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Iowa Fungi Parasitic on Nematodes

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Abstract. Seventeen species of fungi parasitic on nematodes are newly recorded in Iowa. These are *Acrostalagmus obovatus, Arthrobotrys conoides, A. musiformis, A. oligospora, Dactylaria brochopaga, Dactylella acrochaeta, D. doedycoides, Haptoglossa heterospora, Harposporium anguillulae, H. lilliputanum, H. oxycoracum, Meria coniospora, Nematoctonus tylosporus, Spicaria coccospora, Stylopage grandis, S. leiohypha and Triposporina aphanopaga.* A species of *Zoophagus* which captured nematodes was found in rotting wood and leaf mulch. *Arthrobotrys conoides* was the most common nematode parasitic fungus found in forage legume fields. It was followed in prevalence by a sterile fungus. In woodlands, *A. oligospora* predominated followed by *Dactylella gephyropaga.*

In recent years there has been an increased interest in fungi which are parasitic on nematodes. Evidence indicates that these fungi are very common in the soil and decaying plant debris. The writer is aware of only 2 records of such fungi in Iowa, and only 1 of these was observed to capture nematodes. Martin (14) found *Achlyogeton entophytum* A. Schenk on *Cladophora* but this fungus is also known to parasitize nematodes (18). *Dactylella gephyropoga* Drech. was reported as occurring in Iowa by Drechsler (4).

Materials and Methods

A total of 348 samples from various habitats were collected in polyethylene bags or glass vials during 1959-1961. A few grams of each sample were placed in 3 petri dishes containing weak corn meal agar made according to Duddington (11). All samples from forage legume fields were taken from around living roots. Most plates, especially those containing soil from forage legume fields contained an established culture of *Cephalobus* sp. prior to adding the soil. The plates were kept at room temperature and examined periodically for 2-3 months. Cultures or preserved slides were made for all fungi except *Nematoctonus tylosporus* Drech. which was lost while attempting to culture it. All measurements were made from nematode infested cultures.

Results

PHYCOMYCETES

Haptoglossa heterospora Drech. (5).

Endozoic. Spores produced in an elongate sporangium which

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may nearly fill body of nematode, released through papillae, irregular in shape, usually angular, 3.5-6.5 microns in diameter (average 4.7 microns). Infective bodies often glossoid, 4.0-7.5 microns in width (average 5.8 microns).

Pilot Knob State Park: Soil around *Cephalanthus occidentalis* L. near lake; Story Co.: Soil around grass on bank of tributary to Skunk River.

Stylopage grandis Duddington (10)

Nematode capture by adhesive mycelium. Mycelium sparse, non-septate, colorless, about 3-4 microns in diameter. Conidiophores erect, 250-400 microns long, bearing a single conidium at its apex or, after elongation of the conidiophore, a second conidium is produced. Conidia mostly obovoid, 30-60 x 16-30 microns (average 41.2 x 21.8 microns).

Woodman Hollow State Park.

The dimensions of this material fit the limits as given by Duddington (10) but the Iowa material appears to be a smaller form and somewhat more robust. The absence of any orbicular protuberances would eliminate it from being a large form of S. *hadra* Drech.

Stylopage leiohypha Drech. (3)

Nematode capture by adhesive mycelium. Mycelium sparse, non-septate, colorless, about 3 microns wide, no orbicular protuberances present. Conidiophores erect, averaging 120 microns long, about 3.4 microns at the base tapering to 1.5 microns at the tip, bearing a single conidium or by successive elongation of the conidiophore 2-3 conidia are formed. Conidia (Fig. 1) 1-celled, colorless, obovoid to elongate obovoid, 22-40 x 8-15 microns (average 30.2 x 11.7 microns).

This species has been found in several forage legume fields in central and western Iowa and also at Waubonsie and Woodman Hollow state parks.

Zoophagus

To the writer's knowledge there is no report of a species of a *Zoophagus* capturing nematodes

Sommerstorff (17) described Z. *insidians* Sommerstorff as capturing rotifers by means of short hyphal branches at right angles to the main non-septate hypha. These hyphal branches were about 20 microns long and about 3 microns wide. No gemmae were described. Arnaudow (1), in what he called Z. *insidians* from Germany, described gemmae 260-300 microns long and up to 14 microns wide. The short lateral hyphal branches were 20-30 microns long. Sexual organs were described, but zoospores were found only once. Prowse (15), in describing the same species stated that the gemmae were 80-100 x 8-10 microns, but these

were found in only 1 sample. No sexual organs were seen, and zoospores were found only once.

