

## SOME HYPHOMYCETES THAT CAPTURE EELWORMS IN SOUTHERN STATES

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(WITH 6 FIGURES)

Three clampless nematode-capturing hyphomycetes that came to light in Petri plate cultures planted with small quantities of decaying vegetable material obtained from Florida and Louisiana during the winter of 1952-1953 are herein described as new members of the genera *Arthrobotrys* Corda and *Dactylella* Grove. As these fungi were not observed in the numerous cultures I prepared during the last 20 years with slowly decomposing detritus from the District of Columbia and from various localities in the adjacent regions of Maryland and Virginia, there is reason to presume that their distribution in the United States extends mainly in our more southern latitudes. In capturing eelworms one of the three species employs solitary adhesive cells which, unlike the stalked adhesive cells of several related species described earlier, are attached directly to the mycelial hyphae. Adhesive cells of similar positional relationship are made known also in an amoeba-capturing fungus that from its commonplace cross-walls would seem referable to the same predacious series.

### *Arthrobotrys anchonia* sp. nov.

Mycelium saepe sparsum; hyphis hyalinis, ramosis, mediocriter septatis, plerumque 2-5  $\mu$  crassis, hic illic ex ramulis bilocularibus 7-15  $\mu$  (raro usque 25  $\mu$ ) longis et 4-6  $\mu$  crassis laqueos circulares 20-42  $\mu$  latos ferentibus qui in 3 cellulis arcuatis consistunt et aperturam rotundam vel rotundo-triangularam 12-32  $\mu$  latam circumdant; cellulis arcuatis 15-35  $\mu$  longis, extremo 2.8-4.7  $\mu$  crassis, medio 4-7.5  $\mu$  crassis; vermiculo nematoideo in laqueum apertum errato omnibus tribus cellulis abrupte se contrahentibus, animal magnopere comprimentibus, id ita necantibus, integumentum ejus perforantibus, hyphas intus evolventibus quae carnem exhauriunt; hyphis assummentibus mox mediocriter septatis, ex magna parte 2.5-4.2  $\mu$  crassis sed interdum in tubera 5-8  $\mu$  crassa abeuntibus. Hyphae fertiles incoloratae, erectae, saepius 3-8-septatae, 350-500  $\mu$  altae, basi 4-6  $\mu$  crassae, sursum leniter attenuatae, prope apicem 2.5-3.5  $\mu$  crassae, apice usque 8 (saepe 3-5) conidia in uno capitulo

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ferentes; conidiis incoloratis, elongato-obovoideis, plerumque 29–43  $\mu$  (saepius circa 35  $\mu$ ) longis, 15–19  $\mu$  (saepius circa 16.8  $\mu$ ) crassis, raro biseptatis, vulgo uniseptatis denique cellula inferiore plerumque 8–18  $\mu$  (saepe circa 11.5  $\mu$ ) longa et cellula superiore plerumque 17–27  $\mu$  (saepe circa 23.5  $\mu$ ) longa.

Vermiculos nematoideos diversos capiens consumensque habitat in materiis plantarum putrescentibus prope Laplace, Louisiana, etiam in caulibus radicibusque *Phaseoli vulgaris* putrescentibus prope Fort Lauderdale, Florida.

Mycelium on nematode-infested substrata usually scanty, spreading; vegetative hyphae colorless, septate at moderate intervals, mostly 2 to 5  $\mu$  wide, often (especially in presence of nematodes) giving rise on straight or curving stalks to circular rings in perpendicular positions; the stalks 7 to 25  $\mu$  (commonly 7 to 15  $\mu$ ) long, 4 to 6  $\mu$  wide, usually composed of 2 unequal cells, the proximal cell 2 to 8  $\mu$  (mostly 2.5 to 5  $\mu$ ) long, the distal cell 5 to 17  $\mu$  (mostly 5 to 12  $\mu$ ) long; the rings, measuring 20 to 42  $\mu$  in diameter and surrounding a circular or rounded triangular aperture 12 to 32  $\mu$  wide, being regularly composed of 3 arcuate segments 15 to 35  $\mu$  long, 2.8 to 4.7  $\mu$  wide at the ends and 4 to 7.5  $\mu$  wide in the middle—the first and third segments being united to one another as well as to the end of the stalk; on entrance of a nematode into the aperture the arcuate cells contracting abruptly, all three indenting the animal broadly and deeply, thereby strongly constricting it and soon disabling it, then perforating its integument and extending through its body assimilative hyphae to appropriate its fleshy contents; the assimilative hyphae becoming septate at moderate intervals, for the most part 2.5 to 4.2  $\mu$  wide but often terminating in one or more bulbous enlargements or swollen cells 5 to 8  $\mu$  wide. Conidiophores colorless, erect, in later stages containing 3 to 8 cross-walls, 350 to 500  $\mu$  high, 4 to 6  $\mu$  wide at the base, tapering gradually upward to a width of 2.5 to 3.5  $\mu$ , at the tip often furnished with several short stout spurs on which are borne collectively 3 to 8 conidia in a handsome head; conidia colorless, elongate obovoid, mostly 29 to 43  $\mu$  (average 35  $\mu$ ) long, 15 to 19  $\mu$  (average 16.8  $\mu$ ) wide, rarely biseptate, usually uniseptate with the proximal cell commonly 8 to 18  $\mu$  (average 11.5  $\mu$ ) long and the distal cell commonly 17 to 27  $\mu$  (average 23.5  $\mu$ ) long.

Capturing and consuming nematodes of different species, it occurs in decaying plant residues near Laplace, Louisiana, and also in decaying stems and roots of *Phaseolus vulgaris* L. near Fort Lauderdale, Florida.

The bean (*Phaseolus vulgaris*) material from which *Arthrobotrys anchonia* was obtained came from young plants affected with basal stem rot and root rot, which were collected in southern Florida on January 13, 1953. When portions of softened cortex from the diseased seedlings were placed on Petri plates of maize meal agar, mycelium of several species of *Pythium*, including especially *P. spinosum* Sawada, grew out promptly over the substratum. Soon the cultures became abundantly

infested with eelworms. About 10 days after the cultures had been started these animals began to suffer wholesale destruction by predacious hyphomycetes. In the beginning the eelworms were captured for the most part in the adhesive networks of *A. oligospora* Fres. and *A. musiformis* Drechsl. (3: 477-482). Somewhat later—in many instances about 15 days after the cultures were prepared—hyphae furnished with constricting rings were found spreading through the agar substratum, with the result that an increasing proportion of nematodes subsequently succumbed in the strangulating organs. Some tracts of annulated mycelium ultimately gave rise to conidiophores with solitary heads of slender uniseptate conidia typical of my *A. dactyloides* (3: 482-487), while other tracts produced conidiophores with solitary heads of conidia which, though also uniseptate, were markedly widened at the distal end, so that with respect to shape they seemed generally intermediate between the obovoid conidia of *A. oligospora* and the tapering obconical conidia of my *A. conoides* (3: 473-477).

The more robust form developed also in more than a dozen maize-meal agar plate cultures that after being overgrown by *Pythium ultimum* Trow had been further planted with small quantities of decaying vegetable detritus collected on December 20, 1952, near Laplace, Louisiana. In these cultures it again made its appearance rather tardily, after the number of infesting nematodes had been greatly reduced through capture by *Dactylaria haptospora* Drechsl. (4: 456-461), a knob-bearing species apparently very abundant in southern Louisiana, and by the familiar retiary species *A. oligospora*, *A. conoides*, and *A. musiformis*. As in the cultures prepared with Florida material it sometimes formed conidial apparatus at no great distance from *A. dactyloides*, though among strangulating species it was accompanied most often by my *Dactylella aphrobrocha* (8: 12-22). When its obovoid conidia were removed from the lofty conidiophores by touching them with a slab of sterile agar held on a flamed platinum spatula, and were then transferred to tubes of sterile maize-meal agar, pure cultures were readily obtained.

