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STUDIES ON STRONGYLOIDIASIS OF THE PEACOCK

II. *STRONGYLOIDES PAVONIS* N. SP. (NEMATODA: STRONGYLOIDIDAE) FROM THE GREEN PEAFOWL *PAVO MUTICUS* LINNAEUS

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Numerous larvae of *Strongyloides* were obtained from the feces of a green peacock, *Pavo muticus* LINNAEUS. The bird was a young, male green peacock imported from Southeast Asia via Hong Kong into the Maruyama Zoo, Sapporo, on April 22, 1962.

Clinically, the bird was weakened and emaciated because of continuous diarrhoea and anorexia since its arrival. The fecal examination disclosed the presence of *Strongyloides* sp. together with *Heterakis* sp., *Capillaria* sp. and a cestode species. The bird, therefore, was treated with anthelmintics; the result was reported by SAKAMOTO et al. (1964) and SAKAMOTO (1968). Adult parasitic females were obtained by this treatment. The parasites at the free-living stage, rhabditiform and filariform larvae and rhabditiform adults, were obtained by the cultivation of fecal materials.

The infective larvae were given orally and subcutaneously to chickens, *Gallus gallus domesticus* (BRISSON) (white Leghorn and New Hampshire lines), Indian peafowls, *Pavo cristatus* LINNAEUS, Japanese quails, *Coturnix coturnix japonica* TEMMINCK et SCHLEGEL, domestic pigeons, *Columba livia domestica* LINNAEUS, domestic ducks, *Anas platyrhyncha domestica* LINNAEUS, Japanese tree-sparrows, *Passer montanus kaibatoi* MUNSTERHJELM, white mice, *Mus musclus* LINNAEUS (CF#1 strain), white rats, *Rattus norvegicus* BERKENHOUT (Wistar strain), and rabbits, *Oryctolagus cuniculus domesticus* (GMELIN). Among these, only the chickens and Indian peafowls were found to be infected with this parasite, and many adult, parasitic females were obtained from their caeca. We have succeeded in serial passages of the parasite using chickens and peafowls up to the present.

DESCRIPTION

Strongyloides pavonis n. sp.

1. Adult parasitic female (Table 1)

Fine, thread-like nematode. Length of body 2.73~4.19 mm (average 3.41 mm); maximal width 0.043~0.060 mm (0.050 mm), ratio to body-length 1.05~1.86% (1.47%). Tail short and conical, with a pair of indistinct, papillary elevations on the lateral sides. The end of the

TABLE 1 *Measurements of parasitic females of avian Strongyloides*

(unit of length: μ)

SPECIES	BODY LENGTH	WIDTH OF BODY	α	LENGTH OF ESOPHAGUS	β	DISTANCE OF VULVA FROM ANTERIOR END		DISTANCE OF ANTERIOR OVARIUM FROM ESOPHAGUS	DISTANCE OF POSTERIOR OVARIUM FROM ANUS	LENGTH OF TAIL	γ	SIZE OF EGGS		AUTHORS
						Distance	Ratio to body length (%)					Length	Width	
S. avium	2,200	40~55	49~55 *1	700	3.15 *1	1,400	63.7 *1	45	80	55	40	52~56	36~40	CRAM (1929)
" *2	2,610~3,930			546~687	3.8~6.4		57.4~63.8			32~52	59~100	54~60	25~35	CRAM (1936)
" *3	2,930~4,390			624~913	3.6~6.2		54.5~64.3			52~87	40~69.8	"	"	CRAM (1936)
"	1,626~2,136	38~46	35.4~54.7	475~675	2.9~4.5	1,113~1,354	63.7~68.5	37~55	19~59	39~43	37.9~54.7	39~56	24~33	SAKAMOTO & SARASHINA (1968)
"	2,250~3,310			530~660		1,350~2,130		11~104		31~58		39~50	27~31	BARUŠ (1969)
S. oswaldoi	3,000	60	50 *1	480	6.25 *1	1,800	60.0 *1		45~60	50~70	43~60 *1	45~50	30	TRAVASSOS (1930)
"	2,200~3,040	40~50	44~55	450~500	4.28~5.20	1,334~1,633		33~50	61~82	40~50	52~55	41	21~25	FREITAS & ALMEIDA (1936)
S. minimum	1,125~1,780	37~40		512~550						50	22.5~35.6	50	28	TRAVASSOS (1930)
S. cubaensis	2,200~2,350	42~50		540~560						70~76				PÉREZ VIGUERAS (1942)
S. turkmenica	1,740~2,070	33~45		381~554		916~ *1 1,224				42~49		35~42	21~24	KURTIEVA (1954)
S. ardeae	1,500~2,100	30~40		480~780						30~50				LITTLE (1966)
S. herodiae	2,370~2,800	32~36		530~660		1,470~1,730		51~100	87~91	48~53		44	27	BOYD (1966)
S. pavonis														
Range	2,730~4,190	43~60	54~95	725~915	3.47~5.19	1,685~2,495	59.0~65.3	16~195	28~95	51~75	31.7~78.9	50~54	35~40	Our data
Average	(3,410)	(50.4)	(68.2)	(805)	(4.26)	(2,090)	(61.1)	(69.7)	(63.4)	(62.3)	(56.3)	(53)	(36)	

