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New or peculiar aquatic fungi. 4. *Rhipidium*, *Sapromyces*, and *Araiospora*, nov. gen.

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WITH PLATES XXI-XXIII.

Of the numerous aquatic forms the discovery of which we owe to the researches of Cornu, the four species which he placed in the genus *Rhipidium*¹ are among the most interesting from their striking peculiarities as well as from the fact that, as far as the writer is aware, they have been observed by no other botanist. It is true that Cornu regarded the *Naegelia* of Reinsch as identical with one of his species of *Rhipidium*; but, as has been mentioned in a previous note,² it seems quite unlikely that this is the case. Owing to the fact that Cornu's account, which was avowedly a preliminary one, has not been supplemented by any details or figures, with the exception of certain illustrations in Van Tieghem's *Traité de Botanique*, it is impossible to form any very accurate idea of the essential differences which separate the species; and for the same reason the true limitations of the genus itself are by no means clear. The difficulty is further increased from the fact that the figures just mentioned do not correspond to the description of the species represented in one very important respect, so that in view of this uncertainty both as to generic and specific characters, the writer

¹ Cornu, *Monographie des Saprolegniées*. Ann. d. Sci. Nat. Bot. V. 15: 15 ff. 1872. Also Bull. Soc. Bot. de France 18: 58. 1871.

² Bot. Gazette 19: 50. 1894.

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has felt obliged not only to describe under a new name the common American species, but to modify the limitations of the genus as described by Cornu.

In general terms *Rhipidium* Cornu may be said to be characterized as possessing a highly developed basal cell, attached to the substratum by rhizoids, which gives rise terminally to a number of filaments successively constricted and bearing sexual and non-sexual reproductive organs. The sexual organs consist of oogonia in which single oospores are produced as a result of fertilization by an antheridium, peculiar from the fact that it always penetrates the oogonium at a definite point on the surface of the latter. The sporangia are more or less oval in form and emit the zoospores in a cylindrical mass surrounded by a thin membrane which ruptures almost immediately, allowing them to escape.

Such in general are the characters of the genus as originally described; and in regard to the species, a comparison of the scattered references which one finds in the "Monograph" affords the following information.

Rhipidium interruptum, as appears from the figures and description of Cornu, has oval sporangia, the filaments being characterized by the presence of numerous constrictions and sympodially (not otherwise) branched below the successively formed terminal sporangia; the segments cylindrical, short, six to eight times as long as broad. The oogonia are spherical and correspond in position to the sporangia, the oospore solitary, "étoilée" or "munie de crêtes très saillantes."³ The antheridia are heterogenous, borne at the tips of long and twisted filaments and apply themselves near the base of the oogonium,⁴ although in the figure given in Van Tieghem⁵ they are represented as being applied near the apex.

R. continuum is described as resembling the preceding species in all respects except that the filaments are continuous, the only constrictions present being those which separate them from the basal cell and from the reproductive organs.

R. elongatum differs from the two preceding species in that the successive segments of the filaments are clavate and very long, attaining a length sometimes of a millimeter. The surface of the oospore is, moreover, undulate, and the antherid-

³ Cornu, Monograph l. c. pp. 15 and 103.

⁴ op. cit. p. 30.

⁵ Traité de Bot. 1024. fig. 617.

ial filament is spirally twisted below the antheridium, which applies itself to the apex of the oogonium by means of a terminal beak-like process. Whether the filaments are umbellately or otherwise branched is not mentioned.

R. spinosum, the fourth and last of the species described, is still more imperfectly known; but may be distinguished from the others by the fact that its sporangia are furnished with stout spines directed upwards and downwards, and are borne sub-umbellately at or near (?) the tips of the segments.

If one compares this fragmentary information, which, although it is perhaps sufficient to distinguish these four species from one another, is quite inadequate to afford a means of separating them from other allied forms, it becomes apparent that, although the two first, together with the American species subsequently described, are undoubtedly congeneric, the others are by no means certainly so. The characters of *R. elongatum* in particular, so far as we are informed concerning them, when compared with those of the species of *Sapromyces*, indicate a generic identity which can hardly be doubted. On the other hand the characters of *R. spinosum* suggest a similar identity with the generic type described below as *Araiospora*. To make these points more clear a brief review of the chief characters of the three genera just mentioned will be necessary.

