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## WORM PARASITES OF THE BROWN RAT (*MUS NORVEGICUS*) IN THE PHILIPPINE ISLANDS, WITH SPECIAL REFERENCE TO THOSE FORMS THAT MAY BE TRANSMITTED TO HUMAN BEINGS

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NINETEEN TEXT FIGURES

### INTRODUCTION

The rôle of rats as carriers and reservoirs of bubonic plague and other bacterial as well as spirochætal infections, has long been well recognized. For this reason various antirat measures have been in vogue in different parts of the world, especially in seaports, for the control and prevention of these diseases. The fact, however, that these animals are often infested with certain parasitic worms that are also a menace to human health, is not so well known. For this reason and because of the fact that the helminthic fauna of rats in the Philippine Islands has never been studied to any great extent, it seemed worth while to undertake a systematic examination of these animals in order to determine their parasites and to find if they harbor forms that are transmissible to man.

### RATS EXAMINED AND THE INCIDENCE OF INFESTATION

The survey was limited to the brown or Norway rat, *Mus norvegicus* Erxleben, 1777 (= *M. decumanus* Pallas, 1778), since this was the only rat constantly available in large numbers. A total of nine hundred fifty of these rodents were dissected

during the period from May 7, 1930, to January 14, 1931. They were trapped in the different sections of the City of Manila and were among those sent to the Bureau of Science by the Philippine Health Service for routine bubonic-plague inspection. A list of the different parasites encountered and their incidence are given in Table 1. One species of roundworm, *Syphacrobvelata*, is not represented in the table, but it is believed to infest rats in the Philippines in view of its having been reported by Riley (1919) in a child residing in Zamboanga, Mindanao.

With the exception of the flukes, a new species of the cestode genus *Raillietina*, and a new nematode in the genus *Rictularia*, all of which are apparently restricted to the Philippines in their distribution, the different worms collected have been reported from other countries. The following were the most common met with in the order they are named: The larval form of *Tænia tæniaformis* (commonly known as *Cysticercus fasciolaris*), *Hepaticola hepatica*, *Raillietina garrisoni* sp. nov., *Strongyloides ratti*, *Hymenolepis diminuta*, *Nippostrongylus muris*, *Trichosomoides crassicauda*, and *Gongylonema neoplasticum*. *Hymenolepis nana* and *Heterakis spumosa*, which are common in rats in many countries, were rarely encountered. *Trichinella spiralis*, the most dangerous worm of rats from the public-health standpoint, was not found at all.

TABLE 1.—Parasites encountered in nine hundred fifty rats.

Name of parasites.	Infestation. Per cent.
Trematodes:	
<i>Euparyphium ilocanum</i>	0.5
<i>Euparyphium guerreroi</i>	0.1
<i>Euparyphium murinum</i> sp. nov.	0.1
Cestodes:	
<i>Tænia tæniaformis</i> (larval form)	94.0
<i>Raillietina garrisoni</i> sp. nov.	86.0
<i>Hymenolepis diminuta</i>	64.0
<i>Hymenolepis nana</i>	1.7
Nematodes:	
<i>Gongylonema neoplasticum</i>	44.0
<i>Hepaticola hepatica</i>	90.0
<i>Heterakis spumosa</i>	0.4
<i>Nippostrongylus muris</i>	58.0
<i>Protospirura muricola</i>	1.3
<i>Rictularia whartoni</i> sp. nov.	0.4
<i>Strongyloides ratti</i>	74.0
<i>Trichosomoides crassicauda</i>	57.0
Acanthocephala:	
<i>Moniliformis moniliformis</i>	4.2

The incidence of the worms did not seem to depend upon the time of the year but rather, in the case of the flukes, at least, on the environment of their hosts. It was noticed at the termination of the survey that these particular parasites were obtained only from some of the rats that were trapped inside the piers of Manila Bay and in the immediate neighborhood of the landing places of boats along Pasig River. This may be regarded as purely accidental, but it may also mean that either the intermediate hosts of these flukes, which most probably are snails, exist in some of the bodies of water in Manila or the rats that harbored them might have been brought to the city from other localities on board of ships and boats. The matter deserves further inquiry.

#### DESCRIPTIONS OF PARASITES

The parasites determined represent two phyla in the animal kingdom, namely, the Platyhelminthes, or flatworms, and the Nematelminthes, or roundworms. The flukes (class Trematoda) and the tapeworms (class Cestoda) are members of the phylum Platyhelminthes, while the so-called true roundworms (class Nematoda) and the proboscis worm (class Acanthocephala) belong to the Nematelminthes.

### Phylum PLATYHELMINTHES Claus, 1885

#### Class TREMATODA Rudolphi, 1808

#### Subclass DIGENEA v. Beneden, 1858

#### Order PROSOSTOMATA Odhner, 1905

#### Suborder DISTOMATA Zeder, 1800

#### Superfamily ECHINOSTOMATOIDEA Faust, 1929

#### Family ECHINOSTOMATIDÆ Looss, 1902

#### Subfamily ECHINOSTOMATINÆ Looss, 1899

#### Genus EUPARYPHIUM Dietz, 1909

**EUPARYPHIUM ILOCANUM** (Garrison, 1908) Tubangui, 1931. fig. 1.

Synonyms: *Fascioletta ilocana* Garrison, 1908; *Echinostoma ilocanum* (Garrison, 1908) Odhner, 1911.

For many years this fluke was regarded as a parasite peculiar to man in the northwestern provinces of Luzon, Philippine Islands. Its occurrence in rats has been only recently demonstrated by the present writer (Tubangui, 1931). In the survey

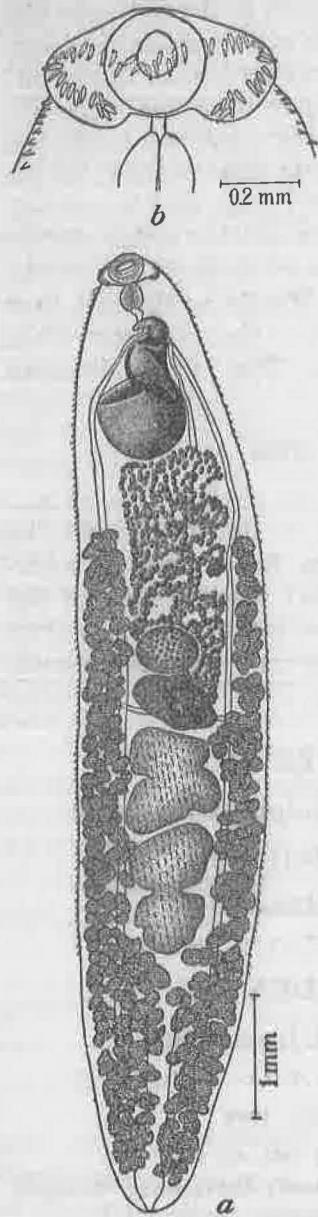


FIG. 1. *Euparyphium ilocanum*.  
 a, Entire worm, ventral view; b,  
 anterior end, showing arrange-  
 ment of spines on cephalic collar,  
 ventral view. (After Tubangui,  
 1931.)

on which this report is based, five or a little more than 0.5 per cent of the nine hundred fifty rats examined were infested with it.

*Description.*—Body moderately large, elongate, 5.57 to 8.02 millimeters in length by 1.33 to 1.58 millimeters in maximum breadth at or near the equator of body. Lateral sides of body from anterior end to acetabulum rolled ventrally. Cuticle armed with flat scalelike structures distributed ventrally from anterior end to second testis or slightly beyond that level, and dorsally from anterior end to anterior level of acetabulum; scales 13.5 to 24.7 by 13.5 to 18.0 microns in size, those at anterior end being smaller. Suckers close together; oral sucker small, subterminal, 0.19 to 0.24 millimeter in transverse diameter; acetabulum large, cup-shaped, at middle of anterior third of body length, 0.60 to 0.69 by 0.64 to 0.74 millimeter in size. Oral sucker surrounded dorsally and laterally by a collar (fig. 1, b) bearing fifty-one spines arranged in two alternating rows; collar 0.38 to 0.46 millimeter in diameter, reniform, its two rounded ventral angles united by a narrow ridge. Collar spines may be grouped as follows: Six ventral corner spines on each side of collar, the smallest of which measures 36.0 by 11.2 microns, the broadest 42.7 by 15.7 microns, and the longest 45.0 by 11.2 microns; fourteen lateral spines on each side, arranged in pairs and eleven dorsal spines; lateral and dorsal spines 31.5 to 45.0 by 11.2 to 13.5 microns in size.

Mouth terminal to subterminal, followed occasionally by prepharynx 0.03 to 0.05 millimeter in length; pharynx 0.19 to 0.20 by 0.15 to 0.17 millimeter in size; œsophagus 0.10 to 0.20 millimeter long, bifurcating immediately in front of genital pore, midway between pharynx and acetabulum or slightly anterior of that level; intestinal cœca reach posteriorly to from 0.24 to 0.43 millimeter from posterior end of body.

Testes tandem, postequatorial, at third fourth of body length, either elongate and each divided into anterior and posterior lobes by transverse constriction or shorter and distinctly 3- to 4-lobed. Cirrus sac large, 0.51 to 0.65 by 0.26 to 0.34 millimeter in size, reaching to but not extending posteriorly beyond equator of acetabulum; incloses prominent seminal vesicle, well-developed pars prostatica, and long protrusible cirrus. Common genital opening preacetabular, behind œsophageal bifurcation, to one side of median line.

Ovary globular or slightly compressed transversely, median, pretesticular, usually behind middle of second fourth of body length, 0.31 to 0.43 by 0.34 to 0.48 millimeter in size; shell gland between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present; uterus well developed, occupying space bounded by ovary, acetabulum, and intestinal cœca. Vitellaria in moderately large follicles, commencing anteriorly on both sides at level about midway between posterior border of acetabulum and anterior border of ovary; anteriorly they are extracœcal, but behind second testis the follicles from the two sides unite and occupy most of posterior region of body; transverse vitelline ducts and vitelline reservoir dorsal of shell gland, directly in front of anterior testis. Eggs, numerous, operculated, light brown or yellowish, 85.5 to 101.5 by 54.0 to 65.2 microns in size.

Excretory system typical of echinostomes in general; excretory bladder long, with several small side branches, dividing into two principal branches behind second testis; excretory pore at extreme posterior end of body.

*Location.*—Small intestine.

*Life history.*—Unknown. It is most probable, however, from what is known of the life history of mammalian trematodes that the intermediate host is a fresh-water snail. It might be interesting to note moreover that the cercariæ of related flukes assume the infective stage by encysting within their own rediæ or in the tissues of their intermediate hosts; others encyst on plants, fishes, or in tadpoles.

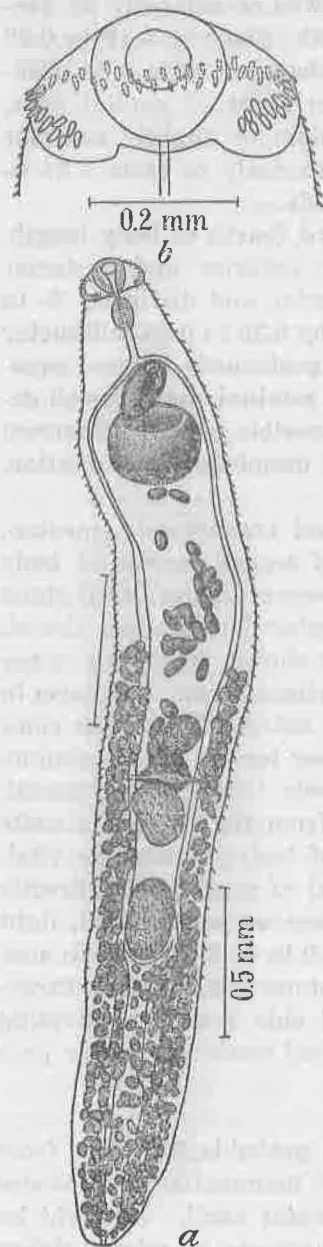


FIG. 2. *Euparyphium guerreroi*.  
 a, Entire worm, ventral view; b,  
 anterior end, showing arrange-  
 ment of spines on cephalic collar,  
 ventral view. (After Tubangui,  
 1931.)

*Prevention.*—Bearing in mind the possible modes of infestation with this parasite as noted in the discussion of its life history, prevention should consist in the avoidance of raw or improperly cooked vegetables, snails, and fishes and unboiled or unfiltered surface water as food and drink, respectively, especially in those places where the fluke is known to occur.

*References.*—14, 16, 21, 31, 41, 51, 55.<sup>1</sup>

EUPARYPHIUM GUERREROI Tubangui, 1931.  
 Fig. 2.