Growing undisturbed on maize-meal agar in the absence of alien organisms *Arthrobotrys anchonia* ordinarily produces a septate mycelium wholly devoid of predacious organs. If a block of agar permeated with such commonplace mycelium is removed to a Petri plate culture well infested with eelworms the new hyphae soon extended radially from the transferred mass will form constricting rings at intervals some distance backward from the advancing tip. The rings and their supporting stalks, as in other constricting species, are developed in planes at ap-

proximately right angles to the parent hyphae (FIG. 1, *A-C*; FIG. 2, *A, B*). Accordingly, in their original positions, they most often are directed edgewise to the observer, so that their cellular make-up is not well displayed. Their structure is shown more advantageously when they have been pushed sideways (FIG. 2, *C*) by passing eelworms, and is most clearly revealed in the occasional instances where under the impact of robust nematodes they have been hustled into nearly horizontal positions (FIG. 1, *D-K*; FIG. 2, *D, E*). Viewed flatways the rings strongly resemble those of *A. dactyloides* and *Dactylaria brochopaga* Drechsl. (3: 514-518). As in these species the two-celled stalk is of the relatively short, stout type wherein the basal cell is generally shorter than the distal cell, rather than of the longer slender type usual in *Dactylella aphrobrocha* and *Dactylella heterospora* Drechsl. (5), where the basal and distal cells are of approximately equal length. Because of considerable variability in the relative position of the septum dividing the stalk in *A. anthonia*, the basal cell here is sometimes scarcely one-third (FIG. 1, *D*; FIG. 2, *A, E*) and sometimes is more than one-half (FIG. 1, *I*) the length of the distal cell. Its length sometimes is greater (FIG. 1, *I*; FIG. 2, *D*) and sometimes is noticeably less (FIG. 1, *F, H*; FIG. 2, *A, B, C, E*) than its width. It is, however, not usually shortened as pronouncedly as the proximal stalk-cell of my *Dactylella bembicodes* (3: 487-492), which sometimes is found reduced to a comparatively thin plano-convex disc.

In *Arthrobotrys anthonia*, much as in *A. dactyloides*, the three arcuate cells that make up the constricting ring have no median protrusion on the side bordering the aperture, so that the aperture lacks the trefoil modification present, for example, in the predacious organs of *Dactylella heterospora*. Here and there rings may be found to have closed emptily (FIG. 1, *L*), but as a rule closure takes place in effecting capture of an eelworm (FIG. 2, *F, a, b*). After its integument has been narrowly perforated the hapless captive is invaded forward and backward by one or more assimilative hyphae (FIG. 1, *M, N*; FIG. 2, *G, H*). These hyphae, as in *A. dactyloides*, often become enlarged at the tip. In some instances not only the terminal segment, but also the penultimate segment undergoes marked enlargement (FIG. 1, *M*). Gradually all fleshy parts of the nematode disappear. The assimilative hyphae show increasing vacuolation and are progressively emptied as the protoplasmic contents migrate backward through the cells of the contracted ring and its stalk into the parent hypha. Ultimately these cells are in turn evacuated, and their membranous envelopes, like those of the assimilative hyphae and like the animal's integument, vanish from sight, leaving

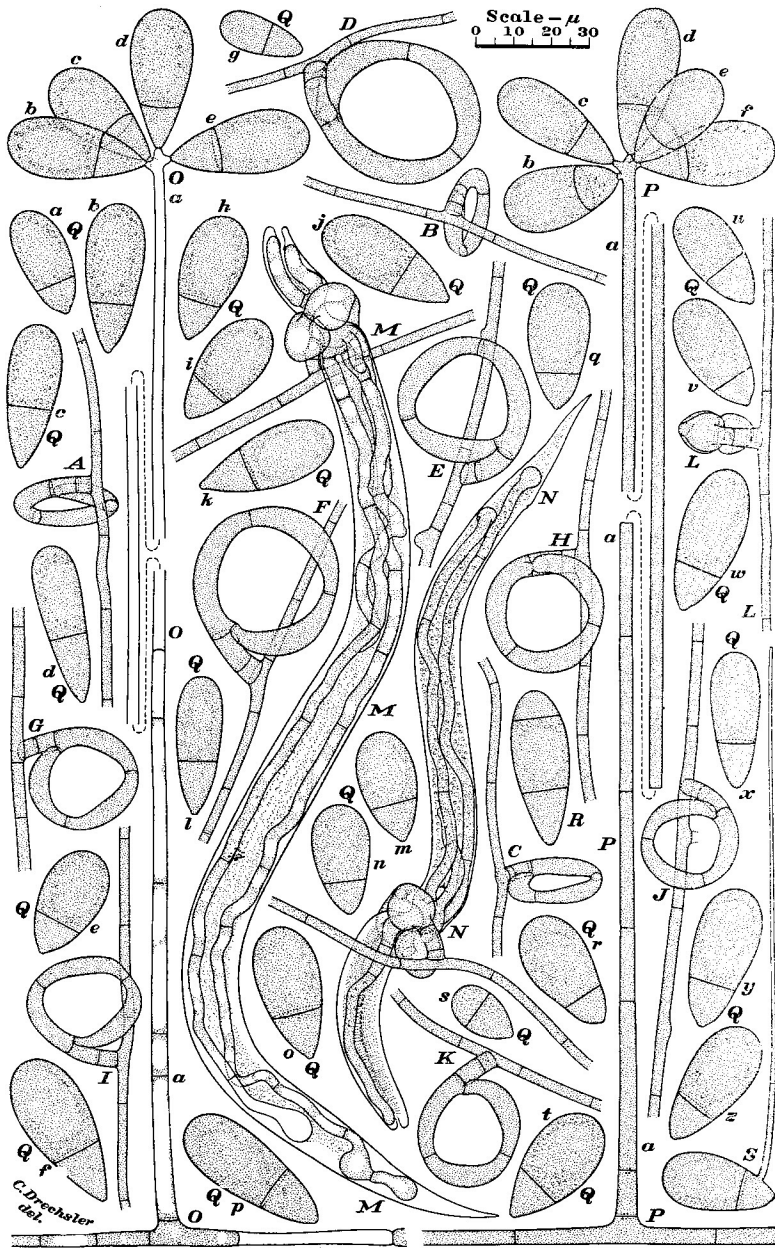


FIG. 1. *Arthrobotrys anchonia* as found in nematode-infested maize meal-agar culture;  $\times 500$ . A-C, Portions of hyphae, each bearing an open constricting ring in normal posture. D-K, Portions of hyphae, each with an open constricting ring

only a slightly protuberant irregularity in the contour of the mycelial filament to mark the earlier attachment of a constricting ring that had operated successfully in the destruction of prey.

Thus nourished through the capture of eelworms the fungus gives rise from procumbent mycelial filaments to erect conidiophores which sometimes attain a height of 0.5 mm, but more often are found measuring 0.4 to 0.45 mm in length. The individual conidiophore (FIG. 2, *I*, *a*) first produces a single conidium (FIG. 2, *I*, *b*) on its tip. In some instances no further development ensues, but much more often additional conidia are produced on short stubby spurs (FIG. 2, *J*), so that many conidiophores (FIG. 1, *O*, *a*; *P*, *a*) eventually bear aloft 4 (FIG. 1, *O*, *b-c*) or 5 (FIG. 1, *P*, *b-f*) conidia in a handsome cluster. Heads of 6, 7, or 8 conidia are formed less often, or, at least, were less frequent in my cultures. As in *A. dactyloides* and *A. musiformis* the conidiophores of the fungus are not given to repeated elongation, but regularly terminate their development with the formation of a single spore cluster.

