

BOTANY.—*Three fungi destructive to free-living terricolous nematodes.*¹ CHARLES DRECHSLER, U. S. Bureau of Plant Industry.

In several earlier papers (5, 6, 8, 9, 10) comparative treatment was accorded to 24 fungi that had been observed to subsist on free-living nematodes infesting old agar cultures started from diseased rootlets or from other decaying vegetable materials. As the agar media employed were of a concentration sufficient to insure a rather firm consistency together with relative freedom from liquid water, the cul-

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tures provided approximately terrestrial rather than aquatic conditions, and therefore not only encouraged the multiplication of eelworms mainly terrestrial with respect to source and adaptation, but also permitted development of the similarly terrestrial fungi habitually destructive to them under natural conditions. The 24 fungi hitherto treated include representatives of two distinct groups—21 species, mainly predaceous in mode of attack, being referable to an interrelated series of hyphomycetes wherein are embraced members of the genera *Arthrotrrys*, *Trichothecium*, *Dactylella*, *Dactylaria*, *Tripodsporina*, and *Tridentaria*; the remaining 3 species being referable to the Zoopagaceae, a distinctive family of conidial phycomycetes mostly destructive to terricolous rhizopods.

Apart from recognizable members of the predaceous mucedinaceous series and of the Zoopagaceae, about a score of additional fungi have been observed to destroy free-living nematodes in agar cultures. Nearly all these forms are parasitic in their mode of attack, infecting their hosts by germination of adhering conidia. Only one among them, the widely distributed and very destructive *Harposporium anguillulae* Lohde, can with any certainty be referred to a species previously reported as parasitic on nematodes. This meager agreement with earlier findings is not surprising when it is considered that in large part the literature on fungus parasites of nematodes records observations made on animals kept under conditions widely different from those obtaining in agar cultures. The relevant contributions by Braun (3), Sorokine (23), Sadebeck (19), Dangeard (4), Lindner (13), Maupas (16), Micoletzky (17), and Sparrow (24, 25) dealt presumably with infections of actively motile eelworms that came about under conditions apparently more nearly aquatic than terrestrial. Baunacke (1), Gofart (11), Korab (12), and Rozsypal (18), on the other hand, were concerned with parasites destructive to the eggs and the almost equally inert larvae in cysts of *Heterodera schachtii* Schmidt. Now, manifestly, infection of active eelworms by fungus spores under aquatic conditions, and infection of inert stages under terrestrial conditions, are not attended by the difficulties usual in infection of actively motile eelworms under terrestrial conditions. For in their brisk movement through soil or through decaying organic materials, terricolous nematodes constantly tend to scrape away the spores adhering to them externally, much as cattle rid themselves of the larger stinging flies in walking through dense shrubbery. Small size, slender or flattened shape, and strong adhesiveness are among the physical attributes whereby the spores of successful parasites are enabled to

withstand the adverse mechanical action to which they are exposed. In the two phycomycetous parasites herein described some of these attributes are derived from developmental modifications that appear to be of taxonomic significance.

HAPTOGLOSSA HETEROSPORA

A fungus evidently referable to one or another of the several zoospore-producing groups in the Phycomycetetes has frequently been observed destroying enormous numbers of nematodes in agar cultures prepared from media of rather soft consistency and planted with decaying portions of roots or stems originating in greenhouse or field. It has also been found destroying nematodes in agar cultures that after being permeated with *Pythium* mycelium had been further planted with pinches of leaf mold collected in deciduous woods in Virginia, Maryland, or Wisconsin. Most of the species of eelworms commonly infesting soft agar cultures started from vegetable materials that have undergone partial decomposition in contact with moist ground, appear susceptible to attack by the fungus, though differences in the rapidity of their destruction are often noticeable. The appearance of the fungus in a petri-dish culture leads usually within a few days to the extermination of all active individuals of the susceptible species present. In its spectacular destructiveness and widespread distribution the fungus invites comparison with *Harposporium anguillulae* and with the larger of the reticulate predaceous hyphomycetes, particularly *Arthrobotrys oligospora* Fres., *A. conoides* Drechsl., *A. musiformis* Drechsl., and *Dactylaria thaumasia* Drechsl.

During the earlier stages of its development within a nematode the fungus is relatively inconspicuous. At about the time the infected animal becomes incapable of further locomotion, the parasite may be discerned imbedded in the granular and globulose material resulting from degeneration of musculature and organs (Fig. 1, A). With further appropriation of the degenerating material it improves markedly in visibility and increases somewhat in volume (Fig. 1, B), so that when the last remnant of digestible substance has been absorbed, it is revealed with much distinctness inside the otherwise empty host integument (Fig. 1, C-G).

In an individual host animal the parasite may be represented by a single thallus (Fig. 1, F) or by many thalli (Fig. 1, A-E, G). Instances of infection by a single thallus or by two or three thalli are especially frequent early in the course of an epizootic. As the epizootic continues the number of thalli in the individual infected eelworm increases rapidly, with the result that in the end instances of infection by more than 50 (Fig. 1, C) or even more than 100 thalli are not infrequent. This increase in number, naturally, is accompanied by proportional decrease in size, and, somewhat secondarily, by some change in shape; the larger vegetative bodies being generally of cylindrical conformation, with bluntly rounded ends, whereas the smaller specimens are mostly of prolate ellipsoidal conformation. Irregular modifications of outward form, such as median constrictions and narrowed terminal prolongations, occur here and there. The larger vegetative bodies are frequently somewhat curved or crooked, either because of crowding by their fellows (Fig. 1, B, G), or because of constraint from the posture taken by the host animal in its death (Fig. 1, F).

