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SOME NOVA SCOTIAN AQUATIC FUNGI.—BY CLARENCE L.
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Read 11th January, 1909.

The *Saprolegniineæ* constitute a group of the *Phycomycetes* characterized by their possession of a well developed mycelium of more or less richly branched siphonaceous filaments and by the production of two kinds of reproductive bodies, viz. : (1) small, non-sexual spores, generally appearing as warm spores, and (2) sexual spores.

The order has been divided into the following families :

A. Strictly aquatic fungi, with a mycelium of generally stout siphonaceous filaments ; zoosporangia approximately cylindrical, not at all or little broader than the supporting filaments ; sexual fertilization doubtful ; conidia wanting.

a. Vegetable filaments of uniform thickness.

1. *Saprolegniaceæ*.

b. Vegetable filaments constricted at intervals.

2. *Leptomitaceæ*.

- B. Fungi with a mycelium of delicate thread-like hyphæ, mostly saprophytic, rarely parasitic, living in water or facultatively in moist air; zoosporangia generally spherical, resembling in form the oogonia and strongly marked off from the vegetative portions of the hyphæ; formation of oospores preceded by a sexual act; conidia present.

3. *Pythiaceæ*.

The zoospores are produced in sporangia and are formed in large numbers by the simultaneous division of the contents of these organs, and, as has been stated, usually escape as swarm spores. In all of the genera of the family *Saprolegniaceæ*, with the exception of *Pythiopsis*, *Dictyuchus*, *Thraustotheca* and *Aplanes*, the swarm spores escape as terminally biciliate zoospores, and soon after their escape encyst. After a period of rest, generally a few hours, they escape from their enclosing membranes and pass through a second swarming stage as more or less kidney shaped laterally biciliate zoospores. After a second encystment germination takes place. This phenomenon is referred to as diplanetism. In *Pythiopsis*, the second swarming stage is suppressed and germination takes place immediately upon the escaping zoospores first coming to rest. In *Dictyuchus*, the zoospores encyst within the sporangia and finally escape, each by a separate opening through the outer wall, and then appear with lateral cilia. In this genus the first swarming stage is suppressed. The same suppression is also found in *Thraustotheca*, and in the genus *Aplanes* the disappearance of the swarming stages is practically complete. Here the spores germinate within the sporangium, the germ tubes pushing out through the wall.

The history of the swarm spores in the family *Leptomitaceæ* has not been so completely worked out, but in the genera *Leptomitus* and *Apodachlya*, they appear to be diplanetic.

In the third family of the order, *Phthiaceæ*, the swarm spores are monoplanetic.

The sexual reproduction in the order is by means of oogonia and antheridia. The former are, as a rule, spherical and terminal on the main filaments or lateral branches, or at times intercalary, when they may be spherical, barrel shaped or cylindrical. The antheridia are cylindrical, club shaped or ovate cells cut off from the ends of special branches which become appressed against the walls of the oogonia, and in some cases at least send through the walls of the latter organs fertilisation tubes. A modification of the common type of antheridium is found in *Saprolegnia hypogyna* Pringsheim, and in *Achlya hypogyna* Coker & Pemberton¹. In these species an antheridial cell is cut off from the oogonial branch by a septum a short distance below the basal wall of the oogonium, and a tube-like growth from this basal wall pushes up directly into the cavity of the latter organ. In some forms antheridia are absent, and it appears to be doubtful whether in the great majority of the first two families of the group, even when they are present, they have not become functionless. The contents of an oogonium gives rise to one or more oospheres which ripen into resting oospores and lie free in the cavity of the oogonium. The ripening process generally occupies two or more weeks. In the ripe condition the fat contents of an oospore usually collect in one or a few large globules. When the oil globule occupies one side of the spore and is not included by the remaining spore contents, the spore is described as "excentric." When the oil globule is surrounded by the other spore contents the descriptive term "centric" is applied. A good example of the first is found in *Achlya americana* Humph., and of the second condition in *Achlya apiculata* DeBary.

The walls of the oogonia may be smooth or provided with more or less numerous outgrowths; they may become uniformly thickened or definite areas may remain unmodified, giving rise to pits. These unthickened areas or pits are best brought out by treatment with chlor-zinc-iodine solution, which gives to the

walls generally a color which has been described as an indian red, while the pits appear as light areas.

The members of the first two families grow in water on decaying vegetable and animal remains, such as dead algæ, sticks, the bodies of insects, etc., and may readily be procured for study by collecting some of the debris and slime from the bottom of any more or less permanent pool and throwing on the water the dead body of an insect such as the common house fly, first sterilized by soaking for a short time in absolute alcohol. In from 24 to 48 hours the body of the fly will generally be found to be covered with a filamentous growth quite visible to the naked eye. Several species will, as a rule, be found to have developed, and so general is the distribution of these forms of life, that, in my own experience, only about one attempted culture in every twenty was a complete failure.