The gemmae of the Iowa material are intermediate between the German material of Arnaudow and that of Prowse. They have been found in four collections where the fungus has been obtained. In fact, it is by the erect gemmae that the fungus is most easily recognized. The mycelium is non-septate, 5-7 microns wide, capturing nematodes by short, sticky hyphal branches 15-45 microns long (Fig. 2). These branches are at right angles to the parent hyphae and spaced at intervals of about 50-100 microns. Gemmae (Fig. 3) are erect and may be almost sessile or borne on stalks up to 45 microns long. The gemmae are non-septate at first but become septate with age. They range from 150-240 x 9-10 microns (average 179 x 10 microns).

The gemmae have been seen to germinate by mycelium. Zoosporangia or sexual structures have not been noted. Sparrow (19) has pointed out the lack of agreement in the material of various workers and suggests that possibly several distinct fungi exist under the name of Z. *insidians*. Until more material is collected and the nature of, or the presence or absence of zoosporangia or sexual structures is better established, a specific epithet for the Iowa material is delayed.

This *Zoophagus* sp. was found in decaying wood and leaf mulch in moist woods and deep ravines at Dolliver Memorial and Woodman Hollow state parks.

FUNGI IMPERFECTI

Acrostalagmus obovatus Drech. (7)

Endozoic. Mycelium septate, about 2 microns wide, branched. Conidiophores septate, at first erect, up to 150 microns long, 2 to 3 microns wide, bearing lageniform phialides singly or in whorls of 2-3. Phialides 6.7-8 x 2.5-3.0 microns (average 7.1 x 2.6 microns), bearing at its apex clusters of conidia. Conidia 1-celled, ellipsoid to obovoid, about 3.0 x 1.5 microns, mostly about 2.0 x 1.5 microns.

This fungus was found around *Polytrichum* sp. in bog at Pilot Knob State Park.

Arthrobotrys conoides Drech. (4)

Nematode capture by sticky networks. Mycelium hyaline, septate, 4-8 microns wide, giving rise to sticky networks. Networks mostly 30-40 microns in outside diameter. Conidiophores hyaline, erect, septate, up to 420 microns long, about 8 microns at the base tapering to about 2 microns at the tip, bearing a head of conidia, or by elongation of the conidiophore, several heads. Conidia (Fig. 4) hyaline, 2-celled, obconical, constricted at the septum, with the basal cell distinctly smaller, spores 25.5-34.5

microns (average 29.9 microns) long x 9.0-16.5 microns (average 13.6 microns) wide, basal cell 9.0-1.5 microns (average 11.5 microns) long.

Common in forage legume field in central and western Iowa. Also found at Ledges, Maquoketa, Pilot Knob and Woodman Hollow state parks.

Arthrobotrys musiformis Drech. (4)

Nematode capture by sticky arches and loops. Mycelium hyaline, septate, 3-7 microns wide, giving rise to somewhat horseshoe shaped arches and loops. The loops may remain discrete or may form small networks much less extensive than with many other species of *Arthrobotrys*. Loops often about 30-35 microns in outside diameter with the greatest hyhpal width about 9 microns wide. Conidiophores hyaline, septate, 200-400 microns long, 5-9 microns wide at the base tapering to about 3 microns at the tip, bearing a loose conidial head. Conidia hyaline, 2-celled, ellipsoid, straight to slightly curved, 27-39 microns (average 33.5 microns) long x 9-12 microns (average 10.7 microns) wide, basal cell 9-18 microns (average 14.2 microns) long.