*1: Values calculated by us from the original descriptions
*2: Specimens from small intestine
*2: Specimens from caeca
α : Body-length/width of body
β : Body-length/length of esophagus
γ : Body-length/length of tail

tail had a globular swelling; sometimes, a pair of very tiny, lustered nodules are seen on the globular swelling. Cuticle annulated and thin; the annular striations regular, begin just behind the head and end near the posterior end. Mouth hexagonal and very shallow, surrounded by three labiate elevations with six papillae. Esophagus slender, filariform, and slightly thickened towards its posterior end, 0.725~0.915 mm (0.805 mm) in length; ratio to body-length 19~28 % (23.3 %). Nerve ring at 0.138~0.194 mm (0.168 mm) from head end. Intestine runs straight. Anus opens on ventral surface, elevating slightly, at 0.051~0.075 mm (0.62 mm) from tail end; ratio to body-length 1.27~3.18 % (1.78 %). Vulva at 1.68~2.50 mm (2.09 mm) from head end; ratio to body-length 59.0~65.3 % (61.1 %). Vulva, with a pair of labiate elevations, opens transversely. Uterus opens directly to vulva. Uteri divergent oppositely, directly from vulva, and connected by short ducts to ovaries. Anterior and posterior ovaries elongated, reflected respectively at 0.016~0.195 mm (0.070 mm) from end of esophagus and 0.028~0.095 mm (0.063 mm) from anus, and each ovary had one spiral twist. The terminal portions of the ovaries overlap at the level of vulva. About 5 to 20 uterine eggs at various cell-division stages, are arranged in a single row. Uterine eggs elliptical, thin-shelled, 0.050~0.054 mm (0.053 mm)×0.035~0.040 mm (0.036 mm).

2. Rhabditiform larvae at the first stage (Table 2)

Body not very slender. Cuticle very thin, with very fine annulations over the entire body. Length of body in newly hatched larvae 0.192~0.264 mm (0.217 mm), maximal width 0.014~0.018 mm (0.016 mm); ratio to body-length 6.1~7.5 % (7.2 %). Head rounded. Mouth cylindrical. Esophagus short and rhabditiform, with a bulb at its posterior end, and is narrow at anterior part of bulb. Length of esophagus 0.064~0.075 mm (0.069 mm); ratio to body-length 27.2~34.5 % (31.0 %). Nerve ring 0.033~0.045 mm (0.037 mm) from head end. Genital anlage 0.095~0.137 mm (0.123 mm) from head end. Tail conical and pointed. Length of tail 0.033~0.043 mm (0.039 mm); ratio to body-length 15.9~22.2 % (17.3 %).

3. Filariform larvae at the third stage (Table 3)

Body very slender. Cuticle very thin, with annulations extending over the whole body. Anterior end tapers gradually. Length of body 0.570~0.647 mm (0.609 mm), maximal width 0.017~0.021 mm (0.019 mm); ratio to body-length 2.52~3.54 % (3.15 %). Mouth small, pore-like, and shallow. Esophagus very long, cylindrical filariform, 0.216~0.275 mm (0.252 mm) in length; ratio to body-length 36.0~43.5 % (41.7 %). Tail tapers gradually. Length of tail 0.060~0.089 mm (0.075 mm); ratio to body-length 10.5~14.7 % (12.0 %). Phasmids on lateral sides near middle of the tail. The end of tail is notched. The notch is relatively shallow. Nerve ring and genital anlage situated at 0.081~0.114 mm (0.097 mm) and 0.320~0.396 mm (0.363 mm), respectively, from head end.

