SEVERAL ADDITIONAL PHYCOMYCETES SUBSISTING ON NEMATODES AND AMOEBAE

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(WITH 4 FIGURES)

THE NEMATODE-CAPTURING PHYCOMYCETE WITH PYTHIUM-LIKE CHLAMYDOSPORES

In a brief summary published 12 years ago (**7**: p. 269, *fig. 15C, 15D;* p. 270, lines 7–19) a fungus was recorded that had been found capturing nematodes by means of adhesive material secreted by its unseptate hyphae; the same hyphae later giving rise to globose chlamydospores which with respect to their frequently intercalary position as well as with respect to size and shape strongly resembled the chlamydospores or sporangia of many species of *Pythium*, including the several species so widely familiar in causation of damping-off. The fungus soon afterwards was discussed in regard to its manner of capturing prey (**8**: p. 142, 143), and subsequently (**11**: p. 211) was mentioned as appearing, from similarities of mycelium and predaceous habit, closely related to the conidial phycomycete I then described as *Stylopage hadra*. Its resemblance in vegetative development and predaceous habit to both *S. hadra* and *S. leiohypha* Drechsl. (**12**) was pointed out in a more recent paper (**19**: 248–249) where also

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its manner of reproduction was brought into the family Zoopaga-
ceae through the erection of an additional genus, *Cystopage*,
on an apparently closely related nematode-capturing form, *C.
lateralis* Drechsl., whose consistently lateral chlamydospores
differ rather markedly from those of any familiar oomycetous
species. Still lacking a binomial, the *Pythium*-like fungus of
more ambiguous morphology could be mentioned in a recent
review only as an unnamed phycomycete (**21**: p. 276, 290). In
supplying a name, now rather belatedly, occasion is taken to
amplify the meager characterization previously given.

The fungus appears to be abundant on decaying vegetable
materials in the region adjacent to Washington, D. C.; its de-
velopment having been noted year after year in Petri plates of
soft maizemeal agar planted with leaf mold or discolored roots
collected near Beltsville, Md., in Arlington, Va., and near Fair-
fax, Va. Since it has come to light especially often in cultures
prepared during the months of April, September, and October,
from freshly collected materials, there is reason to presume that
in nature, as in the laboratory, it flourishes best under cool,
somewhat wet conditions, and that at the higher temperatures
of summer its activity declines earlier than the activity, in
general, of the nematode-capturing hyphomycetes. Its hyphae,
like those of other fungi of similar biological habit, do not grow
out from plantings of decaying material into an underlying agar
substratum until eelworms have multiplied and are infesting the
culture in some number. Once they have made their appearance
they extend themselves sparsely through the culture, the indi-
vidual filaments pursuing courses, which if less conspicuously
straightforward than those of *Cystopage lateralis*, are yet little
given to pronounced deviation. As soon as they have begun
pushing their way into the transparent agar, the hyphae can be
observed capturing the eelworms whose presence apparently
evoked their development. Before long, where suitable prey, as,
for example, *Plectus parvus* Bastian, abounds, enormous numbers
of animals may often be seen vainly struggling to escape, or
following their disablement, undergoing expropriation of their
contents (FIG. 1, *A–E*). Capture is effected, as in *C. lateralis*,
Stylopage hadra, and *S. leiohypha*, through adhesion to glutinous

material which when freshly secreted appears clear and virtually colorless but later becomes golden yellow; the change in respect to coloration being accompanied by a change from a softly plastic to a firm consistency.   As in the other three nematode-capturing zoopagaceous forms and, for that matter, as also in the many nematode-capturing hyphomycetes that utilize adhesive material, the localized masses of sticky secretion can be seen only after an eelworm has been taken, and then only on the portions of hypha that are, or have been, in contact with the animal.   From such experience as has been gained so far neither the present fungus nor any other fungus specially adapted for capture of nematodes would seem to secrete beforehand adhesive material in masses visible to ordinary microscopical inspection; though, as was intimated earlier (8), the violent withdrawal of eelworms when brushing against the predaceous networks or the stalked knob-cells of various nematode-capturing hyphomycetes suggests that some modification of the hyphal surface, vividly perceptible to animals threatened by it, may be present even when the microscope fails to reveal any cause for alarmed behavior.   It is true that *Arthrobotrys entomopaga* Drechsl. (22), which now and then captures nematodes in some number, secretes adhesive material copiously beforehand, but there can be no question that the predaceous apparatus of this hyphomycete is primarily adapted for capture of springtails; so that the closer analogy to the trapping devices of the sundews or more especially of the carnivorous phanerogamic genera *Byblis* and *Drosophyllum* may be held to reflect the rather different requirements for capturing insect prey.

While many captured nematodes are fastened to a mycelial filament in only a single place (FIG. 1, *A*, *B*, *C*, *E*), some are fastened in 2 places (FIG. 1, *D*), and others in no less than 3 places. In any case when the individual captive has become quiescent, presumably from exhaustion, its integument is penetrated by an infective process extended from the hypha through the cushion of adhesive material.   After the animal's protective layer has been breached, the infective process gives off several assimilative branches often hardly more than half as wide as the external filament.   These branches grow lengthwise through the fleshy interior, bringing about globulose degeneration of musculature

and organs in their advance.   The firm tissues of the oesophagus
and valve resist destruction somewhat better than the softer
parts (FIG. 1, C, D, E), but before long these likewise disintegrate.
In a short time the globuliferous degeneration products are ab-
sorbed with such completeness that nothing of the animal remains
visible except the integument, and, in male specimens, the spicula.
Thereupon the assimilative branches also become evacuated, by
movement of their protoplasmic contents backward into the
parent hypha; their empty membranes, like the host integument,
soon collapse and disappear from view, leaving only the per-
sistent lump of yellow adhesive material, together, perhaps, with
some portions of hyphal envelope, to indicate a concluded in-
stance of predaceous action.

Production of chlamydospores in Petri plate cultures often
begins about 8 or 10 days after vegetative development has be-
come noticeable, and may therefore proceed simultaneously with
vegetative development if the supply of living prey is replenished
through active multiplication of suitable nematodes; though as a
rule capture of eelworms will then have greatly diminished in
frequency.   Formation of a chlamydospore ordinarily is accom-
plished by withdrawal of protoplasmic contents from the adjacent
portions of mycelial hypha; the progressive migration of granular
material resulting in a succession of retaining walls spaced at
intervals of 5 to 50 μ (FIG. 1, F–Z).   While generally of sub-
spherical shape, the chlamydospores may in their definitive con-
dition include a short cylindrical part at either end (FIG. 1, F),
or may consist of two globose parts connected by a living portion
of outwardly unmodified hypha (FIG. 1, G, a, b).   Aside from
axial prolongations, the subspherical shape of the chlamydo-
spores is often modified in some degree by the presence of lateral
diverticulations, which frequently are found empty (FIG. 1, N, S,
T, U), yet sometimes remain filled with protoplasm (FIG. 1,
V, P).   Occasionally a chlamydospore may bear a sigillate lump
of yellow adhesive material with membranous vestiges of a cen-
trally perforating branch, or, more rarely, may bear two such
lumps (FIG. 1, I).   Manifestly these lumps are entirely similar
to those on evacuated hyphae (FIG. 1, G, H, I, S, T, U) and must
likewise be interpreted as recording the capture and destruction

of a nematode; the predaceous action, in most instances, probably having been completed, or at least well started, before the development of the chlamydospore began.

The position of the chlamydospores relative to the hyphae bearing them, while hardly to be regarded as a feature of much fundamental importance, yet provides the most convenient diagnostic character of the fungus under consideration. In *Cystopage lateralis*, the only congeneric form known to prey on nematodes, the chlamydospores are invariably formed laterally; whereas in the present species they are more often intercalary (FIG. 1, *F–W*) than lateral (FIG. 1, *X–Z*), though lateral development is apparently never absent here, and in some cultures may even become rather frequent. With the difference in relationship to the parent hypha is associated an appreciable difference in shape; the pouch-like and lobate types of chlamydospores abundant in cultures of *C. lateralis* being only rarely approximated in the present fungus. Further, the two fungi seem to differ in geographical distribution. *C. lateralis* has been found in nearly all collections of leaf mold taken from deciduous woods in northern Wisconsin, but has not been obtained from any of the more numerous collections of leaf mold and decaying roots taken from deciduous woods near Washington, D. C., during the last ten years. The present fungus, on the other hand, has been found represented as meagerly in material from Wisconsin as it has been found represented abundantly in material originating near the District of Columbia. In naming it, however, an epithet contrasting with "lateralis" appears less disadvantageous than any term that might be suggested by the meager distributional information now available.

