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SOME NON-CATENULATE CONIDIAL PHYCOMYCETES PREYING ON TERRICOLOUS AMOEBAE

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(WITH 5 TEXT FIGURES)

In a summary (3) published in 1933 were set forth briefly the morphological features of five fungi that had been found capturing and killing *Amoebae* in aging agar plate cultures started from plantings of diseased rootlets and other decaying vegetable materials. The continuous mycelium in four of the five forms (3, *figs. 2–5*) obviously characterized them as Phycomycetes, as did also the direct origin of the subspherical sexual spores through fusion of paired filaments figured for three of the species (3, *figs. 3–5*). No definite assignment of the fungi was then attempted, partly for the reason that the meager differentiation of the fusing elements, together with the extraordinarily small dimensions of the sexual apparatus, introduced serious difficulties of interpretation. Moreover, though the study of the asexual reproductive phase entailed less optical uncertainty, the conidia showed no close parallelism in structure or in manner of origin to those of any of the better known groups in the Phycomycetes, being suggestive rather of types known among the Mucedinaceae especially with respect to shape and, in two of the species, to the presence of empty appendages.

More recently the four minute non-septate predacious forms were discussed (6) as members of a new major group of Phycomycetes for which the term Zoopagaceae was suggested as being a tolerably appropriate one. The fairly unambiguous morphology of the several remarkable endoparasitic, ectoparasitic and predacious species about which more particularly the new group was integrated, furnishes now a background for a more satisfactory description of the minute *Amoeba*-capturing organisms than could have been undertaken earlier. In addition to the four taken up in the summary, an equal number of closely related predacious species that later came under observation are included for discussion. All eight are represented in their vegetative phase by an extensive mycelium on which terricolous *Amoebae,* mostly of the smaller and medium sizes, are captured through adhesion. The general biological relationship is thus broadly comparable to that described previously in the account of *Zoopage phanera* Drechsl., though the endozoic parts, instead of constituting a distinctive compact haustorium, make up a branching system only little differentiated from the mycelium generally.

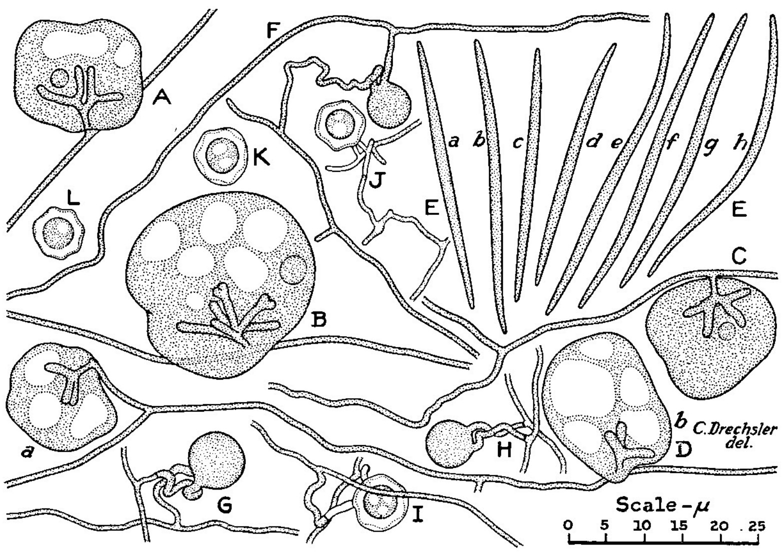

FIG. 1. *Acaulopage rhapidospora.*

If the conidia of the species herein described are hardly to be regarded as of large size in comparison with those of fungi generally, they are yet of generous dimensions when viewed in relation to the delicate mycelia and the minute sexual structures associated with them. An analogous proportionality in size obtains in the predacious *Zoopage phanera,* but not in any of the related parasites, internal or external, assigned (6) to the genera *Endocochlus, Cochlonema* and *Bdellospora,* even though the latter two genera share in the catenate development of asexual spores represented in *Zoopage.* The explanation of these size relationships lies very probably in the requirements entailed in a predacious as contrasted with a parasitic habit. A conidium designed to be ingested by its *Amoeba* host manifestly needs to be no larger than of a size just sufficient to start a new thallus. The production of a short germ tube and of a minute thallus later to be detached, exemplified in the development of the conidium of *Endocochlus asteroides* Drechsl., likewise requires only a moderate expenditure of protoplasmic substance. Nor does the proliferation of an incipient haustorium by the conidium of *Bdellospora helicoides* Drechsl., preceding the instigation of autonomous development, require any great outlay of material. On the other hand, an organism dependent for its existence on the capture of animals as minute and as slow of movement as the smaller *Amoebae,* and besides present often only in rather small number, would obviously have need from the very beginning of a fairly extensive mycelium. The interception and capture of prey under conditions at all difficult would obviously require beforehand a rangy development of germ hyphae from the substance of the conidium itself (FIG. 5, F).

Because of their dimensions and the frequency with which they make their appearance on old isolation plate cultures, the conidia of the fungi under consideration can hardly have escaped being seen by mycologists at least occasionally in the course of routine operations. That they have evoked little if any comment is very probably to be attributed in part to their mostly commonplace appearance, and in part to the difficulty of determining the manner in which they are borne. Thus, for example, the very distinctive conidia produced by the species now to be described as *Acaulopage tetraceros* have for many years put in appearance from time to time in my own cultures, but their haphazard distribution on the substratum and the absence of anything recognizable as conidiophores, uniformly gave the impression that they represented spores of some *Tetraploa*-like hyphomycetous form that had been introduced accidently and been scattered about through disturbances incident to microscopic examination. Similarly the sexual apparatus of some of the forms described herein are objects that have been long familiar to me in old isolation plate cultures, but since the hyphae supporting them become almost wholly invisible after being evacuated, they were confused with the angular cysts of

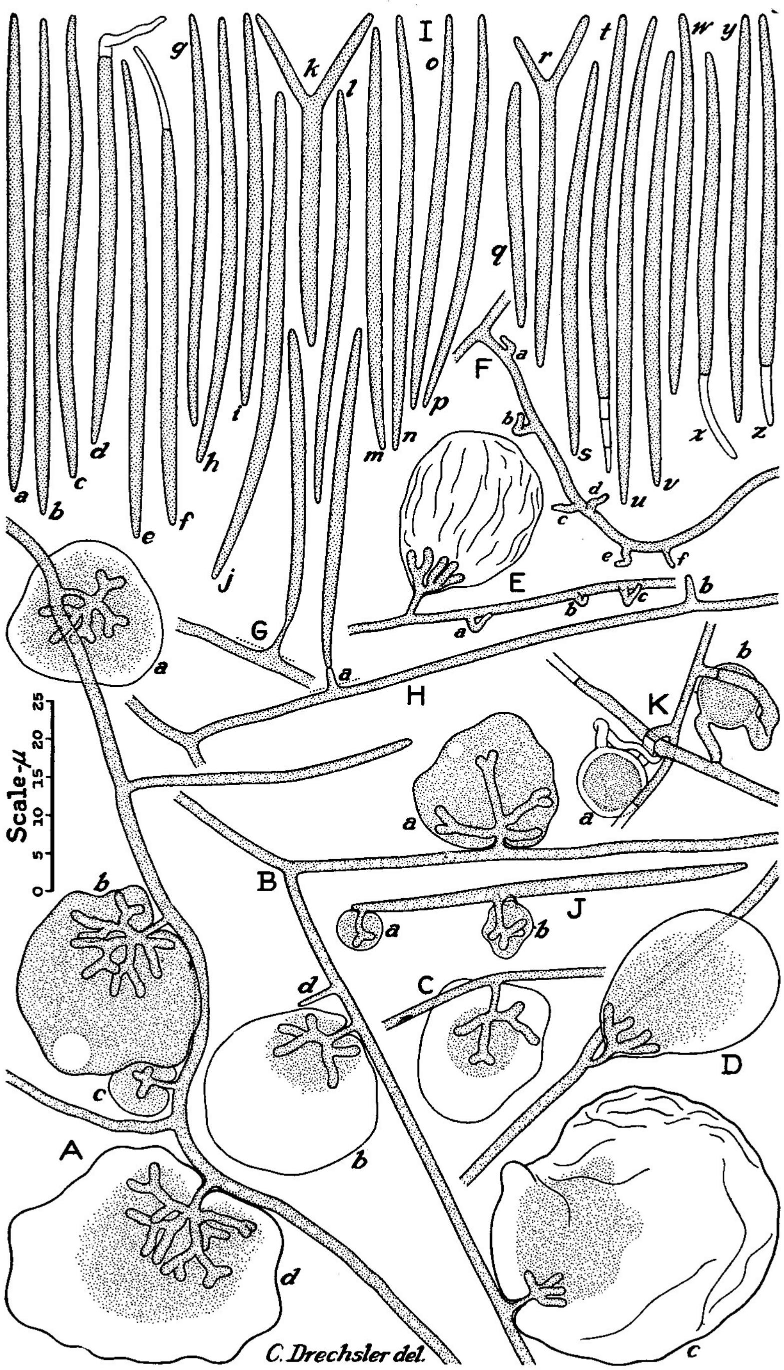

FIG. 2. *Acaulopage macrospora.*

some small protozoans habitually and abundantly present in such preparations.

