BIOLOGICAL NOTES ON *TETRADONEMA PLICANS*, COBB, A NEMATODE PARASITE OF *SCIARA COPROPHILA* LINTNER

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INTRODUCTION

In January, 1915, while studying the life history of the Mycetophilid fly *Sciara coprophila* Lint., which is often found breeding in potted plants, the writer found one batch of maggots parasitized by a peculiar nematode. The unusual appearance of this worm led to a study of its life history. Several photographs and figures were made at the time as a matter of interest, but aside from recording the effectiveness of this parasite in the destruction of Sciara maggots,* nothing was done until the beginning of 1918, when the nema under discussion was sent to Dr. N. A. Cobb for determination.

DISTRIBUTION

In an endeavor to determine the range of distribution, the number of specific hosts and the percentage of infestation in nature, a careful search has been made of every Sciara fly and maggot obtainable. These were collected from fields of alfalfa and of wheat, from meadow grasses, from beneath the leaves in the woods, conservatories, and from green houses, but aside from the material cited at the beginning of this paper, none was ever found parasitized by this nematode. Grub worms and angle worms living in similar situations have been found free also. Experiments to infect these last have failed, although I have seen small angle worms swallow the eggs on several occaions. These angle worms were, in every case, isolated, and kept under observation. They did not become infected.

A study of the one lot of infected Sciaras and those artificially infected in the experimental work shows that the gravid female parasite may be found in larvae, pupae and adult flies. From two to twenty parasites of both sexes may be found in a single host; on the average, ten worms came from each host, and the number of males ran a little greater than of females.

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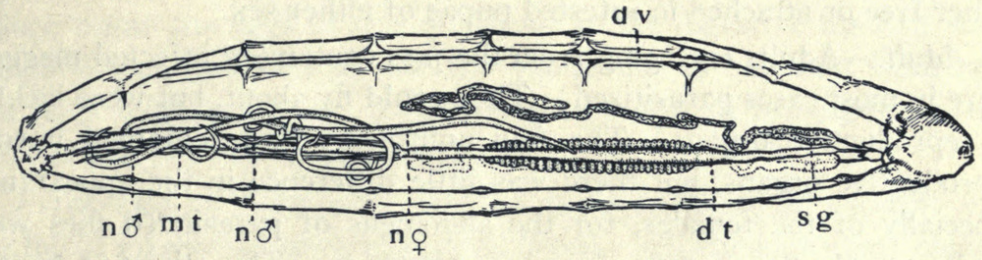
*In the Journal of Economic Entomology for December, 1916, the writer mentioned this nematode as an enemy of Sciara maggots and figured the gravid female nematode.

APPEARANCE OF AFFECTED HOST

When one compares a normal maggot with an infected one, a marked contrast is noted (Figs. 1 and 2). In the former, the maggot appears white, due to the large definite fat bodies present. There are present also segmentally arranged fat masses about the spiracles. The head capsule is shiny black, and, as shown, not conspicuously smaller than the diameter of the anterior part of the maggot. On the other hand, the parasitized maggot gives no evidence of either the long fat masses or the segmentally arranged fat bodies. The head capsule is very likely to be small, indicating the failure of the maggot to make its normal moults. The nematodes within appear white by reflected light (Fig. 2). An examination of such a maggot shows plainly the pulsations of the dorsal vessel, with its muscular wings and pericardial cells, are most plainly seen. In one maggot the female parasite was disrupted in such a way as to release her eggs into the body cavity of the maggot. These eggs were seen buffeted about within the transparent skin of the maggot by the movement of its organs. The dorsal



Sciara maggot dissected, *d v,* dorsal vessel; *d t,* digestive tract; *s g,* salivary gland; *m t,* malpigian tubules; *n,* nematode.

vessel was burdened with the continuous coursing of nematode eggs from the rear to the front. Several times the eggs temporarily clogged the dorsal vessel near its anterior outlet, only to break away under the pressure like a released log jam and go racing on with the circulatory fluids.

EFFECT UPON THE HOST

Larva.—The young maggot of 2 mm. may have the body teeming with newly hatched nemas, which are visible under the microscope, without showing much deviation from normal, but very shortly the long fat bodies begin to decrease in size. In the normal maggot these fat bodies are long masses that cling to the salivary glands and surround the malpighian tubules, and the lateral masses, segmentally arranged close to the muscles of the body, one on either side, also a smaller mass beneath each nerve ganglion. These finally disappear altogether, leaving the body very clear. The digestive tract, with its appendages, the heart and the nervous system, can all be seen plainly.