Dung. Woodman Hollow State Park. Collected by L. H. Tiffany

Arthrobotrys oligospora Fres. (12)

Nematode capture by sticky networks. Mycelium hyaline, septate, about 3 microns wide, giving rise to sticky networks. Conidiophores erect, usually 300-400 microns long, about 8 microns wide at the base tapering to about 2 microns at the tip, bearing a single conidial head, or by elongation of the conidiophore, several heads may be formed. Conidia hyaline, 2-celled, obovoid, with the basal cell distinctly smaller, 23.0-30.0 microns (average 25.0 microns) long x 12-18 microns (average 15.5 microns) wide, basal cell 8.0-12.0 microns (average 9.5 microns) long.

Occasional in forage legume fields in central and western Iowa. Also found in Ledges, Maquoketa, Pilot Knob, Waubonsie, and Woodman Hollow state parks, and in a deciduous woods in Story Co.

Dactylaria brochopaga Drech. (4)

Nematode capture by constricting rings (Fig. 5). Mycelium spreading, hyaline, septate, 2-4.5 microns wide, producing at right angles to the hypha constricting rings 23-33 microns in outside diameter. Rings composed mostly of 3 arcuate cells borne on a 2-celled stalk. Conidiophores erect, hyaline, septate, 4-7 microns wide at the base tapering upward to a height of 200-300 microns and bearing a cluster of up to 8 conidia. Conidia (Fig. 6) hyaline, straight or slightly curved, mostly cylindrical,

mostly 3 but occasionally 2-septate, 42-48 microns long x 7.5-9.9 microns wide, the 2 end cells being larger than the 2 center cells.

Alfalfa field in Taylor Co.; Ledges, Pilot Knob and Woodman Hollow state parks.

Dactylella acrochaeta Drech. (8)

Nematode capture by constricting rings. Mycelium sparse, septate, 2-4 microns wide, spreading, bearing constricting rings at right angles to the hypha. Rings usually composed of 3 cells borne on a 2-celled stalk, approximately 20-30 microns in outside diameter. Conidiophores borne on mycelium external to host, hyaline, erect, about 100-300 microns long, bearing a single conidium at its apex, or by elongation of the conidiophore, producing more than 1 conidium. Conidia usually 3-celled by 2 transverse septa, broadly spindle-shaped, 30-39 x 19-23 microns average 36.3 x 21.5 microns), the end cells being very small. At the tip of most conidia is borne a filamentous appendage 75-270 microns long and approximately 1 micron wide.

Dolliver Memorial and Woodman Hollow state parks.

Dactylella doedycoides Drech. (6)

Nematode capture by constricting rings. Mycelium sparse, spreading, about 3 microns wide, bearing constricting rings at right angles to the hypha. Rings composed of 3 cells borne on a 2-celled stalk, 25-45 microns in outside diameter. Conidiophores borne on hyphae external to host, erect, hyaline, septate, 200-450 microns long and bearing a single conidium at its apex. Conidia top-shaped, 3-celled by 2 transverse septa, 30-36 x 15-19 microns (average 33.3 x 17.5 microns), of which the center cell is by far the largest, measuring an average of 22 microns in length.

Woodman Hollow State Park

Dactylella gephyropaga Drech. (4)

Drechsler reported this fungus from Iowa previously (4).

Nematode capture by adhesive processes and rectangular meshes. Mycelium sparse, septate, 2-4 microns wide, giving rise to adhesive columns, which, often by branching parallel to the parent hypha, form rectangular meshes. Conidiophores, hyaline, erect, 250-450 microns long at the tip of which is borne a single conidium. Conidia top-shaped, 3-4 septate, 32-44 microns (average 38.4 microns) long x 14-18 microns (average 15.6 microns) wide; when 4-septate, the central barrel-shaped cell is by far the largest.

This species appears to be quite common in woodlands. In the present study, it was found in Dolliver Memorial, Ledges, Maquoketa, Pilot Knob, Waubonsie and Woodman Hollow state parks.

Harposporium anguillulae Lohde (13)

Endozoic (Fig. 7). Mycelium septate, about 2-4 microns wide. Conidiophorous hyphae formed external to host, erect or prostrate. Fertile branches mostly subspherical, about 2.5-4 microns in diameter, bearing a single conidium. Conidia arcuate, 7.5-10 x 1-2 microns (average 8.4 x 1.5 microns). Chlamydospores 4.5-7.5 x 4.5-6.0 microns average 6.3 x 4.7 microns).