*Description.*—Body slender, elongate, measuring 2.92 to 4.03 millimeters in length by 0.37 to 0.50 millimeter in maximum breadth across acetabulum or anywhere between this organ and anterior testis. Cuticle armed with flat scales, dorsally from anterior end to level of acetabulum and ventrally from anterior end to posterior testis or slightly beyond that level; scales 6.0 to 15.0 by 5.5 to 9.4 microns in size, anterior ones being smaller. Oral sucker small, subterminal, 0.10 to 0.12 millimeter in transverse diameter; acetabulum larger, at middle of anterior third of body length, 0.27 to 0.36 by 0.31 to 0.34 millimeter in size. Oral sucker surrounded dorsally and laterally by a collar (fig. 2, b) bearing fifty-five spines arranged in two alternating rows; collar 0.22 to 0.26 millimeter across, reniform, its two ventral angles united by a narrow ridge. Collar spines may be grouped

<sup>1</sup>The numbers refer to the list of references, which are arranged alphabetically and numbered, at the end of this paper.

as follows: Five ventral corner spines on each side of cephalic collar, 24.7 to 31.5 by 9.0 to 11.9 microns; fifteen lateral spines on each side, 27.0 to 29.2 by 9.0 microns; and fifteen dorsal spines, 11.2 to 13.5 by 6.7 to 9.0 microns in size.

Mouth subterminal to terminal, followed by prepharynx 0.03 to 0.07 millimeter long; pharynx 0.10 to 0.11 by 0.07 to 0.08 millimeter in size; oesophagus 0.08 to 0.15 millimeter long, bifurcating in front of level of genital pore; intestinal cæca long, narrow in diameter, reaching from 0.21 to 0.24 millimeter from posterior end of body.

Testes tandem, postequatorial, at third fourth of body length, oval or sausage-shaped, often transversely constricted into anterior and posterior lobes; anterior testis usually smaller, at least shorter, 0.19 to 0.36 by 0.15 to 0.22 millimeter in size; posterior testis 0.27 to 0.39 by 0.12 to 0.20 millimeter in size. Cirrus pouch oval, 0.17 to 0.27 by 0.10 to 0.13 millimeter in size, not reaching posteriorly beyond equator of acetabulum; incloses large seminal vesicle, moderately developed pars prostatica, and protrusible cirrus. Common genital opening preacetabular, behind oesophageal bifurcation, to one side of median line.

Ovary globular or slightly compressed, 0.10 to 0.15 by 0.07 to 0.13 millimeter in size, immediately preëquatorial, pretesticular; shell gland prominent, filling most of the space between ovary and anterior testis; receptaculum seminis absent, Laurer's canal present; uterus short, with few coils. Vitellaria in small to moderately large follicles, commencing anteriorly at middle of second fourth of body length, those on left side usually commencing at a more posterior level; behind second testis follicles from two sides unite and extend to posterior end of body; transverse vitelline ducts and vitelline reservoir dorsal of shell gland and immediately in front of first testis. Eggs few, operculated, thin shelled, light brown or yellowish, 78.7 to 85.5 by 54.0 to 60.7 microns in size.

Excretory system of usual echinostome type; excretory bladder long, tubular, dividing into two branches behind second testis; excretory pore at extreme posterior end of body.

*Location.*—Small intestine.

*Life history.*—Unknown.

*Reference.*—55.

**EUPARYPHIUM MURINUM** sp. nov. Fig. 3.

The description of this parasite is based on the examination of two lots of material. One lot, consisting of a small number of specimens, is part of our collection and was obtained from a



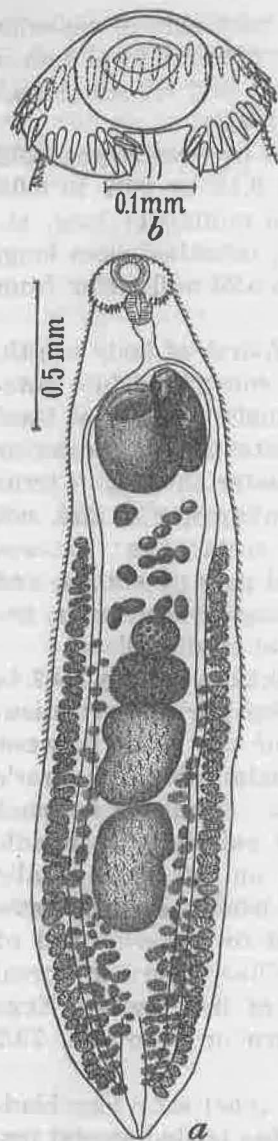


FIG. 3. *Euparyphium murinum* sp. nov. a, Entire worm, ventral view; b, anterior end, showing arrangement of spines on cephalic collar, ventral view.

rat that was at the same time infested with *E. ilocanum*. The other lot consisting of numerous specimens and labelled "parásitos encontrados en el intestino de un ratón, Manila, Agosto, 1909," was collected by Dr. Luis Guerrero. It was kindly turned over to me for determination by Dr. Onofre Garcia who found it among the parasitological collections of the University of Santo Tomas, Manila. I take this opportunity to express my thanks to Doctor Guerrero and Doctor Garcia.

This fluke differs from the two preceding species in the number of its collar spines, of which there are forty-five to forty-six, and in the position of its cirrus pouch that extends posteriorly beyond the equator of the acetabulum. In the number of its collar spines it is similar to *Echinostoma gotoi* Ando and Ozaki, 1923, another rat trematode, but again it may be distinguished from the latter by the position of its cirrus sac and also by the character of its uterus, which is short and contains only a few coils and eggs.

*Description.*—Body small, elongate, 2.65 to 4.50 by 0.45 to 0.65 millimeters in size. Cuticle armed with flat scales, dorsally from anterior end to acetabulum and ventrally from anterior end to posterior level of first testis or slightly beyond. Oral sucker small, subterminal, 0.10 millimeter in transverse diameter; acetabulum 0.32 to 0.42 by 0.23 to 0.32 millimeter in size, at anterior fourth of body length. Head collar reniform, 0.23 to 0.27 millimeter across, bearing forty-five spines arranged in two alternating rows and measuring 37.5 to 44.2 by

8.0 to 9.2 microns. Occasionally there are forty-six collar spines due to the presence of a small accessory dorsal spine (fig. 3, b).

Mouth subterminal; prepharynx absent or very short; pharynx oval, 0.10 to 0.13 by 0.07 to 0.09 millimeter in size; oesophagus 0.07 to 0.12 millimeter long, bifurcating immediately in front of level of genital pore; intestinal cæca long, reaching to near posterior end of body.

Testes tandem, postequatorial, oval to sausage-shaped, with smooth borders or slightly constricted at middle; anterior testis usually smaller, 0.32 to 0.48 by 0.16 to 0.25 millimeter in size; posterior testis 0.33 to 0.53 by 0.15 to 0.26 millimeter. Cirrus pouch oval, 0.25 to 0.36 by 0.10 to 0.13 millimeter in size, usually to one side of median line, dorsal to acetabulum and extending posteriorly beyond the equator of this organ; incloses seminal vesicle, pars prostatica, and protrusible cirrus. Common genital pore immediately preacetabular, a little to one side of median line.

Ovary globular or slightly transversely oval, preëquatorial, pretesticular, 0.10 to 0.15 millimeter in transverse diameter. Shell gland conspicuous, between ovary and first testis. Receptaculum seminis absent, the distal portion of oviduct being dilated and probably functioning as seminal receptacle; Laurer's canal present. Uterus short, with few coils. Vitelline glands in the form of distinct follicles extending from 0.10 to 0.60 millimeter behind acetabular level to near posterior end of body. Eggs few, oval, operculated, thin shelled, yellowish, 88.4 to 95.2 by 57.8 to 61.2 microns in size.

Excretory system of the usual echinostome type; excretory bladder tubular, bifurcating behind second testis; excretory pore at extreme posterior end of body.

*Specific diagnosis.*—*Euparyphium*: Body elongate, 2.65 to 4.50 by 0.45 to 0.65 millimeters in size. Head collar 0.23 to 0.27 millimeter in transverse diameter, with forty-five spines measuring 37.5 to 44.2 by 8.0 to 9.2 microns. Prepharynx very short or absent, oesophagus 0.07 to 0.12 millimeter long. Testes oval to sausage-shaped, with smooth borders or slightly constricted at middle; cirrus sac oval, 0.25 to 0.36 by 0.10 to 0.13 millimeter in size, reaching posteriorly beyond equator of acetabulum. Ovary globular or transversely oval, preëquatorial; vitellaria extend from 0.10 to 0.60 millimeter behind acetabular level to posterior end of body. Eggs few, 88.4 to 95.2 by 57.8 to 61.2 microns in size.

*Location.*—Small intestine.

*Locality.*—Manila, Philippine Islands.

*Type specimens.*—Philippine Bureau of Science parasitological collection, No. 64; paratypes in parasitological collection of the University of Santo Tomas, Manila.

*Life history.*—Unknown.

*References.*—1, 10, 11, 13, 30, 31, 55.

Class CESTODĀ Rudolphi, 1808

Subclass CESTODA (s. str.) Monticelli, 1892

Order CYCLOPHYLLIDEA Braun, 1900

Superfamily TÆNIOIDEA Zwicke, 1841

Family TÆNIIDÆ Ludwig, 1886

Subfamily TÆNIINÆ Stiles, 1896

Genus TÆNIA Linnæus, 1758

TÆNIA TÆNIAFORMIS (Batsch, 1786) Wolffhügel, 1911. Fig. 4.

Synonym: *Tænia crassicollis* Rudolphi, 1810.

The larval stage of this tapeworm is commonly known as *Cysticercus fasciolaris* Rudolphi, 1808 (= *Strobilocercus fasciolaris* Sambon, 1924). It is one of the commonest parasites of the brown rat, the livers of 94 per cent of the animals examined being infested with it. The adult stage has so far been found only in cats. Krabbe, according to Stiles (1906), pointed out long ago that in Jütland sandwiches of chopped raw mice were eaten by the common people for the relief of anuria and suggested that this custom might be responsible for the occasional presence of the parasite in man. Thus far, however, no case of the sort has been reported.

*Description.*—The larvæ are inclosed in globular cysts, partly visible on the surface of the liver of infested rats as whitish semitransparent areas. These cysts are 5 to 16 millimeters in diameter and are easily separated from the hepatic tissue. The larvæ themselves are elongate, measuring 30 to 200 millimeters in length by 2 to 6 millimeters in maximum width near the anterior end. The body (fig. 4, a) is strobilate, which character differentiates it from the other bladderworms (*Cysticercus* species), for which reason Sambon (1924) proposed for it the term *Strobilocercus*. In living specimens the anterior portion is usually wider and thicker due to the contraction of

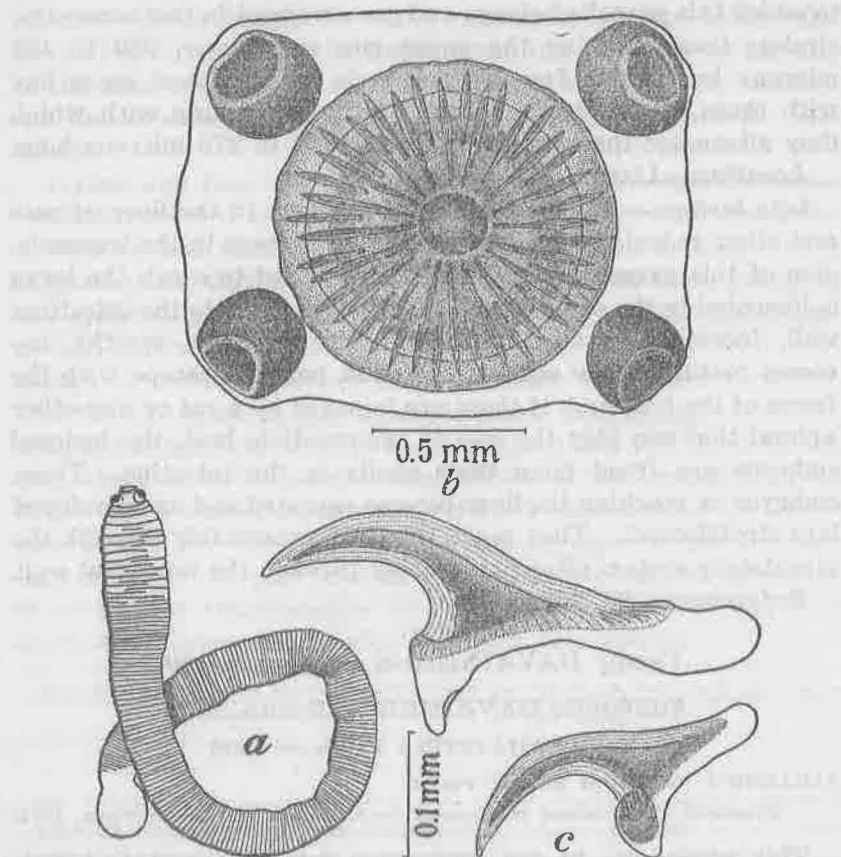


FIG. 4. *Tænia tæniaformis*. a, Entire larva (after Sambon, 1924); b, scolex, anterior view; c, rostellar hooks.

the body at this region and presents a terminal wedge-shaped depression due to the invagination of the scolex. The posterior end is usually more slender, terminating in a very much reduced bladder. Sometimes the segmentation of the body is so distinct and the length so great that this larvæ has been mistaken for a small mature tapeworm. Occasionally rudimentary reproductive organs are present among some of the segments. The scolex (fig. 4, b) is large, thick, 1.3 to 1.7 millimeters broad; suckers prominent, cup-shaped, 0.32 to 0.38 millimeter in diameter; rostellum short, columnar, 1.12 to 1.14 millimeter in diameter, crowned with 26 to 52 hooks, according to various authors (hooks of Philippine material 38 to 42). The hooks (fig. 4, c) are of the characteristic shape found in the group of tapeworms

to which this parasite belongs and are arranged in two concentric circles; those forming the upper row are larger, 380 to 420 microns long, their free pointed ends being almost on a line with those of the shorter hooks of the lower ring with which they alternate; the smaller hooks are 250 to 270 microns long.