Cystopage intercalaris sp. nov.

Mycelium sparsum; hyphis continuis, incoloratis, plerumque 3–5.5 μ crassis, saepe plus minusve recta procurrentibus, vermiculos nematoideos glutino primum incolorato mox flavo tenentibus, integumentum cujusque animalis capti perforantibus, ramulos assumentes vulgo 2–3 μ crassos intus evolventibus qui carnem exhauriunt; chlamydosporis saepius intercalaribus sed quandoque a latere hyphae mycelii oriundis, flavidis, vulgo globosis vel elongato-ellipsoideis, plerumque 18–35 μ longis, 15–30 μ crassis.
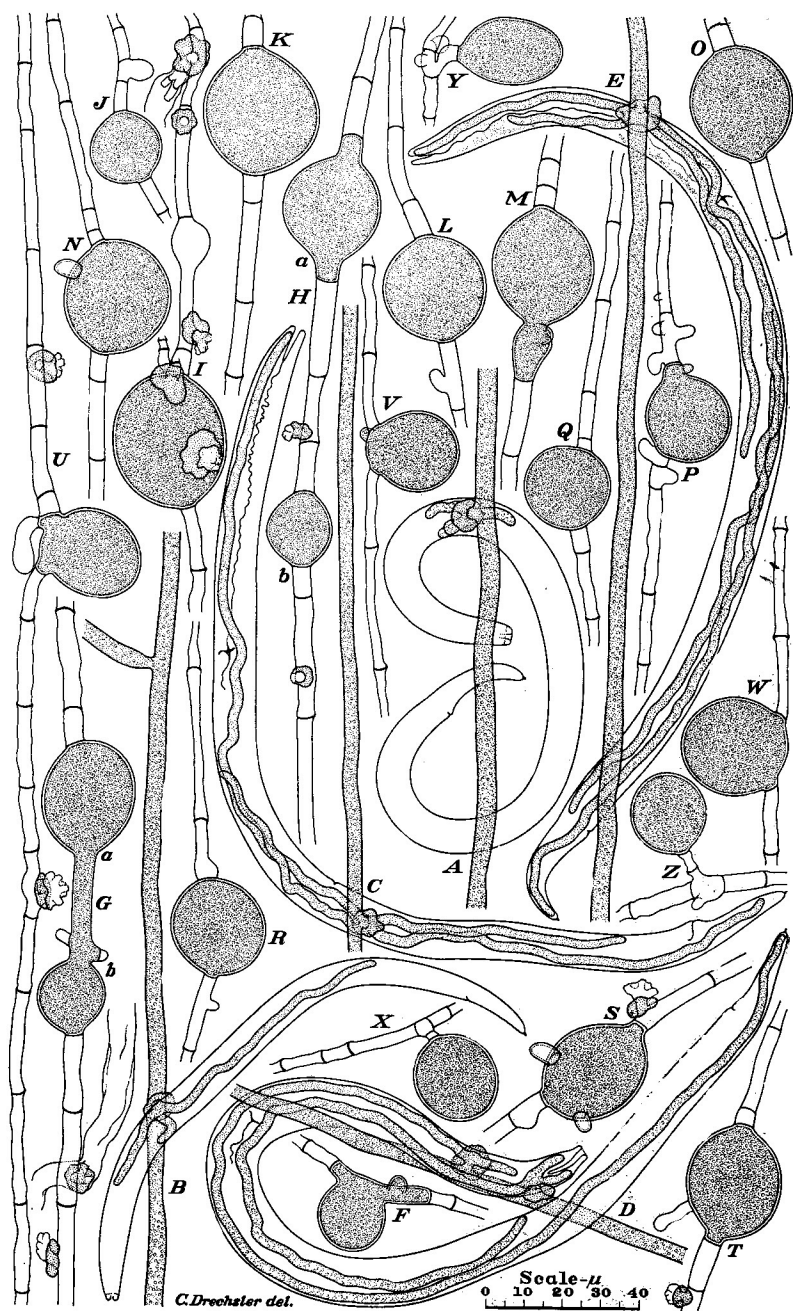
FIG. 1. *Cystopage intercalaris.*

Vermiculos nematodeos diversos usque 500 μ longos capiens consumensque habitat in humo silvestri et radicibus putrescentibus prope Beltsville, Maryland, in Arlington, Virginia, et prope Fairfax, Virginia.

Mycelium sparse; hyphae continuous, colorless, mostly 3 to 5.5 μ wide, by means of an adhesive secretion at first colorless but later becoming golden yellow capturing nematodes, then penetrating the integument of each captive with an infective branch that gives rise within to assimilative filaments, commonly 2 to 3 μ wide, which appropriate the fleshy contents. Chlamydospores usually distinctly yellowish, commonly subspherical or elongate ellipsoidal, mostly 18 to 35 μ long and 15 to 30 μ in greatest width, frequently either mesially or laterally intercalary, and somewhat less often occurring laterally either from lateral development or from development in terminal or subterminal positions in short hyphal branches.

Capturing nematodes up to 500 μ in length, referable to *Acrobeloides*, *Cephalobus*, *Plectus*, *Rhabditis*, and other genera, it occurs abundantly in leaf mold and decaying roots near Beltsville, Md., near Fairfax, Va., and in Arlington, Va.

A SEXUAL STAGE POSSIBLY BELONGING TO CYSTOPAGE INTERCALARIS

In an earlier account (**11**: p. 211, lines 11–18) I made mention of a nematode-capturing phycomycete that had been observed in its sexual reproductive stage. The fungus to which reference was made came to light early in January, 1934, in a maizemeal-agar culture planted 35 days before with several pinches of leaf mold originating from deciduous woods in Arlington, Va. Although predaceous activity had virtually come to an end, apparently because of the small number and sluggish behavior of the surviving nematodes, numerous empty integuments, many of them with an outline and with annulations suggestive of *Acrobeloides bütschlii* (DeMan) Thorne, were found attached to sigillate masses of yellow adhesive material that studded the unseptate, sparsely branched mycelial filaments (FIG. 2, *A*). Each sigillate mass showed clearly a central perforation, and often in addition, membranous vestiges of a haustorial system; wherefore it was evident that numerous eelworms had somewhat earlier been captured and depleted of their fleshy contents.

The entire mycelium of the fungus was looked over carefully
for conidiophores, conidia, and chlamydospores, but no asexual
reproductive structures could be discovered anywhere. As the
mycelial hyphae measured 2.5 to 4 μ in width, they would seem
to have been slightly coarser than those of *Stylopage leiohypha*,
and slightly more delicate than those of *S. hadra*, *Cystopage
lateralis*, or *C. intercalaris;* the dimensional difference in either
direction being, however, too small to permit, in itself, recogni-
tion of a separate species. Identity with *C. lateralis* appears
almost certainly excluded, since that form has not hitherto been
seen in cultures prepared with leaf mold from the region sur-
rounding Washington, D. C. Absence of bulbous hyphal pro-
tuberances at the places where nematodes were attached cannot
be considered to exclude possible identity with *S. hadra*, for
when developing on soft agar substrata *S. hadra* often fails to
produce such protuberances. Accordingly the predaceous my-
celium may belong to *S. hadra*, or with perhaps slightly greater
probability to either *S. leiohypha* or *C. intercalaris;* or, again, it
may represent a species whose asexual reproductive phase has as
yet not come under observation.

