

## QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

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**A SURVEY OF NEMATOPHAGOUS FUNGI  
IN QUEENSLAND**

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**SUMMARY**

Fifty-seven species of nematophagous fungi in 19 genera were isolated from 1 733 soil samples. The most commonly recorded species were *Arthrobotrys conoides*, *A. dactyloides*, *Dactylaria thaumasia*, *Harposporium anguillulae*, *Monacrosporium elliposporum* and *M. gephyropagum*.

**I. INTRODUCTION**

Surveys of nematophagous fungi have been carried out in Great Britain (Duddington 1951, 1954), Denmark (Shepherd 1956), the Union of Soviet Socialist Republics (Soprunov 1958), the United States of America (Norton 1963, Feder 1962), Canada (Estey and Olthof 1965) and New Zealand (Fowler 1970). There are no published reports of surveys of nematophagous fungi in Australia. This paper presents information on their occurrence and distribution in Queensland.

**II. MATERIALS AND METHODS**

One thousand seven hundred and thirty-three soil samples were collected from cultivated areas and areas of native vegetation. Figure 1 shows the distribution of sampling sites which were mapped using areas of 10 000 hectares on the grid reference system of Burgess and Ogle (1972). All grid squares north of 52 on the N-S reference are above the Tropic of Capricorn. The distribution of a species is indicated by the number of grid squares within which it was found.

The method of Colbran (1966) was used when sampling cultivated areas and a single sample of 700 to 1 000 g from within a 1 metre radius of a plant was taken in uncultivated areas. Nematodes and other microfauna and flora were extracted from soil by the two-flask method of Seinhorst (1955). After the suspension was concentrated by centrifuging at 2 000 r.p.m. for 3 min, the supernatant was discarded and the remainder poured into a well of 15 mm



## III. RESULTS

The number of recordings of the 57 species of nematophagous fungi isolated are presented in tables 1 and 2. Thirty-one species are trapping forms and 26 are endozoic. The six most commonly occurring species, *Arthrobotrys conoides*, *A. dactyloides*, *Dactylaria thaumasia*, *Monacrosporium ellipso sporum* and *M. gephyropagum* were also the most widely distributed species, although the most commonly recorded species was not the most widely distributed.

TABLE 1  
NUMBER OF SAMPLES AND GRID SQUARES IN WHICH ENDOZOIC SPECIES WERE FOUND

Species	Samples	Grid Squares
<i>Acrostalagmus bactrospor</i> Drechsler .. ..	9	3
<i>A. obovatus</i> Drechsler .. ..	1	1
<i>A. zeosporus</i> Drechsler .. ..	12	5
<i>Catenaria vermicola</i> Birchfield .. ..	2	2
<i>Cephalosporium balanoides</i> Drechsler .. ..	18	7
<i>Entomophthora vermicola</i> McCulloch .. ..	7	3
<i>Gonimochaete horridula</i> Drechsler .. ..	29	11
<i>Haptoglossa heterospora</i> Drechsler .. ..	105	13
<i>Harposporium anguillulae</i> Lohde .. ..	600	34
<i>H. bysmatosporum</i> Drechsler .. ..	10	7
<i>H. crassum</i> Shepherd .. ..	9	4
<i>H. dicorymbum</i> Drechsler .. ..	1	1
<i>H. helicoides</i> Drechsler .. ..	42	14
<i>H. leptospira</i> Drechsler .. ..	24	11
<i>H. oxycoracum</i> Drechsler .. ..	89	15
<i>H. subuliforme</i> Drechsler .. ..	2	2
<i>Meria coniospora</i> Drechsler .. ..	36	9
<i>Meristacrum asterospermum</i> Drechsler .. ..	35	15
<i>M. pendulatum</i> McCulloch .. ..	3	1
<i>Myzocyttium vermicola</i> (Zopf) Fischer .. ..	36	14
<i>Nematoctonus campylospor</i> Drechsler .. ..	8	4
<i>N. haptocladus</i> Drechsler .. ..	3	3
<i>N. leiosporus</i> Drechsler .. ..	18	11
<i>N. leptosporus</i> Drechsler .. ..	1	1
<i>N. pachysporus</i> Drechsler .. ..	9	7
<i>Paecilomyces coccosporus</i> (Drechsler) .. ..	87	10
Brown and Smith		
Total samples .. ..	1 733	74

Tables 3 and 4 indicate the grid squares in which species were found. Two species, *Candelabrella javanica* and *Stylopaga hadra* were found only in the tropics.

