporangia connected by short isthmuses or openings and discharging the secondary zoospores through the peripheral papillae. Secondary zoospores usually 4 per sporangium, ovoid to slightly elongate while actively motile, with a tapering anterior end, 3.4—4.2×4.8—5.1 μ, encysting on the host cell and forming a broad penetration tube in germination; empty zoospore cyst persistent. Cystogenous plasmodia of same size and shape as sporangial plasmodia but denser and darker in appearance; dividing into cysts at maturity. Cystosori highly variable in size, shape and structure, subspherical, 28—90 μ, ovoid, 15—44×22—80 μ, oblong, 14—41×32—65 μ, irregular to elongate and consisting of linear rows of cysts, almost circular and flattened, slightly dumb bell-shaped to reniform; rarely consisting of only 2, 4, 6 or 8 cysts.

Parasitic in *Pythium* sp., from brackish soil, Mandapam Camp, Madras State (K a r l i n g, 1964 b), and non-bracking soil from the Botanical Gardens, Univ. of Jodhpur, Rajasthan State, where G h e m a w a t (1964) found *Sorodiscus radicicolus*.

Olpidiopsidaceae

At present only three genera and ten species, which might be referred to this family, have been reported from India, but it is very questionable that *Rozellopsis* belongs in this family. Species of the *Olpidiopsidaceae* are characterized by *Olpidium*-like, endobiotic, holocarpic thalli, biflagellate zoospores, and thick-walled, sexually or asexually formed resting spores which give rise directly to zoospores upon germination. Sparrow (1943, 1960) inculded this family in the Lagenidiales, but the author (1942 d) described it as one of the groups of simple, biflagellate, holocarpic Phycomycetes without assigning it to any order.

Rozellopsis Karling, 1942 b

Mycologia 34 : 205.

Thallus endobiotic, holocarpic, more or less indistinguishable from but apparently immiscible with host protoplasm; becoming invested with a wall at maturity and forming one sporangium, or cleaving (?) into several segments which become separated by host walls, maturing in basipetal succession, and developing into sporangia or resting spores. Sporangia variable in size and shape with one to several exit papillae which extend through the host wall; usually filling the host sporangia or hypertrophied portion of the hyphae completely; sporangium wall lightly pressed against, seemingly fused with and usually indistinguishable from that of the host. Zoospores slightly variable in

size and shape, with one to several minute globules, biflagellate and heterocont, shorter flagellum usually extending forward and the longer one backward during motility; usually swirling in the sporangium before emerging fully formed and swimming away. Content of zoospore flowing into host cell through an infection tube in germination, leaving the empty zoospore case on the outside. Resting spores unknown in monosporangiate species; solitary in septigenous species, lying free within the host cell and separate from host wall, variable in size, brown and spiny; content coarsely granular with a large vacuole or globule of hyaline substance; germination unknown.

Thallus cum matricis protoplasmate permixtus, propterea plus minusve indistinctus, in maturitate pariete praeditus et sporangium unum formans vel etiam in segmenta nonnulla basipetaliter maturantia, nunc sporangia, nunc sporangia perdurantia formantia dilabens; sporangia quoad formam et magnitudinem variabilia, papillula unica vel papillulis nonnullis matricis cellulam perforantibus se evacuantia, plerumque matricis sporangia vel hyphas eius hypertrophice immutatas omnino implentia; sporangii pariete leniter adpresso, cum matricis membrana, ut videtur, confluente et ab ea vix distincto; zoosporae quoad formam et magnitudinem vix vel parum variabiles, globulo unico vel globulis nonnullis praeditae, biflagellatae, flagello breviore plerumque prorsus, flagello longiore retrorsum spectante; sporangia perdurantia magnitudine variabilia, a matricis pariete bene distincta, brunnea et spinulosa, plasmate granuloso et vacuola majuscula vel globulo hyalino (oleoso?) farcta; germinatio ignota.