Following exhaustion of their food supply the thalli of the fungus are transformed into sporangia. The smaller specimens (Fig. 1, I, J, K) each put

forth laterally a single broad protrusion that presses the animal's integument outward in a perceptible bulge. More or less simultaneously cleavage lines appear in the granular protoplasmic contents, dividing them into units of approximately equal volume. Suddenly the broadly rounded tip of the protrusion yields, and the delimited protoplasmic lumps are in large part forcibly expelled through the opening. Transformation of the larger thalli usually entails development of several protuberances at some distance from one another. In instances where five or six beaks are formed, two or three of them may participate in dehiscence. Regardless of the number of openings present, a considerable proportion of the protoplasmic lumps usually fail to be discharged (Fig. 1, H, *b, c*; L, O), and must await their liberation by the disintegration of host integument and sporangial membrane.

After being propelled some distance into the adjacent medium, the discharged protoplasts round up individually to form irregularly globose immotile spores (Fig. 1, H, *c*; L). Each of the encysted bodies soon gives rise to a bud, which then grows out (Fig. 1, Q) to form eventually a flattened structure with an elongated lateral lobe that is usually curled at its tip in a tonguelike manner (Fig. 1, M). Often the axial or proximal portion of the flattened structure, like the envelope of the immotile spore to which it remains attached, is found evacuated of contents, all of the protoplasmic material having been collected in the glossoid lobe. Before long, hundreds of the curiously constituted units thus resulting from asexual reproduction surround the integumentary remains of each host animal like a dense cloud.

When a healthy nematode passes through such a cloudlike array, some of the reproductive bodies become fixed to it; attachment being accomplished apparently through adhesion of the concave surface of the glossoid lobe to the animal's integument. Upon perforation of the integument by a minute opening the protoplasmic contents of the reproductive body migrate inward to form a small saclike structure. This structure then proceeds to develop autonomously, thereby again giving rise to a cylindrical or ellipsoidal thallus.

During the later and more readily discernible stages in their development some of the thalli can be seen attached to the animal's integument by a conical connection devoid of protoplasmic contents (Fig. 1, G). In this conical part is to be recognized unquestionably the saccate body by which invasion was initiated. The larger number of thalli, however, show no evident connection to the integument, a circumstance that might imply either that thalli often multiply by division, or that connections originally present often are destroyed as a result of movement by the animal. An approximate end-to-end arrangement of thalli (Fig. 1, A, B) occasionally to be observed argues somewhat in favor of the former alternative, while the latter is supported more especially by the frequent absence of any observable connection between integument and fungus in animals parasitized by only a single thallus (Fig. 1, F). Since such single thalli, when occurring in large animals, attain impressively large dimensions without dividing into units of smaller size, it may be presumed that vegetative division is at least not a constant feature in the development of the fungus. The presence of very numerous thalli in infected animals during the later stages of an epizootic in an agar culture is very obviously attributable to the enormous numbers of germinated spores then distributed through the medium. Often in such later stages the incipient infections from individual spores are so numerous and close together that the intruding protoplasts, operating virtually as a mass, will extensively separate integument from naked musculature. In the head region, especially, such wholly pathological separation—not to be confused with hastened

