

A CONTRIBUTION TO OUR KNOWLEDGE OF THE ZOOSPORIC FUNGI

S. N. DASGUPTA

1-B, Judges Court Road, Calcutta-700 027

AND

RACHEL JOHN

Ayamanam, Kottayam-686002, Kerala

A B S T R A C T

The quest for the aquatic phycomycetes of Lucknow revealed the presence of a large number of zoosporic fungi most of which is described in the present paper. This systematic study comprises seven uniflagellate, inoperculate genera, viz., *Olpidium* (5:3), *Rozella* (1:0), *Rhizophydium* (18:14), *Phlyctochytrium* (2:2), *Blyttomyces* (2:2), *Entophlyctis* (5:4), *Rhizoclostridium* (1:0) and two uniflagellate, operculate genera, *Chytridium* (11:6), *Macrochytrium* (1:0) and three biflagellate genera *Olpidiopsis* (2:2), *Myzocytiium* (3:2), *Lagenidium* (11:9). The initial figure within the brackets indicates the number of species and that after the colon, the number of new species. Except for *Rozella* and *Rhizoclostridium* all the genera revealed new species. Thus *Phlyctochytrium*, *Blyttomyces*, *Myzocytiium*, *Olpidiopsis* have two each, *Olpidium* three, *Entophlyctis* four, *Chytridium* six, *Lagenidium* nine and *Rhizophydium* fourteen.

Of special interest among the new species is the biflagellate *Olpidiopsis decipiens* which is morphologically similar to uniflagellate *Rhizophydium decipiens* variously identified by different authors. Yet more important is *Blyttomyces spinosus* sp. nov. in which discharge pore appears in any part of the surface of the sporangium, as well as the new discovery of the discharge of zoospores in a globular mass, the latter process that narrows down the distinction between *Blyttomyces* and *Phlyctochytrium*.

INTRODUCTION

The study of the aquatic phycomycetes of India had its beginning in 1907 with Edwin J. Butler, followed by H. P. Chaudhuri in 1931. The survey of the aquatic phycomycetes of Lucknow and its neighbourhood by the authors between 1951 and 1956 met with phenomenal success. The collection of the fungi of all the neighbouring habitats proved to be most successful from two locations. One from the road side ditches along the Sultanpur Road, near the military farm about 11 miles south east of Lucknow University. The other from the tanks in the garden of the Botany Department of the Lucknow University, adjoining the mycological laboratory. In the former the substratum in which the fungi were found, were largely a species of *Spirogyra* (*S. affinis*), *Cladophora*, *Oedogonium* and other green algae. In the latter the substratum was

mostly a species of *Closterium* from healthy to various stages of degeneration, as well as a number of unidentified animalcules.

Numerous species representing wide range of genera and families belonging to the zoosporic fungi were discovered and communicated to the Botany section of the Indian Science Congress. The importance of these discoveries came to be well recognised by the active workers in the field. Papers on a few species were published, but the publication of the remaining ones is now in progress.

The present work deals with the Chytridiomycetous genera belonging to the order Chytridiales, besides a few which belong to the order Lagenidiales. Based on the ultrastructure of the planospore (zoospores) of a limited number of selected species of Chytridiomycetes, Karling (1977) has made a thorough revision of Chytridiomycetous

genera and proposed 4 orders of which Chytridiales is one. A comparison of Karling's system with that of Sparrow shows that the operculum character of the chytrid to which Sparrow assigned a major taxonomical value has been devalued. The family Olpidiaceae remains unaltered, Phlyctidiaceae is replaced by Rhizidiaceae, since merely on the basis of rhizoid characters *Phlyctidium* as a genus separate from *Rhizophydium* is invalid. Rhizidiaceae comprises inoperculate genera *Rhizophydium*, *Phlyctochytrium* and *Blyttiomycetes* of the repudiated Phlyctidiaceae as well as the genera *Chytridium* and *Macrochytrium* of the operculate family Chytridiaceae, but under different subfamilies, Rhizidioideae and Chytridioideae.

Karling's classification based on the ultrastructure of zoospores is not much different from the classical system and it is not clear to what extent it determines the position assigned to the genera in the evolutionary series. With the modification replacing the nomenclature of Phlyctidiaceae by Rhizidiaceae, for the identification of species, the authors have followed the classification as presented by Sparrow in his comprehensive monograph on aquatic phycomycetes (1960).

The work presented here describes altogether 62 zoosporic species of which 34 species belong to seven uniflagellate, inoperculate genera. These are *Olpidium*, *Rozella*, *Rhizophydium*, *Phlyctochytrium*, *Blyttiomycetes*, *Entophlyctis* and *Rhizoclostridium*; 12 species belonging to two uniflagellate operculate genera *Chytridium* and *Macrochytrium*, as well as 16 species belonging to three biflagellate, zoosporic genera, namely *Olpidiopsis*, *Myzocyttium* and *Lagenidium*, belonging to the Lagenidiales.

All the *Olpidium* species described here are parasites on animalcule excepting one which is parasitic in an *Entophlyctis* species, itself parasitic in a species of *Closterium*. In *Rozella* one species is parasitic in a

Blastocladia species, *Rhizophydium* represented by 18 species of which 14 are new. The two new species of *Phlyctochytrium* are additions to four species already discovered from India by Karling (1966). Of the two species of *Blyttiomycetes* described for the first time from India, *B. spinosus* sp. nov. revealed several important, interesting features such as the presence of exit pore in different positions of the sporangial surface, the liberation of zoospores in a globular mass not observed earlier. The second character narrows down the gap between *Blyttiomycetes* and *Phlyctochytrium*, as anticipated by Sparrow (1960). The genus *Phlyctochytrium* as well as *Rhizophydium* have been recently reclassified as *Spizellomyces* by Barr on the basis of the ultrastructure of the zoospores as revealed in his cultural and ultrastructural studies. But as he specifically mentions, "it is strictly cultural classification and does neither augment nor replace the earlier and more classical system" (Barr, 1984).

Among the uniflagellate operculate genera, two are represented, namely *Chytridium* with 11 species of which 6 are new and *Macrochytrium botrydioides* var. *minutum* var. nov. The biflagellate zoosporic fungi are represented by 3 genera: *Olpidiopsis*, *Myzocyttium* and *Lagenidium*. Of the two species of *Olpidiopsis* described, *O. decipiens* parasitising in an *Oedogonium* species is of particular taxonomic interest as almost an identical fungus also parasitic in *Oedogonium* and which has been differently identified by different workers exhibits only one flagellum as against biflagellate condition of the zoospores of the fungus under discussion thus placing this fungus in the genus *Olpidiopsis* in the order Lagenidiales. The genus *Myzocyttium* is one of the earliest fungus to be described by Chaudhuri (1931) from India. Three species of this genus were found of which 2 are new. The genus *Lagenidium* is represented by 11 species of which 9 are new.

The present work in classical systematics of zoosporic fungi is a valuable addition to our existing knowledge on the subject.

OLPIDIUM

The genus *Olpidium* is characterised by endobiotic, holocarpic, inoperculate sporangium. The species described here were found in the sediment collected from the floor of a tank in the garden of the Botany Department, Lucknow University. These are mostly parasitic in the eggs of the animalcules one infecting the adult of a species of rotifer, another is a parasite growing in another phycomycete appearing as a species of *Entophlyctis* which itself grows in a *Closterium* sp. unlike other *Olpidium* species described here where zoospore discharge is through apical papilla in this parasite the zoospore discharge is by the deliquescence of vesicle that protrudes outside by the rupturing of the host wall.

Olpidium gregarium (Nowak.) Schroeter, Kryptogamenfl. Schlesien 3(1) : 182, 1885-1889 : *Chytridium gregarium* Nowakowski, in Cohn, Beitrage Biol. Pflanzen 2 : 77, Pl. 4, Fig. 2, 1876. (Fig. 1)*

Thallus holocarpic, unicellular; sporangium endobiotic, occurring in a group of four, filling the entire space of the egg, two large, broadly ellipsoidal, $27.5-30\mu$ two smaller pyriform, $22-28.5 \times 14.5-15.5\mu$; smaller size apparently due to compact condition resulting from the limitation of space in the egg; discharge tube single, arising as a papilla from each sporangium, $5.9 \times 3.5-5.0\mu$ pierces through the egg cell wall and protrudes slightly beyond the outside wall, 4.5μ ; papilla thin walled, tip convex; rhizoidal structure absent; contents of the sporangium filled with granular cytoplasm gradually developing into zoospores; mature

zoospores and their discharge not observed; resting spore not found.

Parasite in an egg of a rotifer, present in the sediments collected from the floor of one of the tanks in the garden of the Botany Department, Lucknow University.

The chytrid has been identified as *Olpidium*, several members of which are known to be parasitic in the eggs of rotifers. It closely resembles *Olpidium gregarium* (Nowakowski) Schroeter in certain characters such as the shape of the sporangium and the short, stout discharge papilla protruding just outside the egg-wall as described by Butler (1907) and Karling (1954).

Butler in his detailed study has demonstrated that the size of the sporangium in this chytrid is determined by the availability of space in the host cell, that the diminution of size is relative to the number developed; single sporangium in an egg $60 \times 40\mu$ (ovoid), double $33-36\mu$ (spherical) and when numerous $20-25\mu$ (spherical) $30 \times 22\mu$ (ellipsoidal); (size calculated from the magnifications given for the figures, as no size is given in the text).

Sporangia of Karling's chytrid also show a wide range apparently not connected with the egg space, $28-70\mu$ (spherical), $15-32 \times 16-38\mu$ (ovoid), almost identical to those of the original chytrid of Nowakowski $30-70\mu$ (spherical), $18-30 \times 17-32\mu$ (ovoid). In the present chytrid no spherical sporangia was observed; the ellipsoidal ones were larger, $27.5-33 \times 20-24\mu$, the smaller pyriform $22-28.5 \times 14-16\mu$. Zoospore discharge in a mass at the orifice of the papilla and faintly striated spherical or ellipsoidal resting spores, as described by Butler, were not observed. Besides *O. gregarium* there is no other rotifer infesting species of *Olpidium* comparable to the present chytrid which has, therefore, been identified as *Olpidium gregarium* (Nowakowski) Schroeter. This chytrid from India was first reported by John (1956). But the first published description of *O. grega-*

* Figure numbers in parenthesis refer to the present authors' illustrations.

rium collected from brackish soil of Mandapam camp, Tamil Nadu, India is by Karling (1964). The *Olpidium gregarium* described by Butler (1907), though published from Pusa, India, was collected from the soil of Black Forest, near Freiburg, Germany, and hence not an Indian species.

***Olpidium longum* sp. nov. (Figs. 2-4).**

Sporangiiis endobioticis, uno vel duobus, positis liberis, haud complementibus cellulas hospitis, subglobosis, $17-25\mu$ diam., ovalibus vel ellipsoides, $25-28\mu$ longis et $19-21\mu$ latis; raro extramatrix tum minoribus $17 \times 15\mu$, pariete tenui, laevi, incolorato, papilla efferenti una, apicali, tubulari, protrudenti extus parietem hospitis, omnino $15-30 \times 3.5-5\mu$ longa, parte protrudenti $4.5-15\mu$ longa, ubi extramatrix parte protrudenti ca 9μ longa, apicali, convexa tenui; zoosporis et sporis dormientibus nondum observatis.

Thallus holocarpic, unicellular; sporangium endobiotic, occurring singly or in group of two, filling only a part, never the entire, egg space, lying loosely free in the cell contents, sometimes extramatrix in the empty space between the retracted cell contents and the egg wall, spherical, $17-25\mu$ in diameter, ovoid or ellipsoidal, $25-28\mu$ long and $19-21\mu$ broad, when extramatrix smaller, $17 \times 15\mu$, wall thin, colourless, smooth, contents dense, granular, eventually developing into zoospores; discharge tube single, arises from the apical end of the sporangium, pierces through and protrudes beyond the wall outside, tubular, the size related to the distance between the base of the tube and the egg wall; the entire tube $15-30 \times 3.5-5.0\mu$ protruding portion $4.5-15\mu$ in length, in extramatrix ones the tube length is $10-12\mu$, protruding portion 9μ long, apical and convex, thin; rhizoidal structure absent; zoospores, their maturation and liberation not observed; resting spore not found.

The chytrid is a parasite in the eggs of certain animalcules present in the sediments collected from the bottom of a tank in the garden of the Botany Department Lucknow University, which contained numerous *Closteria* with old and degenerating thalli of *Ancylistes*, filaments of *Spirogyra* in various stages of disintegration and other vegetable debris.

The chytrid with its spherical or ellipsoidal sporangium, long tubular discharge tube, and total absence of rhizoids resembles *Olpidium* (Chytridiales), *Olpidiopsis* (Lagenidiales) and *Pythiella vernalis* Couch (Saprolegniales). But as zoospores were not observed in the present chytrid, the criterion for classification employed was the host character, which is significantly different in each case. Thus the members of *Olpidiopsis* are known to be parasitic in the hyphae of phycomycetes and fresh water and marine algae; *Pythiella vernalis* is parasitic in the hyphae of *Pythium* as well as the filaments of *Cladophora*. It is only some species of the genus *Olpidium* that have been found to be parasitising the eggs and adults of rotifers and other animalcules. The chytrid described here has thus been diagnosed as belonging to the genus *Olpidium*.

The specific identification has also been based on sporangial character, the nature and size of the discharge tube, even though in modern classification of *Olpidium* these are considered to be of little taxonomic value. For example, the three known species of *Olpidium*, *O. gregarium*, *O. granulatatum* and *O. rotiferum* are all distinguished by the nature of the flagellum and globule in the zoospore. Nevertheless, all these members distinguished by zoospore characters also exhibit distinguishing morphological characters. The morphology based classification resorted to here may find confirmation in the difference in some or other zoospore character on further investigation of the species.

Morphologically, the sporangia of the present species are spherical ($17-25\mu$ diam.), or ellipsoidal ($25-28 \times 19-21\mu$), loosely free in the cell, partially occupying the egg space, with single apical discharge tube $15-30\mu$ long \times $3.5-5.0\mu$ broad, differing from all other known species of *Olpidium* parasitic in the rotifer eggs in all these characters. The chytrid is, therefore, identified as a new species.

Holotype deposited at the HCIO, Division of Mycology and Plantpathology, IARI, New Delhi, 110 012. HCIO No. 37088.

***Olpidium incognitum* sp. nov.** (Figs. 5-6).

Sporangium endobioticum, positum liberum intus cellulis hospitis, singulare, anguste pyriforme, $50 \times 20\mu$ parietes tenui, laevi, incolorato; papilla efferens una, apicalis, conica, robusta, protuberatio basalis conspicua pariete parum incrassato, $9 \times 5-3.5\mu$ protrudens extus. ca 7μ ; raro in uno ovo secundum sporangium, ellipsoideum minus, $12 \times 8\mu$ in spatio enani inter parietem hospitis et contentum celluli retractum, papilla efferens $8 \times 3.5\mu$, tubularis, sine protuberations basali, zoosporae et sporae dormientes nondum observatae.

Thallus holocarpic, unicellular; sporangium endobiotic, single in the egg of rotifer, lying free in the contents of the egg, occupying the middle of the space; narrowly pyriform, $50 \times 20\mu$, wall thin, smooth, colourless, contents of sporangium filled with refractive granules; papilla at the apical end of the sporangium prominent, single, conical or tubular, stout, slightly thicker wall, $9 \times 3.5-5.0\mu$ with prominent bulge at the base, pierces through the wall of the egg, protruding outside, extending about 7μ beyond the host wall; another individual shows a second sporangium, smaller, developing in the space between the wall of the egg and its retracted cell contents, laterally placed, ellipsoidal, $12 \times 8\mu$, with relatively large papilla, $8 \times 3.5\mu$ which pierces through and

extends 5μ beyond the host wall without basal bulge; papilla tip dissolves to form a wide pore, 3.5μ diam through which zoospores are liberated; rhizoids absent; zoospores not observed; resting spore unknown.

Parasitic in the egg of a rotifer of unknown identity, present in the sediments collected from the bottom of a tank in the garden of the Botany Department, Lucknow University.

As in *O. longum*, in this species too, zoospores have not been observed. But the overall sporangial physiognomy and the nature of host indicate that the chytrid belongs to the genus *Olpidium*. In specific characters the species does not conform to any known species of *Olpidium* parasitic in the rotifers. There are distinct differences in the shape and size of the sporangium and in the shape of the papilla.

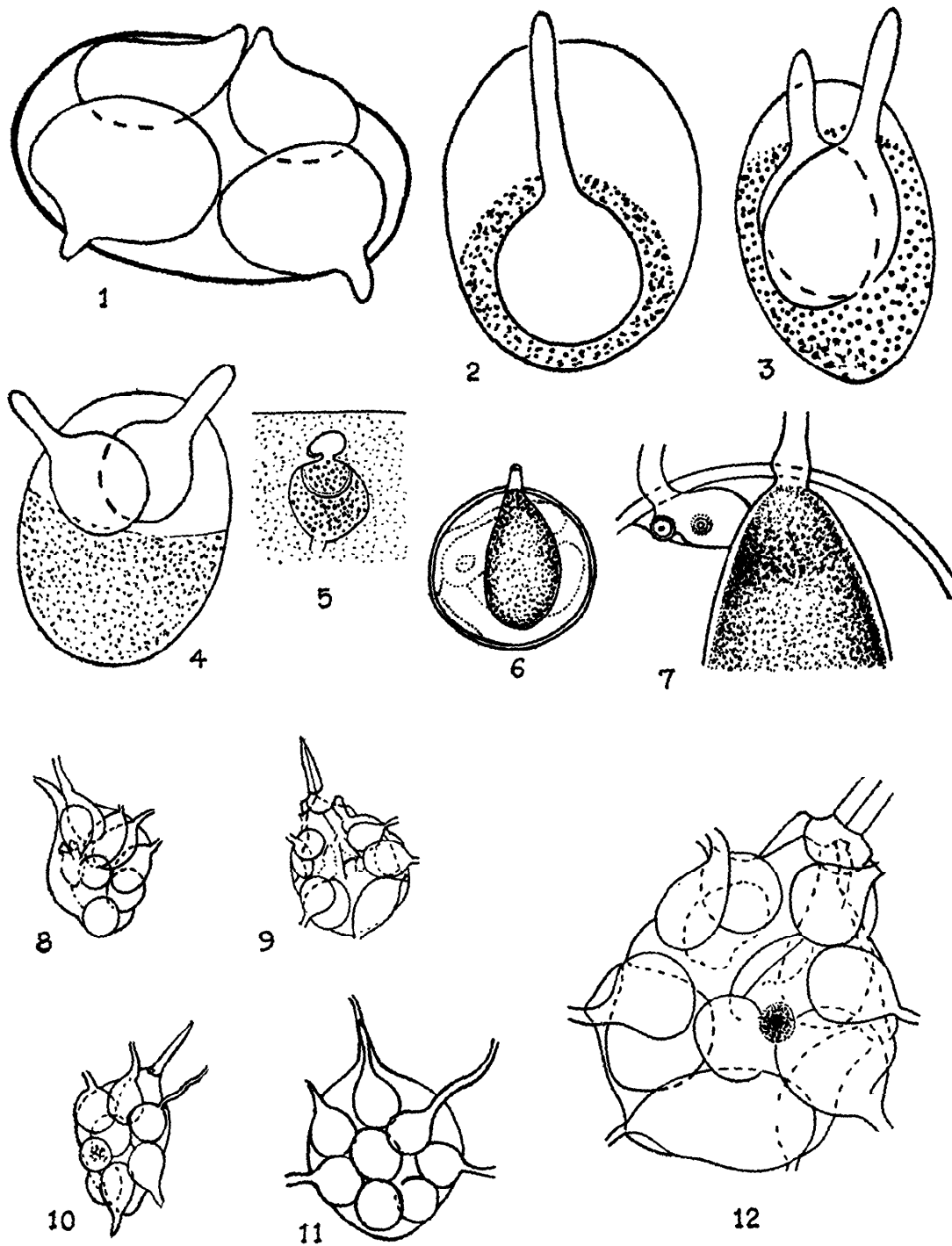
The host egg cell contains only one large sporangium. Along with it a second sporangium was found only in one rare instance, which differed in size, being only roughly a quarter of the normal sporangium and without a basal bulge. It is not unlikely that the second fungus is altogether a different one. Alternatively it may only be a diminutive form of *Olpidium incognitum* due to its extramatrical development at the upper half of the egg.

Holotype deposited at the HCIO, Division of Mycology and Plantpathology, IARI, New Delhi, 110 012. HCIO No. 37089.

***Olpidium pseudoeuglenae* sp. nov.** (Fig. 7).

Sporangiis endobioticis, singularibus, excentricis, et liberis in cellulis hospitis, in dimidio superiore, sphaericis, $3-4\mu$ diam., pariete hyalino, laevi, et basali concavo; pariete parallelo, concavo, cellulae hospitis contentum limitenti; sporangiis vesiculo formantibus, quibus rumpentibus membranam superiorem parietis hospitis, protrudentibus extus; continuis ab isthmis, subsphaericis, pariete tenui, incolorato; zoosporis prodien-

tibus intus sporangium et emissis in vesiculo sporis et sporis dormientibus nondum per isthmum, ante effusum exteriorem ; zoo- observatis.



Figs. 1-12 : Legend at the end of the article

Thallus holocarpic, unicellular ; sporangium endobiotic, occurring singly, lying eccentrically and loosely in the host cell at its shoulder region between the retracted cell contents and host wall, spherical, $3-4\mu$ in diameter, hyaline, smooth, basal wall concave, parallel concave wall delimits the cell contents of the host : vesicle formed by the sporangium ruptures the upper surface of host wall, protrudes out, extramatrix, subspherical, thin walled, hyaline, equal or slightly smaller than the sporangium in size, continuous with the sporangium by an isthmus, remnant of apical zoospore cyst persists at one end : rhizoid totally absent ; zoospores formed only inside the sporangium and not in the vesicle as well, their mode of discharge and the liberated zoospores not observed ; resting spore not found.

Parasitic in an undetermined species of chytrid itself inhabiting a *Closterium* sp. collected from the sediments at the bottom of a tank in the garden of Botany Department, Lucknow University, Lucknow.

The chytrid parasite closely resembles *Olpidium euglenae* Dangeard, parasitic in a holozoic *Euglena* sp. but differs from it in some essential details. In *O. euglenae* vesicle is as large or larger than the sporangium and what is most characteristic feature of the chytrid is that the zoospores are formed in the sporangium as well as in the extramatrix vesicle. The discharge of zoospore is in two instalments, the first from the vesicle by the dissolution of the apical wall and second from the extrusion of the sporangial zoospores into the vesicle which are then discharged out. In the present chytrid on the other hand the vesicle is equal or smaller, sometimes retains small segment of wall attached to its surface which appears as remnant of apical zoospore cyst on host sporangium. The zoospores here are formed in the sporangium only as evident from the zoospore initials present in it. There is no indication of zoospore forma-

tion in the vesicle. The discharge of zoospores is in one instalment. The vesicle receives the zoospores from the sporangium and discharges them outside through a pore formed by the dissolution of the apical wall.

This characteristic alone, the non-formation of the zoospores in the vesicle of the present chytrid can well distinguish it from otherwise similar and the closest species *Olpidium euglenae* Dangeard. Besides, the host of this parasite appears to be an undetermined species of chytrid an aquatic phycomycete, whereas *Euglena* sp. the host of Dangeard's *Olpidium* is a holophytic alga. Only two other aquatic phycomycetes, *Allomyces* (resting spores) and *Rhizophlyctis* (thallus, sporangium, resting spores) are known as hosts of *Olpidium*, *O. allomycetos* and *O. rhizophlyctidis* respectively.

Holotype deposited at the HClO, Division of Mycology and Plantpathology, IARI, New Delhi, 110 012. HClO No. 37090.

Olpidium rotiferum Karling, Lloydia 9 : 6, 1946. (Figs. 8-12).

Sporangium endobiotic, holocarpic, without rhizoid, not entirely filling the host cell, inoperculate, predominantly pyriform, $10-26\mu \times 9-15\mu$, the largest observed $26 \times 15\mu$ or spherical $7-18\mu$ in diameter, smooth walled ; discharge tube single of variable length, 2.5μ wide emerging outside by piercing through the host cell wall at any point ; zoospore discharge through the pore formed at the apical end by dissolution of the apical end ; zoospores not observed ; resting spore thick walled spherical, $7-10\mu$ in diameter, faintly brown, lying loosely in the sporangium without vesicle ; germination not observed.

Parasitic in the adult rotifers, present in the sediments collected from the floor of a tank in the garden of the Botany Department, Lucknow University.

Three species of *Olpidium*, namely *O. gregarium*, *O. granulosum* and *O. rotiferum*

are known to occur in the eggs and adults of the rotifers. These two new species, *O. longum* and *O. incognitum* both parasitic in the eggs of the rotifers have been added by the authors. The present paper describes another species *Olpidium rotiferum*, parasitic in the adults of rotifer, a species already described for the first time by Karling from Brazilian soil. (Karling 1946).

Olpidium rotiferum Karling is characterised by the presence of predominantly pyriform sporangia which measure, $12-40\mu \times 20-70\mu$, and spherical ones measure $15-30\mu$ in diameter; some ovoid falling within the range. The same species was again recorded by Karling in rotifer eggs and adults from soil of Kotah, Rajasthan. (Karling 1966), but the sporangia were somewhat smaller pyriform ones measuring, $10-35\mu \times 14-38\mu$ and spherical ones $12-32\mu$ in diameter. Here too, there were several ovoid sporangia falling within the range. Resting spore in the two are somewhat different in colour.

The *Olpidium* species under discussion, although almost identical in shape, of the sporangium is smaller than those of the type species and nearer to those from Kotah. For example, pyriform sporangia are $9-15\mu \times 10-26\mu$ and spherical ones are $7-18\mu$ in diameter. The resting spores too, in Brazilian and Kotah species are $12-15$ and $8-16\mu$ respectively; in the present species, however, these are smaller, $7-10\mu$ in diameter. In Brazilian and Kotah species the resting spores have been found loosely in a vesicle, which has not been observed in the present one. These differences notwithstanding, the present *Olpidium* species has been identified as a member of *Olpidium rotiferum* Karling.

ROZELLA

A species of *Blastocladia* trapped by baited fruits, when investigated showed the presence of sporangia very heavily infected

with Chytrids *Phlyctidium*, *Rhizophydium* as well as *Rozella* described here as *Rozella blastocladiae* (Minden) Sparrow.

Rozella blastocladiae (Minden) Sparrow

Pleopidium blastocladiae Minden. Kryptogamenfl. Mark Brandenburg 5 : 253. 1911 (1915). (Fig. 13).

Sporangium assuming the shape of the hypertrophied, club-shaped host, 28μ broad where widest at the middle; zoospores and their mode of discharge not observed; resting spore intramatrical, embedded at the apical end of the host sporangium, spherical, brown, thick walled, covered with dense spines, 10μ in diameter; germination not observed.

Parasitic in the sporangium of *Blastocladia* sp. collected from the baited fruit of *Pyrus* in one of the tanks in the garden of the Botany Department of the Lucknow University, Lucknow.

The resting spore of the present chytrid was found embedded at the apical end of the sporangium of *Blastocladia* sp. It is characterised as spherical, brown, thick walled, covered with dense spines. In external characters the resting spore is identical to the spherical, spinous, brownish resting spore of *Rhizophydium blastocladianum* sp. nov., described elsewhere, with which the present fungus was found intimately associated. There are, however, two important points of distinction. The resting spore in the present species is devoid of adhered male thallus, in contradistinction to the sexually formed resting spore with conspicuous adnate, male thallus in *Rhizophydium blastocladianum*. A sexual mode of formation of resting spore is not unknown in the nearly related species of the group. It is found in *Rhizophydium traversum* (Braun) Rabenhorst. The other character that distinguishes the two, however, lies in the intramatrical resting spore embedded near the tip of the host sporangium in the present species

as opposed to the extramatrical, scattered resting spores in *R. blastocladianum*.

Taking these characters into consideration, the chytrid is identified as belonging to the genus *Rozella* parasitic in the sporangium of *Blastocladia* sp. A chytrid parasitic in the sporangium of *Blastocladia pringaeheimii* Thax. was originally described by Minden (1911) as *Pleolpidium blastocladiae*. This was transferred to the genus *Rozella* by Sparrow in 1938 as *R. blastocladiae*. A comparison of the two species show that the characters are practically identical. The resting spore in *R. blastocladiae* is spherical, brown, thick walled, the exospore densely covered with tenuous spines, the size of the resting spore is unknown and it is embedded at the tip region of the host sporangium. The present chytrid is thus identified as *Rozella blastocladiae* (Minden) Sparrow.

RHIZOPHYDIUM-I

Sparrow (1960) in the classification of the Chytridiales as given in his monograph placed the genera *Phlyctidium* and *Rhizophydium* in the family Phlyctidiaceae "which correspond roughly to the family 'Rhizidiaceae' (excluding *Rhizidium* and its close allies) of most monographers". Sparrow (1973) retained the classification in his article in the treatise FUNGI. Karling (1977) however, in his comparatively recent Iconograph, has maintained his earlier view that the nomenclature *Phlyctidium* is illegitimate and transferred its members to the genus *Rhizophydium* and replaced the family Phlyctidiaceae of Sparrow by Rhizidiaceae.

The validity of the genus *Phlyctidium* has long been controversial. Originally described by Braun (1856) as a subgenus of *Chytridium* it was raised to the status of a genus by Rabenhorst (1868). Its generic status was recognised by Serbinow (1907) and by Minden (1915) but not by Schroeter (1885)

nor by Scherffel (1926) who held the view that the criterion employed, the unbranched condition of the rhizoid to distinguish *Phlyctidium* from *Rhizophydium* was not of generic order, a view shared by Sparrow and Karling (Whiffen 1942). In his monograph however, Sparrow (1960, p. 210) retained the genus *Phlyctidium* assigning an utilitarian reason combined with certain specific characters of the rhizoids for this treatment.

Regarding the legitimacy of the nomenclature *Phlyctidium*, the observations of Sparrow (1960, p. 211) are stated below : "Karling (1939) suggested the suppression of the name *Phlyctidium* because of its earlier use by Wallroth (1833) for a genus of Ascomycetes and the substitution of a new name *Tylochytrium*. All species of Wallroth's genus have long since been transferred to other genera and *Phlyctidium* possesses no status among the Ascomycetes. In view of this, as well as the long-and well established use of the name for certain chytridiaceous fungi, *Phlyctidium* should be treated as a *nomen conservandum*, a course now evidently concurred in by Karling (1946)". Karling (1977) evidently resiled from this position and in his Iconographia maintained that the nomenclature *Phlyctidium* is illegitimate.

The present authors following Sparrow's classification, as for the entire work, originally identified certain species of chytridiaceous fungi as *Phlyctidium*, which recognising the tenuousness of the criterion employed by Sparrow, besides the non-recognition of the genus by many leading specialists in the field, have now been named *Rhizophydium* but treated as a separate group in which the rhizoidal system is specialised haustorium, the distinguishing character of Sparrow's *Phlyctidium*.

In this section, have been described such species of *Rhizophydium* in which the rhizoidal system is filamentous, delicate, and branched. There are seven species of which four are parasitic on algae and three species

parasitic on *Blastocladia* an aquatic Phycomycete.

Rhizophydium sphaerocarpum (Zopf) Fischer Rabenhorst Kryptogamenfl., 1(4) : 95. 1892.

Rhizidium sphaerocarpum Zopf, Nova Acta Acad. (Leop. Carol., 47 : 202, 1884). (Fig. 14).

Sporangium epiendobiotic, resting on host wall or partially inside the cell, sessile, single or double walled, inner wall thicker, smooth, inoperculate, spherical, 12-20 μ in diameter, or subspherical, 30 μ long \times 20 μ wide, urceolate when empty, 20 μ in diam., wide apical pore 10 μ in diameter; rhizoid wholly endobiotic, arise usually from the axial point or from more than one point at the basal end of the sporangium, stout, thicker, mostly double-contoured at the base and proximal end, gradually tapering, branches arise at the distal end, 2-3 in number, delicate, tapering, penetrate into zygosporangium or ramify into cell matrix; cell contents granular; discharge takes place from the apical pore of the sporangium which then assume urceolate shape; zoospores and their mode of discharge not observed; resting spore in its formative stage lying loosely in the sporangium.

Parasitic on the zygosporangium of a *Spirogyra* sp., collected from a ditch by the side of Sultanpur Road about 11 miles south east of Lucknow University.

In generic characters the fungus conforms to the genus *Rhizophydium*. In specific characters it conforms to the species *Rhizophydium sphaerocarpum* (Zopf) Fischer, in which the sporangia are subspherical, ovoid, urceolate, 20 μ high \times 18 μ in diameter, the protruding papilla 4-7 μ in diameter, endobiotic rhizoids generally unbranched. Sparrow (1960) has placed in *Rhizophydium sphaerocarpum* those species which have ovoid, spherical or urceolate sporangium and large discharge papilla excluding those

which are either without rhizoid or with richly branched rhizoid.