Its sexual reproduction, at all events, yielded zygospores in
moderate quantity. The development of these bodies occurred
only where two main mycelial filaments crossed or came close
together (FIG. 2, *A–C: a, b*). Paired zygophoric branches in-
variably arose from separate filaments; their growth taking place
with abrupt changes in direction (FIG. 2, *A*), together sometimes
with meager branching and haphazard intrication (FIG. 2, *B, c, d*).
Now and then the paired branches became more pronouncedly
intricated by winding helically about each other (FIG. 2, *C*).
After the sexual branches had united apically, the globose zygo-
sporangium sometimes grew out from near the union (FIG. 2,
B, c), but no less often it was formed on a stalk, about 5 μ long,
arising from near the union (FIG. 2, *A; B, d*); and in other in-
stances it developed laterally on one of the zygophoric branches,
as much as 15 μ below the fused tip (FIG. 2, *C*). When the
zygosporangium had attained a diameter of 14 to 16 μ, its growth
ceased, and its spherical membrane became thickened unevenly
in being transformed into a somewhat crustose, externally corru-

gated yellow envelope (FIG. 2, *D*). Directly under this envelope
the zygospore wall was then laid down as a colorless layer with
a uniform thickness of about 1 μ. The contents of the more
mature zygospores consisted in large part of coarsely and uni-
formly granular material, within which were discernible from 5
to 10 homogeneous reserve globules, mostly 2.5 to 3.5 μ in diam-
eter, together with at least one refringent body (FIG. 2, *D*).

THE SEXUAL STAGE OF COCHLONEMA PUMILUM

In a maizemeal-agar plate culture that after being permeated
with *Pythium* mycelium had been further planted with a small
quantity of leaf mold taken from deciduous woods near Fairfax,
Va., on November 10, 1942, there was observed 28 days later
some development of the small endoparasite 1 described in a
previous paper (**17**) as *Cochlonema pumilum*. The fungus sub-
sisted evidently on the same protozoan species that it had at-
tacked in the earlier material; the identity of the testaceous host
animal being especially clear since more than a few of the para-
sitized individuals measured only 20 to 25 μ in length (FIG. 3,
A, *B*), and thus shared the small dimensions noted in my earlier
account. However, most of the individual rhizopods were of
greater size, measuring commonly from 30 to 38 μ in length and
from 18 to 22 μ in width (FIG. 3, *C–M*), and therefore offered
better agreement with Wailes' (**35**) description of *Euglypha laevis*
(Ehrenb.) Perty, the species to which the host animal was re-
ferred. Despite the frequent presence of plural conidia within
them (FIG. 3, *C*), the larger infected animals, like the smaller
ones, were never seen to contain more than a single thallus; so
that the thalli here attained greater dimensions and naturally,
when asexual reproduction supervened, gave rise to correspond-
ingly more abundant conidial apparatus. Thus, in many in-
stances, 3 or 4 conidial chains, each about 500 μ long, were found
arising from near the mouth of the empty host testa; the total
number of conidia then produced being about 3 or 4 times greater
than had been observed in the earlier material where only small
animals were present.

Although the larger number of thalli in the culture expended
their protoplasmic materials entirely in giving rise to conidial

apparatus, sexual reproduction by development of zygospores was, nevertheless, rather frequent, being displayed by relatively small thalli within small animals (FIG. 3, B) as well as by the more robust thalli within the larger animals (FIG. 3, D–M). If occasionally—perhaps in one among fifteen or twenty instances—a thallus showed evidence of having given rise to some conidia before initiating development of a zygospore, it was yet much more usual for the individual thallus either to form conidial apparatus exclusively, or to devote all its contents to the production of a single zygospore. The earlier stages of sexual reproduction never came under observation, nor did the sexual apparatus whose development had begun show any further development in any of the several 8-hour periods during which it was studied under the microscope. This persistent inactivity has meaning in itself, since, in general, sexual development among the Zoopagaceae is not, as with species of *Pythium* and *Phytophthora*, for example, adversely affected by the environal conditions attending microscopic inspection, but on the contrary, is often encouraged by them. From analogy with the congeneric form I described as *Cochlonema symplocum* (19) there is reason to presume that sexual development was at a standstill during the periods of observation because of unsuitably high temperatures— 75° to 85°C.—maintained in the laboratory during working days in winter, and that it was initiated and could proceed only at the lower temperatures intervening on week-ends and during periods of unusually cold weather.

Whatever may be the environal conditions governing its development, the globose zygosporangium of *Cochlonema pumilum* is always formed in a position approximately between the two ends of the thallus. As the thallus is strongly curved, its ends are usually close together when definitive size is attained; so that from spatial necessities, the globose cell often comes to extend backward toward the fundus of the animal host (FIG. 3, D, F, L), or to lie for the most part to one side of the plane of the thallus (FIG. 3, E, J), or to jut forward toward the mouth of the animal host (FIG. 3, B). In favorable instances where a profile view is afforded of relationship between thallus and zygosporangium, a structural connection is sometimes discernible between the
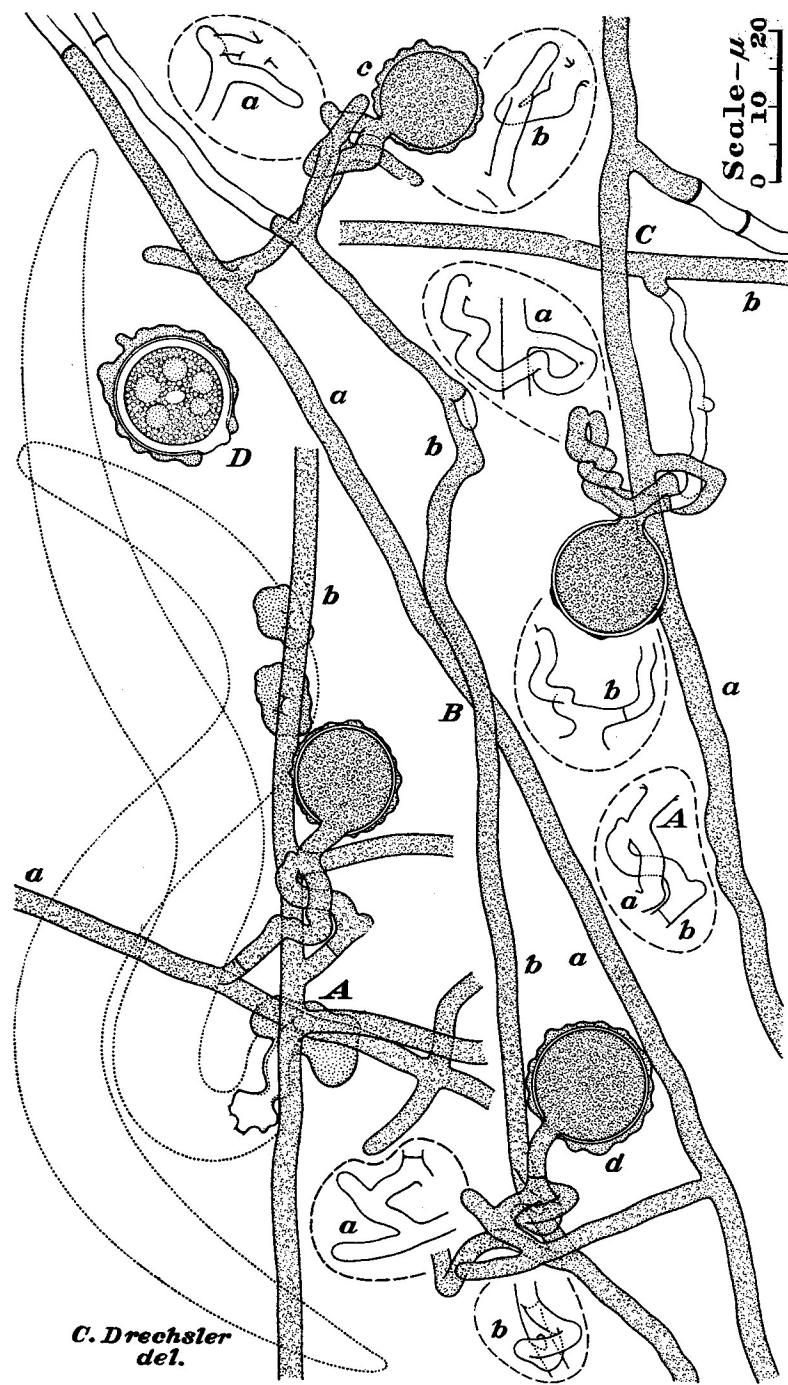
Scale—μ

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del.

Fig. 2. Sexual stage of a nematode-capturing fungus belonging
in the Zoopagaceae.

proximal end of the thallus and the zygosporangium (FIG. 3, D, K), while at other times the distal end of the thallus appears united to the zygosporangium (FIG. 3, B, F), and somewhat rarely both ends of the thallus seem joined to the zygosporangium (FIG. 3, G). Although now and then (FIG. 3, K) the zygosporangium shows such broad attachment to the thallus that hardly any modification in the thallodic extremity would need to be assumed, more often a narrowing of the thallodic extremity suggests that a short prolongation, interpretable as a zygophoric branch, must have been put forth to initiate sexual development (FIG. 3, D, E, F).