*Location.*—Liver.

*Life history.*—The encysted strobilocercus in the liver of rats and other rodents represents the infective stage in the transmission of this parasite to its final host. If fed to a cat, the larva is liberated in the small intestine, attaches itself to the intestinal wall, increases in size, and, after two to three months, becomes mature. The eggs of the adult parasite escape with the faeces of the host and, if these are ingested by a rat or any other animal that can play the rôle of intermediate host, the inclosed embryos are freed from their shells in the intestine. These embryos on reaching the liver become encysted and are developed into strobilocerci. They reach the liver presumably through the circulatory system after penetrating through the intestinal wall.

*References.*—20, 27, 37, 49.

Family DAVAINIDÆ Fuhrmann, 1907

Subfamily DAVAININÆ Braun, 1900

Genus RAILLIETINA Fuhrmann, 1920

RAILLIETINA GARRISONI sp. nov. Fig. 5.

Synonym: ? *Davainea madagascariensis* (Davaine) of Garrison, 1911.

This appears to be the commonest intestinal cestode infesting the brown rat in the Philippines. It bears a close resemblance to *R. celebensis*, but differs from the latter, as described by Janicki (1902) and by Meggitt and Subramanian (1927), in having a larger number of testes and uterine egg capsules and in the larger size of its cirrus pouch. It is, therefore, proposed as a new species and is named *Raillietina garrisoni* in honor of the late Dr. P. E. Garrison.

The parasite deserves more than passing notice due to its possible identity with *Davainea madagascariensis* (Davaine) of Garrison, 1911, which was collected at autopsy by Dr. Vernon L. Andrews from the small intestine of a male adult Filipino in Manila. According to Joyeux and Baer (1929) Garrison's material differs in the size of its rostellar hooks and of the cirrus pouch from the types described under the same name by other observers, and it is, therefore, likely that it represents another

species. According to the same authors it is allied to *R. celebensis* but differs from the latter in the size of its cirrus sac and in the number of its testes, which characters, it will be recalled, are the very ones that distinguish *R. garrisoni* from *R. celebensis*.

Joyeux and Baer are of the opinion that Garrison's *Davainea madagascariensis* and other rare human cestodes are parasites of wild animals that are accidentally transmitted to man. They suggest as one way of establishing the identity of these parasites the systematic collection and determination of the tapeworms of wild animals that habitually come in close contact with human beings in countries where such parasites have been recorded. The survey on which this report is based was, therefore, in line with the suggestion of the French authors and it is here shown that there exist important similarities in the morphology of *R. garrisoni* and of *D. madagascariensis* as described by Garrison (Table 2). In view of this and in view of the common occurrence of *R. garrisoni* in rats, a number of the parasites of which are transmissible to man, it is quite probable that Garrison's tapeworm is identical with this species.

TABLE 2.—Comparison between *Railletina garrisoni* sp. nov. and *Davainea madagascariensis* (Davaine) of Garrison, 1911.

	<i>D. madagascariensis.</i>	<i>R. garrisoni.</i>
Total length.....mm	390.....	Up to 600.
Size of terminal gravid segments...do	2.0-2.5×1.0-1.5.....	1.60-2.12×1.05-1.40.
Diameter of head.....do	0.32-0.40.....	0.40-0.80.
Diameter of sucker.....do	0.105-0.125.....	0.10-0.15.
Number of rostellar hooks.....		90-140.
Length of rostellar hooks.....μ	23.5-25.2.....	20-26.
Number of testes.....	50.....	36-50.
Size of cirrus sac.....mm	0.12-0.16×0.064-0.100.	0.13-0.18×0.054-0.085.
Position of genital pores.....	Normally unilateral; anterior.	Normally unilateral; anterior.
Diameter of uterine egg capsule...mm	0.20-0.40.....	0.06-0.15 (measured from mounted specimens).
Number of eggs per egg capsule.....	1-3; generally 2.....	1-4; generally 3.
Size of eggs with elongated shell intact.....μ	50-64×19-23.....	52-80×22-26.
Length of embryonal hooks.....μ	4-5.....	4-6.

*Description.*—Total length up to 600 millimeters, the maximum breadth in the region of mature proglottids. Head (fig. 5, b) subglobular, 0.40 to 0.80 millimeter in diameter; suckers unarmed, 0.10 to 0.15 millimeter in diameter; rostellum 0.13 to

0.18 millimeter in diameter, armed with 90 to 140 hammer-shaped hooks (fig. 5, *a*) that are 20 to 26 microns in length and arranged in two alternating circular rows; rostellum with a spiny collar, the spines being comma-shaped and averaging about 5 microns long. Neck short, 0.28 to 0.36 millimeter in width. Segments broader than long except at posterior end where gravid proglottids may be nearly twice as long as wide (fig. 5, *d*); immature segments 0.08 to 0.17 millimeter long by 0.30 to 0.60 millimeter wide, mature segments 0.43 to 0.65 by 1.40 to 1.65 millimeters, and gravid segments 0.95 to 2.12 by 0.15 to 1.40 millimeters. Genital pores normally unilateral and dextral, situated near anterior extremity of lateral border of segments.

Main portion of excretory system represented by two pairs of lateral longitudinal vessels, ventral and dorsal; ventral pair more lateral in position, larger in diameter and connected in the posterior part of each segment by transverse canal; dorsal vessels small and with no transverse canals. Peripheral nervous system represented by a longitudinal nerve on each side, at middle between ventral excretory vessels and lateral margins of proglottids. Muscular system feebly developed and arranged as in other cestodes; consists of minute longitudinal and transverse fibers located immediately beneath cuticle and of longitudinal, transverse and dorsoventral fibers in parenchyma, of which the longitudinal and dorsoventral ones are most conspicuous.

Testes (fig. 5, *c*) small, roundish, 40 to 50 microns in diameter, confined within parenchyma between excretory vessels, 36 to 50 in number, of which 9 to 15 are on the poral side of the median line and 26 to 35 aporal. Vas deferens a long, much-convoluted tube near anterior border of segment, running almost transversely from median line to cirrus sac, passing with corresponding vagina between excretory vessels and ventral to longitudinal nerve. Cirrus sac distinctly gourd-shaped, 0.13 to 0.18 by 0.054 to 0.085 millimeter in size, extending either transversely or a little obliquely towards cephalic end from genital pore to longitudinal nerve.

Ovary (fig. 5, *e*) median, bilobed, each lobe being oval, with smooth surface and measuring 0.12 to 0.15 by 0.08 to 0.10 millimeter. Vagina a narrow canal, posterior to vas deferens and cirrus pouch, running transversely from median line to genital pore; before opening into genital pore it is usually slightly dilated to form a small receptaculum seminis. Near the median

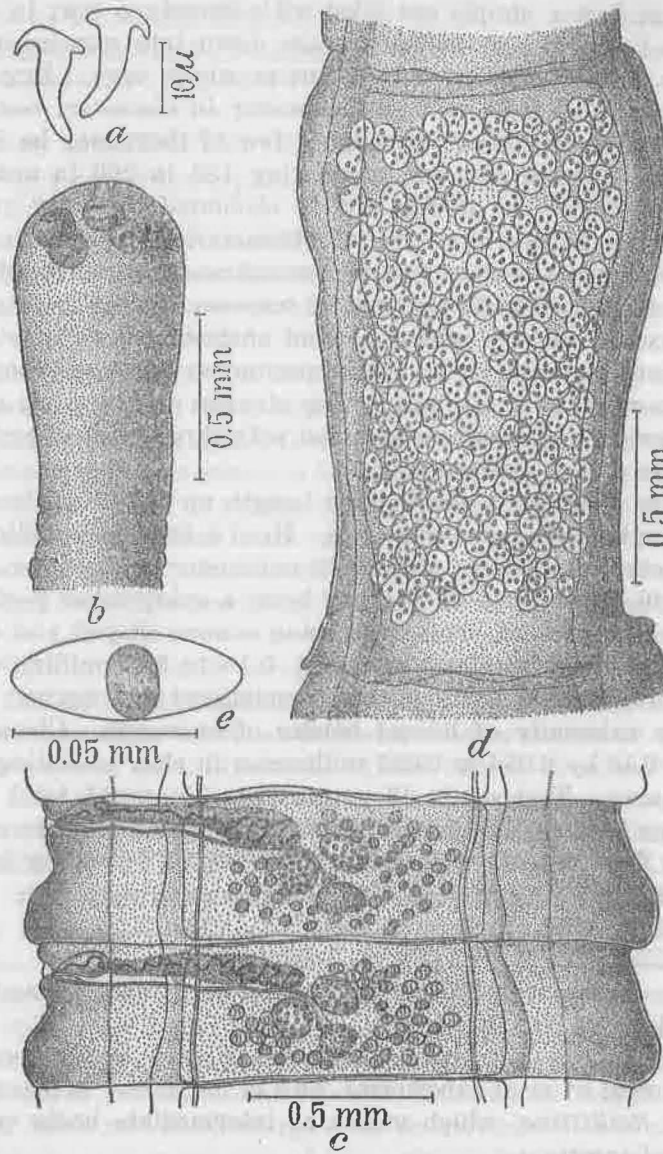


FIG. 5. *Raillietina garrisoni* sp. nov. a, Rostellar hooks; b, scolex; c, mature segment; d, gravid segment; e, egg.

line the vagina bends posteriorly and joins the oviduct, forming a slightly dilated tube, the oötype complex, between ovary and vitelline gland. Vitelline gland roundish to oval, immediately posterior to ovary, and measuring 0.09 to 0.13 millimeter across.



Uterus at first a simple sac filled with immature ova; in fully developed gravid segments it breaks down into numerous egg capsules, each containing 1 to 4, but mostly 3, eggs. Egg capsules (fig. 5, *d*) 0.06 to 0.15 millimeter in diameter, confined within excretory vessels, although a few of them may be found lateral to these canals, and numbering 180 to 200 in anterior gravid segments and 300 to 400 in elongated posterior gravid proglottids. Eggs (fig. 5, *c*) of characteristic shape, the onchosphere surrounded by two thin membranes: outer membrane elongated oval, 52 to 80 by 22 to 26 microns in size; inner membrane usually closely applied around onchosphere, round, 18 to 22 microns in diameter in fresh specimens; between inner and outer membranes a few connecting strands or fibers are sometimes present; onchosphere supplied with three pairs of embryonal hooks 4 to 6 microns long.

*Specific diagnosis.*—*Raillietina*: Length up to 600 millimeters, maximum breadth 1.4 millimeters. Head 0.40 to 0.80 millimeter in diameter; rostellum 0.13 to 0.18 millimeter in diameter, with 90 to 140 hooks 20 to 26 microns long; a spiny collar posterior to rostellum present, the spines being comma-shaped and about 5 microns long. Suckers unarmed, 0.10 to 0.15 millimeter in diameter. Genital pores normally unilateral and dextral, near anterior extremity of lateral border of segments. Cirrus sac 0.13 to 0.18 by 0.054 to 0.085 millimeter in size, extending only up to nerve. Testes 9 to 15 poral, 26 to 35 aporal, total 36 to 50. Egg capsules 180 to 400, each containing 1 to 4, generally 3, eggs; found mostly within excretory vessels, but a few lateral to them.

*Location.*—Small intestine.

*Locality.*—Manila, Philippine Islands.

*Type specimens.*—Philippine Bureau of Science parasitological collection, No. 12.

*Life history.*—Unknown. Probably similar to the mode of development of most tapeworms, and in particular to other species of *Raillietina*, which utilize as intermediate hosts various forms of insects.