While the *Saprolegniaceæ* are normally saprophytes, various species, of the genera *Saprolegnia* and *Achlya* may become facultative parasites and have been the cause of serious epidemics among fish, the salmon appearing to be particularly susceptible to their attacks. The fungus may develop on various parts of the body of the fish, infesting the eyes and gills and eventually causing blindness and death. The mortality among the fresh water fish in the aquaria of the U. S. Fish Commission at the World's Fair, Chicago, in 1892, was so great as to call for a special investigation when the trouble was found to be due to a *Saprolegnia*, probably *S. mixta*².

All of the forms which are herein described and figured belong to one or other of the families, *Saprolegniaceæ* and *Leptomitaceæ*, and were collected during 1907 and 1908 in the vicinity of Pictou, N. S.; Lower Mt. Thom, Pictou Co.; and Sydney, N. S. The number is not large, but the area covered was small and, in addition to those here described, a considerable number of forms appeared in the cultures made which are not referred to; the observations of them not being sufficiently

complete for certain determinations. This paper will, at least, serve to direct the attention of our botanists to the group which will, no doubt, be found to be well represented in our flora.

Family, SAPROLEGNACEÆ.

In this family the generic divisions are based upon the characteristics of the sporangia and zoospores; the specific divisions upon the characteristics of the sexual organs. The three genera which have appeared in the cultures made are **Saprolegnia**, **Achlya** and **Aphanomyces**.

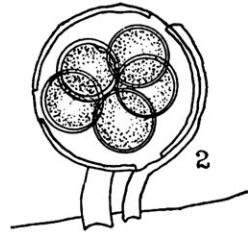
In the first, the zoospores escape from the sporangium by a common mouth and swarm separately. The sporangia are, as a rule, renewed by the filament continuing its growth up through the empty sporangium. A second sporangium may be cut off before the tip reaches the top of the old sporangium and thus several empty sporangia may be found one within the other (fig. 1). In a few cases, the innovation of sporangia is by cymose branching.

In the genus **Achlya** the zoospores, on escaping from the sporangium, collect to form a hollow sphere at its mouth and there encyst (Fig. 16). The sporangia are renewed by the filament containing its growth by a lateral branch arising at the base of the old sporangium (Figs. 10 & 16). In both of the preceding genera the swarm spores are produced in an indefinite number of rows in the sporangia.

In **Aphanomyces**, the zoospores are produced in a single row, and after escape encyst at the mouth of the sporangium in the same manner as in the genus **Achlya**. In this genus, too, the rule is that but one oospore is produced in an oogonium, while in **Saprolegnia** and **Achlya** the number is generally indefinite within certain limits.

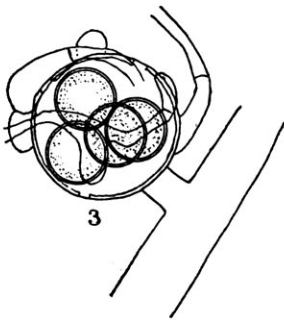
Genus, *Saprolegnia* Nees von Essenbeck.

S. monoica Pringsh. (Figs. 1 and 2). Hyphæ robust, generally not very long. Sporangia cylindrical. Oogonia abundant, spherical, on short generally straight lateral branches or terminal on the main filaments. Walls with very large pits, oospores 2-12, usually 4-6; 24μ - 27μ in diameter, centric. Antheridial branches, rather stout, arising from the main filaments near the oogonial branches, one or more to each oogonium. Antheridia nearly cylindrical, long and partially encircling the oogonium.



This species appeared in a culture made from material taken from a swamp alongside Columbus Avenue, in the city of Sydney, in May, 1908, and in November of the same year in a culture made from a collection from a pool near the Washing Brook in the same town.

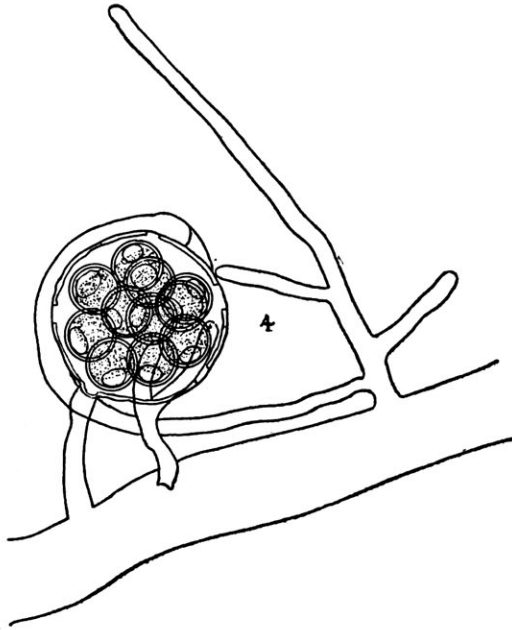
S. diclina Humph. (Fig. 3). Hyphæ as a rule not very long, rarely exceeding .5cm. Sporangia cylindrical. Oogonia spherical, terminal on short straight lateral branches or on the main filaments, rarely intercalary. Walls pitted, but the pits are small and inconspicuous. Oospores 4-25, generally 8-10 in an oogonium; 22μ - 26μ in diameter, centric. Antheridial branches of diclinous origin, delicate. Numerous antheridia attached to each oogonium, short clavate.



This species appeared in cultures made from material taken from a small brook flowing from Kehoe's Lake, near Sydney, and also from material collected at Cossitt's Lake.