In the production of a zygospore, just as in the production of conidia, the distal portion of the thallus is always evacuated first; its membrane often being found empty and somewhat collapsed at a stage when the proximal portion is still, through increasing vacuolization, contributing its protoplasm to the growing zygosporangium (FIG. 3, E, F, G, K). Even after it has lost all its contents, the proximal part retains its original outline rather well, giving the impression that it is surrounded by a sturdier wall (FIG. 3, D, H, I, J) than the distal part. Where, as is often true, the empty thallodic envelope contains only the one partition that separates the collapsed distal part from the unshrunken proximal part (FIG. 3, B, J, L, M), the whole apparatus usually offers an appearance strongly suggestive of a developmental sequence as follows: (1) division of the thallus into two gametangia; (2) conjugation between two short zygophoric prolongations put forth, respectively, from the proximal end of the proximal gametangium and the distal end of the distal gametangium; and (3) production of a zygospore at or near the place of conjugation. As nothing has been observed directly at variance with such a developmental sequence, it is held to prevail generally in the species; though, owing mainly to optical difficulties usual in parasitized testaceous rhizopods, many specimens are so ambiguous in what they reveal that if they were considered individually other interpretations might be entertained.

Thus, in the numerous examples where the relationship of the zygosporangium to the thallus is not shown in profile, and more especially in the many examples where one or both ends of the

thallus lie concealed under the zygosporangium, double attachment of the globose body is neither visible nor directly surmisable; so that development of an azygospore rather than of a zygospore might be in progress. However, if azygospore formation were at all frequent, occasional specimens should reveal one end of the thallus to be free and clearly separated from the globose body— a condition that has not been observed so far. Then, too, where double attachment of the globose body to the thallus cannot be made out, a possibility exists that a supernumerary conidium, perhaps concealed under the globose body itself, may have taken part in the antecedent sexual union after the manner of conidia in the allied forms I have described as *Stylopage cephalote* (15) and *Acaulopage marantica* (16). If such conidium-thallus conjugation prevailed clear instances of it should now and then be discernible; but no clear instances have come to light, and although in one case the zygosporangium appeared intercalated between the thallus and an empty conidial envelope (FIG. 3, *K*), the relationship of parts found here was best explained on the assumption that the empty conidium was the spore-parent of the thallus, and that it came into its unusually distant position through the development of the zygosporangium at the juncture of its germ tube with the thallus. Again, some little ambiguity not, however, attributable to optical difficulties arises frequently in specimens where the thallus, after yielding its contents to the zygosporangium, shows two (FIG. 3, *I*) or even three (FIG. 3, *D*, *H*) transverse partitions; the plural cross-walls, of course, making for an appearance less suggestive of division into two gametangia that is offered by specimens with only one cross-wall. Since the extra partitions are manifestly laid down as retaining walls in the progressive evacuation more particularly of the longer proximal thallodic segment that presumably constitutes the proximal gametangium, they can hardly be considered to have much special significance.

Once the thallus has been completely evacuated, a thick, distinctly yellowish zygospore wall with a scalloped outer contour is laid down close under the colorless and slightly collapsed zygosporangial envelope (FIG. 3, *H*, *I*, *J*). This wall surrounds rather coarsely granular protoplasm within which, at full maturity, one

or two reserve globules and one or two smaller refringent bodies are often somewhat indistinctly discernible (FIG. 3, *B*, *L*, *M*). As only a single thallus develops within the individual animal host, and as in instances of sexual development the entire protoplasmic contents of the thallus are usually given to the single zygosporangium, it is not surprising that the dimensions of the zygosporangium and zygospore, like those of the thallus, are governed mainly by the dimensions of the infected protozoan. For a fungus which in its vegetative body, as also in its asexual reproductive structures, is rather small in comparison with allied forms, the sexual structure may be considered somewhat large—the diameter of the zygosporangium varying mostly from 9 to 15 μ, and that of the zygospore from 8 to 14 μ. The zygospore wall was found ranging from .8 to 2.2 μ in thickness, while the protoplast surrounded by it varied from 5.5 to 10 μ in diameter.

A BRANCHED COCHLONEMA PARASITIC ON A TESTACEOUS PROTOZOAN

A maizemeal-agar plate culture that after being permeated with *Pythium* mycelium had been further planted on Jan. 20, 1937, with leaf mold newly collected from deciduous woods in Arlington, Va., revealed when examined 3 months later about 50 specimens of a testaceous rhizopod from each of which ascended a few chains of cylindrical conidia generally similar to the conidial chains of *Cochlonema pumilum* and of the congeneric form I described earlier as *C. cylindricum* (**14**). Although no living specimen of the animal could be found, the well preserved testae (FIG. 3, *N*, *O*) were without much difficulty referred to *Sphenoderia dentata* Penard (**28**)—the same species, therefore, that later (**17**) was observed parasitized by my *C. fusisporum* and my *Pedilospora dactylopaga*. Within each testa was seen an empty convolved thallus differing from the thalli of *C. pumilum* and *C. cylindricum* in being consistently branched. The branching, if mainly of the dichotomous type, was much less regularly dichotomous than is usual in the genera *Cochlonema* and *Endocochlus*. In most instances a strongly curved hyphal trunk was usually recognizable, which from a position often somewhat closer to its base than to its tip gave off monopodially

a short stout branch that at once broadened into 2 lobes (FIG. 3, N) or divided dichotomously into 2 short arms. In addition, the hyphal trunk frequently bore a short stout branch near its distal end (FIG. 3, N).

The empty thalli contained usually from 2 to 4 cross-walls, which manifestly had been laid down as retaining walls during the progressive evacuation of protoplasm by way of the single reproductive filament. This filament, as in all related species, followed a somewhat irregular course through the mouth of the animal, to give rise externally to the several conidial chains whereby the presence of the parasite had been betrayed. When mounted for examination under a cover glass, the chains crumbled into their component spores. These spores (FIG. 3, P) were found to be slightly wider than those of *Cochlonema cylindricum*, and in more noticeable measure wider than the similarly cylindrical spores of *C. pumilum*.

As the fungus seems rather markedly distinguished from its two most closely related congeners by the character of its thallus, it is described under a specific name meaning "branched."

Cochlonema ozotum sp. nov.

Hyphae alitae incoloratae, saepius 40–45 μ longae, 6–7 μ crassae, axe plerumque semel convolutae, vulgo in medio et prope apicem ramis simplicibus vel bifidatis vel bifurcis praeditae, ex basi per os animalis hypham genitabilem circa 1.5 μ crassam proferentes quae 2–3 catenulas conidiorum 300–750 μ longas profert; conidiis incoloratis, cylindraceis, utrimque leviter rotundatis, vulgo 4.6–8 μ longis, 1.3–1.5 μ crassis.

Sphenoderiam dentatam interficiens habitat in humo silvestri in Arlington, Virginia.