Because of similarities in its monocephalous sporulating habit as well as in the morphology of its predacious rings *Arthrobotrys anchonia* must be held related most closely to *A. dactyloides*, though, as has been noted, its distally widened, somewhat obovoid conidia (FIG. 1, *Q*, *a-z*. FIG. 2, *K*, *a-z*; *L*, *a-e*) are reminiscent rather of *A. oligospora* and *A. conoides*. Parallelism with the latter two species and divergence from *A. dactyloides* are evident not only in the outward shape of its conidia but also in their unequal partitioning into a small basal cell and a much larger distal cell. According to the metric data given in the diagnosis the distal cell in *A. anchonia* would seem about twice as long as the basal cell; and further, on the average, would seem twice the width of the distal cell in the medially uniseptate conidia of *A. dactyloides*. The metric data in question were derived from measurements of 100 conidia selected at random in mounts prepared from nematode-infested agar plate cultures. The 100 measurements for length, expressed in the nearest integral number of microns, were distributable as follows: 29  $\mu$ , 2; 30  $\mu$ , 2; 31  $\mu$ , 4; 32  $\mu$ , 11; 33  $\mu$ , 12; 34  $\mu$ , 14; 35  $\mu$ , 16; 36  $\mu$ , 8; 37  $\mu$ ,

turned flatwise to the observer. *L*, Portion of hypha with a constricting ring that has closed emptily. *M*, *N*, Portions of hyphae, each with a constricting ring that after closing on an eelworm (*Eucephalobus* sp.) has extended assimilative hyphae through the captive. *O*, Prostrate hypha with an erect conidiophore, *a*, that bears 4 conidia, *b-c*. *P*, Prostrate hypha with an erect conidiophore, *a*, which supports 5 conidia, *b-f*, in a head. *Q*, Detached uniseptate conidia, *a-z*, showing variations in shape, size, and position of cross-wall. *R*, Biseptate conidium. *S*, Conidium with slender filamentous aerial outgrowth. (Owing to lack of space *O* and *P* are shown in parts whose proper connection is indicated by broken lines.)

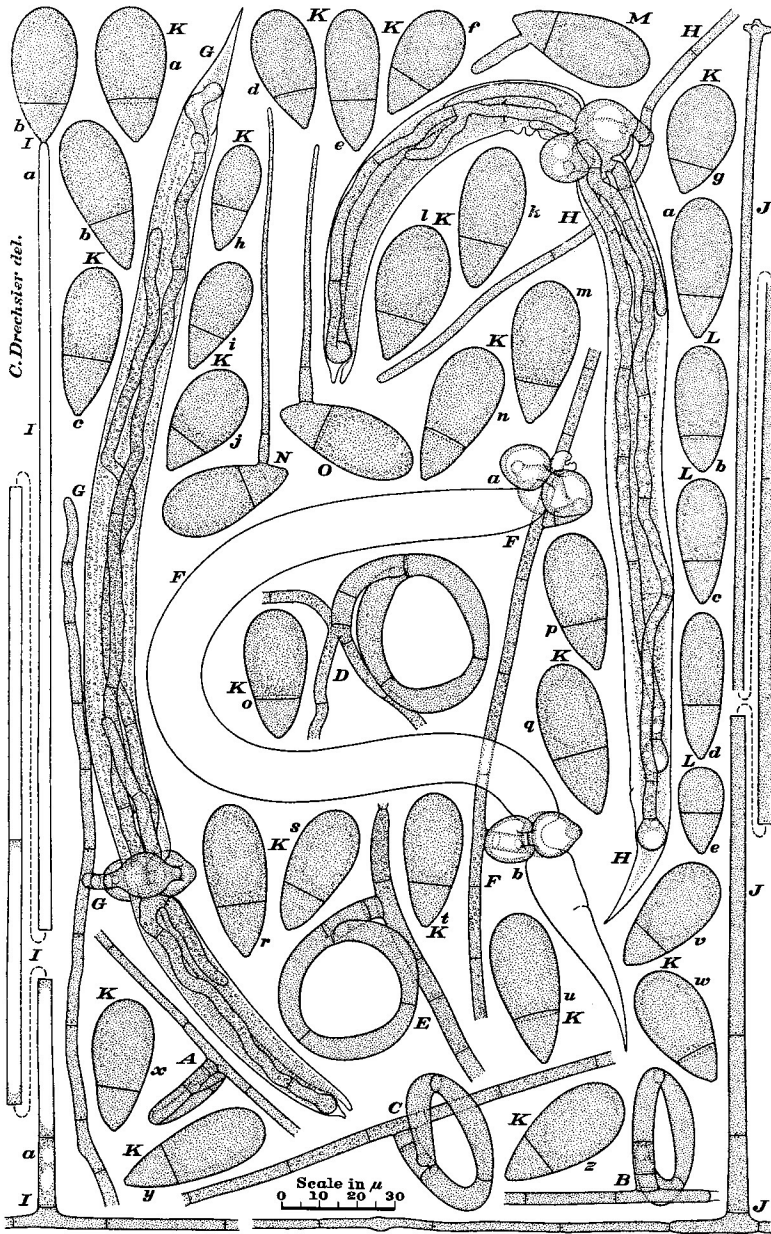


FIG. 2. *Arthrotrichs anchonia* as found in nematode-infested maize-meal-agar culture;  $\times 500$ . A, B, Portions of hyphae, each with an open constricting ring in normal posture. C, Portion of hypha with an open ring turned slightly sideways.

11; 38  $\mu$ , 13; 39  $\mu$ , 3; 40  $\mu$ , 2; 41  $\mu$ , 1; 43  $\mu$ , 1; while the measurements for greatest width were distributable thus: 15  $\mu$ , 5; 16  $\mu$ , 28; 17  $\mu$ , 46; 18  $\mu$ , 20; 19  $\mu$ , 1. When many hundreds of conidia were examined some exceptionally large individuals as much as 45  $\mu$  long, or as much as 20  $\mu$  wide, came under observation, together with some undersized individuals (FIG. 1, *Q*, *g*, *s*. FIG. 2, *K*, *h*; *L*, *e*) not greatly beyond the dimensional range of my *A. cladodes* (3: 459-464). A few biseptate specimens were also found, their 2 cross-walls usually delimiting a large median cell from a smaller basal and a smaller apical cell (FIG. 1, *R*).

These few biseptate spores, no less than the obovoid uniseptate conidia normally formed by *Arthrobotrys anchonia*, resemble somewhat the distended conidia produced now and then by *A. dactyloides* (3: 484-485, 537, f. 18, *K*, *a-p*). Production of distended conidia, however, can not well be considered typical of *A. dactyloides*, as it takes place only sparingly in nematode-infested cultures, though often occurring somewhat abundantly when robust mycelium of the fungus that has developed in pure culture on rich maize meal agar becomes heavily infested with mites. Yet production of distended conidia by *A. dactyloides*, even in meager quantity, would make difficult any recognition of *A. anchonia* as a separate species if the latter fungus were distributed, like the former, in our middle and northern latitudes as well as in our southern states.

Conidia of *Arthrobotrys anchonia* germinate readily on moist fresh substratum by putting forth one or more vegetative germ hyphae (FIG. 2, *M*). In aging cultures they often extend a slender outgrowth vertically in the air (FIG. 1, *S*; FIG. 2, *N*, *O*).

