Some Zoosporic Fungi of New Zealand. V.

Species of Asterophlyctis, Obelidium, Rhizoclosmatium, Riphonaria and Rhizophlyctis.

By John S. Karling

(Department of Biological Sciences, Purdue University, Lafayette, Indiana, U.S.A.)

With Plates XVII—XIX

Asterophlyctis

This genus was established by Petersen in 1903 for a saprophyte, *A. sarcoptoides*, which he found on the exuviae of caddis flies in Denmark, and up to the present time it has been regarded as a monotypic genus. However, a second species has been found in New Zealand on strips of chitin which were added to a water culture (CLOl) *) from Lake Ohau, Canterbury Province). It is characterized primarily by irregular resting spores which are borne at the apex of an empty basal cell, and in this respect it differs markedly from the type species. Accordingly, it is described as a new species and named *A. irregularis*.

Asterophlyctis irregularis sp. nov.

Saprophytica. Sporangia extramatricalia, sessilia, subglobosa, 18—27 μ diam. vel ovoidea, 26—39 × 50—55 μ; pariete hyalino, verruculis 7—82 conoideis, obtusiusculis, raro bipartitis, ad basim usque ad 4 μ diam. et usque ad 8 μ prominulis praedito; apophysis subglobosa, 5.5—11 μ diam., ad basim vel ad latera rhizoideis plus minusve ramulosis, ad 4 μ crassis, usque ad 210 μ extendentibus praedita; zoosporae globosae, 4.8—5.3 μ diam. e poro subbasilari vel basilari prorumpentes, globulo hyalino, splendido ornatae; sporae perdurantes irregulares, 6—18 μ diam.; pariete crassiusculo, brunneo, plasmate, granuloso farctae; germinatio ignota.

Sporangia sessile, subspherical, 18—27 μ diam., ovoid 26—39 × 50—55 μ, with a hyaline wall which bears 7—82 simple, triangular, rarely bifurcate, tapering pegs, up to 4 μ diam. at base by up to 8 μ high. Apophysis subspherical, 5.5—11 μ diam.; rhizoids arising from base or sides of apophysis, main axes up to 4 μ diam., extending for distances up to 210 μ. Zoospores emerging through a sub-basal or basal

*) The soil and water samples studied in New Zealand are identified by letter symbols which were described in the first paper of this series.

pore, spherical, 4.8—5.3 μ diam., with a conspicuous hyaline refractive globule. Resting spores irregular in shape, 6—18 μ diam., with a thick brown wall and coarsely granular content; borne at the apex of a hyaline empty basal cell; germination unknown.

Saprophytic on chitin in water from Lake Ohau, Canterbury Province.

This relatively small species occurred in abundance together with *A. sarcoptoides* on strips of chitin which had been added to a water culture (CLOI) containing *Nitella* and *Chara* from Lake Ohau. It grew fairly well on chitin agar prepared in the manner described by the author (1945 a), and on this medium as well as on chitin the sporangial thalli developed in much the same manner as those of *A. sarcoptoides*. The sporangium usually develops from the zoospore (fig. 3), and as it grows in size it become somewhat irregular in shape as pegs begin to develop on its surface. These vary greatly in number, 7—82, and are simple, or rarely bifurcate. The tips are thickened (fig. 4) and refractive, and in some cases appear to be solid. The intramatrical apophysis develops as an enlargement in the germ tube, and become subspherical to ovoid, or irregular at maturity and bears several stiff-looking rhizoids on its surface (fig. 1). Dehiscence and discharge of the zoospores from the sporangium occurs through a basal or sub-basal pore (fig. 6).

The young resting-spore thalli are readily distinguishable from the sporangial thalli by the denser and more coarsely granular content of the incipient resting spore (fig. 7). As the latter develops the upper portion becomes irregular in outline (fig. 8). With further development the basal portion becomes vacuolate (fig. 9) as the denser granular refractive content moves upward (fig. 10), and eventually becomes empty of protoplasm. The incipient spore soon becomes enveloped by an irregular, thick brown wall and sits on the apex of the empty cell. The mature spores vary markedly in shape (fig. 11—16) and are filled with angular refractive bodies. Rarely, do smooth-walled spores occur (fig. 16). Although resting-spore cultures on chitin have been studied for almost a year, germination of the spores has not occurred in them.

Asterophlyctis sarcoptoides Petersen, 1903. J. de Bot. 17: 218, figs. 3—8.

Saprophytic on strips of purified shrimp chitin in cultures, pH 6.2, with *Nitella* and *Chara* from Lake Ohau as well as acid, pH 4.1, muck and water from a *Sphagnum* bog near Knob Flats, Eglinton Valley.

Apparently, it tolerates a fairly wide pH range. The developmental stages of the sporangia directly from the zoospore (fig. 17) or from a swelling of the germ tube (fig. 18) were essentially the same as described by Antikajian (1949) in her classical study of this species. Most of the sporangia were deeply-lobed (fig. 17) with as many as 15 protrusions and formed a subspherical, or lateral, or almost basal exit

tube for discharge of the zoospores. In one case the tube was 57 μ long by 6 μ in diameter. In her material Antikajian found that they may attain a length and diameter of 156 μ and 10 μ, respectively. Sparrow (1960) described the sporangia as discharging the zoospores through a lateral or basal pore, although previous workers had reported and described the presence and function of exit tube. Only rarely in the New Zealand specimens were lateral or basal pores observed, and from these observations as well as from previous ones on specimens in Indiana, Texas, and New York, U.S.A., the author believes that discharge through a tube which varies in length is more common than through a papilla.