*Prevention.*—Due to reasons given above, this tapeworm may be looked upon with suspicion as one of those parasites of rats that are transmissible to man. Since the life history has not yet been worked out, however, no definite prophylactic measures can be given except to advocate the destruction of rats and mice, the proper disposal of the stools of infected persons, and the

practice of all-around cleanliness, by means of which all parasitic infestations can be avoided.

*References.*—17, 22, 25, 27.

Family HYMENOLEPIDIDÆ Railliet and Henry, 1909

Subfamily HYMENOLEPIDINÆ Ransom, 1909

Genus HYMENOLEPIS Weinland, 1858

**HYMENOLEPIS DIMINUTA** (Rudolphi, 1819) Blanchard, 1891. Fig. 6.

Synonyms: *Tænia diminuta* Rudolphi, 1819; *Hymenolepis flavopunctata* Weinland, 1858; *Tænia flavomaculata* Leuckart, 1863.

This common tapeworm of rats was first reported in man by Weinland in 1858. Since that time up to 1922, according to Riley and Shannon (1922), a total of sixty-one cases of human infestations with this parasite have been recorded from various parts of the world. To these should be added the one case detected by Schwartz and Tubangui (1922) in a native Filipino, the twenty Indian cases found by Chandler (1927), and the single case recently reported by Spindler (1929) from the United States.

*Description.*—Strobila composed of 800 to 1,300 proglottids; length 100 to 600 millimeters, depending upon number of proglottids; maximum width at posterior end in region of gravid segments, 2.5 to 4.0 millimeters. Head (fig. 6, *a*) almost globular, 0.20 to 0.60 millimeter broad; rostellum rudimentary, pyriform, without hooks; suckers globular, near apical portion of head, 0.08 to 0.16 millimeter in diameter. Neck short. Segments wider than long; immature segments 0.045 to 0.200 by 0.305 to 0.835 millimeter in size, mature segments 0.238 to 0.380 by 0.084 to 1.670 millimeters, and gravid segments 0.305 to 0.684 by 1.805 to 3.115 millimeters. Posterior border of segments only slightly wider than anterior borders, for which reason serration of strobila not as marked as in other cestodes. Genital pores usually unilateral and sinistral, at middle or at anterior third of lateral margins of proglottids. Main portion of excretory system consists of two pairs of lateral longitudinal vessels: a larger ventral pair connected in the posterior part of each segment by a transverse canal and a smaller dorsal pair with apparently no cross-connectives; the terminals of the ventral and dorsal vessels of one side are united in the region of the head. Muscular system fairly well developed, consisting of circular and longitudinal subcuticular fibers and another set of

longitudinal, transverse, and dorsoventral muscle fibers in the parenchyma.

Normally there are three testes in each mature segment—one poral and two aporal—arranged, more or less, in a straight line across segment and separated by ovary (fig. 6, b). Occasionally this arrangement is reversed; that is, there are two testes on the poral side of the ovary and one on the aporal side. Exceptionally, the two aporal testes are placed obliquely or one behind the other. In some segments, instead of the usual three testes, there may be only two, or there may be four to six. The testes are spherical, 0.12 to 0.14 millimeter in diameter. The vas deferens before entering the cirrus pouch is dilated to form a prominent seminal vesicle. Cirrus sac 0.17 to 0.30 by 0.02 to 0.04 millimeter in size in mature segment, 0.24 to 0.40 by 0.04 to 0.06 millimeter in gravid segments, extending from genital pore to or just past excretory vessels; incloses slender, protrusible cirrus.

Ovary bilobed, 0.35 to 0.40 millimeter across, median, intertesticular; surface indented to form small lobules. Vitelline gland lenticular in shape, immediately postovarial. Shell gland small, rounded, between ovary and vitelline gland. Receptaculum seminis large, prominent, extending transversely from median line to excretory vessels; it then becomes narrow in diameter and is continued as the vagina. The latter leads to the common genital pore, passing ventral and slightly posterior to the cirrus pouch. Uterus in pregravid segments in the form of a transversely elongated and apparently solid mass of cells representing young undeveloped ova; it soon becomes hollowed out, sending diverticula in all directions, and in the fully developed state it has the appearance of a sac incompletely divided by partitions into egg capsules and occupying nearly the entire space within a gravid segment (fig. 6, c). Mature eggs (fig. 6, d) spherical or slightly oval, the embryo proper or onchosphere being surrounded by three membranes, as follows: A thicker, very faintly radially striated outer membrane, 54 to 86 microns in diameter; a thinner envelope immediately surrounding embryo, oval in shape, 24 by 20 to 40 by 35 microns in size, often with two polar projections but without filaments as is the case with the eggs *Hymenolepis nana*; and an intermediate layer between outer and inner membranes, apparently composed of albuminous substance and often appearing as two delicate smooth membranes with intervening space filled by

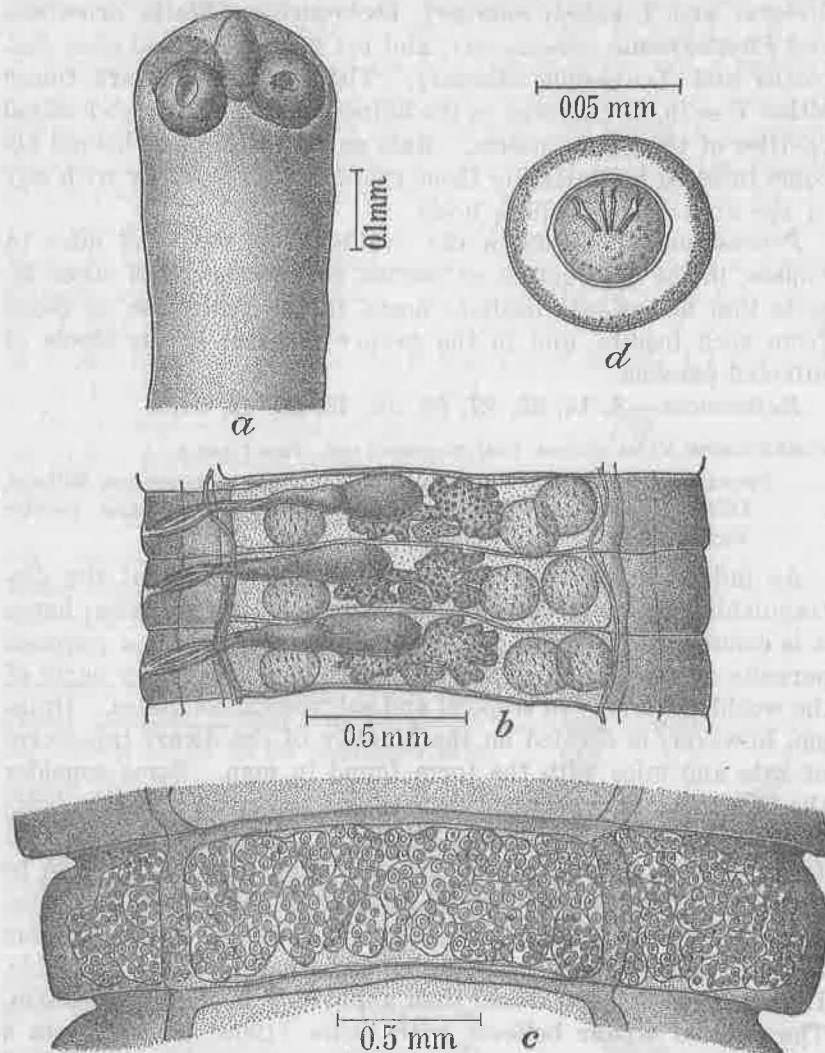


FIG. 6. *Hymenolepis diminuta*. a, Head; b, mature segment, dorsal view; c, gravid segment; d, egg.

granular substance. Embryonal hooks 10 to 16 microns in length.

*Location*.—Small intestine.

*Life history*.—Involves an intermediate host. If ingested by any of the following insects, the eggs will develop into infectious larvæ known as cysticercoids: Meal moth (*Anisopia farinalis*), earwig (*Anisolabis annulipes*), beetles (*Akis spinosa*, *Scaurus*

*striatus* and *Tenebrio molitor*), cockroaches (*Blatta orientalis* and *Phyllodromia germanica*), and rat fleas (*Ceratophyllus fasciatus* and *Xenopsylla cheopis*). The cysticercooids are found either free in, or encysted in the adipose tissue of, the abdominal cavities of the above insects. Rats as well as human beings become infected by ingesting these cysticercooids together with any of the above intermediate hosts.

*Prevention.*—Consists in the avoidance of rats and mice in houses, in the destruction of beetles, cockroaches, and other insects that act as intermediate hosts, in the protection of foods from such insects, and in the proper disposal of the stools of infected persons.

*References.*—8, 14, 25, 27, 33, 35, 40, 48, 49, 51.

**HYMENOLEPIS NANA** (Siebold, 1852) Blanchard, 1891. Figs. 7 and 8.

Synonyms: *Tænia murina* Dujardin, 1845; *Tænia ægyptiaca* Bilharz, 1852; *Hymenolepis fraterna* Stiles, 1906; *Hymenolepis longior* Baylis, 1922.

As indicated by its name (*nana*, or dwarf) one of the distinguishing characteristics of this cestode is its small size; hence it is commonly known as the dwarf tapeworm. It is a common parasite of rats and mice and of human beings in many parts of the world, especially in tropical and subtropical countries. Opinion, however, is divided on the identity of the dwarf tapeworm of rats and mice with the form found in man. Some consider the two forms as representing one and the same parasite (*vide* Woodland, 1924), while others believe that they are distinct (*vide* Joyeux, 1925). If the latter opinion should prove to be true, the rodent parasite would have to be designated as *Hymenolepis fraterna* Stiles, 1906, the older name, *Tænia murina* Dujardin, 1845, being preoccupied and, therefore, not available. The designation *nana* would then apply only to the human form. The present writer believes with Stiles (1906) that "from a standpoint of prevention they should at present be considered as identical," which opinion has been justified by the successful cross-infection experiments of Saeki (1920) and Woodland (1924) as well as by the recent epidemiological observations of Chandler (1927). The latter investigator concluded from his observations that rats are an important epidemiological factor in the dissemination of *H. nana*, for he found the distribution of the parasite in human beings in India to correspond very closely with that of another rat-borne disease; namely, bubonic plague.

The occurrence of this parasite in human beings in the Philippines has been recorded by Riley (1919), who found it in a

fæcal sample obtained from an American Bohemian child residing in Zamboanga, Mindanao, and forwarded to him by Dr. A. F. Coutant. The child was one of a family of five and it appears from the data furnished by the sender that the other members of the family were similarly infested with the worm in question. Among the files of the Bureau of Science for 1928 on the results of the routine examination of fæcal specimens submitted by the Philippine Health Service for evidences of intestinal parasitism, there is also an unpublished record of its presence in a young Chinese boy living in Manila. In Philippine rats, on the other hand, this is the first report of its occurrence, and it seems that it is rare in these animals, for it was found in only 1.7 per cent of the total number of rats examined.

*Description.*—Strobila composed of 96 to 840 proglottids; length 5 to 90 millimeters, depending upon number of segments; maximum width 0.20 to 0.90 millimeter, near posterior end. Head (fig. 8, *a*) subglobular, 0.13 to 0.48 millimeter in diameter; suckers globular, 0.07 to 0.15 millimeter in diameter; rostellum well developed, freely movable, armed near its anterior end with 20 to 30 characteristic hooks (fig. 7, *b*); latter 14 to 18 microns in length, with curved dorsal root directed anteriorly on rostellum and, directed posteriorly, a thick ventral root about equal in length to a sharp pointed prong with which it forms a sort of fork. Neck slender, 0.08 to 0.10 millimeter in length by 0.08 to 0.30 millimeter in width. Anterior segments very short; following segments increase in length and breadth but remain broader than long; most posterior segments, however, may be occasionally stretched and be as long as wide or even longer than wide. Measurements on Philippine material as follows: Immature segments 0.02 to 0.03 millimeter long by 0.14 to 0.17 millimeter wide, mature segments 0.04 to 0.08 by 0.17 to 0.32 millimeter, gravid segments 0.08 to 0.12 by 0.30 to 0.37 millime-

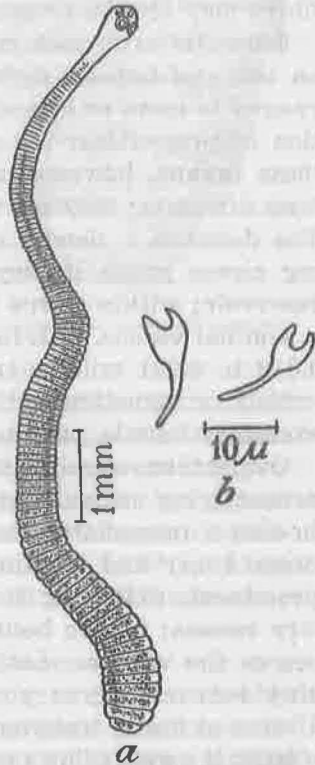


FIG. 7. *Hymenolepis nana*. *a*, Entire worm (from Ransom, 1904); *b*, rostellar hooks.

ter. Genital pores generally all on left side, near anterior border of segments.