Vegetative hyphae colorless, often 40 to 45 μ long, 6 to 7 μ wide, with respect to their main axis circularly convolved in one turn, provided with branches near the apex and also in a position nearly midway between base and apex, the branches whether simple or bifid or forked being short and stout; each vegetative hypha extending from its base and through the mouth of the animal host a colorless reproductive hypha, about 1.5 μ wide, which sends up usually 2 or 3 colorless hyphae 300 to 750 μ long to be transformed into chains of closely arranged conidia; these conidia of cylindrical shape, with slightly convexed ends, colorless, measuring mostly 4.6 to 8 μ in length and 1.3 to 1.5 μ in width.
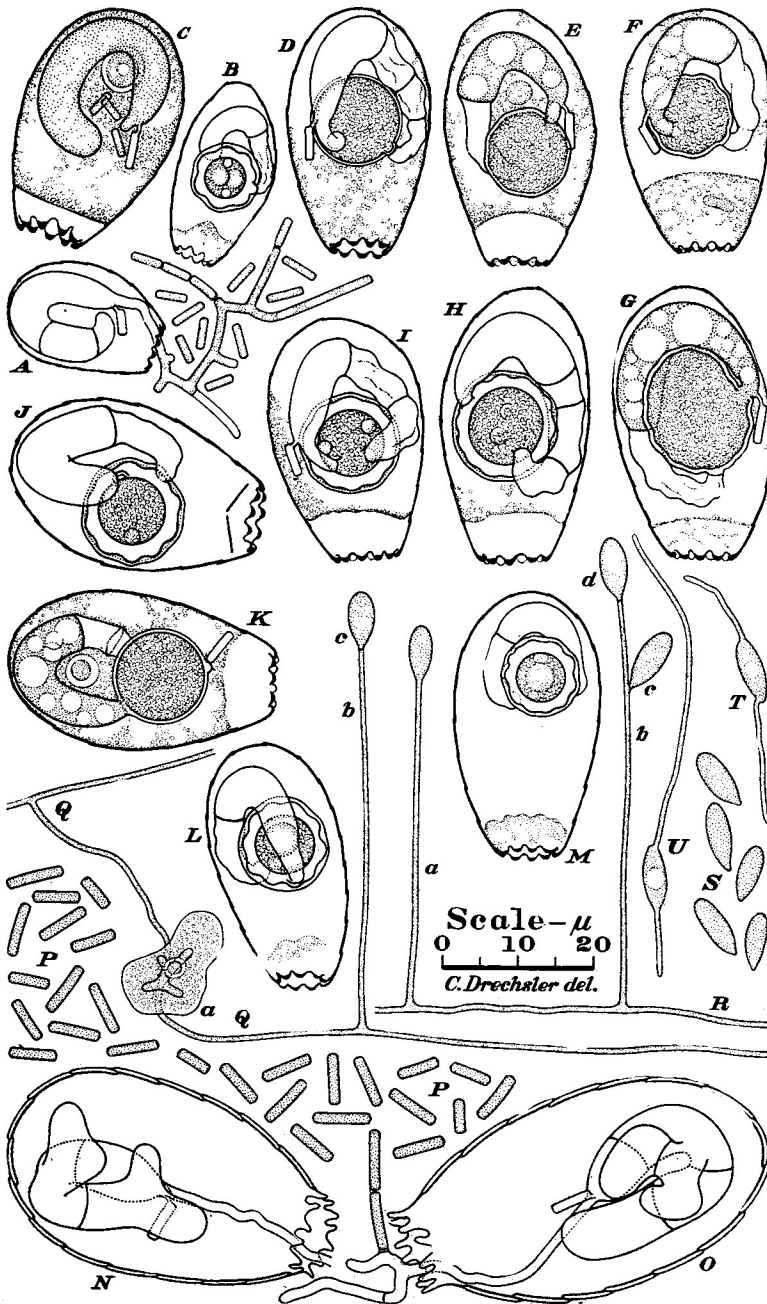
FIG. 3.   *A–M, Cochlonema pumilum; N–P, Cochlonema ozotum;*
Q–U, Stylopage minutula.

Destructive to *Sphenoderia dentata* it occurs in leaf mold in Arlington, Va.

A MINUTE SPECIES OF STYLOPAGE WITH PLUMP CONIDIA

A maizemeal-agar plate culture that after being permeated with *Pythium* mycelium had been further planted on Dec. 14, 1936, with leaf mold newly collected from deciduous woods in Arlington, Va., revealed on examination 17 days later some development of a sparse mycelium composed of very delicate hyphae (FIG. 3, *Q, R*) along which minute *Amoebae* (FIG. 3, *Q, a*) were held attached by means of yellow adhesive material. The captured animals, mostly 7 to 15 μ wide when drawn into a rounded form, contained in their colorless protoplasm a single subspherical nucleus, about 2.5 μ in diameter, wherein was visible a slightly darker globose part approximately 1.8 μ in diameter. A dichotomous haustorium with noticeably swollen, digitate assimilative branches was extended into each captive. After it had taken up the cell contents of the prey, the haustorium in turn became evacuated, through withdrawal of its protoplasm backward into the parent hypha; whereupon its empty membrane, as also the collapsed protozoan integument, soon disappeared from view.

The fungus displayed meager asexual reproduction in sending up sparsely scattered delicate conidiophores from hyphae prostrate on the substratum. These conidiophores (FIG. 3, *Q, b; R, a*) were often found bearing only a single conidium of elongate obovate shape (FIG. 3, *Q, c*), but frequently, too, after having produced one conidium they resumed growth to produce another on the new apex (FIG. 3, *R, b, c, d*). When conidia became detached (FIG. 3, *S*) and fell on the moist agar substratum, they germinated readily; in most instances they extended a delicate germ tube from each end (FIG. 3, *T, U*).

With respect to its generally minute dimensions the fungus shows close resemblance to the delicate congeneric species I described earlier as *Stylopage lepte* (10). Its conidia, however, are conspicuously shorter and broader than those of *S. lepte;* their shape being suggestive rather of *S. hadra* and *S. leiohypha.* In

comparison, more especially, with these two robust forms the fungus appears well deserving of the name here applied to it.

Stylopage minutula sp. nov.

Mycelium sparsum; hyphis sterilibus continuis, incoloratis, parce ramosis, vulgo .6–.9 μ crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intus evolventibus quod carmen exhaurit; haustorio basi semel vel bis dichotomo, ita 2–4 ramulos 1–1.3 μ crassos ferente; hyphis fertilibus continuis, erectis, incoloratis, saepe 40–60 μ altis, .6–.9 μ crassis, uno conidio genito saepe repullulantibus et aliud conidium gerentibus; conidiis incoloratis, ellipsoideis vel elongato-obovoideis, basi paulo acutis, 7.5–9 μ longis, 2.6–3.6 μ crassos.

Amoebas plerumque 7–15 μ latas capiens consumensque habitat in humo silvestri in Arlington, Virginia.

Mycelium sparse; vegetative hyphae continuous, colorless, fili-form, sparingly branched, commonly .6 to .9 μ wide, adhering to minute animals, perforating the pellicle of each captive and intruding a haustorium which bifurcates once or twice near its base to terminate in 2 to 4 short digitate assimilative branches 1 to 1.3 μ wide. Conidiophores continuous, colorless, erect, often 40 to 60 μ long and .6 to .9 μ wide, after producing a first co-nidium terminally often elongating to bear a second one; conidia unseptate, colorless, ellipsoidal or elongate obovoid, often slightly pointed at the base, commonly measuring 7.5 to 9 μ in length and 2.6 to 3.6 μ in width.

Capturing and consuming *Amoebae* mostly 7 to 15 μ wide it occurs in leaf mold in Arlington, Va.

A SPECIES OF ACAULOPAGE WITH APPENDAGED
DICHOTOMOUS CONIDIA

Several maizemeal-agar plate cultures that were started with decaying pieces of waterlily (*Nymphaea odorata* Ait. and *N. tuberosa* Paine) leaves collected near Butternut, Wis., on July 12, 1935, permitted abundant development of a zoopagaceous fungus resembling in varying degree the congeneric forms I have de-scribed under the binomials *Acaulopage macrospora*, *A. cerato-spora*, and *A. tetraceros* (10). On its sparingly branched my-celium (FIG. 4, *A–E*) *Amoebae* from 5 to 20 μ in diameter were found attached by means of yellow adhesive material. The smallest of the captured animals were seen invaded usually by a single assimilative branch, slightly narrower than the parent filament (FIG. 4, *A, a, c; B*). In animals of somewhat greater

dimensions the infective process, after penetrating the integument, would often divide into 2 assimilative branches (FIG. 4, *A*, *b*, *d*, *e*, *f*; *C*; *D*), while in the largest prey that came under observation the sarcode was permeated by a bush-like haustorium with as many as 5 branches (FIG. 4, *E*).

Thus nourished on *Amoebae*, apparently to the exclusion of other sources of food, the fungus gave rise to conidia on hyphae (FIG. 4, *F*, *G*) that seemed to be narrower and to ramify somewhat more freely than the predaceous filaments. As these hyphae often revealed distally a rather abrupt curvature, not unlike the curvature familiar in fertile hyphae of *Acaulopage tetraceros*, there was reason to suspect that the conidia formed terminally on them should normally have stood erect. However, in the presence of nematodes and mites, even the conidia whose unbranched clavate form betokened an early stage of development (FIG. 4, *F*, *G*) were mostly found prostrate on the substratum. During their later stages of growth the conidia would bifurcate distally at an angle usually approximating a right angle (FIG. 4, *H–N*); the primary bifurcation often being followed by a secondary bifurcation in one of the two divergent arms (FIG. 4, *O–R*), and occasionally by bifurcation in both arms (FIG. 4, *S*). When branching was concluded the terminal prongs, whether 2, 3, or 4 in number, were partly emptied by retraction of protoplasm, the emptied part of each prong persisting as a membranous appendage. Now and then a terminal prong, especially if undersized, retained its contents throughout (FIG. 4, *M*), but on the other hand some conidia became emptied not only distally in their prongs, but also in lesser measure, proximally through withdrawal of contents from a small conical part at the base (FIG. 4, *H*, *I*, *J*, *L*).