The zoospores were ovoid, 4.3—4.8 × 5—5.3 μ, with a conspicuous hyaline refractive basal globule and swarmed in a vesicle which was continuous with the interior of the sporangium. Sparrow (1937) failed to note the presence of a vesicle around the swarming zoospores, but Antikajian demonstrated its presence by staining with Janus green B.

The resting spores in the New Zealand material varied from 15—30 μ in diameter, including the spines, and bore up to 16 solid, straight, or curved, tapering spines (fig. 19) which varied from 5.5 to 8 μ in length. The thick-walled zoospore cyst and germ tube were attached to many of the resting spores, showing that they had developed from an enlargement of the germ tube. In the one shown in fig. 19, the zoospore cyst had developed three short rhizoids, similar to ones described by Antikajian (1949, figs. 56—63). That this structure does not represent a small "male" thallus whose content has fused with another one to form the resting spore seems evident by the fact that similar ones with rhizoids may occasionally be found in relation to the development of sporangia as shown in figure 18. No evidence of "sexual conjugation of thalli by means of rhizoidal anastomosis" as described by Sparrow (1960) was observed in the New Zealand specimens.

Obelidium

This genus is reported to include three chitinophilic species, *O. mucronatum* Nowakowski, *O. hamatum* Sparrow, and *O. megarhizium* Willoughby, and among these only *O. mucronatum* was observed in New Zealand. However, this species exhibited such great variability in pure monozoosporic cultures on chitin agar that it coasts some doubt about the validity of the other two species.

Obelidium mucronatum Nowakowski, 1876. Cohn, Beitr. Biol. Pflanz. 2: 86, pl. 5, fig. 1—5.

Saprophytic on strips of purified shrimp chitin from soil sample AGBI and water from an outdoor tub, Bot. Dept., Univ. of Otago, Dunedin.

As noted above this species exhibited such marked variability in both of the collections that the author believed at first that he had more than one species at hand. Subsequently, he found that it could be grown readily on chitin agar, and from isolated thalli on this substratum he was able to obtain axenic monozoospore cultures. In such cultures, also, *O. mucronatum* varied markedly in morphology and development. Sparrow (1938) has described and illustrated fully the variations exhibited by a collection on exuviae of midges and caddisflies in Michigan, and the author has confirmed most of his observations from the New Zealand specimens on shrimp chitin. Additional variations and information have been obtained from a study of the species in pure culture on chitin agar, and the following observations will relate to these additions.

One of the conspicuous structures in living, young and full-grown sporangia on agar cultures, as well as on chitin in nature, is the large primary nucleus and nucleolus. This structure is clearly visible as a vacuole-like area or body under the ordinary light microscope, and particularly under the phase microscope, and the author has illustrated it as such in many of the sporangia (fig. 20, 32, 33, 35, 39, 41, 42, 44, 45). In living material it is very similar in appearance to the primary nucleus of species of *Chytriomyces* (Karling, 1947 a), *Asterophlyctis sarcoptoides* (Antikajian, 1949), and other chytrid species. Thalli growing attached to chitin agar can be cut out readily on small agar blocks, fixed, embedded, sectioned and stained, and in such preparations the primary nucleus appears as a sharply defined body with a conspicuous nucleolus and a well-developed chromatic reticulum (fig. 21). It remains in this state until after the sporangia are full-grown, as occurs in many chytrids the author has studied, and shortly before sporogenesis is to begin it enters the prophases of division and then divides by the development of an intranuclear spindle (fig. 22). Subsequent mitoses (fig. 23) occur in fairly rapid succession, whereby the sporangium becomes multinucleate. Shortly after completion of the mitoses the zoospore initials are delimited by progressive cleavage. Previous workers did not report the presence of the large primary nucleus, although in *O. megarhizum* Willoughby (1961, fig. 1 c) illustrated a structure in three young thalli which is similar to the nucleus described above. However, he identified it as a vacuole.

In living material shortly before sporogenesis and dehiscence the content of the sporangium has the appearance shown in fig. 24. This sporangium is neither stalked nor apophysate, and the thick-walled basal portion above the septum is cup-shaped. Sometimes, the thickening of the wall occurred in the apophysis below the septum (fig. 39, 42). Also, the walls of the main axes of the rhizoids are usually thickened (fig. 24, 36).

In dehiscence of the sporangium, the subapical exit papilla

deliquesces, as shown by previous workers, and the zoospores, enveloped by a thin layer of matrix, emerge slowly in a mass (fig. 25). After most of the zoospores have merged and begun to swarm, it becomes evident that they are confined in a thin hyaline vesicle (fig. 26, 27). As swarming continues and becomes pronounced the vesicle changes rapidly in shape as the zoospores dart against it (fig. 27). Quite often in agar cultures and on chitin sporangia become detached from the apophysis and rhizoids and float free. When they dehisce (fig. 26) and the zoospores swarm rapidly in the vesicle, the sporangium may be jerked about in the mounting medium. The vesicle is continuous with the interior of the sporangium, and this becomes evident as the zoospores reenter and depart from the sporangium into the vesicle. After 2 minutes or more of rapid swarming the zoospores rupture the expanding membrane and escape. Thus, swarming of the zoospores in a vesicle in *O. mucronatum* is similar to that which occurs in *Asterophlyctis, Chytriomyces, Siphonaria* and other genera. Previous workers (Sparrow, 1937, 1938, and Willoughby, 1961) did not observe the presence of a vesicle in *Obelidium*, but in *O. megarhizum* Willoughby reported that the zoospores "undergo collective swarming for up to 3 minutes before they disperse," which suggests that a vesicle may be present in this species, also. The author has observed it in nearly a hundred instances in *O. mucronatum* and believes that its presence is a normal occurrence.