Main portion of excretory system consists of two pairs of lateral longitudinal excretory vessels: a small dorsal pair and a larger ventral pair of vessels, the latter united in the posterior portion of each segment by a transverse canal; ventral and dorsal vessels of one side united in the region of the scolex and form an anastomosis at the base of the rostellum. Peripheral nervous system represented by a pair of longitudinal nerves, one on each side of strobila, lateral to excretory vessels. Muscular system weakly developed, consisting of outer circular and inner longitudinal subcuticular fibers and of longitudinal fibers in parenchyma; transverse and dorsoventral parenchymal fibers may also be present, but very few and weakly developed.

Three testes in each mature segment (fig. 8, *b*), normally one on left and two on right side of median line and usually arranged in more or less straight transverse line at posterior portion of proglottids; the arrangement, position, and number of these organs, however, are liable to variation as in *Hymenolepis diminuta*; they are globular, 28 to 34 microns in diameter. Vas deferens a slender canal for the most part; before entering cirrus pouch it may be dilated to form a small seminal reservoir; within cirrus pouch it may also be enlarged to form a seminal vesicle. Cirrus pouch club-shaped, 0.065 to 0.072 by 0.018 to 0.021 millimeter in size, its long axis directed transversely or sometimes obliquely forwards from genital pore to excretory vessels, passing dorsal to longitudinal nerve.

Ovary transversely elongated, bilobed, 0.10 to 0.12 millimeter across, lying ventral to testes. Vitelline gland rounded to oval in shape, immediately postovarial. Shell gland very small, between ovary and vitelline gland. Receptaculum seminis large, prominent, extending transversely from median line to excretory vessels; it then becomes narrow in diameter and is continued as the vagina. Latter leads to common genital pore, passing between cirrus pouch and excretory vessels and nerve. Uterus at first a transversely elongated cellular mass in front of ovary; it soon hollows out and assumes in the oldest segments the form of a sac containing many infoldings or incomplete partitions (fig. 8, *c*); it is more or less completely filled with eggs numbering 80 to 180 in each gravid segment. Eggs (fig. 8, *d*) oval or globular, with two distinct membranes separated by an intervening space containing a finely granular transparent sub-

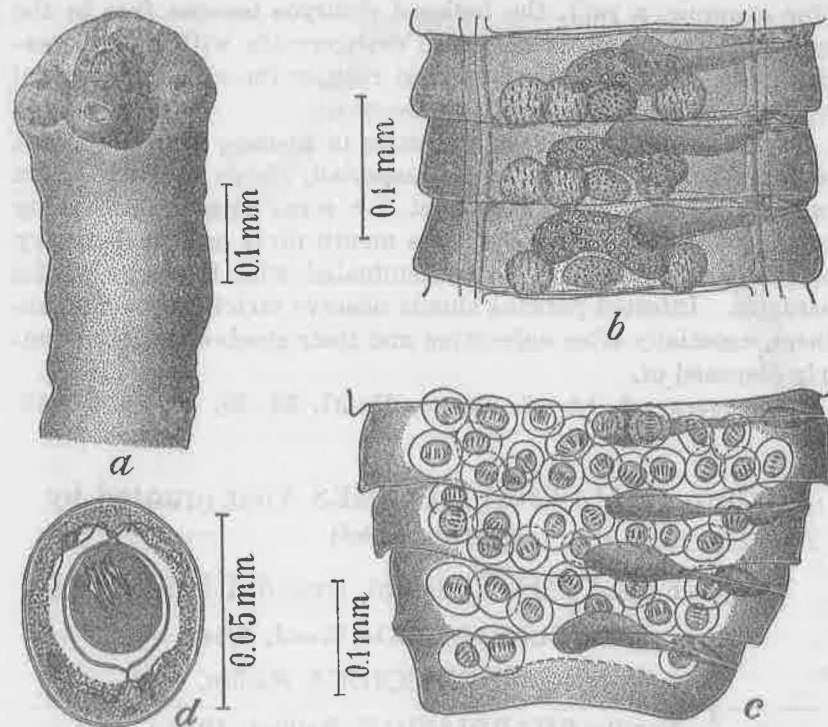


FIG. 8. *Hymenolepis nana*. a, Head; b, mature segment, ventral view; c, gravid segment; d, egg.

stance; outer egg membrane, according to various authors, 30 to 60 microns in diameter; inner membrane 16 to 34 microns in diameter, usually with more or less conspicuous mammillate projection at each pole and filamentous appendages; embryonal hooks 10 to 14 microns long. (Measurements of eggs of Philippine material as follow: Outer membrane 45 to 60 by 34 to 51 microns, inner membrane 30 to 34 by 23.5 to 27.2 microns.)

*Location*.—Small intestine.

*Life history*.—This parasite is unique among the other cestodes in that it has a one-host life-cycle; that is, it is capable of completing its development from egg to adult in a single individual host. This peculiar life history was first demonstrated by Grassi (1887) and has subsequently been confirmed by the more recent studies of Joyeux (1920), Woodland (1924), and others.

The mature eggs (onchospheres) are discharged with the feces of an infested animal. If swallowed by a proper host



(for example, a rat), the inclosed embryos become free in the intestinal tract and develop into cysticercoïds within the intestinal villi. The cysticercoïds then reënter the alimentary canal where they grow into adult tapeworms.

*Prevention.*—Avoid rats and mice in houses; keep foods out of the reach of rats and mice, especially foods that are eaten raw, or after cooking are kept for some time before being eaten; avoid introducing into the mouth dirty and unnecessary objects that are apt to be contaminated with the eggs of the parasite. Infested persons should observe strict personal cleanliness, especially after defecation and their stools should be properly disposed of.

*References.*—8, 14, 18, 23, 24, 25, 27, 33, 36, 48, 49, 51, 58, 59.

**Phylum NEMATHELMINTHES Vogt (quoted by Carus, 1863)**

**Class NEMATODA Rudolphi, emend. Diesing, 1861**

**Order EUNEMATODA Ward, 1916**

**Superfamily RHABDIASOIDEA Railliet, 1916**

**Family RHABDIASIDÆ Railliet, 1915**

**Genus STRONGYLOIDES Grassi, 1879**

**STRONGYLOIDES RATTI Sandground, 1925, fig. 9.**

Synonym: *Strongyloides papillosus* (Wedl, 1856) Hall, 1916.

This minute worm was found in scrapings from the mucous membrane of the small intestine of 74 per cent of the rats examined. In a large number of the cases it was associated with *Nippostrongylus muris*. As indicated by Sandground (1925), it may be distinguished from *S. papillosus* (Wedl, 1856) of sheep, goats, and rabbits, with which it has been confused, by its smaller size, the finer striations of its cuticula, and the course of its ovaries.

*Description.*—Parasitic generation, represented by females, 2.20 to 2.75 millimeters long by 30 to 35 microns thick. Body filiform, attenuated anteriorly; posterior end behind anus suddenly tapers into a short pointed tail. Cuticle finely striate. Mouth surrounded by three minute papillæ; leads directly to œsophagus. Œsophagus 0.70 to 0.78 millimeter long, gradually increasing in diameter posteriorly. Excretory pore 0.10 to 0.12

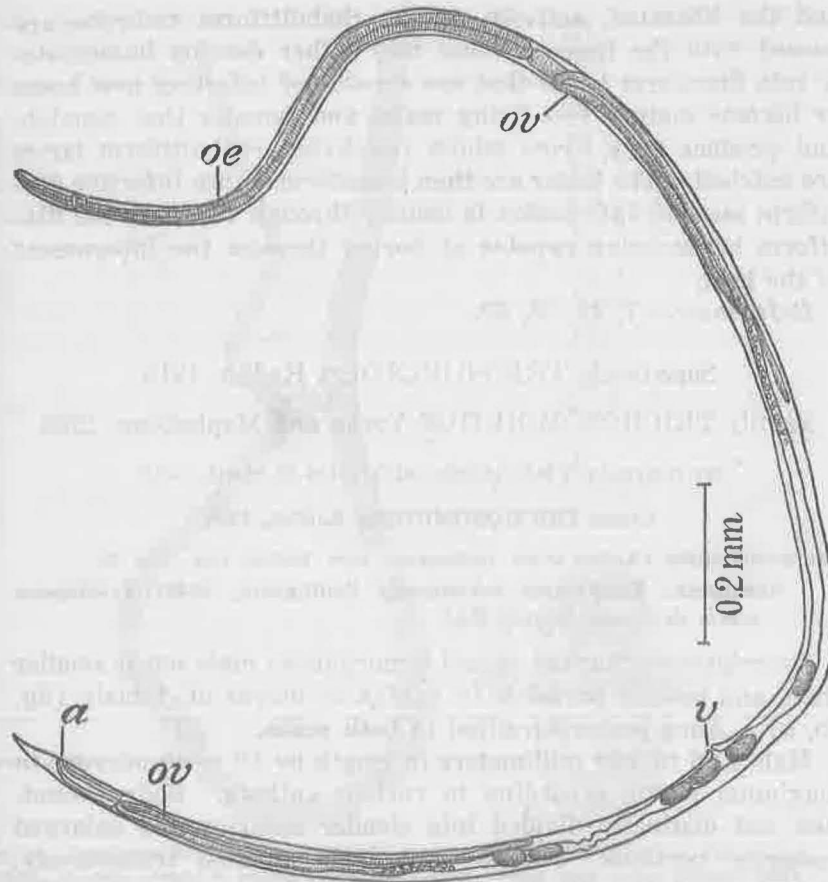


FIG. 9. *Strongyloides ratti*, entire worm. a, Anus; oe, oesophagus; ov, ovary; v, vulva.

millimeter from anterior end. Nerve ring immediately in front of excretory pore. Anus 42 to 45 microns from posterior end. Vulva with prominent lips, 1.70 to 1.82 millimeters from anterior end. Ovaries directly recurrent, their bends being close to oesophageal and anal ends of digestive tract; each is continued as oviduct, then as uterus, so that uteri are divergent. Eggs few in number (maximum 10 or 11 in both uteri), 51 to 56 by 27 to 29 microns in size (according to Sandground, 47 to 52 by 28 to 31 microns); they contain larvæ at deposition.

*Location.*—Small intestine.

*Life history.*—As shown by Sandground (1926), the life history is very similar to that of *Strongyloides stercoralis* of man. The eggs hatch while still in the small intestine of the host

and the liberated, actively motile, rhabditiform embryos are passed with the fæces. These may either develop immediately into filariform larvæ that are capable of infesting new hosts or become mature free-living males and females that copulate and produce eggs, from which free-living rhabditiform larvæ are hatched. The latter are then transformed into infective filariform larvæ. Infestation is usually through the skin, the filariform larvæ being capable of boring through the integument of the host.

*References.*—7, 19, 38, 63.

Superfamily TRICHUROIDEA Railliet, 1916

Family TRICHOSOMOIDIDÆ Yorke and Maplestone, 1926

Subfamily TRICHOSOMOIDINÆ Hall, 1916

Genus TRICHOSOMOIDES Railliet, 1895

TRICHOSOMOIDES CRASSICAUDA (Bellingham, 1840) Railliet, 1895. Fig. 10.

Synonyms: *Trichosoma crassicauda* Bellingham, 1840; *Trichosoma muris decumanani* Rayer, 1843.

*Description.*—Marked sexual dimorphism: male much smaller than, and usually parasitic in vagina or uterus of, female (fig. 10, *a*). Anus posteroterminal in both sexes.

Male 1.60 to 5.20 millimeters in length by 19 to 40 microns in maximum width, according to various authors. Body thread-like, not distinctly divided into slender anterior and enlarged posterior portions. Cuticle very finely striated transversely. Anterior end (fig. 10, *b*) with terminal stylet and prepuce-like cuticular sheath, according to Thomas (1924). Œsophagus 0.70 to 1.28 millimeters long or about one-half to one-third of total body length. Testis single, tubular, originating from anterior region of body and extending to near posterior end, where it is transformed into a small seminal vesicle. Spicule, bursa, or copulatory organs of any sort absent.