#### **Dactylella megalospora** sp. nov.

Mycelium effusum; hyphis sterilibus incoloratis, ramosis, mediocriter septatis, plerumque 2-6  $\mu$  crassis, saepe laqueos tenaces arcuatos vel circulares in reticula interdum conjunctos proferentibus; his laqueis reticulisque vermiculos nematoideos illaqueantibus, deinde tum integumentum animalis captivi anguste perforantibus,

*D*, *E*, Portions of hypha, each with an open ring turned flatwise. *F*, Portion of hypha with 2 rings, *a* and *b*, that have closed in capturing a single eelworm (*Eucephalobus* sp.). *G*, *H*, Portions of hyphae, each with a closed ring that holds a captured eelworm (*Eucephalobus* sp.); from each ring assimilative hyphae have been extended lengthwise through the captive. *I*, Prostrate mycelial hypha with an erect conidiophore, *a*, bearing a single conidium, *b*. *J*, Procumbent hypha with erect conidiophore denuded of its spores. *K* (*a-s*), *L* (*a-e*), Detached uniseptate conidia showing variations in size, shape, and position of cross-wall. *M*, Detached conidium from which a vegetative germ tube is being extended. *N*, *O*, Detached conidia, each with an erect slender filamentous aerial outgrowth. (Owing to lack of space *I* and *J* are shown in parts whose proper connection is indicated by broken lines.)



tuber mortiferum globosum intrudentibus, hyphas intus evolventibus quae carnem exhauriunt. Hyphis fertilibus incoloratis, erectis, simplicibus vel interdum breviter ramosis, plerumque 1-7-septatis, 150-450  $\mu$  altis, basi vulgo 6-8  $\mu$  crassis, sursum leniter attenuatis, prope apicem saepe 2-3  $\mu$  crassis, unum conidium vel interdum aliquot conidia ferentibus; conidiis incoloratis, late fusoides vel elongato-ellipsoideis vel obovoideis, plerumque 40-75  $\mu$  longis, 18-35  $\mu$  latis, 2-5-septatis, una cellula eorum (in late fusoides quadrisepatis solitariis conidiis saepissime cellula media) multo longiore et latiore quam aliis cellulis.

Vermiculos nematoideos capiens consumensque habitat in radicibus et caulibus *Phaseoli vulgaris* putrescentibus prope Fort Lauderdale, Florida.

Mycelium spreading; vegetative hyphae colorless, branched, septate at moderate intervals, mostly 2 to 6  $\mu$  wide, often (especially in the presence of nematodes) giving rise to arched or circular hyphal meshes, which, though at first discrete, are later frequently compounded into more or less extensive networks; the meshes and networks capturing nematodes through adhesion and entanglement, then narrowly perforating the integument of each captured animal and intruding one or more infective bodies of subspherical shape, from which are extended assimilative hyphae, mostly 2 to 5  $\mu$  wide, that appropriate the fleshy contents. Conidiophores colorless, erect, often containing 1 to 7 cross-walls, commonly 6 to 8  $\mu$  wide at the base, tapering gradually upward to a distal width of 2 to 3  $\mu$ , when developed on nematode-infested substratum usually 350 to 450  $\mu$  high, unbranched and bearing a single conidium, but when developed on an artificial nutrient substratum often only 150 to 250  $\mu$  high, and then frequently bearing mostly near the apex 1 to 5 spurs usually 10 to 40  $\mu$  long, on each of which, as on the axial tip, a conidium is produced. Conidia colorless, broadly fusoid or elongate-ellipsoidal or obovoid, mostly 40 to 75  $\mu$  long and 18 to 35  $\mu$  wide, commonly divided by cross-walls into 3 to 6 cells one of which greatly exceeds the others in length and width; the large cell somewhat variable in position, but occurring most often in median position in the especially distinctive large, broadly fusoid, quadrisepate conidia, frequently 55 to 75  $\mu$  long and 23 to 35  $\mu$  wide, that are produced singly on nematode-infested substratum.

Capturing and consuming motile nematodes, it occurs in decaying roots and stems of *Phaseolus vulgaris* near Fort Lauderdale, Florida.

The bean material to which reference is made in the foregoing diagnosis was taken from several diseased seedlings kindly collected by Dr. W. D. Moore in southern Florida on January 20, 1953. When the softened bean roots and bean stems were put on Petri plates of maize-meal agar, mycelium of my *Pythium myriotylum* promptly grew out in every instance. The resulting cultures permitted abundant multiplication of eelworms and thereby soon afforded opportunity for copious development of several predacious hyphomycetes, including *Arthrobotrys*

*oligospora*, *A. musiformis*, and *A. dactyloides*. After the eelworm population had suffered marked reduction, *Dactylella megalospora* somewhat belatedly came under observation. Its adhesive networks (FIG. 3, A), formed at wide intervals on long mycelial filaments, conformed closely to the more usual type of retiary apparatus exemplified in *A. oligospora*, showing no departures in design or dimensions such as distinguish the networks of *A. musiformis* and *Dactylaria polycephala* Drechsl. (3: 527–531). In *A. megalospora*, as in other retiary species, capture of eelworms was effected by entanglement and adhesion (FIG. 3, B). Narrow penetration of the captive's integument, intrusion of one or more infective bodies, and extension of assimilative hyphae lengthwise through the fleshy interior (FIG. 3, C) ensued in familiar sequence.

Evidently obtaining its nourishment wholly by the destruction of eelworms, *Dactylella megalospora* gave rise in the cultures started from Florida bean material to rather sparsely scattered conidiophores (FIG. 4, B, a; C, a) about 400  $\mu$  in height, each supporting aloft a single conidium (FIG. 4, B, b; C, b). The conidia thus produced were predominantly of broadly fusiform shape and most often consisted of 2 small proximal cells, a large dolioform median cell, and 2 small distal cells (FIG. 4, D–S). In their symmetry and cellular make-up they resembled especially the conidia of *Dactylella aphrobrocha* and *Dactylella coelobrocha* Drechsl. (7). With respect to outward form they appeared intermediate between the conidia of the two strangulating fungi, being prolonged at the narrowing basal and distal ends more strongly than the conidia of *D. aphrobrocha*, but less strongly than the conidia of *D. coelobrocha*. Twenty-five of the solitarily produced, quadrisepate conidia, selected at random, gave measurements for total length that ranged from 57.5 to 72  $\mu$ , and averaged 65.3  $\mu$ ; while the measurements for greatest width ranged from 24 to 35  $\mu$ , and averaged 30.8  $\mu$ . The component cells of the 25 spores gave measurements for length with ranges and averages as follows: basal cell, 9.4 to 13.5  $\mu$ , 11.2  $\mu$ ; parabasals, 5.2 to 7.3  $\mu$ , 6.3  $\mu$ ; median cell, 29.2 to 39.4  $\mu$ , 34.7  $\mu$ ; penultimate cell, 4.2 to 6.8  $\mu$ , 5.5  $\mu$ ; apical cell, 4.2 to 9.4  $\mu$ , 7.6  $\mu$ . The basal cell here clearly exceeded the apical cell in length, whereas in the quadrisepate conidia of *D. coelobrocha* the apical cell appears generally longer than the basal cell. Very often the delimiting wall at the relatively narrow, somewhat truncate basal end was found modified by a lump-like deposit of opaque material—a modification usually absent in allied species.