The flagellum develops vesicles or globules along its length as the zoospores come to rest, and is gradually absorbed into the body of the spore (fig. 29). Frequently, in agar cultures as well as on chitin several zoospores germinate in close proximity and produce clusters of thalli (fig. 30). On chitin strips and on chitin agar the thalli apparently digest and assimilate the constituents of chitin, producing thereby a clear zone which corresponds in size to the areas occupied by the rhizoids. This is particularly evident in chitin agar cultures where the position of separate thalli can be detected macroscopially by the clear zones.

Sometimes, the zoospore develops two, almost lateral, germ tubes (fig. 31) which develop into rhizoids (fig. 32). In such cases the basal portion of the incipient sporangium may enlarge downward below the attachment of the rhizoids and become thick-walled so that a thallus of the type shown in fig. 33 is formed. In other instances the germ tube may elongate markedly with the result that a long-stalked thallus is produced (fig. 34—36). In contrast to this no, or only a short stalk may be produced (fig. 37—39) so that the broadly pyriform sporangium is sessile or nearly so. Other variations in agar cultures are shown in figs. 40 to 42. Usually, only one apical spine is formed, but occasionally sporangia with two spines may occur (figs. 43—45).

In 1937 Sparrow described a second species, *O. hamatum*, on larval cases of midges which is characterized by the presence of two oppositely-placed spines on the stalk that are usually tilted upward

towards the sporangial body. Also, Willoughby (1961) created a third species, *O. megarhizum*, that possesses one or two main coarse rhizoids trunks as its distiguishing characteristic. Some of the variations found in monozoosporic agar cultures of *O. mucronatum* are similar to both of these species and raise the question, in the author's mind, at least, of whether or not these two species are only variations or varieties of the type species. Particularly significant in relation to Sparrow's species are the thalli shown in figs. 25 and 46. Both of these thalli are stalked and bear spines on the stalk, and these may be simple and continuous, or branched and rhizoid-like at the tips. These suggest that the spines are aborted or potential extramatrical rhizoids. Other thalli were characterized by a thick up to 8 μ diam., rhizoidal trunk (fig. 47) which bore extramatrical branches as in *O. megarhizum* and spines as well. Such rhizoid axes or trunks were largely extramatrical (fig. 47) or intramatrical as figured by Willoughby.

Rhizoclosmatium and Siphonaria

Rhizoclosmatium hyalinum sp. nov.

Saprophyticum. Sporangia sessilia hyalina, pariete laevi, plerumque ovoidea, and basim leniter applanata, 38—45 × 48—64 μ, subirregularia vel anatropica, nunc papilla majuscula usque ad 18 μ diam. metiente, laterali vel saepe basilari, nunc tubulo brevi, 3—4 μ lato, 4—12 μ longo praedita; apophysis subglobosa, 12—18 μ diam., irregularis vel elongata, 8—10 × 17—23 μ. Rhizoidea usque ad 8 μ lata, crassiuscule tunicata, rigidula, nunc copiose nunc parce ramosa et usque ad 250 μ extendentia. Zoosporae globosae, 4.6—5 μ diam., globulo minuto, hyalino, splendido ornatae. Sporae perdurantes subglobosae, 26—30 μ diam. vel ovoideae ad basim leniter applanatae, 20—26 × 30—34 μ, pariete hyalino, levi, 4—6 μ crasso, plasmate grosse granuloso farctae; germinatio ignota.

Sporangia hyaline, sessile, usually ovoid, and slightly flattened at base, 38—45 × 48—64 μ, or slightly irregular or anatropous with a large, up to 18 μ diam., lateral or almost basal exit papilla, or a short, 3—4 μ diam., by 4—12 μ long, exit tube. Apophysis subspherical, 12—18 μ diam., irregular, or elongated, 8—10 × 17—23 μ, transversely to the sporangium. Rhizoids arising from several points on periphery of apophysis, coarse, main axes rarely up to 8 μ diam., becoming thick-walled and stiff-looking, frequently or sparingly branched and extending for distances up to 250 μ. Zoospores spherical, 4.6—5 μ diam., with a small hyaline refractive globule; flagellum 26—30 μ long; swarming in a vesicle after emerging. Resing spores subpherical, 26—30 μ diam., ovoid and slightly flattened at the base, 20—26 × 30—34 μ, with a hyaline smooth, 4—6 μ thick, wall and coarsely granular content; germination unknown.

Saprophytic on exuviae of insects and strips of chitin in water

from an outdoor tub with *Elodea*, Bot. Dept., University of Otago, Dunedin.