4. Adult rhabditiform male (Table 4)

Body rather plump, but more slender than that of female. Tail bent ventrally, conical and tapered. Cuticle very thin, and annulated over the whole body. Length of body 0.725~0.960 mm (0.837 mm), maximal width 0.043~0.058 mm (0.050 mm); ratio to body-length 5.2~6.5 % (5.9 %). Head rounded. Mouth hexagonal and shallow; circumoral elevation with six papillae, divided indistinctly into three labiated lobes. Esophagus short, 0.099~0.127 mm (0.117 mm); ratio to body-length 12.2~15.6 % (13.9 %), and similar to that of rhab-

TABLE 2 *Measurements of rhabditiform larvae of avian Strongyloides*

(unit of length: μ)

SPECIES		BODY LENGTH	WIDTH OF BODY	α	LENGTH OF ESOPHAGUS	β	LENGTH OF TAIL	γ	AUTHORS
S. avium		280							CRAM (1929)
S. oswaldoi	rh[1]	222~238	14~16	14.9~15.9	66~83	2.9~ 3.4	25~30	7.9~ 8.9	FREITAS & ALMEIDA (1936)
	rh[2]	221~280	10	22.1~28.0	24	9.2~11.6	23~27	9.6~10.4	
S. pavonis	Range	192~264	14~18	13.3~16.5	64~75	2.9~ 3.7	33~43	4.5~ 6.3	Our data
	Average	(217.8)	(16.1)	(13.8)	(68.5)	(3.2)	(38.9)	(5.8)	

rh[1]: Rhabditiform larvae from parasitic females
rh[2]: Rhabditiform larvae from free-living females
α : Body-length/ width of body
β : Body-length/ length of esophagus
γ : Body-length/ length of tail

TABLE 3 *Measurements of filariform larvae of avian Strongyloides*

(unit of length: μ)

SPECIES		BODY LENGTH	WIDTH OF BODY	α	LENGTH OF ESOPHAGUS	β	LENGTH OF TAIL	γ	AUTHORS
S. avium		560	28	20.0*	240	7/4			CRAM (1929)
"		400~572			157~259	2.2~2.5	50~63	8~9	CRAM (1936)
S. pavonis	Range	570~647	17~21	28.3~39.7	216~275	2.3~2.7	60~89	6.8~9.5	Our data
	Average	(609)	(19.5)	(31.8)	(252)	(2.4)	(74.5)	(8.3)	

* : Value calculated by us from the original description
α : Body-length/ width of body
β : Body-length/ length of esophagus
γ : Body-length/ length of tail

TABLE 4 *Measurements of rhabditiform adult males of avian Strongyloides*

(unit of length: μ)

SPECIES	BODY-LENGTH	WIDTH OF BODY	α	LENGTH OF ESOPHAGUS	β	LENGTH OF TAIL	γ	LENGTH OF SPICULUM	LENGTH OF GUBER-NACULUM	AUTHORS
S. avium	780			145	5.4*	86	9.1*	30		CRAM (1929)
"	601~715			77~121	5.9~7.8	43~67	10.7~13.9	30	20	CRAM (1936)
S. oswaldoi	533~615	24~28	22.0~22.2	115	4.6~5.3	58~65	9.2~9.5	33	22	FREITAS & ALMEIDA (1936)
S. pavonis										
Range	725~660	43~58	15.4~19.3	99~127	6.4~8.2	56~83	9.7~17.1	32~34	20~24	Our data
Average	(837)	(49.6)	(17.0)	(117)	(7.2)	(74.5)	(11.4)	(33.4)	(22.8)	

* : Values calculated by us from the original descriptions
α : Body-length/ width of body
β : Body-length/ length of esophagus
γ : Body-length/ length of tail

TABLE 5 *Measurements of free-living females of avian Strongyloides*

(unit of length: μ)