In the present fungus the sporangial characters are substantially the same as those of the type species. The discharge papilla is a large one as evidenced by the 10 μ wide apical pore of the urceolate sporangium from which zoospores have been discharged. Rhizoids, however, are more well developed, but not extensively branched. Formed at the axial end of the sporangial base, these are double-contoured at the proximal part, unbranched for a long length, gradually tapering into a filament from which two or three filamentous branches arise as these near the zygosporangium. In some again rhizoids arising as filaments (not double-contoured) from several basal points are unbranched or sparingly branched at the distal end. What appears as resting spore of the fungus at an early stage of formation, is perhaps represented by a globular mass of cell contents retracted from the sporangial wall, thick walled, about 20 μ in diameter, lying loosely free in the sporangium and not the entire sporangium transformed into a resting spore. The fungus has been identified as *Rhizophydium sphaerocarpum* (Zopf) Fischer. Karling (1964) described the species growing on dead pollen of *Pinus sylvestris*, from brackish soil, Mandapam camp. (Tamil Nadu). This is the second record of the species from India.

Rhizophydium mammillatum (Braun) Fischer Rabenhorst. Kryptogamenfl., 1(4) : 93. 1892 (sensu Dangeard, Le Botaniste, 2 : 242, 1890-91. Syn. *Chytridium mammillatum* Braun Monatsber. Berlin Acad. 1855 : 381; Abhandl. Berlin Akad., 1855 : 32, 9-12, 1856. (Fig. 15A).

Thallus epi- and endobiotic, monocentric, eucarpic; sporangium extramatrical, sessile, smooth walled, thin, colourless, broadly pyriform or ovoid or citriform, 10-13 μ high \times 7-10 μ in diameter, growing single on the

cospore; papilla apical, elongated, 3.4μ high \times $1.5-2.0\mu$ wide, inoperculate; apophysis absent; penetration hypha at the base of the sporangium endobiotic, small, extended into the cospore; rhizoidal system originates from the distal end of the penetration hypha, tenuous, sparingly branched, ramifying inside the cospore faintly discernible; dehiscence of the papilla not observed, dehiscent sporangium indicates discharge of zoospores through the orifice formed by the dissolution of the tip of the papilla; zoospore and resting spore not observed.

Parasitic on the cospore of a species of *Oedogonium*, collected from a ditch by the side of Sultanpur Road, 11 miles south of Lucknow University.

The chytrid in generic characters conforms to the genus *Rhizophydium*. In its specific characters such as ovoid or citriform sporangium with pronounced apical, upright, terminally placed papilla, persistent sporangial wall after zoospore discharge, and in its infestation of filamentous green alga, the chytrid resembles *Rhizophydium mammillatum* (Zopf) Fischer as well as *Rhizophydium minutum* Atkinson. It is in the size of the sporangium of rhizoidal characters of one species or other that difference exists. In *R. minutum* the sporangia are small, 5.6μ in diameter and slender rhizoids arise directly from the sporangial base whereas in *R. mammillatum* sporangia are much larger $10.33 \times 10.22\mu$ and rhizoids arise from slender main axis. In the present fungus sporangia ($10.12 \times 7.10\mu$) are double in size of those of *R. minutum* while conforming to the smallest among the sporangia of the typical species of *R. mammillatum*. The rhizoids are delicate and sparsely branched arising from a penetration hypha at the basal end of the sporangium, agreeing in this respect with the rhizoids of *R. mammillatum*.

Notably in shape the sporangia of the fungus under discussion is very similar to those of *R. minutum*, and though much

larger can be placed with this species. Nevertheless combined with the fact that in *R. minutum* rhizoids arise directly from the base and in the present fungus rhizoids arise from a main axis, which is characteristic of the rhizoids of the typical *R. mammillatum*, primacy is given to the latter character and the fungus is identified as *Rhizophydium mammillatum* (Zopf) Fischer.

Rhizophydium constantineani Saccardo, Sylloge fungorum, 17 : 512. 1905. *Rhizophydium vaucheriae* Constantineani, Rev. Gen. Bot., 13 : 380, 1901. (Fig. 15B).

Thallus epi- and endobiotic, monocentric, sucarpic; sporangium formed by the expansion of the zoospore resting on the host cell wall, develops either singly or in groups in the host cell wall, epibiotic, sessile, spherical, small, $6.5-11\mu$ in diameter, thin walled, smooth, colourless; papilla absent; cell contents with many refractive granules; rhizoid originates as infection hypha of resting zoospore or directly from a sporangial basal axis singly or as two diverging filaments, scarce delicate, sparsely branched at the distal end, ramifying into the cell matrix, or absent; zoospores and their mode of discharge not observed; resting spore not found.

Parasitic on a species of *Closterium* collected from one of the tanks in the garden of the Botany Department, Lucknow University, Lucknow.

The epibiotic sporangium with nonapophysate, endobiotic, filamentous rhizoids characterised the fungus, thus placing it in the genus *Rhizophydium*. In specific characters the fungus appears to be almost identical to the *Rhizophydium constantineani* Saccardo. In both, the sporangium is sessile, spherical or subspherical, wall thin, smooth, hyaline, typically small, 6.8μ in diameter in *Rhizophydium constantineani* against $6.5-11\mu$ of the present species. The rhizoids are delicate consisting of a few short

branches which arise from the main axis. In some sporangia rhizoid is totally absent. A further comparison with *R. constantineani* is not feasible as in the present case zoospores have not been observed nor their mode of discharge.

The typical *R. constantineani* is parasitic on *Vaucheria*. It has also been reported on *Oedogonium*, as well as on *Cosmarium* a desmid (Richards 1956). The present species is parasitic on *Closterium* sp. also a desmid. This partially known fungus is identified as *Rhizophydium constantineani* Saccardo.

Rhizophydium collapsum Karling, Sydowia, 17 : 285-289, 1964. (Fig. 15C)

Thallus epi- and endobiotic, monocentric, eucarpic, growing singly, several in a series on the host; sporangium inoperculate, sessile, broadly obovate, obpyriform, subbasal constriction forming a small, terminal papilla continuous with the main body, $18-22\ \mu$ high $\times 15-20\ \mu$ wide, wall thin, hyaline, smooth without any prominence, cell contents granular with several refractive globules; rhizoid of restricted length, filamentous, arises from uniaxial point of the basal papilla, divergent, sparsely branched at the distal end; branches delicate; zoospores and their mode of discharge not observed; resting spore not found.

On *Closterium* sp. collected from one of the tanks in the garden of the Botany Department, Lucknow University.

This fungus is identified only from the epibiotic sporangium and endobiotic rhizoid arising directly from the sporangial base, the generic character of *Rhizophydium*. The absence of apophysis distinguishes it from *Phlyctochytrium*. Normally apophysate or inapophysate character poses no identification problem except in border line species or when substratum condition induces variations involving apophysis creating uncertainty whether the species belong to the genus *Rhizophydium* or *Phlyctochytrium*.

In specific characters the species exhibits obovate or obpyriform sporangium with small basal papillar extremity formed by the constriction of sub-basal end. It is from this that rhizoids arise as a minute axis which diverges into two sparsely branched strands of limited length. Rhizoids appear to be lacking in some sporangia, in some these may be obscured by dense cell contents. The sporangial surface is smooth without any prominence to indicate the presence of even the rudiment of discharge pore or papilla which as in *R. collapsum* is known to appear immediately prior to zoospore discharge.

The species of *Rhizophydium* answering description of the present fungus and closest to it, appears to be *R. collapsum* Karling which is characterised by the extramatrical, sessile, hyaline and smooth sporangium. The basal portion of the sporangial wall is slightly thickened, exit papilla lacking. The rhizoid is intramatrical, finely branched at the base; the main axis narrow (Karling 1964, p. 289). The present fungus fully conforms to the features of *R. collapsum* in all these respects. The sporangia too, are almost identical in size. The broadly obpyriform sporangia of *R. collapsum* are $14-16\ \mu \times 12-20\ \mu$ in diameter and those of the present fungus are $18-22\ \mu$ high $\times 15-20\ \mu$ in diameter. The constricted basal end is also evident in *R. collapsum*. The free floating, broadly obpyriform, sporangium of *R. collapsum* as illustrated by Karling (1964, p. 289 fig. 4) appears to be more or less identical to the illustration of the present fungus. Only in this case sporangia are no longer free floating, but have settled down on the host *Closterium* sp. and some are without rhizoid as in the figure in Karling's as mentioned above, and others have developed two divergent strands of rhizoids with sparse delicate branches at the distal end. The zoospores and their mode of discharge have not been observed in the present fungus nor the evanescence of the wall of the discharged

sporangium. Nevertheless the two seem to be identical in structural configuration and other characters.

In consideration of the above the present chytrid has been identified as *Rhizophydium collapsum* Karling. Karling, however, found *R. collapsum* growing saprophytically in dead pinus pollen in Mandapam camp (Tamil Nadu) whereas the present fungus is found in a species of *Closterium*. The chytrid is recorded for the second time from India.

***Rhizophydium blastocladianum* sp. nov.**
(Fig. 16).

Thallus monocentricus, gregarius, hospes infectus cum sporangia numerosa, omnino in superficie, sporangium epibioticum, sessile, inoperculatum, hyalinum, gracile, pariete laevi, late vel anguste pyriforme, $16-38\ \mu$ altum $\times 9-22\ \mu$ latum, apice rotundatum, convexum; zoosporae emissae per porum angustum vel latum, porus $5-10\ \mu$ latus, formatus extremi apicalis deliquescenti; zoosporae et illarum modus emissi non observatae; spora quiescens epibiotica, sparsa, extramatrix, parietibus duobus, paries exterior spinosus, paries interior gracilis, atro-brunneus, sphaericus, $10-12\ \mu$ diam., contentum granulatum, sexualiter formatum, thallus parvus (masculus) laevis, hyalinus, sphaericus, parietibus duobus, $2.5-4\ \mu$ in diametro thallum majorem (foemineum) affixus, post fecundationem spora quiescens exorians; germinatio spora quiescentis non visa.

Thallus monocentric, gregarious, host infected with numerous sporangia all over the surface, hypertrophied; sporangium epibiotic, sessile, inoperculate, hyaline, thin, smooth walled, shape variable, broadly or narrowly pyriform, $16-38\ \mu$ high $\times 9-22\ \mu$ wide, apex rounded, convex, wall rigid, shape remains unchanged when empty; endobiotic system absent; zoospore initials formed by the cleavage of dense sporangial contents, having refractive granules filling it complete-

ly, maturity takes place inside the sporangium; discharge of zoospores through pore, narrow or broad, formed by the deliquescence of apical end, $5-10\ \mu$ wide; liberated zoospores and their mode of discharge not observed; resting spore epibiotic, scattered, extramatrix double walled, outer wall spinous, and inner wall thin, dark brown, spherical, $10-12\ \mu$ in diameter, contents granular, formed sexually, a small thallus (male) double walled, smooth, hyaline, spherical, $2.5-4\ \mu$ in diameter, becomes directly attached to a larger thallus (female) or makes contact with it by means of a short germ tube, fertilisation takes place, eventually giving rise to the resting spore, to which the empty case of the male thallus remains adnate; germination of resting spore not observed.

Parasitic on *Blastocladia* sp. developing saprophytically on baited apple fruit in tanks in the garden of the Botany Department, Lucknow University, Lucknow.

The present chytrid is characterised by sporangium totally devoid of endobiotic system such as haustorium or rhizoid. If at all present these could not be detected in any of the large number of sporangia gregariously resting on the host wall. The total lack of vegetative system is the characteristic of the holocarpic family of Olpidiaceae. But whereas the members of Olpidiaceae, without exception, are endobiotic it is wholly epibiotic on the present chytrid.

The species is placed among those of *Rhizophydium* in which sporangium is pyriform, discharge pore apical, the sporangial wall after zoospore discharge is persistent. The *Rhizophydium* species belonging to this category are *R. zoophthora* (Dang.) Fischer, parasitic in the adults and eggs of rotifers, and *R. eudorinae* Hood, *R. brauni* (Dang.) Fischer, and *R. simplex* (Dang.) Fischer, all parasitic in algae, developing in the gelatinous sheath of respectively *Eudorina*, *Apicystis* and *Pandorina*, all Volvo-

cales, as well as *Cryptomonas*. Each of these species possesses delicate, unbranched rhizoids, and resting spore when present is asexually formed. The present species of *Rhizophydium*, however, is parasitic on *Blastocladia* sp., a saprophytic aquatic phycomycete. Only two more genera of Phycomycetes, *Pythium* and *Choenophora* are also known to be parasitised by *Rhizophydium*.

The *Rhizophydium* species described here does not conform to any of those mentioned above. Its epibiotic sporangia rest on the host wall, form no rhizoid, resting spores covered with spines, are formed sexually, by the fertilisation of large female thallus by a small male thallus. The empty male cyst remains adnate to the resting spore. The sexually formed resting spores are not uncommon in the genus *Rhizophydium*. It has been recorded in about ten species of *Rhizophydium* parasitic mostly on Planktonic algae by Canter (1950) such as *R. planktonicum*, *R. sphaerocystidis*, *R. difficile* etc. and in two species *R. goniosporum*, *R. granuloporum*, both parasitic in *Tribonema bombycina* an alga by Scherffel.

The present species of *Rhizophydium* differs entirely from all the species so far known.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi, 110-012. HCIO No. 37135.

***Rhizophydium rhizinum* sp. nov. (Fig. 17).**

Thallus epiendobioticus, monocentricus; sporangium epibioticum, sessile, inoperculum, late pyriforme, 22μ altum, $\times 12\mu$ latum, extremum distalem constrictum, collum formans; collum $5-7\mu$ altum $\times 4.5-5\mu$ latum, paries tenuis, laevis, hyalinus; rhizoidea, ubi praesentia, orientiae superficiei basali sporangii epunctibus duobus, separatis, abaxialibus, gracilis, delicata, hyalina, eramosa, raro nulla; zoospora emissae per apicalem, magnum, $4.5-7\mu$ latum; porus formatus extremi apicalis deliques-

centi; zoosporae et illarum modus emissi non observatae; sporangium vacuum partialiter collapsum; spora quiescens non observata.

Thallus epiendobiotic, monocentric; sporangium epibiotic, sessile, inoperculate, broadly pyriform, 22μ high $\times 12\mu$ broad, distal end constricted, forming a neck, $5-7\mu$ high $\times 4.5-5\mu$ wide, wall thin, smooth, hyaline; rhizoids when present arise directly from the basal surface of the sporangium, from two separate, abaxial points, thin, delicate, hyaline, unbranched, rarely absent; zoospore discharge through large apical pore, as wide as the neck is high, $4.5-7\mu$, formed by the deliquescence of apical end, zoospores and their mode of discharge not observed; empty sporangium collapse partially; resting spore not observed.

Parasitic on sporangium of *Blastocladia* sp. developing saprophytically on baited pyrus fruit, in a tank in the garden of the Botany Department, Lucknow University.

The chytrid has been diagnosed as a species of *Rhizophydium*. The thallus is characterised by sporangium developing singly (non-gregarious habit), broadly pyriform with the neck constricted at the base. The apical end dissolves to form an wide orifice, through which zoospores are liberated. The rigid sporangial wall persists after discharge, though indication of partial collapse is visible. Rhizoids which are occasionally absent, arise directly from sporangial surface, and are thin, delicate, unbranched and of limited growth.

It is evident from these characteristics that the chytrid belongs to *R. minutum* group displaying similar endobiotic and epibiotic system, the members of which are specifically distinguished, besides certain sporangial differences by the algal host it parasitises. While these species are exclusively parasitic in green algae, the present chytrid is parasitic on an aquatic phycomycete. The only nearly related *Rhizophydium*

species that is known to parasitise aquatic Phycomycetes is *R. carpophilum* (Zopf) Fischer. It is parasitic on cogonium and cospore of *Saprolegnia* and *Achlya* species, as well as sporangium of *Olpidiopsis saprolegniae* and cospore of *Monoblepharis macrendra* and several others. A comparison with illustrations as given by Sparrow and Karling of the species of *R. carpophilum* obtained by them shows that while the endobiotic system is similar, the spherical shape of the sporangium and the gregarious habit distinguish it from the present species.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37136.

***Rhizophydium reflexum* sp. nov.** (Fig. 18).

Thallus epidendrobionic, monocentric ; sporangium endobioticum, inoperculatum, sessile, irregulariter formatum, late pyriforme, asymmetricum, basi valde arcuatum, curvatum vel reflexum (anotropum), erectum, $15-22\mu$ longum $\times 10\mu$ latum, pariete tenui, laevi, hyalinoque ; systema endobiotica evoluta ; haustorium perparvum, rotundatum, gongylodes, ad extremum basalem sporangii, produens rhizoidea delicata graciliae punctibus multis ; interdum haustorium rhizoideumque nullum ; zoosporae emissae per porum ; porus extremi apicalis deliquescenti formatus, $2-4.5\mu$ latus ; zoosporae et illarum modus emissi non observatae.

Thallus epiendobiotic, monocentric ; sporangium epibiotic, inoperculate, sessile, irregularly shaped, broadly pyriform, asymmetrical, base strongly arched, curved or reflexed (anotropous), upright, $15-22\mu$ long $\times 10\mu$ wide, wall thin, smooth, hyaline ; endobiotic system developed ; haustorium very small, rounded, knob-like structure, at the basal end of the sporangium, giving rise to short thin, delicate rhizoids from more than one point, in some both haustorium and rhizoid absent ; zoospores emerge through the pore,

formed by the deliquescence of the apical end, $2-4.5\mu$ wide ; zoospores and their mode of discharge not observed ; resting spore not observed.

Parasitic on the sporangium of *Blastocladia* sp., developing saprophytically, on baited pyrus fruit, in a tank in the garden of the Botany Department, Lucknow University.

In the presence of endobiotic system, consisting of knob-like haustorium, which gives rise to rhizoids, thin, delicate, sparse, as common in many members of *Rhizophydium*, the chytrid has been diagnosed as belonging to the genus *Rhizophydium*. The epibiotic sporangium of the present chytrid closely conforms to the sporangium as described for *Phlyctidium anatrosum* (Braun) Rabenhorst, in which sporangia are upright, procumbent, irregular, broadly pyriform, ovoid, asymmetrical, strongly arched or reflexed (anotropous), rarely symmetrical, attached laterally near the narrower end of the algal cell. The irregular development appears to be due to the incurvature at the lower region of the sporangium, at a certain stage of its development, followed by the unequal growth of the bottom surface. This results in the curved, reflexed, anotropous condition, the characteristics of the present species. The shape to a great extent depends upon the region where incurvature occurs. The early stage of such growth is seen in the lower, figure for the species.

Phlyctidium as a genus distinct from *Rhizophydium* is not recognised by Karling (1977) and many authorities. According to this view, *Phlyctidium anatrosum* becomes synonymous to *Rhizophydium anatrosum*. Sparrow (1960) while recognising the tenuous somewhat artificial nature of the difference between the two genera retained in his classification, *Phlyctidium* as a distinct genus for those species whose endobiotic system is specialised haustorium, knob, sacs, unbranched, tubes etc., and *Rhizophydium* as those in which rhizoids are filamentous, branched,

delicate, the characteristics of the present chytrid. There is, however, difference in endobiotic system in the two genera. In *P. anatrosum* haustorium is very small, rounded or short peg-like, whereas in the present chytrid it is knob-like and with delicate rhizoids. The important difference lies in the nature of the substratum, *P. anatrosum* is parasitic on algae *Chaetophora*, *Oscillaria*, *Tribonema* (Xanthophyceae), the present chytrid is parasitic on the sporangium of a *Blastocladia* sp. an aquatic phycomycete. This character apart from endobiotic system, distinguish the two.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37137.

RHIZOPHYDIUM-II

In this section the authors describe such species of *Rhizophydium* in which the rhizoidal system is specialised haustorium, knob, sac or tube etc. and the haustorium gives evidence of being isodiametric or is distally expanded, unbranched throughout and must be depicted by a double than a single line—the criteria employed to distinguish the genus *Phlyctidium* by Sparrow (1960) in his monograph. There are altogether eleven species, all new, conforming to a few if not all of these characters.

***Rhizophydium urceolatum* sp. nov. (Fig. 19).**

Thallus monocentricus; sporangium epibioticum, sessile, inoperculatum, lageniforme, 17-29 μ altum \times 7-9 μ in parts latissima, colum breve, 5 μ longum, pariete tenui, laevi, hyalinumque; haustorium parvum, sphaericum, corpus inexpansus zoosporae incystatae, ad extremum basale axiale dispositum, sub sporangium, vel sublaterale, rhizoideum nullum, zoospora emissa per porum apicalem 2.5 μ latum, zoospora non visa; sporangium vacuum partiliter collabens post emissum zoosporarum, spora quiescens extramatrix

parietibus duobus, paries exterior crassus, paries interior tenuis, laevis, hyalina, ellipsoidea, 10-12 μ lata \times 8-9 μ alta, sexualiter prodiens, a fucundationa per thallum masculinum, sphaericum, parvum 2 μ in diam., hyalinum, laevem, pariete tenuem, remanentem adnatum ad sporam quiescentem; germinatio sporae quiescentis non visa.

Thallus monocentric: sporangium epibiotic, sessile, inoperculate, lageniform 17-29 μ high \times 7-9 μ where widest, neck short 5 μ long, wall thin, smooth, hyaline; haustorium a small spherical structure unexpanded body of encysted zoospore, situated at the basal axial end, on which the sporangium rests or somewhat lateral; rhizoid absent; zoospore discharge through apical pore, 2.5 μ wide formed by the deliquescence of the apical end; zoospores and their mode of discharge not observed; empty sporangium after zoospore discharge collapse partially; resting spore extramatrix, double walled, outer wall thick, inner wall thin, smooth, hyaline, ellipsoidal, 10-12 μ wide \times 8-9 μ high formed sexually, fertilised by a male thallus, spherical, small, 2 μ in diameter, hyaline, smooth, thin walled, remains adnate to the resting spore as an empty case; germination of resting spore not observed.

Parasitic on a *Blastocladia* sp. which developed saprophytically on the baited fruits in a tank in the garden of the Botany Department, Lucknow University.

The chytrid belongs to the genus *Rhizophydium*. The sporangium is epibiotic, the endobiotic part is small, spherical, knob-like structure, rhizoid is totally absent in contrast to such species of *Rhizophydium* in which rhizoids develop to a varying degree from an apophysis directly or from the tip of the germ tube.

The present species of *Rhizophydium* is characterised by lageniform sporangium with small knob-like structure, which is the unexpanded body of the zoospore, sessile, basal, axially placed and epibiotic on the

sporangium of a *Blastocladia* sp. The resting spores are double walled, smooth ellipsoidal with adnate male thallus.

A scrutiny of the literature shows that only two species of the group, *Phlyctidium bumillariae* Couch and *Phlyctidium chlorogonii* Serbinow, approximate the present species in the presence of knob-like haustorium. In *P. bumillariae*, however, the sporangium is spherical, in *P. chlorogonii* the sporangium is symmetrically pyriform with a small papilla. In contrast to these the sporangium in the present species is lageniform. There is the presence of abundant resting spores whereas no resting spore has been observed either in *P. bumillariae* or in *P. chlorogonii*.

Further important distinction lies in the host character of all these species. *P. chlorogonii* is parasitic on *Chlorogonium euchlorum* and *P. bumillariae* on *Bumillaria*, the both these hosts are algae. *Chlorogonium* belongs to Chlamydomonadaceae of the order Volvocales and *Bumillaria* belongs to the family Tribonemaceae of the order Heterotrichales (Xanthophyceae). The present species of *Rhizophydium* has *Blastocladia*, a saprophytic aquatic phycomycete as its host.

Associated with the epibiotic sporangium and the extracellular resting spores of *Rhizophydium*, but not belonging to the species was found a germinated resting spore sporangium, 27μ high \times 17μ wide, thin walled, unpunctate, hyaline, smooth walled, wide open orifice with broken edges, precisely similar to the germinated resting spore sporangium, illustrated by Whiffen (1943), belonging to *Blastocladiopsis parva* (Whiffen) Sparrow, originally described by Whiffen as *Blastocladia* (Sparrow 1960, p. 682, fig. H). As *Blastocladiopsis parva* was not among the species of *Blastocladia* of which extensive collections was made by the authors the sporangium in question in most likely to belong to the host species of *Blastocladia* or authors have not been able to recognise

Blastocladiopsis among the *Blastocladia* which may be the true host.

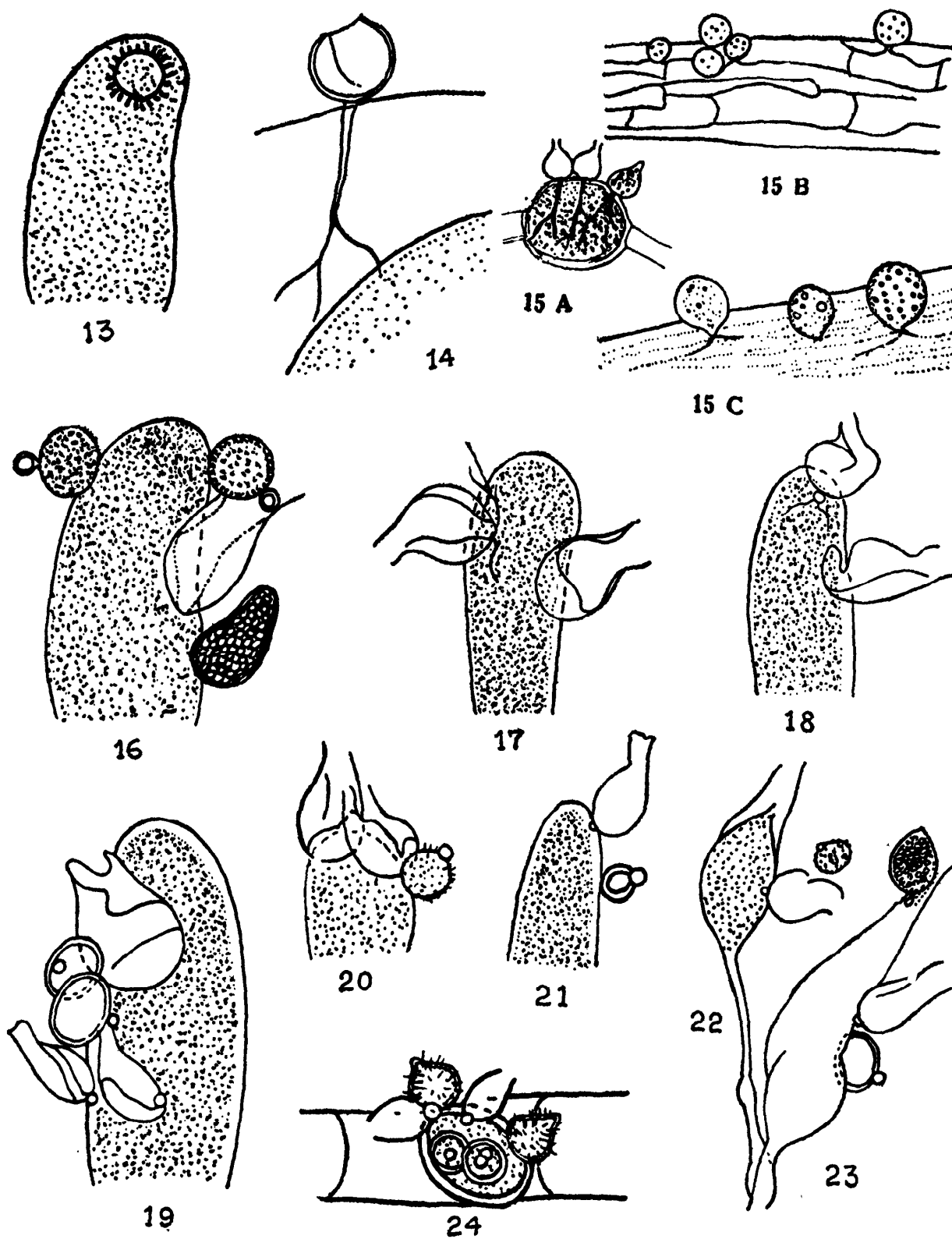
Holotype deposited at the HClO, Division of Mycology and Plant Pathology, IARI, New Delhi, 110 012. HClO No. 37130.

***Rhizophydium lagenaria* sp. nov. (Fig. 21).**

Thallus monocentric; sporangium epibioticum, inoperculatum, lageniforme, $15-17\mu$ altum \times 8μ in parte latissima, collum 6μ , paries tenuis, laevis, hyalina; haustorium parvum, gongylodes, ad extremum basale axiale sporangii, raro nullum; rhizoideum nullum; porus apicalis, $3-4\mu$ latus, extremi apicalis deliquescenti formatus, zoosporae et illarum modus emissi non observatae; paries cassus sporangii rigidus, spora quiescens epibiotica, hyaline, stratis duobus manifestis, exteriore crasso, interiore tenui, sphaerica, 5.5μ in diam., sexualiter formata; thallus masculus sphaericus, 1.5μ in diam, hyalinus, laevis, pariete tenui, facundatio cum thallo foemineo majore, vas vacuum remanens adnatum ad sporam quiescentem; germinatio sporae quiescentis non observata.

Thallus monocentric; sporangium epibiotic, sessile, inoperculate, lageniform, $15-17\mu$ high \times 8μ where widest, neck 6μ , wall thin, smooth, hyaline; haustorium small, knob-like, at the basal axial end of the sporangium on which it rests, occasionally absent; rhizoid absent; pore apical, $3-4\mu$ wide, formed by the deliquescence of the apical end; zoospores and their mode of discharge not observed; empty sporangial wall rigid; resting spore epibiotic, hyaline, two distinct layers, outer thick, inner thin, spherical, 5.5μ in diameter, formed sexually, male thallus spherical, 1.5μ in diameter, hyaline, smooth, thin walled, fertilises larger female thallus, empty case remains adnate to the resting spore; germination of the resting spore not observed.

Parasitic on the sporangium of a *Blastocladia* sp. which develops saprophytically on baited fruits in a tank in the garden of the



Figs. 13-24 : Legend at the end of the article

Botany Department, Lucknow University, Lucknow.

In the flask-shaped epibiotic sporangium with wide open orifice and in the presence of knob-like haustorium representing the endobiotic system which may be absent in the occasional sporangium, the present chytrid is identical to *Rhizophyidium urceolatum* sp. nov. described in preceding pages. It is however, in the nature of the resting spore that the two species are distinguished from each other. In *R. urceolatum* the resting spore is ellipsoidal, 26μ wide \times 22μ high, whereas it is spherical, $5-6\mu$ in diameter in the present chytrid. However, in both, wall is smooth, hyaline, and an empty case of the male thallus remains adnate to the resting spore.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi 110 012. HCIO No. 37131.

***Rhizophyidium spinosum* sp. nov. (Fig. 20).**

Thallus monocentricus; sporangium epibioticum, sessile, inoperculatum, late pyriforme, $20-22\mu$ altum \times 10μ in parte latissima, paries tenuis, laevis, hyalinus, haustorium parvum, sphaericum, gongylodes, ad extremum basale dispositum, rhizoideum nullum, porus apicalis ca 3μ latus, extremi apicalis deliquescenti formatus; zoosporae et illarum modus emissi non observatae; sporangium vacuum partialiter collabens; spora quiescens epibiotica hyalina; parietia spinosa, dilute brunnea, sphaerica, 8μ in diam., sexualiter prodiens, thallus masculus sphaericus, $2-3\mu$ in diam., hyalinus, laevis, pariete tenui, ad thallo foemineo majore affixus, post fecundationem vas vacuum remanens adnatum ad sporam quiescentem; germinatio sporae quiescentes non observata.

Thallus monocentric; sporangium epibiotic, sessile, inoperculate, broadly pyriform, $20-22\mu$ high \times 10μ where widest, wall thin, smooth, hyaline; haustorium small, spherical, knob-like, located at the basal end;

rhizoid absent; pore apical about 3μ wide, formed by the deliquescence of the apical end; zoospores and their mode of discharge not observed; empty sporangium collapse partially; resting spore epibiotic, hyaline, wall spinous, faintly brown, spherical, 8μ in diameter, formed sexually, male thallus spherical, 2.3μ in diameter, hyaline, smooth, thin walled, attached to the larger female thallus, fertilises it and the empty case remains adnate to the resting spore; germination of resting spore not observed.

Parasitic on the sporangium of a *Blastocladia* sp. which develops saprophytically on the surface of the baited fruits in a tank in the garden of the Botany Department, Lucknow University.

The chytrid is characterised by upright, broadly pyriform, epibiotic sporangium basally attached, rhizoidless, knob-like endobiotic haustorium, and ornamented resting spore.

Amongst the known species *P. chlorogonii* Serbinow conforms to the present species both in epibiotic sporangium and endobiotic haustorium whereas *P. eudorinae* Couch has similar sporangium but larger discoid haustorium. Though similar in character, *P. chlorogonii* is parasitic on *Chlorogonium euchlor* of the family Chlamydomonadaceae of order Volvocales, a green alga, whereas the present species of *Rhizophyidium* is parasitic on *Blastocladia*, an aquatic phycomycete. The two species therefore, are specifically different, and even if the yet unobserved resting spore in the species of *P. chlorogonii*, proves in future to be ornamented.

This *Blastocladia*-parasitising *Rhizophyidium* is also different from two other *Rhizophyidium* species also parasitic on the same *Blastocladia* sp. as described by the authors in the previous pages, as *R. urceolatum* sp. nov. and *R. lagenarium* sp. nov. In these the sporangia are flask-shaped, with wide open orifice and partially collapsing wall after zoospore discharge. But highly distinguishing

character is the ornamentation on the wall of the resting spore of the present species. A comparison shows that in *R. urceolatum* resting spores are smooth walled, ellipsoidal, $12\mu \times 9\mu$ in size, those in *R. lagenaria* are also smooth walled, spherical, 5.5μ in diameter, in contrast the resting spore in the present species is spinous, spherical, 8μ in diameter and faint brown in colour.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi, 110 012. HCIO No. 37132.