This species was initially identified by the author as *R. globosum*, but a subsequent comparative study showed that it differs from the type species by a coarser and more extensive rhizoidal system, larger apophyses, sporangia with larger exit papillae which occasionally become extended into short tubes (fig. 54), larger spherical zoospores, and larger resting spores (fig. 57—59) with unusually thick hyaline walls. In the occasional development of short exit tubes and particularly in the production of large thick-walled resting spores it is similar to *Diplophlyctis chitinophila* Willoughby (1962), but differs by the extramatrical position of the sporangia and resting spores. Species of *Diplophlyctis* are intramatrical or endobiotic, and the thalli develop from the germ tube (Karling, 1928, 1930), whereas in *Rhizoclosmatium* the sporangia and resting spores develop directly from the zoospore.

The development of the sporangial and resting-spore thalli as well as the sporangia and resting spores of *R. hyalinum* is shown in figs. 49 to 59, and inasmuch as no significant differences from that of *R. globosum* have not been observed it is not necessary to describe it in detail. However, it should be noted that the primary vacuole-like nucleus is quite conspicuous in living material (fig. 50, 51) as described above in *Obelidium mucronatum*. Also, no contributing thalli, such as described by Sparrow (1937) in *R. globosum*, have been observed in relation to the development of the resting spores.

Rhizoclosmatium globosum Petersen, 1903. J. de Bot. 17: 216, fig. 1, 2.

Saprophytic on purified shrimp chitin from a rainwater culture in an outdoor tub with *Nitella*, Bot. Dept., University of Otago, Dunedin.

Siphonaria variabilis Petersen, 1903, J. de Bot. 17: 220, figs. 11—17.

Saprophytic on purified shrimp chitin in water from Lake Ohau, Canterbury Province.

The author is identifying tentatively as such a relatively small species which occurred sparingly on chitin from a water culture (CLO) containing *Nitella* and *Chara* from Lake Ohau. So few thalli were present that very little could be added to Sparrow's (1937) account of this species.

Siphonaria sparrowii Karling, 1945 b. Amer. J. Bot. 32: 581, figs. 27—53.

Saprophytic on purified shrimp chitin in a water culture (CLO) from Lake Ohau, Canterbury Province.

Rhizophlyctis

Species of this genus differ in development from those of *Rhizidium* by the formation of rhizoids from several points on the periphery of the incipient sporangium, according to current concepts. However, this characteristic is so variable in different as well as in a single species that it is highly questionable as a generic distinction. Sparrow (1960) included both inoperculate and endo-operculate species in this genus on the ground of his interpretation that species with endo-opercula are not truly operculate. However, careful, intensive and prolonged observations on the dehiscence of endo-operculate species (Johanson, 1944; Karling, 1947 b, 1947 c; Willoughby, 1958) do not support this interpretation, and the genus *Rizophyctis* is limited here to only strictly inoperculate species, although the author firmly believes on the basis of present information that this genus should be merged with *Rhizidum*.

Rhizophlyctis petersenii var. **appendiculata** var. nov.

Saprophyctica. Sporangia appendiculata, pyriformia, subglobosa, 45—160 μ diam., leniter irregularia vel ovoidea, canali 18—26 μ diam. lato, 38—80 μ longo praedita; rhizoidea e basi sporangii orta, 7—16 μ crassa, plerumque dichotome ramulosa, ramulis usque ad 1200 μ extendentibus. Zoosporae subglobosae, 4.8—5.2 μ, globulo ferrugineo-aurantiaco et nonnullis granulis minoribus praeditae, glomerulo tarde emergentes et dicedentes; flagellum 32—35 μ longum. Sporae perdurantes ignotae.

Sporangia appendiculate, broadly pyriform, subspherical, 45—160 μ diam., slightly irregular, with an exit canal, 18—26 μ diam., by 38—80 μ long. Rhizoids arising from base of sporangium, main axes 7—10 μ daim., usually branching dichotomously, branches extending for distances up to 1200 μ. Zoospores subspherical, 4.8—5.2 μ diam., with a rusty orange globule and several smaller ones; flagellum 32—35 μ long; emerging slowly to form globular mass and dispersing. Resting spores unknown.

Saprophytic in bleached corn leaves and shrimp chitin from soil samples HBTF and OGB.

This variety differs from *R. petersenii* var. *petersenii* Sparrow (1937) by its appendiculate sporangia and the origin of the rhizoids from the base of the sporangium instead of from several points on its periphery. The size, shape and pigmentation of the sporangia as well as the size and pigmentation of the zoospores are striklingly similar to those of Sparrow's species, and on these grounds the author is identifying it as closely related to Sparrow's fungus. Resting spores were not found, and further comparison in this respect is impossible at present.

The appendiculum noted above begins as a slight thickening of the basal portion of the zoospore wall as the zoospore germinates (fig. 61) and becomes more pronounced as the young thallus develops (fig. 62—63). In some young thalli the appendiculatum may become quite pronounced

and peglike (fig. 64, 65), and in such thalli the sporangia appear as if they had budded out from a portion of the zoospore cyst. The early developmental stages of the sporangia are additionally characterized by the development of numerous large hyaline to faintly yellowish and orange refractive globules in the cytoplasm (fig. 62—65). Some of these globules are quite large, up to 4 μ in diameter, and interspersed among them are numerous smaller ones. As the sporangia mature the material composing these globules becomes progessively dispersed so that shortly before sporogenesis the sporangia are filled with minute globules and granules (fig. 66). At this stage the sporangia are pinkish-to reddish-orange in color. When the zoospores are mature the refractive tip of the exit canal deliquesces, and the zoospores ooze out slowly to form a globular mass (fig. 67) as in *R. petersenii* var. *petersenii*.