The genus *Rhipidium*, if we limit it as above indicated to the three species *R. interruptum*, *R. continuum* and *R. Americanum*, is characterized by a differentiation, more extreme than in the other instances to be described, between its monstrosously developed basal cell and the often very numerous filaments to which it gives rise. This basal cell is distinctly *sui generis*, and although it may be variously modified from the fact that it is often more or less regularly branched or lobed, is utterly different in character from the segments of the branches to which it gives rise. Its walls are usually greatly thickened and it is, as a rule, very abruptly expanded distally; its lower extremity being fastened to the substratum by numerous rhizoids. From the edges or from the upper surface of the expanded portion, from which they are separated by a constriction, are produced the filaments; and on the latter are borne the reproductive organs. These filaments, as in other members of the *Leptomitaceæ*, are characterized by a segmentation which, as we have seen, is very well marked

in *R. interruptum*; while in *R. continuum* the whole filament constitutes a single segment. In *R. Americanum*, on the other hand, we have a transitional form, in which the filament may consist of one or of several segments. The filaments themselves are in all the species apparently simple, although in reality they consist of a succession of sympodial branches which arise below each sporangium after it has formed, the further upward growth of the branch causing the sporangium, though really terminal, to assume an apparently lateral position. This type of filament is distinctly characteristic of the genus as limited above; and, although it occurs neither in *Sapromyces* nor in *Araiospora*, is identical with that which is present in the ordinary sporangiferous filaments of *Apodachlya*. The sporangia, as has just been mentioned, are terminal, and are typically solitary, although they may, especially in rather depauperate specimens, occur several together at the extremity of a filament. Several, however, often succeed one another at intervals on the same filament (fig. 5). The form of the sporangia, although in *R. Americanum* it shows a considerable degree of variation (figs. 7 and 15), tends, in specimens that have developed under favorable conditions, to assume the characteristic shape represented in fig. 6; and the same peculiarity is noticeable in the published figure of *R. interruptum*.

The sporangia produce a comparatively small number of rather large zoospores, which are peculiar not only from their appearance, but from the manner in which they make their escape. As the sporangium matures, a broad and conspicuous papilla is formed at its summit (fig. 7), and its wall is evidently double; for when the zoospores are ready to emerge, the outer wall splits around the base of this papilla which is then carried upwards at the extremity of the emergent mass of spores (fig. 8), remaining attached to the inner wall which also surrounds the spore mass. The latter makes its exit in the form of a cylindrical column (fig. 9) which may reach a length equal to twice that of the sporangium before the thin surrounding wall becomes ruptured, usually at the side (fig. 10), allowing the zoospores (fig. 11) to escape. This process only occurs when the plant is growing under favorable conditions, and very often the inner wall may burst at once, turning the cap to one side and allowing the spores to escape directly from the cavity of the sporangium. The zoo-

spores are biciliate, much flattened, bean-shaped, with a slight indentation on one side, near which the cilia are attached, and are composed of large refractive granules (fig. 11) which give them so characteristic an appearance that they are always recognizable at a glance when seen swimming about in company with other zoospores. This peculiar method of egress is described by Cornu as characteristic of *R. interruptum* and his figure of the zoospores of this species represents the same coarsely granular structure. The zoospores are monoplanetic and in *R. Americanum* only the first stages of germination have been observed. The figures given in the *Traité de Botanique*⁶ illustrate their further development in *R. interruptum*, and indicate that the body of the zoospore itself gives rise directly to the expanded portion of the basal cell, the hypha of germination forming the stalk and producing the rhizoids from its apex. The spore thus develops as it were upside down.