***Rhizophydium gonapodyanum* sp. nov. (Fig. 23).**

Sporangium epibioticum, sessile, ovoideum ad extremum distalem conicum, $22-33\mu$ altum $\times 13\mu$ latum in parte latissima, pariete tenui, hyalinum, laeve, haustorium endobioticum sub perietem cellulae hospitis ad extremum basale axiale sporangii, gongyloides, parvum, 2μ in diam.; rhizoideum nullum; porus 10μ in diam., extremi apicalis deliquescenti formatus, zoosporae emissae per poram; sporangium vacuum exhibiens colum latum apertum ad extremum distalem, Parieta persistenti, non difformi; zoosporae et illarum modus emissi non observatae spora quiescens extramatrix, elliptica, 16μ alta $\times 19\mu$ late, parietibus duobus; paries exterior crassus, paries interior tenuis, uterque laevis, hyalinus; thallus masculus pervus, sphaericus remanens adnatum ad sporam quiescentem; germinatio sporae quiescentis non observata.

Sporangium epibiotic, sessile, ovoid, distal end conical, $22-33\mu$ high by 13μ broad where widest, thin walled, hyaline smooth; haustorium endobiotic directly beneath the host cell wall, at the basal axial end of the sporangium, knob-shaped, small, 2μ in diameter; rhizoid absent; discharge pore 10μ in diameter, formed by the dissolution of the apical end, through which zoospore emerge; empty sporangium exhibit wide open neck at the distal end, wall persistent, not deformed; zoospores and their mode of discharge

not observed; resting spore extramatrix, elliptical, 16μ high $\times 19\mu$ wide, double walled, outer wall thick, inner wall thin, both smooth, hyaline; male thallus small, spherical, persists adhered to the body of the resting spore; germination of the resting spore not observed.

Parasitic on the sporangium of *Gonapodya polymorpha* Thaxter which grew in the baited apple fruit, in tanks in the garden of the Botany Department, Lucknow University.

The chytrid is characterised by ovoid sporangium, endobiotic, small, knob-shaped, basal haustorium, total absence of rhizoid, and extramatrix ellipsoidal, smooth, hyaline resting spore. In these specific characters the chytrid does not conform to any known species of *Rhizophydium*, except *R. urceolatum* parasitic on *Blastocladia*. Here too, there are several points of difference in the sporangium and resting spore of the two species. The sporangium is $17-20\mu \times 7-9\mu$ in size and narrow necked, lageniform in shape in *R. urceolatum* retaining its normal shape even after zoospore discharge, whereas in the present chytrid it is $22-23 \times 8\mu$ in size, distal end conical when young, but empty sporangium after zoospore discharge assumes wide cylindrical form at distal end, pore 10μ in diameter.

The resting spore in both are similar, ellipsoidal, double walled, hyaline, smooth, differing, however, in size, longer, 16μ high $\times 19\mu$ wide, whereas $8-9\mu$ high $\times 10-12\mu$ broad, respectively in the present species and *R. urceolatum*. Apart from these differences, the present chytrid is parasitic on *Gonapodya* belonging to the order Monoblepharidales, *R. urceolatum* sp. nov. is parasitic on *Blastocladia* of the order Blastocladiales.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi 110 012. HCIO No. 37133.

***Rhizophydium stellatum* sp. nov. (Fig. 22).**

Sporangium epibioticum, sessile, late pyri-

forme, 26μ altum \times 18μ latum, paries tenuis, hyalinus, laevis, collum constrictum ; haustorium endobioticum ad extremum basale, axiale, modo subter cellulis parietis hospitis, sub sporangium, gangylodes, parvum, 1.5μ in diametro, porus extremi apicalis deliquescenti formatus, 6μ latus, sporangium vacuum post emissionem zoosporarum retinens formam normalem ; rhizoideum nullum ; zoosporae et illarum modus emissi non observatae ; spora quiescens extramatrix, ovoidea, $13.5\mu \times 10\mu$, vel sub sphaerica, parietibus duobus, paries exterior crassus, verrucosus, paries interior tenuis, cysta mascula parva, sphaerica, adnata ad sporam quiescentem ; germinatis sporae quiescentis non visa.

Sporangium epibiotic, sessile, broadly pyriform, 26μ high \times 18μ wide, wall thin, hyaline, smooth, neck constricted ; haustorium endobiotic, at the basal axial end, directly beneath the host cell wall, on which the sporangium rests, knob-shaped small, 1.5μ in diameter ; discharge pore formed by the dissolution of the apical end, 6μ wide, empty sporangium after zoospore discharge, retains its normal shape ; rhizoid absent ; zoospores and their mode of discharge not observed ; resting spore extramatrix, ovoid, $13.5\mu \times 10\mu$, or subspherical, double walled, outer wall thick, verrucose, inner wall thin ; male cyst small, spherical, adhered to the body of the resting spore ; germination of resting spore not observed.

Parasitic on the sporangium of *Gonapodya polymorpha* Thaxter which developed on the surface of the baited apple fruit, in the tanks in the garden of the Botany Department, Lucknow University.

The chytrid is characterised by broadly pyriform sporangium, knob-like haustorium, absence of rhizoid and verrucose resting spore. In these specific characters the fungus does not conform to any known species of *Rhizophydium*. The only species to which it shows certain similarity is *R. spinosum* sp.

nov. described by the authors. Here too, there are some differences between the two. In *R. spinosum* sp. nov., the sporangium in early stage is pyriform, but after zoospore discharge, the apical end assumes a wide mouthed cylindrical form. In the present fungus, on the other hand, the pyriform sporangium after discharge retains its normal shape ; the apical end forms a wide pore, but not as wide as in *R. spinosum* sp. nov. nor the neck is cylindrical. The resting spore in both are double walled, the outer wall of which is verrucose in the present fungus whereas spinous in *P. spinosum*. In the size again, the latter is spherical, 8μ in diameter, whereas ovoid, $13 \times 10\mu$ or subspherical in the present species. *R. verrucosum* Cjep with verrucose resting spore too is very different. An important distinction lies in the host character. *R. spinosum* is parasite on *Blastocladia* and this fungus on *Gonapodya*. The former belongs to the order Blastocladales and the latter to the order Monoblepharidales. In the light of differences discussed above the chytrid is identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110-012, HCIO No. 37134.

***Rhizophydium blyttiomycerum* sp. nov.**
(Fig. 24).

Thallus monocentricus, eucarpicus ; sporangium epibioticum, sessile, pyriforme vel fusoidem, $20-22\mu$ altum \times $12-14\mu$ latum, paries singulus, tenuis, laevis, hyalinus, zoosporangium persistens, parvum, gongylodes ad extremum basale axiale ; rhizoideum nullum ; zoosporae emissae per porum apicalem, porus extremi apicalis deliquescenti formatus, $5.5-7.5\mu$ latus ; zoosporae et illarum modus emissi non observatae ; spora quiescens nulla.

Thallus monocentric, eucarpic ; sporangium epibiotic, sessile, pyriform or fusoid, $20-22\mu$ high \times $12-14\mu$ wide, wall single,

thin, smooth, hyaline, zoospore case persistent, small, knob-like at the basal axial end acting as haustorium; rhizoid absent; zoospores discharged through a pore formed by the dissolution of the apical end, $5.5-7.5\mu$ wide; zoospores and their liberation not observed; resting spore absent.

Parasitic both on the sporangium of *Blyttomyces spinosus* sp. nov. as well as on the zygospore of *Spirogyra* species on which *B. spinosus* is parasite. The infected filaments of *Spirogyra* were collected from a ditch by the side of the Sultanpur Road 11 miles south east of Lucknow University.

The chytrid is characterised by fusoid or pyriform sporangium whose endobiotic system is small knob-like haustorium, superimposed on the base of the sporangium of the chytrid *Blyttomyces spinosus* itself parasitic on the zygospore of a *Spirogyra* sp. The sporangia found were empty, exhibiting, thin, hyaline, smooth wall, wide open discharge pore formed by the dissolution of the apical end. The endobiotic system is small knob-like haustorium without any rhizoid. The superimposition of the sporangium of the *Rhizophydium* sp. on those of *Blyttomyces spinosus* is suggestive of its parasitic habit. It is also a parasite on zygospore of *Spirogyra*, the host of *B. spinosus*.

In the character of the sporangium and in the endobiotic system the known species of *Rhizophydium* that approximates the present species seems to be *Phlyctidium chlorogonii* Serbinow which is characterised by sessile pyriform sporangium with small protruding papilla, thin, smooth, colourless wall and inconspicuous knob-like haustorium. Even this one does not conform to the present species. The sporangium of *P. chlorogonii*, whose height is not recorded is $6-8\mu$ in diameter, but the width of the sporangium of our species is much larger, $12-14\mu$ and the height is $22-24\mu$. Further against the knob-like inconspicuous haustorium of *P. chloro-*

gonii, similar but fairly prominent haustorium, $5-7\mu$ in diameter characterises this species. The apical discharge pore too, is much wider, $6.5-11\mu$. The more significant distinction lies in the host character. *P. chlorogonii* grows on dead or moribund *Chlorogonia euchlorum* an unicellular motile form of alga belonging to the Chlamydomonadaceae of Volvocales and is practically a saprophyte, the present species of *Rhizophydium* on the other hand is parasitic on the sporangium of *Blyttomyces spinosus* which is an aquatic phycomycete, as well as parasitic on zygospore of the *Spirogyra* sp. which is the host of *B. spinosus*. Thus parasitising both a chytrid and an alga. This creates reservation to the use of the host character alone as the criterion for distinguishing a species.

The host *Spirogyra* exhibits resting spore in its zygospore simultaneously infected by *B. spinosus* and *R. blyttomycerum* which closely conform to the resting spore produced by the former, the only difference lies in its smaller size. Zygospore exclusively infected by *R. blyttomycerum* has not been observed to produce resting spore. But as described in our previous papers the resting spores produced by five other species of *Rhizophydium* parasitising *Blastocladia* and *Gonapodya* are all extramatrical and with adnate male thallus when sexually produced, absent when formed in asexual manner. The resting spore in the present case is endobiotic and without adnate male thallus. It can be deduced from the above that the resting spore is asexually produced and belongs to the species *Blyttomyces spinosus* and not *Rhizophydium blyttomycerum*. The size range of the resting spore of the former has to be extended to include the smaller resting spore observed here.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology IARI. New Delhi-110 012, HCIO No. 37174.

Rhizophydium rotundum sp. nov. (Figs. 25-27).

Sporangia epiendobiotica, sessilia, inoperculata, laeva, sphaerica, $15-22\mu$ in diametre vel subsphaerica; apophysis quae agunt mode haustorii, intramatrix, orientes a basali termino sporangii, laeva, sphaericae, subsphaericae $10-18\mu$ in diam. aliquae specialiter magne, cupiforme, subtendentes sporangium, cistae zoosporae apicales aliquando sporangii sphaerici; rhizoidea nulla; ejicit papillas breves, quod dehiscence cacumen deliquit ad foramen $4-6\mu$ diam. zoosporae numerosae (ca 100) emergentes prolapsentes per ora apicalia facta a mole globoso, membrana mucosa involutae, requiescentes ad os foramenii 1-2 min., deinde disjunctae et ad extra natante; sporangium vacuum retinens usitatum facium; zoosporae sphaericae, $2.5-4\mu$ diam. incoloratae cum granulis centralibus refractivis; flagellum longum posterius; sporae perdurantes endobioticae sitae cum quadam libertate in cellule hospitali, offerentes seriem in modo lineae, sphaericae, $15-20\mu$ diam., membrana robusta cum granulis refractivis; per germinationem oritur sporangium per apicalem porum, sic agens ut prosperangium, endobioticum, sphaericum, circa 8μ diam. cum membrana tenui, incolorata; ultimae evolutiones non observatae.

Thallus monocentric, eucarpic; sporangia epiendobiotic, sessile, inoperculate, smooth, ovoid, $15-22\mu$ in diam. or subspherical; apophysis functioning as haustorium, intramatrix, formed at the basal end of the sporangium, smooth walled, spherical or subspherical, $10-18\mu$ diam., some conspicuously large, cupular, subtending the sporangium; zoospore cyst present at the apical end of some spherical sporangia; rhizoid absent; discharge papilla apical, at dehiscence the tip dissolves to form a pore, $4-6\mu$ diam.; zoospores mature inside the sporangium, numerous (ca 100), emerge outside, gliding through the apical pore forming a globular mass enveloped by a slimy sheath, remain

quiescent at the rim of the orifice for 1 or 2 min. then disentangle and dart away; empty sporangium after zoospore discharge retains its shape; zoospores spherical, $2.5-4\mu$ diam. hyaline with a central refractive globule; flagellum long, posterior; resting spore endobiotic, loosely free in host cell, present in a linear series, spherical, $15-20\mu$ diam. thick walled with refractive granules, on germination forms a sporangium which emerges through the apical pore, thus functioning as prosperangium; sporangium endobiotic, spherical, 8μ diam., thin walled hyaline, full of unformed zoospores, further development not observed.

Parasitic primarily on a species of *Closterium* and on a few filaments of *Cedogonium* sp. and *Zygnema* sp. collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The fungus has been identified as belonging to the genus *Rhizophydium* in which the endobiotic haustorium is discoid, isodiametric and unbranched. In specific character the chytrid belongs to that category of the genus *Rhizophydium* in which the wall of the sporangium is persistent at least for a short time at discharge of the zoospores, of uniform thickness. The present chytrid in its empty state, when the discharged zoospores as a globular mass rest at the rim of the orifice prior to final dispersal, retains its normal shape and the wall is persistent. The ovoid or spherical sporangium with basally attached discoid, unbranched haustorium resembles *Phlyctidium bumilleriae* Couch, about which much is not known. But a distinct difference exists between the two in the size of the sporangium, $5-7\mu$ in diameter in *P. bumilleriae* against $15-22\mu$ in diameter of that of the present chytrid. The haustorium, too, is larger in the present one than that in *P. bumilleriae*, which is described as small, bulbous or discoid. The other characters such as the zoospore size and resting spore could not be compared as these were

not seen by Couch (1932). It is evidently not *P. chlorogonii* Serbinow, considered by Couch to be close to *P. bumulleriae*, in which the sporangium is pyriform and the haustorium is small and knob-like.

Several resting spores were found in the species which were spherical, thick walled, lying loosely free in a linear series in the host cell, fully endobiotic, as opposed to the resting spore of the genus *Septosperma* Whiffen, which has a sterile proximal half separated by a septum, the character that is distinctive of *Septosperma*. In the present chytrid an important finding is the germination of the resting spore giving rise to the spherical sporangium endobiotically, which emerges through the apical pore. It functions as prosperangium.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi, 110 012. HCIO No. 37091

***Rhizophydium tubulatum* sp. nov.** (Figs. 31-33).

Sporangia epiendobiotica, sessilia, inoperculata laeva, sphaerica, 20-28 μ in diametro, vel ovoidea, 20-38 μ alta \times 18-35 μ lata, basis partim inserta in cellula hospitali, assumandum forma urna postquam ejectionae zoosporae, 24 μ alta \times 34 μ lata; vacuum sporangium persistens; cistae zoosporae activae permanens in aliquibus sporangiis; basis partim, apophysis et rhizoidea, endobioticae; apophysis sphaerica, 8-10 μ diam., late fusiforme, 10-15 μ alta \times 10-12 μ lata; rhizoidea quae agunt ut modo haustorii orientis ut prolongatio basis apophysis, raro producent septum, forma cylindrica, sine ramis, 2.2-6.5 μ lata, fines saepe non visibiles in densis cellulis corporis maximalongitudo 60 μ observata; ejectionis foramen apicalis ca 20 μ in diametro a delinquenti cacumine sporangii; zoosporae emergunt ut moles in membrana muco involuta, quiescentes per 1-2 min. ad os in fine se liberant et libere natant, sphaericae, 4.5-7 μ diam.; flagellum solitarium, posterius,

incoloratum; sporae perdurantes non observatae.

Thallus monocentric, eucarpic; sporangia epiendobiotic, sessile, inoperculate smooth, spherical, 20-28 μ in diameter, or ovoid, urn shaped after zoospore discharge 24 μ high \times 34 μ wide, base partly embedded in the host cell matrix, empty sporangial wall persistent; functional zoospore cyst persists in some sporangia; in endobiotic portion, apophysis at the basal end of the sporangium spherical, 8-10 μ in diameter broadly spindle shaped, 10-15 μ high \times 10-12 μ wide; rhizoid functioning as haustorium formed as an extension of the basal end of the apophysis, continuous with it rarely forming a septum, cylindrical, unflated, unbranched, 2.2-6.5 μ diam. terminal end indiscernible in dense cell contents, longest observed 60 μ ; discharge pore apical, about 20 μ diam. formed by the dissolution of the distal part of the sporangial surface; zoospores mature inside the sporangium rarely completes maturity outside, emerge in a mass enveloped in a slimy sheath, remain quiescent for a while at the orifice, eventually pull themselves apart and swim away; mature zoospores spherical with a long, hyaline, posterior flagellum; resting spore not observed.

Parasitic on a species of *Closterium* collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The fungus is identified as belonging to the genus *Rhizophydium*. Sporangium is variable in shape, so also the apophysis which is bulbous or ovoid. The apophysis is continuous with the tubular double contoured, unbranched rhizoid arising from the base, rarely septum partitioning the rhizoid from the apophysis; zoospore cyst is evident in some empty collapsed sporangium, that bears no indication of the presence of discharge pore. After zoospore discharge sporangium wall persists.

In specific characters the chytrid showed some resemblance to *Phlyctidium irregulare*

de Wildeman (1890) in which the haustorium is a continuation of sporangial stalk, tubular and unbranched $2.7-4\ \mu$ wide, as well as to *Phlyctidium olla* Sparrow (1933) in which haustorium is unbranched, inflated tubular, $12 \times 2\ \mu$ and no apophysis. The closest resemblance, however, is with *Phlyctidium apophysatum* Canter (1947) where the haustorium, as name implies is apophysate, continuous with tubular rhizoid, the characters that distinguish the present chytrid, but there are distinct differences. In *Phlyctidium apophysatum* the sporangium is $9-17\ \mu$ in diameter, apophysis $6.7-10\ \mu$ and the longest tubular rhizoid is $24 \times 7\ \mu$ respectively, against those in the present chytrid, sporangium $20-28 \times 18-35\ \mu$, apophysis $10-15 \times 10-12\ \mu$ and the longest discernible rhizoid $60 \times 6.5\ \mu$. Apart from these differences in size, the more important is the distinctive character that in the present chytrid the tubular rhizoid is never swollen, it is uniformly wide surmounted by bulbous or spindular apophysis.

The mode of zoospore discharge is also characteristically different in the two. Unlike in *P. apophysatum* Canter, in the present chytrid zoospores emerge in a mass enveloped in a slimy sheath and rest at the orifice prior to their dispersal. The sporangium after zoospore discharge assumes urn shaped structure. Zoospores are oval in *P. apophysatum* whereas spherical in the present case. The host character, too, is different. *P. apophysatum* is parasitic on *Mougeotia* sp. and this fungus on *Closterium* sp. a desmid.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37092.

Rhizophydium poculiforme sp. nov. (Figs. 28-30).

Sporangia epiendobiotica, sessilia, inoperculate, ellipticae vel subsphaerica, $12-28\ \mu$ lata $\times 10-20\ \mu$ longa, membrana tenue, laeva, basi partim inserta in cellula hospitali ;

haustoria endobiotica, membrana laeva, subsphaerica, $15\ \mu$ diam. rhizoidea nulla ; ejicit papillus breves, robustus, $ca\ 3\ \mu$ altas, quod dehiscent cacumen deliquit ad foramen, $4\ \mu$ diam. ; zoosporae numerosae, emergentes per ora apicula, facta et mole globoso, membrana mucosa involutae, requiescentes ad os foramenii, 1-2 min. deinde disjunctae et ad extra natante ; relique membrana epibiotica evanescit, et pars endobiotica permanet cum magnum poculum $ca\ 20\ \mu$ diam. ; zoosporae sphaericae $2.5-4\ \mu$ diam., incoloratae cum granules refractivis ; flagellum singulum, longum, posteriorum sporae perdurantes non observatae.

Thallus monocentric, eucarpic ; sporangium epiendobiotic, sessile, inoperculate discoid, elliptical or subspherical, $12-28\ \mu$ wide $\times 10-20\ \mu$ high, wall thin, smooth, hyaline, base partially embedded in host cell matrix ; haustorium endobiotic, at the base of the sporangium, smooth walled, subspherical, $15\ \mu$ in diameter, mostly smaller than the sporangium it subtends ; rhizoid absent ; discharge pore short, stout, about $3\ \mu$ high, at dehiscence the tip dissolves to form a pore $4.0\ \mu$ in diameter ; zoospores mature inside the sporangium, numerous, emerge through the apical pore, forms a globular mass at the orifice, enveloped in a slimy sheath, remain quiescent at the rim of the orifice for 1-2 minutes, then disentangle and dart away ; following the spore discharge the wall of the epibiotic portion of the empty sporangium eventually deliquesce whereas the endobiotic portion, large, bowl shaped persists ; zoospores spherical, $2.5-4\ \mu$ in diameter, hyaline with refractive granules ; flagella single, long, posterior ; resting spore not observed.

Parasitic on a species of *Closterium*, collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The chytrid conforms to *R. rotundum* sp. nov. described earlier. The sporangium is epiendobiotic, haustorium endobiotic, dis-

coid, and there is complete absence of rhizoid. Zoospore character, its mode of discharge through the apical pore, the formation of globular mass at the orifice, all are similar. Some difference exists in the shape of the sporangium, and in the discharge pore which is papillate, raised much above the sporangial surface than that of *P. closterii* sp. nov. These, however, are minor differences. The character that distinguishes from *R. rotundum* is the deliquescence of the epibiotic portion of the sporangial wall, following the zoospore discharge. Sparrow (1960) lists in his monograph two species of *Phlyctidium*, namely *P. piriformis* Fott and *P. tenue* Sparrow, in this category in which the wall of the sporangium deliquesces or collapse and fracture following zoospore discharge. In the former, the zoospores are liberated upon the discharge of the uniformly delicate, entire wall of the sporangium. In the latter (*P. tenue*) the lower part of the sporangial wall is distinctly thickened, and at zoospore discharge, the thin upper part collapse and fragments, leaving a thick wall-like cup like base.

The species described here conforms to none of these. Like *P. piriformis* it has uniformly delicate, entire sporangial wall, but unlike it, instead of the whole sporangial wall deliquescing and liberating the zoospores, it is only the epibiotic portion that deliquesces after zoospore discharge; the endobiotic embedded portion retains its normal cup shaped structure, which is not thickened as obtains in *P. tenue*. The haustorial character is also different: discoid in the present species, slender double contoured in *P. tenue* and in *P. piriformis* the rhizoids are slender.

The identity of the present species, as one entirely different from both these known species is evident. The chytrid has thus been identified as a new species because of its bowl-like sporangial remnant.

Holotype deposited at HCIO, Division of

Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37093.

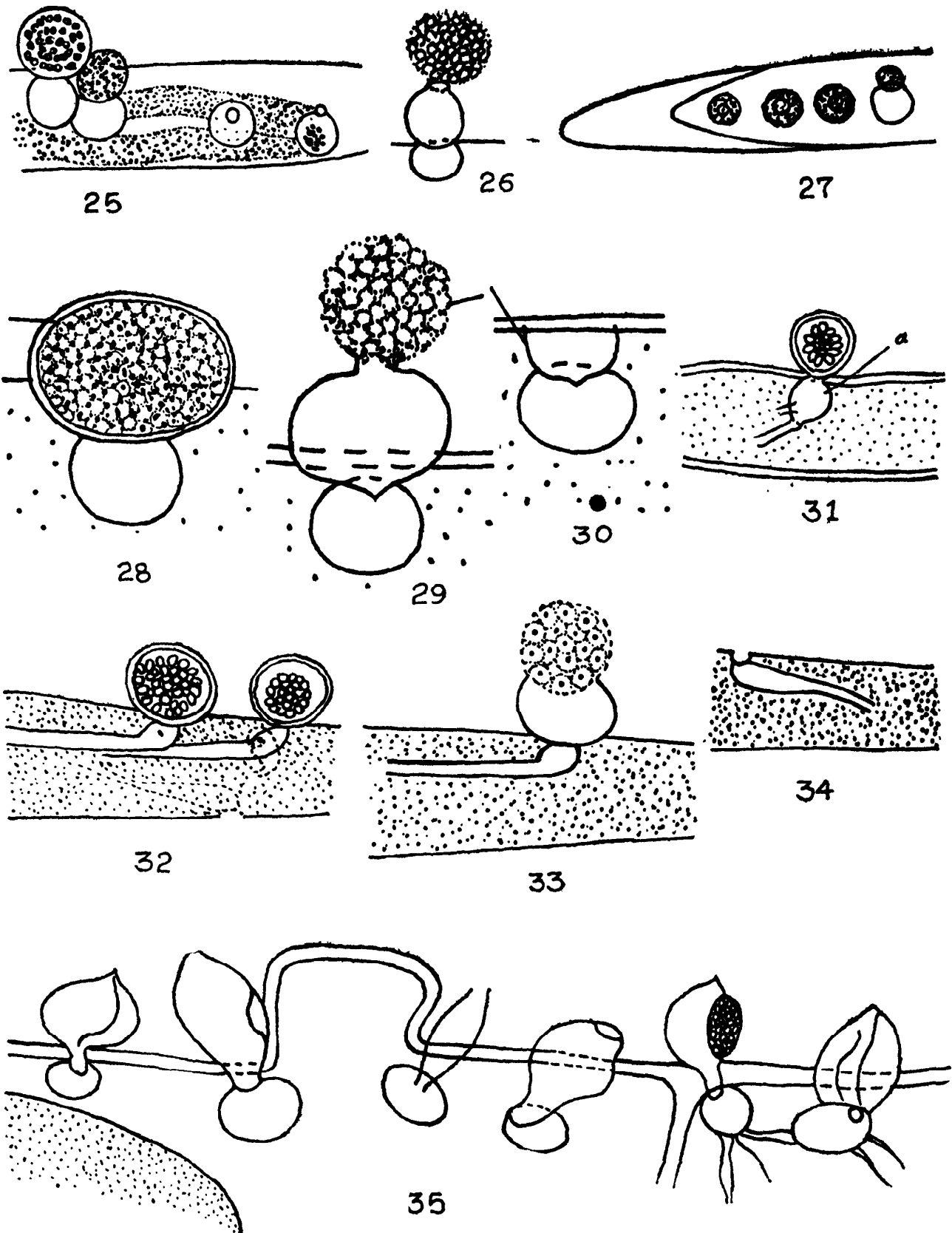
***Rhizophyidium clavatum* sp. nov.** (Fig. 34).

Sporangia epiendobiotica, sessilia, sphaerica vel subsphaerica, 6μ diam., membrana tenue, laeva, basis partim inserta in cellula hospitali; apophysis (haustorium) endobiotica, clavata, 35μ longa \times 10μ lata; rhizoidea quae orientis ut prolongatis basis apophysis, raro produciens septum, forma cylindrica, 30μ longa \times 3μ diam., sine ramis; membrana epibiotica evanescit et pars endobiotica permanet cum minutum poculum; zoosporae modus ejectione et sporae perdurantes non observata.

Sporangium epiendobiotic, sessile, spherical or subspherical, 6μ in diameter, thin walled, smooth, hyaline, base partially embedded in host cell matrix; apophysis (haustorium) endobiotic, abaxial, clavate, approximately 35μ long \times 10μ where widest; rhizoid formed as an extension of the apophysis, tubular, of limited length 30μ long \times 3μ diameter, unbranched, continuous with it, or sometime partitioned by septum; wall of the epibiotic portion of the sporangium fully deliquesce after zoospore discharge, whereas the wall of the embedded endobiotic base persists as an open bowl, attached to the apophysis; zoospores, their mode of discharge and resting spore not observed.

Parasitic on a species of *Closterium*, collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The investigation of a few infected individuals of *Closterium* revealed the presence of several specimens of the present chytrid. All of these were imperfect in form, in which the epibiotic portion of the sporangium had fully evanescenced, leaving only the endobiotic, persistent basal portion, together with the apophysis and rhizoid. Close search for individuals with undischarged sporangium proved to be unsuccessful.



Figs. 25-35 : Legend at the end of the article

The chytrid is characterised by thin wall-ed, spherical or subspherical sporangium by its minute size, $6\ \mu$ in diameter, the embedded base of which is attached to the abaxial tip of the clavate apophysis extended to form tubular rhizoid, as well as in the complete evanescence of the wall of the epibiotic portion of the sporangium and the bowl shaped, persistent base, embedded in cell matrix. Sparrow (1960) in his monograph listed only two species of *Phlyctidium* in which the wall of the sporangium either evanesce to liberate the zoospores or collapse and fragments after their discharge, namely *P. piriformis* Fott and *P. tenue* Sparrow. To these the present authors have earlier added one more species *R. poculiforme* sp. nov. None of these conform to the present chytrid.

There are distinct differences in the endobiotic parts of these four chytrids. In *P. piriformis* the endobiotic part consists of short or long, slender, stalked apophysis arising from sporangium, and filamentous rhizoid. *P. tenue* is distinguished by double contoured, slender haustorium, usually straight, unbranched and isodiametric of variable length; *R. poculiforme* sp. nov. distinguished by discoid haustorium without rhizoid, whereas in the present chytrid, it is clavate apophysis with tubular rhizoid formed as its extension.

The form of evanescence, too, is different. In *P. piriformis*, the deliquescence of sporangium is complete, leaving no basal remnant. In *P. tenue* the cup shaped base persists as the sporangium collapses and fragments after zoospore discharge. Similar cup shaped base exists in *R. poculiforme* sp. nov. as well as in the present chytrid, both embedded in host cell matrix, formed by the partial evanescence of the epibiotic wall of the sporangium.

The cup shaped basal remnant in these three species are different from each other. In *P. tenue* the wall of the persistent base is thick. It is thin in the species *R. poculiforme*

as also in the present chytrid, but the former is $24\ \mu$ in diameter and $6\ \mu$ diameter in the latter. There is a distinct similarity of the chytrid to *R. tubulatum* sp. nov. already described by us, so far as the endobiotic portion is concerned. But besides other differences the wall of the sporangium of *R. tubulatum*, unlike that of the present chytrid, retains its normal shape after zoospore discharge. In the light of the characteristics discussed above, is identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37094.

***Rhizophydium conchiforme* sp. nov. (Fig. 35).**

Sporangia epiendobiotica, inclinata, per occasionem erecta, conchiforme vel fusiforme, $18-30\ \mu$ alta \times $13-18\ \mu$ lata, membrana tenue, laeva, incolorata, portio apicis curvata, apiculus acuminatus, portio remota pauletin contractus, basis terminus papilliformis; apophysis (haustorium) endobiotica, subsporangica, sphaerica, $10-13\ \mu$ diametro vel elliptica, $9-12\ \mu$ altae \times $10-20\ \mu$ latae, membrana tenui, incolorata; isthmus lata, conjunctio sporangium cum apophysis; rhizoida plerumque absentes, quands presentes oriens ab basales positus in apophysis, filamentosae, breves, sine ramis; zoosporae emergunt singillatim per formina apicalia, rariae ut moles mucosa spisda per rima laterales, et requiscentes immobilis ad os 1-2 min. deinde separate et currant abeo; zoosporae sphaerica, $3-4\ \mu$ diam., cum 1-2 centris globules, singulum, longum, posteriorum flagellum; sporae perdurantes non observatae.

Thallus epiendobiotic, monocentric, eucarpic; sporangium inclined, occasionally erect, conchiform, rarely fusiform, $18-30\ \mu$ high \times $13-18\ \mu$ wide, wall smooth, hyaline apical and sharply curved, apiculus pointed, base gradually tapering, terminating in a papilla of variable size; apophysis (haustorium) endobiotic,

subsporangial, subtending the sporangium, discoid, spherical, $10-13\mu$ in diameter, or ellipsoidal, $9-12\mu$ high \times $10-20\mu$ wide, wall thin, hyaline, isthmus wide, sporangium continuous with haustorium; rhizoid absent, rarely arising from the basal end of the haustorium, filamentous, of limited length, unbranched; apiculus deliquesce forming a wide pore; zoospores emerge individually through the pore, settle at the orifice, rarely through a lateral slit as a compact slimy mass, remain motionless for a minute or two, thereafter disentangle and dart away; zoospores spherical, $3-4\mu$ in diameter with 1-2 central globules, single, long, posterior flagellum; resting spore not found.

On the vegetative cell of a *Spirogyra* sp., collected from a ditch by the side of the Sultanpur Road, 11 miles south east of Lucknow University.

The chytrid is characterised by conchiform sporangium which are widest at the middle, tapering both towards the base, and the apical end where it usually forms more or less pointed apiculus. The tapering basal end becomes papillate at the extremity. There are several fusiform sporangia which show gradual transition from narrow to conchate type. The haustorium is disc shaped, spherical or ovoid, subtending the sporangium, very similar to the type formed in *Rhizophyidium rotundum* sp. nov., described earlier. A wide isthmus is formed by the dissolution of the wall at the basal extremity, forming a passage making sporangium continuous with the haustorium. As in *R. rotundum* rhizoid is absent in the present species, though on rare occasion a few basal rhizoids, short and filamentous arising from the base of the discoid haustorium, have been observed. On the maturity of the sporangium, the apical extremity dissolves and form a pore which is prominent, providing normal passage for the fully formed zoospores, which emerge individually, settle motionless for a very shortwhile, then disentangle and

swim away. In *R. rotundum* sp. nov. the zoospores emerging through the pore forms a globular mass at the orifice. Such aggregation has not been observed in the present species. Apart from this normal type of zoospore discharge, a second type has been in which the sporangium fails to form the apical discharge pore, instead a lateral slit is formed through which the zoospores emerge as a compact mass, and eventually disentangle and swim away. This mode of discharge is rare and occur in some sporangia which either formed rhizoid from the discoid haustorium or were rhizoidless. How far these two characters, the presence of rhizoid and also lateral discharge of zoospores in the same sporangium are suggestive of their different identity, requires further investigation to elucidate.