It is evident from fig. 60—65 and the description above that this species has a *Rhizidium* type of development, so far as it is known, and it appears to differ from that of Sparrow's species. Although the latter has been reported several times by Sparrow, its early developmental stages have not been described, and a comparison of the two fungi on this basis ist not possible at present. However, Sparrow (1937, text-fig. 3, 4) illustrated some stages which suggest that the sporangia and resting spores originate as enlargements at the juncture of several rhizoids, and these stages look quite different from the early stages of the New Zealand fungus.

Rhizophlyctis variabilis sp. nov.

Sporangia intra- et extramatricalia, globosa, 18—53 μ diam., subglobosa, 27—56 μ diam., ovoidea, 20—31 × 40—50 μ, late piriformia 8—40 × 19—50 μ, subinde oblonga 28—39 × 55—62 μ, interdum etiam irregularia, pariete hyalino, levi et papilla unica, raro etiam papillis duabus praedita. Rhizoidea varie, interdum etiam at basim sporangii orta, 4—6 μ diam., ramosa, ramulis usque ad 220 μ extendentibus. Zoosporae globosae 3.5—4 μ diam., vel ovoideae, 2.7—3.2 × 4—4.3 μ, globulo minuto hyalino ornatae, tarde emergentes et in vesiculo vagantes. Sporae perdurantes subglobosae, 11—32 μ diam., raro globosae, 10—27 μ diam., ovoideae 15—18 × 22—26 μ, oblongae 8—12 × 16—22 μ subinde subirregulares, pariete levi, brunneo, 1.8—2.4 μ crasso et plasmate minute vel grosse granuloso, aream centralem claram circumdante farctae. Germinatio ignota.

Sporangia intra- and extramatrical, spherical, 18—53 μ diam., subspherical, 27—56 μ diam., broadly or narrowly pyriform, 8—40 × 19—50 μ, ovoid, 20—31 × 40—50 μ, oblong, 28—39 × 55—62 μ, or sligthly irregular, with a hyaline smooth wall and one, rarely two, broad, 6—8 × 10—11 μ, apical exit papillae. Rhizoids usually arising from several points on periphery of sporangium, occasionally from its base,

main axes 4—6 μ diam., branches extending for distances up to 220 μ. Zoospores spherical, 3.5—4 μ, to ovoid 2.7—3.2 × 4—4.3 μ, with a small hyaline globule; emerging slowly and swarming in a vesicle. Resting spores subspherical, 11—32 μ diam., rarely spherical, 10—27 μ diam., ovoid, 15—18 × 22—26 μ, oblong, 8—12 × 16—22 μ, or slightly irregular, with a smooth brown, 1.8—2.4 μ thick, wall and finely to coarsely granular content surrounding a clear area in the center; germination unknown.

Saprophytic in and on partly decayed and distingegrating, bleached corn leaves from soil samples OMS and OTAD.

This species occurred in great abundance and formed resting spores as readily as sporangia. It varied greatly in development and morphology, and is, obviously, a borderline species which might be placed in either *Rhizophlyctis* or *Rhizidium*, according to current concepts of these genera. The sporangium may be partly or almost fully extramatrical and bears a single rhizoidal trunk at its base (fig. 75, 77) as in species of *Rhizidium* or up to 4 rhizoidal axes on its periphery (73, 74, 76) as in species of *Rhizophlyctis*. Also, the zoospores swarm in a vesicle (fig. 77) before dispersing as in species of *Rhizidium*.

During germination the zoospores may form several germ tubes (fig. 69) on its periphery, or one or two basal ones (fig. 70, 71). These variations in germination lead to development of the various types of thalli shown in figs. 73 to 77. In some respects *R. variabilis* resembles *Rhizidium varians* Karling (1949), but I never formed polycentric thalli nor long exit canals as in the latter species.

Rhizophlyctis lovetti Karling, 1946 b. Mycopath. et Mycol. Appl. 23: 216, fig. 1—11.

Saprophytic on fibrin film from soil sample AAD.

Rhizophlyctis fusca Karling, 1964 b. Mycopath. et Mycol. Appli. 23: 216, fig. 12—21.

Saprophytic in and on bleached corn leaves in soil samples MP and WOG.

Rhizophlyctis hirsuta Karling, 1964 b. Mycopath et Mycol. Appl. 23: 221, Fig. 22—26.

Saprophytic on bits of hemp seed and fibrin film in soil sample AAD.

Summary

Two species of *Asterophyctis*, one of *Obelidium*, two each of *Rhizoclosmatium* and *Siphonaria*, and four species and one variety of *Rhizophlyctis* were studied and indentified in New Zealand. Among these *Asterophlyctis irregularis*, *Rhizoclosmatium hyalinum*, *Rhizophlyctis*

variabilis and *R. petersenii* var. *appendiculata* are described as new. Monozposporic cultures of *Obelidium mucronatum* on chitin agar varied greatly in development and structure and exhibited some of the characteristics of *O. hamatum* and *O. megarhizum* as well.