A little later the digestive tract seems subnormal in diameter, but still functional. If the maggot is slit longitudinally, fixed, stained, and the muscular portion and integument spread and mounted upon a slide, the muscular system will present a conspicuous appearance, all the nuclei staining well. The maggot at this stage retains muscular activity, but later remains extended and incapable of movement. A stained mount of such a maggot would show the muscular system in the state of collapse, the heart action being about the only evidence of life. In spite of the general disintegration, the imaginal disks are present, as also the lateral segmentally arranged oenocyte clumps. Maggots, when heavily parasitized, die and disintegrate, leaving within or upon the earth only a mass of several thousand nematode eggs.

Pupa.—Sometimes in light or late infection, the maggot endeavors to pupate; it spins out threads and sheets of silk, then contracts, as is usual before transforming. This marks the end of some; others succeed in casting off the larval skin. Many such pupae are little else than mere shells, the body cavity being filled with the egg-burdened nematodes. In no case could I find traces of reproductive organs, either free or attached in infested pupae of either sex.

Adult.—Adults emerging from the jars containing infected maggots were in most cases parasitized. They could fly about, but were lacking in reproductive organs. The few uninfected flies contained normal reproductive organs, but there was little difference in the appearance, especially of the females, for the abdomens of parasitized flies were swollen with the mature female nematodes. The direct economic aspect of the case of parasitism reported herein lies in the fact that the maggots which feed upon plant roots are destroyed or rendered less active, and the fact that those fortunate enough to transform to the adult fly stage are rendered incapable of perpetuating their kind.

LIFE HISTORY OF TETRADONEMA PLICANS COBB

This nematode has but the one host, which may be larvae, pupa or adult of the Sciara fly. Possibly it may live also in other species than the *Sciara coprophila* in which it was found.

There is considerable dimorphism in the mature nematode. The females are large, reaching a length of 5 mm. or more, while the males are less than 1 mm. long. The striking characteristic of the female is shown in the mature egg laden form (Fig. 4). The swollen portion is caused by the storage of several thousand eggs beneath the cuticula, which serves as a retaining capsule. The notch on the ventral side of the worm marks the position of the genital opening. The relative sizes of the two sexes some time after mating is illustrated in Figure 3. Here the female has begun to lay her eggs as shown by the spindle-

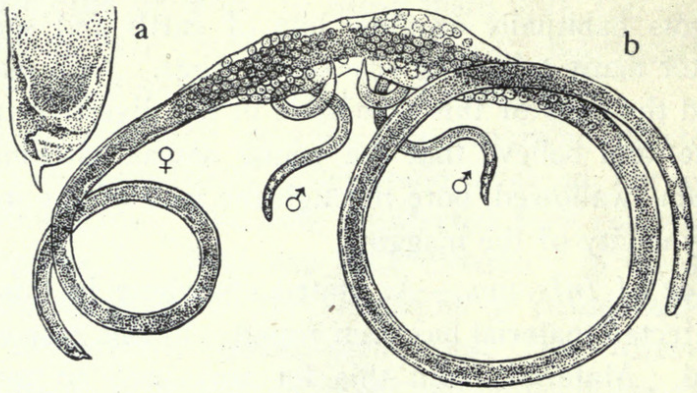
shaped capsule; this continues to enlarge until the female has the appearance shown before but, barring accident, the eggs are not discharged until the death of the worm.

Method of Infection.—The nematode eggs very often have been induced to hatch in the presence of moisture. All efforts to observe the young larvae enter the maggot have failed. When first discovered in the host, they appear identical with those just escaped from the egg and have been detected first in the caudal end of the maggot in the region between the body wall and the digestive tract. The older maggots are much less susceptible to infestation than the younger ones. When young maggots not more than 3 mm. long were placed in earth containing the nematode eggs, they would, in the course of a day or two, be found to contain sometimes as many as twenty-one young parasites. The parasite probably gains access to its host through the alimentary canal. Even newly hatched maggots are of sufficient size to consume solid objects larger than the egg of the nematode. The larger maggots habitually swallow bits of earth and solid pieces of organic matter many times the size of the eggs. As a matter of fact, I have found the eggs of this nematode in the digestive tract of small Sciara larvae, and believe that the young nemas hatching from eggs that have been swallowed, bore through the wall of the digestive tract into the body cavity of the maggot.

Percentage of Infection.—As stated elsewhere in this paper, only one lot of infected material has been found. In this case every maggot was infected. Material from this lot was used to make artificial infections.