The present species does not conform to any known species of *Rhizophyidium* including the several new species described by the present authors.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37095.

PHLYCTOCHYTRIUM

The genus *Phlyctochytrium* was established by Schroeter in 1892, to rename *Chytridium hydrodictyi* Braun (1855), *Phlyctidium hydrodictyi* (Braun) Rabenhorst (1868) a part of his own *Phlyctidium* (1885) as well as *Rhizidium* (Braun) Fischer (1892). It is only recently that the cultural and ultrastructural investigations of the characteristics of the zoospores of the *Rhizophyidium* and *Phlyctochytrium* and a few other related groups of lower fungi that resulted in a completely revised generic classification and the establishment of a new order of Spizellomycetales comprising of 4 genera of which *Spizellomyces* is one, (Barr 1980). Barr, however specifically mentions that "This new classification is strictly intended for culture and

neither augments nor replaces earlier and more classical systems" (Barr 1984). The present authors in their studies retain the classical taxonomic status of these fungi.

The first report of *Phlyctochytrium* from India is from Karling (1966). He discovered 4 species namely *P. chaetiferum* Karling, *P. planicorne* Atkin, *P. indica* Karling a new species, and one unnamed species *P. sp.* The two new species of *Phlyctochytrium* discovered by us, both on a species of *Closterium* have been termed *P. apophysatum* and *P. dissolutum* both identified as new species.

***Phlyctochytrium apophysatum* sp. nov. (Fig. 36).**

Thallus epiendobioticus, monocentricus, eucarpicus, numerosus, sporangium epibioticum, sessile, sphaericum, 40-45 μ in diam., pariete tenui, laevi, ecolorato, apophysis sub sporangio, e puncto singulo axiali oriens, bene evoluta, basi tumida, clavata, 35 μ longa \times 15 μ in parte latissima, vel late fusoida, 30 μ longa \times 30 μ lata; rhizoidea orientia e apice extremi acuti apophysis, filamentosa, flexilia, sensim angustata, sparsim ramosa ad extremum distalem, saepe obscura; porus formatus dissolventi papillae parum prominentis, lateralis, aequatorialis vel sub-basalis, uniporus; zoosporae subsphaericae, 3-4 μ in diametro, cum singulo flagello postico; spora quiescens non observata.

Thallus epiendobiotic monocentric, eucarpic, numerous; sporangium epibiotic, sessile, spherical, 40-45 μ in diameter, thin walled, smooth, colourless; contents heterogeneous with refractive globules; apophysis sub-sporangia arising from a single axial point, well developed, swollen base of diverse shapes, clavate, 35 μ long \times 15 μ where widest or broadly fusoid, 30 μ long \times 30 μ wide, contents with refractive globules; rhizoid arises from the tip of the pointed end of the apophysis, filamentous, flexible, gradually tapering, sparsely branched at the distal end, often obscure

due to dense cell contents; discharge pore formed by the dissolution of slightly raised papilla, lateral, equatorially located or sub-basal, uniporous; zoospores mature inside the sporangia, subspherical, 3-4 μ in diameter, with single, posterior flagellum resting spore not found.

On a species of *Closterium* collected from one of the tanks in the garden of the Botany Department, Lucknow University, Lucknow.

The genus *Phlyctochytrium* is characterised by epiendobiotic thallus. The sporangium is epibiotic, inoperculate, uni-or multiporus, without apiculus. The discharge pore is usually apical. The endobiotic system is apophysis giving rise to rhizoid. It differs from Sparrow's *Phlyctidium* and *Rhizophydium* in the endobiotic system, which is a sphere or a double contoured structure in the former, in the latter, branching system is rhizoid, arising from the tip of the germ tube.

The specific characters of the present *Phlyctochytrium* is that it is epibiotic, sessile, uniporus, perfectly spherical sporangium, 40-45 μ in diameter. The discharge pore formed by the dissolution of slightly raised papilla, is lateral or sub-basal, never apical. The apophysis is subsporangial, having swollen base of diverse shape, clavate or fusoid, pointed end, from which rhizoid arises as a single filament, gradually tapering, sparsely branched at distal end, generally extends right up to the entire length of the host cell.

The present species does not conform to any of the known species of *Phlyctochytrium* including *P. indica* a new species discovered by Karling in 1964, in which sporangium is spherical or broadly citriform, 10-18 μ diameter, exit papilla apical and apophysis elongated, irregular. The other Indian species *P. sp.* Karling has 5-12 barely discernible exit papilla. The only species also parasitic on a species of *Closterium* showing certain similarities is *Phlyctochytrium clos-*

terii (Karling) Sparrow originally described by Karling as *Rhizophlyctium closterii*, though it distinctly showed apophysis. In this species the sporangium is spherical, $(10-18)\mu$ or broadly pyriform with broad, low down apical exit papilla, 8μ in diameter, rhizoidal system arising from subsporangial swollen apophysis, richly branched occasionally extends to entire host cell.

The two species are clearly distinguished by, the shape of the sporangium the location of the discharge pore, the shape of the apophysis, the nature of the rhizoids and their branching. The resting spore is not comparable as it has not been observed in our species.

In consideration of all these differences, the present chytrid has been identified as a new species of *Phlyctochytrium*.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology IARI, New Delhi-110 012. HCIO No. 37175.

***Phlyctochytrium dissolutum* sp. nov.** (Fig. 37).

Thallus epiendobioticus, monocentricus, eucarpicus; sporangium epiloticum, sessile, sphaericum, 35μ in diam., pariete tenui, laevi, incolorato, contentum heterogeneum cum globulis refractivis; apophysis endobiotica, subsporangialis, oriens ad basin e puncto singulo axiali; rhizoideum oriens extremitate acuto distali apophysis, filamentosum, flexile, gradatim angustatum; ramificatis ad extremum distalem plerumque obscura; zoosporae emissae a dissolutione completa parietis sporangialis, zoosporae primo remanentes aggregatae, demum depulsae et natantes; zoosporae subsphaericae, 4μ diam., vel ovaes, cum flagello posteriore spora quiescens non visa.

Thallus epiendobiotic, monocentric, eucarpic, consisting of sporangium, apophysis and rhizoids; sporangium epibiotic, sessile, spherical, 35μ in diameter, wall thin, smooth, colourless, contents heterogeneous with re-

fractive globules; apophysis endobiotic, subsporangial, arising at the base from a single axial point, swollen with refractive globules; rhizoid arises as a prolongation of the pointed distal end of the apophysis, filamentous, flexile, gradually tapering branching at the distal end usually obscured by dense cell contents; liberation of zoospores by complete dissolution of the sporangial wall the zoospore mass remains compact for a while, later disentangle and swim away; zoospores subspherical, 4μ diameter or oval, with a posterior flagellum; resting spore not found.

On a species of *Closterium* collected from one of the tanks in the garden of the Botany Department, Lucknow University, Lucknow.

The chytrid is markedly similar to *Phlyctochytrium apophysatum* sp. nov. in the shape and size of the sporangium, epibiotic in character, endobiotic subsporangial, swollen apophysis and in the origin and nature of the rhizoid. Difference exists in the habit of the chytrids. In contrast to *P. apophysatum* whose thallus is present in a very large number covering almost the entire surface of the infected individuals of *Closterium* species, the sporangium of the present chytrid is found singly or in twos, never numerous. The vital difference lies in the mode of liberation of zoospores. Here at the time of liberation the dissolution of the sporangial wall takes place starting at the basal end, and eventually the entire wall is involved exposing the whole zoospore mass which retains its spherical shape while the zoospores remain compact and quiescent. Eventually the mass breaks up as the zoospores disentangle and swim away.

On the basis of this character, the evanescence of sporangial wall, as the mode of liberation of zoospores which is not known in any other species of *Phlyctochytrium*, the present chytrid is identified as a new species.

Holotype deposited at the HCIO, Division

of Mycology and Plant Pathology, IARI, New Delhi-110 012. HClO No. 37176.

BLYTTIOMYCES

First described by Blytt (1882) from Norway as *Chytridium spinulosum* the fungus was raised to the status of a genus *Blyttiomycetes*, named after Blytt and termed *Blyttiomycetes spinulosus* by Bartsch (1939) from his study of the species collected from Wisconsin, USA. This fungus was subsequently reported from other parts of Europe and also from China. Two more species were described from U.S.A. : *B. laevis* Sparrow (1952) and *B. helicus* Sparrow & Barr (1955). Only these three species of *Blyttiomycetes* were known when the present authors added to the list two more species, both appeared to be new but these remained unpublished. Since then four further species have been recorded, viz. *B. rhizophlyctidis* (Dogma and Sparrow 1969) *B. vaucheriae* (Reith) Dogma (Dogma and Sparrow 1969) followed by *B. harderi* Sparrow & Dogma (1973) from Hispaniola (Dominion Republic) and *B. conicus* Johnson (1977) from southern Scandinavia. Another species described as new by Booth (1969) as *B. aureus* was later on made synonymy of *B. laevis* which Johnson considers to be a variety of *B. laevis*. Besides these, five unnamed species of *Blyttiomycetes* are recorded in literature.

In the present paper the authors have described two species of *Blyttiomycetes* based on freshly collected infected *Spirogyra* sp. from an aquatic habitat of Lucknow.

***Blyttiomycetes spinosus* sp. nov. (Figs. 38-41).**

Sporangia epibiotica, sessilia, cordiforme, $15-35\ \mu$ alta \times $20-35\ \mu$ lata, vel sphaerica $15-35\ \mu$ in diametro; apex cum nodo sicut permanens; zoosporae cistae saepe spiculatum, ornamentis, quae non agunt ut operculum, uniporum, duplex membrana, endosporum tenus, exosporum spissum, cum

aculeis per totum superficiem, aculeis breviter rigidi; apophysis endobiotica, specie variè plerumque flexibilis, anguste tubularis, tumida subfine, acutus cacumen, raro late tubularis cum summitate tumida, vel obpyriforme $13\ \mu$ alta \times $8\ \mu$ larga, saepe absente; exitu pora basalis, lateralis, subapicalis vel apicalis rhizoidea nulla. zoosporae cum exeunt in faciunt et quiescunt in labro pori exitus apicalis in forma massae globularis involuta cum membranula valde tenui, et post aliquod tempus tumultus internae zoosporae individui separant unusquisque ab alio et currant in variis lateribus, sphaericae $6-8\ \mu$ diam. ac posterum uniflagellatae, hyalinae cum globulo prominenti centrali, refractivo; sporae perdurantes endobiotica formati intra zygosporum in serie 4-5, sphaericae $20-30\ \mu$ in diametro, plano, membrana duplicis cum presentia aliquorum-refractorum granulorum; germinatio non observata.

Thallus epiendobiotic, monocentric, eucarpic: sporangium epibiotic, sessile, cordate $15-33\ \mu$ high \times $20-35\ \mu$ wide or spherical $15-30\ \mu$ in diameter, apex surmounted by a knob like persistent zoospore case often apiculated, ornamental not functioning as operculum, uniporus, double walled, endospore thin, exospore thick, aculeated all over the surface, aculae short, rigid; apophysis endobiotic variable in shape usually flexuous, narrowly tubular, subterminally swollen and thickened with pointed tip rarely wide tubular, terminally swollen or obpyriform $13\ \mu$ high \times $8\ \mu$ wide often absent; rhizoid absent exit pore basal, lateral, subapical, apical; zoospores when discharged emerge and settle at the rim of the apical exit pore forming a slimy globular mass invested with a tenuous film, lie quiescent and after a period of internal turbulence the individual zoospores disentangle from each other and dart away, spherical, $6.8\ \mu$ in diameter, posteriorly uniflagellate, hyaline with prominent central refractive globule; resting spore endobiotic, formed inside the zygosporum in a series of

4-5, spherical, 20-30 μ in diameter, smooth, double walled, inner wall thin outer wall thick, a few refractive granules present; germination of resting spore not observed.

The identity of the fungus devolved on the nature of the apiculus. Considering the apiculus to be proper operculum, Blytt (1882) placed it in the genus *Chytridium*. Bartsch (1939) conclusively proved the nature of the apiculus to be ornamental and not operculum in its true sense as it did not provide passage for emerging zoospores and found the exit pore to be lateral, constantly at 40° from the apex. Earlier H. E. Petersen (1910) had also demonstrated the lateral position of the exit pore. Scherffel (1926) too maintained that the apiculate structure was not an operculum. Cjep (1932), however, though he observed in his fungus the lateral position of the exit pore, considered its place to be with *Chytridium*, basing his conclusion on general habit of the fungus.

Bartsch removed the fungus from the genus *Chytridium* and established a new genus *Blyttiomycetes* naming it after Blytt to accommodate the species. *Blyttiomycetes spinulosus* (Blytt) Bartsch is characterised by globose, aculeated sporangium with ornamental apiculus and lateral exit pore, 2-3 tandem apophyses and extensive rhizoids. Of all the known species of *Blyttiomycetes*, *B. spinulosus* is aculeated. The other ornamented species *B. helicus* Sparrow has a series of low helicoid bands on sporangium and *Blyttiomycetes* sp. has spinulose or punctate sporangium. In the present fungus, similarly, the sporangium is aculeated as in *B. spinulosus*. The difference between these two species, however, is enormous. Here the typical sporangium is cordate though some spherical sporangia are also formed. Exit pore is formed almost anywhere on the sporangial surface, lateral, basal, subapical or apical, differing in different sporangium. Of particular interest is the apical exit pore through which zoospores emerge in a glo-

bular mass thereby giving an impression that like operculum it provides passage for emerging zoospores. This feature becomes easily intelligible when it is appreciated that as exit pore has no fixed position on sporangial surface it may occasionally form in the apical region. The apiculus does not provide normal passage but only one among many others. It can also well be that the exit pore is truly subapical nearest to the apex and in course of emergence of zoospores apiculus is also involved in which case the apical and subapical become one and the same.

The other distinctions lie in the endobiotic part; the apophysis and the rhizoids. In the present fungus no apophysis is formed in sporangium directly resting on the zygospor. On the other hand in sporangium located on host cell wall, from which zygospor has retracted, basal apophysis is formed penetrating into the zygospor. These are varied in character, usually flexuous, narrow tubular, subterminal, thick walled, swelling with pointed tip, or obpyriform tapering, and penetrating the zygospor, or rarely rigid, wide tubular, with swollen end (looking like ace of spade). In no case tandem-like apophysis as found by Bartsch, was observed.

Regarding rhizoids which are well formed in *B. spinulosus* significantly none has been observed arising from the apophysis, nor in the absence of apophysis from the basal end of the sporangium. In all such cases apophysis behaves as haustorium. The total absence of the rhizoidal system and the configuration of the apophysis when formed and its haustorial nature are important distinguishing features from *B. spinulosus*. Yet another distinctive character is the mode of discharge of zoospores and their subsequent behaviour. The zoospores on emergence form a slimy globular mass invested with a thin film round it whereas in *B. spinulosus* zoospores emerge individually through the

exit pore and swim away without forming a mass or a period of rest.

From the appraisal of these characters it is evident that the present fungus though similar in ornamentation of sporangium is very distinct in other characters and is a new species.

Blyttomyces spinosus sp. nov. revealed some interesting features relevant to the generic conception of *Blyttomyces*. Firstly, the exit pore character described as subapical by Bartsch in uniporus sporangium of *B. spinulosus*, the type species. The fixity of location of exit pore as generic character as proposed by him proved to be inadequate with the advance of our knowledge, as other species of *Blyttomyces* having more than one exit pore located basally or elsewhere were discovered. Dogma and Sparrow's (1969) *B. rhizophlyctidis* is multiporus and pores located anywhere on the sporangial surface. They also found exit pores appearing under elevated surface and rightly proposed suitable emendations and broadening of the originally proposed generic characters. Other similar discoveries followed.

In the present fungus *B. spinosus* sp. nov. which is uniporus, the variations in the exit pore characters is more extreme. Here, as stated earlier, the individual thallus of the same species may form exit pore in different positions of the sporangial surface. Thus lateral in one, basal in another, subapical or apical in others. The formation of exit pore, too, is not same for all. In some it may be formed where sporangial surface becomes elevated and in others by the dissolution of sporangial wall forming a passage for the liberated zoospores. This inconsistency of position as well as the different modes of their formation in different thallus of the same species devalues the exit pore as specific character.

Secondly, while discussing the position of the "unique and aberrant" appendiculate sporangium of *Phlyctochytrium hirsutum*

Karling (1967) whether it could be admitted to the genus *Blyttomyces*, Dogma & Sparrow (1969) stated that it would depend apart from the discovery (which is unlikely) of resting spore, on the liberation of zoospores in a globular mass as found in *Phlyctochytrium hirsutum* "a character so far not observed in *Blyttomyces*". In the present fungus *B. spinosus* sp. nov. the zoospores have been found to emerge as a globular mass. Thus one condition of transfer of *P. hirsutum* to *Blyttomyces* is satisfied, leaving the resting spore character for final incorporation.

Blyttomyces spinosus sp. nov. thus appears to be unique in constant position of the exit pore, its mode of zoospore discharge as a globular mass, as well as difference in the apophysis and rhizoidal characters or in their complete absence.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37100.

***Blyttomyces lenis* sp. nov. (Fig. 42).**

Sporangium endobioticum, aggregatum in congregations 7-10, sessile, cordiforme, 14-16 μ altum \times 10-14 μ largum vel anguste pyriformum, 10-18 μ altum \times 7-10 μ largum, membrana singularis, tenuis, hyalina, plano, inornata; in cordiformi sporangii apicalis finis papillis, papilla 2-6 μ altae \times 2.4 μ largae apex circumlatum, finiens modo candelae in pyriformum sporangium, apex acuminatum; cistae zoosporae parvae in nodorum modo, basalis vel lateralis, nunquam apicalis. Exitus pora surgit sicut lateralis protusiones superficiem sporangialem. Endobioticae structure, apophysis et rhizoidea non formatae; zoosporae et eorum modus ejectionis non observatae; sporae perdurantes non inventa.

Thallus monocentric, eucarpic; sporangium epibiotic, aggregated in a cluster of 7-10, sessile, cordate, 14-16 μ high \times 10-14 μ wide or narrow pyriform, 10-18 μ high \times 7-10 μ wide, wall single, thin, hyaline, smooth devoid of ornamentation; apical end

in cordate sporangium papillate, $2-6\ \mu$ high \times $2.4\ \mu$ wide, apex rounded; tapering in pyriform sporangium; zoospore cyst small, knob-like, basal or lateral, never apical; exit pore arises as lateral protrusion on sporangial surface; endobiotic structures, the apophysis and rhizoid not formed; zoospores and their mode of discharge not observed; resting spore not found.

Parasitic on zygospore of a *Spirogyra* sp. collected from a ditch by the side of the Sultanpur Road, 11 miles south east of Lucknow University.

In generic characters the fungus belongs to *Blyttomyces*. In specific characters it exhibits smooth walled, hyaline typically cordate sporangium having prominent apical papilla with strongly convex tip. The narrow pyriform sporangium is apiculate conforming to Willoughby's distally elongated sporangium of *Blyttomyces* sp. zoospore cyst is present only in a few sporangia, in others either indiscernible or evanescent. Most sporangia are without exit pore. But in some found formed as lateral protrusion of the sporangial surface. The sporangia which are described and illustrated here are believed to represent the mature stage of the fungus. There is complete lack of apophysis and rhizoid as far as it has been possible to scan, and as pointed out in the previous paper the absence of these organs is largely due to the development of the sporangium directly on the reproductive body of the host.

The fungus differs from all smooth walled species of *Blyttomyces* known so far, in more than one character. *Blyttomyces laevis* Sparrow differs in having ovate sporangium, non-papillate strongly convex apiculus, fusoid apophysis with rhizoidal system. *B. conicus* Johnson another smooth walled species, described as narrowly or broadly conical with sub-basal exit papilla arising as lateral protrusion, ovate apophysis and delicate rhizoid is also different. A

third smooth walled *Blyttomyces* species that is described by Willoughby but not named, in which sporangia are spherical or broadly pyriform with distal end forming enlarged elongated papilla, exit pore arising by the dissolution of the sporangial wall, no elevated surface is formed, multiporus, apophysis is absent, rhizoid is minute. Johnson (1977 p. 87) considers that Willoughby's plants in general thallus configuration are in close structural alliance with *B. conicus*. This seems clear from the shape of the early developmental sporangia of the latter. Johnson structurally derives it from *B. conicus* sporangium by suggesting apical constriction. Similarly cordate sporangium of the present fungus can be derived by attributing median horizontal expansion of the sporangial body of *B. conicus*. However, there is greater resemblance of Willoughby's species to the present fungus than to Johnson's species.

The present fungus though similar, differs from Willoughby's species in several details, namely the cordate sporangium, monoporus condition, total absence of rhizoid, different host which is reproductive body of *Spirogyra* sp. in contrast to the species of *Rhizophydium* of Willoughby's hyperparasitic *Blyttomyces* sp.

In the light of the differences discussed above the fungus is identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37101.

ENTOPHYCTIS

The genus *Entophlyctis* is characterised by fully endobiotic thallus consisting of sporangium and rhizoidal system arising from zoospore cyst which is mostly evanescent, persisting only in two species, *E. apiculata* (Braun) Fischer and *E. bulligera* (Zopf) Fischer. Lacy (1949) was first to describe

Entophlyctis bulligera from India. Much later Karling (1964, 1966) in his studies on Indian chytrids published descriptions of two more species, *E. helioformis* (Dang.) Ramsbottom and *E. texana* but none new. During the intervening period several species of *Entophlyctis* were collected and studied by the present authors.

Entophlyctis bulligera (Zopf) Fischer Rabenhorst Kryptogamenfl., 1(4): 116, 1892. *Rhizidium bulligerum* Zopf, Nova Acta Acad. Leop. Carol., 47: 193, 1884 (Figs. 43, 45).

Thallus monocentric, eucarpic, endobiotic, consisting of sporangium persistent apical knob and rhizoidal system; sporangium endobiotic, usually one in a cell, spherical, 10-15 μ in diameter, smooth, hyaline; apical knob a persistent zoospore case endobiotic, sessile, dome shaped, 2.5-3 μ high \times 3-4 μ broad, functioning as a discharge papilla; rhizoids originate from one or more axial points at the basal half, main axis expanded, double-contoured or thick filamentous, branches arise from distal end, secondary branches short, slender, ramifying into the cell contents; zoospores, formed by the cleavage of the dense refractive granular contents, mature inside the sporangium, numerous, emerge through a pore in the discharge papilla in a single file one closely following the other, constricted while passing through the pore indicating its amoeboid nature, spherical, 2.5-4 μ diam. flagellum single, posterior; resting spore abundant, endobiotic, lying free one in each cell, spherical, 15-20 μ in diameter, double walled, thick, colourless, cell contents dense with one or more highly refractive granules; rhizoids both basal and lateral on the lower half of the resting spore, occasionally on the upper half as well, variable in character; basal rhizoids arising from minute main axis, or from contiguous points, short, coarse, stout expanded base double contoured, tapering

to a point, once branched at the tip: lateral rhizoids mostly thin, filamentous, delicate also branch once at the tip rarely thick, double contoured like the basal ones; persistent zoospore cyst present at the apex; germination of resting spore not observed.

In the vegetative filaments of a *Spirogyra* sp. collected from a ditch by the side of the Sultanpur Road about 11 miles south east of Lucknow University.

The mode of development of the chytrid beginning from the zoospores encysted on the host wall follows the normal course as known for *Entophlyctis* type of development. The chytrid belongs to the genus *Entophlyctis* and conforms to the species of *E. bulligera* in having spherical sporangia, persistent functional zoospore cyst as apical knob, functioning as zoospore discharge pore at maturity, basally developed, double contoured, main axis and extensively branched rhizoids. Sporangial size too, is 8-13 μ , similar to that given by Domjan (1936) for his species and within the range of 12-20 μ diameter given by Lacy (1949) for the Indian species described by him.

The species developed abundant resting spores in the vegetative cells of the host *Spirogyra* under natural conditions of infection. Fully endobiotic these remain loosely free one in each cell with zoospore cyst present as apical knob. Resting spores are spherical, 15-25 μ in diameter with thick epi- and endospore, provided with rhizoids which are widely dissimilar to the sporangial rhizoids. Rhizoids originate from one or two points at the basal end of the sporangium, main axis double contoured and secondary branches filamentous. Whereas the resting spore rhizoids are both basal and lateral. The basal ones are short, coarse, double contoured, expanded proximally, tapering to a point and the lateral ones are filamentous branched at the tip.

The chytrid has been identified as *Entophlyctis bulligera* (Zopf) Fischer, and

provides the first record of the formation of resting spore in the species.

Entophlyctis bulligera var. **brevis** var. nov. (Fig. 44).

Sporangium endobioticum, sphaericum, 8-13 μ in diametro, pariete tenui, laevi, hyalino, cum zoosporocysta persistens endobiotica, apicaliter gongylodes, 2.5-3 μ in diam. ; rhizoidea orientia e uno puncto vel punctis pluribus ad extremitatem basalem sporangii, crassa, axis principalis expansus ad basin, angustatus, apice acutus, brevis, maxime longitudine 20 μ , sparsim ramosus, ramificatio restricta ad cellulam infectam ; zoosporae et illarum modus emissi non observatae ; spora quiescens non visa.

Sporangium endobiotic, spherical, 8-13 μ in diameter, thin walled, smooth, hyaline, with persistent, endobiotic, zoospore cyst as apical knob, 2.5-3 μ in diameter ; rhizoids arising from one or more points at the basal end of the sporangium, stout, double contoured, main axis expanded at the base, tapering, pointed tip, short, maximum length 20 μ , sparsely branched, ramification restricted to the infected cell ; zoospores and their mode of discharge not observed ; resting spore not found.

In the vegetative filaments of *Spirogyra* sp., collected from a ditch, by the side of the Sultanpur Road, 11 miles south east of Lucknow University.

The sporangium of the present chytrid is practically identical to that of the *Entophlyctis bulligera* (Zopf) Fischer. It is spherical, hyaline, 8-13 μ in diameter against 10-15 μ , and the apical knob is 2.5-3 μ in both. The rhizoidal characters too, are similar to some extent, stout, tapering, the main axis double contoured and expanded at the base. Zoospore and resting spore could not be compared as these were not observed in the present chytrid.

The highly distinctive and the distinguishing features of the, however, lie in the size

and extent of the rhizoidal system, the sparse branching, and restricted ramification. The entire body occupying only a small part of the infected cell. All these present an overall picture of a form of chytrid wholly different from *Entophlyctis bulligera*.

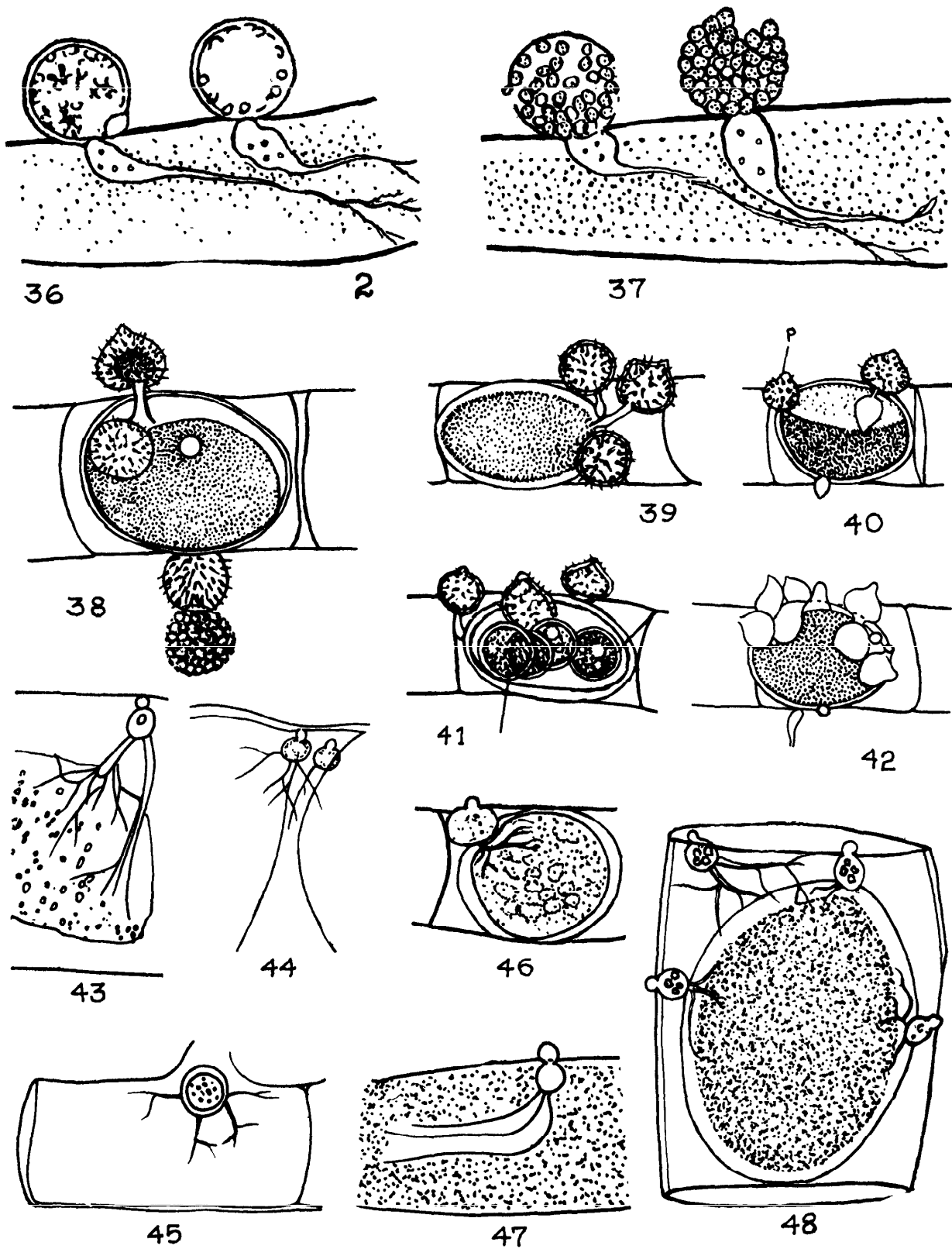
Neither *E. bulligera* nor any other *Entophlyctis* species conform to the present one. It is therefore, identified as a new variety and is designated *Entophlyctis bulligera* var. *brevis*.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37103.

Entophlyctis mammilliformis sp. nov. (Fig. 46).

Sporangia endobiotica, plerumque due intus una cellula varie sita in corpus reproductum vel submembranes cellulae hospitantis, elliptica, 8-13 μ alta \times 11-18 μ lata, cum membrana tenui, laeve, incolorata, inoperculata ; cistae zoosporae permanentes ad apicalem finem, endobioticae, sessiles, in forma cupola, 3.5-5 μ alta \times 3-4.5 μ lata, agentes sicut papillum ejectionis ; apophysis nulla ; rhizoidium oriens a uno vel pluribus punctis basale rare laterale, varie naturae, breve, tenue, filamentosum vel robustum, acuminatum cum duplici liniemento, sine ramis, vel cum ramis raris ; zoosporae et eorum modus ejectiones non observatae ; sporaes perdurantes non inveniuntur.

Thallus monocentric, eucarpic ; sporangium endobiotic, usually two in a cell, variously resting on the reproductive body that it infects and the inner surface of the host wall, ellipsoidal, 8-13 μ high \times 11-18 μ in diameter wall smooth, thin, hyaline, inoperculate ; persistent zoospore case at the apical end, endobiotic, sessile, dome shaped, 3.5-5 μ high \times 3-4.5 μ wide, emerges outside at maturity, functioning as discharge tube ; rhizoids arise from one or more basal points, rarely lateral, variable in character, short, filamentous, pointed, double contoured, unbranched,



Figs. 36-48 : Legend at the end of the article

once branched or thick rhizoidal strands 2-3 arising from main axis, forming thick, minute secondary branches; zoospores and their mode of discharge not observed; resting spore not found.

On the reproductive bodies of a *Spirogyra* sp., collected from pond in Mohanlalganj, about 10 miles east from Lucknow University.

The chytrid is identified as belonging to the genus *Entophlyctis*. It is wholly endobiotic, and is characterised by the presence of empty zoospore cyst at the apical end of the sporangium, which functions as discharge pore at maturity, as well as by the presence of rhizoidal system which arises directly from the base of the sporangial surface.

In the persistent nature of the zoospore cyst the chytrid conforms to *Entophlyctis apiculata* (Braun) Fischer and *Entophlyctis bulligera* (Zopf) Fischer. The sporangium of *E. apiculata* rests between the retracted host cell contents and the host cell wall. The rhizoids penetrate and remain imbedded in the cell contents, are short, delicate and sparsely branched, arising from a short main axis. The host in this case is *Chlamydomonas*.