SPECIES	BODY-LENGTH	WIDTH OF BODY	α	LENGTH OF ESOPHAGUS	β	DISTANCE OF VULVA FROM ANTERIOR END		LENGTH OF TAIL	γ	SIZE OF EGGS		AUTHORS
						Distance	Ratio to body-length (%)			Length	Width	
S. avium	860			156	5		58.2	110	7.8*	48	22	CRAM (1929)
"	601~840			97~128	6.2~6.5		47.5~51.3	73~88	8.2~9.5			CRAM (1936)
S. oswaldoi	632	32	19.7*	97	6.5*			83	7.6*	48	24	TRAVASSOS (1931)
"	721~880	57~66	12.7~13.8	127~140	5.7~6.5	344~467		86~98	8.6~9.0	41~57	20~33	FREITAS & ALMEIDA (1936)
S. pavonis												
Range	910~1,360	56~87	12.6~18.6	117~156	7.0~10.2	433~606	43.8~50.0	91~182	6.6~12.0	39~48	27~36	Our data
Average	(1,110)	(71.7)	(15.6)	(133)	(8.4)	(532)	(47.8)	(122)	(9.2)	(42.8)	(30.6)	

* : Values calculated by us from the original descriptions

α : Body-length/ width of body

β : Body-length/ length of esophagus

γ : Body-length/ length of tail

ditiform larva. Cloaca opens at 0.056~0.083 mm (0.075 mm) from tail end; ratio to body-length 5.9~10.3% (8.8%). Two spicula archwise, 0.032~0.034 mm (0.033 mm) in length. Gubernaculum triangular, 0.020~0.024 mm (0.023 mm); about 2/3 of spicule-length. Tail possesses an unpaired medioventral, cone-shaped papilla and 9-paired caudal papillae. The latter arranged as follows; 3 preanal (1 lateral and 2 subventral), 1-paired adanal and 5 postanal (2 subventral and 3 subdorsal). Sometimes, a few tiny indistinct papillary elevations are found arranged irregularly. Anterior extremity of testis reaches 0.112~0.190 mm (0.154 mm) from head end, but does not reach to end of esophagus.

5. Adult rhabditiform female (Table 5)

Body stout and tapers gradually toward anterior end. Posterior end conical and pointed. Cuticle very thin, with fine annulations over the entire body. Length of body 0.910~1.360 mm (1.110 mm), maximal width 0.056~0.087 mm (0.072 mm); ratio to body-length 5.4~7.9% (6.4%). Head rounded. Mouth hexagonal and shallow. Circumoral elevation divided indistinctly into three labiate lobes; six tiny papillae are observed on the circumoral elevation. Esophagus short and rhabditiform, 0.117~0.156 mm (0.133 mm) in length; ratio to body-length 9.8~14.3% (11.9%). Second narrow part of esophagus is surrounded by nerve ring at 0.091~0.111 mm (0.099 mm) from the head end. Center of posterior bulb at 0.106~0.142 mm (0.120 mm) from head end. Anus opens on ventral surface protruding slightly at 0.091~0.182 mm (0.122 mm) from tail end; ratio to body-length 8.3~15.1% (11.1%). Vulva opens transversely at 0.433~0.606 mm (0.532 mm) from head end; ratio body-length 43.8~50.0% (47.8%). Vulva is surrounded by a pair of labiate elevations. Uteri, divergent oppositely, open directly to vulva, and continuous to ovaries, through short oviducts. Anterior and posterior ovaries long, reflex respectively at 0.010~0.043 mm (0.029 mm) from posterior end of esophagus, and 0.030~0.117 mm (0.069 mm) from anus. The terminal portions of the ovaries overlap each other at the level of vulva. Uterine eggs, about fifteen to thirty five in a single row or in double rows, elliptical and thin-shelled, 0.039~0.048 mm (0.043 mm)×0.027~0.036 mm (0.031 mm) in size, and contain divided cells in various degrees or larvae.

Discussion

In the past, eight species of avian *Strongyloides* have been reported, but descriptions were limited to the parasitic females, excepting *S. avium* and *S. oswaldoi*. The measurements of parasitic females of known species and the present species are shown in Table 1. The body-length of the parasitic female of the present species is longer than that of other species except for *S. avium*, and the width of body is similar to that of *S. avium* and *S. oswaldoi*. The value α (body-length/body-width) is larger than any other species of avian *Strongyloides*. The esophagus is longer than that of other species except for *S. avium*. The distance of the vulva from head end is usually longer than that of other species, but there is overlapping among the present species, *S. avium* and *S. oswaldoi*. Accordingly, there is no available evidence excepting the value α

to differentiate the present species from *S. avium* and *S. oswaldoi*. In the present species, a pair of indistinct, papillar elevations are observed on the lateral sides of tail. These structures are considered as the phasmids, because the phasmids of filariform larvae occupy the same position. The paired nodules on the rounded swelling of the tail end of the parasitic female are thought to be rudimentary structures attributable to the notches in the filariform larva. These findings were not described in any other species of avian *Strongyloides*.