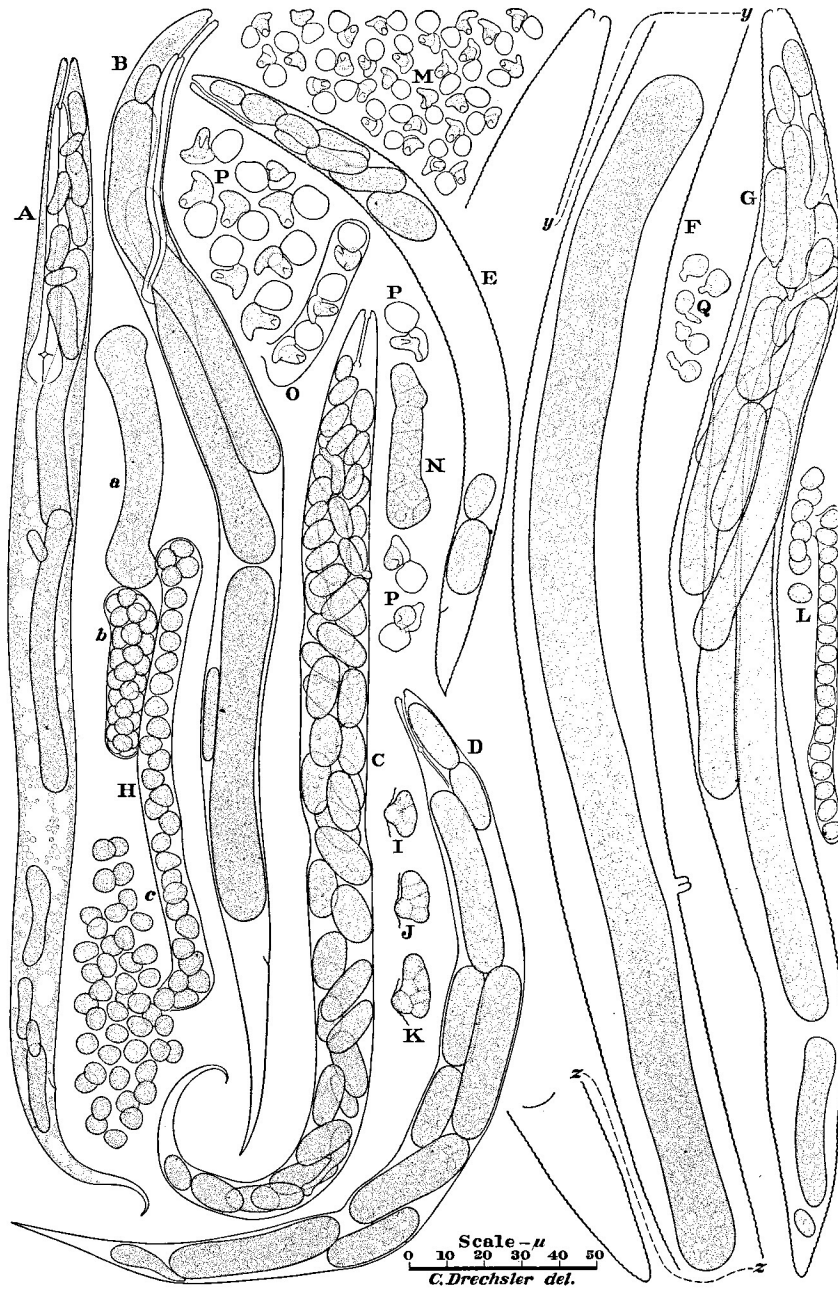


Fig. 1.—(See opposite page for explanation)

molting—is often associated with conspicuous deformation of fleshy structures.

With respect to size the immotile spores from each individual sporangium show only moderate variation. Most frequently, perhaps, they range in diameter between 4.5 and 6 μ (Fig. 1, H, *b, c*; L; M). Many sporangia, however, give rise to spores ranging in diameter between 8 and 10 μ (Fig. 1, N; O; P). It is not apparent that spores of intermediate dimensions are produced except as unusually oversized specimens in clusters referable to one category, or as undersized specimens in clusters referable to the other category. As sporangia producing the larger spores frequently occur in the same host animal with sporangia producing the smaller spores, the difference in dimensions can not readily be held traceable to differences in environmental conditions. Unstained living material reveals no divergence in manner of development or in mode of infection associated with the inequality of size.

Presumably the production of flattened lobate or glossoid infective structures by the discharged immotile sporangiospores represents a developmental process equivalent to the emission of motile zoospores from encysted sporangiospores familiar in the saprolegniaceous genera *Achlya* and *Aphanomyces*. Certainly, the type of asexual reproduction concerned here shows less similarity to the *Pythium*-like reproduction that is found associated with more or less swollen endoparasitic thalli in the genera *Lagena*, *Lagendidium*, and *Myzocytium*, than to the *Achlya*-like reproduction associated with swollen endoparasitic thalli in *Ectrogella* and *Aphanomyopsis*, as these genera were understood by Scherffel (21). With *Ectrogella* and *Aphanomyopsis*, moreover, the fungus under consideration offers further morphological parallelism in the pronouncedly granular consistency of the protoplasm in its thalli—a consistency which Scherffel held with some justification to distinguish the Saprolegniaceae and Peronosporales from the Ancylistales and Chytridiales.

In its curious emission of immotile infective structures from immotile sporangiospores the fungus would seem to provide a plausible transition between the *Achlya*-like diplanetism of *Ectrogella* and *Aphanomyopsis*, on the one hand, and the direct discharge of immotile infective sporangiospores in *Protascus subiliformis* Dangeard (4), a parasite destructive to nematodes, on the other. The existence of such a transitional type of asexual reproduction lends support to Maupas (16) and Maire (14) in their interpretation of the conical sporangiospores of *P. subiliformis* as bodies homologous to motile

Fig. 1.—*Haptoglossa heterospora*, drawn to a uniform magnification with the aid of a camera lucida; $\times 500$ throughout. A, B, C, D, Nematodes probably referable to *Rhabditis dolichura* Schneider, containing respectively 16, 5, 54, and 10 thalli of the fungus. E, Nematode, referable to *Cephalobus* sp., containing 10 thalli of the fungus. F, G, Specimens of *Acrobelloides bütschlii* (De Man) Thorne occupied respectively by 1 and 18 thalli of the fungus; owing to lack of space F is shown in three parts, which connect at the points *y* and *z*. H, Three neighboring thalli: *a*, in an early stage of transformation into a sporangium, showing two papillae of dehiscence; *b*, a sporangium, partly evacuated, within which the numerous retained spores have encysted; *c*, a sporangium showing in profile a papillar orifice through which many zoospores have been discharged, though a large number, too, have encysted within. I, J, K, Three small sporangia, each showing a papilla of dehiscence some little time previous to discharge of spores. L, Sporangium after partial emission of spores. M, Discharged spores of the usual smaller size, each of which has given rise to a lobate infective body. N, Sporangium with two papillae of dehiscence; its contents showing demarcation into spores of the larger size. O, Sporangium within which three spores of the larger size have germinated to form infective bodies. P, Spores of the larger size, each with an infective body attached to it. Q, Spores of the smaller size, showing different stages in the emission of infective bodies.

zoospores of the aquatic phycomyces. Indeed, the transitional type of sporangiospore development herein set forth may have been known to these authors, as Maupas took occasion to allude to "les spores, également immobiles, de mon *Ectrogella?* sp." I have not found any published account of the form to which this allusion applied, yet as it is recorded by his obituarist (22) that Maupas worked rather extensively on fungi parasitic on nematodes, the doubtful *Ectrogella* species may have been encountered as a parasite on eelworms, and may therefore have been a fungus related to, or perhaps even identical with, the one under discussion.