Two hundred and seventy-five samples were collected from areas of native vegetation which include rain-forest, open forest and grassland. The occurrence of nematophagous fungi in these areas is shown in table 5. Thirty-nine of the 57 recorded species were found in areas of native vegetation. *A. conoides*, the most commonly recorded species in the total sampling, was found in only 18 samples from native vegetation. Few species were recorded from grassland areas, and a large number of these samples did not contain nematophagous species.

TABLE 2  
NUMBER OF SAMPLES AND GRID SQUARES IN WHICH TRAPPING SPECIES WERE FOUND

Species	Samples	Grid Squares
<i>Arthrotrrys arthrotrryoides</i> (Berlese) Lindau	84	17
<i>A. conoides</i> Drechsler .. .. .	651	26
<i>A. dactyloides</i> Drechsler .. .. .	213	26
<i>A. musiformis</i> Drechsler .. .. .	123	9
<i>A. pauca</i> McCulloch .. .. .	1	1
<i>A. superba</i> Corda .. .. .	8	5
<i>Candelabrella javanica</i> Rifai and Cooke .. .. .	4	2
<i>Cystopage cladospora</i> Drechsler .. .. .	21	7
<i>C. intercalaris</i> Drechsler .. .. .	23	9
<i>C. lateralis</i> Drechsler .. .. .	52	3
<i>Dactylaria brochopaga</i> Drechsler .. .. .	24	12
<i>D. candida</i> (Nees) Sacc. .. .. .	4	3
<i>D. gampsospora</i> Drechsler .. .. .	5	3
<i>D. haptophora</i> Drechsler .. .. .	4	4
<i>D. haptotyla</i> Drechsler .. .. .	123	15
<i>D. thaumasia</i> Drechsler .. .. .	521	29
<i>Dactylella leptospora</i> Drechsler .. .. .	78	20
<i>Dactylella</i> sp. .. .. .	1	1
<i>Monacrosporium acrochaetum</i> (Drechsler) Cooke .. .. .	1	1
<i>M. bembicodes</i> (Drechsler) Subram. .. .. .	1	1
<i>M. cystosporum</i> Cooke and Dickinson .. .. .	1	1
<i>M. elliposporum</i> (Grove) Cooke and Dickinson .. .. .	278	32
<i>M. eudermatum</i> (Drechsler) Subram. .. .. .	6	5
<i>M. fusiformis</i> Cooke and Dickinson .. .. .	12	4
<i>M. gephyropagum</i> (Drechsler) Subram. .. .. .	127	28
<i>M. lysipagum</i> (Drechsler) Subram. .. .. .	1	1
<i>M. robustum</i> McCulloch .. .. .	8	2
<i>M. salinum</i> Cooke and Dickinson .. .. .	2	2
Sterile mycelium .. .. .	78	20
<i>Stylopaga hadra</i> Drechsler .. .. .	2	2
<i>S. leiohypha</i> .. .. .	9	5
Total samples .. .. .	1 733	74