In the present chytrid the host is a species of *Spirogyra*. Here, too, the main body of the chytrid rests between the host cell wall and the zygospore, and sends down almost identical, short, delicate, sparsely branched or sometimes stouter well branched rhizoids, inside the zygospore. The sporangium is broadly ellipsoidal, mammilliform whereas in *E. apiculata* the shape of the sporangium is broadly pyriform.

The *Entophlyctis bulligera* on the other hand, with its double contoured highly branched, extensive rhizoidal system parasitises the vegetative cells of *Spirogyra*, but has not been found to parasitise the reproductive bodies. The sporangia are spherical in contrast to the mammilliform ones in the present species.

The two are thus, altogether different and no *Entophlyctis* conforms to the present species. The chytrid has been identified as a new species.

Holotype deposited at the HClO, Division of Mycology and Plant Pathology IARI, New Delhi-110 012. HClO No. 37105.

***Entophlyctis sphaerioides* sp. nov. (Fig. 48).**

Sporangia endobiotica, sessilia, subsphaerica, 8-12 μ diametro, plerumque ovoidea vel fusiformes, 15 μ alta \times 13 μ lata; cistas zoosporae permanentes ad apicem, 4.4 μ altae \times 3.4 μ latae, plerumque epibioticae; rhizoides orientes directe ex uno vel aliquibus punctu basilibus quae oriuntur sporangiis, sitis in corpori reproducenti, delicatae et cum ramis raris, quae oriuntur a distantia sunt longior cum multis ramis paulatim anguste, apicem acuminatum, branchis ultimo tenui, filiformes; zoosporae ejectas per foramen, sphaericae, 3-4 μ diametro, incoloratae cum solitario medio globulo; flagellum solitarium, longum, posterius; sporae perdurantes epibioticae, ellipticae, 22 μ altae \times 15.5 μ latae, membrana crassa; continentes cellulas cum globulia numerosis; rhizoidea basales.

Thallus monocentric, eucarpic; sporangium endobiotic, sessile, sub-spherical, 8-12 μ in diameter, mostly ovoid or spindle shaped, 15 μ high \times 13 μ wide, persistent zoospore cyst at the apical end, epibiotic, 4.4 μ high \times 3.4 μ wide; rhizoids arise directly from one or more basal points proximal and wide double contoured, gradually tapering to pointed tip; those growing in the reproductive body exiguous, delicate, branching only once, those growing at a distance from it, longer, branch and rebranch forming copious double contoured tapering branches, the ultimate ones fine thread like, zoospore initials formed by the cleavage of the sporangial contents, mature inside and are discharged outside through a pore formed by the dissolution of the zoospore cyst; zoospores spherical, 3-4 μ diam. hyaline with

a central single globule, flagellum single, long, posterior; resting spore epibiotic, elliptical, $22\mu \times 15.5\mu$, thick walled, contents with numerous globules, rhizoids basal.

Exclusively on the reproductive body of a *Spirogyra* sp. collected from a ditch by the side of the Sultanpur Road about 11 miles south east of Lucknow University.

The chytrid is characterised by endobiotic sporangium with apical zoospore cyst, and the rhizoidal system arising directly from the base of the sporangium—the features that characterise the genus *Entophlyctis*. In specific characters the present chytrid resembles *E. apiculata* in its fusiform sporangium and its location between the host cell wall and the retracted cell contents. But the nature of the rhizoidal system is altogether different, short, delicate and sparsely branched in *E. apiculata* and thicker double contoured in the present species. The chytrid also differs from *E. bulligera* in the nature of the sporangium spindle shaped in the present one and perfectly spherical in *E. bulligera*. The apical zoospore cyst is similar. The rhizoids are double contoured in both, but while it is long, copiously branched, and extensive in *E. bulligera*, it is much shorter and restricted in the present one, resembling to a great extent the rhizoids of particularly those individuals of *E. bulligera* var. *tenuis* which produce short rhizoidal system. The other difference lies in the host characters. Though both are parasitic in a species of *Spirogyra*, *E. bulligera* parasitises the vegetative cells whereas it is the reproductive bodies of *Spirogyra* that are parasitised by the present species. In this respect, the species conforms to *E. mammilliformis* sp. nov. described in the earlier pages in which the infection occurs in the zygospore. But differs from the species both in the sporangial and rhizoidal characters. No known species of *Entophlyctis* resembles this species.

Holotype deposited at the HClO, Division

of Mycology and Plant Pathology, IARI, New Delhi-110 012. HClO No. 37104.

***Entophlyctis caudiformis* sp. nov.** (Fig. 47).

Sporangia endobiotica, crescentia submembrana, interiori cellulæ hospitis, fusioidea, $10-12\mu$ alta \times $8-10\mu$ lata, laevis, incolorata cum membrana tenui, inoperculata; cistæ zoosporae persistentes sicut nodo apicali, sphaerica circa 4.5μ diameter, endobiotica; rhizoidea crescent ex axi breviapud brevium sporangii sicut flocci, flexilia, sine ramis, crassitudine uniforme e basi ad cacumen sita mido proximo parallelia membrana hospitis; longitudino maxima 60μ ; zoosporae et eorum modus ejectionis non observatae; sporae perdurantes non inventae.

Thallus monocentric, eucarpic; sporangia endobiotic, formed below the inner surface of the host cell wall, fusoid occasionally ovoid, $10-12\mu$ high \times $8-10\mu$ in diameter, smooth, hyaline, thin walled, inoperculate; persistent zoospore cyst as apical knob, spherical about 4.5μ in diameter epi-endobiotic; rhizoid arising from a short axial point of the basal end of the sporangium in a tuft, flexuous, unbranched, uniformly thick from the base to the tip, longest 60μ running roughly parallel to the host cell wall; zoospores and their mode of discharge not observed; resting spore not found.

In a *Closterium* sp., collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The fungus belongs to the genus *Entophlyctis*. Like the species described in the preceding pages, the present species is characterised by the presence of persistent zoospore case at the apical end of the sporangium and the rhizoids arising directly from the basal region of sporangium. In structural configuration of sporangium the chytrid differs from the spherical sporangium of *E. bulligera* sp. nov. and *E. brevis* sp. nov. also from the ellipsoidal sporangium of *E. mammilliformis* sp. nov. but practically

identical to the fusoid sporangium of *E. sphaerioides*. But whereas the sporangium rests between the host cell wall and the retracted cell contents in all the species of *Entophlyctis* already described the sporangium in the present species lies imbedded inside the host cell contents.

In rhizoidal characters the fungus widely differs from all the known species belonging to the persistent zoospore cyst group. Rhizoids are narrow, tubular, thick filamentous, stout and extensively branched in *E. bulligera* somewhat similar but short in *E. bulligera* var. *brevis* short tapering or thick strand in *E. mammilliformis* and double contoured, tapering in *E. sphaerioides*. In the present fungus the rhizoids arise from basal axial contiguous points on the sporangium as a tuft, flexuous, filamentous all growing vertically down for a very short length and then take a gradual lateral bend, each separately running roughly parallel to the host cell wall, attaining a maximum length of $60\ \mu$ of uniform thickness and unbranched throughout. The host too, is different. It is *Spirogyra* in the case of the *Entophlyctis* species described in earlier pages but a species of *Closterium* is the host of the present *Entophlyctis*.

Both in the host characters as well as in the distinctive rhizoidal system the chytrid differs from all known species of *Entophlyctis* including those described here. It has therefore been identified as a new species.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37106.

RHIZOCLOSMATIUM

Rhizoclosmatium belongs to Rhizidiaceae, a family characterised by interbiotic thallus, inoperculate sporangium, interiorly developed subsporangial apophysis and extensive richly branched rhizoidal system of which

at least tip is endobiotic. *Rhizoclosmatium* was established by H. E. Petersen in 1903 with monotypic species of *R. globosum*. To this Sparrow added in 1937 another species *R. auranticum*. Subsequently in 1954 a third species of *R. marianum* was added from Japan by Kobayasi and Ookubo, which Sparrow regard as nearer to *Diplophlyctis*. One species of *Rhizoclosmatium* found by the authors is described here.

Rhizoclosmatium globosum H. E. Petersen
J. de Botanique, 17 : 216, 1903 (Fig. 49).

Thallus monocentric, eucarpic, interbiotic, consisting of sporangium, apophysis and rhizoids; sporangium spherical, $12\ \mu$ in diameter, double contoured, walls slightly thickened, smooth, colourless, inoperculate, wholly fertile, except for the extrasporangial portion of the apophysis; apophysis develops interiorly, projects outside the sporangial base, subsporangial, thumb-shaped, structure, $3\ \mu$ high $\times 2.5\ \mu$ wide, wall thin, colourless; rhizoids arise from the base of the apophysis, bifurcating into two strands, diverging to opposite directions, stout, tubular, $1.2\ \mu$ in diameter, tips divide dichotomously forming narrower branches; zoospores and their mode not observed; resting spore not found.

Saprophytic on the exuviae of some animalcule, present in the sediments collected from the bottom of a tank, in the garden of the Botany Department, Lucknow University.

The present chytrid treated as inoperculate and identified as *Rhizoclosmatium globosum*, since no operculum was detected has in external form, its counter part in the operculate *Chytriumyces aureus* (Karling, 1945, p. 363, figs. 41-44), but differs from *C. aureus*, which, as the name implies has golden red sporangial wall. *Rhizoclosmatium globosum* also *Chytriumyces aureus* are most ubiquitous exuviate chytrids, present in the exuviae of Caddie flies (Phryganeidae), dragon flies (Odonata), midges (Chironomidae), may flies (effemerida), and other insect integu-

ments. But unlike *C. aureus* it is not soil inhabitant.

The present species of *Rhizoclostridium* is characterised by perfectly spherical sporangium, double walled, $12\ \mu$ in diameter, wholly fertile, interiorly developed subsporangial apophysis giving rise to diverging branched, stout, tubular rhizoids. *Rhizophydium globosum* as described by Petersen is normally spherical, $9-22\ \mu$ in diameter, wall, thick, smooth, colourless. Some pyriform sporangia are also found. Apophysis is transverse, broadly fusiform, giving rise to extensive, delicate, richly branched rhizoids. In most of these characters these two chytrids are practically similar. But what are highly significant, and have not been observed in our chytrid are the mode of discharge of zoospore as well as their characters. In typical *R. globosum* the shape of zoospore is variable, these are $3-4\ \mu$ long \times $2-3\ \mu$ wide, with colourless centric or eccentric globules, and $20\ \mu$ long flagellum.

Zoospore characters of the species assume special importance when one considers that Sparrow distinguished his species *Rhizoclostridium aurantiacum* from *R. globosum* mainly on the rusty-orange globules present in the zoospores of his species. He believed that the difference is the function of the genotypic factor. He also put forward the view that the larger colourless zoospores represent the female and the smaller coloured zoospores represent the male. Petersen, however, considers that the coloured and colourless zoospores, which may appear separately or may be associated together in the same sporangium, are due to the effect of age and environment. Should *R. marianum*, as Sparrow believes, be better placed with the genus *Diplophlyctis* and as H. E. Petersen believes, *R. aurantiacum* is better merged with *R. globosum*, *Rhizoclostridium* becomes a monotypic genus, with only one species *Rhizoclostridium globosum*, to which our chytrid belongs.

CHYTRIDIUM

The genus Chytridium is characterised by monocentric thallus, its development from all parts or part of the zoospore cyst, completely fertile sporangium that opens by the dehiscence of an operculum and endobiotic resting spore. Until 1966, before Karling in his studies on Indian chytrids, described *Chytridium oedogoni* and *Chytridium parasiticum* no species of *Chytridium* was known from India, although a number of these infecting species of *Closterium*, *Spirogyra* and a few *Cladophora* had been worked out by the present authors in midfifties, it remained unpublished.

Chytridium lagenaria Schenk Ueber das Vorkommen contractiler Zellen im Pflanzenreich, p. 5, figs. 11-13. Wurzburg. 1858. Non *C. lagenaria* Schenk, Verhandl. Phys.—Med. Gessell. Wurzburg, A.F. 8 : 241. 1858. (Fig. 50).

Thallus epi-endobiotic, monocentric, eucarpic; sporangium epibiotic, sessile, mostly spherical, $13-20\ \mu$ in diameter or ellipsoidal $12\ \mu$ high \times $16\ \mu$ wide, wall smooth, colourless; apophysis endobiotic, spherical, or subspherical, $8-10\ \mu$ in diameter or fusiform $12-15\ \mu$ high \times $8-15\ \mu$ wide, rarely a cross wall separates the sporangium from the apophysis; rhizoids endobiotic, arising from a single or more axial points of the basal end of the apophysis, variable in length, thin, filamentous, dichotomously branched at the distal end; operculum convex, smooth, dehisce to form a wide pore, completely thrown off or the remnant remains attached to the rim of the pore; zoospores form and mature inside the sporangium, on discharge glide through the pore, emerge outside forming a globular mass at the orifice, remain motionless for a while, later disentangle from each other and swim away; zoospores hyaline, spherical, $3-4\ \mu$ in diameter, with a single, central globule and a single, long posterior flagellum;

resting spore endobiotic, abundant in each cell, hyaline, smooth, spherical, double-walled, outer thick, inner thin, contents with several refractive granules, those developing in reproductive cell larger, $16-25\mu$ in diameter, those in vegetative cell smaller, $10-14\mu$ in diameter, rhizoid lacking or when present not filamentous type as in the sporangium, but short, stout, double contoured with wide lumen all through, divergent, tapering into pointed end, on germination give rise to epibiotic sporangium either ellipsoidal 24μ long \times 13μ broad or spherical, 20μ in diameter with globular inclusions.

On the vegetative cells and reproductive bodies of a *Spirogyra* sp. collected from a ditch by the side of the Sultanpur Road, 11 miles south east of Lucknow University.

The fungus belongs to the genus *Chytridium* and in specific characters conforms to the species *Chytridium lagenaria* Schenk. Karling (1936) studied in detail the developmental stages in the life history of *C. lagenaria* on *Oedogonium* sp. which conformed to the findings of Sparrow (1932, 1936) in *Chytridium lagenaria* also on *Oedogonium* sp. In the present fungus, too, developmental stages, in *Spirogyra* sp., are similar. Zoospores after a period of swarming encyst on the host wall. The cyst germinates producing a germ tube which penetrates the cell. As it grows in length the distal end forms rudiment of rhizoidal system and simultaneously the proximal end immediately below the zoospore case starts transforming into rudiment of apophysis. The contents of apophysis when mature migrates into zoospore case initiating the development of sporangium which expands ultimately to give rise to fully formed sporangium. The thallus at this stage consists of zoosporangium, apophysis and the rhizoidal system. The two celled thalli recorded by Karling formed by a cross wall separating the sporangium from the apophysis and its rhizoids was observed by the authors only in a few.

The resting spores are essentially, the encysted apophysis. The early stages in the development of both are similar but at a later stage the walls begin to thicken and there are increase in the refractive contents. At maturity the refringent globules coalesce to form one or two large globules in the resting spore. When fully grown the resting spore is completely endobiotic, thick walled, smooth, hyaline, spherical or ellipsoidal, with one or two large refractive globules. The germination of these resting spores and their further development are similar to those of zoosporangia. Each resting spore acting as prosporangium on germination produces a protuberance into which the sporangial contents pass and the protuberance enlarges to form anepibiotic sporangium. Zoospore formation and their liberation are similar as in normal zoosporangium.

The sporangial variation in this chytrid is limited. The 'tremendous' variation in rhizoidal system as noted by Karling in his species is not found in the present chytrid, excepting that those growing on reproductive body produce shorter rhizoids than those growing away from it, besides some stubby and other forms.

It is however in the resting spore that considerable variations occur. The variations are not so much in rhizoids which are all similar, double contoured with prominent lumen throughout, tapering to a pointed end. But difference is exhibited in the size of the sporangium which are distinctly of two sizes, without intergradation. Those growing in cells with reproductive bodies are larger, $16-25\mu$ in diameter and those arising in vegetative cells are smaller $10-14\mu$ in diameter. Such wide difference in the size of the resting spores is unlikely to be due alone to the nutritional status of the reproductive body in the one hand and the vegetative cell on the other. Considering all the aspects the chytrid is identified as *Chytridium lagenaria* Schenk.

Chytridium schenkii (Schenk) Scherffel (Figs. 52, 53).

Thallus epiendobiotic, monocentric, eucarpic; sporangium epibiotic arising from zoospore cyst which persists as small sterile papilla at the base, procumbent or ascending, fusiform, some with proximal concavity, thin walled, hyaline, smooth, $30-40\ \mu$ high \times $12-17\ \mu$ where widest, apex rounded, basal end lobulus, sterile, continuous with the sporangium; apophysis endobiotic, subsporangial, subtending the sporangium, spherical, $13\ \mu$ in diameter, thin walled, smooth, hyaline; rhizoids arising from apophysis filamentous, delicate, unbranched; zoospores and their mode of discharge not observed; resting spore not found.

On vegetative filaments of a *Spirogyra* sp. collected from a ditch by the side of Sultanpur Road 11 miles south east of Lucknow University.

The species closely conforms to the fungus *Chytridium schenkii* (Schenk) Scherffel. In both our fungus and that illustrated by Scherffel the sporangia are fusiform with regular or irregular contour, smooth, distal and proximal end tapering from swollen middle, the apical papilla rounded with smooth, convex operculum and the basal end lobulus sterile. The stance in both is tilted or procumbent and the attachment is either axial or abaxial. The similarity between the two fungi in structural configuration is obvious. The difference, however, lies mainly in the size of the thallus and also in the rhizoid and the host characters. The sporangium in Scherffels species is $15\ \mu$ high \times $10\ \mu$ wide, apophysis $8-10\ \mu$ in diameter and rhizoid well developed and well branched and the host is a species of *Oedogonium*. In contrast in our fungus the sporangium is $30-40\ \mu$ high \times $12-17\ \mu$ wide and apophysis $13\ \mu$ in diameter, altogether a larger species practically double the size; the rhizoids are filamentous, delicate, scanty, and the host is *Spirogyra* sp. The resting

spore in *Chytridium Schenkii* which are endobiotic spherical and germinating into ellipsoidal sporangium could not be compared as these were not observed in our fungus.

The fungus has been identified as *Chytridium schenkii* (Schenk) Scherffel.

Chytridium horariumforme sp. nov. (Fig. 51).

Sporangia endobiotica, obovoidea, $22\ \mu$ alta \times $18\ \mu$ lata, incolorata, membrana laeva, apiculus convexus, portio remota paulatin contractus; apophysis (haustorium) endobiotica, subsporangica, ovoidea, $18\ \mu$ alta \times $13\ \mu$ lata, membrana tenue, incolorata, isthmus $7\ \mu$ lata, sporangium continuous cum haustorium; forma similis horarium; rhizoidea endobiotica, filamentosae, brevis, sine ramis, oriens ab laterale positus in haustorium; operculum apicale, laeve, postque dehiscent vel adhaereo orae pori; zoosporae emergunt singillatim per formina apicalia et requiescentis immobilis, deinde separate et currant abeo; zoosporae sphaerica, $3-4\ \mu$ diameter cum globules; flagellum singulum, posteriorum; sporae perdurantes non observatae.

Thallus epiendobiotic, monocentric, eucarpic; sporangium obovoid, $22\ \mu$ high \times $18\ \mu$ wide, wall smooth, colourless, apex convex, gradually tapering towards the base; apophysis endobiotic, subsporangial, ovoid, $18\ \mu$ high \times $13\ \mu$ wide, wall thin, hyaline, connects with sporangium by means of an isthmus, $7\ \mu$ wide, giving the entire structure an hourglass appearance; rhizoid endobiotic, filamentous, unbranched, short, arising from the lateral wall of the apophysis; operculum apical, convex, on dehiscence open up like a lid, forming a wide apical pore, at the rim of which the operculum remains attached; zoospores emerge individually through the pore, and after a short period of rest at the orifice, disentangle and swim away; zoospores spherical, $3-4\ \mu$ in diameter with globules, and single, long

posterior flagellum ; resting spore not observed.

Parasite on the reproductive cell of a *Spirogyra* sp., collected from a ditch by the side of the Sultanpur Road, 11 miles south east of Lucknow University.

The chytrid is characterised by obovoid, epibiotic sporangium and almost mirror image endobiotic apophysis. The two are continuous by a wide isthmus, giving the species an hourglass appearance. It does not conform to any known species of *Chytridium* belonging to the apophysate group, excepting the species of *Chytridium scherffellii* (Scherffel) Sparrow (originally *Chytridium pusillum* Scherffel), in which sporangium is obovate or fusiform, and is continuous with apophysis through wide isthmus, as in the present species. In both the discharge pore is formed at the apex of the sporangium by the dehiscence of the convex operculum, but whereas the remnant of operculum is found attached to the rim of the pore described here, it is not found in *C. scherffellii* illustrated by Scherffel (Scherffel p. 143).

The fungus *C. scherffellii*, as the original binomial name *pusillum* implies, is small, sporangium $6-10\ \mu$ high $\times 5.5\ \mu$ in diameter, the largest being $10 \times 6\ \mu$, apophysis $4\ \mu$ and zoospore $2\ \mu$ in diameter, while rhizoids are absent. In the present fungus, however, the size is much larger, the sporangium being $22\ \mu \times 18\ \mu$ and the apophysis $18\ \mu \times 12\ \mu$ with prominent filamentous rhizoids. There is difference in the substratum as well. Here in our fungus the host is *Spirogyra* sp., whereas in *C. scherffellii* is parasitic on an epiphytic diatom, *Characiopsis minuta* (?) order Heterococcales (Xanthophyceae-Heterokontae).

The much larger thallus, the presence of rhizoid and the *Spirogyra* as host, clearly distinguish the present fungus from the most closely related *C. scherffellii* (Scherffel) Sparrow.

Holotype deposited at HClO, Division of

Mycology and Plant Pathology, IARI, New Delhi-110 012. HClO No. 37108.

***Chytridium reniforme* sp. nov. (Fig. 54).**

Sporangia endobiotica, reniformia, sessilia, membrana superior valde arca-membrana inferior curvata, pauletin anguate ad basim $22\ \mu$ longa $\times 11\ \mu$ lata portio apicalis acriter curvata, basis in forma poculi, $5\ \mu$ lata, rotunda per partes sterile cum membrana tenui, incolorata, laeve. Apophysis sphaerica, $13.5\ \mu$ diametro cum membrana tenui, laeve, incolorata. Rhizoidea filamentae, delicatae cum paucis ramis, orientes basali, brevi ab axi principali. Zoosporae et eorum modus ejectionis non observatae. Sporae perdurantes in situ cum quidam laxitae libere in cellulis matricis sphaerici $18\ \mu$ diametro laeves, membranae duo. Rhizoidea filamentae, delicatae, cum paucis ramis orientes a basi sicut brevi ab axi principali. Germinatio non observata.

Thallus epiendobiotic, monocentric, eucarpic ; sporangium sessile, reniform, upper surface strongly arched, concavity at the under surface, tapering towards the base, $22\ \mu$ long $\times 11\ \mu$ wide, sharply curved, goblet shaped base, $5\ \mu$ wide rounded, partially sterile, thin walled, smooth, hyaline ; rhizoids filamentous, delicate, scantily branched, arise from basal, short main axis ; zoospores and their mode of discharge not observed ; resting spore found loosely free in the cell matrix, spherical, $18\ \mu$ in diameter, thick, double walled, smooth ; as in sporangium rhizoids filamentous, delicate, scantily branched, arise from short main axis at the base ; germination not observed.

On the vegetative cell of a *Spirogyra* sp. collected from a ditch by the side of Sultanpur Road, 11 miles south east of Lucknow University.

The fungus is characterised by reniform sporangium resting on the narrow rounded base which is partially sterile, representing the remnant of the zoospore cyst. The spor-

angium with arched upper surface, concave under surface, wide distal end and narrower rounded base, thin walled, smooth, and hyaline conform to *Chytridium curvatum* Sparrow. In *C. curvatum* sporangium is strongly arched, broadly obpyriform or clavate, smooth, 18μ long \times 8μ where widest at the top, 5μ wide at the base, thick walled, goblet-like, sterile portion from which a short, peg-like hyaline stalk emerges merely attached to the host wall (Sparrow 1960). In structural configuration the sporangium in the two species is distinctly alike. The slightly larger size of the present thallus is of little significance. The basic distinction, however, lies in the presence of apophysis in our species (apophysate) which is lacking in *Chytridium curvatum* (non-apophysate) and also in the presence of resting spore, not observed in *C. curvatum*. Further well formed and well branched rhizoid, present both in sporangial apophysis and in the resting spore totally lacked in *C. curvatum*.

In view of these differences, notwithstanding complete identity in configuration of the sporangia, the two fungi are regarded as different. The present fungus is thus identified as a new species and regarded as an apophysate counterpart of non-apophysate species of *C. curvatum*.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37110.

***Chytridium adpressum* sp. nov. (Fig. 55).**

Sporangia epibiotica, sessilia, procumbentia, longa axi horizontali ad membranam cellulae hospitantis, incolorata cum membrana tenui, ovoidea, 27μ longa \times 17μ lata, basi rotunda; portio remota pauletin contractus apiculus acuminatus. Reliquiae cistae zoosporiae, permanentis, subapicalis. Apophysis endobiotica, abaxialis ad basim sporangiae, sphaerica, 7μ diam. membrana tenui. Rhizoidea endobioticae, filamentosa orientes a punctis pluribus in basi apophysis,

breves, tenuis cum ramis semel ad cacumen in modo dichotomi. Zoosporae et eotum modus ejectionis non observatae. Sporae perdurantes non inventae.

Thallus epi-endobiotic, monocentric, eucarpic; sporangium sessile, procumbent, long axis horizontal, ovoid, hyaline, thin walled, 27μ long \times 17μ broad where widest, basal end rounded, distally tapering, pointed apiculus; remnant of zoospore cyst persistent, subapical; apophysis endobiotic, abaxial at the base of the sporangium 7μ in diameter thin walled; rhizoid endobiotic, arising from more than one points at the base of the apophysis, short, thin, filamentous, branching dichotomously once at the tip; zoospores and their mode of discharge not observed; resting spore not found.

In the vegetative cell of a *Spirogyra* sp. collected from a ditch by the side of Sultanpur Road, 11 miles south east of Lucknow University.

The fungus does not conform to any known species of *Chytridium* other than *C. appressum* Sparrow. In *C. appressum* the sporangium lies procumbent with its long axis parallel to the host filament. It is also procumbent in the present fungus. But the former is characterised by the sporangium which is obpyriform and slightly constricted towards the base, distally wide, $10-17\mu$ long \times $6-10\mu$ broad. The sporangium of the present fungus is obovoid, larger in size, distally tapering to the pointed apiculus and the basal end broad, hemispherically curved. In *Chytridium appressum* again, the end of the sporangium rests on the substratum, in the present fungus it is the reverse, the broader end of the sporangium rests on the substratum (apophysis). In these respects the two fungi are different. The more significant, however, is the absence of apophysis in *C. appressum* Sparrow. Instead, a basal tubular structure abaxially formed penetrates deep into the host cell, whereas the fungus under investigation is apophysate and like

the former abaxially placed at the basal end of the sporangium from which the rhizoids grow. Again in the present fungus the persistent zoospore cyst is subapical but basal in *C. appressum*. Zoospores and their mode of discharge could not be compared as these were not observed in the present plant. The resting spore too, is unknown in both.

In view of the differences noted above, the fungus is identified as a new species. The fungus, to some extent, appears to be apophysate counterpart of inapophysate *C. appressum* Sparrow.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37111.

***Chytridium sparrowii* sp. nov.** (Fig. 56).

Sporangia orientata ex cyste zoospore, endobiotica, sessilia, late ovoidia, obpyriformia, $23\ \mu$ longa \times $14\ \mu$ lata, inclinata, incolorata, laevia, membrana tenui, superficies superior valde arca, portio remota curvata, basis terminus acriter constrictus papilliformis. Apophysis sphaerica, $13\text{--}14\ \mu$ diametro, membrana tenui. Rhizoidea nulla. Zoosporae et eorum modus ejectionis non observatae. Sporae perdurantes abundanter, endobioticae sphaericae, $18\text{--}20\ \mu$ diametro, situ cum quidam laxitate liberi in matricibus cellulis, membranae duo, laeves, incolorati, cum refractivis granulosi. Germinatio non observata.

Thallus monocentric, eucarpic; sporangium arising from zoospore cyst, endobiotic, sessile, broadly obovoid, or obpyriform, $23\ \mu$ long \times $14\ \mu$ broad, colourless, smooth, thin walled, tilted, strongly arched upper surface, distal end curved, basal end sharply constricted, forming a small papillate basal apophysis spherical, $13\text{--}14\ \mu$ in diameter thin walled; rhizoid lacking; zoospores and their mode of discharge not observed; resting spores abundant, endobiotic, spherical, $18\text{--}20\ \mu$ in diameter, lying loosely free in the cell matrix, double walled, smooth, colourless

with refractive granules; germination not observed.

In vegetative cell of *Spirogyra* sp. collected from a ditch by the side of Sultanpur Road, 11 miles south east of Lucknow University.

While investigating the aquatic phycomycetes of Great Britain, Sparrow (1936) came across *Chytridium schenkii* (Dang.) Scherffel, (the revised name *Chytridium schenkii* (Schenk) Scherffel) parasitic in *Oedogonium* sp. in company with an epiphytic alga, a diatom, *Harpochytrium hedinii*. In this, along with the obpyriform, sometimes curved or irregular sporangium with intramatrical spherical base, occasional rhizoid and spherical smooth walled resting spores, Sparrow (1936; 43: Pl. 15, fig. 16) found that "Plants closely resembling those of *Chytridium pusillum* Scherffel were sometimes formed". It is this atypical plant, apparently foreign, as illustrated by Sparrow, which is identical to the plant observed by the present authors in a cell of *Oedogonium* sp.

The similarity between these two plants lies in the structural configuration of the sporangium as well as apophysis and resting spore characters. It is believed that the resting spores in Sparrow's fungus found closely associated with the atypical plant belongs to it and not to *C. schenkii*. Both the plants are endobiotic, obpyriform, inclined about 45° ; in both the upper surface is strongly arched, distal and hemispherical, and the constricted basal end forms a small papillate base; apophysis spherical, thin walled, resting spores spherical double walled; In size the sporangium of our fungus is $23\ \mu$ long \times $14\ \mu$ wide, apophysis $13\text{--}14\ \mu$ in diameter and resting spore $18\text{--}20\ \mu$ in diameter. The sporangium of Sparrow's fungus on the other hand is $17\ \mu$ long \times $13\ \mu$ broad, apophysis $7\text{--}9\ \mu$ in diameter and resting spore $13\ \mu$ diameter (size calculated from the figures based on the magnification given in the legend). Thus the sporangial size is practically the same, the apophysis is larger

and so also the resting spore and the shape and the nature of the cell wall and the other characters of the last two are also similar. Rhizoids are absent in both. The two plants are practically identical in their physiognomy and the authors have no hesitation to regard these as one and the same plant.

In order to accommodate Sparrow's plant the description of our plant needed only slight modification involving extension of the range of their size. The consequent revised description is : sporangium $17-23\ \mu$ long \times $13-14\ \mu$ broad, apophysis $13-14\ \mu$ in diameter and resting spore $12-20\ \mu$ in diameter. Regarding the taxonomic position of the plant, Sparrow had noted its resemblance to *Chytridium scherffellii* (Scherffel) Sparrow and further stressed the fact in his monograph (Sparrow 1960 pp. 515, 520) and also pointed out that the present fungus differed from *C. scherffellii* in having larger sporangium and larger apophysis.

The authors consider the plant, which includes Sparrow's plant, to be a species distinct from *C. scherffellii*. As described above, the plant is characterised by the sporangium $17-23\ \mu$ long \times $13-14\ \mu$ broad, and apophysis $7-14\ \mu$ in diameter. Scherffel's species on the other hand, as the original binominal *pusillum* indicates is small, $6-10\ \mu$ high \times $5-6\ \mu$ in diameter, the largest being $10 \times 6\ \mu$. But more than size it is the structural configuration that distinguishes the present plant from *C. scherffellii* which are characterised by typically obovoid, erect, rounded top, gradually tapering towards the base and continuous with the apophysis through an wide isthmus forming an hour-glass structure against the obpyriform, papillate base, tilted sporangium of the present fungus. The resting spore abundant in the present fungus was not seen in *C. scherffellii* yet another distinction is the substratum character. In *C. scherffellii* the host is an epiphytic diatom *Characiopsis minuta* (?) in the present plant

it is both *Oedogonium* and *Spirogyra*. In the light of these similarities and differences discussed above the present plant is considered to be distinct from *C. scherffellii*. The removal of the atypical plant with resting spore as a new species leads to the question of specific identity of Sparrow's *C. schenkii*. The fungus devoid of atypical plant appears to conform to *C. scherffellii* as suggested by Sparrow. But further thorough investigation is needed for conclusive identification.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37112.

Chytridium fusiforme sp. nov. (Fig. 57).

Sporangia oritur a permanenti, basi, cistae zoosporae, erectae, sessiliae, irregulariter fusiforme, constrictum et declinans a proxima et distantia fini cum tumido medio, apice et basi rotunda cum membrana tenui, laevi, incololata. Operculum convexum. Apophysis endobiotica sita subsporangium, substendens sporangium erectum, sphaericum. Rhizoidea absentes. Zoosporae et eorum modus ejectionis non observatae. Sporae perdurantes abundantes, endobioticae siyus cum quidam laxitate in cella matrici, incololatae, laeves sphaericae, $9-12\ \mu$ in diametro. Germinationes non observatae.