The oogonia are formed like the sporangia, but are usually, if not invariably terminal, and are similarly distinguished from the filaments which bear them by the characteristic constriction. They are almost perfectly spherical in form and contain a single large oosphere which is not readily distinguishable from the rather abundant peripheral protoplasm until after fertilization has been accomplished. The antheridial filament in the American species, which, unlike the two European forms, is androgynous, arises immediately below the insertion of the oogonium; and is usually very short and slender (figs. 13 and 14), seldom, if ever, exceeding the length represented in fig. 12. The antheridium is rather small and rounded, though abruptly distinguished, and applies itself close to the base of the oogonium, the wall of which it perforates without indentation. The two European forms differ not only from the fact that they are heterogynous, but on account of the much greater development of the antheridial branches which are said to be "fort allongés et volubiles."⁷ The point at which the antheridium applies itself to the oogonium in these species, although, as has been already mentioned, it is represented as towards the summit in the figure given in the *Traité de Botanique* (fig. 617, 1a), may be assumed to be at the base, as in *R. Americanum*, in accordance

⁶*Traité de Botanique* 1024. fig. 617. 2.

⁷Cornu, *Monograph* 28.

with the statement on p. 30 of the Monograph: "le point où se fixe l'anthéridie semble assez constant: c'est vers la base chez les *R. continuum* et *interruptum*."

As the oospore matures the peripheral protoplasm begins to contract around it producing an undulate outline, and as it hardens in forming the exospore, the contained oospore follows its outlines, becoming later quite spherical through the deposition of its proper wall. The undulate outline assumed by the peripheral protoplasm seems to be due, in part at least, to the fact that it adheres to the inner wall of the oogonium, and when it begins to shrink away from the latter, the adherent areas form the "crests" characteristic of the exospore after it has become entirely freed from this attachment. Cornu appears to lay great stress on the alleged fact that the oosphere is itself originally undulate, and that this contour is reproduced in the mature spore. This, however, does not seem to be the case in the American form; the oosphere, when first distinguishable, being evenly spherical. The mature oospore is very thick walled and colorless in the species. Its germination has not been observed.

Such are the characters which seem to the writer to distinguish the genus *Rhipidium* in its restricted sense. Turning now for a moment to the genus *Sapromyces*, a more detailed description of which may be found in the paper previously cited, it will be seen that in general habit it differs from *Rhipidium* from the fact that, although the whole plant arises from a single cell attached by rhizoids to the substratum (fig. 16), this cell is undifferentiated and similar, except at its base, to the segments of the filaments; although its wall is often considerably thickened. In comparing the type of branching also, it is evident that it is fundamentally different, the whole plant being a several times compounded umbel, as regards the origin of the branches as well as that of the reproductive organs. The sporangia are characteristically elongate in form and the oogonia are definitely piriform and subject to external encrustation. The two known species including that subsequently described are in the one case androgynous, in the other heterogynous; the antheridial filament in both cases being peculiar from the fact that it becomes spirally twisted below the curved, oblong to cylindrical antheridium; which is also peculiar in that it applies itself to the oogonium near the apex of the latter, which it perforates as

the result of a definite pressure by which the wall becomes distinctly indented. The species previously described (*S. Reinschii*) has been observed by the writer in great abundance and in perfect condition since the publication of the note above mentioned, and in specimens growing under favorable conditions the emission of the zoospores has been seen to be similar to that of *Rhipidium* except that the membrane surrounding the emerging spore mass is ruptured almost immediately, so that all but a small number of the spores escape in the usual way through the open mouth of the sporangium. In this genus the zoospores are like those of the *Saprolegniæ* in general appearance, and are quite unlike those which have just been described as occurring in *Rhipidium*.

If we compare these characters with what few data are available concerning *Rhipidium elongatum* it is apparent that, although we know nothing as to its type of branching, it strikingly resembles the species of *Sapromyces* in other essential points. Its antheridial branch "présente presque invariablement, au-dessous de l'anthéridie, un tour de spire, sorte de boucle incomplètement formée. Ce fait ne se présente que dans cette espèce, et il est très constant."⁸ And further, "Dans le *Rhipidium elongatum* l'anthéridie a une forme spéciale; elle est oblongue, courbe, et porte à son extrémité un bec recourbé: c'est par ce bec seulement qu'elle touche à l'oogone."⁹ Again "le point où se fixe l'anthéridie semble assez constant: c'est vers le sommet chez *R. elongatum*."¹⁰ Lastly "le prolongement" (from the antheridium) "repousse la paroi de l'oogone, et finit par la perforer comme par suite d'une pression considérable (*Rhipidium elongatum*)."¹¹

If now we examine the characters of the genus described below as *Araiospora*, it is apparent that it represents a transitional form between *Rhipidium* on the one hand and *Sapromyces* on the other. In general habit it resembles *Rhipidium* from the fact that its basal cell, unlike that of *Sapromyces*, is very greatly enlarged; although it is evidently a mere modification of a segment like those of the branches, which, as we have seen, is not the case in *Rhipidium*; while its type of branching and the form of its ordinary sporangia correspond exactly to those of *Sapromyces*. The oogonia, however, as

⁸ Cornu, Monograph 29, note.