TABLE 3  
GRID SQUARES IN WHICH ENDOZOIC SPECIES FOUND

<i>Acrostalagmus bactrosporus</i> ..	9342, 9444, 9445
<i>A. obovatus</i> .. .. .	9444
<i>A. zeosporus</i> .. .. .	9542, 9543, 9444, 9445, 9348
<i>Catenaria vermicola</i> .. .. .	9442, 9542
<i>Cephalosporium balanoides</i> ..	9541, 9442, 9542, 9443, 9244, 9444, 9447
<i>Entomophthora vermicola</i> ..	9240, 9244, 9445
<i>Gonimochaete horridula</i> .. ..	9240, 9341, 9542, 9443, 9543, 9643, 9444, 9445
<i>Haptoglossa heterospora</i> .. ..	9240, 9341, 9342, 9442, 9542, 9443, 9543, 9643, 9244, 9444, 9445, 9348, 8162
<i>Harposporium anguillulae</i> .. ..	8940, 9240, 8641, 9341, 9142, 9342, 9442, 9542, 9343, 9443, 9543, 9244, 9444, 9544, 9245, 9345, 9445, 9246, 8574, 9348, 8949, 8559, 7751, 8951, 9051, 8755, 7756, 8157, 8557, 8160, 8062, 8162, 7963, 7572
<i>H. bysmatosporum</i> .. .. .	9342, 9542, 9443, 9444, 9445, 9246, 9447
<i>H. crassum</i> .. .. .	9442, 9542, 9543, 9444
<i>H. dicorymbum</i> .. .. .	9542
<i>H. helicoides</i> .. .. .	9541, 9342, 9442, 9542, 9443, 9543, 9643, 9444, 9445, 9246, 9348, 8745, 7963, 8064
<i>H. leptospira</i> .. .. .	9342, 9442, 9443, 9543, 9444, 9246, 9347, 9348, 9150, 8162, 7963

TABLE 3—continued

GRID SQUARES IN WHICH ENDOZOIC SPECIES FOUND—continued

<i>H. oxycoracum</i>	.. ..	8540, 9541, 9342, 9442, 9542, 9443, 9543, 9643, 9244, 9444, 9445, 9246, 9446, 9147, 7963
<i>H. subuliforme</i>	.. ..	9442, 9444
<i>Meria coniospora</i>	.. ..	9541, 9542, 9443, 9444, 9445, 9246, 8949, 8162, 7963
<i>Meristacrum asterospermum</i>	.. ..	8540, 9341, 9542, 9143, 9543, 9643, 9244, 9544, 9445, 9246, 9348, 7949, 7963, 7964, 8064
<i>M. pendulatum</i>	.. ..	9444
<i>Myzocyttium vermicola</i>	.. ..	8940, 9240, 9341, 9541, 9542, 9443, 9543, 9444, 9544, 9454, 9348, 8157, 8160, 8162
<i>Nematoctonus campylosporus</i>		9444, 9445, 9348, 8949
<i>N. haptocladus</i>	.. ..	8540, 9348, 8949
<i>N. leispurus</i>	.. ..	9240, 9442, 9542, 9443, 9543, 9643, 9444, 9445, 8540, 8157, 7963
<i>N. leptosporus</i>	.. ..	9444
<i>N. pachysporus</i>	.. ..	9240, 9442, 9543, 9544, 9445, 9348, 8755
<i>Paecilomyces coccosporus</i>	.. ..	9240, 9442, 9542, 9443, 9543, 9244, 9444, 9445, 9348, 7963