Genus, *Achlya* Nees von Essenbeck.

A. americana Humph. (Fig. 4). Hyphæ long, robust. Sporangia abundantly developed, nearly cylindrical. Oogonia spherical, on short, straight lateral branches racemously arranged. Walls more or less abundantly pitted. Oospores up to 15 in an oogonium, 23μ - 27μ in diameter, excentric. Antheridial branches abundant, arising from the main filaments near the

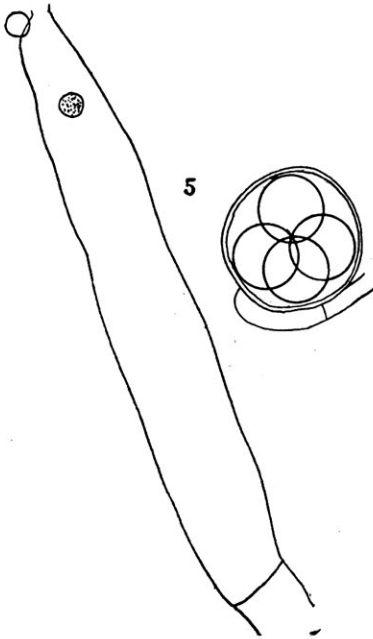


oogonial branches, generally much branched. Antheridia cylindrical, encircling to a greater or less extent the oogonia usually several to each oogonium.

Typical representatives of this species were obtained at Mt. Thom, Pictou Co., and also from a swamp adjacent to Sullivan's Brook, near Sydney. From material collected at Cossitt's Lake, near the same town, there developed a form which may be found to be worthy of varietal rank. In it the walls of the

oogonia were covered with short, blunt, wart-like outgrowths, and the supporting branches of the oogonia were shorter than the typical form. Its characteristics remained constant through several generations, but it was obtained only from the one source. It appears to agree very closely with Trow's *A. americana* var. *cambrica*³.

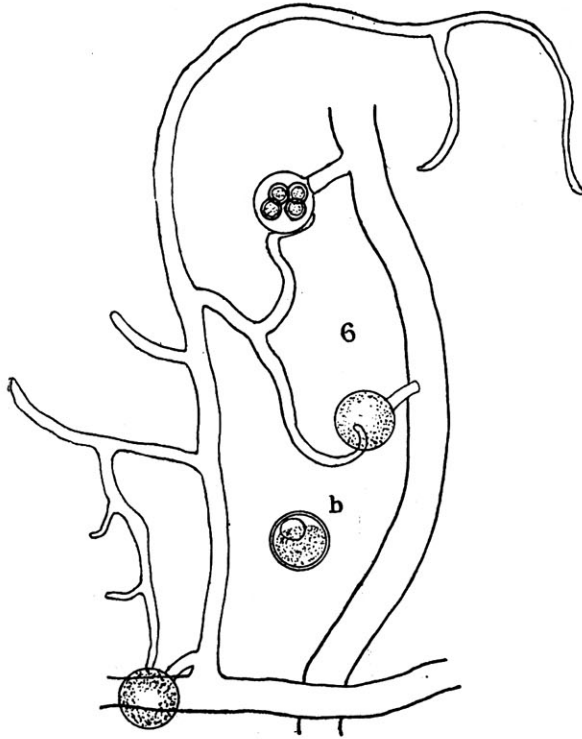
A. deBaryana Humph. = *A. polyandra* deBary (Figs. 5-8).



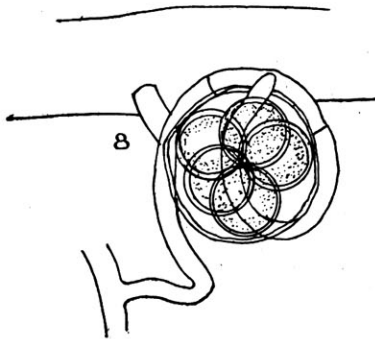
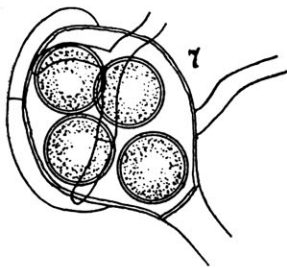
Hyphæ robust and long, reaching one centimetre. Sporangia produced in moderate numbers — somewhat spindle shaped, with a longer tapering apex than in most *Achlyas*, often developed in basipetal succession. Oogonia spherical, terminal on short, straight lateral branches, racemosely arranged or on main filaments. Walls thickened, but not pitted. Oospores 2-10 in an oogonium, usually 2-5; 23μ - 35μ in diameter, excentric. Antheridial branches produced on filaments bearing oogonia, very long and much branched, the

branches uniting indifferently with oogonia borne on the same filament or on others. The antheridia are long, cylindrical or slightly clavate and wrapped about the oogonia—several to each.