Achlyogeton entophytum Schenk and *A. rostratum* Sor., both reported by Sorokine (23) as being parasitic on nematodes, differ from my fungus in that their thalli become partitioned into somewhat distended segments, which, though functioning individually as sporangia, remain connected with one another. In their development the zoospores of *A. entophytum* reveal an *Achlya*-like diplanetism, except for the difference, if Schenk's account (20) is to be trusted, that the motile stage is uniciliate rather than biciliate. While Schenk's representations relative to the number of cilia are so much at variance with expectations that their correctness has been questioned, the observations of Martin (15) and Tokunaga (26) have corroborated the existence of a secondary motile stage; and it seems certain, at least, that in *A. entophytum* the zoospore protoplast does not remain attached to the empty cyst envelope as an immotile infective body.

Erection of a new genus, under a name compounded of two words meaning "to fasten" and "tongue," is made necessary by the curious development of the sporangiospores in the present fungus.

Haptoglossa gen. nov.

Thalli singuli vel complures in viva animalia crescentes, elongato-cylindrati vel elliptici, maturitate protoplasmatis dense granulosis repleti, omnino sporangia evadentes; sporangio uno vel aliquot tubis papillisve mox instructo, sporas inertes expellente; sporis inertibus a vesicula non circumdatis, quisque corpus planum inertem inficiens proferente.

Vegetative thalli elongate-cylindrical or ellipsoid in shape, developing singly or in variable numbers within living animals, at maturity filled with densely granular protoplasm and in their entirety becoming converted into sporangia; the individual sporangium provided with one or several evacuation tubes or evacuation papillae, through which ready-fashioned spores are forcibly expelled without formation of any enveloping vesicle; spores immotile and without cilia, each putting forth an immotile infective body, often of flattened lobate shape.

Haptoglossa heterospora sp. nov.

Thalli hyalini, elliptici vel elongato-cylindrati, 7-350 μ longi, 4-18 μ crassi; sporangiis 1-6 humilibus papillis praeditis, per 1-4 ora 4-7 μ lata dehiscensibus, aliis sporas 4.5-6 μ crassas aliis sporas 8-10 μ crassas eicientibus; sporis hyalinis, globosis vel rotundo-angulosis; corporibus inficientibus planis, 5-10 μ longis, a latere lobo lingulato curvato 3-8 μ longo apice attenuato instructis.

Vermiculos nematoideos multarum specierum enecans habitat in terra et humo silvestri et materiis plantarum putrescentibus in Maryland et Virginia et Wisconsin.

Vegetative thalli hyaline, ellipsoidal or elongate cylindrical, 7 to 350 μ long, 4 to 18 μ in transverse diameter; sporangia developing 1 to 6 short

broad papillae of which 1 to 4 may be functional in providing apertures of dehiscence mostly 4 to 7 μ wide. Spores hyaline, globose or with rounded angles, those produced in some sporangia 4.5 to 6 μ in diameter, those produced in other sporangia mostly 8 to 10 μ in diameter. Infective bodies flattened, consisting individually of an axial portion 5 to 10 μ long, together with a broad-based glossoid lobe mostly 3 to 8 μ long, more or less upcurved at its tapering end.

Destroying nematodes of many species, it occurs in soil, leaf mold, and decaying vegetable materials in Maryland, Virginia, and Wisconsin.

MERISTACRUM ASTEROSPERMUM

A conidial phycomycete manifestly related to the entomogenous Entomophthoraceae was observed destroying nematodes in some agar plate cultures to which had been added pinches of leaf mold taken from deciduous woods near Butternut, Wis., in September, 1938. Among the eelworms subject to destruction several species belonging evidently to the genera *Rhabditis*, *Aphelenchoides*, and *Plectus* could be distinguished.

Infection is accomplished by the fungus in question through the germination of a conidium or of several conidia attached to the integument of a susceptible animal, most often toward its anterior end (Fig. 2, A, B, C). Usually the means of attachment is clearly visible in a sizable deposit of adhesive material between spore and integument. The proximal portion of the germ tube—the portion most directly concerned in penetration of the integument—is commonly set off from its distal continuation within the fleshy interior by yellow coloration and somewhat irregular thickening of its wall. When the invading element has attained a length of approximately 10 μ , it widens abruptly to form a terminal swollen body, in which the protoplasmic contents of the conidium and infection tube then migrate. The swollen body thereupon continues its development by extending itself lengthwise through the animal as a stout assimilative hypha or thallus. Progressive destruction of musculature leads to increasingly pronounced disablement of the eelworm, and finally to its death. Vegetative growth of the assimilative hypha comes to an end only when the digestible contents of the host have been completely appropriated.

Early in the course of an epizootic within a petri-dish culture, infection of nematodes by single conidia is more frequent than infection by plural conidia. Later, as conidia of the fungus become more abundant, plural infection, with resultant development of two (Fig. 2, B, C, D), three, or four thalli, tends to predominate. On conclusion of their vegetative growth the assimilative hyphae, with the exception of occasional small specimens, undergo division into a number of segments, which appear rather obviously homologous to the "hyphal bodies" familiar in the entomogenous genera *Empusa* and *Entomophthora*. Division in each instance is accomplished by deposition of a cross wall (Fig. 2, D, b, c) and subsequent disarticulation of the delimited parts. The thallic segments may be elongate-ellipsoidal (Fig. 2, D, a, e), or somewhat curved-cylindrical (Fig. 2, D, b, c, g); or, again, may have a more irregular shape with bulging expansions (Fig. 2, D, f) or short diverticulate lobes (Fig. 2, D, d).