An epithet having reference to the characteristic branching of its conidia may serve in distinguishing the fungus from the several appendaged species most closely related to it.

Acaulopage dichotoma sp. nov.

Mycelium sparsum, hyphis sterilibus continuis, incoloratis, parce ramosis, 1.3–1.6 μ crassis, ad animalia minuta inhaerentibus, pelliculam cujusque capti perforantibus, haustorium intus evolventibus quod protoplasma exhaurit; haustorio nunc simplici nunc ad instar arbusculae ex 2–5 ramulis assumentibus
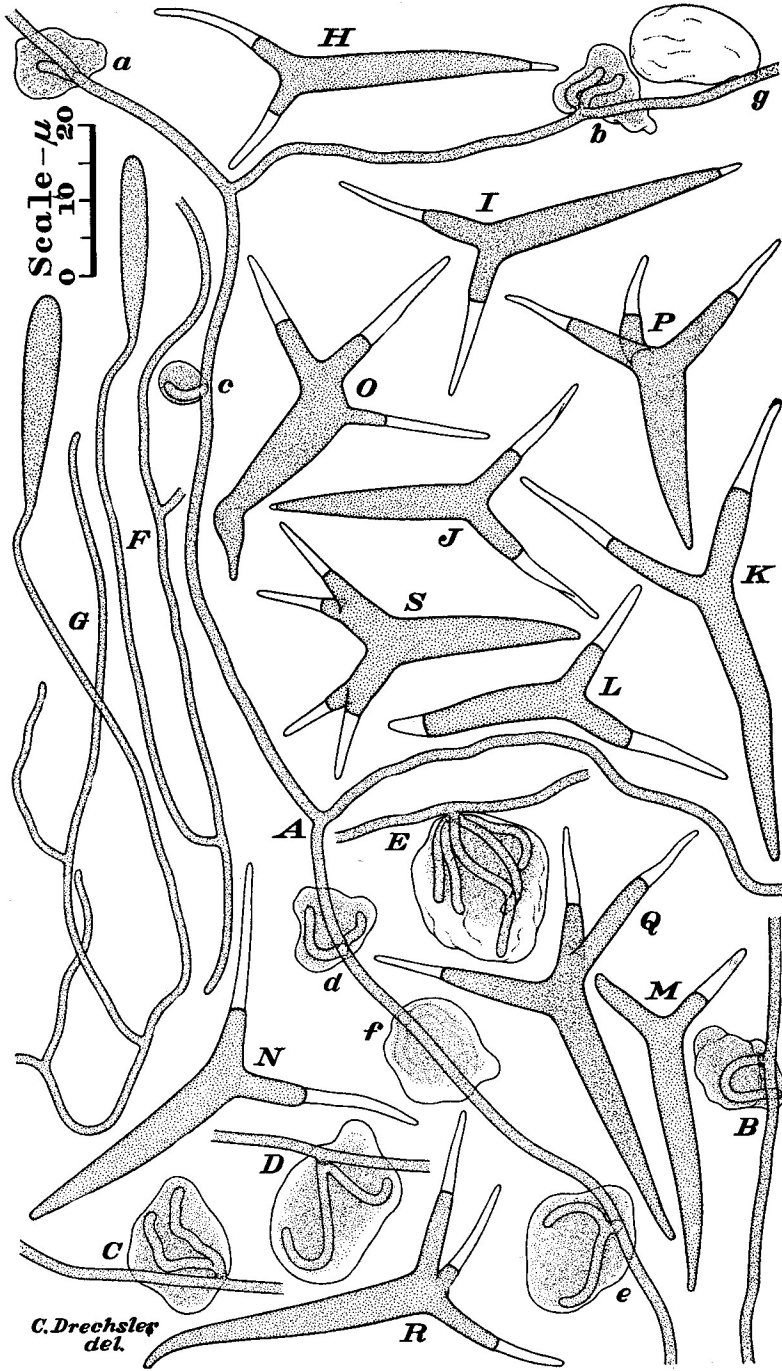
FIG. 4. *Acaulopage dichotoma.*

5–25 μ longis 1.2 μ crassis constante. Hyphae fertiles continuae, incoloratae, mediocriter ramosae, vulgo circa 1 μ crassae, apice conidia singulatim gignentes; conidiis incoloratis, plerumque semel vel bis bifurcis, itaque vulgo ypsiliformibus vel tricornibus vel quadridentibus, trunco eorum inversum conico, saepe 25–40 μ longo, sursum 4.5–7 μ crasso quandoque in parte infima 1–5 μ longa vacuo, ramis eorum cornuatis divaricatis, 10–30 μ longis, deorsum 2–5 μ crassis primum protoplasmatis omnino repletis mox in parte supera 5–20 μ longa fere inanibus.

Amoebas 5–20 μ latas capiens consumensque habitat in foliis putrescentibus Nymphaeae odoratae et Nymphaeae tuberosae prope Butternut, Wisconsin.

Mycelium sparse; vegetative hyphae continuous, colorless, sparingly branched, 1.3 to 1.6 μ wide, capturing small animals by means of yellow adhesive material, perforating the pellicle of each captive and intruding a haustorium which may consist of a simple branch or of 2 to 5 branches, 5 to 25 μ long, about 1.2 μ wide, in bush-like arrangement. Conidiophorous hyphae continuous, colorless, moderately branched, usually about 1 μ wide, producing conidia singly at the tip. Conidia colorless, mostly branched dichotomously once or twice to terminate in 2, 3, or 4 tapering divergent prongs; the main axial part of the spore obconical, often 25 to 40 μ long, 4.5 to 7 μ wide distally, sometimes empty at the base for a distance of 1 to 5 μ; the prongs mostly 10 to 30 μ long, 2 to 5 μ wide proximally, at first filled with protoplasm throughout but nearly always soon becoming empty distally for a distance of 5 to 20 μ.

Capturing and consuming *Amoebae* 5 to 20 μ wide it occurs in decaying leaves of *Nymphaea odorata* and *Nymphaea tuberosa* near Butternut, Wis.

TAXONOMIC CONSIDERATIONS RELATING MORE ESPECIALLY TO CYSTOPAGE INTERCALARIS AND ZOOPHAGUS INSIDIANS SOMMERSTORFF

Although at first sight such types of conidial apparatus as are produced by *Cochlonema ozotum* and *Stylopage minutula* look commonplace and generally insignificant, they nevertheless prove to an unusual degree adequate for taxonomic purposes once they are known to be associated with a thallus or mycelium in which cross-walls are never laid down as partitions between adjacent living vegetative cells. Unfortunately the intercalary and frequently intramatrical chlamydospores of *Cystopage intercalaris* have far less distinctiveness, since resting bodies not greatly different from them are formed in various species of Oomycetes

and Zygomycetes. In particular, as has been noted, the chlamy-
dospores of *C. intercalaris* strikingly resemble the conidia of some
widely familiar species of *Pythium*. When they are compared,
for example, with the conidia of *P. ultimum* Trow, a species
often occurring as causal agent of root rot in the same vegetable
materials as *C. intercalaris*, a close similarity is revealed with
respect to shape, to size, to manner of attachment, to texture of
the densely granular porridge-like protoplasmic contents, and to
mode of germination by production of vegetative hyphae. While
such correspondence in structural features might, by itself, have
only rather slight descriptive interest, it becomes deserving of
more attention from the fact that the rotifer-capturing *Zoopha-
gus insidians* Somm., concerning which an unusually copious
literature is available, has for the most part been treated, because
of reported similarity in zoospore development, as being either
closely related to *Pythium* (**31**) or as belonging in *Pythium* (**23**).
Under the circumstances a suspicion could naturally arise that
the chlamydospores of *C. intercalaris*, like the conidia of *P.
ultimum*, might well be homologous with the globose zoosporangia
of such species of *Pythium* as *P. Debaryanum* Hesse, and that,
consequently, the fungus producing them might perhaps belong
in the Pythiaceae rather than in the Zoopagaceae. The features
suggestive of relationship in the Pythiaceae need to be examined
in conjunction with developmental features ascribed to *S. in-
sidians* that would seem to reveal more credible homologies with
typical conidium-producing members of the Zoopagaceae.