Undoubtedly, too, the very fact that predacious fungi ordinarily make their appearance in an isolation plate culture only after it has been overrun by various much more luxuriant and conspicuous saprophytic forms, has helped to keep them in obscurity. This tardiness in making their appearance is due evidently not so much to the generally somewhat slow rate of growth of the fungi themselves as to the time required for conditions to arise permitting any development of them at all. Conidial apparatus is usually not produced in such quantity as might invite notice until the underlying vegetative mycelium has attained some extension. Since all members of the group are apparently entirely dependent for their nourishment on animals, extensive mycelial growth of the predacious forms can not take place until prey is present in quantity. However, an abundant supply of *Amoebae,* or for that matter, of nematodes, is usually not available until the relatively few living specimens in the piece of decaying vegetable material from which the culture was started, have multiplied for a week or two. There is evidence indicating that the animals in question feed on the bacterial slime and fungous spores present on the cultures, rather than directly on the agar substratum; so that the establishment first of a congenial fungous and bacterial flora, and then of a suitable fauna of microscopic invertebrates, needs to precede any noticeable development of predacious types. As might be expected under the circumstances, predacious forms unlike many of the common Phycomycetes, show no mycelial degeneration from contact with bacterial slime.

The character of the rapidly growing fungi first extending themselves over an agar plate, in influencing the trend of subsequent development of a subsidiary microflora, and thereby the composition of the infesting microfauna, affects greatly the abundance and identity of the predacious Phycomycetes appearing later, just as it affects greatly the abundance and identity of the predacious Hyphomycetes. Fungi with a dense dry aerial mycelium, or with sporophores in dense arrangement, as, for example, species of *Mucor, Rhizopus, Penicillium, Alternaria* or *Hormodendron,* not only give little encouragement to bacterial development, but im-

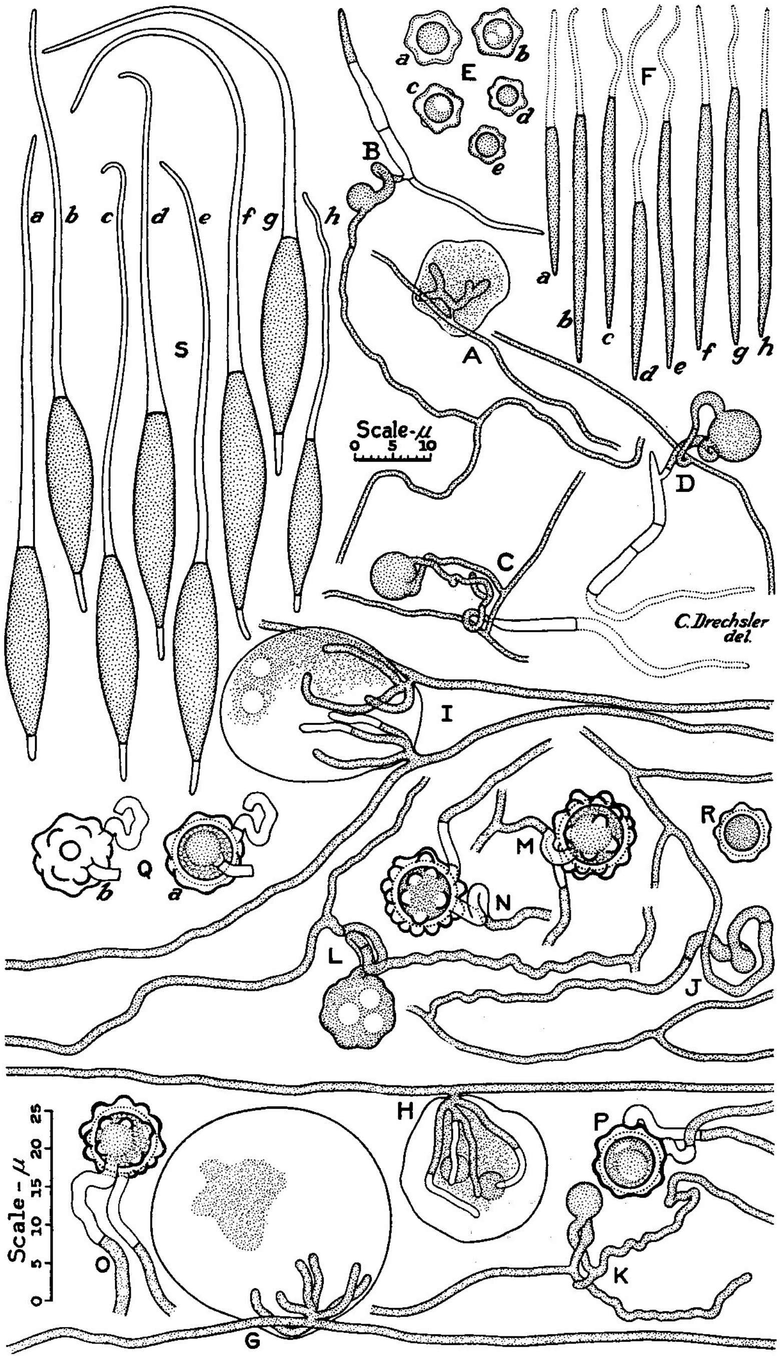

FIG. 3. A–F, *Acaulopage rhicnospora*. G–R, *Acaulopage ceratospora*.

pede physically the locomotion entailed in the feeding activities of *Amoebae* and nematodes. If fungi of such character are first to establish themselves in a Petri dish culture, prospects for the development of predacious forms like those herein discussed, are decidedly poor. On the other hand, if the culture is first occupied by various widely distributed species of *Aphanomyces* or *Pythium*, whose moist superficial mycelium is very favorable to bacterial development, and whose aerial growth soon collapses to furnish an unimpeded field for feeding, a number of predacious forms may appear in quantity.

The abundance of predacious fungi that appear in isolation plate cultures also depends greatly on the conditions attending incubation. The high temperatures prevailing during summer in Washington, D. C., are generally unfavorable, perhaps mainly because they inhibit the multiplication of infesting animals. Unless, therefore, refrigeration is resorted to neither *Amoeba*-capturing nor nema-capturing fungi are likely to be encountered often during the season in which the isolation especially of organisms causing plant diseases, is most actively carried on. Scarcely less important than temperature is the presence of moisture in available form. A hard culture medium as, for example, maizemeal agar containing over 30 grams of agar-agar to the liter, is often too firm in consistency to permit protozoans or nematodes to force their way through it; besides being sometimes so lacking in free superficial moisture that the animals may be impeded even in their movements on the surface, and perhaps also in a measure starved for want of an adequate supply of bacterial slime. Indeed, even when softer media containing 15 to 20 grams of agar-agar to the liter are employed in Petri dish cultures, *Amoebae* and nematodes and the fungi preying on them flourish much better if surface evaporation is reduced through confinement in a fairly tight container.

In view of the difficulties attending the adventitious development of predacious fungi the frequency with which they yet make their appearance in isolation plate cultures, is remarkable. Almost any bit of decaying vegetable matter that has been in contact with the moist ground for any protracted period of time, can with appropriate handling be made to yield several of them. There is good reason to believe that the fungi herein described as new, by no means constitute mycological rarities, but deserve rather to be reckoned among the more nearly ubiquitous of plants. Moreover, as the eight species were encountered altogether incidently in the course of only a few months of observation directed primarily toward other objects, it may be presumed that a purposeful search would uncover a much larger number of related forms.

In method of holding their prey the eight species show much uniformity. An *Amoeba* after capture is always to be seen attached, whether to a mycelial element, or, as is often the case in some species, to a fallen conidium, by means of a minute mass of golden yellow adhesive material. From the mycelial element or the conidium is thrust forth a narrow process which passes through the deposit of adhesive material and perforates the animal's pellicle to give rise inside to a more or less characteristically branched haustorium or haustorial system. When the protoplasmic contents of the *Amoeba* are nearing exhaustion, the protoplasm of the haustorium begins to withdraw back into the parent mycelial filament. Eventually the haustorium is completely evacuated and thereupon, like the collapsed pellicle surrounding it, becomes altogether invisible; so that an instance of capture is afterwards found recorded, and then usually only rather dubiously, in a somewhat inconspicuous scar-like or slightly protuberant modification in the contour of the hypha or conidium.