This genus *) was proposed by the author (1942 a) for the *Rozella*-like species with biflagellate, heterocont zoospores and described fully in a subsequent paper (1942 b). He (1942 c) assigned it tentatively to the doubtful family Woroninaceae, but P r o w s e (1954) believed that it might be regarded a representative of a distinct family within the Phycomycetes. S p a r r o w (1960), however, placed it in the family Olpidiopsidaceae of the Lagenidiales. Until it is better known it may be kept tentatively as well in this as in any other closely related family. At present it includes both non-septigenous monosporangiate and septigenous species, but only one monosporangiate species was found in India.

R o z e l l o p s i s i n f l a t a (Butler) Karling, 1942 a. Amer. Jour. Bot 29 : 34.

Pleolpidium inflatum Butler, 1907. Mem. Dept. Agric. India, Bot. Ser. 1 : 126, pl. 7, figs. 17—21.

Sporangia terminal in host, spherical, 32—85 μ diam., ovoid, 38—46×48—70 μ, or pyriform with 1—4 exit tubes. Zoospores reniform,

*) Inasmuch as *Rozellopsis* has not been validated by a Latin description, the author is doing so here.

4.5—5.2×7—8 μ, with several minute, refringent globules, shorter flagellum extending forward and longer one backward in swimming, rolling over slowly and swimming smoothly in extended curves. Resting spores unknown.

Parasitic in *Pythium* sp. from soil in a park in Calcutta, Bengal State, causing marked hypertrophy of the hyphal tips.

Olpidiopsis Cornu, 1872

Ann. Sci. Nat. Bot. V. 15 : 114.

Pleocystidium Fisch, 1884. Sitz'b. Phys. Med. Soc. Erlangen 16:60.
Diplophysa Schroeter, 1886. Cohn's Kryptog'fl. Schlesiens 3:195.
Olpidiopsis (Cornu) Fischer, 1892. Jahrb. wiss. Bot. 13:363; Rabenhorst Kryptogamen-Fl. 1, (4) : 37.
Pseudolpidium Fischer (pro parte) 1892. Rabenhorst Kryptogamen-Fl. 1, (4):33.
Bicilium Petersen, 1909. Bot. Tidsskr 29 : 357; 1910. Ann. Mycol. 8 : 503.
Pseudolpidiopsis Minden, 1910. Kryptog'fl. Mark Brandenburg 5 : 255.

Thallus endobiotic, holocarpic, appearing more or less naked but immiscible with the host protoplasm when young but soon becoming invested with a cellulose wall. Sporangia solitary or numerous in a host cell, variable in size and shape, smooth, verrucose, warty or spiny, with one to several exit tubes of variable diameter and length. Zoospores with numerous minute, hyaline refractive globules, predominantly ellipsoid, elongate to almost reniform, biflagellate, iso- or heterocont, emerging fully formed and swimming directly away, or sometimes lying quiescent in a mass at the exit orifice for a few moments before becoming actively motile. Resting spores formed sexually by the fusion of thalli, or asexually, variable in size, shape, and color, with a smooth, knobby, warty or spiny thick wall; forming zoospores directly upon germination.

Olpidiopsis saprolegniae (Braun) Cornu, 1872. Ann. Sci. Nat. Bot. V, 15:145, pl. 3, fig. 1—10.
Chytridium saprolegniae Braun, 1855 a. Ber. K'gl. Preuss. Akad. 384; 1855 b, Abh. K'gl: Akad. wiss. Berlin 1855: 61, pl. 5, fig. 23.
Olpidium saprolegniae Braun, l. c., p. 75.
Diplophysa saprolegniae (Cornu) Schroeter, 1885. Cohn's Kryptog'fl. Schlesiens 3 : 195.
Pseudolpidium saprolegniae Fischer (pro parte) 1892. Rabenhorst's Kryptog.-Fl. 1, (4) : 35.
Olpidiopsis echinata Petersen, 1909 Bot. Tidsskr. 29 : 405, fig. 18 a; 1910, Ann. Mycol. 8 : 540, fig. 18 a.