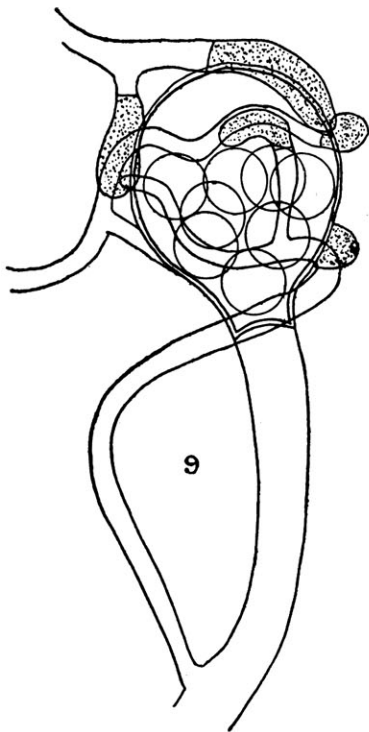
The material in which this species appeared was taken from a pool near the Grand Lake Road, Sydney, near a large brook flowing into Grand Lake. The walls of the oogonia, while not definitely pitted, show a few small more lightly stained areas



when treated with chlor-zinc-iodine, indicating thinner portions probably where the germ tubes have penetrated. This is said to be one of the commonest European species, but has not before been described from America.



A. polyandra Hild. (Fig. 9). Hyphæ robust and long, frequently exceeding a centimetre in length. Sporangia somewhat spindle shaped, not very abundant. Oogonia terminal on rather long lateral branches which are generally curved and at times helically coiled, or terminal on the main filaments. Walls not much thickened, smooth and unpitted, slightly brownish when old. Oospores 1-20 in an oogonium, commonly 8-12; 23-30 μ in diameter, centric. Antheridial branches arising from the oogonial branches or from the main filaments near them, generally more or less branched. Antheridia usually short clavate, several to each oogonium.

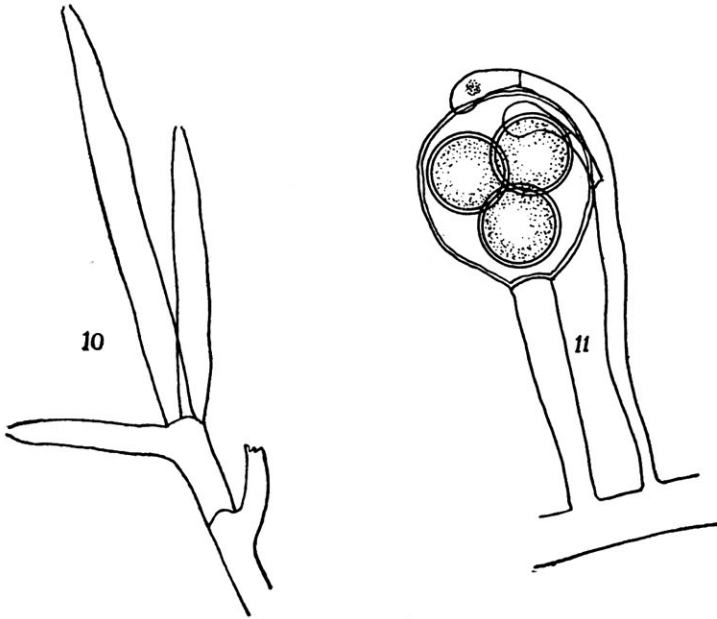


This species appeared on materials collected from a number of sources at Lower Mt. Thom, Pictou county, and appeared to be the most common of the *Saprolegniaceæ* in that district. In young cultures the oogonia are spherical, but in old cultures, when they are being abundantly developed, they frequently become more or less irregular in shape-ovate or obovate. This characteristic was constant in a large number of cultures made. Not infrequently, too, an apiculus appeared on an oogonium. This species appears to be very closely related to the next, differing from it principally in the smaller size and greater numbers of its oospores, in the more branched character of the antheridial branches, and in the more abundant production of sporangia. In old cultures, as in

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A. apiculata, the oogonial branches frequently branch, each twig terminating in an oogonium. Rarely an intercalary cylindrical oogonium has occurred in cultures.

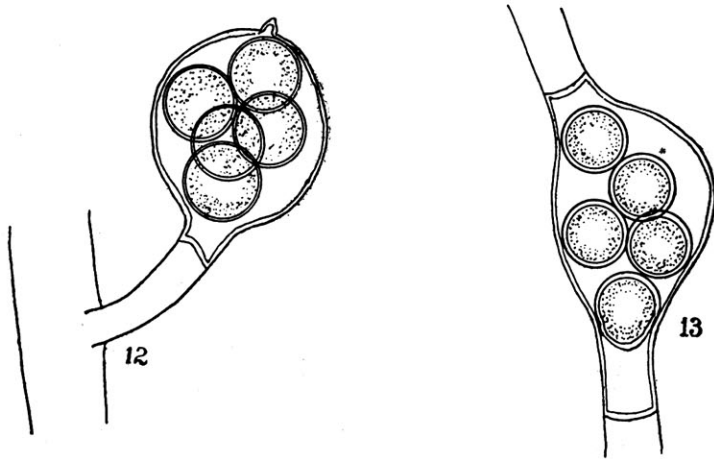
A. apiculata deBary (Figs. 10-13). Hyphæ stout, at times considerably exceeding 100μ in diameter at the base and reaching 1.5cm. in length. Zoosporangia generally very abundant, somewhat spindle shaped. Oogonia spherical or slightly ellipsoidal,



terminal on lateral branches, racemosely arranged and usually curved; rarely intercalary; commonly terminating in a short apiculus. Walls smooth and unpitted. Oospores 1-10, generally 3-5 on an oogonium, large and dark-colored when young, $33-40\mu$ in diameter, centric. Antheridial branches arising as in the last species, but frequently unbranched. Antheridia, several to each oogonium, short clavate or almost ovate.