Conidia diverging from the predominant symmetrically quadrisepate type were not scarce in the nematode-infested cultures where *Dactylella megalospora* was first discovered. Triseptate specimens occurred there

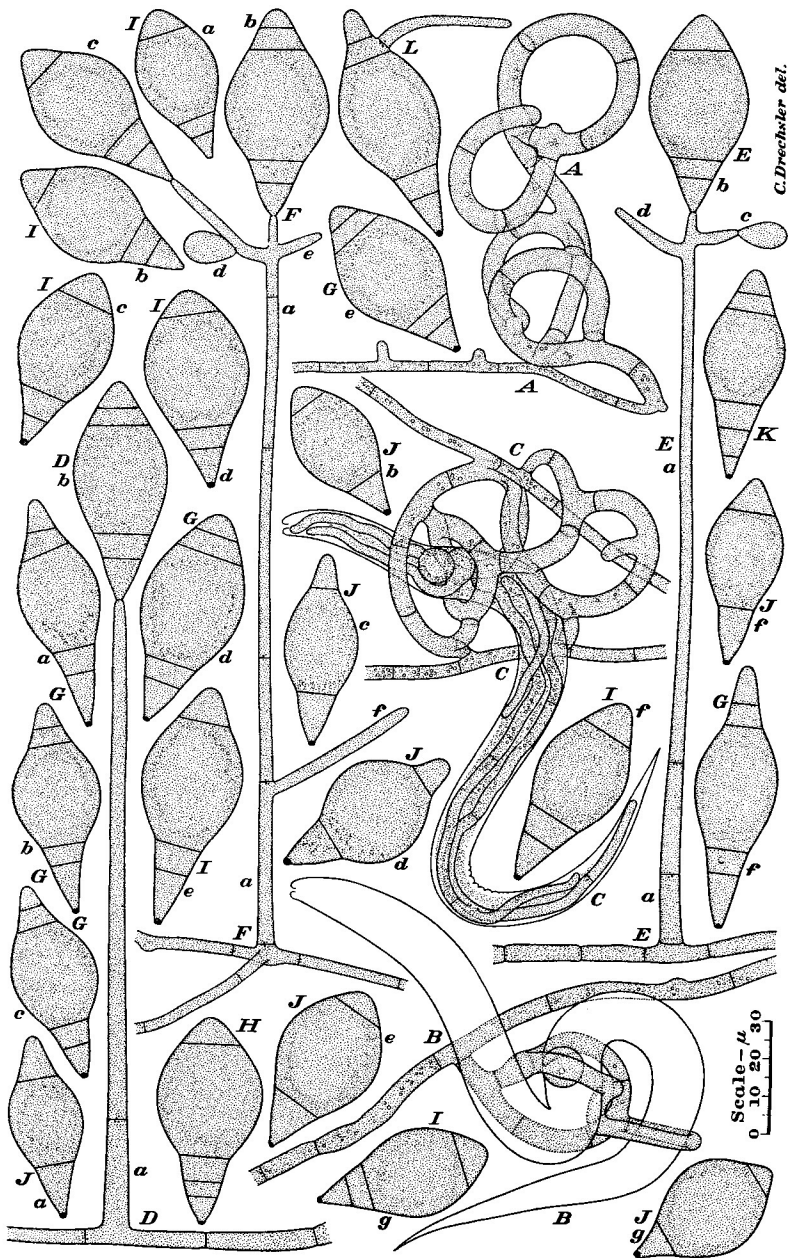


FIG. 3. *Dactylella megalospora* as found on nematode-infested substratum (A-C) and on slabs taken from maize meal agar cultures (D-L);  $\times 500$  throughout. A, Hyphal network of several meshes. B, Small hyphal network with a captured

in considerable numbers, some showing the distended cell in penultimate position (FIG. 4, *T*), others showing it in parabasal position (FIG. 4, *U*). Biseptate specimens also occurred, and in these the distended cells were sometimes found in terminal position (FIG. 4, *V*).

*Dactylella megalospora* was isolated without difficulty by removing its conidia from the tall conidiophores to tubes of sterile maize meal agar, the removal being accomplished by means of a sterile agar slab held on a flamed platinum spatula. In the absence of alien organisms the fungus generally elaborates no predacious networks. However, when blocks of agar well permeated with mycelium are excised from a pure culture and placed on nematode-infested substratum, adhesive meshes and networks will usually be formed not only on the new hyphae that soon grow out somewhat radially but also on many of the older hyphae (FIG. 4, *A*) that were present in the agar block at the time it was transferred.

The conidiophores produced by *Dactylella megalospora* in pure culture often attain only half the usual height of those developed in nematode-infested cultures. Some of these short conidiophores are unbranched (FIG. 3, *D, a*) and bear a single conidium (FIG. 3, *D, b*). Others (FIG. 3, *E, a; F, a*), in addition to bearing a conidium (FIG. 3, *E, b; F, b*) on the axial tip, produce one (FIG. 3, *E, c*) or more conidia (FIG. 3, *F, c, d*) on lateral spurs. Owing perhaps to the narrow attachment of the conidia many spurs (FIG. 3, *E, d; F, e, f*) are rather soon left denuded. In general the conidia formed in pure culture appear smaller and more variable with respect to size, shape, and septation than those formed on nematode-infested substratum. Their length commonly ranges from 40 to 60  $\mu$  and their width from 17 to 25  $\mu$ . The quadri-septate individuals among them, with the distended cell frequently in median (FIG. 3, *G, a-f*) or penultimate (FIG. 3, *H*) position, are sometimes not more numerous than the triseptate (FIG. 3, *I, a-g*) or biseptate (FIG. 3, *J, a-g*) individuals. Quinqueseptate individuals (FIG. 3, *K*) are produced only in small numbers. Detached conidia germi-

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eelworm into which a globose infective body has been intruded. *C*, Hyphal network with a captured eelworm showing 3 globose infective bodies from which assimilative hyphae have been extended forward and backward. *D*, Portion of hypha with a short unbranched conidiophore, *a*, bearing a single conidium, *b*. *E*, Portion of hypha with short conidiophore, *a*, bearing 2 conidia, *b* and *c*, as well as a denuded subapical spur, *d*. *F*, Portion of mycelium with short conidiophore, *a*, supporting 3 conidia, *b-d*, and 2 denuded spurs, *e* and *f*. *G*, Detached quadri-septate conidia, *a-f*, in which the median cell is largest. *H*, Quadri-septate conidium in which the penultimate cell is largest. *I*, Triseptate conidia, *a-g*, in which the penultimate cell is largest. *J*, Biseptate conidia, *a-g*, in which the median cell is largest. *K*, Quinqueseptate conidium in which the antepenultimate cell is largest. *L*, Germinating quadri-septate conidium.