Sporangia usually numerous in a host cell, hyaline, smooth or (?) spiny, spherical, 18—142 μ, ovoid, 50—92×80—96 μ, ellipsoid, or elongate, 14—39×22—140 μ, with one to several short or elongate, straight, curved or irregular exit tubes. Zoospores isocont, (?) ovoid or somewhat bean-shaped with the flagella attached near the anterior end. Resting spores usually formed by fusion of thalli, ovoid to spherical, 28—107 μ diam., brown; endospore thick, exospore usually covered with short spines. Companion or male thalli when present 1—4 per resting spore, hyaline, smooth, ovoid to spherical, 15—40 μ diam.; germination of resting spores unknown.

Parasitic in *Saprolegnia diclina,* Gorakhpur, Uttar Pradesh (Srivastava and Bhargava, 1963) and *Saprolegnia* sp. from soil along the Ghat Road at an elevation of 3,500 ft., Madras State.

Olpidiopsis fusiformis Cornu, 1872. Ann. Sci. Nat. Bot V. 15 : 147, pl. 4, fig. 1—4.
Pseudolpidium fusiforme Fischer, 1892. Rabenhorst's Kryptog.-Fl. 1(4) : 37.
Olpidiopsis minor Fischer, l. c., p. 39.

Sporangia solitary or numerous in host hyphae, smooth or spiny, elongate, fusiform, 20—65×80—220 μ, ovoid, 7—12×20—60 μ, spherical, 15—110 μ, with 1—3 exit tubes. Zoospores isocont (?), ovoid, slightly elongate, 2—2.5×4—5 μ. Resting spores spherical, 22—48 μ, ellipsoidal, 18—29×26—45 μ, yellowish-brown, exospore covered with broad subulate spines, up to 10.5 μ high, which are joined at their bases to form a reticulum; content coarsely granular with one to several large refractive globules; companion or male cells when present 1—3 per resting spore, hyaline and smooth, ovoid to spherical, 15—26 μ diam.; germination of resting spores unknown.

Parasitic in *Achlya polyandra,* Dhera Dun (Sydow, H. and P., and Butler, 1907; Butler, 1907), *Achlya klebsiana,* Gorakhpur, Uttar Pradesh (Srivastava and Bhargava, 1963), and *Achlya* sp. from soil along the Ghat Road, Madras State, at an elevation of 3500 ft.

Olpidiopsis luxurians Barrett, 1912. Ann. Bot. 26 : 231, pl. 23, figs. 1, 5—7, 10—14, 17, 21 b, 22; pl. 24, figs. 24—25, 28—30; pl. 25, fig. 43. 45; pl. 26, fig. 74, 76—90.

Sporangia solitary or numerous formed in terminal or intercalary swellings of host hyphae, variable in size, ovoid to spherical, 22.5—60 μ diam., with a smooth hyaline wall. Exit tubes 1—3, 7.5—37.5 μ in length and extending usually beyond the host wall. Zoospores elongate, 2—3 μ long, with the 2 flagella attached at or near the anterior end. Resting spores spherical, 28—45 μ diam., exospore brownish, with numerous conical spines, 4—5.5 μ in length. Companion or male cells 1—3 per

spore, ovoid or spherical, 15—21 μ diam., with a thin, smooth, hyaline wall; germination of resting spores unknown.

Parasitic in *Aphanomyces laevis,* Gorakhpur, Uttar Pradesh (Srivastava and Bhargava, 1963).

The identity of this species has been questioned. The author (1942 d) listed it as a synonym of *O. aphanomycis* Cornu, and Sparrow (1943, 1960) regarded it as being intermediate between *O. fusiformis* and *O. saprolegniae* because of the coarseness of the spines on the resting spores.

Olpidiopsis achlyae McLarty, 1941. Bull. Torrey Bot. Club 68 : 62, figs. 1—26.