As all attempts to isolate the predacious forms under discussion have failed, it is not known whether adhesive material would be elaborated by them in pure culture, removed from the presence of *Amoebae* as well as from any physical activity simulating the movements of these protozoans. In some of the larger forms the glutinous material may often be clearly seen as minute yellow lumps directly attached to the hyphae at irregular intervals; and even more minute lumps can sometimes be made out though necessarily with greater difficulty, in examining the hyphae and conidia of the more delicate species. On several occasions while observations were being made on the struggles of a captured *Amoeba* to free itself, it was noticed that stretches of the engaged filament in either direction from the prey, on which at first no yellow lumps had been evident, bore unmistakably a number of such lumps an hour or two later. A responsiveness to environmental conditions is possibly involved here, comparable to that manifested by the predacious Hyphomycetes, all of which have so far consistently failed to produce organs of capture when grown undisturbed in pure culture.

Of living structural parts constituting in their connection with the yellow adhesive material rudimentary organs of capture, the Zygomycetes treated herein offer only a meager and somewhat questionable display. In the several species with sessile bush-like haustorial systems nothing suggestive of prehensile structures have been seen; nor would it seem readily possible that such structures could here be present. However, in species having stalked haustorial systems, short delicate processes with slightly expanded tips have been observed projecting from filaments (FIG. 2, E, F; FIG. 5, J) or from detached conidia (FIG. 5, J; 3, *fig. 4, D*). These processes correspond closely to the lateral spurs on which newly captured *Amoebae* are held (FIG. 2, A, B, D, E; 3, *fig. 4, B, C*); and would seem, therefore, to represent special prehensile structures, which after growing through the pellicles of the prey and branching dichotomously inside, come to make up the stalks of the haustorial systems. This interpretation is not necessarily contradicted by the fact that the haustorial stalk is often found wholly inserted in the captured animal (FIG. 2, C, J; 3, *figs. 3, B, D*; 5, *B*) since such positional relationship might as readily result from a captured animal engulfing a ready-formed prehensile process, as from the stalk growing into the animal after its capture. Unfortunately the adhesive material that might enable identification of the processes in question as prehensile structures beforehand is generally too minute in quantity to be discerned at all clearly. To add to the difficulties of interpretation, it happens that in species producing conidia directly on prostrate hyphae, the stumps (FIG. 2, B, *d*; H, *b*) left after disarticulation of these conidia have approximately the same dimensions as the processes presumed to function in the capture of prey (FIG. 2, E, *a–c*; F, *a–f*).

Though the apparatus of capture is in any case extremely simple, it is nevertheless decidedly efficacious in operation,—a circumstance to which the physical feebleness of *Amoebae* generally, combined with the relative firmness and durability of the pellicle recognizable more especially in the terricolous types of these animals, may contribute in no small measure. Yet the efficacy of adhesive material, unaided by any sort of structural engagement, is revealed not only in *Amoeba*-capturing members of the Zoopagaceae but also in a nematode-capturing member of the family that was figured earlier (**2**, *fig. 8, A, C*) and is now more fully discussed elsewhere (**7**) under the binomial *Stylopage hadra*. Indeed, essentially the same method of capture is known among the predacious Hyphomycetes. For although the stalked, glandular knob-cells in the nema-capturing fungus illustrated synoptically (**2**, *fig. 7, A–C*) and subsequently (**4**) identified as *Dactylella ellipsospora* Grove (**8**) (=*Monosporidium repens* Zopf (**10**), =*Monacrosporium leporium* Bubák (**1**), =*M. elegans* Rostrup (**9**) non Oudemans), as well as the sessile elongate-ellipsoidal glandular cells produced by the rhizopod-capturing *Pedilospora dactylopaga* Drechsl. (**5**), are morphologically differentiated organs, they clearly operate altogether by adhesion.

SPECIES WITH SESSILE OF NEARLY SESSILE CONIDIA

In five of the species the conidia are borne directly on the hyphae creeping on the surface of the substratum, which make up a large part of the vegetative mycelium. Apparently any superficial hyphal element is capable of giving rise to asexual spores, proximity to the air and adequate nourishment constituting the only obvious requirements for such reproduction. Each conidium develops as an erect aerial outgrowth from the parent filament. After disarticulation a basal stump remains, which, although longer in some species than in others, is in none worthy of being considered a conidiophore. The lateral attachment of the conidia to the prostrate filaments provides a partial similarity to *Endocochlus asteroides* that is sustained in the presence of terminal appendages on the conidia of some of the forms. Yet in view of the pronounced dissimilarity in morphology of the vegetative thallus, reference to *Endocochlus* seems definitely precluded. A new genus is therefore proposed under a name intended to bring into relief the absence of distinct conidiophores.

Acaulopage gen. nov.

Mycelium effusum; hyphis continuis, hyalinis, parce ramosis, materia glutinosa flavida animalia minuta tenentibus, ramo pelliculam eorum penetrantibus, tum haustorium intus evolventibus et carnem vel protoplasma exhaurientibus. Conidia aerea, incolorata, hinc illinc ex hyphis repentibus assurgentia oriunda. Zygosporangia globosa in materia subjacenti e copulatione duarum similium hypharum orta.

Mycelium spreading; hyphae continuous, hyaline, rather sparingly branched, capturing minute animals by means of yellowish adhesive material, penetrating the pellicle or integument of each by means of a lateral branch, then producing a haustorium within that exhausts the fleshy or protoplasmic contents. Conidia aerial, colorless, arising erect at intervals from prostrate hyphae. Zygosporangia globose, produced in the substratum through the union of two similar filaments.

ACAULOPAGE RHAPHIDOSPORA

Of the forms eligible for inclusion in the genus perhaps the simplest one morphologically is to be recognized in the species (FIG. 1) having acicular conidia without appendages, that was figured earlier (3, *fig. 4, A–E*). This species has been seen rather frequently on old agar plate cultures, though it well deserves to be reckoned among the most inconspicuous of organisms. It can be detected most readily by very carefully examining with a dry objective of fairly high magnification the superficial growth present in old plate cultures, especially in areas immediately surrounding the pieces of decaying vegetable material used in starting them originally. The conidia (FIG. 1, E, *a–h*) in such an examination, are to be discerned as rather sparsely distributed needle-like structures, which, projecting from the surface of the substratum nearly vertically into the air, come into view, for the most part, only endways. For a more satisfactory inspection of the conidia, and for any view of the mycelium whatever, a thin surface layer of the substratum may be sliced off with a moistened razor, carefully removed to a slide, covered with a thin cover-glass, and examined under a water-immersion or oil-immersion objective of high magnification.

In a mount thus prepared the mycelium is seen to consist of filaments (FIG. 1, A–D, F) so delicate that they are exceeded in width by many of the bacteria among which they ramify. The short elements that make up the dichotomously branched haustorium visible within many of the captured *Amoebae* (FIG. 1,