Ledges, Pilot Knob, Waubonsie, and Woodman Hollow state parks; a deciduous woods in Story Co. This species is apparently common and widespread.

Harposporium lilliputanum Dixon (2)

Endozoic. Mycelium septate, internally about 2-4 microns wide, externally about 2 microns wide. Conidiophorus hyphae formed externally, erect or prostrate, septate. Fertile branches mostly subspherical, 4.0-6.7 x 3.0-3.3 microns (average 4.9 x 3.1 microns) bearing a single sterigma up to 3.3 microns long on which are borne a cluster of conidia. Conidia arcuate, 4.0-8.0 x 1.2-1.4 microns (average 5.9 x 1.3 microns).

This species has been found only on *Bunonema* in Iowa.

Pilot Knob, Woodman Hollow State Park; deciduous woods in Story Co. It also has been found in Denmark (16) and England (2).

Harposporium oxycoracum Drech. (7)

Endozoic. Mycelium septate, about 2-4 microns wide. Conidiophorous hyphae formed externally, erect or prostrate. Fertile branches mostly subspherical, 3-4 microns in diameter bearing a single sterigma 1-2 microns long on which is borne a conidium. Conidia 1-celled hyaline, hook-like to medium curved, bearing a single basal knob immersed in mucus, 14-21 x 1-1.5 microns (average 18.7 x 1.4 microns).

Ledges and Pilot Knob state parks.

Meria coniospora Drech. (7)

Endozoic (Fig. 8). Mycelium septate, aobut 3 microns wide, growing inside animal host. Conidiophorous hyphae formed external to host, 2.5-3 microns wide, 20-80 microns long, septate. Phialides formed at septa, 1-2.5 microns long, each bearing several conidia in a head. Conidia 1-celled, hyaline, conical, 4.0-6.0 x 2.0-3.5 microns (average 5.4 x 2.4 microns), often knobbed at its terminal end.

A form was found in 1 sample with spores definitely longer than described above or by Drechsler. It appears as an elongated form of *M. coniospora* with dimensions of 6.0-9.0 x 1.5-2.0 microns (average 7.8 x 1.7 microns).

Ledges, Pilot Knob and Woodman Hollow state parks.

Nematoctonus tylosporus Drech. (7)

Endozoic. Mycelium hyaline, 2-3 microns wide. Conidiophores external to host, 0.5-1.5 mm high, bearing clamp connections. Conidia borne on sterigmata, 1-celled, spindle-shaped, 18-22 x 2-3 microns wide, knobbed at apex.

Soil around red clover, Boone Co.

Spicaria coccospora (Drech.(7)

Endozoic. Mycelium hyaline, septate, about 2-3 microns wide. Conidiophores usually at first erect, mostly simple. Phialides arranged in whorls, flask-shaped, 6-10 x about 2 microns, each bearing several conidia. Conidia catenulate, hyaline, 1-celled, 1.3-1.6 microns in diameter.

Soil around red clover, Boone Co.; around *Polytrichum* sp. in bog, Pilot Knob State Park.

Triosporina aphanopaga Drech. (4)

Mycelium sparse, haline, septate, 1.5-2 microns wide, penetrating nematodes. Conidiophores hyaline, septate, erect, 140-250 microns long, hearing at its terminus a single conidium. Conidia hyaline, inversely pyramidal, about 26 microns in length, number of septa often difficult to distinguish but 10 commonly seen, bearing 4 conical cells at its upper top angles.

Around *Atrichum undulatum* (Hedw.) Beauv. at Pilot Knob State Park; around moss at Woodman Hollow State Park.

Sterile Mycelium—Duddington (9) reported sterile fungus which he designated Number 186 and which was later (11) said to be the second most frequently found nematode parasitic fungus in British soils. During the present study a sterile fungus was found in which nematodes become stuck to a sterile mycelium (Fig. 9). Invasion of the nematode occurs until all that can be seen is the empty cuticle. Sporulation has never been seen, and all attempts to culture it have failed. Whether this constitutes more than one fungus and whether it is the same as Dr. Duddington described is not known.

Habitat Relationships

Habitat relationships of 348 samples are summarized in Table 1. A total of 455 records of different nematode parasitic fungi were found in these samples, with no occurrences in 17 samples.