Sporangia solitary or up to 50 in a host hypha, smooth or covered with fine or coarse non-cellulosic spines or bristles, spherical, 15—18 μ diam., ovoid, ellipsoid or elongate, 12—110×102—320 μ with 1—3 exit tubes of variable lenght. Zoospores ovoid to somewhat reniform, 2—3×4—5.8 μ, with numerous minute refringent granules and 2 approximately equal flagella attached laterally near the anterior end. Resting spores formed by fusion of thalli or developing asexually, spherical or ovoid, 20—110 μ, brown, with several or usually one large refringent globule; endospore smooth and containing cellulose, exospore not containing cellulose, 1—1.5 μ thick, with warty protuberances, small or large, narrow or broad-based spines, hair-like fibrillae, or with an entire, undulating or slightly serrate margin. Companion or male cells when present 1—3 per resting spore, thin-walled, hyaline, smooth, 129—30×15—25 μ, ovoid to spherical; resting spore forming zoospores directly upon germination.

Parasitic in *Achlya* sp. at Lucknow, Uttar, Pradesh; (Das Gupta and John, 1953) and *A. flagellata,* from soil in a tea estate 39 klms. west of Munnar, Kerala State.

The author (1942 d) as well as McLarty are inclined to regard this species as identical with or closely realted to *O. fusiformis.*

Olpidiopsis aphanomycis Cornu, 1872. Ann. Sci. Nat. Bot. V, 15 : 148, pl. 4, figs. 5—11.

Pseudolpidium aphanomycis (Cornu) Fischer, 1892. Rabenhorst's Kryptog.-Fl. 1 (4) : 37.

Sporangia solitary or up to 20 in a host hypha, smooth or spiny, spherical, 26—192 μ, ovoid, 17—40×30—68 μ, fusiform, or elongate, with one to several exit tubes. Zoospores ovoid, to sligthly reniform with 2 nearly equal flagella, coming to rest at the exit orifice for a few minutes before swimming away. Resting spores formed asexually or sexually by fusion of thalli, ovoid to spherical, 24—48 μ diam.; endospore thick, exospore covered with conical spines, 2—4 μ high, or blunt warts; content granular, usually with 1 large refractive globule; companion or male cells when present 1—3 per resting spore, hyaline,

smooth, ovoid to spherical, 16—30 μ diam.; germination of resting spores unknown.

Parasitic in *Aphanomyces laevis* at Pusa (Butler, 1907; Sydow, H. and P. and Butler, 1907; Butler and Bisby, 1931) and *Aphanomyces* sp. at Munnar, Kerala State, and Madras, Madras State.

Olpidiopsis pythii (Butler) Karling, 1942 d. The simple holocarpic biflagellate Phycomycetes, p. 47.

Pseudolpidium pythii Butler, 1907. Mem. Dept. Agric. India, Bot. Ser. 1 : 129, pl. 7, figs. 9—16.

Sporangia solitary or numerous, ovoid, ellipsoidal or spherical, 21—38 μ diam., with 1 exit tube of varying length. Zoospores somewhat reniform, with one to several small refringent globules, isocont (?), flagella laterally inserted; swarming near the exit orifice for a brief period, then coming to rest in a dense cluster, finally swimming away slowly. Resting spores solitary or numerous, often in association with sporangia, developing asexually, ovoid or spherical, 19—30 μ diam., with fine, thread-like, short, evenly-spaced spines; germination unknown.

Parasitic on *Pythium* sp., Calcutta, Bengal State.

The Indian collection resembles Butler's species very closely and is identified as such, although no opportunity was available for host range studies.

Olpidiopsis schenkiana Zopf. 1884. Nova Acta Ksl. Leop.-Carol. Deut, Akad. Nat. 47 : 168, pl. 15, figs. 1—32.

Pleocystidium parasiticum Fisch, 1884. Sitz'b. Phys.-Med. Soc. Erlangen 16 : 60, figs. 24—39.

Olpidiopsis parasitica (Fish) Fischer, 1892. Rabenhorst's Kryptog.-Fl. 1 (4) : 40.

Diplophysa schenkiana (Zopf) Schroeter, 1892. Engler und Prantl, Die Nat. Pflanzenf. I, 1 : 85, fig. 68 A—D.

Pseudolpidiopsis schenkiana (Zopf) Minden, 1911. Kryptog'fl Mark Brandenburg 5 : 257.