Bibliography.

Antikajian, G. 1949. A developmental morphological and cytological study of *Asterophlyctis* with special reference to its sexuality, taxonomy, and relationships. Amer. J. Bot. 36: 245—263, 63 figs.

Johanson, A. E. 1944. An endo-operculate chytridiaceous fungus: *Karlingia rosea* gen. nov. Amer. J. Bot. 31: 397—404, 37 figs.

Karling, J. S. 1928. Studies in the Chytridiales. II. Contribution to the life history and distribution of *Diplophlyctis intestina* (Schenk) Schroeter in cells of American Characeae. Amer. J. Bot. 15: 204—214, 2 figs. pl. 14.

— 1930. Studies in the Chytridiales. IV. A further study of *Diplophlyctis intestina* (Schenk) Schroeter. Amer. J. Bot. 17: 770—778, 2 figs. pls. 46—49.

— 1945 a. Brazilian chytrids. VI. *Rhopalophlyctis* and *Chytriomyces*, two new chitinophilic operculate genera. Amer. J. Bot. 32: 362—369, 61 figs.

— 1945 b. Brazilian chytrids, VII. Observations relative to sexuality in two new species of *Siphonaria*. Amer. J. Bot. 32: 580—587, 53 figs.

— 1947 a. New species of *Chytriomyces*. Bull. Torrey Bot. Club 74: 334—344, 48 figs.

— 1947 b. Brazilian chytrids. X. New species with sunken opercula. Mycologia 39: 56—70, 56 figs.

— 1949. Two new eucarpic inoperculate chytrids from Maryland. Amer. J. Bot. 36: 681—687, 48 figs.

— 1964 a. Indian chytrids. I. Eucarpic monocentric species. Sydowia 17: 285—296, 31 figs.

— 1964 b. Indian chytrids. III. Species of *Rhizophlyctis* isolated on human fibrin film. Mycopath. et. Mycol. Appl. 23: 215—222, 26 figs.

— 1966 a. The chytrids of India with a supplement of other zoosporic fungi. Beihefte 3. Sydowia VI: 1—125.

— 1966 b. Some zoosporic fungi of New Zealand. I. Sydowia 19: 213—226.

— 1967 a. Some zoosporic fungi of New Zealand. II. Synchytriaceae. Sydowia 20: 51—66.

— 1967 b. Some zoosporic fungi of New Zealand. III. *Phlyctidium*, *Rhizophydium*, *Septosperma* and *Podochytrium*. Sydowia 20: 67—85.

— 1967 c. Some zoosporic fungi of New Zealand. IV. *Polyphlyctis* gen. nov., *Phlyctochytrium* and *Rhizidium*. Sydowia 20: 86—95.

Nowakovski, L. 1876. Beitrag zur Kenntniss der Chytridiaceen. Cohn, Beitr. Biol. Pflanz. 2: 73—100, pls. 4—6.

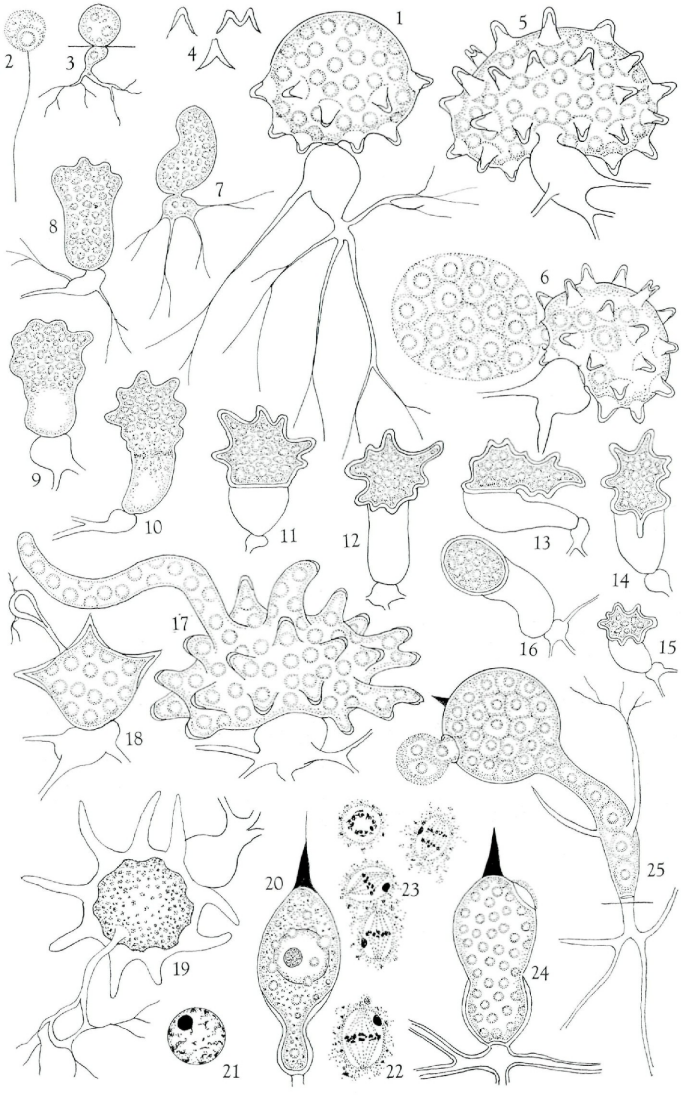
Petersen, H. E. 1903. Note sur les Phycomycetes observes dans les teguments vides des nymphes de Phryganees avec description trois especes nouvelles de Chytridinees. J. de Bot. 17: 214—222, 17 figs.