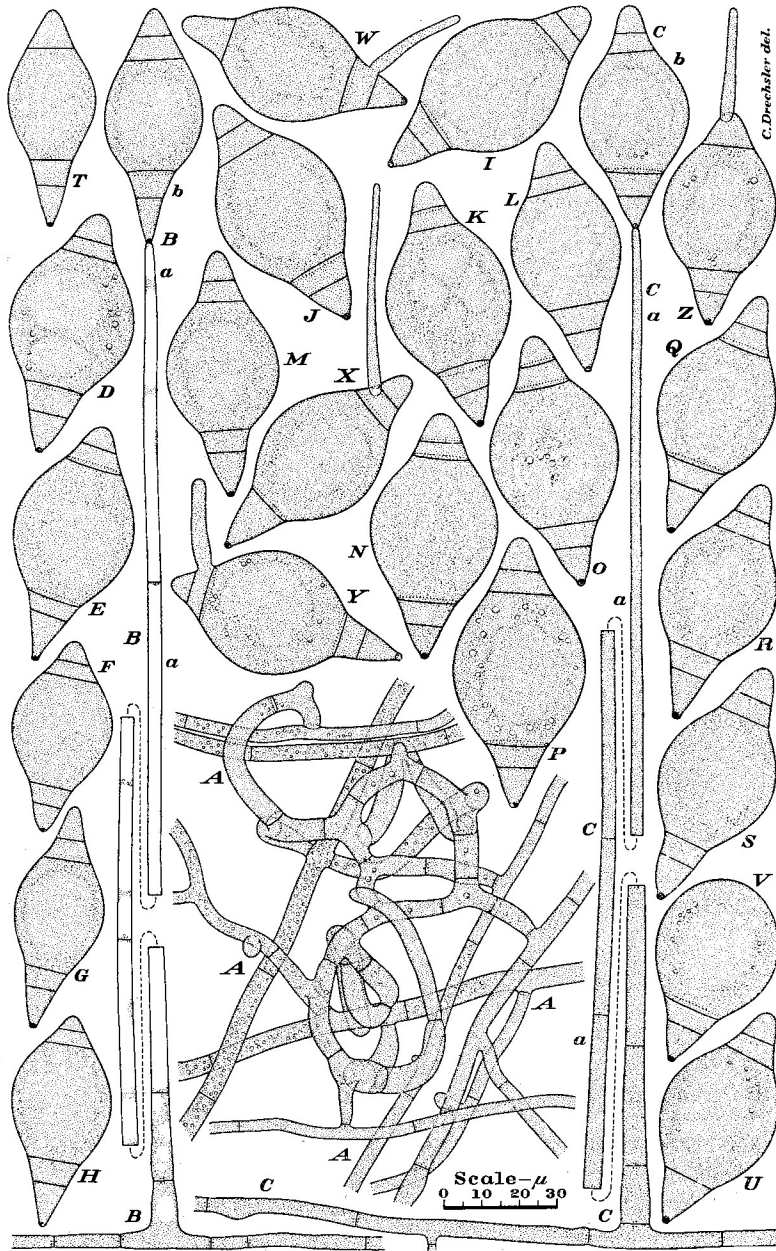


FIG. 4. *Dactylella megalospora* as found on agar slab removed from pure culture to nematode-infested substratum (A), and as appearing commonly when development has been wholly on nematode-infested substratum (B-Z);  $\times 500$  throughout.

nate rather freely both in pure culture (FIG. 3, *L*) and on nematode-infested substratum (FIG. 4, *W-Z*), the germ-tube either developing as a delicate aerial outgrowth (FIG. 4, *X*) or as a more robust vegetative hypha (FIG. 4, *Y*).

*Dactylella megalospora* apparently has its closest known relatives in the retiary species I described under the binomials *Dactylaria thaumasia* (3: 518-523), *Dactylaria psychrophila* (6: 154-166) and *Dactylaria eudermata* (8: 31-41). While its taxonomic affinities might have been indicated somewhat better by assigning it likewise to *Dactylaria*, such assignment seems at present hardly justified by the slight tendency toward capitate sporulation hitherto shown by the new fungus. Its conidia resemble those of *Dactylaria psychrophila* in their decidedly large dimensions as well as in their frequently quadrisepate partitioning, but differ rather markedly in their strongly ventricose shape resulting from pronounced distention usually of the median cell and less often of the parabasal or penultimate cell.

### ***Dactylella phymatopaga* sp. nov.**

Mycelium sparsum; hyphis sterilibus incoloratis, ramosis, mediocriter septatis, plerumque 1.8-3.5  $\mu$  crassis, hic illic saepe tuberibus tenacibus praeditis; tuberibus tenacibus obovoideis vel elongato-ellipsoideis, plerumque 6-9.5  $\mu$  longis, basi 2-3  $\mu$  crassis, sursum 3.8-5.5  $\mu$  crassis, prope basim vulgo hyalinis sed in parte posteriore saepissime protoplasmatis granulosis repletis, saepe ad vermiculos nematoideos inhaerentibus itaque animalia tenentibus, integumentum eorum perforantibus, bullam debilitantem intrudentibus, hyphas intus evolventibus quae carnem exhauriunt; hyphis assumentibus mox mediocriter septatis, plerumque 2-4.5  $\mu$  crassis; hyphis fertilibus incoloratis, erectis, 3-9-septatis, saepius 250-325  $\mu$  altis, basi 3.5-4.5  $\mu$  crassis, sursum leniter attenuatis, apice circa 2  $\mu$  crassis, ibi unum conidium ferentibus; conidiis hyalinis, vulgo fusoides, basi truncatis, apice rotundatis, plerumque 40-60  $\mu$  longis, 11-18  $\mu$  crassis, vulgo quadrisepatis, cellula eorum media (ante-paenultima) longiore et crassiore quam aliae cellulae.

Vermiculos nematoideos (*Aphelenchoideum* subtenuem inter alios) capiens consumensque habitat in materiis plantarum putrescentibus prope Laplace, Louisiana.

Mycelium often scanty; vegetative hyphae colorless, branched, septate at moderate intervals, mostly 1.8 to 3.5  $\mu$  wide, often (especially in the presence of nematodes) bearing adhesive protuberances at intervals of

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*B, C*, Portions of hyphae, each with unbranched conidiophore, *a*, bearing a single conidium, *b*. *D-S*, Quadrisepate conidia in which the median cell is largest. *T*, Triseptate conidium in which the penultimate cell is largest. *U*, Triseptate conidium in which the antepenultimate cell is largest. *V*, Biseptate conidium in which the apical cell is largest. *W-Z*, Germinating conidia. (Owing to lack of space *B* and *C* are shown in parts whose proper connection is indicated by broken lines.)

5 to 125  $\mu$  (mostly at intervals of 10 to 50  $\mu$ ); adhesive protuberances sessile, obovoid or prolate ellipsoid, mostly 6 to 9.5  $\mu$  long, 2 to 3  $\mu$  wide at the base, measuring 3.8 to 5.5  $\mu$  in greatest width, usually filled at the base with homogeneous contents but in the distal region filled with granular protoplasm, often holding fast to nematodes, then individually perforating the integument of the adhering animal and intruding a globose infective body from which assimilative hyphae are extended to appropriate the fleshy contents; assimilative hyphae eventually divided into segments often 15 to 25  $\mu$  long and 2 to 4.5  $\mu$  wide; conidiophores colorless, erect, often containing 3 to 9 cross-walls, commonly 250 to 325  $\mu$  high, 3.5 to 4.5  $\mu$  wide at the base, tapering gradually upward, about 2  $\mu$  wide at the tip on which a single conidium is borne; conidia colorless, usually spindle-shaped, truncate and rather narrow at the base, rounded at the distal end, mostly 40 to 60  $\mu$  (average about 49.2  $\mu$ ) long, 11 to 18  $\mu$  (average about 14.4  $\mu$ ) wide, commonly divided by 4 cross-walls into 5 cells whereof the one in middle position usually exceeds the others in length and width.

Capturing and consuming various nematodes (*Aphelenchoides subtenuis* among them) it occurs in decaying plant materials near Laplace, Louisiana.

*Dactylella phymatopaga* was first discovered as it developed sparingly in two maize-meal-agar plate cultures that had been planted with decaying vegetable material collected in southern Louisiana on December 20, 1952. In both cultures it appeared somewhat tardily, after several other clamless predacious hyphomycetes, including the new *Arthrobotrys anchonia* and the knob-bearing *Dactylaria haptospora*, had operated extensively in the destruction of eelworms. The admixture of *Dactylaria haptospora*, fortunately, added no special difficulty since the stalked adhesive knobs of that species were very readily distinguishable from the sessile knobs (FIG. 5, A, a-j; B, a-c; C, a-c; D, a-c; E, a-d; F, a-e; G, a-c; H, a; I, a; J, a, b; K, a; L, a. FIG. 6, A, a, b; B, a, b; C, a-c; D, a, b) borne laterally on the mycelial hyphae of the present fungus. When occasion offered, these sessile adhesive organs (FIG. 5, G, d; H, b) functioned successfully in the capture of motile nematodes, most of the animals taken belonging to a slender species which Dr. G. Steiner determined as probably being *Aphelenchoides subtenuis* Cobb. Penetration of the captive's integument, invasion of its interior (FIG. 5, G, d; H, b), and expropriation of its fleshy substance took place much as in related forms. When all living contents had been withdrawn from the assimilative hyphae their empty membranes soon vanished, but the membranous envelopes of the infective body and the adhesive cell (FIG. 5, I, b, c) often became thickened and then remained

visible long after movement of protoplasm backward into the parent hypha was completed.