Pseudolpidiopsis parasitica (Fish) Minden, l. c., p. 258.

Sporangia solitary or numerous, hyaline, smooth, ovoid, ellipsoid, rarely spherical, elongate, 21.6—26.4×39—81.6 μ, with 1—2 stout and short, or elongate, up to 60 μ long, straight or curved exit tubes. Zoospores ovoid, pyriform, or slightly reniform, 4×6 μ, with several hyaline, refractive globules; emerging singly, fully formed and swimming directly away, or emerging and lying in a mass at the exit orifice before swimming away; secondary swarmers heterocont (Scherffel, 1925) with flagella laterally attached, shorter flagellum extending forward and longer one backward in swimming. Resting spores formed sexually by fusion of thalli, hyaline, smooth, ovoid or spherical, 30—40 μ

diam., thick-walled, contents granular with a large refractive globule; companion or male cells 1—5 per resting spore, hyaline, smooth, ovoid or spherical, 16—8—21.6 μ diam., resting spores forming zoospores directly upon germination.

Parasitic in *Spirogyra* sp. at Pusa (Butler, 1907; Sydow, H. and P. and Butler, 1907), and in a freshwater lake 4 klms. west of Uchippuli, Madras State.

This species occurred abundantly in a species of *Spirogyra* which was collected from an irrigation ditch at Poondi, Madras State, in 1965. The thalli, however, were quite variable in size and shape and often much larger than those previously reported for this species. In several specimens they varied from 35—52 in diameter and 66—140 μ in length. Also, the zoospores were slightly smaller, 4—4.5×5—5.6 μ, instead of 7×8 μ as reported above.

Olpidiopsis ricciae Du Plessis, 1933. Ann. Bot. 47 : 761, 12 figs,

Sporangia solitary or up to 12 in a rhizoid, ovoid, ellipsoid, 20—35.7×24—40 μ, dehiscing by an irregular fissure or through an exit tube. Zoospores globose or slightly ovoid, 2.4—4 μ diam., heterocont, flagella attached at anterior end, 8.3 μ and 17.5 μ long, respectively; shorter flagellum directed forward and longer one backward in swimming. Resting spores formed asexually, or sexually, globose, ellipsoid, elongate, or almost cylindrical, often laterally and terminally depressed, 12.8—32×14.4—48 μ, hyaline or dark brown, with a thick, warty exospore. Companion or male cell when present hyaline, smooth and spherical; germination of resting spores unknown.

Weakly parasitic in the rhizoids of *Riccia, Marchantia, Plagiochasma, Fimbriaria, Aneura* and *Notothylas,* Mysore State (Thirumalachar, 1948).

Petersenia (?) irregularis (Constantineanu) Sparrow, 1943. Aquatic Phycomycetes, p. 634.

Olpidiopsis irregularis Constantineanu, 1901. Rev. Gen. Bot. 13 : 373, figs. 76 A—K, 77.

Thalli, 1 to 3 in an enlargement of host hyphae, usually deeply lobed and contorted with branches of variable lengths, sometimes ovoid, reniform, 30—48 μ in greatest length; transformed completely into a sporangium at maturity. Exit tubes inflated before passing through host wall, up to 16.5 μ diam., ending flush with the host wall or extending 5—25 μ beyond it in the surrounding medium. Zoospores somewhat reniform, 4—4.5×5.8—6 μ, with several minute refractive granules, shorter flagellum extending forward and longer one backward during motility. Resting spores unknown.

Parasitic in hyphae of *Aphanomyces* sp., Madras, causing spherical, 40—82 μ diam., or ovoid swellings.

Whether or not this is the species which Constantineanu and Sparrow (1934) described on *Saprolegnia* sp. and *Achlya* sp. remains to be proven. Cultures of this parasite were maintained for several weeks, but no resting spores developed. Possibly, it may be heterothallic. Attempts to infect *Achlya klebsiana* and *A. imperfecta* in India were unsuccessful.