This species appeared in a large number of cultures made from materials collected at Mt. Thom, Pictou county, and in

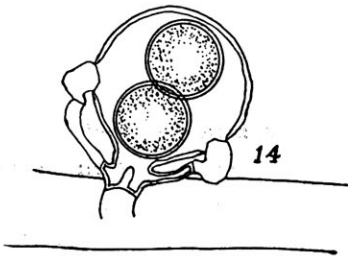
the vicinity of Sydney. It appears to be one of our most common *Saprolegniaceae*. The frequency of the development of an



apiculus appears to vary considerably in cultures obtained from different sources. In some, practically all of the oogonia are so terminated, while in others not more than one in three is so furnished.

A. racemosa Hildeb. (Fig. 14). Hyphæ of moderate length, robust. Sporangia generally abundantly produced, cylindrical.

Oogonia terminal on main filaments and on lateral branches, racemosely arranged. Walls unevenly thickened, but not pitted, brownish when old. Oospores 1-6 in an oogonium, most commonly 3-4, 23μ - 30μ in diameter, centric. Antheridial branches arise from the oogonial

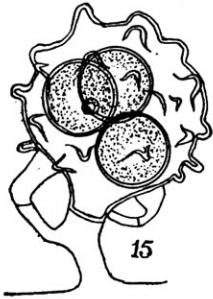


branches or from the walls of the oogonium or occasionally from the main filament near the oogonial branches. Antheridia 1-3 to each oogonium, short clavate, turned at right angles to the

long axis of the antheridial branch and applied by their apices to the walls of the oogonium.

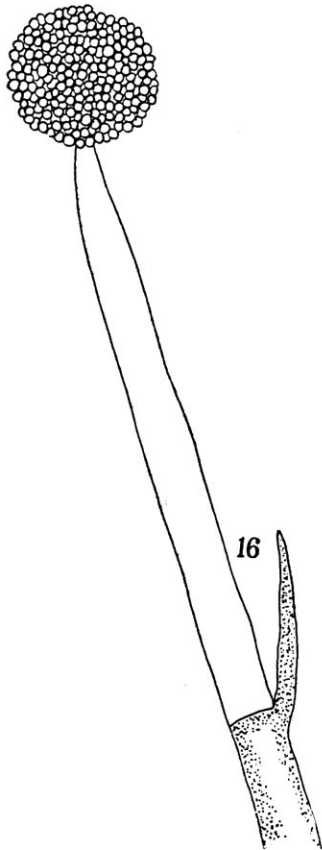
This species appeared in material taken from the Columbus Avenue swamp, Sydney, and from various other sources near the same town. The irregularly thickened walls of the oogonia and the antheridia are very characteristic. It is not of rare occurrence in cultures, but, in my experience, has not appeared so frequently as the following well marked variety.

A. racemosa var. *stelligera* Cornu (Fig. 15). This variety differs from the type in that the walls of the oogonia are more or less closely beset with short, rounded outgrowths. The number of oospores varies from 1-7. Their average diameter is, in my experience, somewhat greater than in the type and the antheridial branches appear to take their origin more frequently from the walls of the oogonia. As has been stated the form appears to be more common than the type in the districts from which collections were made.



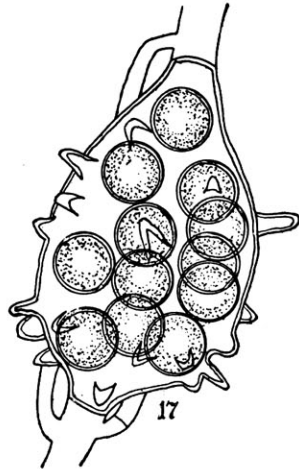
A. acadiensis sp. nov. (?). (Figs. 16-19). Hyphæ generally very stout and long, frequently exceeding 100μ in diameter and attaining a length of 1.5cm .

Zoosporangia almost cylindrical or somewhat fusiform, sparingly developed, in some cultures rare. Oogonia terminal on main filaments or on usually long lateral branches or intercalary. The oogonial walls are provided with more or less numerous blunt outgrowths, sometimes comparatively long, and the terminal oogonia have, as a rule, strongly developed apiculi. The oogonia, in older cultures, are produced in series, frequently 5-7 in a chain. The intercalary oogonia are barrel-shaped or cylindrical. In addition to the outgrowths the walls of the oogonia are also pitted. The oospores may reach 40 in an



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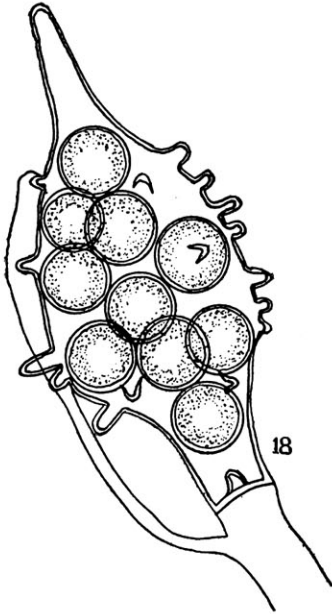
oogonium, are centric in structure and measure from $30-35\mu$ in diameter. Antheridial branches are rarely absent, generally two or three arising from the filament



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a short distance below the basal wall of the oogonium. These are often branched. Antheridial branches from adjacent filaments not infrequently attach themselves to an oogonium. The antheridia are almost cylindrical or slightly clavate, comparatively long.