Thallus endobiotic, monocentric, eucarpic ; sporangium arising from persisting basal zoospore cyst, erect, sessile, irregularly fusiform, constricted and tapering towards both proximal and distal and from the swollen middle, ends rounded, $25\ \mu$ high \times $13\ \mu$ wide, thin walled, smooth, hyaline, operculum convex ; apophysis endobiotic, subsporangial, subtending the erect sporangium, spherical, $11\ \mu$ in diameter, thin walled smooth, hyaline ; rhizoid lacking ; zoospores and mode of discharge not observed ; resting spores abundant, endobiotic, lying loosely free in the cell matrix, hyaline, smooth, double walled, spherical, $9-12\ \mu$ in diameter ; germination not observed.

In the vegetative cell of a *Spirogyra* sp. collected from a ditch by the side of Sultanpur Road, 11 miles south east of Lucknow University.

The fungus characterised by fusiform sporangium with concavities at both ends appears to be different from sporangium of *Chytridium schenkii* described earlier by the present authors. But such form could be derived attributing irregular development to the proximal and distal parts from the swollen middle of the fusiform sporangium. Similar irregular features in some sporangium of *C. schenkii* (Schenk) Scherffel has been shown to be due to the lateral and basal development of persistent zoospore cyst resulting in axial apophysis becoming abaxial and the erect stance as inclined.

In size the sporangium is $25\ \mu$ high \times $11\ \mu$ where widest, which is much larger than the ones given for *C. schenkii* Scherffel, $15\ \mu$ high \times $10\ \mu$ wide. This, however, conforms to the smallest of the sporangium of *C. schenkii* of the present authors, whose largest is $40\ \mu$ high \times $17\ \mu$ wide. The apophysis as well as the resting spore of the present chytrid are similar to those as described in Scherffel's and also in our species *C. schenkii*. But rhizoid character is different. It is totally lacking in the present species, while short, filamentous in *C. schenkii* described by us, but in *C. schenkii* (Schenk) Scherffel, it is well developed, branched, extending to neighbouring cells and sometimes extramatrical.

The present chytrid thus differs from *C. schenkii* (Schenk) Scherffel by its wholly endobiotic, irregularly fusiform and larger sporangia and total lack of rhizoid. In consideration of these the chytrid has been identified as a new species.

The present study has revealed several chytrids belonging to the *C. schenkii* complex. For example, *C. schenkii* (Schenk) Scherffel, *C. scherffelii* (Scherffel) Sparrow, *C. conchiforme* sp. nov., *C. sparrowii*, sp. nov.,

and *C. fusiforme* sp. nov. To these may be added *C. gibbosum* Scherffel, and *C. aggregatum* Karling, considered by their respective authors as doubtfully different from typical *C. schenkii*. Sparrow (1960 p. 515) considers that "In its present form *Chytridium schenkii* is probably a composite species made up of several varieties, some of which have been described as distinct species. A thorough investigation of all species of chytrid under discussion here, is needed for the determination of their true identity and relationship.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37113.

***Chytridium acuminatum* Braun Monatsber.**

Berlin Akad., 1855 : 380 ; Abhandl. Berlin Akad., 1855 : 29. (Figs. 58-61).

Sporangium extramatrical, sessile, smooth-walled, ovate, broadly or narrowly urceolate when empty, $13-19\ \mu$ high \times $6.5-11\ \mu$ in diameter, usually in cluster of 4-6 sporangia on one oospore ; operculum surmounting the apex of the sporangium conical, acuminate, $3-4\ \mu$ high \times $2.2-3.5\ \mu$ wide at the base ; penetration tube peg-like, cylindrical, originates directly from the base of the sporangium ; apophysis absent ; rhizoid absent ; zoospores formed by the cleavage furrows in glistening dense, homogeneous contents of sporangium, attain maturity while still inside, when operculum is thrown open at the time of discharge, emerge outside the sporangium embedded in slime, remain quiescent for a minute or two and then separate out and glide apart one by one ; hyaline, spherical, $3-4\ \mu$ in diameter with one centrally situated refractive globule, and a long posterior flagellum, which is easily observed under phase contrast microscope when zoospores try to pull apart from the slimy mass ; empty urceolate sporangia present abundantly ; resting spore endobiotic, smooth, thick walled spherical, $20-25\ \mu$ in diameter, more

than one refractive granules present in the cell contents ; on germination produces endobiotically, thin walled prosperangium, spherical or broadly pyriform, $22\ \mu$ in diameter, with several globules.

Parasitic on oospore of a species of *Oedogonium* collected from a ditch by the side of Sultanpur Road, 11 miles from south east of Lucknow University.

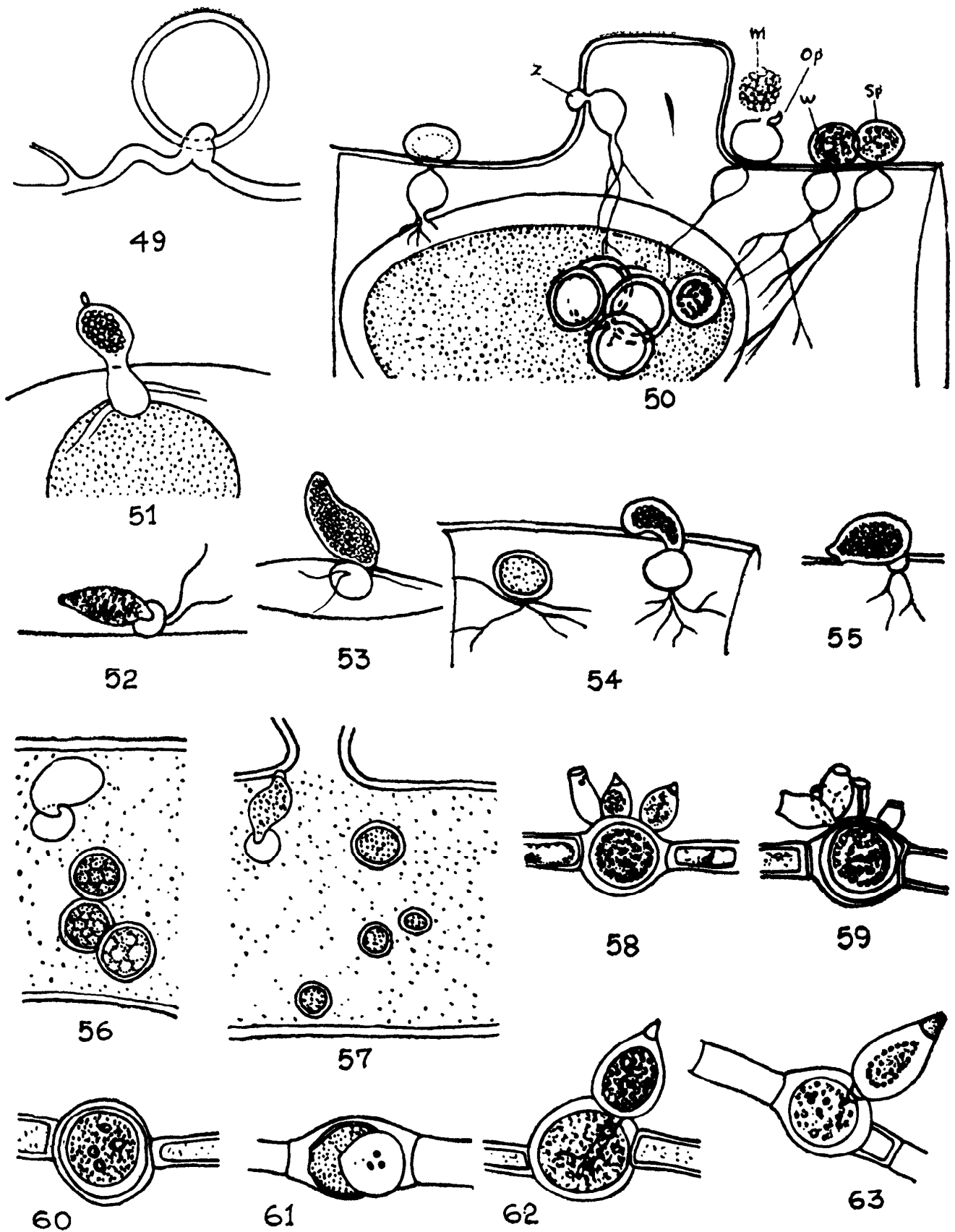
Chytridium acuminatum was originally described by Braun in 1855 on *Oedogonium rothii* and subsequently recorded by Cornu (1872) on Zygospor of *Mougeotia* sp. from France, by Sorokin (1883) on Diatoms from Asiatic Russia and later by Scherffel initially in 1897, again in 1902 and 1906 in *Oedogonium vaucherii* from Hungary. Scherffel's *C. acuminatum*, however has been identified by Sparrow (1960) as *C. brevipes* a species also originally described as a new species by Braun in 1956. About a century later, Shen and Siang (1948) described a Chytrid from China as *C. olla* which also prove to be *C. brevipes* Braun according to Sparrow (1960). *C. acuminatum* as well as *C. brevipes* were discovered from India by the present authors in 1954. The fungus is characterised by epibiotic, non-apophysate, rhizoidless sporangium arising in a cluster of 4-6 broadly ovoid or narrowly urceolate or ascidium-like $13-19\ \mu$ high $\times 6.5-11\ \mu$ in diameter and prolonged conical operculum. In structural configuration of the sporangium it conforms to *C. olla*, *C. brevipes* and *C. acuminatum* complex. But *C. olla* is known to possess broad umbonate operculum and apophysis with rhizoids arising from it. The two are thus distinctly different. *C. brevipes* which also has conical operculum conforming in this respect to the present fungus but unlike it grows singly, comparatively larger in size and possesses apophysis variable in character, knob-like or conical septum. This too, is therefore distinct. The present chytrid well conforms to, and is identified as *C. acuminatum* Braun.

The species status of *C. acuminatum* is however controversial. Established by Braun in 1855 it was regarded as only a smaller form of *C. olla* Braun by Fischer (1892) and Minden (1915). Scherffel (1926) professed the validity of the species in the light of the results of the investigation carried out by him. But the chytrid he studied as *C. acuminatum* has since been identified as *C. brevipes* Braun (Sparrow 1960). Thus invalidating his contention so far as *C. acuminatum* is concerned. However, *C. acuminatum* Braun has been treated as a distinct species by Sparrow (1960) until further investigation proves otherwise.

The identity of *C. acuminatum* of the present authors as found in natural condition, as a species distinct from *C. olla* Braun, is not so much based on the size of the sporangium as on their growth in cluster, the presence of prolonged conical operculum, complete absence of apophysis and the rhizoid, differing in all these respects from the typical species of *C. olla* Braun.

Chytridium brevipes Braun Monatsber. Berlin Akad., 1856 : 587. (Figs. 62, 63).

Thallus epi-endobiotic, monocentric, eucarpic ; sporangium develops singly from zoospore on host cell wall sending out peg-like penetration tube into the oospore ; extramatrix, sessile, thin, smooth-walled, hyaline with pointed apiculus when mature, broadly ovoid or narrowly urceolate, $25-38\ \mu$ high $\times 20-22\ \mu$ in diameter ; operculum surmounting the apex, prolonged conical, acuminate, $7.5-12\ \mu$ high $\times 4.5-8\ \mu$ wide at the base ; apophysis knob-like or subsporangial swelling wide at the base, gradually tapering, divided into more than one celled structure by cross wall septa, constricted at the septal region, somewhat moniliform, tip pointed ; rhizoid when present arises from the base of the apophysis, slender, delicate, sparsely branched at the tip, barely visible, sometimes absent ; zoospores mature inside the sporangium



Figs. 49-63 : Legend at the end of the article

operculum thrown off on dehiscence forming a wide pore through which zoospores emerge; zoospores and their mode of discharge not observed; resting spore not found.

Parasitic on zoospore of an *Oedogonium* sp. collected from a ditch by the side of Sultanpur Road, 11 miles south east of Lucknow University.

The chytrid is characterised by epibiotic, solitary, ovoid or narrowly urceolate sporangium, its prolonged conical, acuminate operculum, and knob-like or constricted, conically moniliform, 2-3-celled apophysis with or without rhizoid. The species resembles *C. olla* Braun, *C. acuminatum* Braun and *C. brevipes* Braun. But *C. olla* differs in its broadly umbonate operculum and in the nature of the apophysis and the rhizoid; and *C. acuminatum* in its smaller sporangia and their growth in cluster, and the total lack of endobiotic part. There is a pronounced resemblance of the chytrid to *C. brevipes*, in which too, the sporangia are ovoid, operculum conical, acuminate. The size too is practically the same, $27 \times 20 \mu$ against our species, $35 \times 20-22 \mu$ the maximum size observed by Scherffel $56 \times 40-45 \mu$. Apophysis is present in both. In our species it is knob-like or constricted 2-3-celled subsporangial structure. In typical *C. brevipes*, 2-celled large spherical, subsporangial swelling cut off from the sporangium on maturity by knob-like or conical septum. Rhizoids are variable in the former, may be present or absent in the typical species. In the light of the above observations the chytrid is identified as *Chytridium brevipes* Braun.

The species status of *C. brevipes* Braun too, is controversial. Like *C. acuminatum* Braun it is regarded as a smaller form of *C. olla* by Fischer (1892) and Minden (1915) finding support in the extreme variation in the sporangium of *C. olla* observed by Kny (1871), in over crowded condition as small as $11.9 \times 10.6 \mu$ attaining maximum size of $100 \times 57 \mu$ when growing singly, embracing far be-

yond the range covered by the sporangia of *C. acuminatum* and *C. brevipes*. The view that *C. brevipes* is a smaller variety of *C. olla* was controverted by Scherffel who in his earliest investigation of the species collected in 1897 from Iglo, Hungary, on *Oedogonium* sp. Later in two subsequent investigations of the same species on *Oedogonium vaucherii*, collected from the same locality, he first concluded against his former view (1904), that the chytrid is nothing but a smaller form of *C. olla* and proposed elimination of *C. acuminatum* as a distinct species (Scherffel 1914 p. 108). Finally again, resiling from this position on the basis of his observation that its sporangia, even when solitary and free from competition, retain their relatively smaller size, Scherffel came to the conclusion that the *C. acuminatum* is a valid species distinct from *C. olla*. (Scherffel 1926).

It is to be noted, however, that the species investigated by Scherffel as *C. acuminatum* Braun has been identified as *C. brevipes* Braun, in view of the well developed subsporangial, spherical apophysis and treated as such by Sparrow (1960) in his monograph, with the remark that further work is needed before the chytrid is reduced to synonymy. The present authors too, are of the view that the chytrid represents a species distinct from *C. olla*.

Chytridium kolianum Domjan Folia cryptogam, 2(1) : 27, 1936. (Figs. 64, 65).

Thallus epi-endobiotic, monocentric, eucarpic; sporangium epibiotic, sessile, smooth, hyaline, thin walled, spherical or ellipsoidal, $12.5-15 \mu$ high \times $15-25 \mu$ in diameter; apophysis endobiotic, subsporangial, broadly obovoid or fusoid, 15μ high \times 12.5μ wide; isthmus connecting apophysis with the sporangium, 3μ wide; rhizoids two originating as prolongations from opposite ends of apophysis, short, double contoured, unbranched; operculum entire upper part of the sporangium extending well below the equatorial

belt, convex, thin walled, smooth, hyaline, on dehiscence opening by a sharp circular rent (circumscissile) round the sporangium, thrown off as a dome-shaped large lid, 12-25 μ in diameter, persisting extramatrically, eventually disintegrating; the remnant sporangial base persists as an open bowl-like structure; zoospores in slimy mass becomes exposed on dehiscence, remain quiescent for a short period, disentangle and swim away, spherical, 3-4 μ in diameter, hyaline, posteriorly uniflagellate; resting spore not observed.

In *Closterium* sp. collected from one of the tanks in the garden of the Botany Department, Lucknow University.

Chytridium kolianum has been recorded only once on Spirogyra and Zygnema from Hungary by Domjan (1936). The chytrid is characterised by epibiotic sporangium, endobiotic apophysis, the two continuous by means of wide isthmus, two short rhizoids one at each end of the apophysis, dome shaped operculum, circumscissile dehiscence. The chytrid resembles *C. gibbosum* Scherffel in the character of the apophysis which is a flattened, swollen structure with two short rhizoids from its two opposite ends, and in no other character. On the other hand it resembles *Chytridium kolianum* Domjan, in all except isthmus and rhizoidal characters. In *C. kolianum* the sporangium is ellipsoidal, smooth, thin walled, 12.5-20 μ high \times 17.5 μ in diameter. The apophysis is endobiotic, subsporangial, ellipsoidal, 12-25 μ high \times 10-22 μ in diameter; operculum which is whole of the upper part of the sporangium is 17 μ in diameter and dehiscence is a circumscissile. In the present chytrid too, the sporangium is ellipsoidal and smooth, hyaline, 12.5-15 μ high \times 15-25 μ in diameter, apophysis endobiotic, broadly fusoid or obovate, 15 μ high \times 12.5 μ wide, operculum whole of the upper part of the sporangium extending below the equatorial belt, dome shaped 12-25 μ in diameter, dehiscence circumscissile. The distinction however, lies in the isthmus

and in rhizoidal characters. In our chytrid isthmus is wide, and rhizoids are two short prolongations from opposite ends of the apophysis whose base may be cleft into two whereas in *C. kolianum* isthmus is absent, and rhizoids are normal filamentous and branches not well developed. The host in the present fungus is *Closterium* sp. and the *C. kolianum* is saprophytic on Oogonium of *Oedogonium* sp.

In the light of the above observations, the chytrid has been identified as *Chytridium kolianum* Domjan.

***Chytridium closterii* sp. nov. (Fig. 66).**

Sporangia epibiotica, sessilia, sphaerica, 8-15 μ diametro, laevia, incolorata cum membrana tenui. Apophysis endobiotica, oriens e puncto axali sporangii et ambo continuua, ovoidea 8-11 μ longa \times 4.5-6 μ lata, membrana tenui, laevi. Rhizoidea absentes. Operculum laeve, largum, convexum, supra dimidio partem, totius sporangii, extendens infra sequatoriam regionem. Dehiscencia per acrem rotundam scissuram circum ategene sporangium (circumscissile). Rejecta ut eupula 7-10 μ diametro denique disintegrata. Reliquiae basis sporangii permanentes sicut poculum apertum 6-13 μ latum. Verae dehiscutiones zoosporae atque eorum ejectionis et posteriores modi operandi non observatae. Sporae perdurantes non inventae.

Thallus epi-endobiotic, monocentric, eucarpic; sporangium epibiotic, sessile spherical, 8-15 μ in diameter, smooth, thin walled, hyaline; apophysis endobiotic arising from basal axial point of sporangium, continuous with it, ovoid, 8-11 μ long \times 4.5-6 μ broad, thin walled, smooth; rhizoid absent; operculum large convex whole of the upper half of the sporangium extending well below the equatorial belt, smooth; dehiscence by a sharp circular rent around the sporangium (circumscissile), thrown off as a dome, 7-16 μ in diameter, eventually disintegrating; the remnant of the sporangial base persists as an

open bowl, $6-13\ \mu$ wide; actual dehiscence, zoospores and their subsequent behaviour not observed; resting spores not found.

On *Closterium* sp. collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The chytrid with its epibiotic, spherical, smooth, hyaline, sporangium is essentially similar to *Chytridium kolianum* Domjan described by the present authors. Operculum character is also similar. In both, the dehiscence is circumscissile, and the operculum is thrown off as a dome shaped structure, exposing the zoospores and the sporangial base persists as an open bowl. The present chytrid, however, differs in its somewhat smaller size, and characteristically in its endobiotic part. In contradistinction to *C. kolianum*'s broadly fusoid apophysis with wide isthmus, the apophysis here is ovoid, connected with the sporangial base by its narrow apical tip, functioning as narrow isthmus. Rhizoid is totally absent, lacking even in rudiment of rhizoid found in *C. kolianum*. The smaller size of the entire thallus, sporangium and apophysis, far more significant difference in the structural configuration of the apophysis and the nature of the isthmus connecting it with the sporangium and the total lack of rhizoid differentiates the present chytrid from *C. kolianum*. As far as the authors are aware no other chytrid conforms to the present species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012, HCIO No. 37117.

MACROCHYTRIUM

The genus *Macrochytrium* was established by Minden in 1902 to accommodate one monotypic species, *M. botrydioides*. The genus is characterised by epibiotic, monocentric, eucarpic thallus in which sporangia are epibiotic, operculate, the endobiotic part giv-

ing rise to a system of wide-lumened branched rhizoids. The fertile sporangia open up by an apical operculum.

Macrochytrium botrydioides var. *minutum* var. nov. (Fig. 67).

Thallus monocentric, eucarpic, coenocytic, single celled, consisting of main axis, basal rhizoids, and distended apical end, entire length $40\ \mu$, main axis cylindrical, $10\ \mu$ long \times $2\ \mu$ broad, base successively bifurcates forming a number of wide lumened tubular rhizoids which further branch and rebranch ending in pointed tip; contour of the wall smooth without wrinkle, or knee-like outgrowth; apical end distended, narrow obpyriform, $15\ \mu$ long \times $10\ \mu$ in diameter, broad round apex, wall smooth, colourless, filled with dark brown granular cell contents mostly collected at the apical end, no cross wall divides the distended tip from the rhizoidal axis to form the sporangium; dehiscence, zoospore not observed; resting spore not found.

Saprophytic on submerged pears used as bait for collection of *Blastocladia* from a tank in the garden of the Botany Department, Lucknow University, Lucknow.

The chytrid described here resembles *Macrochytrium botrydioides* Minden, but there are some fundamental differences. In both the thallus is single celled, the main axis is cylindrical, the apical end narrow-obpyriform. The swollen apical end does not, however, represent the sporangium in either case. The rhizoid at its proximal end is broad, tubular, much branched, the axis is filled with dense cell contents. The similarities between them cease here. No further differentiation of the thallus of the present species has been observed.

The sporangium of *Macrochytrium botrydioides* is known to be produced by the distended tip of the lateral branch originating below the apical end which gradually pushes aside the blunt apical tip of the true axis to

a lateral position and itself occupies the upright position of the main axis. While the displaced true apical tip forms a knee-like protuberance, this upright axis eventually becomes distended to form the sporangium delimited by a cross wall, situated vertically on the main cylindrical axis, from the base of which the rhizoidal system makes its appearance. The maximum length of the thallus is 800μ , the average normal specimens of which as found by Minden was $300 \times 20\mu$. It is the largest monocentric chytrid. The very minute size of the present chytrid, 40μ in its entire length, and the apical end $15\mu \times 10\mu$, the lack of cross wall delimiting the swollen apex to form the sporangium, no displacement of true apical end by lateral branch growing just underneath it, the rhizoidal axis devoid of wrinkle or knee-like growth, all points to the fact that either it is altogether a different variety or the chytrid represents a very early developmental stage of *M. botrydioides*, perhaps soon after germination, much prior to the formation of sporangium or resting spore. The authors are inclined to the former view.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology IARI, New Delhi-110 012. HCIO No. 37178.

MYZOCYTIUM

In an earlier paper the present authors (Das Gupta and John, 1953) described *Myzocytiium proliferum* Schenk, parasitic in a species of *Spirogyra*. The fungus which is of wide occurrence in wide range of green algae was also described from India previously by Chaudhuri (1933), Mundkur (1935), and Lacy (1955) all in *Spirogyra*. Again in 1963 and 1965 it was found by Karling also in *Spirogyra* sp. Three more species of *Myzocytiium* have been discovered by the authors of which *M. megastomum* de Wildeman occurs in a species of *Closterium*, *M. rotiferum* sp. nov.

parasitic in the adult of a rotifer sp. while the third designated as *M. anomalum* sp. nov. also inhabits *Closterium* sp.

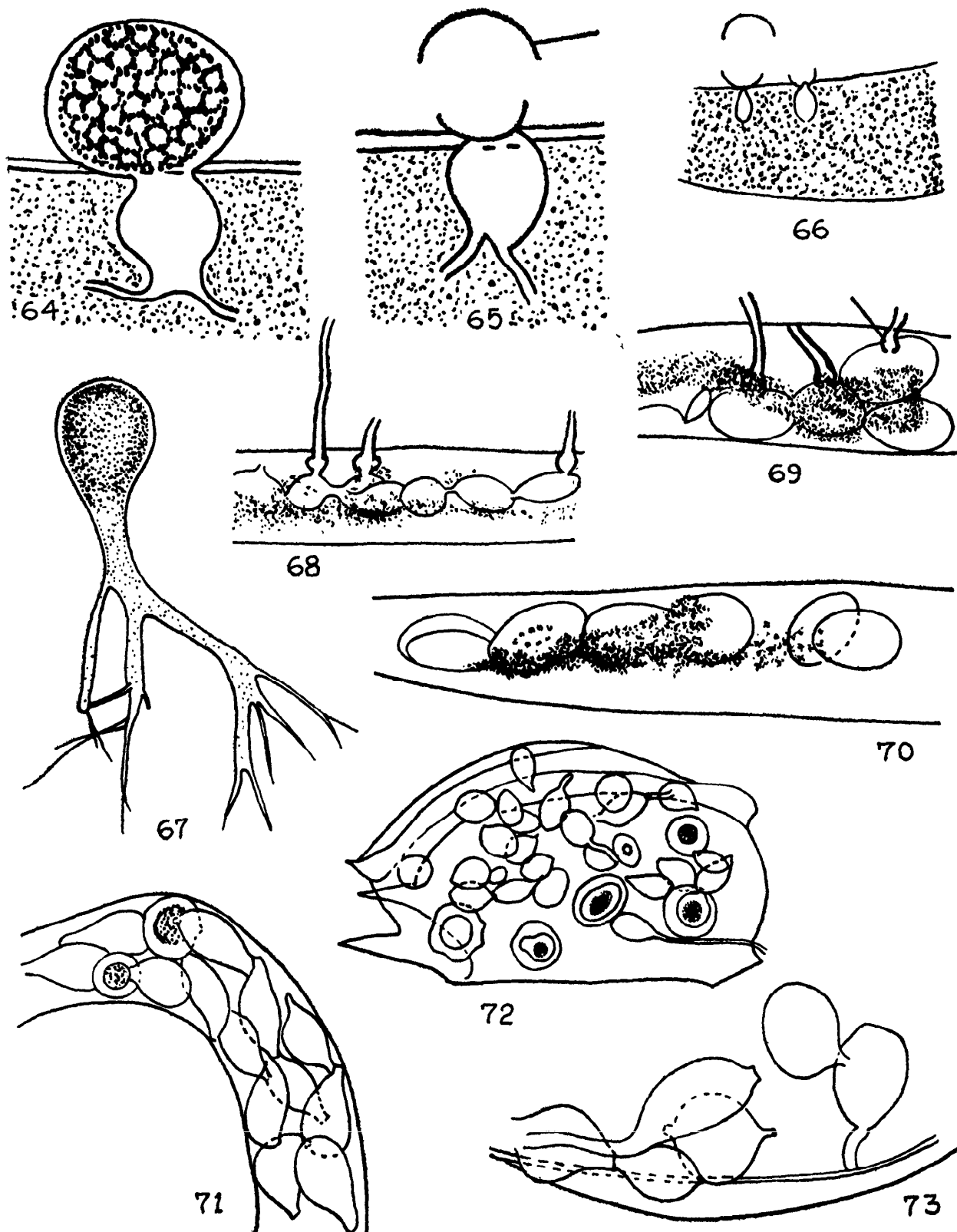
Myzocytiium megastomum de Wildeman
Ann. Bot. Belge Micro (mem.) 17 : 53, 1893. (Figs. 68-70).

Thallus holocarpic, unbranched; sporangium endobiotic, occurring as a bead-like linear series, separated by cross wall or linked by short, narrow tube, ellipsoidal, $10-22\mu$ long \times $7-10\mu$ high, ovoid $10-15 \times 5-8\mu$, or lenticiform $9-12 \times 5-8\mu$, thin walled hyaline; discharge tube single, arises as protuberance from sporangial wall, passes unconstricted through the host cell wall terminating at the surface immediately after emergence, or attain variable length maximum found 60μ , extracellular portion irregularly cylindrical, narrow, $2.5-5\mu$ in diameter, intramatrix portion shows extended swelling, rarely bulbous, $4.5-7\mu$ wide; zoospores and their mode of discharge not observed; gametangium ellipsoidal, $12-15\mu \times 6.5-8\mu$; emerging resting spore, smooth, hyaline, ellipsoidal, about the same size.

In a *Closterium* sp. collected from one of the tanks in the garden of the Botany department, Lucknow University.

Schenk (1858) established the genus *Myzocytiium* with the species of *proliferum*. De Wildeman (1893) distinguished *M. megastomum* as a species distinct from *M. proliferum*; the distinguishing feature being discharge tube with a more or less well defined swelling beneath the inner face of the host cell wall. Since then the species has been described by Scherffel (1914), Skvortzow (1925), Ciep (1935), Martin (1937), Berdan (1938), Canter (1948), Sparrow and Barr (1955).

The present fungus conforms to the species *Myzocytiium megastomum*. The sporangia are arranged in a linear series, of variable shape, oval, elliptical or lenticular, $10-12\mu \times 5-10\mu$, smaller than those of the typical



Figs. 64-73; Legend at the end of the article

species which is $22.50 \times 9.32 \mu$. The discharge tube originates from the sporangial wall developing as a narrow flexible tubes which pierces through the host cell wall, unconstricted and emerges outside to attain various lengths some terminating at the wall surface. The swollen base that distinguishes *M. megastomum* from *M. proliferum* formed beneath the inner surface of the host wall is 4.7μ in diameter.

Myzocytrium anomalum sp. nov. (Fig. 71).

Thallus holocarpicus, endobioticus, eramosus; sporangium discretum, plerumque pyriforme, constrictum ad extremitate apicali, raro fusiformis cum constrictionibus ad extremitatibus ambabus, laeve, hyaline, $25-40 \mu$ longum, $15-20 \mu$ latum, sporangia irregulariter disposita in serie bus irregularis duplo-linearis varie inter-se imbricatis; tubus emissi non observatus in ullo sporangio; zoospores non visa; reproductio sexualis a antheridio et oogonio sphaerico; spora quickens non visa.

Thallus holocarpic, endobiotic, unbranched; sporangium discrete, predominately pyriform, constricted at the apical end, occasionally spindle-shaped with constriction at both ends, smooth, hyaline, measuring $25-40 \mu$ long by $15-20 \mu$ broad; sporangia haphazardly arranged in an irregular, double linear series, variously overlapping each other; discharge tube not found to be formed in any sporangium; zoospore not observed; sexual reproduction by unspecialised antheridium fertilising spherical oogonium by direct fusion or by the formation of small papilla; resting spore not found.

In *Closterium* sp. collected from a tank in the garden of the Botany Department, Lucknow University.

The present fungus is strikingly different from the two algae-inhabiting *Myzocytrium* species, *M. proliferum* and *M. megastomum* in the arrangement of sporangia as well as other characters. In this fungus sporangium

is discrete, biserial in host haphazardly arranged in irregular series. Some sporangia at one end overlaps the top of the next, bases overlap each other; in others again apical end points to opposite directions. In all these, however, the long axis of the sporangium lies parallel to the host cell wall. The host is strongly arched. The sporangia are varied in shape, pyriform, fusoid, lenticular with constriction at both ends, all in the same host cell. In size these are $25-40 \mu$ long \times $10-15 \mu$ wide. While discharge tube is commonly formed in each of the sporangium in *M. proliferum* and *M. megastomum*, none of the sporangium in the present species has been found to form discharge tube. Sporangia arranged in double series are perhaps not uncommon. Canter for example illustrates seriate elliptical sporangia in a *Closterium* sp. none of which has reached the stage of maturity of formation of discharge tube (Canter 1947, p. 81, fig. C).

Male and female gametangia are more or less similar in structure in *M. proliferum* and *M. megastomum* and fertilisation is by a pore or tube. In the present fungus, the male gametangium is unspecialised, mostly pyriform-like sporangium, the female gametangium, oogonium is spherical. The reproduction is accomplished by the fertilisation of oogonium by the antheridium, in which pointed apical end or basal papilla acts as fertilization tube.

In the presence of the non-linked, discrete, mostly overlapping sporangia haphazardly arranged into two irregular series, lying parallel to the host cell wall, of varied shape, arched host cell, the complete absence of discharge tube sexual reproduction by dissimilar male and female gametangia, the fungus, though closely related, is very distinct from any of the known species of green algae inhabiting *Myzocytrium*.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology IARI, New Delhi-110 012. HCIO No. 37184.

Myzocyttium rotiferum sp. nov. (Figs. 72, 73).

Thallus holocarpicus, eramosus; sporangium numerosum, irregulariter dispositum, variabile, subsphaericum, $7-8\mu$ in diam., pyriforme, $8-10\mu$ latum \times $6-7\mu$ altum, parvisimum 2.5μ in diam., non lobulatum; tubus emissi flexilis, tubularis, $6\mu \times 2\mu$, operiens intus corpus hospitis, raro magnus, $15-20\mu \times 1.5-2\mu$, penetrans per parietem hospitis et apertus extus a dissolutione apicis; zoosporae et illarum modus emissi non observatae; gametangium sporangii simile, pariete laevi, raro undulato; oospora parthenogeneticaliter evoluta, plerumque ovoidea, ecolorata, $7-11\mu \times 5-7\mu$, pariete crasso, laevi, remanens laxa in gametangio; germinatio non observata.