At this point mention is made of a parasite which Thirumalachar and Lacy (1951) described as the cause of a leaf spot disease of *Panicum repens* at Bangalore. Inasmuch as biflagellate zoospores were produced in sporangia they named and diagnosed it as a species of *Petersenia.*

Petersenia panicicola Thirum. and Lacy, 1951. Mycopath. 5 : 75

Thallus intramatrical, unicellular, lobed and contorted, at first plasmodial, later forming resting sporangia, 17—27×10—15 μ diam. Resting sporangia pale cinnamon-yellow, medium thick-walled up to 1.7 μ measuring 13.5—17×12—15 μ, germinating by bicilliate zoospores; exit tubes short and inconspcuous

On living leaves of *Panicum repens* L., Bannerghatta, Bangalore.

Whether or not this is a species of *Petersenia* remains to be proven, in the author's opinion, because the thallus is described as being plasmodial at first. Sparrow (1960) apparently was unaware of the description of this species inasmuch as he did not list it with the other species of this genus.

Lagenidiaceae

Thallus endobiotic, holocarpic, occupying one or several host cells, unicellular, or multicellular and hypha-like, branched or unbranched; transformed at maturity into reproductive organs. Sporangia highly variable in size and shape, terminal or intercalary, dehiscing by the formation of exit papillae or long tubes. Zoospores delimited wholly, or partly in the sporangium and maturing at the orifice of the exit tubes, or delimited wholly on the outside in a vesicle; usually with a single swarm period, but in some species encysting after a brief motile period and later giving rise to zoospores of the laterally biflagellate type; sexual reproduction usually heterogamous; sex organs undifferentiated, or differentiated vegetative cells, fertilization tube occasionally formed; oospore when present thick-walled, formed singly in female gametangium; resting spores one or more in a thallus, or segment of it.

Myzocytium Schenk, 1858

Über das Vorkommen contractiler Zellen im Pflanzenreich, p. 10, Würzburg.

Thallus holocarpic, endobiotic, tubular, one-celled, or consisting of a linear series of sporangia or gametangia separated by transverse

septa. Sporangia usually with one exit tube. Zoospores incompletely delimited in the sporangium and maturing in an evanescent vesicle at the tip of the exit tube; sometimes emerging fully formed, reniform, laterally biflagellate. Female gametangia without periplasm, content fusing with that of a similar male gametangium through a pore or short tube to form a thick-walled resting spore.

Myzocytium proliferum Schenk, 1858. Über das Vorkommen contractiler Zellen in Pflanzenreich, p. 10.

Thallus unbranched. Sporangia occurring in bead-like chains, separated by 2-layered refractive walls, spherical, 13—28 μ, broadly fusiform or ovoid, 13—18×15—26 μ, with a single cylindrical, 2—3 μ diam., exit tube. Zoospores reniform, 3.6—6 μ diam. by 5.4—10 μ long, laterally biflagellate, undergoing final maturation in a vesicle at the orifice of the exit tube. Gametangia similar in size and shape to sporangia; resting spore filling gametangium, with a smooth, thick hyaline wall and a large eccentric refractive globule; germination unknown.

Parasitic in *Spirogyra affinis* at Punjab (Chaudhuri, 1931; Mundkur, 1938) and *Spirogyra* sp. in Lucknow (Das-Gupta and John, 1953) and Patna (Lacy, 1955).

In addition to its occurrence as noted above the author found it in *Spirogyra* sp. in a freshwater lake east of Uchippuli in 1963, and again in 1965 at Poondi, Madras State.

Lagenidium Schenk, 1859

Verhandl. Phys.-Med. Gesell. Würzburg, A. F. 9 : 27.

Resticularia Dangeard, 1890—91. Le Botaniste 2 : 96.

Thallus holocarpic, endobiotic, occupying one or more host cells, one-celled, or extensive, saccate, tubular, branched or unbranched, segmented by transverse septa to form sporangia or gametangia, or both. Sporangia usually with one exit tube, variously-shaped. Zoospores fully formed in the sporangium, or in a vesicle at the exit orifice, often encysting at exit orifice to form cysts and later germination to form secondary zoospores. Thalli monoecious or dioecious; gametangia frequently and usually lacking periplasm; male gametangium or antheridium developing a fertilization tube through which its content enters the female gametangium; oospore with a thick, wall, granular parietal cytoplasm and a large oil globule.