Asexual reproduction may be considered to begin when the individual thallic segment puts forth a hypha, about 3.5 to 5 μ wide, that after emerging from the enveloping host integument grows through the overlying medium (Fig. 2, E, F) out into the air. If the host animal has succumbed deep in the medium, the outgrowing hypha often needs to make its way

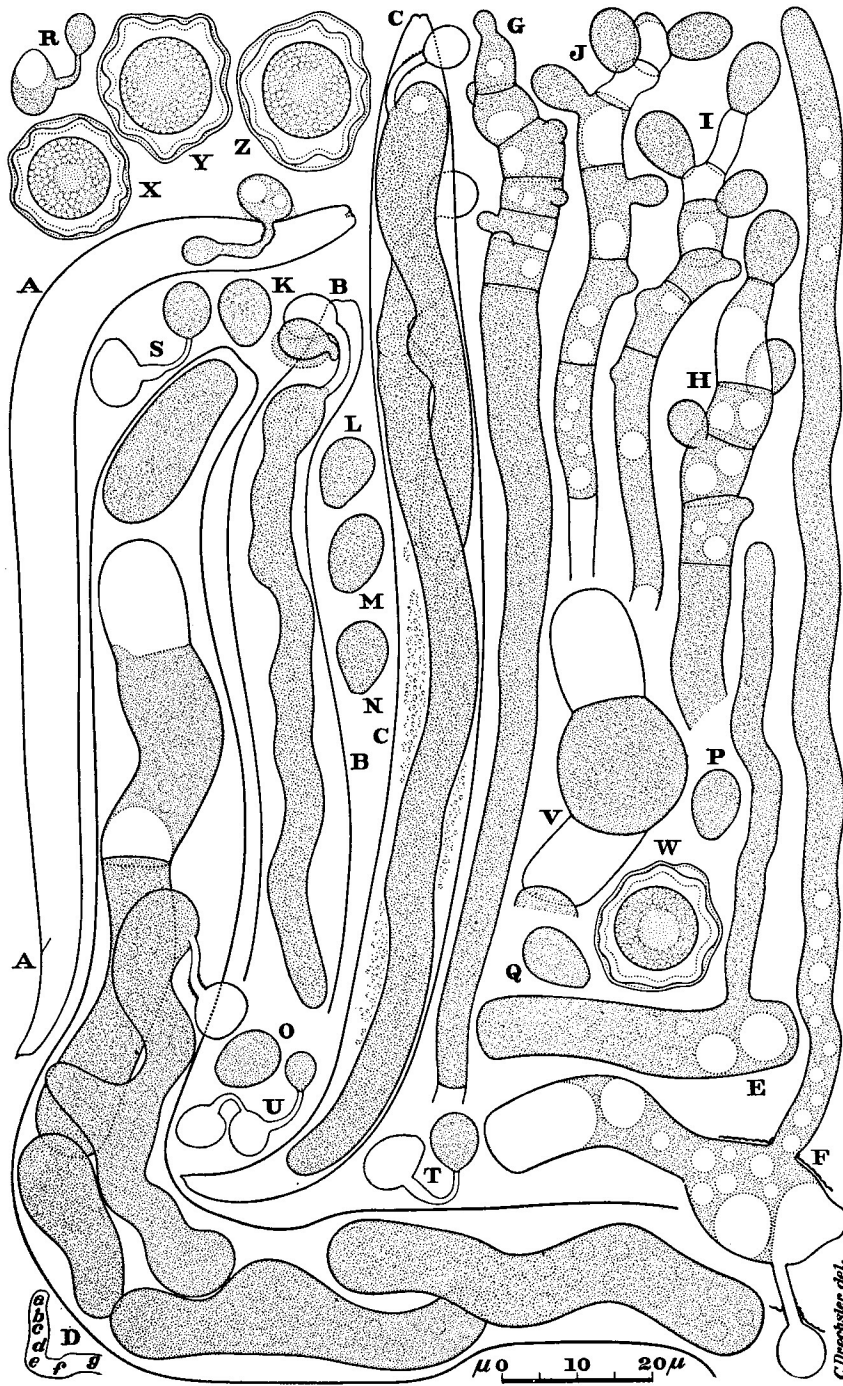


Fig. 2.—(See opposite page for explanation)

through solid material for a distance of 1 to 3 mm; whereas if the animal happened to die on the surface the hypha may extend itself into the air immediately. The aerial hypha or aerial prolongation, usually less than 0.5 mm in length, widens out perceptibly in its distal portion, and rather commonly is disposed here in a helicoid spiral of two, three, or four turns (Fig. 3, A). Into this somewhat modified terminal portion of hypha is soon transferred all the protoplasm from the entire thallic or reproductive unit. Transverse septa are now laid down in basipetal succession, dividing the densely filled hyphal termination into cells of approximately equal protoplasmic content. After a bud has been put forth terminally from the apical cell, a similar bud is put forth laterally in basipetal succession from each of the lower cells (Fig. 2, G), each of the buds receiving the entire protoplasmic contents of the parent cell (Fig. 2, H, I, J), and then being delimited by a basal septum as an obovoid conidium (Fig. 2, K-Q). Detachment of the conidia appears to ensue spontaneously soon after they attain full development. Once they lie on the surface of the medium they are ready to adhere to any susceptible nematode that may come in contact with them; such adhesion then inaugurating another sequence of endoparasitic and reproductive development. However, when opportunity for infection is not presented within a certain period of time, the detached conidium gives rise to a secondary conidium closely resembling the primary one except for its somewhat smaller size (Fig. 2, R, S, T). The secondary spore is regularly borne aloft a few microns above the surface of the medium by means of a delicate filament often more or less prostrate in its proximal portion, but ascending or erect in its distal portion. Through development similar to that whereby it originated a secondary conidium may in turn give rise to a tertiary one (Fig. 2, U).