The conidial apparatus produced by *Dactylella phymatopaga* in the nematode-infested cultures appeared of relatively uniform character. Each conidiophore in its erect posture (FIG. 5, *J*, *c*; *K*, *b*) formed a single conidium (FIG. 5, *J*, *d*; *K*, *c*) on its tip. Often it would then fall over on to the moist substratum, with some of its proximal segments still filled with protoplasm. From one of these living segments (FIG. 5, *L*, *b*) would now be sent up a new conidiophore (FIG. 5, *L*, *c*) that would bear a new conidium. The same sequence of events could then be repeated again and again with resultant development of additional spores.

The conidia of *Dactylella phymatopaga* (FIG. 5, *M*, *a-u*) show general parallelism in outward shape and cellular make-up to those of *Dactylella ellipsospora* Grove (3: 492-496), *Dactylaria haptotyla* Drechsl. (8: 41-49), and *Dactylaria sclerohypha* Drechsl. (8: 49-58) among the several species employing stalked adhesive knobs in the capture of nematodes. After falling on a stale substratum they often give rise, more especially from the parabasal cell (FIG. 5, *N*), to a slender aerial outgrowth which frequently develops into a conidiophore and bears a secondary conidium. Through repetition of the process conidia of successively higher orders may be formed, each somewhat smaller than the parent it replaces, though in all observed instances the reduction in size was not pronounced. Measurements on 25 quadriseptate conidia selected at random, and therefore very probably including some individuals of the secondary and tertiary orders, were used to obtain the averages for the main conidial dimensions given in the diagnosis. The 25 measurements for total length and for greatest width ranged from 41.3 to 58.0  $\mu$  and from 11.2 to 17.3  $\mu$ , respectively, while supplementary measurements for lengths of the 5 component cells gave ranges and averages as follows: basal cell, 6.8 to 12.4  $\mu$ , 9.3  $\mu$ ; parabasal cell, 5 to 9.7  $\mu$ , 7.6  $\mu$ ; middle cell, 14.7 to 25.5  $\mu$ , 19.1  $\mu$ ; penultimate cell, 4.1 to 7.6  $\mu$ , 5.8  $\mu$ ; apical cell, 5.3 to 11.8  $\mu$ , 7.4  $\mu$ .

If conidia of *Dactylella phymatopaga* fall on moist fresh agar they usually germinate by extending one or more germ hyphae on or into the substratum. These procumbent or submerged germ hyphae sometimes originate near the proximal end of the basal cell (FIG. 5, *O*, *P*). In the presence of motile eelworms they soon give rise to sessile adhesive knobs (FIG. 5, *Q*, *a-m*), and are then ready to subsist predatorily. Predacious organs, however, are not usually formed where no alien organisms are present, and therefore are not generally produced



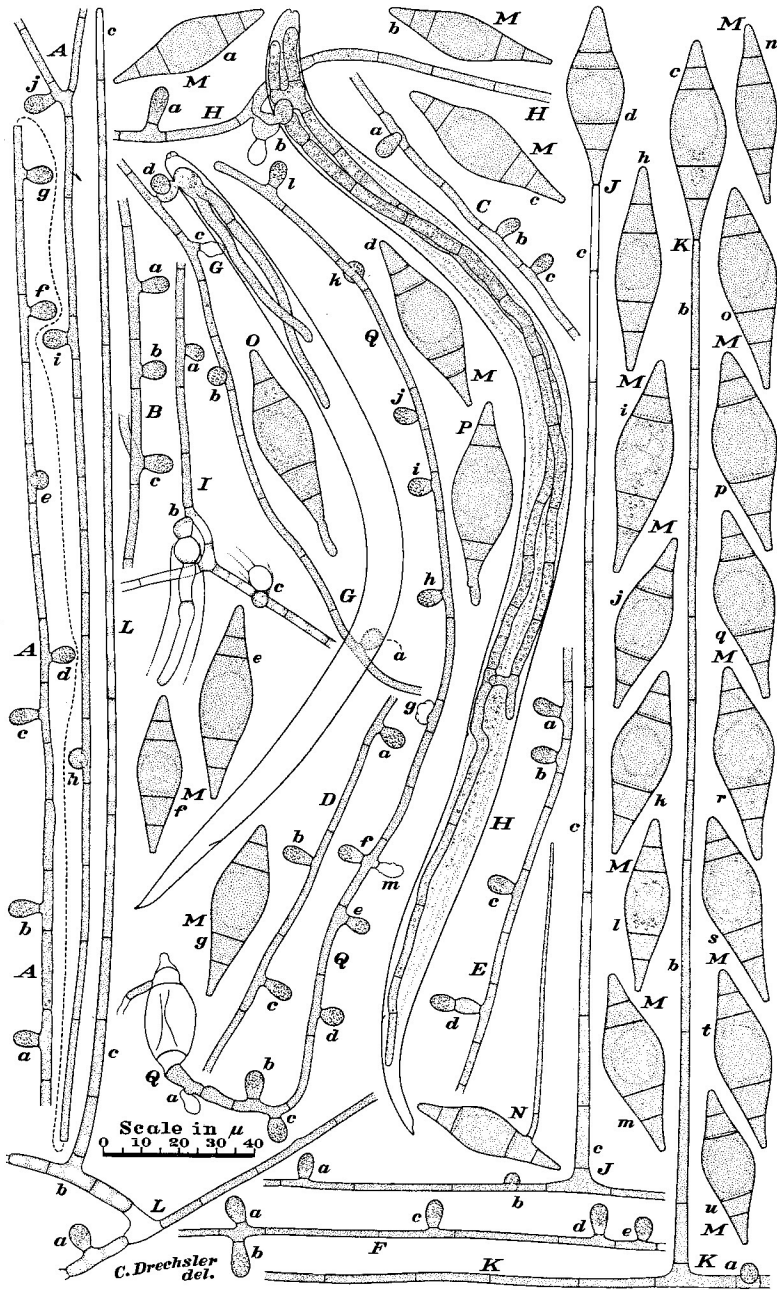


FIG. 5.

in the pure cultures often readily obtained by transferring conidia from the erect conidiophores to tubes of maize meal agar, if contamination is avoided throughout use of sterile agar slabs held on a flamed platinum spatula. In such cultures the fungus usually produces no conidial apparatus, but, instead, often forms rather extensive wefts of cottony aerial mycelium.

*Dactylella phymatopaga* is recognizable as a separate species mainly by its adhesive knobs. These knobs (FIG. 6, *A*, *a*, *b*; *B*, *a*, *b*; *C*, *a-c*; *D*, *a*, *b*) are distinguished from the similarly unicellular adhesive knobs of several other nematode-capturing hyphomycetes in that they are sessile rather than stalked, obovoid rather than globose, and contain granuliferous protoplasm at the distal end rather than being filled throughout with relatively homogeneous protoplasm. In respect to their lack of stalks they show parallelism not only with the digitate protuberances employed by the related *Pedilospora dactylopaga* Drechsl. (1) in capturing testaceous rhizopods, but also with the globose protuberances used by my *Dactylella tylopaga* (2) in capturing *Amoeba verrucosa* Ehrenb. The protuberances of *P. dactylopaga*, whether formed on the mycelial hyphae or on detached conidia, are, however, much smaller than the adhesive knobs of the present fungus, and differ, besides, in not being delimited from the parent cell by a cross-wall. It is not certain that the protuberances of *D. tylopaga* are likewise not delimited at the base, as only a few of these organs occurred in the material from