⁹ op. cit. 31.

¹⁰ op. cit. 30.

¹¹ op. cit. 40.

well as the antheridia, resemble those of *Rhipidium*, being spherical, without encrustation, and containing an abundant peripheral protoplasm. The antheridia, also, are exactly like those of *Rhipidium*, and apply themselves to the oogonium in the same position and in the same way; perforating the wall without indentation. On the other hand the genus differs from either of the other two in possessing two kinds of sporangia, one of which is identical with the type found in *Sapromyces*, as has been already mentioned, the other quite different in shape and furnished with numerous prominent spines; while the oospore is unique from the fact that it becomes surrounded by a cellular envelop derived from the peripheral protoplasm. The antheridial filaments, moreover, arise from special segments which are always derived from the same segment that produces the oogonia which they fertilize, and grow downward to the base of the latter, often producing one or more branches, each terminated by an antheridium.

In view of the presence of spinose sporangia borne more or less umbellately, it seems not improbable that the fungus just described may be very properly considered, at least provisionally, as generically identical with *Rhipidium spinosum*; since all we know of this species from the figures given by Cornu is that the sporangia may be oval to oblong and spinose,¹² or piriform and unarmed,¹³ and that they may be sub-umbellately borne.¹⁴

In view of the various distinctions above enumerated, a provisional summary of the members of the Leptomitaceæ may be indicated as follows; the group being separated as a distinct family in accord with the classification adopted by Schroeter in his revision of the Phycomycetes.¹⁵ It may be said, however, that should the family be united with any other, it must evidently be with the Pythiaceæ, if we recognize them as distinct from the Peronosporaceæ, or with the latter if we do not; since their reproductive processes coincide with those of the two last mentioned families rather than with those of the Saprolegniaceæ. It will be observed that in the following synopsis, *Gonapodya* has been retained in the family, where, in the writer's opinion, it may be provisionally placed

¹² op cit. pl. 5. figs. 4 and 9.

¹³ l. c. figs. 1 and 2.

¹⁴ l. c. fig. 6.

¹⁵ Engler und Prantl, Naturl. Pflanzenfam. 93: 101. [Th. I. Abth. 1.]

until we have more definite information by means of which its true position may be finally determined; and also that the form described by Humphrey as *Apodachlya completa* has been omitted, in view of the fact that the non-sexual reproduction of this remarkable plant was not observed and that the nature of the sexual process described must remain a matter of great uncertainty until further observations can be made upon it.

LEPTOMITACEÆ.—Filaments segmented through the presence of successive constrictions. Oogonia containing a single oosphere surrounded by periplasm.

?**GONAPODYA.**—Typical segments short and broad. Sporangia pod-shaped, successively several times proliferous. Zoospores 1-ciliate (always?).

Two species: *G. siliquaeformis* (Reinsch) Thax., Europe and America; *G. polymorpha* Thax., America.

LEPTOMITUS.—Filaments slender branched, the segments long cylindrical. Non-sexual reproduction effected by the conversion of a terminal or of several superposed segments into zoosporangia which are but slightly if at all differentiated. Oospores unknown.

One species: *L. lacteus* Ag., Europe and America.

APODACHLYA.—Filaments simple or sparingly branched. Sporangia terminal, or originally terminal, becoming apparently lateral through the sympodial branching of the segments which bear them, broadly oval or piriform and distinctly differentiated from the segments. Zoospores becoming encysted, as in *Achlya*, immediately after their exit from the sporangium (always?), diplanetic. Oospores unknown.