As for the morphology of avian *Strongyloides* in the free-living generation, no reports have been found, excepting a few ones concerning *S. avium* and *S. oswaldoi*. In the rhabditiform larvae, the body of the present species is shorter than that of the above two species, and the tail is clearly longer than that of *S. avium* (Table 2).

Concerning the structure of infective filariform larvae, we can find only one report of *S. avium* by CRAM (1929, 1936) (Table 3). The filariform larvae of the present species is more slender than that of *S. avium*. Namely, the body-length of the present species is longer than that of *S. avium*, and the width is narrower to the contrary. The end of the tail of the present species is notched, but CRAM did not describe this structure in *S. avium*.

In adult free-living males, the present species is larger in length and width than *S. avium* and *S. oswaldoi*. CRAM (1936) described that the adult free-living male of *S. avium* possessed a median ventral cone-shaped preanal organ and, at least 7 pairs of caudal papillae, arranged as follows; 3 preanal (1 subventral, 2 lateral), 1 adanal, 3 postanal (1 lateral, 1 subventral, 1 subdorsal); in addition, a phasmid about half way between the postanal subventral and subdorsal papillae on each side. FREITAS and ALMEIDA (1936) observed a papilla in front of the cloaca on the tail of adult male of *S. oswaldoi*. On the other hand, an unpaired medioventral, cone-shaped papilla and 9-paired caudal ones consisted of 3-paired preanal (1 lateral and 2 subventral), 1-paired adanal and 5-paired postanal (2 subventral and 3 subdorsal) are recognizable on the tail of adult male of the present species. Additionally, 2- to 3-paired in conspicuous, papillar elevations are seen in some of the specimens, arranged irregularly in the postanal position.

The adult free-living female of the present species is significantly large in length and width as compared with those of *S. avium* and *S. oswaldoi*. The lengths of the esophogus of these species show partial overlapping, but the value β (body-length/length of esophagus) of the present species is evidently higher than that of the latter two species. The distance of vulva from head end in the present species is larger in measurement than that of the two. In the uteri of the well-developed adult females, the arrangement of eggs in double rows is often recognized; this finding has not been described in other avian *Strongyloides*.

On the other hand, the experimental investigations revealed that the affinity and pathogenicity of the parasitic females of this species to peafowls (*Pavo muticus* and *P. cristatus*) are higher than those to chickens. The results of pathological study will be published in detail in the next reports.

Judging from the above-mentioned morphology of the parasites in free-living generation and pathogenicity of parasitic females, it is concluded that the present species is dfferent from *S. avium* and *S. oswaldoi*.

Accordingly, it can be confidently stated that this parasite is distinguishable as a new species from any other species of *Strongyloides* reported up to the present.

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Explanation of Plates

Plate I

Strongyloides pavonis n. sp.

A. Adult free-living female

B. Adult free-living male

C. Posterior end of adult free-living male

D. Adult parasitic female

E. Posterior end of adult parasitic female

F. Rhabditiform larva

G. Egg from parasitic female

H. Filariform infective larva

A
B
C
D
E
F
G
H
100 μ
100 μ
50 μ
100 μ
50 μ
50 μ
50 μ
100 μ

PLATE II

Fig. 1 Adult free-living male × 220

Fig. 2 Adult parasitic female × 40

Fig. 3 Adult free-living female × 120

1
2
3

PLATE III

Fig. 4 Anterior end of parasitic female × 40

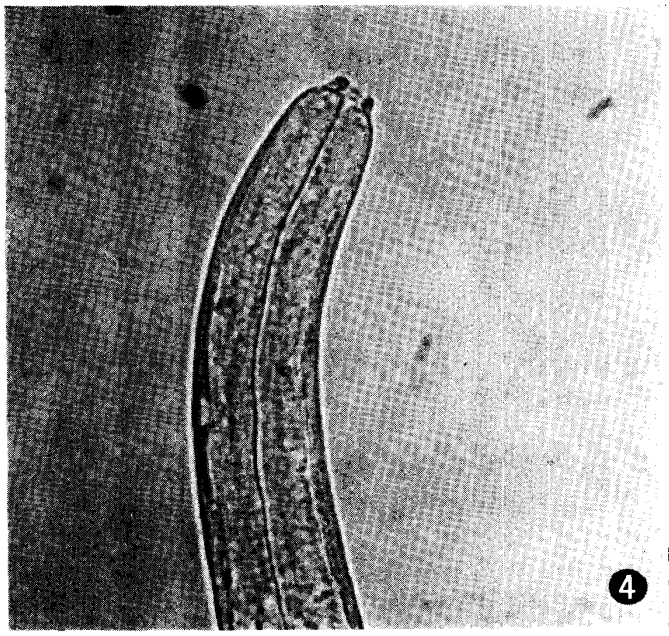
Fig. 5 Posterior end of parasitic female; lateral view × 450