Female 10.5 to 14.6 millimeters in length by 0.175 to 0.200 millimeter in maximum thickness near posterior end. Body covered with transverse cuticular ridges except at extreme anterior end; it is divided into a slender anterior portion, corresponding to length of Œsophagus, and into a thicker posterior portion occupied by intestine and reproductive organs. Head rounded, 20

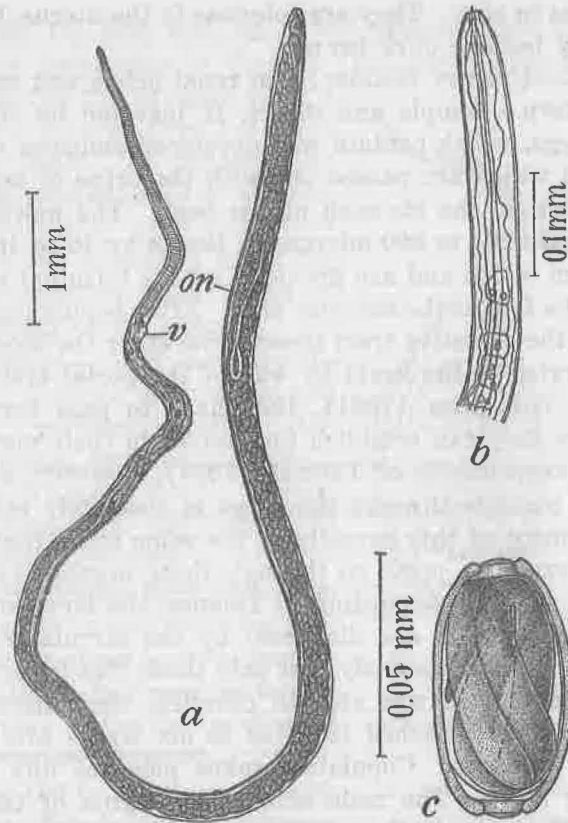


FIG. 10. *Trichosomoides crassicauda*. a, Mature female with male in uterus (after Hall, 1916), m, male worm; v, vulva; b, anterior end of mature male (after Thomas, 1924); c, egg.

to 22 microns in diameter. Mouth simple, minute. Œsophagus a capillary tube, 1.50 to 1.90 millimeters long, which is equal to between one-sixth and one-eighth of total body length; most of the anterior portion of Œsophagus apparently free of surrounding cells, the rest passing through a chain of large Œsophageal cells. Vulva ventral, immediately behind Œsophageal termination. Vagina long, thin-walled, directed posteriorly, distinguished from uterus by presence of dark brown eggs. Uterus reaches to near posterior end of body. Eggs (fig. 10, c) generally oval but may be subspherical or cylindrical, thickshelled, plugged at both poles, embryonated at deposition, 61.2 to 72.0 by 25.0

56.0 microns in size. They are colorless in the uterus, but in the vagina they become dark brown.

*Location.*—Urinary bladder; also renal pelvis and ureters.

*Life history.*—Simple and direct. If ingested by the proper host, the eggs, which contain well-developed embryos when oviposited and which are passed out with the urine of an infected animal, hatch in the stomach of the host. The newly-hatched larvæ measure 264 to 390 microns in length by 10 to 16 microns in maximum width and are provided with a terminal stylet and a prepuce-like fold at the anterior end. After boring out through the wall of the digestive tract these larvæ enter the blood stream and are carried to the heart by way of the portal system. According to Yokogawa (1921), they have to pass through the lungs before they can establish themselves in their normal habitat. The experiments of Thomas (1924), however, do not indicate that passage through the lungs is absolutely essential in the development of this parasite in the same sense that *Ascaris* larvæ, for example, must go through these organs before they can become adults. According to Thomas, the larvæ of *Trichosomoides crassicauda* are dispersed by the circulatory system to different parts of the body, but only those that become lodged in the urinary tract are able to complete their development. The adult state is reached in three to six weeks after the ingestion of the eggs. Copulation takes place at any point in the urinary tract. The male enters the vagina of the female and may either remain there permanently or wander out again.

*References.*—19, 52, 61, 63.

#### Family TRICHURIDÆ Railliet, 1915

##### Subfamily CAPILLARIINÆ Railliet, 1915

##### Genus HEPATICOLA Hall, 1916

HEPATICOLA HEPATICA (Bancroft, 1893) Hall, 1916. Fig. 11.

This appears to be one of the commonest parasites of the brown rat in the Philippines, about 90 per cent of the rat livers examined showing the presence of irregular white or yellowish spots that mark the presence of the worm's eggs. It is at the same time one of those helminths that are able to establish themselves in a variety of hosts other than rats and mice. It has been reported from the European hare (*Lepus europus*), the rabbit, and the prairie dog (*Cynomys ludovicianus*). The guinea pig, dog, and monkey are also susceptible to

it. In man the first and, up to the present time, the only report of its occurrence is that by Dive and Lafrenais (1924), who recovered the parasite from a British soldier who lived for three years in India. At autopsy the subject presented a liver abscess, in the proximity of which were masses of the parasite's eggs; the worms themselves were found in the periphery of the abscess.

*Description.*—Body capillary divided into anterior oesophageal and posterior portions. Cuticle delicately striate, apparently without bacillary band. Mouth simple. Worms, both male and female, 40 to 50 millimeters long.

Male 28 microns thick at posterior end; anterior and posterior portions of body about equal in length. Spicule absent, but represented by membranous sheath prolonged from posterior extremity.

Female 100 to 120 microns thick at middle of body and 65 microns at tail. Anterior portion of body about half as long as posterior portion. Vulva (fig. 11, *a*) prominent, 6 to 7 millimeters from anterior end, opening at level of posterior oesophageal region. Tail very short, blunt and conical. Oviparous; eggs lemon-shaped, double walled, 54 to 58 by 32 to 34 microns in size, plugged at each pole (fig. 11, *b*); outer eggshell striate, inner shell homogeneous.

*Location.*—Liver.

*Life history.*—The life history is simple and direct; that is, it does not involve any intermediate host. The eggs, as encountered in the liver of recently dead rats, are nonsegmented or in the very early stage of segmentation, and are not infectious.

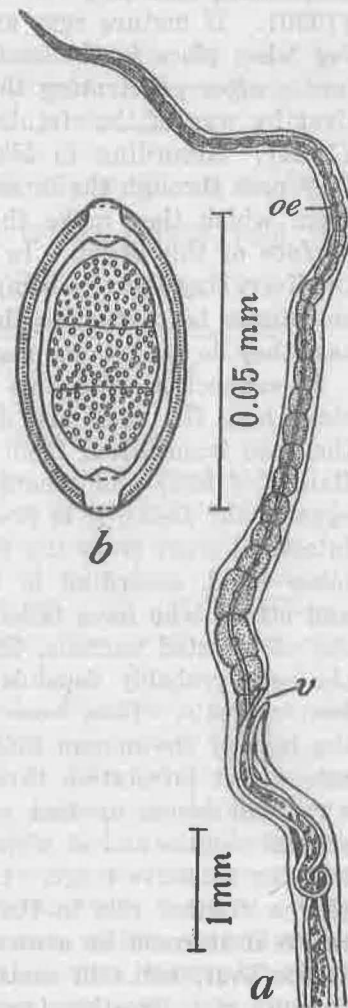


FIG. 11. *Hepaticola hepatica*. *a*, Anterior end of mature female (after Nishigori, from Yorke and Maplestone, 1926); *oe*, oesophagus; *v*, vulva; *b*, egg.

Their development to the infectious embryonated stage is quite slow, taking about five to six months according to Bancroft and to Railliet, and only twenty-three days according to Momma (1930). If mature eggs are ingested by a proper host, hatching takes place in the small intestine and the newly liberated larvæ, after penetrating through the intestinal wall, reach the liver by way of the circulatory system, according to Fülleborn (1924). According to Nishigori (1925) and Asada (1925), they pass through the intestinal wall into the abdominal cavity, from which they make their way into the liver through the surface of this organ. In any case, the larvæ, after reaching the liver, stay there to complete their development. Larvæ may sometimes be carried to the lungs and other organs, in which case they do not become mature and sooner or later die.

In connection with this mode of development it is not yet clear how the eggs are discharged from the body and how they are transmitted from one host to another. According to Railliet (1892) and others who state that they have seen the eggs in the fæces, it is presumed that they escape through the intestinal tract from the liver through the bile duct. On the other hand, according to Bancroft (1893), Weidman (1925), and others who have failed to detect their presence in the fæces of infested animals, the belief is that the transmission of the eggs probably depends upon the cannibalistic habit of the host animals. This, however, could hardly be considered in the case of the human infestation recorded above. Even with rats direct infestation through cannibalism is possible only if a rat will devour another rat (infested) that has been dead for several months and in which the eggs have had time to develop into the infective stage. Indirectly, however, cannibalism may play a distinct rôle in the spread and propagation of the parasite if it could be shown that the immature eggs, as found in the liver, will still continue their development after passing through the digestive tract of a rat. In this connection the recent observations of Momma (1930) and Shorb (1931) are interesting. These authors cultured eggs derived from the fæces of flies and cats that had been fed on infested rat livers and found that they developed normally to the infective stage. It may, therefore, be deduced that the eggs of *Hepaticola hepatica* are disseminated through the natural decomposition and disintegration of the dead bodies of infested animals and through the capture and ingestion of infested rats and mice by their own

kind, or by cats, and other rat-preying animals. According to Momma, flies may play a rôle in the dispersal of the ova since they are often seen in large numbers around the decomposing bodies of dead rats.

*Prevention.*—Avoid rats and mice in houses; the dead bodies of these animals should not be allowed to decompose in the open, but should be buried deeply in the ground or burned; protect foods from rodents and from flies.

*References.*—2, 3, 12, 14, 15, 19, 28, 29, 32, 45, 51, 57, 63.

Superfamily STRONGYLOIDEA Weinland, 1858; Hall, 1916

Family TRICHOSTRONGYLIDÆ Leiper, 1912

Subfamily HELIGMOSOMINÆ Travassos, 1914

Genus NIPPOSTRONGYLUS Lane, 1923

NIPPOSTRONGYLUS MURIS (Yokogawa, 1920) Lane, 1923. Fig. 12.

Synonym: *Heligmosomum muris* Yokogawa, 1920.

*Description.*—Body small, filiform, coiled, blood red in color when fresh. Cervical alæ absent, but cuticle inflated in head region (fig. 12, *a*); length of cuticular expansion 0.058 to 0.063 millimeter. Cuticle with ten longitudinal ridges originating behind inflated area; transverse striation of cuticle evident on these ridges. Mouth simple, leading into small buccal cavity. Œsophagus 0.30 to 0.40 millimeter long. Nerve ring 0.20 to 0.23 millimeter from anterior end. Excretory pore a short distance in front of nerve ring. Cervical papillæ lacking.

Male 3.2 to 3.5 millimeters long by 0.08 millimeter in maximum thickness at middle of body. Bursa well developed, with conspicuous asymmetrical lateral lobes and rays and small dorsal lobe (fig. 12, *b*). Right lobe larger, at least longer, than left lobe, its supporting rays differing from those of opposite side: ventroventral ray small, slender, widely separated from lateroventral which is also thin but longer; externolateral and mediolateral thick and close together except at their tips; posterolateral small and delicate; externodorsal on both sides thin and slender, arising at slightly higher level from common trunk with dorsal ray. In the left lateral bursal lobe, the ventroventral, lateroventral, externolateral and mediolateral rays are almost similar in form, being long and thin; posterolateral thicker and curved dorsally, ending in a conical tip. Dorsal ray bifurcate at its tip, each limb ending in two or three digitations. Spicules yellowish in color, equal, filiform, 0.44 to



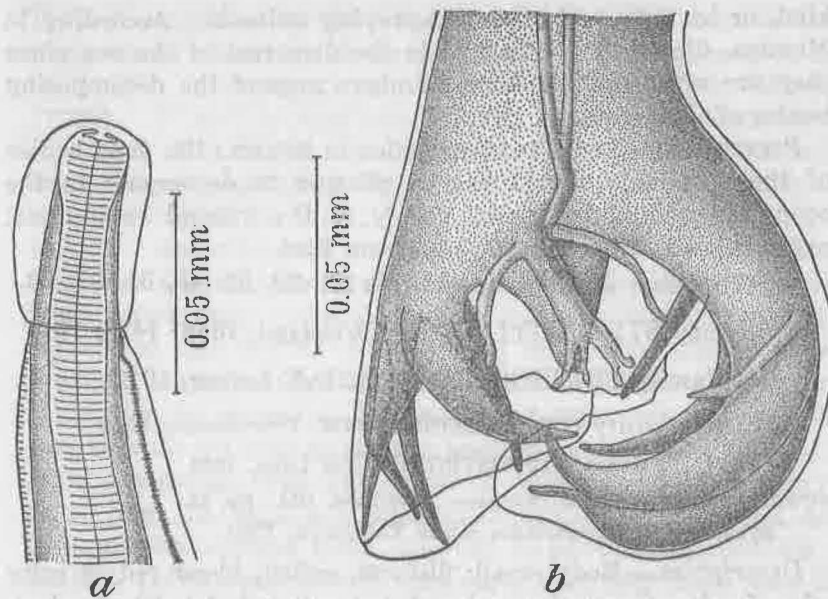


FIG. 12. *Nippostrongylus muris*. a, Anterior end, lateral view; b, bursa, dorsal view.