Two species: *A. pirifera* Zopf, and *A. brachynema* (Hild.) Prings. (probably synonymous), America (Thaxter) and Europe.

RHIPIDIUM.—Plant consisting of a monstrosly developed basal cell distinct in character from the segments of the numerous filaments to which it gives rise, distally expanded and either simple lobed or branched. The filaments apparently simple, but monopodially branched below the originally terminal sporangia. Zoosporangia for the most part solitary, broadly oval, the zoospores biciliate, composed wholly of coarse refractive granules, emerging from the sporangia in a cylindrical mass surrounded by a thin membrane and surmounted by the papilla of dehiscence; monoplanetic, swarm-

ing as soon as freed by the rupture of the surrounding membrane. Androgynous or heterogynous, the oogonia spherical, containing a thick-walled oospore. The antheridia small, applied to the oogonium near its base, the pollinodium perforating the wall without indenting it.

Three species: *R. interruptum* Cornu, *R. continuum* Cornu, Europe; *R. Americanum*, nov. sp. America.

Araiospora, nov. gen.—Plant consisting of a greatly enlarged basal cell attached by rhizoids from its base, and similar in character to the segments of the filaments which arise often in considerable numbers from its distal extremity. Filaments repeatedly umbellately branched, cylindrical or nearly so. Zoosporangia arising from the distal end of the segments in whorls or umbels of two kinds, the one smooth, the other differently shaped and furnished with prominent spines. Zoospores finely granular, biciliate, monoplanetic, emerging in a mass at first surrounded by a thin membrane which ruptures almost immediately. Oogonia in whorls or umbels, often associated with the zoosporangia, spherical, separated from the segment, like the zoosporangia, by a constriction. Oospores solitary, thick-walled, surrounded by a cellular envelop derived from the periplasm. Antheridial branches arising from special segments, simple or branched, the small rounded antheridia applying themselves close to the base of the oogonium.

Two species: *A. pulchra*, nov. sp., America; (?) *A. spinosa* (Cornu), Europe.

SAPROMYCES.—Plant arising from a basal cell attached by rhizoids from its base and resembling in all respects the segments of the filaments which arise in small numbers from its apex. Filaments as in *Araiospora*. Zoosporangia rather elongate, sub-cylindrical or broadly clavate. Zoospores as in *Araiospora*. Oogonia borne in whorls or umbels, piriform, often encrusted. Oospores solitary, thick-walled. Androgynous or heterogynous, the antheridial filaments arising distally from the segments, the portion immediately below the antheridium twisted on itself. Antheridium long oblong, curved, applying itself to the apex of the oogonium by means of a beak-like process by which the wall of the latter is indented before perforation.

Three species: *S. Reinschii* (Schroeter) Fritsch, America and Europe; *S. androgynus*, nov. sp., America; *S. elongatus* (Cornu), Europe.

The new species above alluded to may be characterized as follows:

Rhipidium americanum, nov. sp.—*Plate XXI, figs. 1-15.*

Basal cell very variable in form and size, attached by copious rhizoids; above more or less regularly one or more times successively dichotomously branched or lobed, the lobes or branches erect or spreading in a radiate fashion, the upper or external edges giving rise to numerous filaments from which they are distinguished by the characteristic constrictions. The filaments continuous or less frequently consisting of two or three sub-clavate segments. Sporangia typically ovoid tapering from the broad base to the bluntly rounded apex, but varying greatly in form, erect, originally terminal, one to four succeeding one another on a single filament; rarely two or three borne together terminally. Oogonia terminal, spherical, the thick-walled oospore colorless, the exospore elevated in a series of anastomosing ridges which give the spore an irregularly stellate outline. Antheridial filaments short, slender, arising immediately beneath the oogonium from the same segment; the antheridium small, rounded, applied close to the base of the oogonium. Basal cell 75 to 400μ long. Filaments 50 to 800μ long, seldom longer. Sporangia 30×20 to $86 \times 27\mu$, average $50 \times 35\mu$. Oogonia $40-55\mu$. Oospores $30-45\mu$ in diameter.

On various decaying vegetable substances in ponds and ditches, vicinity of Cambridge, Mass., and of Kittery Point, Maine.