Development and Behavior of the Host.—The life cycle of this nematode has been followed from its earliest observed stage to the mating of the sexes and the formation of the egg capsules about the females, all of which takes place within the body of the maggot, and is clearly visible due to the transparency of infested larvae. The young nematodes as they are found in the maggot are of two kinds and of the same size as those that have hatched from eggs in a drop of water. This precludes any possibility of an alternate host. The method of studying the life cycle was to examine carefully young maggots taken from noninfested stock and then place them in small stenders with earth containing nematode eggs. Examinations were made several times daily. The eggs mixed with the debris swallowed by the maggots were not to be noticed in the living maggots, but when the latter were killed and the digestive tracts removed and cleared in cedar oil, as many as a dozen nematode eggs were found in the mid gut of one maggot. In the living maggots the first newly hatched

worms were to be noted in the body cavity at the posterior end of the body. Here they would often get into the way of the blood stream entering the dorsal vessel, and be buffeted back and forth. The slenderer worms were usually coiled at both ends, while the shorter plumper forms remained outstretched or slightly curved. From this time on the growth of the worms is rapid and usually timed, so that their eggs are produced before the maggot is ready to pupate. In cases of slight or late infection, the nematode cycle may not be completed until the pupal stage has been reached or even the adult fly produced. In adult flies have been found gravid females, heavily egg laden and also small nematodes equaling in size those of a few days of age. These I take it have been arrested in their development by the growth and maturity of older worms. Indeed even in a given maggot isolated for study the range of development of the various worms has been so great that I have found it difficult to tabulate the stages.



a, Caudal end of mature female. *b,* Female with two males attached.

On the average, very young parasites have been found in maggots from 1.5 mm. to 4 mm. long. Mating begins when the female nematodes are less than 1 mm. long, a size they may attain in from five to ten days. The remaining growth of the female, which attains some 5 to 7 mm. in length, and of the egg capsule involves the next two weeks.

Mating.—As the worms approach sexual maturity, marked activity is noted which may precede mating by a day or two. They begin to coil and uncoil about each other in an energetic manner. The males are the more active, coiling about the body of the female with the caudal end almost indiscriminately, until finally the genital opening is grasped, and the male rests with caudal end tightly clasped about the female, and the anterior end directed away at about a right angle. The spicules hold the males so firmly in position that they are often difficult to dislodge with dissecting needles. As many as three or four males may become attached to one female, and remain until the female completes

her egg capsule and dies. The males that remain unmated finally are relegated to the caudal end of the female, where they become granular in appearance and sluggish in action, finally dying. The males remaining attached to the female also show this granular appearance.

Oviposition.—The eggs of this nematode are retained beneath the thin cuticula of the female. As the female comes to the age of oviposition, the ova may be seen within her body in various stages of development. They appear both cephalad and caudad of the genital pore. Oviposition may be slow at first, and the first eggs can be seen to pass out and slip along under the cuticula. This is seen plainly in living females at the beginning of oviposition. The nature of this cuticular egg storage chamber may be studied in glycerin jelly mounts of such females in toto or by means of sections. The egg (Fig. 5) possesses a fairly thick shell, somewhat testaceous in color. It appears somewhat disk-shaped. The photograph shows them in flat view. When an egg is placed upon edge it forms an oblong outline, well shown in sections. It measures 33.2μ in diameter and 16.6μ in thickness. In the egg-burdened female will be found eggs in all stages of development, from unsegmented eggs to those containing actively coiling embryos, the latter not being abundant until the egg capsule is fairly well started.

NUMBER OF EGGS PER FEMALE PARASITE

Host	Size of Host	No. Parasites		Size of Parasites, Female	Total Number Eggs	Remarks
		Female	Male			
Pupa	Small	1	3	5 mm.	1,262	Embryos, all stages
Adult	Normal	1	6	5.2 mm.	2,046	Embryos, all but late coil stage
Larva	Enlarged	1	?	?	5,123	All stages of embryo
Larva	4 mm.	1	3	5 mm.	262	Egg capsule just beginning
Larva	6 mm.	1	2	4.9 mm.	1,763	Still egg laying
Larva	5 mm.	1	3	5 mm.	1,240	Still egg laying
Adult	Abdomen enlarged	1?	2	5.1 mm.	2,484	
Larva	5 mm.	1	1	5.1 mm.	5,520	
Larva	6 mm.	1	3	5 mm.	2,005	
Larva	7 mm.	1	2?	5 mm.	3,750	
Larva	7 mm.	2	5	5 mm.	4,700	

Incubation and Hatching.—Eggs containing mature embryos from young females, when dissected out and placed in water, hatch within twenty-four hours; eggs from old females hatch very shortly, from a few minutes to a few hours. The embryo may be seen coiling about within the shell for some time before it forces its way out. Newly hatched larvae are of two kinds, a very slender form with a curve at the caudal end 125μ long, and a plumper, slightly curved form 90μ long. The former, in hatching, often has some difficulty in freeing itself from the egg. In one case the little worm struggled for a half hour; it was free save for the caudal end, which hooked firmly into the

egg shell. The nema twisted about through the water, stopping now and then to give the whole body a series of vibrations in an attempt to get free. It was thirty minutes before a sudden and forceful effort set it at liberty.