0.50 millimeter in length by 6 to 7 microns in maximum width at their proximal ends, with sickle-shaped extremities that are usually united together. Gubernaculum colorless, 44 to 46 microns long.

Female 4.0 to 4.6 millimeters in length by 0.135 millimeter in maximum thickness at middle of body. Posterior end behind vulva reduced abruptly in diameter ending in a short, curved, conical tail; in contracted specimens this region of the body may appear swollen and bell-shaped due to the invagination of the cuticle which carries with it the anus and the vulva. Anus about 32 microns from tip of tail. Vulva in front of anus, about 80 microns from tip of tail; vagina muscular, separated from uterus by ovejector; uterus short, modified anteriorly into receptaculum seminis; ovary long, with short anterior loop. Eggs few in number, thin shelled, segmented at deposition, 58 to 60 by 30 to 32 microns in size.

*Location.*—Small intestine.

*Life history.*—The life history of this nematode has been worked out by Yokogawa (1922). When passed out in the fæces of the host, the eggs are in various stages of segmentation. Under favorable conditions their development is continued outside and hatching takes place after about twenty to twenty-four hours.

The newly hatched larvæ attain the infective stage after about five days. The infection of new hosts is accomplished, as in the case of hookworms, by the larvæ entering the body either through the skin or by way of the mouth, the former method having been shown to be more effective. After passing through the lungs the larvæ settle down in the intestine where they reach sexual maturity in seven to ten days after infestation.

*References.*—26, 60, 62, 63.

Superfamily OXYUROIDEA Railliet, 1916

Family OXYURIDÆ Cobbold, 1864

Subfamily SYPHACIINÆ Railliet, 1916

Genus SYPHACIA Seurat, 1916

*SYPHACIA OBVELATA* (Rudolphi, 1802) Seurat, 1916. Fig. 13.

This parasite is listed by Shipley (1908) and by Stiles and Hassall (1910) among the nematodes reported from *Mus norvegicus*. As already stated, it was not encountered in the present survey, but attention is called to it in view of its recorded occurrence in the Philippine Islands by Riley (1919) who identified it from specimens found in a sample of human stools obtained from an American Bohemian child residing in Zamboanga, Mindanao, and forwarded to him by Dr. Albert F. Coutant. The following description is mostly adopted from Hall (1916).

*Description.*—Body elongate, fusiform. Cuticle transversely striate, not dilated in head region. Two small cervical alæ present (fig. 13, *a*). Mouth bounded by three lips, each bearing a median papilla on its outer face; mouth cavity simple. Œsophagus club-shaped with a posterior bulb containing a valvular apparatus and separated from the rest by a constriction. Excretory pore a little posterior of level of Œsophageal bulb.

Male (fig. 13, *b*) 1.3 millimeters long by 115 microns thick, with two or three cuticular "mamelons" on ventral surface. Posterior extremity coiled in a spiral and ending in a long pointed tail. Narrow caudal alæ present, limited to first part of tail, supported by two pairs of preanal and one pair of postanal pedunculated papillæ (fig. 13, *c*). Spicule simple, slightly curved, 85 microns long by 7 microns thick at base; gubernaculum shaped like a ploughshare, 37 microns long, directed transversely posterior of spicule. Cloacal aperture 210 microns from tip of tail; posterior lip of aperture with a small chitinous hook that may be of use in copulation.

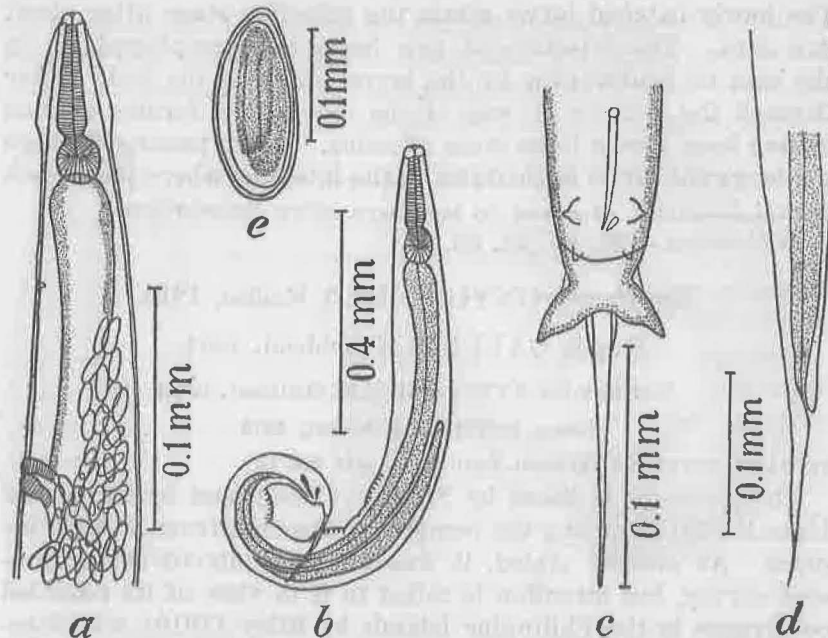


FIG. 13. *Syphacia obvelata*. *a*, Anterior end of female, lateral view; *b*, male, lateral view; *c*, posterior end of male, ventral view; *d*, posterior end of female, lateral view; *e*, egg. (All from Yorke and Maplestone, 1926.)

Female 3.5 to 5.7 millimeters long by 115 to 215 microns thick. Body terminates in a long, narrow tip posteriorly (fig. 13, *d*.) Oesophagus, exclusive of bulb, 255 to 330 microns long by 50 to 70 microns thick; oesophageal bulb 85 to 100 by 75 to 110 microns in size. Nerve ring 100 to 130 microns from anterior end. Anus 515 to 705 microns from tip of tail. Vulva prominent, behind excretory pore, situated on conical cuticular prominence 540 to 740 microns posterior of head. Vagina extends posteriorly from vulva, elongate, about 170 microns long. Uterine branches do not extend posterior of anus. Eggs 110 to 142 by 30 to 40 microns in size, nonembryonated at time of oviposition (fig. 13, *e*).

*Location*.—Cæcum and large intestine.

*Life history*.—Unknown. Probably similar to that of closely related nematodes, such as, *Enterobius vermicularis*, the human pin worm, the life history of which is simple and direct.

*Prevention*.—Taking for granted that the life history of this parasite is simple and direct, the preventive measures that suggest themselves are the observance of personal cleanliness, es-

pecially after defecation, the proper disposal of the stools of infected individuals, the destruction of rats and mice, and the protection of foods from the droppings of these animals.

*References.*—14, 19, 34, 42, 44, 50, 51, 63.

Family HETERAKIDÆ Railliet and Henry, 1914

Subfamily HETERAKINÆ Railliet and Henry, 1912

Genus HETERAKIS Dujardin, 1845

HETERAKIS SPUMOSA Schneider, 1866. Fig. 14.

Synonym: *Ganguleterakis gangula* Lane, 1914.

*Description.*—Body small, tapering slightly towards the anterior end. Cuticle with fine longitudinal and transverse striations and with lateral flanges in oesophageal region (fig. 14, *a*). Head 70 to 75 microns in diameter. Mouth with three subequal lips, each lip carrying two lateral papillæ. Oesophagus 0.75 to 0.83 millimeter long, subcylindrical, terminating in a well-developed bulb; latter 0.15 to 0.17 millimeter in diameter, provided with a valvular apparatus. Distance from anterior end to nerve ring 0.22 to 0.24 millimeter; to excretory pore 0.29 to 0.31 millimeter; to cervical papillæ 0.30 to 0.34 millimeter.

Male 6.0 to 7.4 millimeters in length by 0.25 millimeter in maximum thickness. Tail short and sharply pointed. Caudal alæ well developed, provided with ten pairs of papillæ grouped as follows (fig. 14, *c*): an anterior group of two pairs of ventral papillæ lateral to genital sucker, a middle group of two pairs of ventral and three pairs of lateral papillæ in the cloacal region, and a posterior group of three pairs of lateral papillæ near tip of tail. The anterior group of papillæ are all slender; in the middle group the ventral pairs are short and knobby, while the lateral pairs vary in size and appearance, the first pair being the largest, the second pair thick but short, and the last pair longer but slender; the posterior group of papillæ are relatively small, the middle pair being the largest among them. Genital sucker slightly oval transversely, pedunculate, with a strong chitinous rim interrupted posteriorly by a papilliform projection; average size 0.076 by 0.087 millimeter and about 0.15 millimeter from cloacal opening. Spicules subequal, tapering distally, 0.280 to 0.315 millimeter in length. Gubernaculum absent. Cloacal opening 0.29 to 0.32 millimeter from tip of tail.

Female 7.8 to 9.5 millimeters in length by 0.30 to 0.32 millimeter in maximum thickness. Tail long and acutely pointed (fig. 14, *b*). Anus 0.58 to 0.64 millimeter from tip of tail.

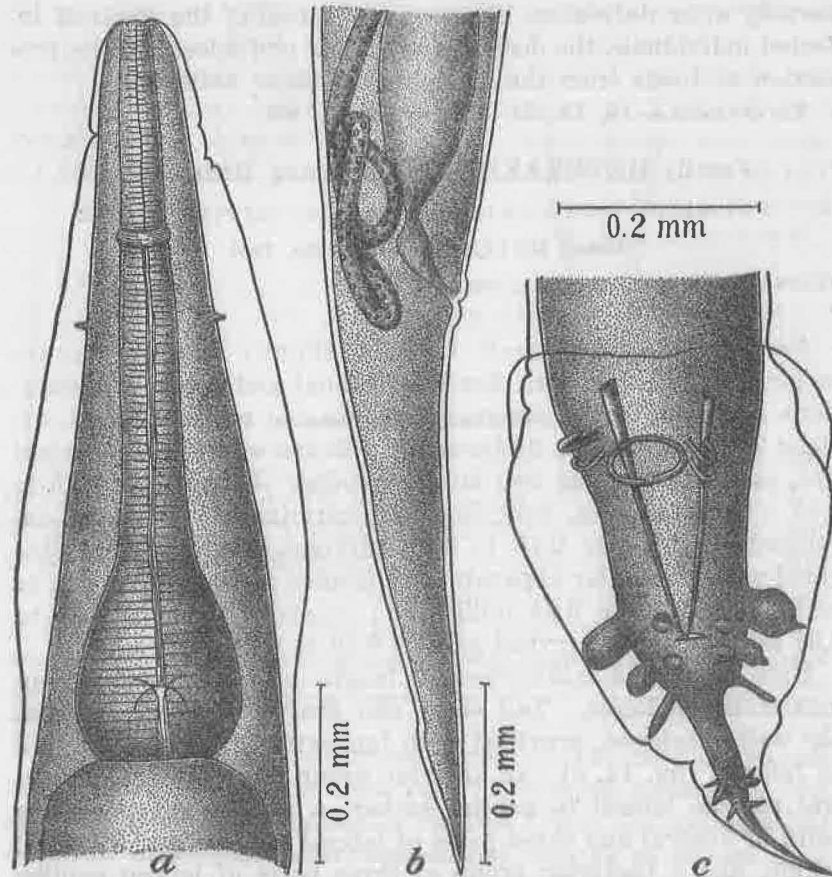


FIG. 14. *Heterakis spumosa*. *a*, Anterior end of female, ventral view; *b*, posterior end of female, lateral view; *c*, posterior end of male, ventral view.

Vulva slightly posterior of middle of body length. Vagina muscular, is at first directed anteriorly, then bends posteriorly and divides into anterior and posterior uterine branches. Ovaries in numerous transverse coils in anterior and posterior end of body. Eggs oval, thick shelled, in the early stage of segmentation at deposition, 56 to 65 by 38 to 40 microns in size; shell about 4 microns in thickness.

*Location*.—Large intestine (cæcum).

*Life history*.—Not worked out, but possibly similar to that of *Heterakis gallinæ* of poultry, in which case it is simple and direct. Briefly the life history of *H. gallinæ* is as follows: The eggs are passed outside with the fæces of the host. Under

favorable conditions of temperature and moisture, the egg becomes embryonated; that is, a larva is developed inside each egg, and is then infective. If the egg is swallowed by a proper host, hatching takes place in the intestine and the liberated larva soon settles down in the cæcum to grow into an adult. The larvæ do not wander into the lungs as is the case with the larvæ of *Ascaris*.

*References.*—19, 63.

Superfamily SPIRUROIDEA Railliet and Henry, 1915

Family SPIRURIDÆ Oerley, 1885

Subfamily SPIROXYINÆ Baylis and Lane, 1920

Genus PROTOSPIRURA Seurat, 1914

PROTOSPIRURA MURICOLA Gedoelst, 1916. Fig. 15.