This species is by no means uncommon in the localities mentioned and may be obtained throughout the season from April to September, though more abundant in the late spring and early summer. It is remarkably variable and were it not that intermediate forms showed every imaginable gradation between such extremes as are represented in figs. 2 and 3 it would not be difficult to separate it into at least two species. The differences in habit as well as in the form of the sporangia seem largely due to the surroundings under which the individual has developed, and the nutritive character of the substratum on which it grows. On sour green apples for example one almost always obtains the form represented in fig. 3 and it is only in such rather depauperate specimens that I have observed the occurrence of more than one terminal sporangium. Such forms are also much more likely to pro-

duce oospores, and their zoosporangia are also subject to the greatest amount of variation both in form and in size.

Like *Blastocladia*, with which it is very often associated, it usually grows under rather unfavorable conditions, being surrounded by a mass of bacteria and other foreign organisms and under these circumstances it is apt to assume abnormal and irregular forms. Under such conditions the discharge of the zoospores, which is in any case a very rapid process, is usually not accomplished in the characteristic fashion above described, through the rupture of the inner membrane at the moment of dehiscence. The filaments are far more commonly unsegmented, and each sympodial branch is as a rule distinctly clavate in form, tapering towards its point of origin just below the sporangium. The oogonia in all observed instances have been terminal and as a rule are formed after the production of zoospores has begun to cease. The species is more closely allied to *R. continuum* than to *R. interruptum* and may prove identical with it when the former has been intelligibly described. The dichotomous branching of its basal cell, and its androgynous character as well as its very short antheridial filaments serve to distinguish it in the absence of further knowledge of the European form.

***Araiospora pulchra*, nov. sp.**—*Plate XXIII, figs. 20-25.*

Basal cell variably developed, usually large, sub-cylindrical, the ramiferous extremity sub-conical, bearing often numerous (forty or less) acropleurogenous branches in a more or less distinctly umbellate fashion and separated from it by the usual constrictions. The branches composed of more or less cylindrical segments and repeatedly umbellately branched, the segments sub-cylindrical becoming more slender and usually longer as they succeed one another. Sporangia borne in whorls or umbels, sub-cylindrical or broadly clavate, and smooth; or broadly oval to piriform and furnished with large spines radiating in all directions but sometimes short and stout and confined to the distal extremity. Oogonia borne like the sporangia, the constricted portion which separates them from the segment very short. Oospore spherical, the thick wall colorless, surrounded by a single layer of more or less hexagonal peripheral cells derived from the periplasm. Basal cell 1 to 1.5^{mm} long by 50-25 μ . Filaments 2750-275 μ long. Sporangia 120 \times 30-175 \times 35 μ average 125 \times 30 μ . The spinose forms about 45-60 \times 48-70 μ the spines 10-35 μ long.

Oogonia $50-60\mu$. Oospores $35-45\mu$. Peripheral cells about $7 \times 10\mu$.

On submerged sticks in ponds and ditches, vicinity of Cambridge, Mass., and of Kittery Point, Maine.

This strikingly beautiful form is very common in the vicinity of Cambridge and may be found in abundance at almost any time during the late spring and summer. It is subject to considerable variation as regards the relative development of the basal cell and of the filaments arising from it. In some cases the latter are branched not more than once or twice as is represented in fig. 20, and in such instances the oogonia greatly outnumber the sporangia. In other cases the filaments are far more highly developed being many times successively branched, the branches growing more slender and usually longer as they are successively formed, and bearing many more zoosporangia than oogonia. It is in such individuals that the spinose sporangia most frequently occur and often greatly outnumber these of the ordinary type. The cellular envelop of the oospores remains about them after the oogonium wall has disappeared, and may be seen to consist of distinct cells. The latter are slightly inflated and the wall of the oospore follows the contour of their inner margins. The species seems to differ from the *Rhipidium spinosum* of Cornu from the different shape of its sporangia and from the fact that in the spinose form the spines are radiate and not directed "en haut ou en bas."¹⁵ Nevertheless the species, like the *Rhipidium* just described, may yet prove synonymous with the European form.

Sapromyces androgynus, nov. sp.—Plate XXII, figs. 16-19.