This species is the largest and most striking of the *Achlyas* observed and, in the vicinity of Sydney, is apparently one of the most common. It also appeared in material collected in a pool on the "Barren" near Pictou, N. S. The filaments are unusually stout in vigorous cultures, sometimes reaching 140μ in diameter at the base, and at times attaining a length of almost 2^{cm}. This species appears to be more sensitive than



most *Achlyas* with regard to the behaviour of the zoospores. When a culture is placed in a small quantity of water in a watch glass all of the sporangia



may fail to empty and the zoospores germinate after the manner of an *Aplanes*. Under such circumstances the germ tubes shew a rapid growth of

from 30-40 μ per hour. In other cases, where the environment does not appear to be favorable to normal development, the zoospores may escape and, after the first encystment, germinate without a second swarming stage, as appears to be normal manner in *A. aplanes* Maurizio⁴. Cultures of the species were made for some months in water containing a few living sphagnum plants, and under these conditions the zoospores invariably followed the normal course. At will, the *Aplanes* condition could be induced by removing the culture for a few hours to a watch glass, but it soon disappeared upon return to its original habitat. When oogonia are produced in a chain or series the antheridial branches attached to the distal members of the series take their origin from the walls of the oogonia next below, as in the case of *Saprolegnia androgyna* Archer⁵, (*Aplanes braunii* deBary). The number of oospores in the first formed oogonia on the main filaments or large branches is generally large, ranging from 8-15, and frequently from 15--25. In old

cultures the larger filaments or branches may give rise to fine branches terminating in oogonia containing only one or two oospores and with walls, showing but a few blunt protuberances. In one culture this species was attacked by a parasite identical with or closely resembling *Olpidiopsis saprolgnia* A. Braun.

A species which bears a very close resemblance to the present one is that described and figured by Dr. Humphrey⁶, as *Saprolgnia treleaseana*. The generic position of that species was determined from the observation of one empty sporangium by Dr. Trelease. Its vegetative habit is, according to Dr. Humphrey, very *Achlya* like. In all of the cultures made of *A. acadensis* the sporangia were produced in sufficient numbers, although sometimes scarce, to render its generic position readily established. Through the kindness of Dr. Johnston, of Johns Hopkins University, I have been enabled to examine the only preparation of *S. treleaseana* in Dr. Humphrey's collection. This preparation shews oogonia and resting sporangia, which correspond closely with those of the present species. No mention is made by Dr. Humphrey of the pitting of the walls in *S. treleaseana* and as the pits are always obscured by the outgrowths, and are generally only evident after treatment with chlor-zinc-iodine, no comparison could be made in this respect between the two species. I have provisionally described the present form under a new name, but further investigation of Dr. Humphrey's species in its type locality may shew that they are identical, in which case the older specific name would prevail, and it would be known as *Achlya treleaseana*.

Genus **Aphanomyces** deBary.

A. stellatus deBary (Fig. 20). Hyphæ delicate, $6\mu-7\mu$ wide, little branched. Zoospores forming in a single row and after escape collecting in a cluster at the mouth of the sporangium. Oogonia terminal, the walls with blunt outgrowths giving a star-like appearance. Oospores single, filling the oogonium, $20\mu-25\mu$ in diameter. Antheridia present, one to each oogo-

nium, the antheridial branch arising from the same filament as the oogonium, some distance below the latter.

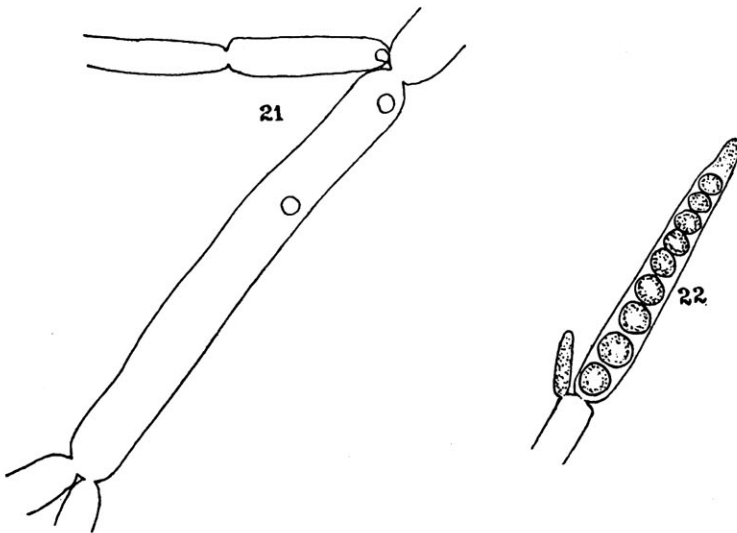


Hyphæ with sporangia, apparently those of an *Aphanomyces*, appeared in several cultures from materials collected at various points near Sydney, but in only one case, from material collected at Cossit's Lake in October, 1908, did oogonia appear. The maximum diameter of the oogonia on the plants examined was about 30μ . I am not aware that this species has been previously reported from America.