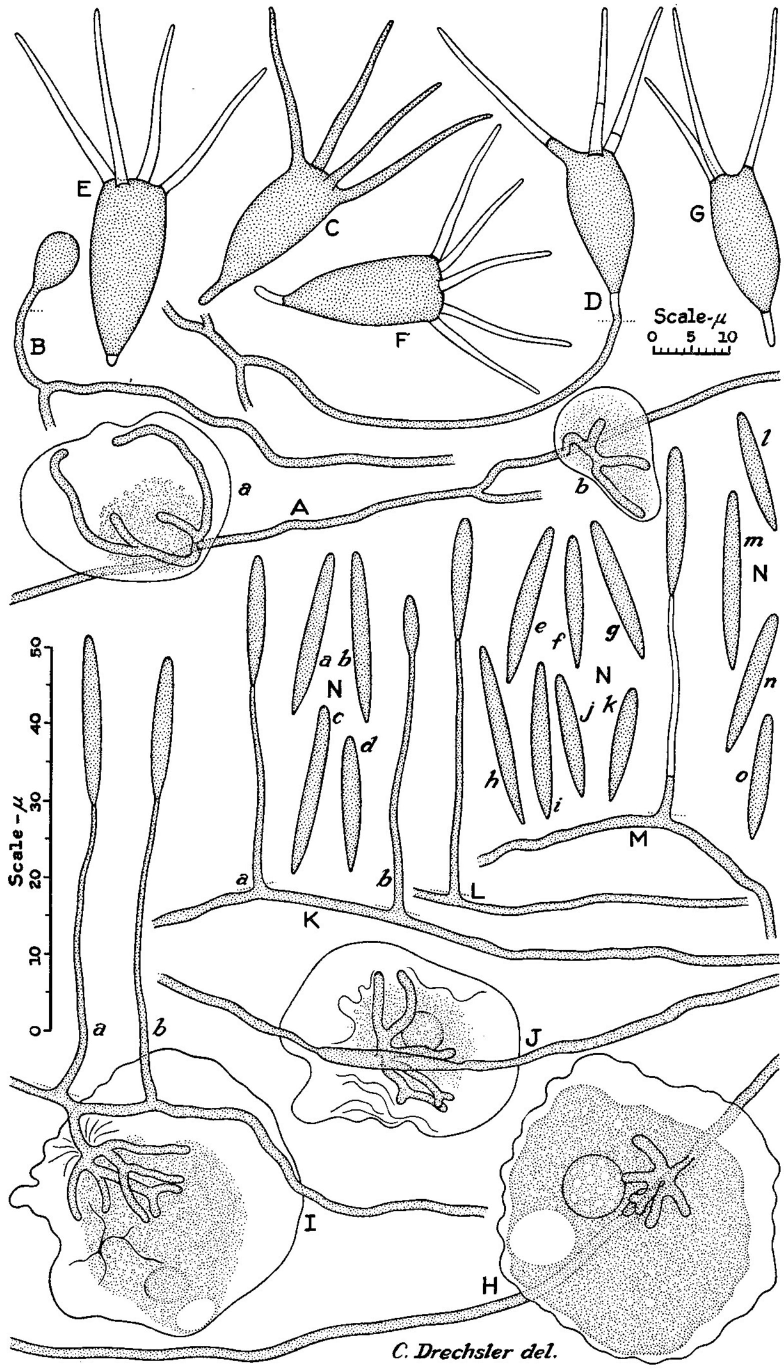

FIG. 4. A–G, *Acaulopage tetraceros*. H–N, *Stylopage haploe*.

A–D) are about twice as wide as the mycelial filaments generally. Haustoria within the larger animals are more extensive and more abundantly branched than those in the smaller ones. The *Amoebae* caught include mostly specimens ranging in diameter between 10 μ and 25 μ. In most of the larger newly captured specimens and also in some of smaller sizes, a subspherical nucleus can be made out (FIG. 1, A, C; 3, *fig. 4, B*). This nucleus together with other less definite features suggests that the usual prey consists of the smaller and the medium-sized individuals of *Amoeba sphaeronucleolus* Greeff.

Sexual apparatus is formed both on and under the surface of the substratum. Two outwardly undifferentiated hyphal branches meet, fuse at their tips, and from the place of fusion give rise to the globose zygosporangium (FIG. 1, F). A septum makes its appearance in each of the fusing hyphae, though apparently not until the zygosporangium has attained nearly its definite size (FIG. 1, G, H). It appears probable that in spite of this tardiness the delimited portions of filament are approximately homologous to the gametangia of the more familiar Zygomycetes. In any case their contents pass into the zygosporangium in much the same way as the protoplasm of gametangia generally. The zygosporangium thereupon becomes walled off as a spherical cell, and develops internally a zygospore which at maturity has a relatively thick wall with bullate protuberances. Over this sculptured zygospore the slightly relaxed zygosporangial membrane collapses, sometimes rather closely, so that an arrangement of parts very similar to the arrangement in the sexual apparatus of *Zoopage phanera* is brought about (FIG. 1, I–L).

A specific term having reference to the needle-like shape of the conidia seems appropriate for the fungus.

Acaulopage rhaphidospora sp. nov.

Sparsa; hyphis incoloratis, .6–.9 μ crassis, haustoria dichotoma ex ramulis 1–1.5 μ crassis composita evolventibus. Conidia continua, paulo acicularia, recta vel leniter curvata, 25–45 μ, saepius 30–40 μ, longa, 1.2–1.7 μ crassa. Zygosporangia primo levia, sphaeroidea, 5–7 μ diam., in maturitate membrana circa zygosporam collabente; zygospora incolorata vel flavida, sphaeroidea, 4.5–6.5 μ diam., membrana .5–1.3 μ crassa, 10–25 verrucis ornata.

Habitat in terra et in materiis plantarum putrescentibus, *Amoebas* minores, saepius 10–25 μ latas, quae magnam partem probabiliter *Amoebae sphaeronucleoli* sunt, capiens et consumens, prope Washington, D. C.

Sparse; hyphae colorless, .6 to .9 μ wide, producing haustoria consisting of branches 1 to 1.5 μ wide. Conidia continuous, somewhat needle-shaped, straight or slightly curved, 25 to 45 μ, mostly 30 to 40 μ long, and 1.2 to 1.7 μ wide. Zygosporangium at first smooth, spherical, 5 to 7 μ in diameter, its wall at maturity collapsing rather closely around the zygospore; the zygospore colorless or yellowish, subspherical, 4.5–6.5 μ in diameter, with a wall .5 to 1.3 μ thick and ornamented with 10–25 bullate protuberances.

Occurring in soil and decaying plant materials, capturing and consuming smaller *Amoebae* that measure often 10 to 25 μ in diameter and belong probably in large part to *Amoeba sphaeronucleolus;* near Washington, D. C.

ACAULOPAGE MACROSPORA

A species very similar to the one just described but having generally greater dimensions was found in some quantity in a single agar plate culture. Its mycelial filaments (FIG. 2, A–H), though far from coarse, are approximately twice as wide as those of *Acaulopage rhaphidospora.* The *Amoebae* that are captured on them and on the conidia include animals larger than any taken by *A. rhaphidospora,* as well as extremely minute individuals (FIG. 2, A–E, J). They reveal, however, essentially the same morphological features as those preyed upon by *A. rhaphidospora,* and would seem likewise referable, in the main, to *Amoeba sphaeronucleolus.* Correlated evidently with the generally greater size of the animals captured is a more extensive development of the haustorial system (FIG. 1, A). The haustorial branches are of about the same width as the mycelial hyphae from which they have origin, thus providing a contrast in dimensional relationships with the species already described, wherein the homologous elements are conspicuously wider than the ordinary filaments.

Sexual apparatus was found associated with the fungus, though only in small quantity and in apparently immature condition (FIG. 2, K). As in other members of the group paired branches regularly arise from separate hyphae. The zygosporangium, while half again as large in diameter as that of *Acaulopage rhaphidospora,* is similarly smoothly spherical on attaining full size, and likewise shrinks somewhat with the contraction of protoplasmic contents incident to the development of the zygospore proper.

Conidia (FIG. 2, I, *a–z*) were produced by the fungus in greater quantity than in any non-catenulate member of the Zoopagaceae observed so far. Examined under a dry objective they stood forth from the substratum in a conspicuously bristling array. In length and in width they exceed the conidia of *Acaulospora rhaphidospora* by approximately a half, and taper less markedly toward apex and base, which as a consequence are more bluntly rounded off. In some conidia the contents were found withdrawn from one or the other of the ends, leaving the empty portion attached as an appendage (FIG. 2, I, *d, f, t, x, z*) comparable, no doubt, with the more distinctive conidial appendages present in other members of the group. Apical bifurcation was seen in some conidia, occurring (FIG. 2, I, *k, r*) apparently as an occasional irregularity.

The sterigmata on which the conidia are borne (FIG. 2, G; H, *a*) represent in this species structures more substantial than in any of the other forms placed in the genus, remaining behind after disarticulation of the spores as tapering projections about 3 μ long (FIG. 2, B, *d*; H, *b*). Lateral processes rather similar to them except in being bent or contorted in various ways, werê observed on some of the hyphae (FIG. 2, E, *a–c*; F, *a–f*). The difficulty of interpreting these processes has already been referred to. It is not impossible that sterigmata might be constrained into conspicuous irregularity of form through changes in position of the parent hyphae such as might be effected, perchance, by the jostling of young earthworms or of the larger nematodes. Somewhat more plausibility, however, would seem to attach to the explanation that the processes constitute prehensile contrivances, which, after successfully intercepting and holding prey, penetrate into the animals to form the stalked haustorial systems characteristic of the species.

A term having reference to the unusual length of the conidia is deemed appropriate as a specific name for the fungus.

Acaulopage macrospora sp. nov.

Paulo sparsa; hyphis incoloratis 1–2 μ crassis, haustoria divaricata usque ter vel quater repetite irregulariter bifurcata evolventibus. Conidia elongato-cylindracea, utrimque leniter attenuata et abrupte rotundata, 30–70 μ longa, 1.6–2.5 μ crassa, sed interdum sursum bifurcata, etiam interdum parte infera vel parte supera evacuata. Zygosporangia primo levia, sphaeroidea, circiter 9 μ diam., membrana ad maturitatem circa zygosporam leniter collabente.

Habitat in radicibus putrescentibus, *Amoebas* 5–40 μ latas, quae magnam partem probabiliter *Amoebae sphaeronucleoli* sunt, capiens et consumens, prope Washington, D. C.