Sommerstorff's (**29**) only observations possibly relating to re-
production of the predaceous fungus described by him were made
on a single specimen of rotifer whose unattached dead body he
found occupied by evacuated hyphae from which extended erup-
tive branches, open at the tip. Lying near this dead animal
were seen numerous empty globose cysts, about 10 μ in diameter,
and also a clustered aggregation of approximately 8 zoospore-like
amoeboid cells. After some rotational and trembling movements
these cells came to rest, rounded up, and encysted. On the
following morning only empty envelopes remained where the
cysts had been, the protoplasts evidently having escaped follow-
ing extension of a short germ tube. Sommerstorff regarded this

isolated instance of zoospore formation insufficient for any state-
ment regarding the systematic position of his fungus, and merely
ventured the opinion that since he was dealing with a phyco-
mycete of aquatic habit propagation by zoospores, as in the
Saprolegniales, was not improbable. The sequence of conditions
described by him would, indeed, seem to correspond better to
zoospore development in the Saprolegniaceae than to zoospore
development in the Pythiaceae. At all events the free unat-
tached condition of the dead rotifer appears less indicative of
destruction by a fungus given habitually to a predaceous mode
of attack than to destruction by a fungus which either is addicted
exclusively, like *Hydatinophagus Apsteinii* Valk. (**32**, **33**), to
attacking rotifers in some usual parasitic manner, or, like *Som-
merstorffia spinosa* Arn. (**2**), displays both ordinary parasitic
attack by means of zoospores and predaceous attack through
capture by means of adhesive organs. The meager persuasive-
ness of Sommerstorff's taxonomic comment was abated further
by Mirande's (**27**) report that though several times he found
similar cysts on rotifers attacked by *Zoophagus insidians*, closer
examination always showed them to represent a superadded
chytrid.

In Gicklhorn's (**24**) account *Zoophagus insidians* is set forth
as giving rise within the host animal to large sporangia, spherical
in shape or often protruding distally, each delimited at the base
by a thick septum; the sporangial contents, consisting of numer-
ous immotile individualized zoospores imbedded in slime, reach-
ing the exterior after rupture of the distal protrusion; the slime
thereupon swelling rapidly, and the zoospores escaping as later-
ally biciliate motile swarmers. From the magnification indicated
for the figures illustrating them, the zoospores would appear to
measure only about 2.5 μ in diameter. The small size of these
bodies, their very distinct individualization within the sporan-
gium, and their emission in a matrix of slime, are features
unparalleled in *Pythium;* yet Gicklhorn assigned the fungus to a
position within the Pythiaceae close to that genus. He described
a further type of asexual reproduction, wherein hyphae, 5 to 10 μ
wide, after growing out of the animal abstrict terminally a num-
ber of globose conidia, about 15 μ in diameter, which collect in a

botryose or capitate cluster, eventually to fall off and to germinate by producing individually a predaceous hypha.

The sporulation that Gicklhorn took for conidial development was interpreted by Arnaudow (3) as more probably representing zoospore production of the same type he himself found in *Zoophagus insidians* (1). In this type of zoospore production, we are told, development follows the course characteristic of *Pythium*, but after the laterally biciliate zoospores, about 10 μ wide, have come to rest and rounded up they escape from the cyst envelope and again swim about as laterally biciliate swarmers, to encyst, eventually, a second time. This iterant swarming Arnaudow regarded as diplanetism of a sort not known, as far as he could ascertain, among other fungi; wherefore he concluded that the zoosporangia in question could not belong to some other aquatic fungus, were the possibility to be considered that alien phycomycetes might occur within captured animals in the role of table companions. Now, the repetitional development which Arnaudow held to be unknown elsewhere had in fact been adequately set forth 14 years earlier in Butler's (4) original description of *P. diacarpum*. Later, quite similar development was reported as occurring also in *P. Butleri* Subr. (5), in *P. dissotocum* Drechsl. (6, 18), in *P. adhaerens* Sparrow (30), in *P. angustatum* Sparrow (30), and in *P. epigynum* Höhnk (25). The zoosporangial stage observed by Arnaudow would seem, therefore, all the more certainly referable to the Pythiaceae; but, on the other hand, this stage can no longer be held necessarily connected with *Z. insidians* on the ground that it is absent elsewhere. Increased significance might consequently be read into Arnaudow's admission that with the cultural methods he employed his demonstration of connection between the observed zoosporangia and *Z. insidians* was not to be regarded as complete (nicht als lückenlos). The uncertainty expressed in this admission was, however, strongly disclaimed by Valkanow (34) who on encountering *Z. insidians* three times in his freshwater aquaria made observations which, we are told, not only confirmed Arnaudow's description of sporangial structure but also uncovered in stained preparations a very clearly visible connection between the mycelium and the evacuation tube of the sporangium. From a conviction, apparently,

that the number of swimming stages passed through by zoospores after their individualization is here of more moment taxonomically than the condition in which the sporangial contents are discharged, Valkanow referred the fungus to a position in the Saprolegniaceae near the three *Aphanomyces*-like genera *Synchaetophagus*, *Hydatinophagus*, and *Sommerstorffia*.

Whatever doubts Arnaudow may have had concerning the realty of zoospore development in *Zoophagus insidians* assuredly did not apply to a second type of asexual reproduction described by him, wherein a mycelial filament, through terminal budding, would give rise, following repeated subapical elongation, to a succession of eelworm-shaped bodies, 260 to 300 μ long and up to 14 μ wide. These bodies he designated as gemmae, though explaining that unlike the gemmae in species of *Saprolegnia* they did not represent functionally frustrated oogonia, or frustrated sporangia, or mycelial segments delimited by cross-walls. His description of their development offers obvious correspondence more especially to conidial development in the zoopagaceous form I have described as *Stylopage rhabdospora* (13), though their reported disarticulation previous to any septation or evacuation of the slender frangible sterigmatic attachment would seem alien to all modes of conidial disjunction so far observed in known members of the Zoopagaceae. In *Z. tentaclum*, judging from Karling's (26) original description of this somewhat smaller congeneric rotifer-capturing species, elongated fusiform gemmae or conidia, unquestionably homologous to those of *Z. insidians*, are not only produced but also become disjointed after a manner familiar among the Zoopagaceae: the production of these spindle-shaped bodies, like the production, again, of conidia in *S. rhabdospora*, taking place successively at the tips of fertile hyphae given to repeated subapical prolongation; their disjunction thereupon being accomplished, much like conidial disarticulation in my *Cochlonema nematospora* (13) and my *C. megaspirema* (14), after evacuation of protoplasm from the narrow sterigmatic attachment has been followed by deposition of retaining walls at the ends of the separated protoplasts. The presence of a number of septa within the several gemmae of *Z. insidians* that were figured by Arnaudow in advanced stages of germination, makes for

further correspondence with the conidia of *S. rhabdospora*, since the latter, too, lay down retaining walls as their contents migrate progressively into elongating germ hyphae. Though containing a manifestly large mass of protoplasm newly elaborated during periods when abundant nourishment sustained high vegetative vigor, the gemmae of *Z. insidians* always gave rise to predaceous mycelia, never being found undergoing conversion into zoosporangia. This was true also of the conidia of *Z. tentaclum* whose content of protoplasm should be sufficient for fairly liberal zoospore production even if their more modest measurements— 40 to 80 μ in length and 3 to 6.5 μ in width—brings them well within the range of dimensions displayed by the conidia of known members of the Zoopagaceae. Indeed, zoosporangia were not seen in *Z. tentaclum* at all, nor, for that matter, antheridia and oogonia.