Family LEPTOMITACEÆ.

Genus *Leptomitus* Agardh.

Leptomitus lacteus (Roth), Agardh. (Figs. 21, 22). Hyphæ delicate, constricted at intervals, the largest rarely exceeding 40μ in diameter at the base, decreasing in successive segments rarely branching elsewhere than at the distal ends of the segments. Cellulin grains conspicuous about 10μ in diameter

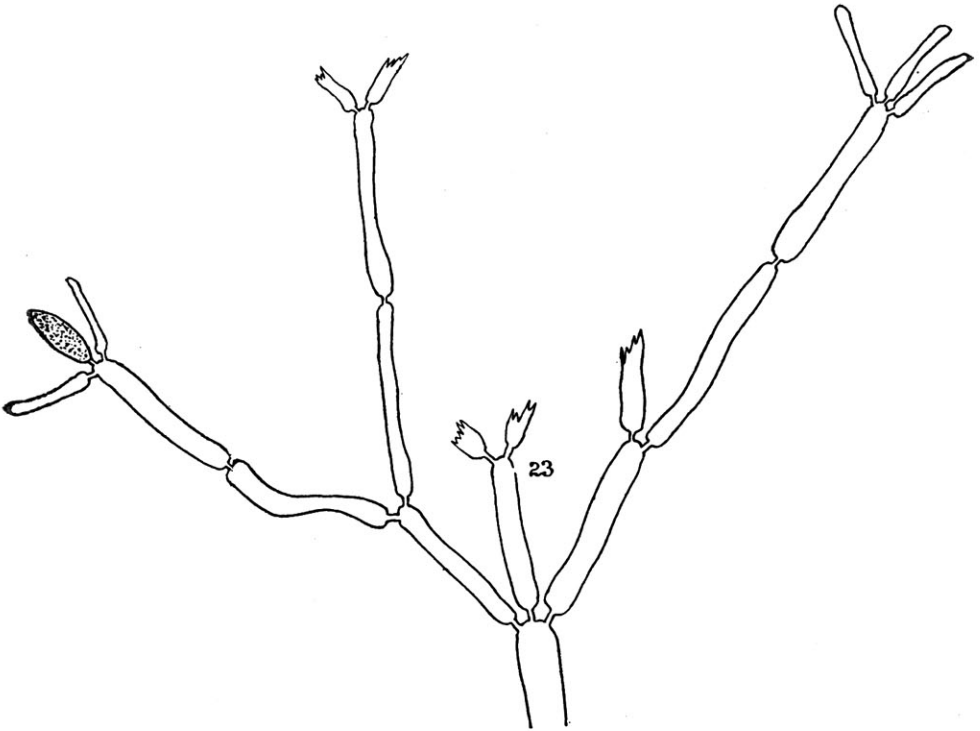


and frequently forming a plug at the constrictions between successive segments. Sporangia formed from slightly swollen segments, often in series. Zoospores in a single row averaging about 13μ in diameter, sometimes encysting within the sporangium, but generally escaping and swarming separately. Except in terminal sporangia the escape papilla is lateral.

This species was of frequent occurrence in the cultures made appearing first in December, 1907, in a culture made from tap water of the Sydney water supply. Grown on dead flies it forms a thick, white, felted covering over the substratum.

Genus **Sapromyces** Fritsch.

Sapromyces Sp. (Figs 23 and 24). A form belonging to this genus appeared in a culture made from material collected



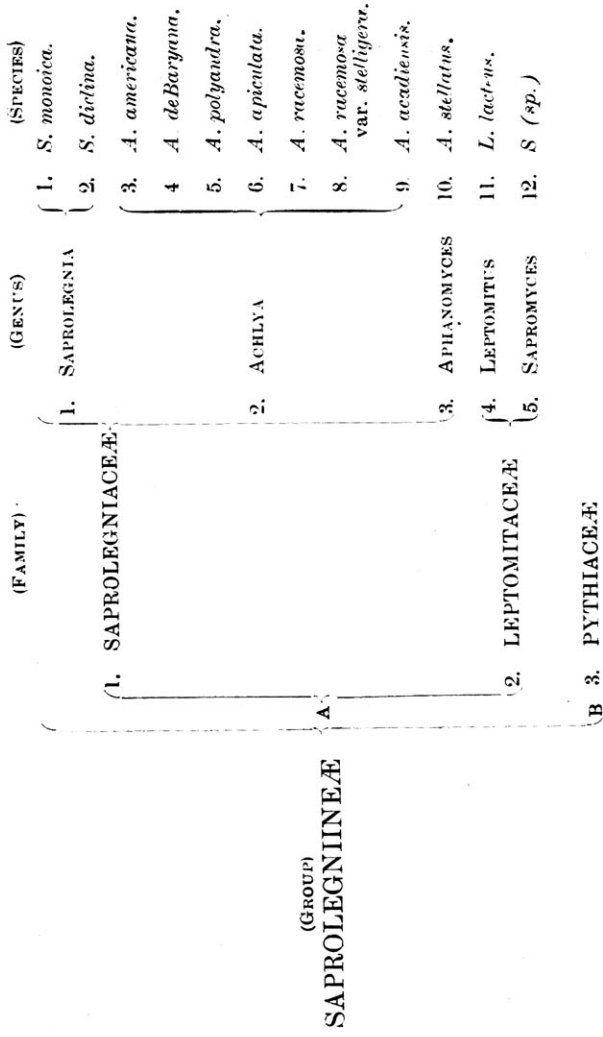
at the upper extremity of Gilholme's Lower Lake, about four miles from the city of Sydney and south of the Cow Bay Road.