Thallus holocarpic, unbranched; sporangium numerous, arranged irregularly, variable in shape, subspherical, $7-8\mu$ in diameter, pyriform, $8-10\mu$ wide \times $6-7\mu$ high, smallest 2.5μ in diameter, non-lobulate; discharge tube flexible, tubular $6\mu \times 2\mu$, opening inside the body of the host, occasionally large, $15-20\mu \times 1.5-2\mu$ penetrating through the host wall and open up outside by the dissolution of the tip zoospores and their mode of discharge not observed; gametangium similar to sporangium wall smooth, rarely undulating; oospore developing parthenogenetically, mostly ovoid, colourless, $7-11\mu \times 5-7\mu$, wall thick, smooth, lying loosely in the gametangium, germination not observed.

Parasitic in the adult rotifer, found in the sediment, collected from the bottom of one of the tanks in the garden of the Botany Department, Lucknow University.

The only rotifer inhabiting *Myzocyttium* species so far known is *Myzocyttium zoophthorum* as described by Sparrow (1960). It is characterised by irregularly arranged sporangia, saclike, often lobular, $5-17\mu$ in diameter, of variable length, separated by narrow, inconspicuous septa, branched, discharge tube generally short, and broad, zoospores are discharged outside; the oospore

perfectly spherical, double-walled. In all these characters our rotifer inhabiting species appears to be basically different. In the present species the thallus is not branched, the sporangium is not saclike, nor lobular. On the other hand the sporangium is subspherical, oval, pyriform, discrete entity, irregularly scattered, occasionally appearing as linked series. The discharge tube is filamentous, tubular, usually short occasionally long, liberation of zoospores is both inside the host body or outside it. Zoospores and their mode of discharge could not be compared as these have not been observed by us. The gametangia and oospores in our species are subspherical or oval. The distinction between the two is thus very clear.

Sparrow (1960) on his comments on the species described by him as *Myzocyttium zoophthorum* states that the lobular branched thallus observed in the infected rotifer, may well be the thallus of *Lagenidium lineare* a species imperfectly known, intimately associated with the *Myzocyttium* species in the host body of the rotifer. While this may to some extent explain the differences that exists between the two species, our fungus appears to be basically different from the one described by Sparrow. The species of the host rotifer also seems to be different.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37183.

OLPIDIOPSIS

The first record of the Indian *Olpidiopsis* was by Butler (1907) who described the species of *Olpidiopsis minor* Fischer, revised by Karling as *O. fusiformis* Cornu, the species of *Pseudolpidium aphanomyces* (Cornu) Fischer revised as *O. aphanomyces* (Cornu) Saccardo. The third, *Olpidiopsis schenkiana* Zopf, retained its original diagnosis. To these three, Das-Gupta and John added the species *Olpidiopsis achlyae* McLarty in 1953. Since

then several species have been recorded. These are *O. fusiformis*, *O. luxurians*, *O. saprolegniae* var. *saprolegniae* (Srivastava and Bhargava 1963); *O. varians*, and *O. indica* (Srivastava 1964, 1975); *O. incrassata* (Srivastava G. C. & R. C. 1976) all from Gorakhpur; also *O. saprolegniae* var. *indica* (Thakurji 1967) from Varanasi. Almost all these species besides *O. pythiae* have been recorded from South India (Karling 1966).

The present fungus diagnosed as *Olpidiopsis decipiens* sp. nov. parasitizes a species of *Oedogonium*, infecting exclusively its oogonium. The thallus of the chytrid, the sporangium, single or two or three in a cluster, ovoid in shape, develop extramatrically within the oogonium. The discharge tube emerges through the oogonial pore or piercing through the oogonial wall. The filaments of *Oedogonium* with the sporangia inside the infected oogonia with emerging tips of discharge tubes, present a characteristic appearance, similar to the *Rhizophydium decipiens* (Braun) Fischer.

***Olpidiopsis decipiens* sp. nov. (Figs. 74-84).**

Sporangium endobioticum, solitarium vel duo/tria in fasciculo in oogonio quiescenti laxo in ooplasmate in uno latere separatum a membrana ooplasmica, oogonium hand omnino complens, late vel anguste ovoideum, 20-30 μ altum \times 15-20 μ latum, pariete laevi, hyalino; rhizoideum nullum, tubus emissi apicalis, unus in quoque sporangio, crassus, brevis, maxime 10 μ longus, ad basin parum tumidus, parte superiore curvata prope orificium; zoospora reniformis cum flagello affixo in latere concavo, emissa per poram perfecte maturam; spora quiescens remanens laxa in oogonio in uno latere, interdum cum sporangio, ellipsoidea, 20-25 μ alta \times 15-20 μ lata, brunnea, laevis, pariete duplicato cum endospora tenui et exospora non striata, contentum cum globulis refractivis: germinatio sporae quiescentis non observata.

Sporangium endobiotic, solitary or two or

three in a cluster in the oogonium resting loosely on the ooplasm at one side separated by an ooplasmic membrane, never occupying the entire oogonial space, broadly or narrowly ovoid 20-30 μ high \times 15-20 μ wide, wall smooth, hyaline; rhizoid absent; discharge tube apical, one in each sporangium, stout, short, maximum 10 μ long, slight swelling at the base, upper part characteristically curved near the orifice, emergence outside the oogonial pore, or opening made by piercing through any point in the oogonial wall, right from the cap cell, down to the supporting cell; opening narrow to very wide depending on the number of discharge tubes emerging through it; zoospore reniform with the flagella attached to the concave side, discharged through the pore fully matured; resting spore lying loosely in the oogonium at one side, sometimes along with the sporangium, occupying only a part of the oogonial space, ellipsoidal, 20-25 μ high \times 15-20 μ wide, brown, smooth, double walled with thin endospore and thick, unstriated exospore; contents with one to several refractive globules; development parthenogenetic; germination of resting spore not observed.

Parasitic exclusively in the oogonium of *Oedogonium* species collected from one of the tanks in the garden of the Botany Department of the Lucknow University.

The fungus infecting the species of *Oedogonium* and forming one or more extramatrically which rest loosely on the ooplasm delimited by a thin membrane. The sporangium filling the entire cavity space, produce generally one discharge tube, occasionally two which emerge outside through the oogonial pore or by piercing the oogonial wall.

Similar to the sporangium having the same size and shape, resting spores are formed either singly in the oogonium or associated with the sporangium occupying similar position. The shape of the resting spore is ellipsoid almost identical to the shape of the

sporangium and evidently transformed sporangium. (Figs. 82, 83). The zoospores produced by the sporangia are biflagellate.

The species *Rhizophydium decipiens* was originally identified by Braun (1855) as *Chytridium decipiens* parasitic in the oogonium of *Oedogonium echinosporum*, *Oedogonium tumidulum* and also *Oedogonium vaucherii*. Since then successive workers Cornu (1872) and Lagerheim (1888) found the fungus in the oogonia of different species of *Oedogonium* and identified as belonging to *Phlyctidium* and *Olpidiella* respectively. Fischer (1872) in his monograph, removed the fungus from the genus *Chytridium* and placed it with *Rhizophydium*. Petersen (1909) placed the fungus in *Olpidium*. Scherffel (1926), who made a thorough investigation of this fungal parasite in *Oedogonium vaucherii*, *O. cardiacum*, *O. sexangulare* and *O. rufescens*, confirmed its position in *Rhizophydium*.

Though similar in external characters, the fundamental difference between the two fungi, *Rhizophydium decipiens* to the present one, lies in the zoospore characters. In *R. decipiens* zoospores are spherical, 3-4 μ in diameter with characteristic eccentric fat drop. A single flagellum is drawn along the zoospore while swarming after liberation. The body of the swarmer is capable of strong amoeboid change of form (Scherffel, 1926). Whereas in the fungus under observation the zoospores are reniform with two flagella arising from the concave side, and swarming with normal gliding movement. The former is chytridiaceous and the latter is Lagenidiaceous. (Fig. 84).

The presence of rhizoids in *Rhizophydium decipiens* is controversial. No rhizoid has been demonstrated by any worker so far. Petersen (1909) considered rhizoid as non-existent, and placed it in *Olpidium*. Though unobserved Fischer considered rhizoids to be present but masked by dense cytoplasm. Even the meticulous investigation of several

species of *Oedogonium* by Scherffel (1926) failed to reveal rhizoid, making the possibility of its occurrence extremely doubtful.

In the present fungus too, no rhizoid has been detected. Any rhizoid arising from extramatrix sporangium, inside the infected oogonium and entering ooplasm is most unlikely to elude detection particularly while passing through the intervening space between sporangium and ooplasm wall. It is thus concluded that the rhizoid is not produced by the chytrid under study. In the absence of rhizoid and particularly because of the biflagellate condition, the diagnosis of the chytrid as a member of the *Olpidiopsis* is inevitable.

An important feature of the study of the chytrid *Rhizophydium decipiens* by Scherffel (1926) is his observation that the discharge tube from the sporangium always emerges through the pore in the oogonial wall, and never piercing through the oogonial wall itself. Scherffel considered the ability of the chytrid to pierce through oogonial wall so specific that he argued that even though rhizoid is absent, the chytrid cannot be placed in the genus *Olpidium* as was done by Petersen.

In the present fungus the discharge tube is formed from any part of the sporangium and not only emerges through the oogonial pore but also pierces through the oogonial wall at any point close to the discharge tube as our illustrations show. The evidence of penetrating ability is provided by the fixity of the position of the pore in the oogonial wall of given *Oedogonium* species. Smith (1938, p. 75) states that "the shape and position of the opening are quite characteristic for a species and are characters of diagnostic importance in separating species from one another". This referred to the genus *Oedogonium*. Thus, if the pore were the only passage in all the infected oogonia of a species the position of the discharge tube in all oogonia should have been identical.

In the present fungus the emergence of the discharge tube through various points of the oogonial wall from below the cap cells down to the supporting cells of the host, is clear evidence that the discharge tubes pierce through the oogonial wall when no pore is near by; poral opening provides only a convenient passage for emergence.

Scherffel's illustrations describing the sporangia of *Rhizophydium decipiens* in host oogonia appear to support our observations. In his fig. 98 the zoosporangium is shown to emerge through the pore just at a spot as shown in fig. 76 and 78 of our fungus. The species involved is *Oedogonium cardiacum*. In his fig. 101, the oogonium of the same species, *O. cardiacum*, shows two resting spores at the opposite ends of the pore-site as shown in fig. 98, near the supporting cells, indicating the location of pore at the cap cell end, assuming that pore provides the only passage for the emergence of discharge tube. In fig. 99 again, the discharge tubes of three zoosporangia in a cluster are shown to emerge through a wide apical pore, precisely as in fig. 79 of our fungus. In this case however, the name of the species concerned has not been mentioned. It may well be *Oedogonium cardiacum*. It is thus clear from the illustrations that the openings of the three different oogonia are in three different positions. At least two, if not all the three, oogonia belong to the same species of *Oedogonium cardiacum*. But only one of these openings can be the normal pore. From this it is concluded that the discharge tube in Scherffel's fungus does pierce through the oogonial wall, negating his assertion to the contrary.

The identity of the present fungus as a species different from *Rhizophydium decipiens* is undoubted. It has been placed in the genus *Olpidiopsis* due to its biflagellate zoospores and because of its obvious close similarity with *Rhizophydium decipiens* the

fungus has been termed *Olpidiopsis decipiens*.

The two fungi, both specialised parasites in oogonium of *Oedogonium*, one chytridiaceous with uniflagellate zoospore found to be of common occurrence the other lagenidiaceous with biflagellate zoospore found only by the present authors, indicate parallel development of the two species in the two orders, Chytridiales and Lagenidiales. In the course of their development some differences have arisen, such as the position of the discharge tube, their ability to penetrate through the oogonial wall in one, and supposed lack of it in another, emergence through the oogonial pore being common to both. Such parallelism is not uncommon and are demonstrated by several operculate species of Chytridiales, having their counterpart in the inoperculate, or even in different orders.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology IARI, New Delhi-110-012. HCIO No. 37179.

***Olpidiopsis decipiens* (in *Bulbochaete* sp.)**

Thallus holocarpic, unicellular; sporangium endobiotic, 1-3 in a cluster, exclusively parasitic in the terminally formed oogonium of the host cell, resting on the ooplasm, never occupying the entire oogonial space, restricted to one side 20μ high \times 15μ broad, single walled, thin, smooth, hyaline; discharge tube arising as protrusion from apical end, stout, short, about 6μ long, each penetrating the oogonial wall at separate points, somewhat hulging at the point of emergence, pore wide; rhizoid absent; zoospores not observed; resting spore ellipsoidal, 20μ high \times 25μ wide, inner wall thin, outer wall thick, brown, smooth, striations absent, lying loosely in the oogonium at one end, occupying only a part of the oogonial space; development parthenogenetic; germination not observed.

Parasitic in the oogonium of *Bulbochaete* sp. collected from one of the tanks in the

garden of the Botany Department, Lucknow University.

In the preceding pages *Olpidiopsis decipiens*, a new species, parasitic in the oogonium of a species of *Oedogonium* has been described, pointing out its remarkable similarity to a chytridiaceous species diagnosed as *Rhizophydium decipiens* (Braun) Fischer ; variously described by different workers as *Olpidiella*, also *Olpidium* but confirmed as *Rhizophydium* by Scherffel (1926).

The fungus infecting the *Bulbochaete* species as described here is identical to the one described as *Olpidiopsis decipiens* infecting oogonium of *Oedogonium* sp. In both, sporangium is ovoid, rhizoid absent, the discharge tube is formed by the prolongation of the apical end of the sporangium, the emergence of which is both through the oogonial pore as well as by piercing the oogonial wall at the subapical or the lateral region of the oogonium.

It is important to note, that the penetration of the oogonial wall by discharge tube was more clearly observed here in the present host. The illustrations presented here exhibit that when more than one discharge tube is formed by the sporangium, each has its independent passage, which may remain separate with intervening oogonial wall intact or may occasionally rupture to form a large pore as found in some infected oogonium of *Oedogonium* species acting as the host. The resting spores which are similar in character to the sporangium lie loosely in the oogonium extramatrically. As in the species infecting *Oedogonium*, the germination of resting spore has not been observed in this fungus infecting *Bulbochaete* species. But there is one case in which a resting spore formed a papilla, through which some contents had been discharged probably representing unformed zoospore.

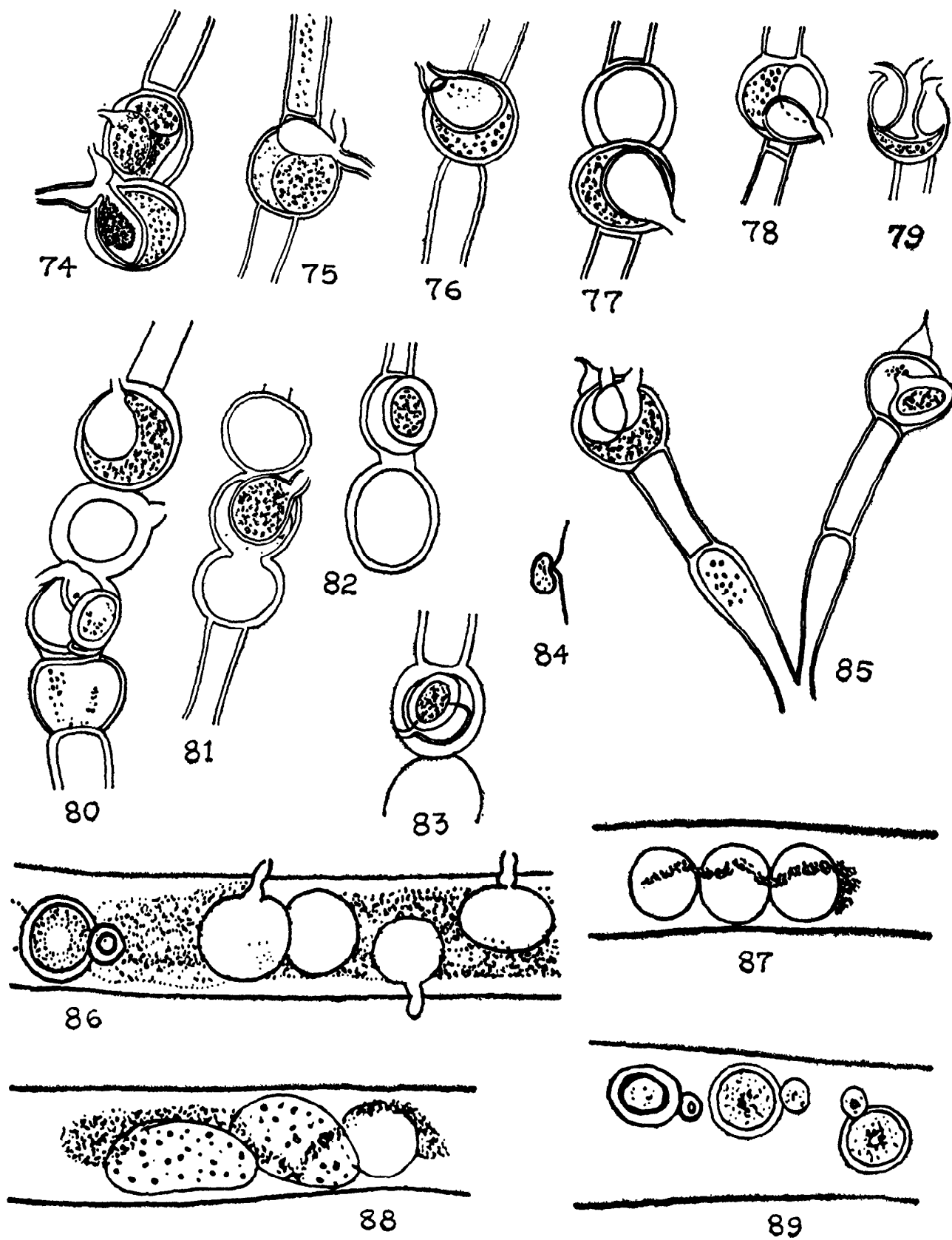
The filaments of *Bulbochaete* species were found in limited number, intermingled with copious filaments of healthy and infected

Oedogonium species, of which only a few were found infected. *Bulbochaete* as a genus is known to be parasitised by only three species of *Chytridium* and one species of *Rhizophydium*. Now a third parasitic species *Olpidiopsis decipiens* is described here. Evidently *Bulbochaete* is much less susceptible than the genus *Oedogonium* (Fig. 85).

***Olpidiopsis sphaericis* sp. nov.** (Figs. 86-89).

Sporangium endobioticum, discretum, laxe seriatim dispositum in hyphis hospitis, sphaericum, 10-17 μ in diam., pariete tenui, ecolorato ; tubus emissi unus in uno sporangio, ad medium positus, 12-15 μ longus, cylindricus, 2.5-3 μ diam., valde constrictus ad parietem cellulae hospitis et expansus ad superficiem interiorem exterioremque parietis, duos tumores bulbosos formans, brevis, terminans admodum extus, haud longe filamentosus : zoosporae et illarum modus emissi non observatae ; spora quiescens sphaerica ; 13-15 μ diam., laevis, pariete duplicato, cum uno globulo magno, centralis, semper cum cellula compaginata, sphaerica vel subsphaerica, 3-7 μ in diam., germinatio non observata ; spora quiescens sexualiter formata, post fecundationem oospora habens parietem duplicatum.

Sporangia endobiotic, discrete, loosely arranged linearly in the host hyphae spherical, 10-17 μ in diameter, wall smooth, colourless ; discharge tube one in a sporangium medianly placed, 12-15 μ in length, cylindrical, 2.5-3 μ diam., strongly constricted when passing through the host cell wall and expanded locally on the inner and outer face of the wall, forming two bulbous swellings, short, terminating just when outside, never long filamentous ; zoospores and their discharge not seen ; resting spore spherical, 13-15 μ in diameter smooth, double walled, with one large globule, centric, consistently with a companion cell, spherical or subspherical 3-7 μ in diameter ; germination not



Figs. 74-89 : Legend at the end of the article

observed; resting spore formed sexually, a larger thallus conjugating with a smaller thallus, both in the earlier phase single walled, after conjugation oospore develops double wall.

Parasitic in hyphae of a *Zygnema* sp. collected from a road side ditch, Sultanpur Road, 11 miles south east of Lucknow University.

The fungus is characterised by globose, discrete, rhizoidless, linearly arranged sporangia and resting spore consistently with companion cell. As the zoospores have not been observed, in the absence of our knowledge of the flagellate condition, particularly its number the basic criterion for determination of its systematic position remains undetermined. The recourse is therefore taken of the indirect evidence that helps to determine in the identification of the species.

On the basis of the observed characters the fungus may be placed either in the genus *Olpidium* or in the genus *Olpidiopsis*. In *Olpidium*, among the known species in green algae, one, *Olpidium zygneticola* inhabiting *Zygnema* sp. the same host as that of the present fungus, very similar in sporangial characters, but the difference in vegetative characters lies in the absence of bulbous base in discharge tube which is uniformly narrow. The other is *Olpidium rotiferum* in the zygospore of *Spirogyra* sp. in which the characteristic bulbous swelling in the emerging discharge tube which becomes strongly constricted as it passes through the zygote wall and expands locally on its outer surface, but widely differing in sporangial and other characters. In *Olpidiopsis* too, apart from *O. schenkiana* described in a previous paper, there are four species conforming in sporangial characters. But of these all except *O. oedogoniarum* have ornamented resting spores: *O. oedogoniarum*—however with spherical, smooth resting spore possess elongated, ovoid, sac-like sporangium.

The character that unquestionably determines the position of the fungus as a mem-

ber of *Olpidiopsis* as opposed to *Olpidium* is the production of resting spore with attached companion cell. The smaller male thallus gets attached to the larger female thallus both thin walled eventually transformed into double walled resting spore. The species however, does not conform to any other known species of *Olpidiopsis* parasitic in green algae as discussed above.

Holotype deposited at the HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37181.

LAGENIDIUM

Lagenidiales is the recent name of the order which was earlier originally known as Ancylistales. But the switch over to the name Lagenidiales came when the genus *Ancylistes* was transferred to the order Entomophthorales, following the discovery of Berdan (1938) of its conidial reproduction instead of zoosporic. The name Lagenidiales was proposed by Karling.

The order Lagenidiales is characterised by zoospores with two flagella of approximately equal length, oppositely directed, endobiotic, holocarpic, thallus unbranched or occasionally branched, segments of limited growth, persistent zoosporangium, production of zoospores either within the zoosporangium or at the orifice of the discharge tube, surrounded by a vesicle and oogamous sexual reproduction. The order is represented by three families Olpidiopsidaceae, Lagenidiaceae and the third a marine family Sirolpidiscaeae.

In India, Butler (1907) was the first to describe Lagenidiales, representing three species all belonging to the family Olpidiopsidaceae, viz., *O. fusiformis* Cornu, as *O. minor* Fischer, in the hyphae of *Achlya polyandra*, *O. schenkiana* Zopf. parasitic in the living hyphae of *Spirogyra* and *O. aphanomyces* (Cornu) Saoc. as *Pseudolpidium aphanomyces* (Cornu) Fischer in hyphae of *Aphanomyces laevis*.

Butler was followed by Chaudhuri (1931) who described second genus *Myzocytium*, *M. proliferum*. Later Karling (1966) in his study of Indian aquatic fungi described 6 species of *Olpidiopsis* and one species each of *Rozellopsis* and *Petersonia* of the family Olpidiopsidaceae as well as 4 species of *Lagenidium* and one species of *Myzocytium* of the family Lagenidiaceae. Of all these 13 species described by Karling none was new species. In the intervening period between the work of Chaudhuri and that of Karling extensive studies had been carried out on aquatic phycomycetes by Das Gupta and John in mid-fifties. In the course of their investigations the authors came across many members of the order Lagenidiales of which 2 species belonged to genus *Olpidiopsis* and three species to the genus *Myzocytium* and 11 to *Lagenidium*. Nine of the *Lagenidium* species proved to be new.

Lagenidium rabenhorstii Zopf, Sitzungber. Bot. Vereins Prov. Brandenburg, 20 : 77, 1878 ; Nova Acta Acad. Leop.-Carol, 47, 145, pl. 12 figs. 1-28, pl. 13 figs. 1-9, 1884. (Figs. 90-92).

Thallus tubular, 70-75 μ long by 2.5 μ wide in normal cell, confined to and occupying almost the entire length of the host cell, 90 μ long by 30 μ wide, curved, irregular, segmented, 4-5 in number, elongated segments, 25-40 μ by 4.5 μ , intercalary or terminal segments swell to form similar irregular swollen branches 3-6 μ wide ; sporangia of the same size and shape, as the thallus segment, producing single discharge tube, narrow, straight or curved from the terminal end, base occasionally swollen, passes through the host wall unconstricted, longest 15.5 μ projects short distance 4.5 μ beyond the wall of the host ; zoospores their formation and mode of discharge not observed ; plant dioecious ; female gametangium arising in a terminal segment, spherical, with rounded apical protuberance 9 μ diameter, male game-

tangium (antheridium) absent ; oospore develops in the female gametangium parthenogenetically, spherical, 6.6 μ in diameter, double walled, smooth, hyaline, filling almost the entire gametangium ; germination of oospore not observed.

Parasitic in the vegetative filaments of *Spirogyra* sp. collected from a ditch by the side of the Sultanpur Road, 11 miles from Lucknow University. Zygosporangium and gametangium are not infected.

Lagenidium rabenhorstii first described by Zopf (1874) has since been recorded in many European and other countries, China as well as India, where it was discovered by the present authors (1956), and later by Karling (1966). Both dioecious and monoecious species were found and for the sake of convenience are separately treated here.

The dioecious species of the present authors agree well with those described by Zopf and Cook and other authors. The thallus is confined to the infected cell. The sporangia are unspecialised cells same as the thallus segments. Each segment has a discharge tube of uniform bore, just jutting out of the cell, no constriction at the penetration point while passing through the cell wall. None showed zoospore containing vesicle. The female gametangium formed as a terminal segment gives rise to oospore parthenogenetically. No thallus segment behaves as an antheridium to effect fertilisation. Dioecious forms are known to occur in this species. (Figs. 90-92).

Lagenidium rabenhorstii Zopf, Sitzungsber. Bot. Vereins Prov. Brandenburg, 20 : 77, 1878 ; Nova Acta Acad. Leop.-Carol., 145, pl. 12, figs. 1-28, pl. 13, figs. 1-9, 1884. (Fig. 93).

Thallus tubular, curved, irregularly branched, lobular, septate, segments of different size and shape, highly constricted at the septal region, variously branched, sporangium

difference lies in the thallus character and its complex configuration.

In the light of these differences the fungus has been identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37119.

Lagenidium obovatum, sp. nov. (Figs. 96-97).

Thallus tubularis, curvatus, ramosus, segmenta 4-6, varie formata, amplitudine variabilia, elongata, tumida, septata, angusta in regione septali; sporangia non speciale formata, segmenta hyphalia aequantia similiaque, variabilia; tubus emissi 7.5-15 μ longus, 1.3-2.5 μ latus, oriens e sporangio varie formato vel e oospora parthenogenetica, uniformiter angustus, non constrictus, parum projectus extus parietem cellulae hospitis; zoosporae et illarum modus emissi non observatae; sporae quiescentes sexuales sphaericae, 8-12 μ in diametro, terminales vel subterminales cum ramo bifido terminali; reproductio sexualis, a antheridio oogonioque; oogonium intracellulare; antheridium obovoideum, hyalinum, pariete laevi, 10-15 μ longum, 8-12 μ latum, tubus fecundationis prodiens e extremo angustato, brevis, conicus, oogonium penetrat et fecundat; oosporae sphaericae, 13-15 μ in diam., parietibus 2-stratis, laeves, hyalinae, cum uno globulo ad centrum; una oospora parthenogeneticaliter formata, visa in gametangio, sphaerica, hyalina, 7.5 μ in diametro, germinans a tubo emissi oriens e oospora; germinatio oosporae, sexualiter formatae, non observata.

Thallus tubular, curved, branched, segments 4-6 of variable size and shape, elongated, humped, septate, narrow at septal region; sporangia unspecialised, same in size and shape as hyphal segments, variable, discharge tubes 7.5-15 μ long by 1.3-2.5 μ wide, arising from variously shaped sporangia or from parthenogenetic oospore uniformly narrow, unconstricted while passing through the host

cell wall, extending a short distance beyond cell wall; zoospores and their discharge not observed; sexual resting spores full of dense cell contents spherical, 8-12 μ in diameter, terminal or subterminal with bifid terminal branch; sexual reproduction by antheridium and oogonium; oogonium intracellular; antheridium a specialised structure, obovoid, smooth walled, hyaline, 10-15 μ long by 8-12 μ wide; fertilisation tubes produced from the tapering end short, conical, penetrates and fertilises the oogonium; oospores spherical, 13-15 μ in diameter, double walled, smooth, hyaline with one globule at the centre; one parthenogenetically formed oospore found in a gametangium, spherical, hyaline, 7.5 μ in diameter, germinates by formation of discharge tube arising directly from the oospore; germination of sexually formed oospore not observed.

Parasitic in the vegetative cells of *Spirogyra* sp. collected from a ditch by the side of the Kursi Road, 4 miles from Lucknow University.

The fungus is characterised by simple thallus configuration. The thallus segments are irregularly lobed and swollen. Some of the segments are transformed into sporangium and produce uniform bore unconstricted discharge tube one from each sporangium, that projects outside. None of them shows the presence of zoospore containing vesicle. Sexual reproduction occurs in the species as shown by the presence of intracellular female gametangium and antheridium. The antheridium in the present species is a specialised structure, obovoid conical, pointed fertilisation tube, that penetrates the oogonium and effects fertilisation giving rise to smooth walled oospore. It is to be noted that there are several oospores in the thallus some of which do not seem to have accompanying antheridium, and appear to be produced parthenogenetically. One of these is distinctly similar to the parthenogenetically produced oospore in the dioecious species of

L. rabenhorstii, described by the authors earlier.

Specialised form of antheridium is rare in *Lagenidium* species. Of all the species recorded in Sparrow (1960), it is only *Lagenidium pythii* Whiffen that has specialised cell as antheridium, smooth walled, spherical or ovoid in structure. In all others the male gametangium is of diverse shapes, resembling the sporangial segment of the thallus rarely semispecialised.

The presence of specialised antheridium has been taken as the criterion to distinguish the present species from other species of *Lagenidium*, where sexual reproduction occurs. In view of the fact that in the present fungus the specialised antheridium is obovoid in structure, the fungus has been identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37120.

***Lagenidium pyriforme* sp. nov. (Fig. 95).**

Thallus tubularis, curvatus, septatus, segmenta varie formata, amplitudine variabilia, sporangium segmentum hyphalem simile, tubi emissi plures e sporangio, uniformiter angusti, non constricti ubi penetrans per pariete in celluloso vicino, 33-44 μ longi, 4.5 μ lati; zoosporae et illarum modus emissi non observatae; reproductio sexualis a antheridio et oogonio; oogonium in gametangio foemineo vel extracellulare; antheridium pyriforme, 15-18 μ altum, 5.5-11 μ latum; conjunctio antheridiorum duorum a tubo hyphali basali observata; tubus fecundationis unus vel plures, unus fungens oriens e extremo basali vel e puncto laterali, brevis, conicus, oogonium penetrat et fecundat; oospora sphaerica, 13 μ in diam., laevis, hyalinus, pariete crasso; germinatio oosporae non observata.

Thallus tubular, curved, septate, segments of variable size and shape; sporangium same as hyphal segment; discharge tube more than

one from a sporangium, uniformly narrow, unconstricted while passing through the wall into the neighbouring cell, measuring 33-44 μ long by 4.5 μ wide; zoospores and their mode of discharge not observed; reproduction sexual, by antheridium and oogonium; oogonium in female gametangium or extracellular; antheridium, a specialised structure, pyriform, 15-18 μ high by 5.5-11 μ broad, fusion of two antheridia by a basal hyphal tube observed; fertilisation tube one or more, only one functional, arising from basal end or from a lateral point, short, conical, penetrating into and fertilising the oogonium; oospore spherical 13 μ in diameter, thick walled, smooth, hyaline; germination of oospore not observed.

Parasitic in the vegetative cells of *Spirogyra* sp., collected from a ditch, by the side of the Sultanpur Road, 11 miles from Lucknow University.

The fungus is characterised by simple thallus configuration. The thallus segments are irregularly lobed, contorted, occasionally swollen also producing a number of pyriform as well as spherical structures. Some of the segments behave as a sporangium giving rise to narrow unconstricted, uniform bore discharge tube which projects outside, but none showed the presence of zoospore containing vesicle.

In this species too, sexual reproduction occurs as evidenced by the presence of oogonium associated with antheridium. The antheridium is a specialised pyriform structure, abundantly produced as stated earlier, with conical pointed fertilisation tube produced from the axial end of the broad base, that penetrates into the oogonium and effects fertilisation giving rise to smooth walled spherical oospore. In some, the fertilisation tube arises from the lateral position of the broad base.

In thallus character as well as the sexual reproduction in which the specialised antheridium fertilises the oogonium giving rise

in the present fungus is sculptured with characteristic golden gleam. Besides in thallus character, too, the two species are entirely different. It is narrow tubular with undulated, wrinkled cell walls of complex configuration and in *L. papillosum* thallus is of simple character resembling *L. rabenhorstii* (Pringsheim) Zopf.

Taking the antheridium and oospore as well as thallus characters as criteria the fungus is identified as a new species of *Lagenidium*.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37123.