Lagenidium rabenhorstii Zopf, 1878. Sitzungsber. Bot. Vereins Prov. Brandenburg 20 : 77; 1884, Nova Acta Acad. Leop.-Carol. 47 : 145, pl. 12, figs. 1—28, pl. 13, figs. 1—9.

Thallus occupying a single cell, cylindrical or irregular in diameter, with short or long, crooked, straight, clavate or irregular

branches, 2—8 μ diam. Sporangia variable in number, shape and size, separated by narrow, sometimes constricted septations, with a single cylindrical or tapering exit tube. Zoospores delimited in a vesicle at the orifice of the exit tube, laterally biflagellate, reniform, 4—6 μ diam., by 7—8 μ long. Female gametangium intercalary, lateral or terminal, spherical, ovoid or fusiform, 12—15 μ diam.; male gametangium elongate to cylindrical with a fertilization tube. Oospore spherical, 13—22 μ diam., with a smooth, hyaline, thick wall, partly filling gametangium; germination unknown or doubtful.

Parasitic in *Spirogyra* sp., Lucknow, U. P. (John, 1954) and in a fresh-water lake 4 klms. east of Uchippuli, Madras State.

Lagenindium pygmaeum Zopf, 1887. Abhandl. Naturw. Gesell. Halle 17 : 96, p. 1, figs. 29—31, pl. 2, figs. 1—12.

Thallus tubular, irregularly lobed, contorted, subspherical, ovoid, or reniform; transformed into a single sporangium with a short broad exit tube. Zoospores partially delimited in the sporangium and maturing in a vesicle at the orifice of the exit tube, laterally biflagellate, broadly fusiform, 5×8 μ. Gametangia similar to sporangia, formed by septation of the thallus; male gametangium developing a fertilization tube. Oospore (?) lying losely in gametangium, spherical, 15—30 μ diam., with a thick hyaline wall and a large globule: germination unknown.

In dead pollen of *Pinus sylvestris*, from brackish soil, Mandapam Camp, Madras State.

Lagenidium entophytum (Pringsheim) Zopf, 1884. Nova Acta Acad. Leop.-Carol. 47 : 154, pl. 13, figs. 10—18, pl. 14, figs. 1—5.

Pythium entophytum Pringsheim, 1858. Jahrb. wiss. Bot. 1 : 289, pl. 21, fig. 1.
Myzocytium entophytum (Pringsheim) Cornu, 1872. Ann. Sci. Nat. Bot. V. 15 : 21.
Lagenidium americanum Atkinson, 1909. Bot. Gaz. 48 : 336, fig. 6.

Thallus irregularly contorted, thick and bent, with numerous short lateral lobes or branches. Sporangia delimited by thick refractive, constricted septations; forming a single exit tube of variable length and up to 3 μ in diameter, often inflated against inner wall of host cell. Zoospores delimited at orifice of exit tube in a vesicle, reniform, 4—6×5—7 μ, laterally biflagellate. Oospore (?) parthenogenetically formed and partly filling a tubular segment of thallus, spherical, 12—17 μ diam., with a thick, golden, slightly dentate outer wall; germination unknown.

Parasitic in the zygote of *Spirogyra* sp. at Patna (Lacy, 1949) and 4 klms. east of Uchippuli, Madras State.

Lagenidium distylae Karling, 1944 e. Lloydia 7 : 330, figs. 69—107.

Thallus usually elongate, tubular, curved, irregular, lobed, sometimes branched, 6—12 μ diam., composed of 2—8 segments, 6—9× 30—40 μ. Sporangia of same size and shape as segments with one short, 4×7 μ, or long, 3×25 μ exit tube; content of sporangium emerging as a naked mass, becoming enveloped by a vesicular membrane and undergoing cleavage into zoospores. Zoospores reniform, 6×8 μ, swarming and then encysting; cystospores 6.6—7 μ diam., germinating to form a second motile stage. Oogonia and antheridia borne on same thallus; oogonia ovoid, broadly fusiform and locally swollen, up to 20 μ diam., and 30 μ long. Antheridia elongate, tubular, 5—8×20—30 μ. Oospores hyaline, smooth, spherical, 12—18 μ, ovoid, 8—10×12—15 μ, content granular with a large vacuole; germination unknown.