There are certain similarities to the surveys of Duddington (9) and Shepherd (16) and also some striking differences. As found by these and other authors, *Arthrobotrys* spp. are the predominant fungi, but, contrary to these surveys, *A. conoides* was much more prevalent than *A. oligospora*. In the present study, *A. conoides* was most abundant in forage legume fields, but *A. oligospora* predominated in woodland soils. *Dactylella gephyropaga* was common in woodlands but not in soil around forage

legumes. The only nematode parasitic fungi found in a boreal bog at Pilot Knob State Park were of the endozoic type.

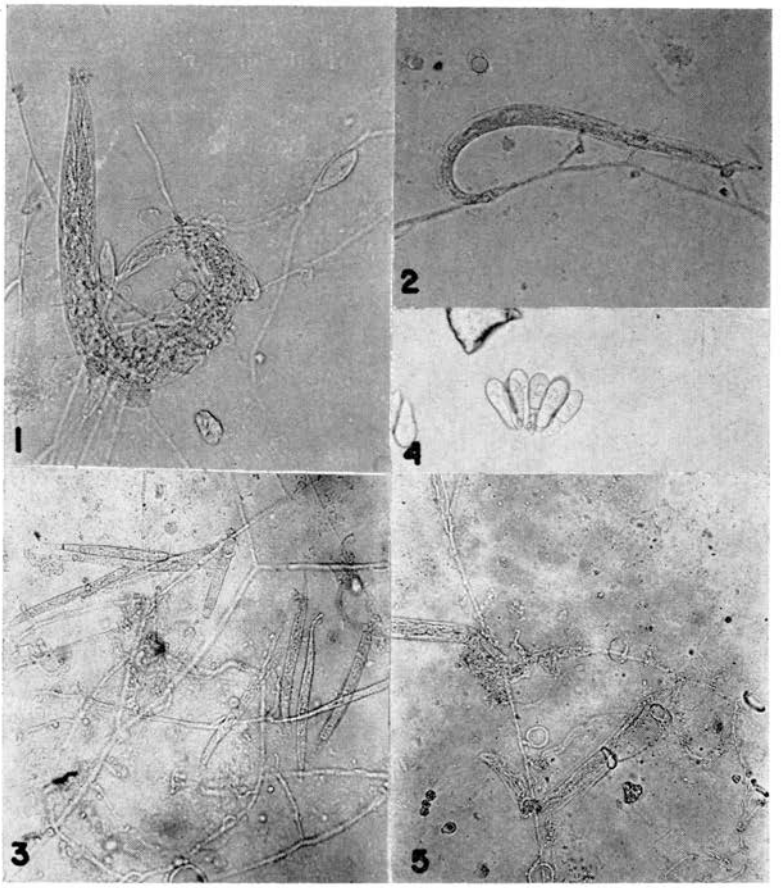

Figure 1. Nematode captured by *Stylopage leiohypha*. The obovoid spores are those of *S. leiohypha*.
Figure 2. Nematode captured by sticky processes of *Zoophagus* sp.
Figure 3. Gemmae and adhesive processes of *Zoophagus* sp.
Figure 4. *Arthrobotrys conoides* conidia.
Figure 5. Nematode captured in constricting rings of *Dactylaria brochopaga*.