TABLE 4

GRID SQUARES IN WHICH TRAPPING SPECIES WERE FOUND

<i>Arthrobotrys arthrobotryoides</i>		9240, 9541, 9242, 9342, 9442, 9542, 9243, 9443, 9543, 9244, 9444, 9445, 8547, 9447, 9348, 8162, 7963
<i>A. conoides</i>	.. ..	9240, 9341, 9541, 9242, 9342, 9442, 9542, 9443, 9543, 9643, 9244, 9444, 9445, 9146, 8547, 9347, 9447, 9348, 8550, 9150, 8951, 9051, 8557, 8060, 8162, 7963
<i>A. dactyloides</i>	.. ..	8540, 9240, 8641, 9541, 9342, 9442, 9542, 9143, 9343, 9443, 9543, 9244, 9444, 9445, 9545, 9246, 9446, 8547, 9147, 9447, 9348, 7553, 8754, 8755, 8157, 8162
<i>A. musiformis</i>	.. ..	9542, 9443, 9444, 9544, 9445, 9447, 9051, 8162, 7572
<i>A. pauca</i>	.. ..	9442
<i>A. superba</i>	.. ..	9342, 9444, 9445, 8949, 8150
<i>Candelabrella javanica</i>		8162, 7572
<i>Cystopage cladospora</i>	.. ..	9442, 9543, 9444, 9445, 9447, 7963, 8064
<i>C. intercalaris</i>	.. ..	9240, 9341, 9541, 9443, 9543, 9444, 9445, 9446, 7963
<i>C. lateralis</i>	.. ..	9443, 9444, 9445
<i>Dactylaria brochopaga</i>	.. ..	9341, 9442, 9542, 9443, 9543, 9444, 9445, 8848, 9348, 8949, 8157, 8162
<i>D. candida</i>	.. ..	9240, 9443, 9348
<i>D. gampsospora</i>	.. ..	9444, 9445, 7963
<i>D. haptospora</i>	.. ..	9341, 9142, 7744, 7572
<i>D. haptotyla</i>	.. ..	9240, 9242, 9342, 9442, 9542, 9443, 9543, 9144, 9444, 9445, 9347, 9348, 9150, 8162, 7963
<i>D. thaumasia</i>	.. ..	9240, 9141, 9541, 9242, 9342, 9442, 9542, 9343, 9443, 9543, 9643, 9244, 9444, 9544, 9445, 9246, 9446, 9546, 8547, 9348, 9150, 8451, 8951, 8557, 8162, 7963, 8064, 7965
<i>Dactylella leptospora</i>	.. ..	8540, 9341, 9541, 9242, 9442, 9542, 9443, 7744, 9244, 9444, 9445, 9348, 8951, 9051, 8755, 8358, 7461, 7761, 8162, 7963
<i>Dactylella</i> sp.	.. ..	9445
<i>Monacrosporium acrochaetum</i>		9341
<i>M. bembicodes</i>	.. ..	9240
<i>M. cystosporum</i>	.. ..	9141
<i>M. ellipsosporum</i>	.. ..	9240, 9141, 9341, 9441, 9342, 9442, 9542, 7443, 9443, 9453, 9643, 9244, 9444, 9544, 9345, 9445, 9246, 9346, 8547, 9447, 9348, 9150, 8951, 9051, 8852, 8754, 8160, 8062, 8162, 7963, 7964, 8064
<i>M. eudermatum</i>	.. ..	9341, 9444, 9445, 9246, 9051

TABLE 4—continued

## GRID SQUARES IN WHICH TRAPPING SPECIES WERE FOUND—continued

<i>M. fusiformis</i> .. .. .	9443, 9543, 9643, 9444
<i>M. gephyropagum</i> .. .. .	8940, 9240, 9241, 9341, 9441, 9541, 9342, 9442, 9542, 9143, 9343, 9443, 9543, 9643, 9244, 9444, 9245, 9445, 9146, 9246, 9147, 9447, 8949, 8951, 8755, 8062, 7963, 7572
<i>M. lysipagum</i> .. .. .	9445
<i>M. robustum</i> .. .. .	9444, 9445
<i>M. salinum</i> .. .. .	9444, 9051
Sterile mycelium .. .. .	9240, 9541, 9542, 9343, 9443, 9543, 7744, 9244, 9444, 9345, 9445, 9446, 9348, 8949, 9150, 8160, 7461, 8162, 7963, 7964
<i>Stylopaga hadra</i> .. .. .	7963, 7964
<i>Stylopaga leiohypha</i> .. .. .	9244, 9444, 8951, 9051, 8157