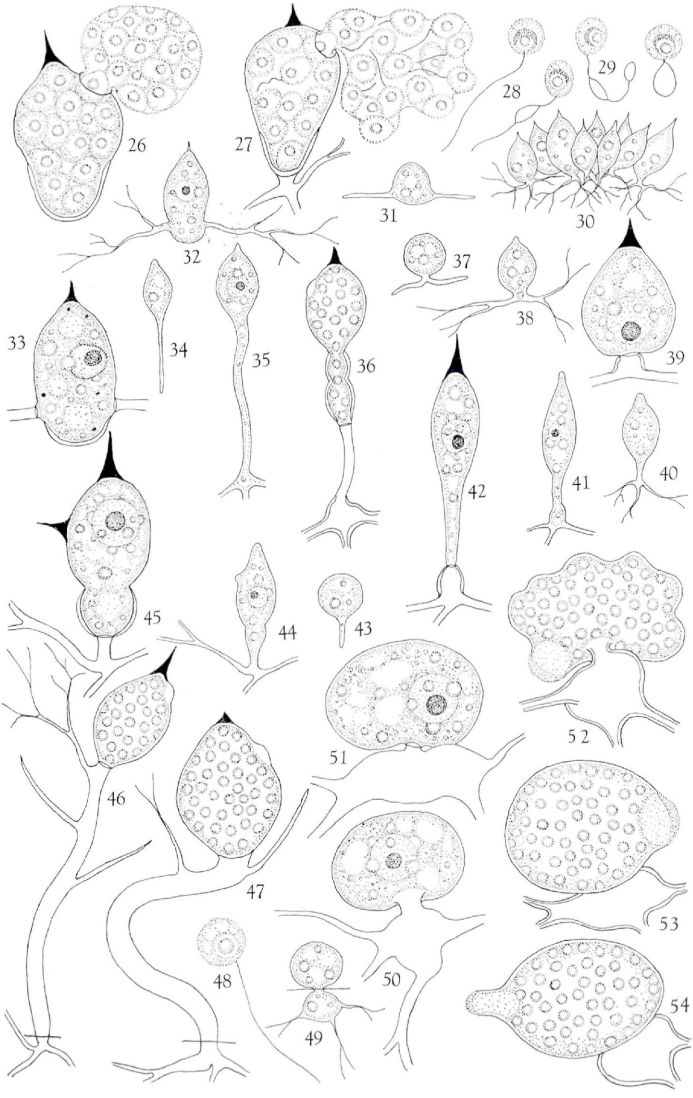
Sparrow, F. K. Jr. 1937. Some chytridiaceous inhabitants of submerged insect exuviae. Proc. Amer. Philos. Soc. 78: 23—53, 5 figs., 4 pls.

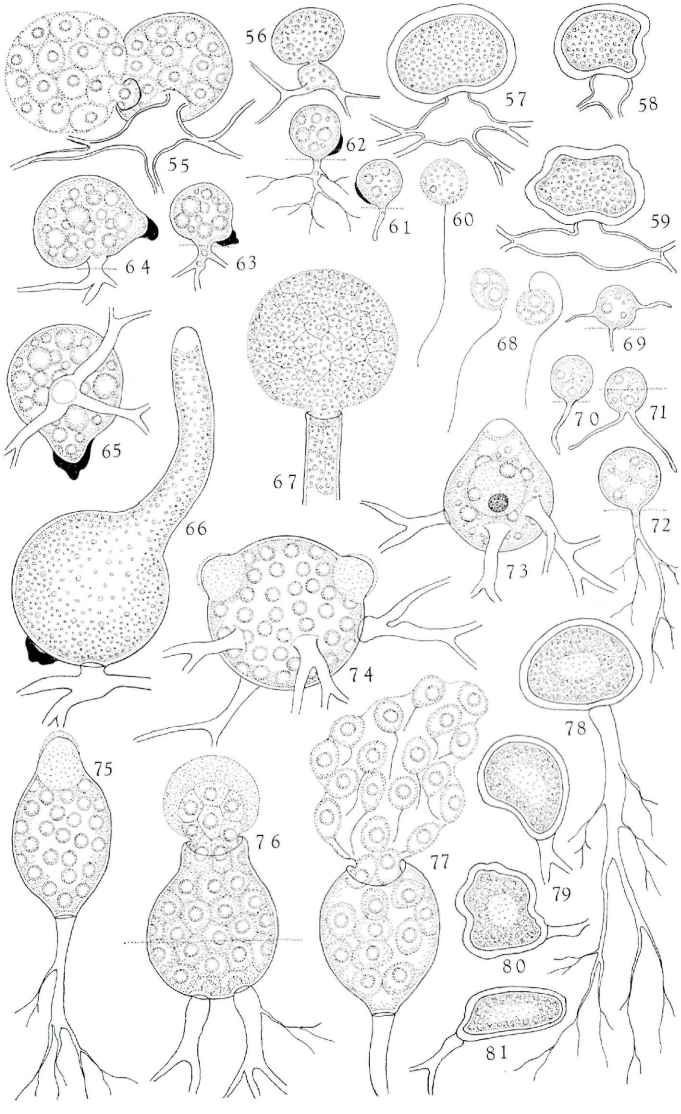
— 1938. The morphology and development of *Obelidium mucronatum*. Mycologia 30: 1—14, 44 figs.