Somewhat sparse; hyphae colorless, 1–2 μ wide, giving rise to spreading haustoria irregularly dichotomously branched up to 3 or 4 times. Conidia elongate-cylindrical, tapering gradually toward the abruptly rounded basal and distal ends, 30 to 70 μ long, 1.6 to 2.5 μ wide, but sometimes distally bifurcate, and sometimes also, with basal or distal portion evacuated. Zygosporangium at first smooth, subspherical, approximately 9 μ in diameter, with a wall collapsing somewhat about the zygospore towards maturity.

Occurring in decaying roots, capturing and consuming *Amoebae* 5 to 40 μ in diameter, probably belonging mostly to *Amoeba sphaeronucleolus,* near Washington, D. C.

ACAULOPAGE RHICNOSPORA

The tendency toward evacuation of a portion of the conidium expressed occasionally in *Acaulopage macrospora,* is manifested with much regularity in a species otherwise closely resembling *A. rhaphidospora.* When undisturbed material of this species in a Petri dish culture is examined under a dry objective, the conidia directed nearly vertically are seen to terminate individually in a shriveled collapsed prolongation usually somewhat shorter than the basal part (FIG. 3, F, *a–c, f–h*; 3, *fig. 5, C, b*), but sometimes equally long or even slightly longer (FIG. 3, F, *d*). When such material is mounted in water, the empty appendage becomes all but invisible even under the best of immersion objectives, so that its position and size are often revealed only through its interruption of the rather uniformly granular field that the development of bacteria on the surface of the substratum ordinarily provides.

Although the shriveled appendages make for a distinctive appearance, their presence can hardly be considered an altogether decisive diagnostic character. The possibility that the very slender conidia bearing them may represent merely conidia of *Acaulopage rhaphidospora* that have become evacuated in the distal portions, perhaps through development coming with increasing age, is difficult to dispose of conclusively. However, observations repeated at intervals on stands of acicular conidia devoid of appendages did not disclose apical evacuation on any considerable scale;

whereas in stands displaying appendages apparently in conformity with a usual structural peculiarity, the necessary apical evacuation seemed to have occurred soon after the conidia attained their definitive dimensions. Since, moreover, the appendaged conidia in general slightly exceeded the acicular ones both in total length and in width, it would seem somewhat safer to consider them as being produced by a separate species.

The mycelium like that of *Acaulopage rhaphidospora* is composed of extraordinarily delicate filaments (FIG. 3, A–D; **3**, *fig. 5, B*). Within the minute *Amoebae* caught on these filaments are produced haustoria, which consist, as in *A. rhaphidospora*, of a few thicker but relatively short branches borne dichotomously on a short delicate stalk (FIG. 3, A; **3**, *fig. 5, B*). Sexual apparatus is formed readily and in moderate abundance. The fusing filaments arise consistently from separate elements. Sometimes two branches from separate mycelial filaments are represented in the union (**3**, *fig. 5, E, a*), sometimes two germ tubes from separate conidia (**3**, *fig. 5, E, b*), and sometimes a hyphal branch paired with a germ tube from a conidium (FIG. 3, B–D). The wall of the originally smooth subspherical zygosporangium appears at maturity to collapse closely about the sculptured zygospore proper (FIG. 3, E, *a–e*); so that in relationship of parts as well as in development, the sexual apparatus offers a rather accurate parallelism with that of *Zoopage phanera*.

A term having reference to the withered aspect of the conidia would seem appropriate as a specific name for the fungus.

Acaulopage rhicnospora sp. nov.

Sparsa; hyphis incoloratis, .6–.9 μ crassis, haustoria dichotoma ex ramulis 1–1.5 μ crassis composita evolventibus. Conidia hyalina, 20–55 μ longa, 1.5–2 μ crassa, parte supera saepius in maturitate evacuata itaque appendicula marcida constituens, parte infera deorsum attenuata. Zygosporangia primo levia, sphaeroidea, 4.5–7 μ diam., in maturitate membrana circa zygosporam collabente; zygospora incolorata vel flavida, sphaeroidea, 4–6.5 μ diam., membrana .5–1.3 μ crassa, 10–25 verrucis ornata.

Habitat in terra et in materiis plantarum putrescentibus, *Amoebas* minores saepius 10–15 μ latas capiens et consumens, prope Washington, D. C.

Sparse; hyphae colorless, .6 to .9 μ wide, producing dichotomously branched haustoria with branches 1 to 1.5 μ wide. Conidium hyaline, 20 to 55 μ long, 1.5 to 2 μ wide, the distal part at maturity often evacuated and then constituting a withered appendage, the proximal part tapering toward the base. Zygosporangium at first smooth, subspherical, 4.5 to 7 μ in diameter, its wall at maturity collapsing rather closely about the zygospore; the zygospore colorless or yellowish, subspherical, 4 to 6.5 μ in diameter, with a wall .5 to 1.3 μ thick and ornamented with 10 to 25 bullate protuberances.

Occurring in soil and in decaying plant materials, capturing and consuming the smaller *Amoebae* that measure mostly 10–15 μ in diameter, near Washington, D. C.

ACAULOPAGE CERATOSPORA

Of all fungi predacious on *Amoebae* the one that has been observed most frequently is a species of *Acaulopage* having a mycelium only slightly more delicate than that of *A. macrospora*. The *Amoebae* caught on the mycelial filaments (FIG. 3, G–I) include small and medium-sized animals, at least some of which appear to correspond fairly satisfactorily in morphology to *Amoeba sphaeronucleolus*. The haustorium shows a basal, bush-like type of branching rather different from the dichotomous branching characteristic of the three congeneric forms already described. The branches, moreover, are approximately of the same diameter as the mycelial filament from which they arise, providing therefore a contrast to the relationship evident in *A. rhaphidospora* and *A. rhicnospora* where the haustorial branches are conspicuously wider than the hyphae generally.

Though produced rather sparingly even on well-nourished mycelia, the conidia (FIG. 3, S, *a–h*) arrest attention both by their dimensions and their distinctive structure. On full maturity, the finely granular protoplasm of the asexual spore is concentrated in an elongated ellipsoidal cell. At its narrow proximal end this cell is delimited by a small septum from a short, narrow, empty basal appendage; at its more broadly truncated distal end it is delimited by a larger septum from a long, empty, tapering appendage. The distal appendage, usually half again or twice as long as the living cell, appears, like that of *Acaulopage rhicnospora*, shriveled when viewed in its natural state on the dry substratum. The evacuated membrane composing it, however, is thick enough in the present species that it can be made out clearly in a moist preparation under a good immersion objective.

Sexual apparatus is sometimes formed in moderate quantity, but more often is completely absent. It has not been possible to determine definitely whether the fungus is heterothallic; though, as in other members of the genus, the two conjugating branches always arise from separate filaments (FIG. 3, J–L). The fully grown zygosporangium, unlike the homologous structure in *Acaulopage rhaphidospora* and *A. rhicnospora,* is moderately sturdy and rather beautifully ornamented with bullate protuberances (FIG. 3, M–R). As far as can be determined under the optical difficulties introduced by the sculpturing of the zygosporangium, the zygospore proper is surrounded by a smooth spherical wall. Thus, whereas both of the sexual hyphae are connected directly with the zygosporangium, as in *Zoopage phanera,* the sculpturing and eventual shape of mature zygosporangium and zygospore show parallelism rather with *Bdellospora helicoides.*

A term having reference to the hornlike shape of the distal conidial appendage is deemed appropriate as a specific name for the fungus.

Acaulopage ceratospora sp. nov.

Sparsa; hyphis incoloratis, .9–1.8 μ crassis, haustoria arbusculiformia divaricata ex aliquot ramulis composita evolventibus. Conidia hyalina, in totam 60–110 μ longa, tripertita: parte supera vacua, sursum attenuata, paulo subulata, 30–70 μ longa, basi 1–3 μ crassa, apice .5–.8 crassa, appendicula saepe marcida facta; parte media protoplasmatis viventis repleta, elongato-ellipsoidea, 20–34 μ longa, 4–6 μ lata; parte infima vacua, saepe deorsum paulo attenuata, 2–6 μ longa, .8–1.2 μ crassa. Zygosporangia flavida, sphaeroidea, 6–11 μ diam., 15–25 verrucis ornata; verrucis .5–1.5 μ altis, 1.5–3 μ diam. Zygosporae globosae, verisimiliter leves, membrana crassa, loculo interno 4.5–8 μ diam.

Habitat in terra et in materiis plantarum putrescentibus, *Amoebas* quae parte probabiliter *Amoebae sphaeronucleoli* sunt capiens et consumens, prope Washington, D. C.