Like *S. Reinschii* though somewhat smaller. The oogonia piriform, sometimes encrusted by a blackish scaly deposit. Oospores spherical, the thick colorless wall more or less modified by the presence of elevations which sometimes give it a roughly undulate outline. Antheridial branches arising close to the base of the oogonium from the same segment, a spiral twist usually present below the antheridium which applies itself to the apex of the oogonium and is similar in form to that of *S. Reinschii*. Total length $500-1000\mu$. Zoosporangia about $75 \times 26\mu$. Oogonia $27-30 \times 35-50\mu$. Oospores $20-26\mu$.

¹⁵ Cornu, Monograph 15.

On submerged sticks in ponds and ditches, vicinity of Cambridge, Mass.

This species is not uncommon about Cambridge, but I have never found it growing in any very great abundance. It almost invariably produces oospores and its androgynous character is constant. It differs from *S. Reinschii* in its smaller habit, in the modification of its exospore, which, however, is not always very pronounced, and especially in the origin of its antheridial branch which in the last mentioned species always arises at a distance from the oogonium, a fact that has been established by the examination of abundant material collected about Kittery Point.

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EXPLANATION OF PLATES XXI-XXIII.

Rhipidium americanum Thaxter.

- Fig. 1. General habit of a more typical plant, the basal cell dichotomously thrice-lobed, the filaments showing occasional segmentation.
- Fig. 2. General habit of a much branched specimen bearing both oogonia and zoosporangia.
- Fig. 3. A radiately branched depauperate plant seen from above, the zoosporangia not yet mature.
- Fig. 4. Lobe of a depauperate plant with mature filaments.
- Fig. 5. Portion of the margin of the lobe of a basal cell showing the origin of several filaments and the whole of a single filament bearing three sporangia, two of them empty.
- Fig. 6. Zoosporangium of typical form.
- Fig. 7. Zoosporangium of typical form in which the zoospores and the papilla of dehiscence have been formed.
- Fig. 8. Sporangium killed at the moment of dehiscence. Showing a portion of the spore mass extruded, surrounded by its envelop and terminated by the papilla of dehiscence.
- Fig. 9. Dehiscent sporangium just before the rupture of the envelop surrounding the spore mass which is still terminated by the papilla of dehiscence.
- Fig. 10. The same a moment later. The envelop has broken at the right allowing the zoospores to escape. The papilla of dehiscence is still attached to the envelop.
- Fig. 11. Zoospores, the lowest in dorsal view.
- Fig. 12. Oogonium, the periplasm in process of forming the exospore.
- Fig. 13. Mature oospore in oogonium, the former seen in surface view.
- Fig. 14. Mature oospore in oogonium, seen in optical section.
- Fig. 15. An abnormal form of sporangium common in depauperate individuals.

Sapromyces androgynus Thaxter.

Fig. 16. General habit of a small plant bearing both oogonia and zoosporangia.

Fig. 17. Group of zoosporangia, two of them empty.

Fig. 18. Oogonium during fertilization, before the antheridial filament has become twisted.

Fig. 19. Group of two oogonia with mature oospores and twisted antheridial filaments.

Araiospora pulchra Thaxter.

Fig. 20. General habit of an oosporiferous plant of medium size.

Fig. 21. Terminal portion of a basal cell bearing several filaments with oogonia and both varieties of zoosporangia.

Fig. 22. Two sporangia, producing zoosporangia similar to the spinose type, in which the spines are absent or undeveloped.

Fig. 23. Segment bearing two typical spinose sporangia and one of the ordinary form, one of the spinose form emitting its zoospores and shown in optical section.

Fig. 24. Segment bearing an antheridial segment and two oogonia, one seen in optical section, the other represented in surface view.

Fig. 25. Portion of segment bearing an antheridial segment and an oogonium in which the peripheral cells are in process of formation.

*** NOTE. The figures are photo-lithographed from ink drawings and reduced about one-third from the originals. The approximate magnifications in diameters are as follows: Figs. 1 to 3, $\times 50$. Figs. 4, 16, 20, 21, $\times 90$. Figs. 5, 22 to 24, $\times 240$. Figs. 6 to 15, 17, 18, $\times 320$. Fig. 25, $\times 925$.



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