— 1960. Aquatic Phycomycetes. VII—1187 pp., Univ. of Michigan Press, Ann Arbor.

Willoughby, L. G. 1958. Studies on soil chytrids, III. On *Karlingia rosea*







Johanson and a multi-operculate chytrid parasitic on *Mucor*. Trans. Mycol. Soc. 41: 309—319, 4 figs., pl. 17.
— 1961. Chitinophilic chytrids from lake muds. Trans. Brit. Mycol. Soc. 44: 586—592, 2 figs. pls. 37, 38.
— 1962. The ecology of some lower fungi in the English Lake District. Trans. Brit. Mycol. Soc. 45: 121—136, 5 figs.

Description of Figures.

Figs. 1—16. *Asterophlyctis irregularis*. Fig. 1. Mature sporangial thallus; pegs on lower half of sporangium; rhizoids sparingly branched and stiff-looking. Fig. 2. Zoospore. Fig. 3. Very young sporangial thallus. Fig. 4. Variations in structure of sporangial pegs. Fig. 5. Large sporangium with numerous pegs. Fig. 6. Discharge of zoospores through a basal pore and their swarming in a vesicle. Fig. 7. Incipient resting-spore thallus with coarsely granular and globular content. Fig. 8—10. Stages in development of resting spore. Fig. 11—16. Variations in sizes and shapes or resting spores.

Figs. 17—19. *Asterophlyctis sarcoptoides*. Fig. 17. Large, deeply-lobed sporangium with a long curved exit canal. Fig. 18. Small somewhat triangle-like sporangium with attached germ tube and zoospore cyst bearing rhizoids. Fig. 19. Resting spore with curved and straight spines, attached germ tube, and zoospore cyst bearing rhizoids.

Figs. 20—47. *Obelidium mucronatum*. Fig. 20. Full-grown sporangium with large primary nucleus. Fig. 21. Fixed sectioned and stained primary nucleus. Fig. 22. Division of primary nucleus. Fig. 23. Profile, polar and anaphase views of secondary nuclear divisions. Fig. 24. Sporangium with subapical exit papilla shortly before sporogenesis. Fig. 25. Dehiscence of a stalked *O. hamatum*-like sporangium. Fig. 26. Later stage of dehiscence in a detached free floating sporangium. Fig. 27. Zoospores swarming in a vesicle. Fig. 28. Zoospore. Fig. 29. Zoospores with vesicles in the flagella. Fig. 30. Cluster of young thalli. Fig. 31—33. Stages in development of a thallus with oppositely directed sublateral rhizoids. Fig. 34—36. Stages in the development of a long-stalked sporangium. Fig. 37—39. Stages in the development of a sessile sporangium. Fig. 40—42. Stages in the development of a narrowly fusiform sporangium. Fig. 43—45. Stages in the development of a sporangium with two spines. Fig. 46. *Obelidium hamatum*-like thallus with a long extramtarical stalk bearing two simple unbranched spines and one branched rhizoidal spine. Fig. 47. *Obelidium megarhizum*-like thallus with a broad extramatrical rhizoidal stalk.

Fig. 48—59. *Rhizoclosmatium hyalinum*. Fig. 48. Zoospore. Fig. 49. Young sporangial thallus. Fig. 50, 51. Ovoid, incipient sporangia with conspicuous primary nuclei. Fig. 52. Irregular sporangium with basal exit papilla. Fig. 53. Ovoid sporangium with a broad lateral papilla. Fig. 54. Ovoid sporangium with a short lateral exit canal. Fig. 55. Discharge of zoospores and their swarming in a vesicle. Fig. 56. Young resting-spore thallus with coarsely granular content. Fig. 57—59. Variations in sizes and shapes of resting spores.

Fig. 60—67. *Rhizophlyctis petersenii* var. *appendiculatus*. Fig. 60. Zoospore with one larger and several smaller granules. Fig. 61, 62. Development of young thalli; incipient sporangia developing from zoospore with thickened portion of the wall. Fig. 63—65. Later stages in the development of appendiculate sporangia which are filled with large globules. Fig. 66. Mature sporangium with long curved exit canal. Fig. 67. Discharge of zoospore to form a large globular mass at exit orifice.

Fig. 68—81. *Rhizophlyctis variabilis*. Fig. 68. Zoospores. Fig. 69—71. Variations in zoospore germination; extramatrical and partly intramatrical. Fig. 72. Young *Rhizidium*-like thallus. Fig. 73. Broadly pyriform sporangium with conspicuous primary nucleus and three rhizoidal axes. Fig. 74. Mature sporangium with four rhizoidal axes and two conspicuous exit papillae. Fig. 75. Mature *Rhizidium*-like thallus; sporangium with a broad apical papilla. Fig. 76. Initial stage of zoospore discharge in a partly intramatrical sporangium. Fig. 77. Zoospores swarming in a vesicle. Fig. 78. *Rhizidium*-like resting-spore thallus with an ovoid resting-spore. Fig. 79—81. Further variations in sizes and shapes of resting spores.