Sparse; hyphae colorless, .9 to 1.8 μ wide, producing bushlike spreading haustoria consisting of several branches. Conidium hyaline, 60 to 110 μ in total length, consisting of three parts: a distal, tapering, somewhat awl-shaped empty part, present under dry conditions as a withered appendage, 30–70 μ long, 1 to 3 μ wide at its base and .5 to .8 μ wide at its tip; a middle part filled with living protoplasm, elongate ellipsoidal, 20 to 34 μ long, 4 to 6 μ

wide; a lower empty part often tapering somewhat toward the base, 2 to 6 μ long, .8 to 1.2 μ wide. Zygosporangium yellowish, subspherical, 6 to 11 μ in diameter, ornamented with 15 to 25 warty protuberances, which are .5 to 1.5 μ high and 1.5 to 3 μ in basal diameter. Zygospore globose, apparently smooth, and a thick membrane surrounding a loculus 4.5 to 8 μ in diameter.

Occurring in soil and in decaying plant materials, capturing and consuming *Amoebae* in part belonging probably to *Amoeba sphaeronucleolus,* near Washington, D. C.

ACAULOPAGE TETRACEROS

An even more conspicuous development of empty conidial appendages than is found in *Acaulopage ceratospora* provides the chief distinctive feature of a fungus often encountered on old isolation plate cultures, and on pieces of decaying plant materials that have been kept partly bathed in water for some days. In either cultural environment the fungus apparently subsists entirely on *Amoebae,* the animals captured by it being mostly of the smaller sizes. The haustorial system within the prey, is disposed in a bushlike manner somewhat like the haustorial system of *A. ceratospora,* which it resembles besides in that the elements composing it are approximately of the same diameter as the parent mycelial filament (FIG. 4, A, *a, b*; **3**, *fig. 2, B*).

The conidia, which for the most part are produced rather sparingly, consist individually of a large inversely flask-shaped cell together with a short basal stipe and from 2 to 6, mostly 3 to 5, gradually tapering empty distal appendages. In the earlier stages of its development the conidium first appears as a terminal bulbous enlargement on a very short erect branch arising from a prostrate filament, or on a short erect terminal prolongation of such a filament (FIG. 4, B). From the distal end of the growing enlargement are then thrust forth, in spreading, approximately symmetrical arrangement, the several branches (FIG. 4, C; **3**, *fig. 2, A*) that later through the withdrawal of the protoplasm are converted into the empty subulate appendages. Sometimes apparently this withdrawal is interrupted for a period long enough to entail the laying down of a median partition (FIG. 4, D). On maturity disarticulation occurs a short distance below the point where the filament widens out. As the short cylindrical part thereby included in the conidium, and comparable to the neck of the inverted flask corresponding to the living cell, has generally been evacuated before disarticulation takes place, it usually presents itself subsequently as the empty basal stipe (FIG. 4, E–G; **3**, *fig. 2, C*) already mentioned.

The conidium thus constituted has an appearance little suggestive of phycomycetous affinities, being reminiscent, even if somewhat vaguely, rather of genera in the Mucedinaceae-Staurosporae. That at least two fungi eligible for inclusion in the latter group—the quadrilobate *Monacrosporium*-like form figured earlier (**2**, *fig. 9, A, C*), and *Pedilospora dactylopaga*—subsist through the capture of microscopic invertebrates, contributes to a remarkable parallelism. It is difficult to avoid the presumption that in some manner the curious modifications in the conidia of these Hyphomycetes, and also the similar modifications in the conidia of the phycomycete under discussion, must be related to the predacious habit that these fungi have in common. In cultures of irrigated vegetable materials, as was pointed out previously, conidia of the present fungus keep afloat on the surface of the water, mainly, no doubt, owing to the buoyancy of the empty appendages. The evident utility of the appendages as flotative devices need, however, not preclude other and perhaps more essential usefulness.

The evident relationship of the fungus especially to *Acaulopage ceratospora* would seem to justify, for the time being at least, assignment to the same genus. A term having reference to four hornlike appendages—four being approximately the average number found, as well as the number most often actually present—is deemed sufficiently accurate in arithmetical connotation to be suitable as specific name.

Acaulopage tetraceros sp. nov.

Sparsa; hyphis incoloratis, .9–1.8 μ crassis, haustoria arbu^s^culiformia interdum parte dichotoma evolventibus. Conidia hyalina basi stipitata, apice 2–6 (saepe 3–5) appendicibus divergentibus vestita: cellula viventi protoplasmatis repleta, inversum lageniformis, 16–24 μ (saepius circiter 20 μ) longa, 7–10 μ (saepe circa 8 μ) lata; stipite vacuo, 1–5 μ longo, .8–1.5 μ lato; appendicibus circum apicem latum cellulae viventis dispositis, vacuis, subulatis, 14–26 μ (saepe circa 20 μ) longis, basi 1–2 μ crassis. Zygosporae ignotae.

Habitat in terra et in materiis diversis plantarum putrescentibus, *Amoebas* minores quae parte probabiliter *Amoebae sphaeronucleoli* sunt capiens et consumens, prope Washington, D. C.

Sparse; hyphae colorless, .9 to 1.8 μ wide, producing bushlike haustoria that sometimes are in part dichotomously branched. Conidium hyaline, stipitate at the base, furnished at the apex with 2 to 6, mostly 3 to 5, divergent appendages: the living cell filled with protoplasm, inversely flask-shaped, 16 to 24 μ (mostly about 20 μ) long, and 7 to 10 μ (mostly about 8 μ) wide; the stipe empty, 1 to 5 μ long, and .8–1.5 μ wide; the appendages arranged rather symmetrically about the broad distal end of the living cell, devoid of protoplasmic contents, awl-shaped, 14 to 26 μ (mostly about 20 μ) long, and individually 1 to 2 μ wide at the base. Zygospores unknown.

Occurring in the soil and in different decaying plant materials, capturing and consuming smaller *Amoebae* that probably belong in part to *Amoeba sphaeronucleolus,* near Washington, D. C.

SPECIES WITH CONIDIA BORNE ON ERECT CONIDIOPHORES

In a number of species closely similar to those described under the genus *Acaulopage* the conidia are borne on erect hyphae, which though not differing much from the vegetative filaments in structural details, are functionally quite distinct in being given up exclusively to asexual reproduction. As has been noted previously these species show nothing of the tendency toward the development of empty conidial appendages evident in *Acaulopage.* It may be inferred with some little plausibility perhaps that in elevating the spore to a position well above the substratum, the ecological need for appendages is obviated. However, even if a divergence in ecological relationship were not to be assumed, the divergence in morphology would yet seem so decisive as to dictate a corresponding taxonomic separation. A separate genus is therefore proposed, under a name intended to bring into relief the presence of conidiophores as well as to make reference to the predacious character that the fungi in question share with members of other genera.

Stylopage gen. nov.

Mycelium effusum; hyphis sterilibus continuis, hyalinis, parce ramosis, materia glutinosa flavida animalia minuta tenentibus, ramo pelliculam eorum penetrantibus, tum haustorium intus evolventibus et carnem vel protoplasma exhaurientibus; hyphis fertilibus erectis, unicum conidium apice ferentibus vel plura conidia singulatim post incrementa repetita ferentibus. Conidia hyalina, incolorata. Zygosporangia globosa, intra materiam subjacentem e copulatione duarum similium hypharum orta.

Mycelium effuse; vegetative hyphae continuous, hyaline, rather sparingly branching, holding minute animals by means of yellowish adhesive material, penetrating the pellicle or integument of each by means of a lateral branch, then producing a haustorium, or an internal mycelium, which exhausts the fleshy or protoplasmic contents; fertile hypha erect, bearing a single conidium at its apex, or, following repeated elongation, several conidia produced successively. Conidia hyaline, colorless. Zygosporangium globose, produced in the substratum from the union of two similar hyphae.

STYLOPAGE HAPLOE

Of the several known species referable to the genus the one having at once the shortest and simplest conidiophores, and therefore showing the smallest departure in morphology from *Acaulopage,* appears to be relatively scarce, having been encountered only twice on old isolation agar plate cultures. Its vegetative mycelium (FIG. 4, H–M), if slightly more delicate than that of *A. macrospora,* captures *Amoebae* that not only are of approximately the same range of dimensions (FIG. 4, H–J) but also appear assignable in large part to *Amoeba sphaeronucleolus.* The parallelism is extended in the dichotomous branching and limited spread of the haustorial system developed within the prey (FIG. 4, H–J). The conidia (FIG. 4, N, *a–o*), however, are much smaller than those of *A. macrospora.* They resemble rather closely those of the much more delicate form described herein as *Stylopage araea,* though their somewhat greater dimensions and generally more bluntly rounded apical ends become sufficiently evident as distinguishing features on more careful comparison. Production of successive conidia following repeated elongation of the conidiophore has never been observed in this species; though it might be unsafe to assume that such reproductive development could not occur, for example, in especially well nourished material. A term having reference to the simplicity of the conidial apparatus (FIG. 4, I, *a, b*; K, *a, b*; L; M) is deemed reasonably appropriate as a specific name for the fungus.