Frequently a thallic segment, instead of putting forth a conidiophorous filament, forms a resting spore. By continued enlargement of a vacuole at each end of the segment (Fig. 2, D, b) the granular materials are brought together into a globose mass, which then lays down two somewhat convex end walls to form a subspherical cell (Fig. 2, V). The densely granular contents of this cell now are converted into an endogenous spore that is provided with a separate wall of its own. This wall appears prominently scalloped in profile, and only rather loosely surrounds the coarsely granular subspherical

Fig. 2.—*Meristacrum asterospermum*, drawn to a uniform magnification with the aid of a camera lucida; $\times 1000$ throughout. A, Specimen of *Plectus communis* Bütschli showing early stage of infection by a germ-tube from an adhering conidium. B, Anterior portion of a specimen of *Rhabditis dolichura* with two adhering conidia, one of which has given rise to a growing vegetative thallus in the animal. C, Parasitized nematode, possibly referable to *Aphelenchoides* sp., the contents of which have been almost completely appropriated by two thallii. D, Portion of a specimen of *R. dolichura* containing seven thallic segments of the fungus, a-g; one of these segments, b, which is not yet separated from its neighbor c, shows an early stage in the development of an azygospore; the other segments, a, c-g, subsequently put forth conidiophorous filaments. E, Thallic segment from which a conidiophorous filament is being put forth. F, Thallic segment (with envelope of empty spore attached) likewise with an elongating conidiophorous filament. G, Sporiferous termination of conidiophorous filament, showing basipetal deposition of septa, and early stage in the budding forth of conidia from the delimited cells. H, I, J, Later stages in formation of conidia. K-Q, Disarticulated primary conidia. R, Primary conidium in process of producing a secondary conidium. U, Empty envelopes of a primary and a secondary conidium shown attached to a tertiary conidium. V, Same thallic segment as D, b, but at a later stage, showing delimitation of the sporangial cell within which an azygospore is to be produced. W-Z, Mature azygospores, each within its sporangial wall.

protoplast, in which, on advancing maturity, a homogeneous central reserve globule may be distinguished (Fig. 2, W-Z).

With respect to the disposition of the membrane and contents of its resting spores the fungus shows striking similarity especially to the members of the genus *Endocochlus* (7), in the Zoopagaceae. Although in the few known species of *Endocochlus* the resting spores are always formed as a result of sexual union between portions of separate thalli, development of azygospores in a manner inviting comparison with the fungus under discussion is present in at least one member of the Zoopagaceae, namely in *Zoopage cladosperma* Drechsler (7). Resemblance to the genus *Endocochlus* is expressed also in the production of conidia by individual segments delimited through deposition of cross walls in aerial hyphae. This parallelism in asexual reproduction may well be of taxonomic significance despite some divergence in outward morphology apparent not only in the widening of the sporiferous termination, but also in its helicoid modification. The fungus under discussion shows further similarity to many endoparasitic Zoopagaceae in the frequently rather extended migration of its protoplasm from deeply immersed thallic segments to the aerial terminations of its conidiiferous hyphae.

However, if the granular consistency and ready mobility of its protoplasm are considered together with the division and disarticulation of its vegetative hyphae into disconnected segments, the fungus appears more intimately akin to the Entomophthoraceae than to the Zoopagaceae. The indeterminate elongation of its conidiophorous filaments finds a close parallel in the indeterminate extension of external hyphae from the intramatrical mycelial segments in species of *Ancylistes*, a genus recently shown by Berdan (2) to be properly referable to the Entomophthoraceae. In their obovoid shape the conidia of the fungus reveal a very obvious similarity to those of many species of *Empusa* and *Entomophthora*. Often, besides, a fully developed conidium was seen to be attached to a dome-shaped protrusion of the parent cell; and the denuded empty conidiiferous cells were nearly always found badly collapsed, much like conidiophores of *Conidiobolus villosus* Martin some time after their energetic discharge. Although these details indicate a parallelism with the genera in the Entomophthoraceae known for their forcible projection of conidia, I did not succeed in demonstrating that the fungus under discussion likewise discharges its asexual spores forcibly. It seems probable, however, that the primary conidia are actively propelled, though with much less violence than in species of *Empusa*, *Entomophthora*, and *Conidiobolus*. The secondary and tertiary conidia are almost certainly never shot away, but are produced and held in slightly elevated positions, where opportunity for contact with nematodes given to surface locomotion appears especially favorable.

In the Entomophthoraceae the fungus is distinguished from those hitherto made known by its production of plural conidia, for the most part laterally, on a multiseptate conidiophore. It is accordingly described as the type of a new genus of that family. A term compounded of two words meaning "divided" and "tip" respectively, is deemed an appropriate name for the genus. The sculpturing of its azygospore wall suggests for the fungus a specific epithet made up from two words meaning "star" and "seed," respectively.

Meristacrum gen. nov.

Hyphae assumentes intra animalia viva crescentes, simplices vel non-nihil ramosae, primo continuae, postea—animali emortuo et carne ejus consumpto—in aliquot partes se diffidentes; his partibus disjunctis aut

hyphas fertiles emittentibus aut sporas perdurantes (zygosporas vel azygosporas) gignentibus; hyphis fertilibus in aere se porrigentibus, sursum protoplasmatis repletis, ibi primo continuis, deinde transverse multiseptatis, ex quaque cellula conidium proferentibus.