The observations of it were very incomplete. The branched hyphæ attained a maximum length of about 2^{mm}. in the culture, but might possibly have grown longer as it early became overrun with bacteria, and it was found impossible to maintain it. The sporangia were elongated egg-shaped and averaged about 30 μ x90 μ . The encysted zoospores were about 10 μ in diameter. These were not observed in the act of swarming, but empty sporangia were common and in some, as in the one figured (Fig.

24), a few zoospores had evidently failed to escape and had encysted within the sporangium. Two or three sporangia may be found formed at the extremity of a segment. No structures were observed in this form corresponding to the conceptacula of Reinsch⁷, and which are unhesitatingly referred by Dr. Thaxter to the work of chytridiaceous parasites attacking the sporangia⁸.

CONSPECTUS OF CLASSIFICATION.



REFERENCES.

- (1) Botanical Gazette, vol. 45, p. 194.
- (2) Bulletin of the U. S. Fish Commission for 1893, p. 163.
- (3) "Observations on the Biology and Cytology of a new variety of *Achlya americana*," Annals of Botany, vol. 13, no. 49.
- (4) "Zur Entwicklungsgeschichte und Systematik der *Saprolegnieen*," München, 1894.
- (5) "On two new species of *Saprolegnieæ*." Journal of Microscopical Science 1867, p. 121.
- (6) "The *Saprolegniaceæ* of the United States with notes on the other species." Trans. Am. Philos. Soc., 17: 63-148, 1892.
- (7) "Beobacht. über einige neue *Saprolegniaceen*." Jahr. f. Wissensch. Bot., bd. xi, 1878.
- (8) The genus *Nagebia* of Reinsch. Bot. Gaz., vol. 19, p. 49-55.

EXPLANATIONS OF FIGURES.

(The numbers in brackets give the approximate linear magnification.)

- Saprolegnia monoica* Pringsh. Figs. 1-2.
1. (100) Empty sporangia.
 2. (225) Oogonium.
- Saprolegnia diclina* Humph., Fig. 3.
3. (225) Oogonium with attached antheridia. The connection of these with their filaments of origin is readily severed.
- Achlya americana* Hump., Fig. 4.
4. (225) Oogonium with antheridial branch and antheridia.
- Achlya deBaryana* Humph. = *A. polyandra* deBary, Figs. 5-8.
5. (225) Empty sporangium, young culture.
 6. (100) Two filaments with oogonia and antheridial branch. The production of an oogonium at the base of an antheridial branch as here figured is very rare. (b) A ripe ecentric oospore.
 7. (225) Oogonium with young oospores and antheridia.
 8. (225) Oogonium with much coiled antheridial branch.
- Achlya polyandra* Hildeb., Fig. 9.
9. (225) Typical oogonium with antheridial branches and antheridia. The antheridial branches in this case take their origin in part from the oogonial branch and in part from other filaments.
- Achlya apiculata* deBary, Figs. 10-13.
10. (50) Empty sporangia from vigorous culture.
 11. (225) Oogonium with antheridial branch and antheridia. No apiculus on oogonium.
 12. (225) Typical oogonium—antheridia omitted.
 13. (225) A rare intercalary oogonium.
- Achlya racemosa* Hildeb., Fig. 14.
14. (225) Oogonium with antheridia.
- Achlya racemosa* var. *stelligera* Cornu., Fig. 15.
15. (225) Oogonium with antheridia.
- Achlya acadiensis* sp. nov., Figs. 16-19.
16. (100) Sporangium with encysted zoospores.
 17. (225) An intercalary oogonium.
 18. (225) Terminal oogonium.
 19. (225) A portion of the wall of an oogonium.
- Aphanomyces stellatus* deBary, Fig. 20.
20. (225) Oogonium with oospore.
- Leptomitus lacteus* Agardh. Figs. 21 and 22.
21. (225) A portion of a hypha shewing method of branching and cellulose granules.
 22. (225) A terminal sporangium with zoospores encysted within it.
- Sapromyces* sp. Figs. 23 and 24.
23. (100) Hyphæ shewing method of branching and formation of sporangia.
 24. (225) Empty sporangium with three encysted zoospores.