Stylopage haploe sp. nov.

Sparsa; hyphis sterilibus incoloratis, 1–1.7 μ crassis, haustoria irregulariter dichotoma divaricata evolventibus; hyphis fertilibus incoloratis, 25–40 μ altis, basi saepius 1–1.2 μ crassis, sursum paulatim attenuatis, apice .5–.8 μ crassis, unicum conidium terminale ferentibus. Conidia paulo fusoidea, basi acuta, apice plus minusve rotundata, 15–25 μ (saepius circiter 19 μ) longa, 2.2–2.7 μ (saepius circiter 2.4 μ) crassa. Zygosporae ignotae.

Habitat in materiis plantarum putrescentibus, *Amoebas* saepius usque 40 μ diam., quae magnam partem probabiliter *Amoebae sphaeronucleoli* sunt, capiens et consumens, prope Washington, D. C.

Sparse; sterile hyphae colorless, 1–1.7 μ wide, producing irregularly dichotomous spreading haustoria; fertile hypha colorless, 25 to 40 μ high, 1 to 1.2 μ wide at the base, tapering upward gradually, .5 to .8 μ at the tip, bearing a single terminal conidium. Conidium somewhat fusoid, rather acutely pointed at the proximal end, thicker and more or less bluntly rounded at the distal end, 15 to 25 μ (mostly about 19 μ) long, 2.2–2.7 μ (mostly about 2.4 μ) wide. Zygospores not known.

Occurring in decaying plant materials, capturing and consuming *Amoebae* up to 40 μ in diameter, probably belonging in large part to *Amoeba sphaeronucleolus,* near Washington, D. C.

STYLOPAGE ARAEA

A fungus showing the same general arrangement of parts as the one just described, but presenting a far different and much more graceful appearance, was observed rather frequently on old isolation plate cultures. Small *Amoebae* as well as medium-sized *Amoebae* measuring up to 50 μ in diameter and mostly referable apparently to *Amoeba sphaeronucleolus* are captured on its delicate mycelium (FIG. 5, A). The rangy bushlike haustorial system shows close basal branching, supplemented especially in instances of more extensive development in the larger animals with looser branching some distance above the base (FIG. 5, B, C). Haustorial elements and mycelial filaments are approximately equal in width. Undoubtedly the most distinctive feature of the fungus is found in the height and remarkable slenderness of the conidiophore (FIG. 4, D), which at first sight would appear hardly capable of supporting the sizable obovoid conidium (FIG. 5, E, *a–z, aa*) produced, as far as can be determined, always singly at its tip. A term meaning " slender " is accordingly proposed as appropriate for the species.

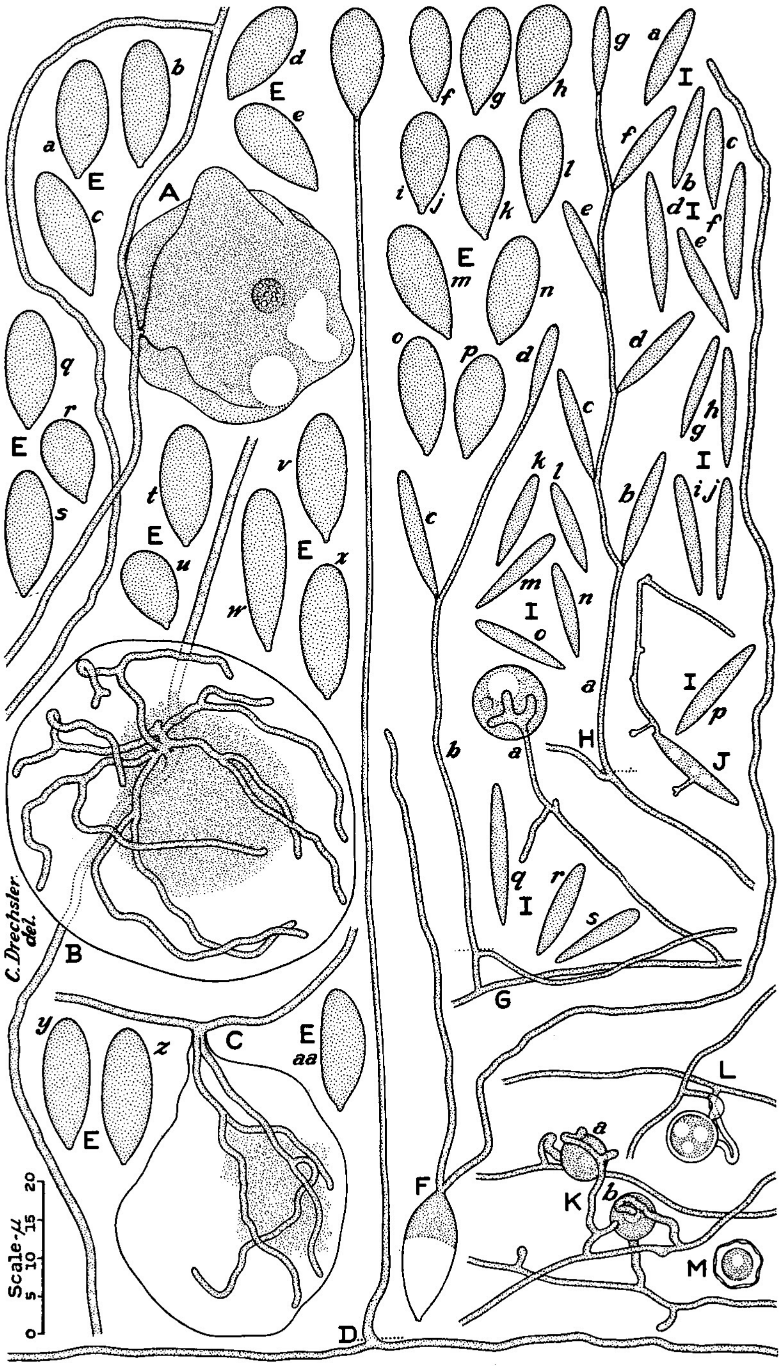

FIG. 5. A–F, *Stylopage araea.* G–M, *Stylopage lepte.*

Stylopage araea sp. nov.

Sparsa; hyphis sterilibus incoloratis, .8–1.3 μ crassis, haustoria divaricata arbusculiformia evolventibus; hyphis fertilibus incoloratis, 150–225 μ altis, .8–1 μ crassis, unicum conidium terminale ferentibus. Conidia incolorata, elongato-obovoidea, basi paulo apiculata, 10–22 μ (saepius circiter 15 μ) longa, 5.4–7 μ (saepius circiter 6.4 μ) lata. Zygosporae ignotae.

Habitat in materiis plantarum putrescentibus, *Amoebas* usque 50 μ diam., quarum multae verisimiliter *Amoebae sphaeronucleoli* sunt, capiens et consumens, prope Washington, D. C.

Sparse; vegetative hyphae colorless, .8 to 1.3 μ wide, producing spreading bushlike haustoria; fertile hypha colorless, 150 to 225 μ high, .8–1 μ wide, bearing a single terminal conidium. Conidium colorless, elongate-obovoid, somewhat apiculate at the base, 10 to 22 μ (mostly about 15 μ) long, 5.4 to 7 μ (mostly about 6.4 μ) wide. Zygospores not known.

Occurring in decaying plant materials, capturing and consuming *Amoebae* measuring up to 50 μ in diameter, the larger ones apparently belonging to *Amoeba sphaeronucleolus*, near Washington, D. C.

STYLOPAGE LEPTE

Making its appearance in isolation plate cultures more frequently than either of the two species of *Stylopage* already discussed, is a third form of which figures were included among the synoptic illustrations published earlier (**3**, *fig. 3*). As was indicated then the fungus in its vegetative stage closely resembles the two species described herein as *Acaulopage rhaphidospora* and *A. rhicnospora;* its extraordinarily narrow mycelial threads similarly capturing *Amoebae* of the smallest sizes and producing within each a dichotomously branching haustorium consisting of short widened elements (FIG. 5, G, *a*; **3**, *fig. 3, B*). Equally close similarity to the two species of *Acaulopage* is evident also in the sexual apparatus, the membrane of the originally smoothly spherical zygosporangium (FIG. 5, K, *a, b*; **3**, *fig. 3, E*) here likewise collapsing rather closely about the very small sculptured zygospore (FIG. 5, M), and thereby bringing about a relationship of parts much like that described earlier in the account of *Zoopage phanera.* In its asexual reproduction, however, the fungus is moderately distinctive. The erect conidiophores (FIG. 5, G, H; **3**, *fig. 3, A*), in spite of their frail appearance do not stop in their development after producing a single terminal conidium, but through repeated elongation very often come to bear successively up to a half dozen conidia (FIG. 5, H, *b–g*) in the arrangement familiar, for example, in *Phytophthora infestans* (Mont.) De Bary. The conidia themselves (FIG. 5, I, *a–s*) have an obvious resemblance to those of the generally more robust *S. haploe,* but are somewhat smaller and because of their more marked apical tapering have, on the whole, a more distinctly fusoid shape. Besides giving rise to germ-tubes that grow out into delicate mycelia (FIG. 5, J), they often directly produce haustoria (**3**, *fig. 3, D*) within *Amoebae* that happen to come in contact with them.