TABLE 5

## SAMPLES FROM NATIVE VEGETATION IN WHICH NEMATOPHAGOUS SPECIES FOUND

Species	Rain-forest	Open forest	Grassland
<b>Endozoa species</b>			
<i>Acrostalagmus bactrospor</i> .. .. .	1	0	0
<i>A. zeosporus</i> .. .. .	0	1	0
<i>Cephalosporium balanoides</i> .. .. .	1	1	0
<i>Gonimochaete horridula</i> .. .. .	5	2	1
<i>Haptoglossa heterospora</i> .. .. .	1	2	0
<i>Harposporium anguillulae</i> .. .. .	12	37	6
<i>H. helicoides</i> .. .. .	0	4	0
<i>H. leptospira</i> .. .. .	0	3	0
<i>H. oxycoracum</i> .. .. .	0	23	0
<i>Meria coniospora</i> .. .. .	0	2	0
<i>Meristacrum asterospermum</i> .. .. .	0	3	2
<i>M. pendulatum</i> .. .. .	0	1	0
<i>Myzocyttium vermicola</i> .. .. .	1	2	1
<i>N. haptocladus</i> .. .. .	0	0	1
<i>N. leiosporus</i> .. .. .	0	4	0
<i>Paecilomyces coccosporus</i> .. .. .	0	1	0
<b>Trapping species</b>			
<i>Arthrobotrys arthrobotryoides</i> .. .. .	11	4	0
<i>A. conoides</i> .. .. .	8	10	0
<i>A. dactyloides</i> .. .. .	6	11	5
<i>A. musiformis</i> .. .. .	7	3	0
<i>A. superba</i> .. .. .	0	0	1
<i>Candelabrella javanica</i> .. .. .	4	0	0
<i>Cystopage cladospora</i> .. .. .	0	1	0
<i>C. intercalaris</i> .. .. .	0	2	0
<i>C. lateralis</i> .. .. .	1	2	1
<i>Dactylaria brochopaga</i> .. .. .	1	0	0
<i>D. haptospora</i> .. .. .	2	0	1
<i>D. haptotyla</i> .. .. .	2	4	0
<i>D. thaumasia</i> .. .. .	8	44	1
<i>Dactylella leptospora</i> .. .. .	0	6	5
<i>Monacrosporium acrochaetum</i> .. .. .	1	0	0
<i>M. bembicodes</i> .. .. .	0	1	0
<i>M. ellipsosporum</i> .. .. .	4	31	1
<i>M. eudermatum</i> .. .. .	3	0	0
<i>M. fusiformis</i> .. .. .	0	7	0
<i>M. gephyropagum</i> .. .. .	7	15	5
<i>M. robustum</i> .. .. .	0	3	0
Sterile mycelium .. .. .	0	3	2
<i>Stylopaga leiohypha</i> .. .. .	0	2	0
Samples without nematophagous fungi	12	44	24
Total samples .. .. .	54	178	43

TABLE 6  
ASSOCIATION OF NEMATOPHAGOUS FUNGI WITH CROPS

Species	Total isolations	Ginger	Citrus	Pineapple	Tobacco	*Couch grasses
<b>Endozoic</b>						
<i>Haptoglossa heterospora</i>	105	65	4	0	1	6
<i>Harposporium anguillulae</i>	600	120	64	59	48	19
<i>H. oxycoracum</i> .. ..	89	4	4	7	2	18
<i>Paecilomyces coccosporus</i>	87	14	1	4	44	2
<b>Trapping</b>						
<i>Arthrobotrys conoides</i> ..	651	171	59	75	48	4
<i>A. dactyloides</i> .. ..	213	6	80	4	7	44
<i>A. musiformis</i> .. ..	123	37	13	16	2	0
<i>Cystopage lateralis</i> ..	52	4	1	2	25	4
<i>Dactylaria haptotyla</i> ..	123	14	3	9	40	0
<i>D. thaumasia</i> .. ..	521	41	32	73	55	7
<i>Monacrosporium ellipsosporum</i> .. ..	278	77	20	26	10	1
<i>M. gephyropagum</i> ..	127	6	36	1	16	1
Total samples ..	1 733	260	154	152	123	77

\* *Cyanodon dactylon* and *Digitaria didactyla* from bowling greens.