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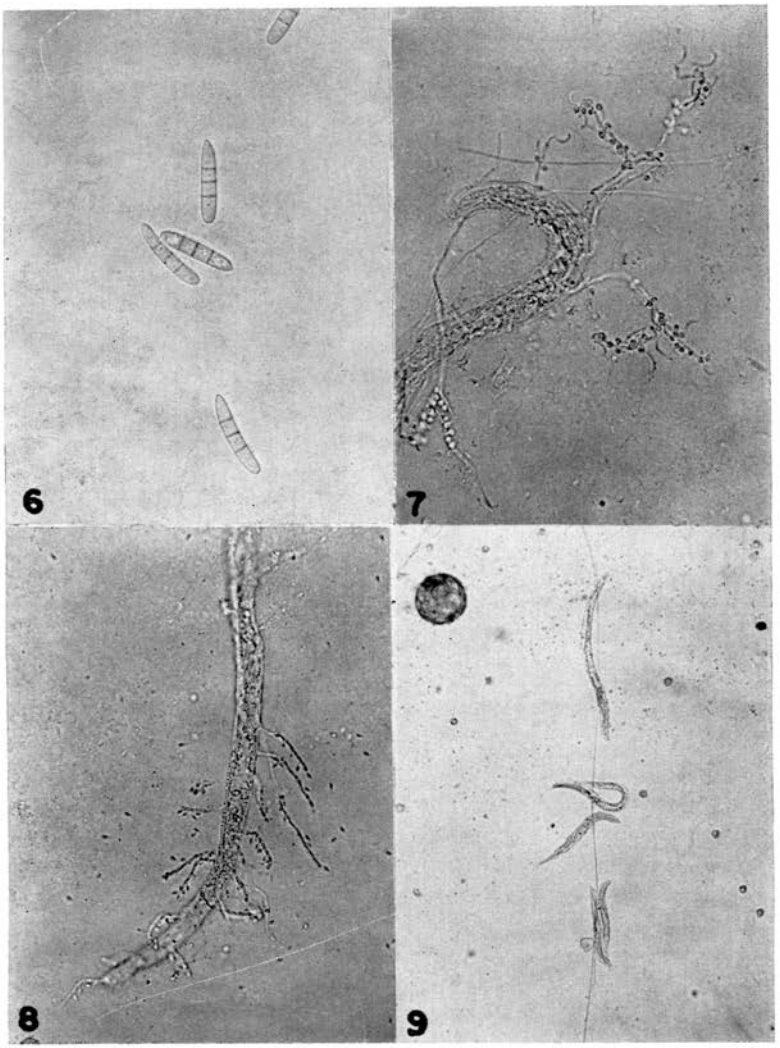

Figure 6. *Dactylaria brochopaga* conidia.
Figure 7. Nematode parasitized by *Harposporium anguillulae*
Figure 8. Nematode parasitized by *Meria coniospora*
Figure 9. Nematodes captured by mycelium of a sterile fungus.

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Table 1

Percentage of occurrence of nematode parasitic fungi in 348 Iowa Samples

	Forage legumes	Woodlands							
	soil	Bog	Rotting logs	Leaf mulch	Moss and soil	soil	River bank	misc.	Total
Acrostalagmus obovatus	0	14	0	0	0	0	0	0	T
Arthrobotrys conoides	56	0	10	17	0	10	8	11	42
A. musiformis	0	0	0	0	0	0	0	11	T
A. oligospora	6	0	20	26	64	60	33	33	17
Catenaria sp.	1	0	0	0	0	0	0	0	1
Dactylaria brochopaga	T	0	40	13	0	8	0	11	4
Dactylella acrochaeta	0	0	10	13	9	0	0	11	2
D. doedycoides	0	0	10	4	9	0	0	0	1
D. gephyropaga	1	0	20	61	27	30	0	11	10
Haptoglossa heterospora	0	0	0	0	0	3	8	0	1
Harposporium anguillulae	0	14	20	9	18	8	8	0	3
H. lilliputanum	0	0	0	22	0	3	0	0	2
H. oxycoracum	0	0	10	4	0	5	0	0	1
Harposporium sp.	0	0	0	0	0	5	0	0	1
Meria coniospora	0	14	10	22	0	8	0	0	3
Meria sp.	0	0	0	0	0	3	0	0	T
Nematoctonus tylosporus	T	0	0	0	0	0	0	0	T
Spicaria coccospora	T	14	0	0	0	0	0	0	1
Stylopage grandis	0	0	0	4	0	0	0	0	T
S. leiohypha	8	0	0	0	9	0	0	11	6
Stylopage sp.	0	0	0	4	0	13	8	0	2
Triposporina aphanopaga	0	0	0	0	18	0	0	0	1
Zoophagus sp.	0	0	30	4	0	0	0	0	1
Sterila mycelium	41	0	10	9	0	13	17	25	4
Unidentified	1	0	10	4	9	8	0	13	3
No nematode parasitic fungi	0	57	10	4	9	8	42	25	5
Total Samples	237	7	10	23	11	40	12	9	348

T = less than 0.5%

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