Vegetative hyphae developing within living animals, simple or somewhat branched, at first continuous, later (after death of the animal and exhaustion of its fleshy contents) often dividing into disjointed segments, which either put forth conidiophorous hyphae or give rise to resting spores (zygospores or azygospores); the individual conidiophorous hypha extending some distance into the air, in its densely filled terminal portion becoming divided by transverse septa into a number of cells, each of which then produces a single conidium.

***Meristacrum asterospermum* sp. nov.**

Hyphae assumentes hyalinae, simplices vel parvulum ramosae, saepius 50–500 μ longae, 5–12 μ crassae, in articulos disjunctos plerumque 25–30 μ longos se diffidentes; quoque articulo mox utrimque rotundato, aut unam hypham fertilem emittente aut unam azygosporam gignente; hyphis fertilibus saepe 0.5–3 mm longis, 200–500 μ in aere se porrigentibus, parte propiore saepe immersa 3–5 μ crassa mox vacua et sparsum septata, parte posteriore aerea saepius in spiram levem contorta, 6–9 μ crassa, primo protoplasmatis repleta, continua, deinde in 5–15 cellulas 4–20 μ longas divisa quae singula conidia proferunt. Conidiis hyalinis, obovoideis, plerumque 8–11 μ longis, 6–8 μ crassis, modo singulas hyphas germinationis circa 10 μ longas, 1.5 μ crassas in vermiculum nematoideum intrudentibus, modo quoque unum conidium ordinis secundi ex hypha germinationis assurgente 5–10 μ longa, basi circa 2 μ et apice 0.8 μ crassa ferente. Azygosporiis hyalinis vel flavidulis, globosis, circa 15–20 crassis, maturitate membrana late verrucosa vel undulata cellulam viventem sphaeroideam 11–14 μ crassam laxè circumdante.

Vermiculos nematoideos enecans habitat in humo silvestri prope Butternut, Wisconsin.

Vegetative hyphae hyaline, simple or slightly branched, mostly 50 to 500 μ long, 5 to 12 μ wide, when well developed dividing into segments 25 to 60 μ long; the thallic segments becoming rounded at their ends, each putting forth a single conidiophorous filament or giving rise to a single azygospore. Conidiophorous filaments mostly 0.5 to 3 mm long, usually extending 200 to 500 μ into the air; the proximal part usually 3 to 5 μ wide, soon becoming empty and septate at long intervals; the distal prolongation, often 6 to 9 μ wide and noticeably disposed in a helicoid spiral, becoming divided through basipetal deposition of transverse cross walls into 5 to 15 cells, mostly 4 to 20 μ long, each of which by budding gives rise to a single sessile, hyaline, obovoid conidium, 8 to 11 μ long and 6 to 8 μ wide. Conidium after disarticulation often adhering to a nematode, then thrusting into it an infective germ tube, about 10 μ long and 1.5 μ wide, which develops into a vegetative hypha; or, failing to adhere to a nematode, giving rise on an ascending sporophore, 5 to 10 μ long, 2 μ wide at the base, and 0.8 μ wide at the tip, to a somewhat smaller secondary conidium. Azygospore loosely contained within the wall of its parent cell, colorless or slightly yellowish, subspherical, 15 to 20 μ in diameter, its pronouncedly undulated wall loosely enveloping a subspherical protoplast 11 to 14 μ in diameter.

Parasitic on nematodes it occurs in leaf mold in deciduous woods near Butternut, Wis.