Fig. 6 Posterior end of parasitic female; ventral view × 400

Fig. 7 Vulval rigion of parasitic female × 450

Fig. 8 Eggs in feces from peacock × 400

Fig. 9 Anterior end of adult free-living female × 485



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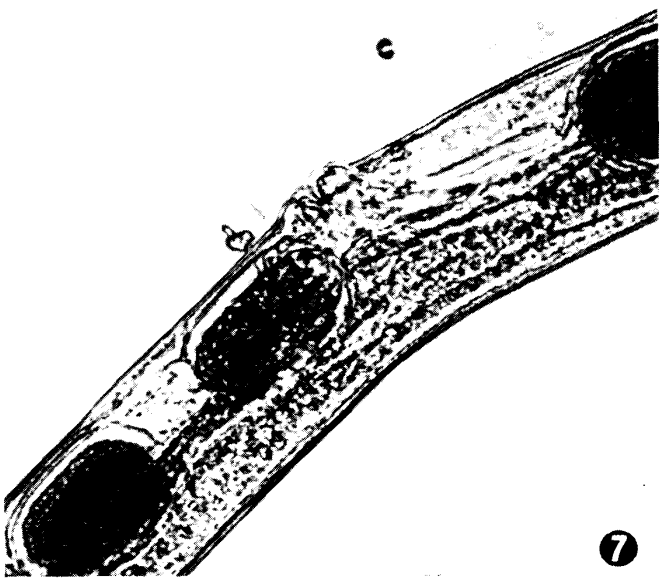

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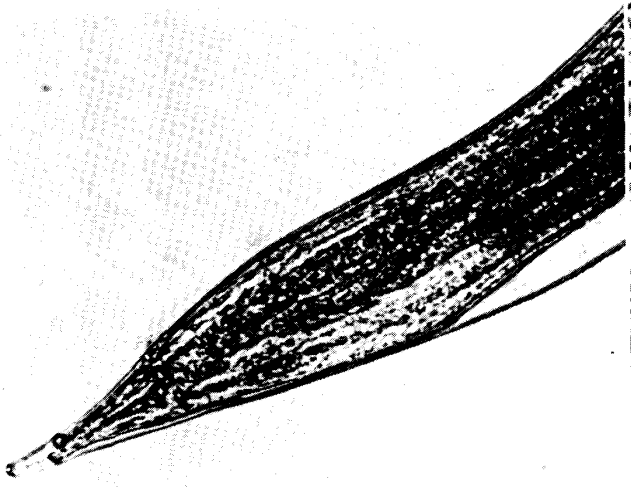

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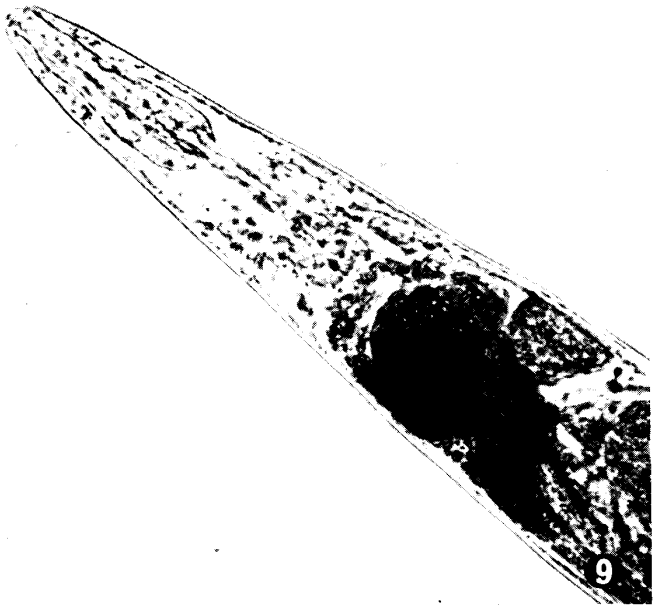