The sexual stage found by Arnaudow in *Zoophagus insidians*— its connection with the rotifer-capturing vegetative stage would seem amply attested by the predaceous spurs shown arising from the undulating sexual branches as well as from the main hyphae bearing these branches (**3**: *fig. 5*)—was considered by him to indicate relationship of the fungus in the Pythiaceae rather than in the Saprolegniaceae. However, his illustrations of the sexual stage seem rather more strongly suggestive of the Zoopagaceae than of any other family of Phycomycetes. Certainly in the Zoopagaceae it is more usual than in the Pythiaceae for the sexual branches to make contact with each other before they have become differentiated distally into conjugating organs; and much more usual, also, for these branches to fuse apically and to lay down a special cross-wall soon after they have been brought together—at a time, that is, when the materials required for the formation of a zygospore have only in small part been accumulated locally. While in some species of *Pythium*, as notably in *P. vexans* deBary, the sexual branches likewise are brought together very early, so that the oogonium and the antheridium develop in intimate contact with each other, these organs are not ordinarily delimited by cross-walls until on reaching their definitive size they contain all the protoplasmic materials destined to enter into the formation of the oospore. Again, while

in many species of *Pythium*, as, for example, in *P. ultimum*, an intercalary antheridium consisting of a segment of the oogonial hypha adjacent to the oogonium may not be distinguished outwardly from other filamentous parts, an antheridium borne terminally on a branch is nearly always distinguishable from neighboring hyphal parts by its greater width or, perhaps, by its clavate or crook-necked shape.   Now, as the sexual apparatus ascribed to *Z. insidians* is of strictly diclinous origin, all antheridia present should be of the more easily recognizable type. Yet none of the hyphal parts attached to the 3 globose bodies drawn by Arnaudow as representing nearly mature oogonia (**3**: *fig. 5, L, M, N*) show any modification marking them as antheridia of a pythiaceous fungus.   For this reason, mostly, the 3 units of sexual apparatus show less resemblance to diclinous sexual apparatus of any species of *Pythium* with which I am acquainted than to the diclinous sexual apparatus of those species in the Zoopagaceae—*Zoopage phanera* Drechsl. (**9**) and *Z. atractospora* Drechsl. (**13**) may be cited as examples—wherein the zygophoric branches become neither much swollen nor spirally intervolved, and wherein the zygosporangium develops in an intercalary position not far from the juncture of the gametangial elements.

From resemblances both in its sexual and its asexual development Arnaudow's gemma-producing fungus would seem to belong more probably in the Zoopagaceae than in the Pythiaceae or Saprolegniaceae.   Among known members of the Zoopagaceae its production of gemmae successively on repeatedly elongated submerged hyphae finds ecological parallelism in the normally submerged conidial development of my *Stylopage scoliospora* (**17**); the asexual reproductive bodies of the two species alike expressing in their unbranched unappendaged condition adaptation to a submerged mode of life, and alike offering contrast with the conidia of *Acaulopage dichotoma*, which through their branched and appendaged condition more nearly betray adaptation to a floating aquatic existence.   It must be admitted, of course, that all correspondence between the gemma-producing fungus and the Zoopagaceae would need to be regarded as illustrative of convergence, and as being wholly without taxonomic import, should

the production of gemmae described by Arnaudow prove to be unmistakably associated with zoosporangial development in one and the same fungus. The evidence hitherto given in favor of such association appears far from decisive; for Arnaudow, as has been noted, explicitly admitted some uncertainly in regard to the connection between his *Pythium*-like zoosporangia and his *Zoophagus insidians*, while Valkanow in claiming to have observed an unambiguous connection between evacuation tube and mycelium did not state that the mycelium in question also gave rise to gemmae. There is reason to suspect, certainly, that the binomial which Sommerstorff established on a purely vegetative stage has been applied by different investigators to fungi widely different in manner of reproduction and in taxonomic relationships. No diversity of application, however, can account for the curious fact that of the several investigators who from first-hand observations ventured to assign the species to the Oomycetes, the one who assigned it most unreservedly to the Pythiaceae ascribed to it a type of reproduction wholly alien to that family, whereas the one who claimed to have found its rotifer-capturing mycelium most unmistakably connected with apparatus serving in zoospore development of a type frequent in *Pythium* insisted emphatically that the species cannot correctly be referred to the Pythiaceae.

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EXPLANATION OF FIGURES

FIG. 1. *Cystopage intercalaris;* drawn to a uniform magnification with the aid of a camera lucida; × 500 throughout. *A,* Portion of mycelial hypha with a captured specimen of *Plectus parvus;* invasion of the animal has been started by the intrusion of four haustorial branches. *B,* Portion of hypha with a captured specimen of. *P. parvus* in a somewhat later stage of invasion. *C, D, E,* Portions of mycelial hyphae, each with a captured specimen of *P. parvus* that is invaded from head to tail by assimilative filaments. *F; G; H, a, b; I–Z:* Chlamydospores with adjacent portions of the hyphae bearing them; showing variations in size, in shape, and in manner of attachment of the reproductive bodies; and illustrating the distribution of septa in the empty hyphae, as well as the distribution of the perforated lumps of adhesive material that earlier had served in capture of nematodes.

FIG. 2. Sexual stage of a nematode-capturing fungus belonging in the Zoopagaceae; drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout. *A,* Two intersecting mycelial hyphae, *a* and *b,* to each of which is attached an empty integument of a nematode referable apparently to *Acrobeloides bütschlii;* the two hyphae have put forth a pair of sexual branches which after fusing apically have produced a zygosporangium on a stalk arising from a position close to their junction. *B,* Two intersecting mycelial hyphae *a* and *b,* from which have been extended two pairs of sexual branches that after fusing have given rise to the two zygosporangia *c* and *d.* *C,* Two intersecting mycelial hyphae, *a* and *b,* from which have been extended a pair of intervolved sexual branches; these branches, after fusing apically, have given rise laterally to a zygosporangium about 15 μ below their junction. *D,* A mature or nearly mature zygospore surrounded by an irregularly thickened zygosporangial envelope. (For the sake of clearness the sexual branches are further shown, in whole or in part, without stippling, in supplementary drawings enclosed by broken lines; the small letters by which they are designated in these drawings correspond to the letters designating the parent hyphae.)

FIG. 3. Drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout.

A–M, Cochlonema pumilum: *A,* Small specimen of host animal, *Euglypha levis,* within which is contained a small thallus of the parasite that has devoted all its contents to the production of conidial apparatus; a few conidia are shown, some attached, others detached. *B,* A small specimen of *E. levis* within which a mature zygospore is shown attached to the membranous envelope of the small thallus that gave rise to it. *C,* A large specimen of *E. levis* within which is contained, besides three ungerminated supernumerary conidia, a well developed thallus of the parasite. *D,* A large specimen of *E. levis,* containing a thallus whose entire contents have migrated into the globose zygosporangium. *E, F, G,* Specimens of *E. levis,* each containing a thallus from which protoplasmic materials are still migrating into an enlarging zygosporangium. *H, I, J,* Large specimens of *E. levis,* each containing a nearly mature zygospore and the empty envelope of the thallus from which it originated. *K,* A large specimen of *E. levis* within which a zygosporangium is being formed apparently in a position between the proximal end of the thallus and the empty membrane of the parent conidium. *L, M,* Large

specimens of *E. levis*, each containing a fully mature zygospore and the empty envelope of the thallus from which the zygospore originated.

N–P, Cochlonema ozotum: N, O, Two empty testae of *Sphenoderia dentata*, each containing the empty membranous envelope of a thallus whose protoplasmic contents went into the production of conidial apparatus. P, Detached conidia, showing usual variation in size and in shape.

Q–U, Stylopage minutula: Q, A mycelial hypha from which a dichotomously branched haustorium has grown into a captured amoeba, *a*; the hypha has further given rise to a conidiophore, *b*, bearing a conidium, *c*. R, Portion of mycelial hypha which has given rise to a young conidiophore, *a*, and to a somewhat older conidiophore, *b*, whereon two conidia, *c* and *d*, have been produced successively. S, Detached conidia, showing usual variation in size and in shape. T, U, Germinating conidia.

FIG. 4. *Acaulopage dichotoma;* drawn to a uniform magnification with the aid of a camera lucida; × 1000 throughout. A, Portion of mycelium to which are attached six captured amoebae, *a–g*. B–E, Portions of hyphae, to each of which is attached a captured amoeba. F, G, Portions of mycelium, each bearing a conidium in an early stage of development. H–S, Detached conidia, showing usual variations in respect to size and manner of branching, as well as in respect to number and length of the empty membranous appendages.