Table 6 shows the number of recordings of 12 commonly occurring fungi under particular crops in relation to their total occurrence. Although the majority of species are in the same order of dominance as in the total sampling, some show a tendency to be associated with a particular crop, for example, *Haptoglossa heterospora* with ginger, *Paecilomyces coccospora* and *Dactylaria haptotyla* with tobacco, and *Arthrobotrys dactyloides* with citrus.

#### IV. DISCUSSION

About half the described species of nematophagous fungi were found in Queensland. The finding of such a large proportion of species may be because of the large number of samples examined. However, in other surveys, the greatest number of species was not always isolated where the greatest number of samples had been examined. Fowler (1970) examined 700 samples from New Zealand and isolated 19 species while Duddington (1951) in England isolated 25 species from 135 samples.

The large number of species found by Duddington may be due to the type of material examined. Whereas Fowler examined only soil, Duddington examined different types of organic matter such as moss and dung which are considered to be rich sources of nematophagous fungi.

The method of isolating fungi from soil may have contributed to the large number of species found in the Queensland survey. The method of Duddington (1955), used in many surveys, is based on a 1 g subsample for isolations from each sample. Fowler (1970) prepared plates in triplicate so that isolations from each site were made on the basis of a 3 g sample. In the method used in the Queensland survey, a soil sample of at least 700 g was used to prepare the isolation plates from each site. Feder (1962) also used a large quantity of soil from each site (200 g) and isolated 17 species from 46 sites.

Queensland covers the large area of 1 727 530 km<sup>2</sup> lying between 10° and 29° S latitude and can be divided into a large number of distinct climatic areas. This may have contributed to the large number of species found. However, temperature does not appear to have affected distribution as the majority of species found in the tropics were also found in temperate areas. Of the two species found only in the tropics, *Stylopaga hadra* is common in Great Britain (Duddington 1951) so cannot be classed as a tropical species, but *Candelabrella javanica* was described from Java and has not been reported elsewhere. As few species were recorded from western grasslands, where the annual rainfall is less than 25 mm, low soil moisture may be limiting distribution.

*Arthrobotrys* species are often the most common taxa recorded in surveys. In this study and in Iowa (Norton 1963), *A. conoides* was the most commonly recorded species. In other areas, Britain (Duddington 1954), New Zealand (Fowler 1970), North Carolina (Feder 1964), Quebec (Estey and Olthof 1965), *A. oligospora* was predominant, but it was not detected in this survey.

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## APPENDIX I

*Dactylella* sp. (figure 2). This fungus, which captures nematodes on adhesive spherical knobs, was isolated from soil around pineapples (*Ananas comosus* (L.) Merr.) at Gildora near Gympie, Queensland. The trapping organs, 6 to 7  $\mu\text{m}$  in diameter are held erect on unicellular stalks, 5 to 9  $\mu\text{m}$  long, 2 to 3  $\mu\text{m}$  wide. Conidiophores are erect, cellular, unbranched 21 to 32  $\mu\text{m}$  high, 2  $\mu\text{m}$  wide and taper towards the tip. Hyaline, filiform conidia, 29 to 48  $\mu\text{m}$  long and 2 to 4  $\mu\text{m}$  wide are produced singly at the apices of conidiophores. The conidia are divided by 3 to 5 (usually 4) septa into cells, the distal one of which is subspherical and adhesive and on which nematodes are trapped.

The production of adhesive knobs distally on conidia previously was recognized in only *D. leptospora* and *Dactylaria haptospora*. *Dactylella* differs from *D. leptospora* in the trap form and from *Dactylaria haptospora* in the length of the spore, in producing spores singly at the conidiophore apex, and in having the hyphal adhesive knobs supported on single-celled stalks.

As the original culture of this species was lost, and attempts to reisolate it from the type locality have been unsuccessful, it has not been erected as a new species.