A term having reference more especially to the frailness of the conidiophore would seem appropriate as specific name for this minute inconspicuous fungus.

Stylopage lepte sp. nov.

Sparsa; hyphis sterilibus incoloratis, .6–1 μ crassis, haustoria dichotoma ex ramulis 1–1.5 crassis composita evolventibus; hyphis fertilibus incoloratis, 25–100 μ altis, .7–.9 μ crassis, usque 6 conidia singulatim post incrementa repetita ferentibus. Conidia fusoidea, basi acuta, ad apicem rotundatum plus minusve attenuata, 12–19 μ (saepius circiter 15 μ) longa, 1.9–2.7 (saepius circiter 2.2 μ) crassa. Zygosporangia primo levia sphaeroidea, 5–7 μ diam. in maturitate membrana circa zygosporam collabenta; zygospora incolorata vel flavida, sphaeroidea, 4.5–6.5 μ diam., membrana .5–1.3 μ crassa, 10–25 verrucis ornata.

Habitat in terra et in materiis plantarum putrescentibus, *Amoebas* magnam partem 10–20 μ latas capiens et consumens, prope Washington, D. C.

Sparse; vegetative hyphae colorless, .6 to 1 μ wide, producing haustoria consisting of branches 1–1.5 μ wide; fertile hyphae colorless, 25 to 100 μ high, .7 to .9 μ wide, bearing up to 6 conidia in succession after repeated elongation. Conidium fusoid, acute at the base, tapering more or less toward the sharply rounded apex, 12 to 19 μ (mostly about 15 μ) long, 1.9 to 2.7 (mostly about 2.2 μ) wide. Zygosporangium at first smooth subspherical, 5 to 7 μ in diameter, its wall at maturity collapsing about the zygospore; zygospore colorless or yellowish, subspherical, 4.5 to 6.5 μ in diameter, with a wall .5 to 1.3 μ thick and ornamented with 10 to 25 wartlike protuberances.

Occurring in soil and in decaying plant materials, capturing and consuming *Amoebae* mostly 10 to 20 μ in diameter, near Washington, D. C.

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EXPLANATION OF FIGURES

Fig. 1. *Acaulopage rhaphidospora;* drawn with the aid of the camera lucida at a uniform magnification; × 1000 throughout. *A–C,* Portions of hyphae with captured *Amoebae,* showing variations in the development of the haustorial system. *D,* Portion of hypha with two captured *Amoebae, a* and *b*. *E,* Conidia, *a–h,* showing variations in size and shape. *F,* Zygosporangium, nearly fully grown, at a stage preceding the appearance of septa in the conjugating branches. *G,* Young zygosporangium after appearance of a septum in one of the conjugating branches. *H,* Young zygosporangium after appearance of a septum in both of the conjugating branches. *I, J,* Mature sexual apparatus with hyphal connections, the dotted contour within each representing the optically uncertain outer profile of the zygospore wall. *K, L,* Mature zygosporangia with zygospores, as they appear after their mycelial connections are no longer visible.

Fig. 2. *Acaulopage macrospora;* drawn with the aid of the camera lucida at a uniform magnification; × 1000 throughout. *A,* Portion of branching hypha on which have been captured four *Amoebae, a–d;* showing variations in the dimensions of the animals, and corresponding differences in development of haustoria. *B,* Portion of branching hypha with three captured *Amoebae, a–c,* and showing a sterigma, *d*. *C, D,* Portions of hyphae, each with a captured *Amoeba*. *E,* Portion of hypha showing a captured *Amoeba* and three lateral processes, *a–c,* probably representing adhesive organs of capture. *F,* Portion of hypha with six lateral processes, *a–f*. *G,* Portion of prostrate hypha with a growing conidium; the surface of the substratum being indicated approximately in the dotted line. *H,* Hypha with one sterigma, *a,* bearing a fully developed conidium, and another sterigma, *b,* after

removal of conidium. *I,* Conidia, *a–z,* showing variations in size and shape, evacuation of apical (*d, f*) and proximal (*t, x, z*) portions, and distal bifurcation (*k, r*). *J,* Conidium with two minute *Amoebae, a* and *b,* captured by it. *K,* Sexual apparatus, showing diclinous origin of two zygosporangia, *a* and *b.*

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

A–F, Acaulopage rhicnospora: A, Portion of hypha with a captured *Amoeba. B–D,* Immature sexual apparatus, each zygosporangium being formed from union of a mycelial branch and a germ tube produced by a conidium. *E,* Mature zygosporangia, *a–e*; the dotted contour in each indicating the optically obscure outer profile of zygospore wall. *F,* Conidia, *a–h,* showing variations in size, shape, and development of apical appendage.

G–R, Acaulopage ceratospora: G, H, Portions of hypha, each with a captured *Amoeba. I,* An *Amoeba* captured and being consumed by two separate hyphae. *J. K,* Sexual apparatus in early stage of development. *L,* Zygosporangium fully grown. *M–P,* Mature sexual apparatus with supporting branches. *Q,* Mature sexual apparatus: *a,* complete, in optical section; *b,* upper aspect of zygosporangial wall alone. *R,* Mature zygosporangium of nearly minimum size. In *M–R* the dotted contour represents the optically uncertain outer profile of the zygospore wall.

Fig. 4. Drawn with the aid of the camera lucida at a uniform magnification; × 1000 throughout.

A–G, Acaulopage tetraceros: A, Portion of hypha with two captured *Amoebae. B,* Portion of hypha with conidium in early stage of development, the dotted line indicating approximately the surface of the substratum. *C,* Conidium fully grown but immature, the stipe and appendages still being filled with protoplasm. *D,* Portion of hypha bearing a nearly mature conidium; the septum in each of the two completely evacuated appendages mark an interruption in the process of evacuation at approximately the same stage as that represented in the third appendage. *E–G,* Mature conidia showing variations in size and shape.

H–N, Stylopage haploe: H, Portion of hypha with a rather large captured *Amoeba. I,* Portion of hypha with a captured *Amoeba* and two erect conidiophores, *a* and *b,* each bearing a conidium. *J,* Conidium that in germinating gave rise to two germ tubes, in addition to producing a haustorial system within an *Amoeba* captured by it. *K,* Portion of hypha with two conidiophores, one, *a,* bearing a mature conidium, the other, *b,* a young conidium. *L,* Portion of hypha with conidiophore and mature conidium. *M,* Portion of hypha with largely evacuated conidiophore bearing a mature conidium. *N,* Conidia, *a–o,* showing variations in size and shape. The dotted lines in *I, K, L* and *M* indicate the approximate position of the surface of the substratum in relation to the individual conidiophores.

Fig. 5. Drawn with the aid of the camera lucida at a uniform magnification; × 1000 throughout.

A–F, Stylopage araea: A, Portion of hypha with newly captured *Amoeba. B,* Portion of hypha with a well developed haustorial system in the overlying captured *Amoeba. C,* Portion of hypha and the haustorial system in a badly depleted *Amoeba,* the attachment being shown in profile. *D,* Conidiophore arising from a prostrate filament, and bearing a single terminal conidium; the surface of the substratum being indicated approximately by the dotted line. *E,* Conidia, *a–z, aa,* showing variations in size and shape. *F,* Germinating conidium still retaining half of its protoplasmic contents after having given rise to two germ tubes of considerable length.

G–M, Stylopage lepte: G, Portion of mycelium from which have been produced a haustorium (*a*) within a captured *Amoeba,* and a conidiophore (*b*) bearing a mature (*c*) and a young (*d*) conidium. *H,* Portion of hypha bearing a well developed conidiophore, *a,* with six conidia, *b–g,* formed successively after repeated elongation. *I,* Conidia, *a–s,* showing variations in size and shape. *J,* Germinating conidium, with two delicate lateral processes, probably functional as organs of capture. *K,* Sexual apparatus, showing origin of young zygosporangia, *a* and *b,* from conjugating branches arising from separate hyphae. *L,* Zygosporangium likewise resulting from union of branches arising from separate hyphae, but in somewhat later stage of development. *M,* Mature zygospore with enveloping zygosporangial membrane. In *G* and in *H* a dotted line indicates approximately the position of the surface of the substratum.