Dispersal.—The distribution of this nematode may take place by migration of the maggots, through infested flies, and through the agency of air or water. The heavily infested maggot disintegrates and the nematode eggs mix with the soil to be eaten by other maggots or tossed about by wind or water. Dispersal by adult flies was proved in the laboratory. Three potted plants containing eggs and very young sciara maggots were placed in the same rearing cage with a can of earth containing infected maggots. From this can infected adult flies flew to the other pots, where some of them died. The dead bodies were full of nematode eggs which shortly brought about an infection of the maggots in the flower pots.

EXPLANATION OF PLATE

Fig. 1. Normal sciara maggot showing large white fat bodies and segmentally arranged discs of adipose tissue.

Fig. 2. Sciara maggot in advanced state of parasitism; white female nematode within.

Fig. 3. Mating female *Tetradonema plicans;* two males attached; egg laying already begun.

Fig. 4. Gravid female nematode swollen by eggs retained beneath cuticula.

Fig. 5. Eggs in various stages of development.

Fig. 6. Female nematode with reproductive organs dissected out.

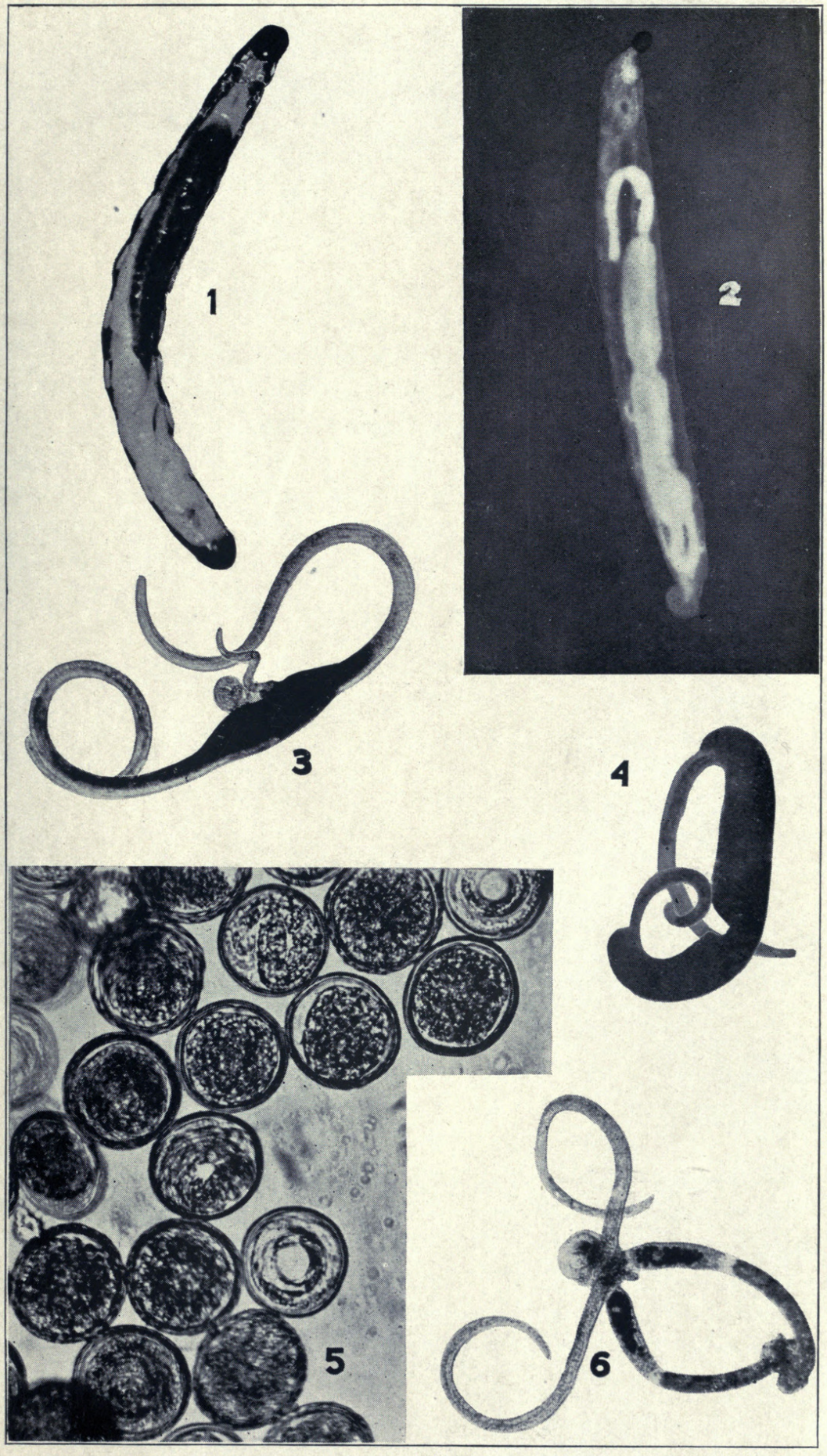


PLATE XIX