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PLATE IV

Fig. 10 Rhabditiform larva × 350

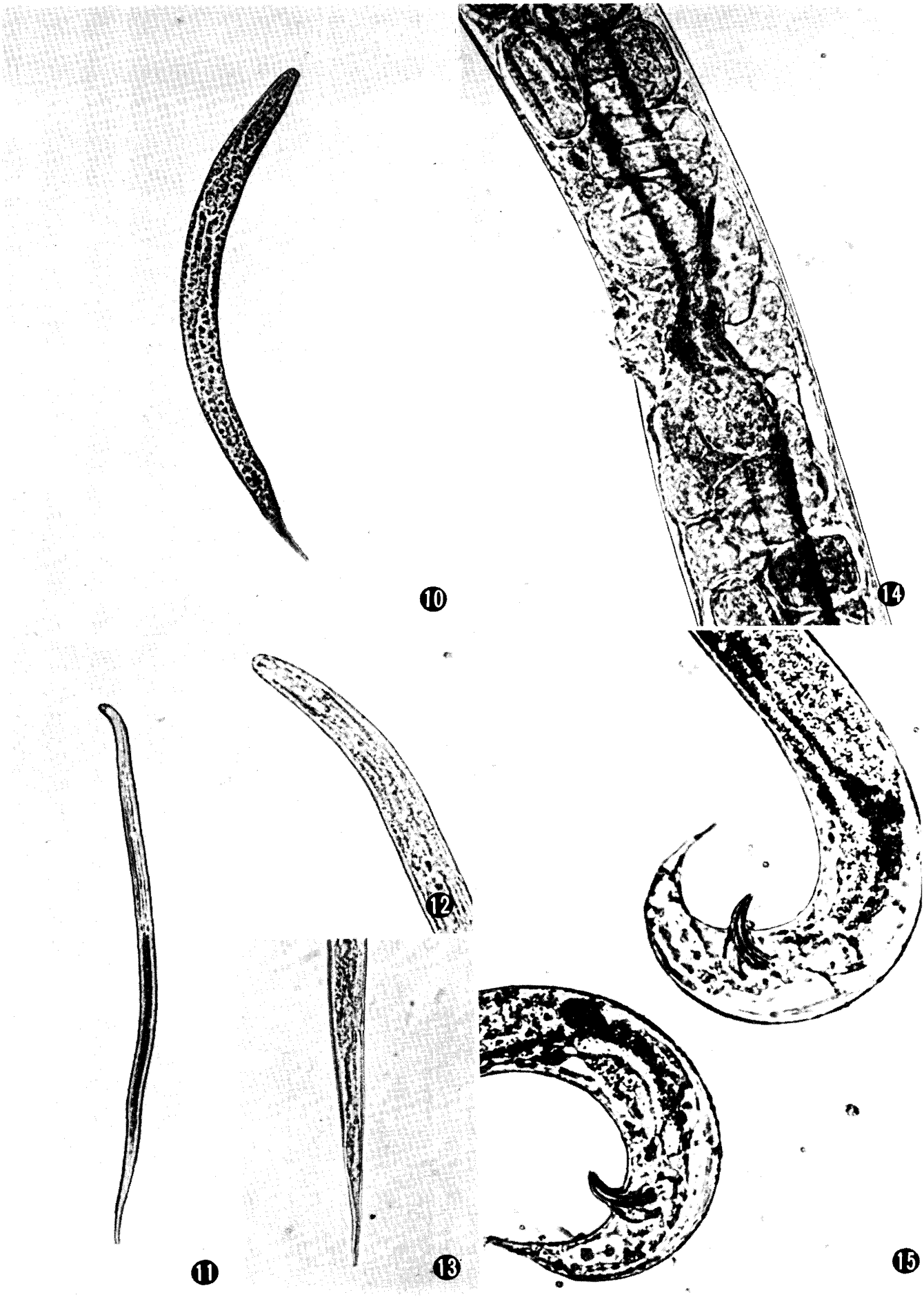
Fig. 11 Filariform infective larva × 140

Fig. 12 Anterior end of filariform infective larva × 470

Fig. 13 Posterior end of filariform infective larva × 470

Fig. 14 Vulval region of adult free-living female × 485

Fig. 15 Posterior end of adult free-living male × 255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