FIG. 5. *Dactylella phymatopaga* as found in nematode-infested maize meal agar culture;  $\times 500$  throughout. *A*, Portion of mycelium with 10 sessile adhesive knobs, *a-j*. *B-D*, Portions of hyphae, each with 3 sessile adhesive knobs, *a-c*. *E*, Portion of hypha with 4 adhesive knobs, *a-d*. *F*, Portion of hypha with 5 adhesive knobs, *e-e*. *G*, Portion of hypha with 4 adhesive knobs, *a-d*; one knob (*c*) has become emptied of protoplasm, and another (*d*) has served in capturing and invading an eelworm probably of the species *Aphelenchoides subtenuis*. *H*, Portion of hypha with 2 adhesive knobs, *a* and *b*; one knob (*b*) has served in capturing an eelworm (probably *Aphelenchoides subtenuis*) which now is invaded from head to tail. *I*, Portion of mycelium with 3 sessile knobs, *a-c*; two of the knobs (*b*, *c*) have each served in capturing an eelworm and are now being emptied of their protoplasm. *J*, Portion of hypha with 2 adhesive knobs, *a* and *b*, and a conidiophore, *c*, bearing a single conidium, *d*. *K*, Portion of hypha with one adhesive knob, *a*, and a conidiophore, *b*, bearing a single conidium *c*. *L*, Portion of hypha with an adhesive knob, *a*, and with the proximal portion of a fallen conidiophore, *b*, that has sent up a new conidiophore, *c*. *M*, Random assortment of 21 conidia, *a-u*, showing usual variation in size, shape, and cellular dimensions. *N*, Detached conidium with erect filamentous outgrowth. *O*, *P*, Two conidia, each with short vegetative germ tube. *Q*, Empty conidium with germ hypha bearing 13 adhesive knobs, *a-m*. (Owing to lack of space *A* is shown in 2 parts whose proper connection is indicated by broken lines.)

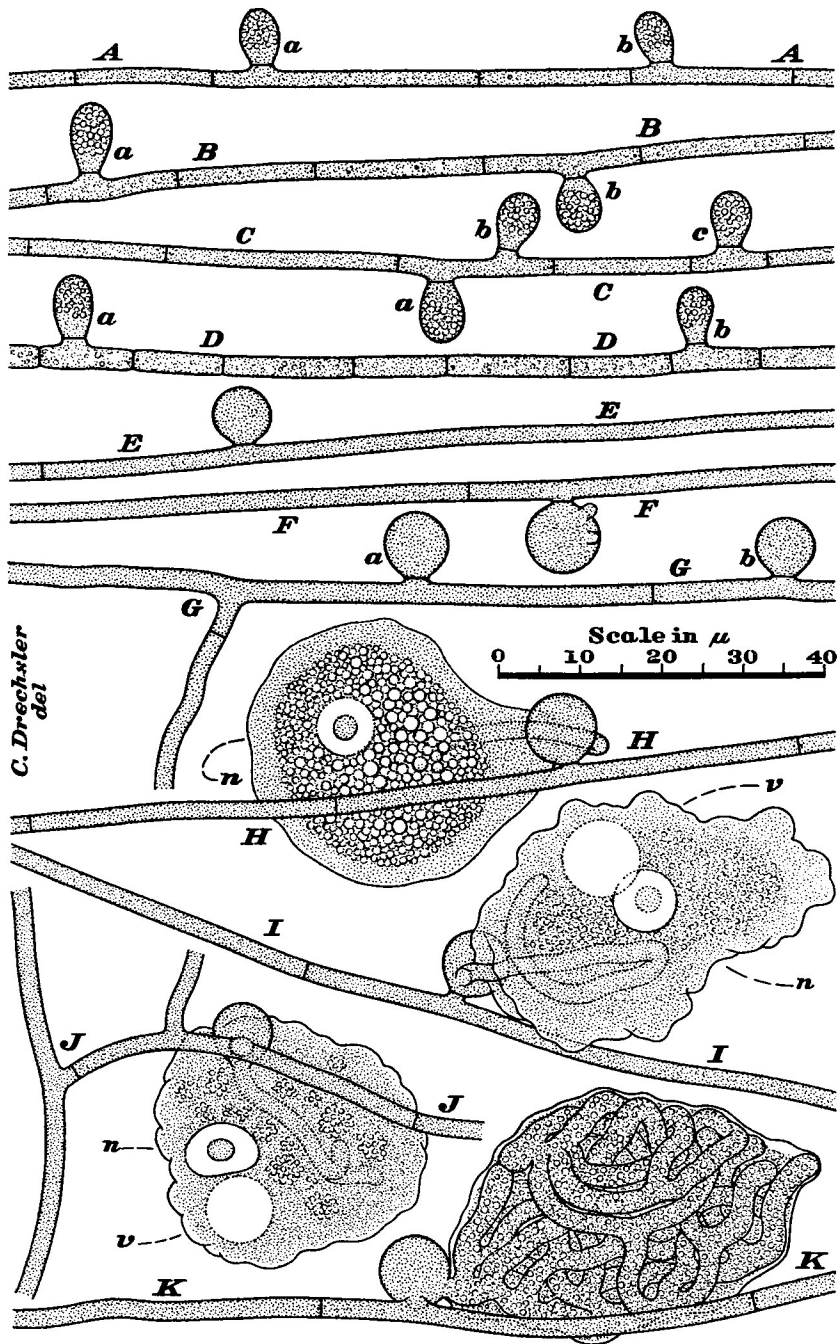


FIG. 6.

which the species was originally described, and no other relevant material has since come under observation.

Another fungus with sessile adhesive knobs recently came to light in a maize-meal-agar plate culture that had been planted with leaf mold kindly collected by W. F. Jeffers on March 7, 1953, near Willards, Maryland. In this fungus the knobs (FIG. 6, *E*; *F*; *G*, *a*, *b*) were of subspherical shape and measured 7 to 9.5  $\mu$  in diameter. They were borne at longish intervals on claspless, sparingly septate hyphae, mostly 1.8 to 2.8  $\mu$  in width. Like the parent hyphae, from which they were delimited individually by a basal septum often about 2  $\mu$  wide, they were filled throughout with protoplasm of homogeneous appearance. They served effectively in capturing a species of *Amoeba* usually about 35  $\mu$  wide when drawn into a somewhat rounded form (FIG. 6, *H-K*). Attack on the adhering animal began with the intrusion of a single hypha. During the earlier stages of invasion the protoplasm of the captive underwent no marked change in texture, its contractile vacuole (FIG. 6, *I*, *v*; *J*, *v*) continued to operate regularly, and its nucleus—a globose body (FIG. 6, *H-J*; *n*) measuring commonly 7 to 8  $\mu$  in diameter and containing a slightly darker endosome 2.5 to 3  $\mu$  wide—showed no abnormality. In later stages the animal's internal structure was gradually obliterated as the simple infective hypha first intruded gave rise to an intricate tangle of assimilative branches (FIG. 6, *K*). Although the predacious mycelium would seem to have obtained ample nourishment no reproductive bodies were formed. The fungus, in any case, appears noteworthy especially because of the similarity of its predacious organs to those of *Dactylella phymatopaga*.

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FIG. 6. Drawn at a uniform magnification with the aid of a camera lucida;  $\times 1000$  throughout. *A-D*, Portions of hyphae of *Dactylella phymatopaga* from nematode-infested maize-meal agar, each with 2 (*A*, *B*, *D*) or 3 (*C*) sessile adhesive knobs. *E*, *F*, Portions of hyphae of unnamed *Amoeba*-capturing fungus, each with a sessile adhesive knob; the knob in *F* shows 2 protuberances which presumably represent incipient infection hyphae that were put forth while an *Amoeba* was temporarily being held captive. *G*, Portion of mycelium of same *Amoeba*-capturing fungus with 2 adhesive knobs, *a* and *b*. *H-J*, Portions of mycelium of same fungus, each with an adhesive knob from which an assimilative hypha has been extended into a captured *Amoeba*; *n*, nucleus of animal; *v*, contractile vacuole of animal, shown in *I* and *J* but not in *H*. *K*, Portion of hypha of same fungus, with an adhesive knob from which an intricate tangle of assimilative branches has invaded a captured *Amoeba*.

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