***Lagenidium cylindriforme* sp. nov.** (Fig. 102).

Thallus latus, cylindricus, curvus, incurvationes profundae vel vadosae, protuberationes formantes, formae irregulares, aseptatus, segmenta pauca, segmentum maximum $31-37\ \mu$ longum $\times 7-30\ \mu$ latum limitatum et occupans zygosporam integram; sporangium segmentum thalli simile, vix visum; tubus emissi nullus vel rudimentalis, oriens e extremo terminali sporangii, angustus, tubularis, constrictus ubi penetrans per pariete zygosporae, tumidus ad basin, non constrictus ubi penetrans per pariete cellulae hospitis, $10.5\ \mu \times 1.5\ \mu$; reproductio sexualis a gametangiis masculis foemineisque; oogonia extracellulalia, antheridium late fusiforme, $8-10\ \mu$ longum $\times 6-7\ \mu$ latum, vel cordatum; tubus fecundationis productus ad extremum basalem, conicus, qui penetrat et fecundat oogonium; oospora numerosa, sphaerica, $9-12\ \mu$ in diametro, parietibus duobus, laevis, hyalina, remanens libera intus extusve thallo, in cellula; germinatio oosporae non observata.

Thallus broad, cylindrical, curved, shallow or deep incurvations forming humps, lobular, irregular shape, aseptate, segments few, largest measuring $31-37\ \mu$ long $\times 7-30\ \mu$ wide, confined to and occupying entire zygosporae;

sporangium same as thallus segments in size and shape, scarce; discharge tube practically absent, when present rudimentary arising from terminal end of the sporangium, narrow, tubular, constricted when passing through zygosporae wall, base swollen, unconstricted when passing through the host cell wall, measuring $10.5\ \mu \times 1.5\ \mu$ wide; reproduction sexual, by means of male and female gametangia; oogonia extra cellular, antheridium broadly fusiform, $8-10\ \mu$ long $\times 6-7\ \mu$ wide or cordate; fertilisation tube produced at the basal end, conical, which penetrates and fertilises the oogonium; oospore numerous, spherical, $9-12\ \mu$ in diameter, double walled, smooth, hyaline, lying free in thallus or outside it, in the cell; germination of oospore not observed.

Parasitic in the zygosporae of *Spirogyra* collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The fungus is characterised by a thallus of simple configuration. The thallus segments 3-4, wide cylindrical irregularly humped. Some segments, very few, behave as sporangium giving rise to short, narrow discharge tube. It is further characterised by abundant spherical, double walled, smooth oospores which are formed by the fertilisation of extracellular oogonium by fusiform or cordate antheridium. The antheridia appear to be semispecialised in character. In antheridial characters the species closest to the present one is *L. obovatum* sp. nov. but entirely different in thallus character. No other species of *Lagenidium* agrees with this species.

In view of these, the thallus character combined with the sexual reproduction by fusiform antheridium, the fungus has been identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37124.

Lagenidium contortum sp. nov. (Fig. 103).

Thallus crassus, tubularis, varie curvatus et constrictus, lobularis, segmenta breviter irregularia limitata et occupantia cellulam singulam; sporangia globularia, segmenta thalli irregularia, episporangium formatum, unum ad quodque angulum cellulae hospitis, late reniforme vel angustum, $22-28\ \mu$ longum, $14-18\ \mu$ latum, lobus basalis ellipsoideus angustus, lobus superior sphaericus; episporangium germinat produciens hyphas dichotome ramosas, $6-8\ \mu$ latas, unus ramus terminat in uno capitulo globoso hyalino laevi, alter in spora quiescenti laevi hyalina 2-pariete, tubi emissi oriens directe e sporangiis, lati cum tumore basali, $34\ \mu$ longi $\times 7\ \mu$ lati vel e episporangio, angusti cum vel sine tumore basali, $8.5-12\ \mu \times 1.5-3.5\ \mu$, vel e capitulo globosa sporangiali, perbreves; planta monoecia, reproductio sexualis, gametangium foemineum extracellulare, antheridium thallicum, varie formatum, irregulariter pyriforme, $8\ \mu$ longum, $4\ \mu$ latum vel elongatum stellatum, $22\ \mu$ longum $\times 8\ \mu$ latum, tubus fecundationis non speciale formatus, sed extremum conicum antheridii penetrat et fecundat oogonium; oospores sphaericae, $15-20\ \mu$ in diam, parietibus 2, crassibus, laevis, aurea; germinatio oosporae non observata.

Thallus thick tubular, variously curved and constricted, lobular, irregular short segments, confined to and occupying a single cell; sporangia globular, irregularly shaped thallus segments, characterised by the formation, at its contact point with the zygosporangium wall of a special body, one at each corner of the host cell, designated as "episporangium", broadly reniform or narrow, $22-28\ \mu$ long $\times 14-18\ \mu$ wide, at concavity, basal ellipsoidal lobe narrow, upper lobe spherical, one episporangium germinates to produce dichotomously branched hypha, $6-8\ \mu$ wide, one branch terminates in an aseptate, smooth, hyaline, globose head, the other in a smooth, hyaline, double walled resting spore; discharge tubes arise directly from sporangia, broad with

basal swelling, $34\ \mu$ long by $7\ \mu$ wide or from episporangium, narrow, with or without basal swelling, $8.5-12\ \mu \times 1.5-3.5\ \mu$, or from globose sporangial head, very short; plant monoecious, sexual reproduction occurs, female gametangium extracellular, antheridium thallic structure of variable shape, irregularly pyriform, $8\ \mu$ long $\times 4\ \mu$ broad or elongated star shaped, $22\ \mu$ long $\times 8\ \mu$ wide, fertilisation tube not a specialised structure but the conical end of the antheridium penetrating into the oogonium to achieve fertilisation; oospore spherical, $15-20\ \mu$ in diameter, thick double walled, smooth, golden in colour; germination of oospore not observed.

Parasitic in the zygosporangium of *Spirogyra* sp. collected from a ditch by the side of Sultanpur Road, 11 miles from Lucknow University.

The fungus is characterised by complex thallus configuration. The segments, are irregularly lobed, short, swollen, contorted, interspersed with spherical cells. In four corners of the host cells there are four large swollen bodies, ovoid or reniform simple or involuted (boxing gloves), functioning as sporangium, to produce long narrow discharge tube of constricted base and of uniform bore after emergence. Similar but larger ones are also produced from intramatrix spherical cells. In no case, however, zoospores were observed nor vesicle containing them.

The point of interest is the presence of semispecialised antheridia which are reniform with tapering base or quadrilobular of which one is tapering. The fertilisation tube arising from the tapering end penetrates the oogonium and effects fertilisation to form oospore. Oospores are spherical, double walled, smooth with faint brown tint.

The fungus conforms to *L. astrum* group of species described earlier in the mode of sexual reproduction, but differs from them in the presence of quadrilobular or tapering reniform antheridium. Equally important

distinction lies in the most complex thallus configuration in this fungus against relatively much simpler ones in *L. astrum* group.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37126.

Lagenidium coenocyticum sp. nov. (Fig. 104).

Thallus late tubularis in parte vesicularis, protuberationes magnae, digitiformes, vel parvae, sphaericae, subsphaericae vel varie formatae, amplitudineque variabiles, sinuosae, coenocyticae, contenta cum granulis refractivis, limitate ad cellulam singulum infectam, pariete laevi, hyalino; sporangium non speciale formatum a delimitatione unius limbi; tubus emissi gradatim angustatus e basi, flexuosus, extus emergens, refringens parietem cellulae hospitis, constrictus ad punctum penetrans; zoosporae et illarum modus emissi non observatae spores quiescente non visae.

Thallus broadly tubular, vesicular in part, protuberances large finger-like, or small spherical, subspherical or variously shaped and size, sinuous, coenocytic, contents with refractive granules, confined to the single infected cell, occupying entire space wall smooth, hyaline; sporangium unspecialised, formed by the delimitation of a limb; discharge tube gradually tapering from the base, flexuous, emerges outside, piercing the host cell wall, constricted at the penetration point; vesicle surmounts the tip which receives the zoospores liberated from the zoosporangium, before ultimate discharge into the medium outside; zoospores, their mode of formation, and discharge not observed; sex apparatus and resting spores not found.

Parasitic in the vegetative cell of filaments of *Spirogyra* sp., collected from a ditch by the side of the Kursi Road, 4 miles north of Lucknow University.

The fungus is distinctly different from all the known species of *Lagenidium* in its

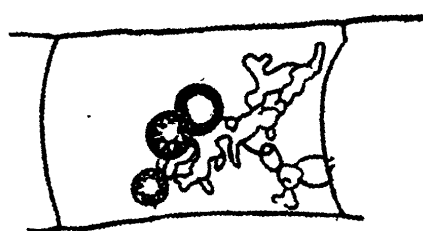
coenocytic, sinuous, tubular, thallus with finger like projections or branches. A new species of *Lagenidium*, *L. tortum*, has been described by the authors in the preceding pages, in which the thallus is coenocytic, segments if present, very rare. But body of *L. tortum* is very narrow as against wide tubular body of the present fungus. The wall, too, is highly tortuous and intensively wrinkled, forming rounded protuberances all along the wall, whereas the wall here is smooth and much less sinuous. In configuration the two are entirely different. The difference also lies in the complete absence of sex apparatus and oospore, and in the presence of sporangium and discharge tube and the vesicle. The only species of *Lagenidium* which, to some extent, seems to be comparable in *Lagenidium destruens* Sparrow, of which thallus consists of short, finger like, irregular, and contorted branches of variable shape and size, a single zoosporangium, zoospores ejected in amorphous mass from the discharge tube to the outside of the host where maturation is completed. The thallus, however, is segmented, and not coenocytic as in present species. Differences lie also in several other aspects. Zoospores and resting spores have not been observed in our fungus which negates comparison of these characters.

Although imperfectly known, the species on available data, is identified as a new species.

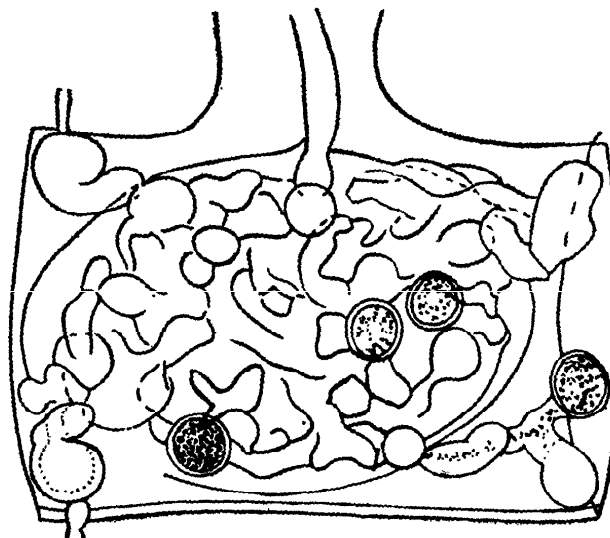
Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37125.

Lagenidium entophyllum (Pringsheim) Zopf, Nova Acta Acad. Leop.-Carol, 47: 154. 1884. (Fig. 105).

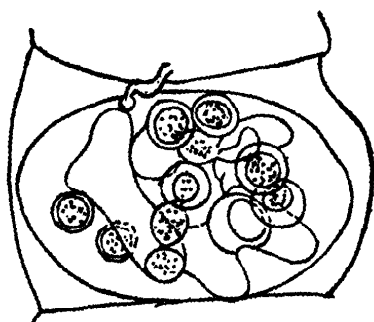
Thallus thick tube, irregularly contorted, lobular segments of varying length, filling the entire zygosporangium, confined to a single host cell; sporangium same as thallus segments in size and shape; discharge tube one



101



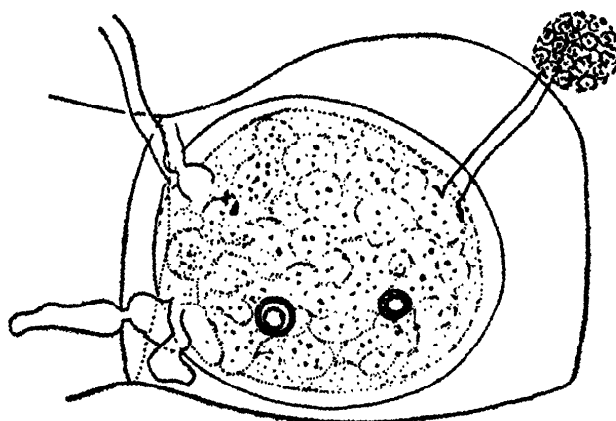
103



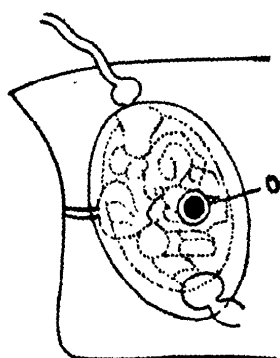
102



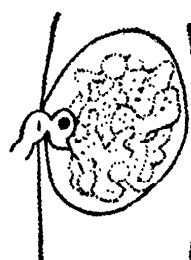
104



105



106



107

Figs. 101-107 : Legend at the end of the article

from each sporangium length variable, 20-30 μ long \times 3-6 μ wide, swollen at the point of contact with zygosporic wall, highly constricted sometimes without constriction when passing through it, uniformly tubular after emergence, slight bulge at the base, unconstricted when passing through the host cell wall; zoospores and their emergence observed; sporangial contents emerge outside, through discharge tube as globular mass, surmounted by a thin membrane, cleavage furrows appear dividing contents into a number of zoospores, which start swarming inside, get separated and with the dissolution of the membrane swim away; zoospores reniform, laterally biflagellate, 5.5-8 μ long \times 4-6.6 μ wide; sexual reproduction does not occur; oogonium inside a gametangium lobe; antheridium absent; oospore formed parthenogenetically, scarce, spherical, 10-15 μ in diameter, double walled, outer wall warty; germination of oospore not observed.

Parasitic in vegetative cells, conjugating filaments and zygosporic of a *Spirogyra* sp., collected from one of the tanks in the garden of the Botany Department, Lucknow University.

The fungus is characterised by thallus of complex configuration. The segments are irregularly lobed, short, swollen, contorted. Some of these segments function as sporangium. Sporangium gives rise to discharge tube which is normally long, narrow, tubular, of uniform bore after emergence outside the oogonial and host cell wall. The authors, however, have come across an unusual form of discharge tube which after emergence assumes a lanceolate structure, swollen above the constriction gradually tapering, with convex apex 27.5 μ long \times 7.5 μ at the base where widest.

An important observation is the zoospore formation in the vesicle, formed at the orifice of the discharge tube 16 μ in diameter, maturation and final dispersal after the dissolution of vesicular membrane. Zoospores in

Zopf's species are 5-7 μ \times 4-6 μ , practically similar to those of the present fungus, 5.5-8 μ \times 6.6 μ , in shape too, reniform in both. Resting spores which are warty in the present species are dented in Zopf's, in both spherical, 10-15 μ in diameter in the former, and 15-16.5 μ diameter in the latter species. In view of these similarities the fungus has been identified as *Lagenidium entophytum* (Pringsheim) Zopf.

Originally the fungus was described by Pringsheim as *Pythium entophytum* (1858), which was transferred to the genus *Lagenidium* by Zopf (1884) and renamed *Lagenidium entophytum*, since then it has been recorded in many countries. In India *Lagenidium entophytum* was first found by Lacy (1949). The present fungus is the second record which exhibited certain developmental stages not previously observed in Lacy's fungus.

***Lagenidium entosphaericum* sp. nov.** (Figs. 106, 107).

Thallus late tubularis, irregulariter curvatus, lobularis, segmenta varie formata, amplitudineque variabilia, contenta cellulae granulis refractivis, limitata ad cellulam infectam; infectio extendens e cellula ad cellulam a tubo emissi invadenti; sporangium sphaericum, 7-9 μ in diam., vel ovoideum, 13 μ latum \times 9 μ altum; tubus emissi oriens e sporangio, 13-20 μ longus \times 2-5.5 μ latus, basi varie tumescens ubi penetrans per pariete oogonii, gradatim angustatus vel iniformiter angustus, post emergentem parum projectus extus parietem cellulae hospitis; zoosporae et illarum modus emissi non observatae; antheridium nullum, oospora parthenogametice formata, sphaerica, 9-12 μ in diametro, pariete laevi; germinatio oosporae non observata.

Thallus wide tube, contorted, irregularly curved, lobular, segments of diverse size and shape, filling entire zygosporic; cell contents with refractive granules; confined to infected cell, infection spreads from cell to cell by

means of invading discharge tubes ; sporangium spherical, 7.9μ in diameter or ovoid, 13μ wide \times 9μ high ; discharge tube originates from the sporangium $13-20\mu$ long \times $2.5-5\mu$ wide ; base variously bulged while passing through the oogonial wall, gradually tapering or uniformly narrow, after emergence projecting only a short distance outside host cell wall, some thallus form copious discharge tubes invading adjoined filament through the connecting conjugation tube ; zoospores and their mode of discharge not observed ; antheridium absent ; oospore formed parthenogenetically, spherical, $9-12\mu$ in diameter, smooth walled, scarce ; germination of oospore not observed.

Parasitic in the zygospore of a *Spirogyra* sp. collected from a ditch by the side of the Kursi Road, 4 miles north of Lucknow University.

The fungus is characterised by wide tubular complex thallus organisation. The segments are irregularly lobed, and some function as sporangium giving rise to discharge tube which are narrow with swollen base or uniformly wide all along, constricted while passing through the oogonial wall and swollen above or below the constriction, devoid of vesicle. It is further characterised by the presence of smooth walled oospore and total absence of antheridium.

In the thallus character, sporangium, discharge tube, and parthenogenetic formation of oospore the fungus is very similar to *L. entophytum* as described earlier. But the difference lies in the fact that in *L. entophytum*, the oospore wall is warty, in the present fungus it is smooth walled.

Parthenogenetically formed smooth walled, spherical zoospores are also found in *L. rabenhorstii* (Prings.) Zopf and *L. gracile* Zopf another fungus described by Zopf (1884) differing from *L. entophytum* in its more slender thallus with very slender discharge tube and as in dioecious species of *L. rabenhorstii* smooth walled oospores are

formed parthenogenetically. Cook (1931) described *L. gracile* with similar thallus character and smooth walled parthenogenetically formed oospore. Thus the present fungus is different from *L. rabenhorstii* and *L. gracile* when complex thallus character is taken as the criterion while the ornamentation of oospore wall of *L. entophytum* distinguishes it from this smooth walled species. In view of these the present fungus is identified as a new species.

Holotype deposited at HCIO, Division of Mycology and Plant Pathology, IARI, New Delhi-110 012. HCIO No. 37128.

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LEGEND OF THE FIGURES

Figs. 1-12 : 1. *Olpidium gregarium* (Nowakowski) Schroeter ; parasite in rotifer egg ($\times 900$). 2. *Olpidium longum* ; one loosely lying intramatrical sporangium ($\times 900$). 3. *Olpidium longum* ; two loosely lying intramatrical sporangia ($\times 900$). 4. *Olpidium longum* ; two loosely lying extramatrical sporangia (\times). 5. *Olpidium incognitum* ; in an egg of animalcule ($\times 1750$). 6. *Olpidium incognitum* ; with a second diminutive extramatrical parasite ($\times 1200$). 7. *Olpidium pseudoeuglenae* ; parasite in a species of chytrid sporangium with vesicle to which remnant of zoospore cyst is attached ($\times 1700$). 8-11. *Olpidium rotiferum* Karling ; parasitising different species of rotifer ($\times 450$). 12. *Olpidium rotiferum* ; fig. 9 magnified ($\times 1200$).

Figs. 13-24 : 13. *Rozella blastocladiæ* (Minden) Sparrow ; resting spore spherical with dense spines in the apical region of sporangium of *Blastocladiella* sp ($\times 450$). 14. *Rhizophyidium sphaerocarpum* (Zopf) Fischer ; on *Spirogyra* sp. ; sporangium after zoospore discharge ; rhizoid basally double contoured, branching at the tip ($\times 450$). 15a. *Rhizophyidium mammillatum* (Braun) Fischer on *Oedogonium* sp ($\times 450$). 15b. *Rhizophyidium constantinense* Saccardo on *Closterium* sp ($\times 450$). 15c. *Rhizophyidium collapsum* Karling on *Closterium* sp ($\times 450$). 16. *R. blastocladianum* on *Blastocladiella* sp. Sporangia epibiotic, resting spore extramatrical, spherical with adnate male thallus, undischarged and discharged sporangia both present ($\times 450$). 17. *R. rhizinum*, on *Blastocladiella* sp. Sporangia epibiotic, with or without basal filamentous rhizoids ($\times 900$). 18. *R. reflexum*, on *Blastocladiella* sp. ; sporangia epibiotic, with or without knob-like haustorium, rhizoid filamentous or nil ($\times 900$). 19. *R. urceolatum* on *Blastocladiella* sp. Sporangia with basal knob-like haustorium, resting spore extracellular, with adnate male thallus ; an extra cellular, germinated resting spore-sporangium of *Blastocladiella* present ($\times 900$). 20. *R.*

spinosum on *Blastocladia* sp. ; sporangia with basal knob-like haustorium, without rhizoid ; resting spore extracellular spinous with adnate male thallus ($\times 900$). 21. *R. lagenaria* on *Blastocladia* sp. ; basal sporangia with knob-like haustorium ; resting spore with smooth double walled and adnate male thallus ($\times 900$). 22. *R. stellatum* on *Gonapodya polymorpha* Thaxter. ; sporangia epibiotic, with knob-like haustorium ; rhizoid totally absent ; extramatrix resting spore with adnate male thallus ($\times 450$). 23. *R. gonapodyanum* on *Gonapodya polymorpha* Thaxter. epibiotic, fully discharged sporangia, with knob-like haustorium ; rhizoid totally absent ; extramatrix resting spore, with adnate male thallus ($\times 450$). 24. *R. blyttiiomyces* ; discharged epibiotic sporangia, with knob-like haustorium, one parasitic on *Blyttiiomyces spinosus* itself parasitic on the zygospore of *Spirogyra* sp. another adjoining one parasitic directly on the same zygospore of *Spirogyra* ($\times 900$).

Figs. 25-35 : 25. *Rhizophydium rotundum*, Sporangium with discoid haustorium ; knob-like zoospore cyst ($\times 450$). 26. *R. rotundum*. Empty sporangium with discharged zoospores as a globular mass at the orifice ($\times 450$). 27. *R. rotundum*, Resting spores in a series, one germinated to form a sporangium ($\times 450$). 28. *Rhizophydium poculiforme*. Sporangium with discoid haustorium ($\times 800$). 29. *R. poculiforme*. Discharged zoospores resting at the orifice of the sporangium as a globular mass ($\times 800$). 30. *R. poculiforme*, bowl shaped persistent endobiotic wall of the sporangium epibiotic wall evanesced ($\times 800$). 31. *Rhizophydium tubulatum*. Subspherical sporangium, bulbous apophysis with tubular rhizoid (haustorium), divided by a septum ($\times 450$). 32. *R. tubulatum* sporangium apophysis with tubular rhizoid (haustorium), continuous without septum ($\times 450$). 33. *R. tubulatum*, empty sporangium with discharged globular zoospore mass at the orifice, wall persistent ($\times 450$). 34. *R. clavatum*, apophysis with tubular rhizoid with or without septum, endobiotic cupular remnant of sporangium persistent, epibiotic portion evanesced ($\times 400$). 35. *Rhizophydium conchiforme* Conchiform sporangium, with discoid haustorium, rhizoid absent, rarely when present filamentous, pore apical or lateral slit, through which zoospore emerge as a compact mass enveloped in a tenuous membrane ($\times 450$).

Figs. 36-48 : 36. *Phlyctochytrium apophysatum* on *Closterium* sp. ; sporangium showing lateral subbasal discharge pore ; apophysis swollen giving rise to rhizoid distally branched ($\times 450$). 37. *Phlyctochytrium dissolutum* on *Closterium* sp. ; with epibiotic, sporangia endobiotic apophysis, distally branched rhizoid ; liberation of zoospores by evanescence of sporangial wall ($\times 450$). 38. *Blyttiiomyces spinosus* on *Spirogyra* sp. ; sporangium and apophysis showing, zoospores in a globular mass at the rim of the apical exit pore ($\times 450$). 39. *B. spinosus*, sporangium and apophysis showing lateral discharge pore at bulging wall ($\times 450$). 40. *B. spinosus* : sporangium with obovoid apophysis ($\times 450$). 41. *B. spinosus* : sporangium with subapical in another basal discharge pore ; endobiotic resting spore in a series in zygospore ($\times 450$). 42. *Blyttiiomyces lensis* on *Spirogyra* sp. ; showing sporangia in a cluster ; exit pore initial at elevated sporangial wall ; zoospore cyst basal or lateral ($\times 450$). 43. *Entophlyctis bulligera* (Zopf) Fischer, parasitic in vegetative cell of *Spirogyra* sp. Endobiotic sporangium with rhizoidal system and persistent apical knob ($\times 450$). 45. *E. bulligera* ; resting spore with variable rhizoidal system ($\times 450$). 44. *Entophlyctis bulligera* var. *brevis*, short filamentous rhizoids ($\times 450$). 46. *Entophlyctis mamilliformis* on zygospore of *Spirogyra* sp. ($\times 450$). 47. *Entophlyctis caudiformis* in *Closterium* sp. ; rhizoids long, filamentous tuft arising from basal axial end of sporangium running parallel to the host cell wall ($\times 450$). 48. *Entophlyctis sphaerioides* on reproductive body of *Spirogyra* sp. ($\times 450$).

Figs. 49-63 : 49. *Rhizoclostridium globosum* H. E. Petersen. Showing Sporangium, interiorly developed thumb-shaped apophysis and divergently growing rhizoids ($\times 1200$). 50. *Chytridium lagenaria* Schenk. in *Spirogyra* sp. ; sporangia at different stages of development ; z. early stage ; w. wall separating sporangium from apophysis ; op. dehiscent operculum attached to the rim of the pore ; m. discharged zoospores forming a globular mass at the orifice. ($\times 450$). 51. *Chytridium horariumforme* ; sporangium obovoid, continuous with ovoid endobiotic apophysis by broad isthmus, with rhizoid ; dehiscent operculum attached to the rim of the orifice ($\times 450$). 52. *Chytridium schenkii* (Schenk) Scherffel ; sporangium fusiform, tilted, apical end ascending at acute angle above the substratum ; apophysis spherical, rhizoids filamentous, scanty ($\times 450$). 53. *C. schenkii* ; sporangium fusiform, tilted, apical end ascending, halfway to upright position, apophysis spherical, scanty, filamentous rhizoids ($\times 450$). 54. *Chytridium reniforme* ; sporangium reniform, ascending, tilted ; rhizoid well developed ; double walled, spherical resting spore with rhizoids ($\times 450$). 55. *Chytridium adpressum* ; sporangium ovoid, procumbent with spherical, apophysis, rhizoids scanty ($\times 450$). 56. *Chytridium sparrowii* ; sporangium ellipsoid, tilted, bent with spherical, apophysis, rhizoids scanty ($\times 450$). 57. *Chytridium fusiforme* ; sporangium irregularly fusiform, erect, both ends papillate, with spherical apophysis, rhizoidless, resting spores may ($\times 450$). 58. *Chytridium acuminatum* Braun. ; sporangia in cluster, ovoid, acuminate without apophysis or rhizoid ($\times 450$). 59. *C. acuminatum* ; sporangia in cluster, empty with apical pore, without apophysis ($\times 450$). 60. *C. acuminatum* ; resting spore filling up the entire oospore space ($\times 450$). 61. *C. acuminatum* ; resting spore germinating ($\times 450$). 62. *Chytridium brevipes* Braun. Sporangium with knob-like subsporangial swelling as apophysis giving rise to tenuous rhizoids ($\times 450$). 63. *C. brevipes* ; sporangium acuminate, with subsporangial apophysis as inverted constricted cone, rhizoidless ($\times 450$).

Figs. 64-73 : 64. *Chytridium kolianum* Domjan ; Sporangium with mature zoospores, broadly fusiform apophysis having two tubular, short, stout, divergent rhizoids ($\times 1200$). 65. *C. kolianum* ; discharged sporangium, dehiscence circumscissile, operculum cast off domeshaped, basal half bowl shaped persistent ($\times 1200$). 66. *Chytridium closterii* ; sporangium with ovoid apophysis, rhizoidless, circumscissile dehiscence, cast off operculum dome shaped, eventually evanescent, basal half bowlshaped persistent ($\times 450$). 67. *Macrochytrium botrydioides* var. *minutum* ; sporangium single celled with smooth central column, without knee-like protuberance,

rhizoids branched ($\times 1700$). 68. *Myzocytiium megastomum* de Wildeman in a *Closterium* sp. sporangia lenticular, linked by narrow or wide isthmuses in a linear series ; discharge tube median or lateral, base bulbous ($\times 450$). 69. *M. megastomum* ; sporangia ellipsoidal, joined or overlapping in a series ; discharge tube median, base bulbous ($\times 450$). 70. *C. megastomum* ; sporangium ellipsoidal, no discharge tube ; one germinating behaving as a pro-sporangium ($\times 450$). 71. *Myzocytiium anomalum* sp. nov. in a *Closterium* sp. ; sporangia pyriform or fusoid in two irregular series, variously interlinked or superimposed ; oospore spherical, male gametangium unspecialised, fertilised by basal tube ($\times 450$). 72. *Myzocytiium rotiferum* in a rotifer. ; sporangia numerous, subspherical or pyriform, irregularly arranged ; discharge tube variable in size, one long emerging outside host wall ; resting spore variable, in shape, with smooth or wavy exterior wall ($\times 450$). 73. *M. rotiferum* ; magnified sporangia of a part of fig. 72 ($\times 450$).

Figs. 74-89 : 74. *Olpidiopsis decipiens* in oogonium of *Oedogonium* sp. Two infected superimposed oogonia, upper with two sporangia, one immature without discharge tube, the other with discharge tube, just emerged, through lateral oogonial wall ; in lower oogonium sporangium with discharge tube fully emerged, through shoulder region of oogonial wall, branching immediately after emergence, base swollen, appearing as divergent horus ($\times 450$). 75. Infected oogonium with two sporangia, one spherical, immature, without discharge tube, the other pyriform with fully emerged discharge tube, on emergence branched ($\times 450$). 76. Sporangium with simple discharge tube, point of emergence near supporting cells ($\times 450$). 77. Sporangium with simple discharge tube, point of emergence near cap cells ($\times 450$). 78. Two sporangia oval, the discharge through the same wide opening, near supporting cell ($\times 450$). 79. Three upright elliptical sporangia in cluster, with apical discharge tube, emerging through the wide open passage formed by the rupturing of top region of oogonial wall ($\times 450$). 80. A chain of 4 superimposed oogonia, sporangium in the top oogonium with discharge tube near cap cell ; in next oogonium discharge pore lateral ; In third oogonium one sporangium having discharge tube at the top, and one resting spore lying loosely in the oogonium, laterally placed ($\times 450$). 81. One oval sporangium, emergence point lateral near shoulder cells, and one resting spore lying loosely in the oogonium ($\times 450$). 82. Resting spore lying loosely in the oogonium, laterally placed ($\times 450$). 83. As in Fig. 82 along with a sporangium with discharge tube ($\times 450$). 84. Zoospore reniform, with two divergent flagella arising from concave side ($\times 1200$). 85. *Olpidiopsis decipiens* parasitic in oogonium of *Bulbochaete* sp ($\times 450$). Terminal oogonium with two sporangia, discharge tube from each emerging outside through two separate adjacent points with the intervening wall intact. Another terminal oogonium with one resting spore lying loosely in the cell, laterally placed, germinating. 86. *Olpidiopsis sphaericis* in *Zygnema* filament ; sporangial discharge tube projecting out ; resting spore double walled, with adnate companion cell ($\times 450$). 87. *O. sphaericis* ; Sporangia in a series, discharge tube lacking ($\times 450$). 88. *O. sphaericis* ; sporangium associated with two compacted cytoplasmic bodies ($\times 450$). 89. *O. sphaericis* ; resting spores with companion cell ($\times 450$).

Figs. 90-100 : 90-92. *Lagenidium rabenhorstii* Zopf. Thallus simple, segmented, dioecious ; parthenogenetic oospore in fig. 90 ($\times 450$). 93. *Lagenidium rabenhorstii* Zopf. Thallus simple, monoecious, segmented, oospore spherical, antheridium unspecialised ($\times 450$). 94. *Lagenidium clavatum*. Thallus complex ; zoospore sphaeroid, antheridium clavate ($\times 450$). 95. *Lagenidium piriforme*. Antheridium pyriform ($\times 450$). 96-97. *Lagenidium obovatum*. Antheridium obovate ($\times 450$). 98-100. *Lagenidium astrum*. Oospore parthenogenetic, star shaped, beaked ($\times 450$).

Figs. 101-107: 101. *Lagenidium tortum*. Thallus rarely segmented, wall wrinkled, antheridium reniform ; oospore ornamented ($\times 450$). 102. *Lagenidium cylindricum*. Thallus broadly cylindrical, antheridium cordate or broadly fusiform ($\times 450$). 103. *Lagenidium contortum*. Thallus complex, contorted or specialised irregularly shaped acuminate cell, fertilisation through apical point ($\times 450$). 104. *Lagenidium coenocyticum*. Thallus coenocytic, sexual reproduction absent ($\times 450$). 105. *Lagenidium entophyllum* (Frings.) Zopf. Thallus complex ; discharge tube projecting out ; zoospore vesicle at the orifice of the discharge tube ; oospore ornamented ($\times 450$). 106-107. *Lagenidium entosphaericum*. Thallus complex, discharge tube projecting out ; oospore smooth walled ($\times 450$).