Parasitic in eggs of *Distyla* sp., in soil from a dry rice paddy 2 klms north of Rhamnad, Madras State.

Saprolegniaceae

Species of this order and family are common in India and fairly well known. Attention is called here to the occurrence of a species which is comparatively rare (Karling, 1952) so far as is known at present.

Sommerstorffia spinosa Arnaudow, 1923. Flora 116 109, 8 figs.

Thallus tubular, straight or bent, stiff, dichotomously branched, non-septate, 5.6—10.4μ wide by 50—680 μ long; branches tapering to pegs or blunt spines, 6—8 μ long by 3—5 μ diam., which are filled with a highly refractive, adhesive (?) substance. Pegs growing into captured prey and developing into a deeply lobed or irregular sporangium up to 20 μ diam., which develops a long 8—12 μ diam by 50—160 μ long, exit tube. Zoospores delimited in the sporangium, gliding out in succession, and forming a globular mass of cytospores at orifice of exit tube as in *Achlya;* cystospores spherical, 6.8—10.2 μ diam., germinating to form laterally biflagellate, elongately reniform, 6—6.7×9—10.4 μ, zoospores which may encyst again and then germinate to form zoospores a second time, primary swarming occasionally suppressed. Zoospores developing directly into sporelings. Oospores developing parthenogenetically in warted oogonia borne on special septate branches; one egg per oogonium; germination unknown.

Predacious on rotifers in a freshwater lake 4 klms. east of Uchipuli and from soil in Simms Park, Conoor, Madras State.

Pythiaceae

Indian species of the family Phythiaceae are well known from the initial studies of Butler (1907) and the more recent ones by Mitra (1935), Thangamani (1961), Rajagopalan (1961), Rangaswami (1962), Rao (1963), Rajagopalan and Ramakrishnan (1963), and others. To this family belongs a genus of predaceous fungi which have special structures for the capture of its prey, and it is mentioned here to record its occurrence in India for the first time.

Zoophagus insidians Sommerstorff, 1911. Österr. Bot. Zeitschr. 61 : 372, pls. 5—6.

Mycelium extensive, slender, 6—7 μ diam., sparingly branched, bearing numerous short pegs or branches, 3—5 μ diam., by 12—22 μ long, which arise at right angles to main hyphae; tips filled with highly refractive substances for capturing rotifers. Occasionally forming septate on non-septate gemmae or conidia, 8—10 μ diam. by 60—100 μ long. Sporangia developing within rotifer body, filamentous and similar to mycelium; content discharged through a 2—3 μ diam., long tube and undergoing cleavage in a vesicle. Zoospores laterally biflagellate, reniform, 3×5 μ; encysting, later germinating and then undergoing a second motile period. Oogonia terminal on a lateral branch, spherical, brownish, bearing a single egg cell. Antheridium diclinous, single, terminal and clavate. Oospore size and method of germination unknown.

Parasitic on rotifers in a freshwater lake 4 klms. east of Uchippuli and from soil in Simm's Park, Conoor, Madras State, and Bangalore, Mysore State.

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For publication of longer papers there will be edited the „Beihefte zur Sydowia", the first volume of which has already appeared as „Festschrift für Franz Petrak". In this supplementary series monographs and other extensive papers of importance will be published as quickly as possible disregarding their extent. Publication will take place under the same conditions as for „Sydowia", changing only point 6 as follows: The costs for reproduction of line drawings will be paid by the publisher, the costs for autotypies by the authors. The autors will recive 5 copies of the „Beihefte" free of charge. Moreover the autors may order any number of copies of their papers only directly from the publisher at the sales price less 25%.

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