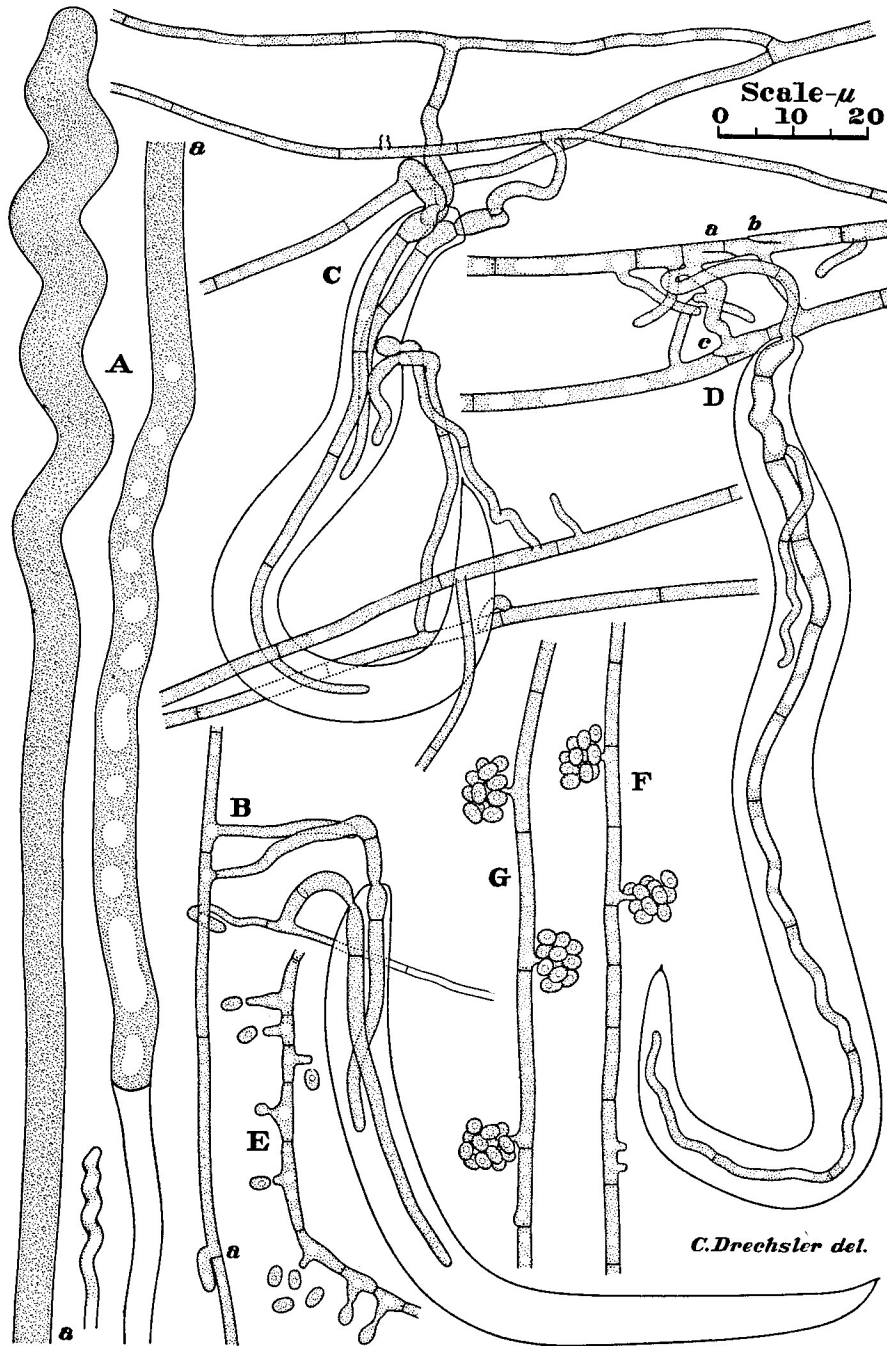


Fig. 3.—(See opposite page for explanation)

CEPHALOSPORIUM sp.

A fungus subsisting on eelworms, yet hardly deserving to be considered either predaceous or vigorously parasitic on these animals, was observed in a few nematode-infested agar cultures to which had been added some pinches of partly decayed tobacco leaves (*Nicotiana tabacum* L.) from a greenhouse near Beltsville, Md. In these cultures it apparently obtained its nourishment exclusively from specimens of *Plectus communis* Bütschli and *P. parvus* Bastian that had become disabled as a result of extensive infection by a protozoan endoparasite producing minute subspherical spores. When a disabled animal was halted near mycelial hyphae of the fungus, these hyphae would send out one or several branches, which soon perforated its integument and intruded a corresponding number of haustorial elements (Fig. 3, B, C, D). In most instances of plural penetration only one or two of the haustorial elements attained extensive development, apparently because the fleshy contents of the eelworm had already in large part been appropriated by the protozoan. Similar restriction of hyphal development within nematodes disabled and partly expropriated of contents by a protozoan parasite was noted earlier in my account (10) of the feebly predaceous *Tridentaria doedycoides* Drechsl.

Although its general habit recalls that of the more delicate species in the predaceous series of hyphomycetes, the fungus at present can neither be definitely assigned to nor excluded from that series. Its mycelial hyphae vary from 1 to 3μ in width. In addition to branches of indeterminate length, they bear here and there short spurlike branches that are often more or less appressed to the parent filament (Fig. 3, B, a). Ordinary cross walls occur in the mycelial hyphae at moderate intervals, and are supplemented by curiously oblique partial septa, which sometimes appear alone (Fig. 3, D, b), and at other times occur united to partial cross walls (Fig. 3, D, a, c). Infective branches are often noticeably stouter than the filaments from which they arise. The haustorial hyphae are often wider in their proximal portions than in their distal prolongations.

Hyaline ellipsoidal spores, commonly 2.5 to 3μ long and 1.5 to 2μ wide, are produced by the fungus on tapering branches, mostly 1.5 to 4μ long, and 1 to 2μ wide at the base. Owing, perhaps, to repeated disturbance by nematodes, these spores, when developed on the surface of a culture, show only a very promiscuous arrangement (Fig. 3, E); whereas in submerged and consequently better protected positions they are found in capitate clusters numbering ten to twenty individuals (Fig. 3, G, F). They have never been observed to infect nematodes, yet their small size would seem to make them incapable of giving rise to mycelia of such extent that disabled eelworms

Fig. 3.—Drawn to a uniform magnification with the aid of a camera lucida; $\times 1000$ throughout. A, Sporiferous termination of a conidiophorous filament of *Meristacrum asterospermum*, showing its distal disposition in an extended helicoid spiral. B, Specimen of *Plectus communis* which, after its disablement by a protozoan parasite, is being invaded besides by two hyphae of *Cephalosporium* sp.; a, a short spurlike hyphal branch. C, Another disabled specimen of *P. communis*, penetrated by five hyphal branches of *Cephalosporium* sp. D, Specimen of *P. parvus* Bastian, disabled by protozoan parasite and then further invaded by a branching filament of *Cephalosporium* sp.; a-c, three oblique partial septa. E, Superficial hypha of *Cephalosporium* sp. with several spore-producing sterigmata. F, G, Submerged filaments showing clusters of spores at the tips of lateral sterigmata. (Owing to lack of space, A is shown in two parts, which are connected in a. The small sketch, in which the lower portions of the successive turns are stippled, is intended to show more clearly the direction of rotation in the helicoid termination.)

might become a likely source of nourishment. These circumstances suggest that the *Cephalosporium* stage present here may constitute an accessory reproductive phase in the development of the fungus, rather than its main conidial phase.

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