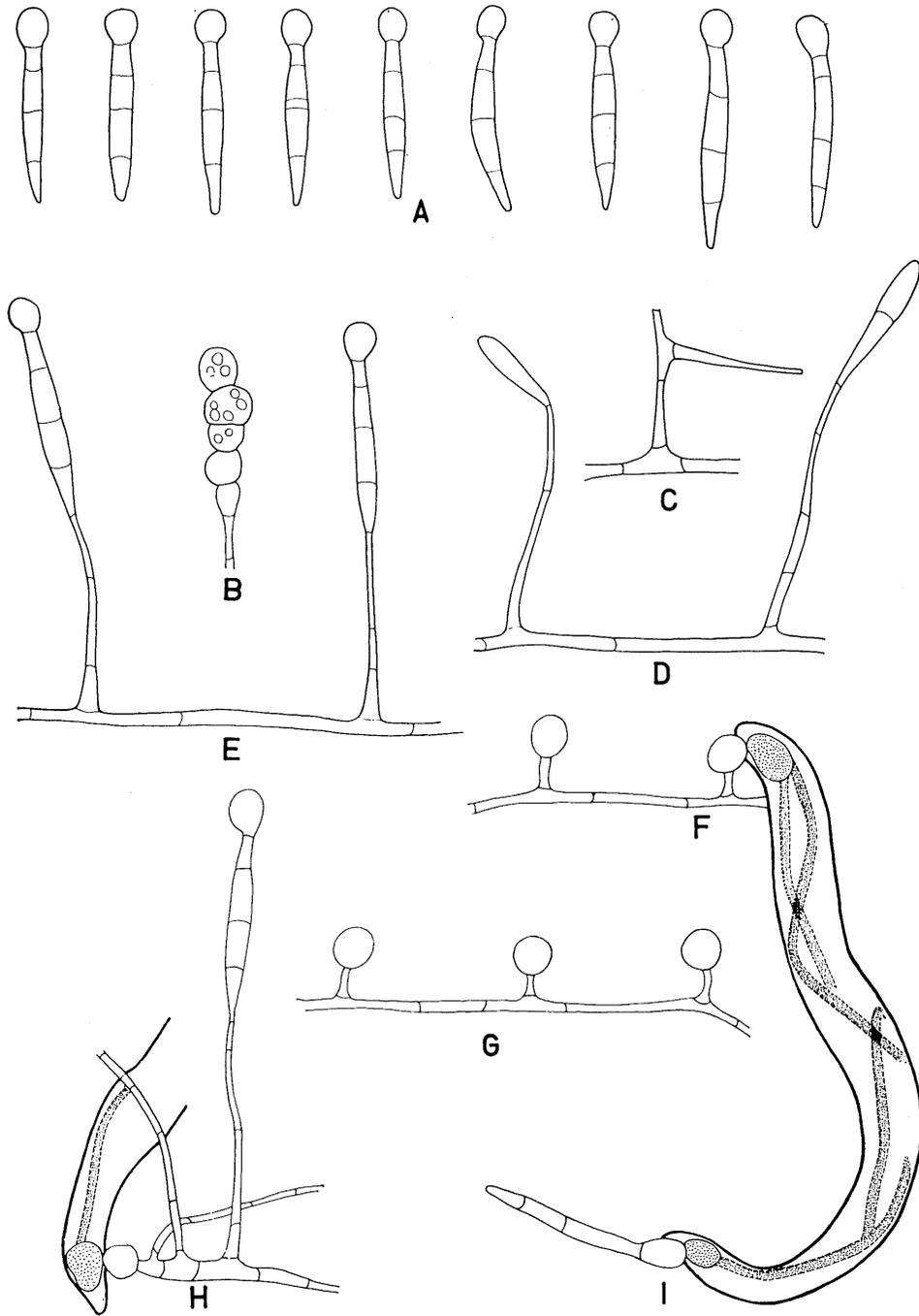


Figure 2.—*Dactylella* sp. A conidia; B chlamyospores; C branched conidiophore; D conidiophores with developing conidia; E conidiophores with mature conidia; F assimilative hyphae within body of trapped nematode; G adhesive knob traps; H adhesive knob of conidium capturing nematode and germ tubes from other cells forming conidiophore and vegetative hyphae; I adhesive knob of conidium capturing nematode.