This is possibly the small *Ascaris* which Schöbl (1913) has observed as being not uncommon in the intestine of Philippine rats. Its normal habitat is the stomach, but after the death of the host it often migrates into the small intestine.

The specimens at hand differ greatly among themselves in size, some females in particular being almost twice as large as other females. In the beginning it was thought that the collection represented two species, but it was later revealed that outside of size there were no other morphological differences.

*Description.*—Body relatively large, regularly attenuated anteriorly. Cuticle transversely striated. Mouth (fig. 15, *b*) with two large lateral lips, each divided into three lobes, of which the middle is larger; each lobe bears two cuticular projections, but no teeth. There are five pairs of head papillæ; namely, one large pair of subventral, a smaller pair of submedian, the dorsal homologues of these, and a minute pair of lateral papillæ. Pharynx (fig. 15, *a*) prominent, laterally compressed, with thick chitinous wall. Œsophagus very elongate, subcylindrical, slightly constricted in region of nerve ring, separated from intestine by valvular apparatus. Cervical papillæ not prominent, in front of nerve ring. Excretory pore ventral, behind nerve ring.

Male 25 to 30 millimeters in length by 0.80 millimeter in maximum thickness at middle of body. Average length of pharynx 0.09 millimeter; of Œsophagus 6.20 millimeters. Distance from anterior end to cervical papillæ 0.32 to 0.35 millimeter; to nerve ring 0.38 to 0.41 millimeter; to excretory pore

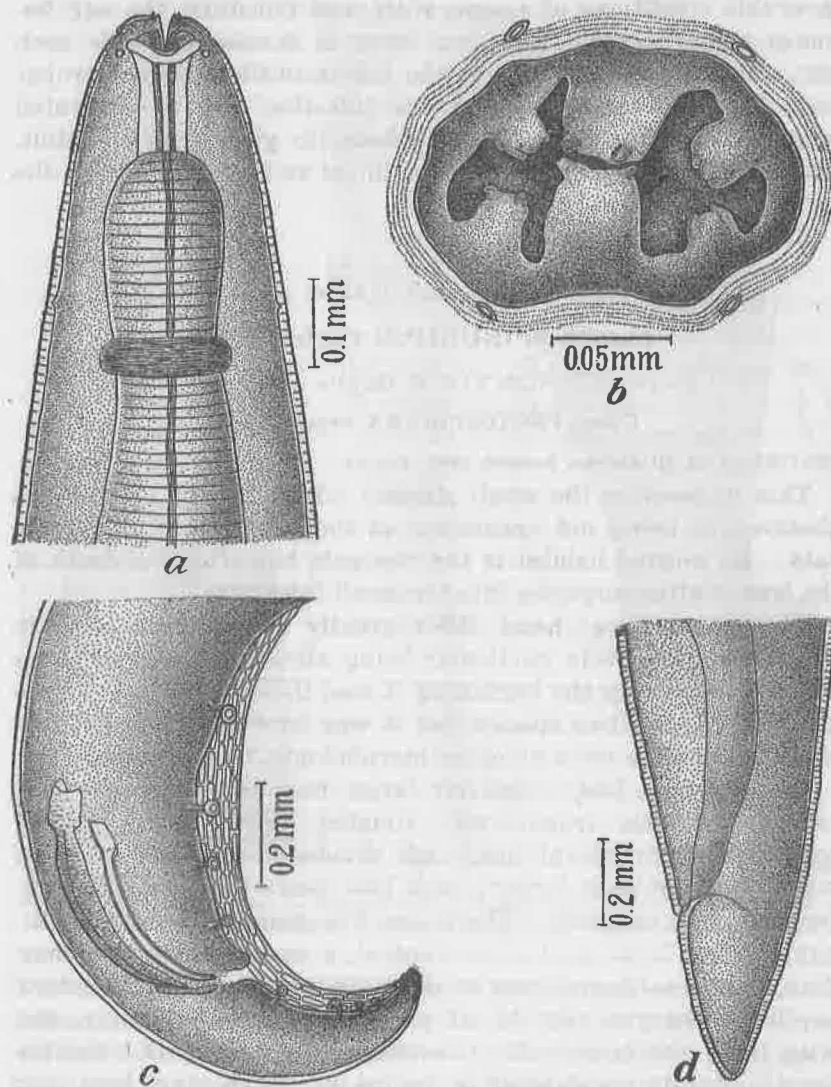


FIG. 15. *Protospirura muricola*. a, Anterior end of female, ventral view; b, mouth, anterior view; c, posterior end of male, lateral view; d, posterior end of female, lateral view.

0.43 to 0.45 millimeter. Caudal end of body conical, spiral, carrying moderately developed symmetrical bursa (fig. 15, c). Latter with cuticular oblong markings and usually supported by nine pairs of pedunculated papillæ, of which four pairs are larger and preanal in position and five pairs smaller and post-anal. Sometimes an extra pair of minute papillæ is present near

tip of tail. Both spicules bent, with enlarged proximal extremities and pointed distal ends, but unequal in size and structure; left spicule spongy, larger, 0.40 to 0.43 millimeter in length by 0.058 to 0.060 millimeter in maximum thickness at proximal end; right spicule hollow, 0.36 to 0.39 by 0.041 to 0.042 millimeter in size. Gubernaculum small, slender, 0.10 millimeter long. Average distance from tip of tail to cloacal opening 0.42 millimeter.

Female 35 to 52 millimeters in length by 1.20 millimeters in maximum thickness at middle of body. Pharynx 0.10 to 0.13 millimeter, oesophagus 6.40 to 7.90 millimeters long. Distance from anterior end to cervical papillæ 0.33 to 0.40 millimeter; to nerve ring 0.38 to 0.47 millimeter; to excretory pore 0.48 to 0.70 millimeter. Caudal end of body bluntly conical (fig. 15, d). Anus 0.40 to 0.42 millimeter from posterior end. Vulva a short distance in front of middle of body length. Uteri divergent, anterior uterus reaching anteriorly to almost as far as oesophago-intestinal junction and the posterior uterus extending to a short distance in front of anus. Eggs oval, embryonated at deposition, thick shelled, 50 to 57 by 38 to 44 microns in size.

*Location.*—Stomach.

*Life history.*—Probably similar to that of *Protospirura muris* (Gmelin, 1790) and of *P. columbiana* Cram, 1926, in which intermediate hosts are involved. Cram gives the life history of *P. columbiana* as follows: If the embryonated eggs of the parasite are fed to cockroaches (*Phyllodromia germanica*), the liberated larvæ find their way to the body cavity, where they begin to encyst in about a month after feeding. The cysts, however, are not infective at this time. After forty-one days they appear to have reached that stage and if fed to rats the encysted larvæ are capable of pursuing further development in the stomach of the latter. They become fully grown and mature one hundred fifteen days after the feeding of the final host.

*References.*—6, 9, 19, 40, 63.

Subfamily GONGYLONEMINÆ Hall, 1916

Genus GONGYLONEMA Molin, 1857

GONGYLONEMA NEOPLASTICUM (Fibiger and Ditlevsen, 1914) Ransom and Hall, 1916  
Figs. 16 and 17.

Synonym: *Spiroptera neoplastica* Fibiger and Ditlevsen, 1914.

Two species of the genus *Gongylonema* have been reported from rats; namely, *G. neoplasticum* and *G. orientale* Yokogawa,



1925. They are said to differ from each other in the following respects: Morphologically, in total size, length of œsophagus, spicules and vas deferens, structure of the spermatozoa, size of the eggs, etc; biologically, in the time necessary for the sexes to reach maturity in experimental infestations. In view, however, of the observations of Seurat (1916) and Baylis (1925) on the degree of morphological variations exhibited by members of the genus, it is not unlikely that the two rodent parasites are identical. Baylis even goes further in suspecting that *G. neoplasticum* is similar to *G. pulchrum* of the pig, between which the differences are much greater and, therefore, more apparent. This, however, could hardly be the case, for, if it were so, it would be difficult to explain why a parasite that is so common in rats has not yet been reported in Philippine domesticated animals. The writer has looked for *G. pulchrum* with uniformly negative results in swine, sheep, goats, and cattle.

This parasite has received considerable attention due to the report of Fibiger and Ditlevsen (1914) that it is instrumental in the production of carcinomatous growths in rats. In the present survey this possible rôle of the parasite was kept constantly in mind, but of the rats found harboring it not one presented a gastric tumor. The condition must be rare in Philippine rats, for Schöbl (1913), who examined tens of thousands of these animals in connection with plague, records only one case of tumor located on the large curvature of the stomach. No determination was made as to the possible origin of the new growth.

*Description.*—Body long, slender, threadlike, terminating in a blunt cone anteriorly. Cuticle transversely striate; bears in cephalic and œsophageal regions more or less globular, egg-shaped or sausage-shaped cuticular plaques or bosses, of variable size and arranged irregularly in longitudinal rows on body surface (fig. 16). Lateral bands present, extending on both sides throughout body length except at most anterior and most posterior regions. Cervical papillæ inconspicuous, in front of nerve ring. Excretory pore ventral, behind nerve ring. Mouth small, surrounded by four very inconspicuous lips; buccal rim 0.02 to 0.03 millimeter in diameter. Œsophagus very long, in two parts— anterior muscular and posterior glandular— separated from intestine by constriction and intestinal valves.

Male 11.0 to 12.0 millimeters in length by 0.20 millimeter maximum thickness at middle of body. Pharynx 0.05 millime-

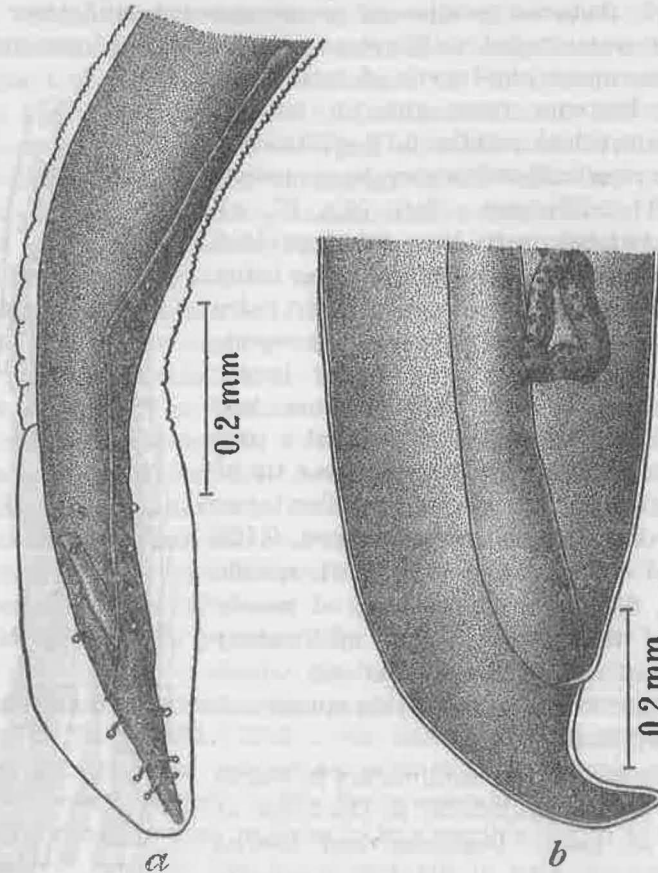


FIG. 17. *Gongylonema neoplasticum*. a, Posterior end of male, ventral view; b, posterior end of female, lateral view.

to 56 by 34 to 36 microns in size, with smooth shell about 3 microns in thickness.

*Location*.—Squamous-celled anterior portion of digestive tract, usually beneath gastric mucosa.

*Life history*.—The development of this parasite requires an intermediate host, which is invariably an insect. Cockroaches, such as, *Blatta orientalis*, *Phyllodromia germanica*, and *Periplaneta americana*; dung beetles, such as, *Ateuchus*, *Aphodius*, and other genera of the family Scarabæidæ; cellar beetles and mealworm beetles of the family Tenebrionidæ are all possible intermediate hosts. Hall (1916) describes the life history as follows: The eggs of the worm are passed out of the body in desquamations of the epithelium of the digestive tract with the

fæces. If ingested by any one of the above insects, they hatch in the intestine, and the liberated embryos, which measure 250 by 13 microns, follow a certain route and are finally found encapsulated in the musculature of the prothorax and legs of the intermediary host. At this stage the larvæ are 0.792 to 1.215 millimeters long and are coiled in spirals within their individual cysts. They are rather slender and possess a conical tail that often terminates in two or three papillalike projections of variable size. Occasionally a wing-shaped prominence with fringed or serrate edges is present. Anteriorly the larvæ are very similar in appearance to the mature worms, except that the pharynx is relatively longer than in the adult and the œsophagus is nearly as long as the intestine. In the beginning the growth of the encapsulated larvæ is faster towards the anterior end, but later the rate of growth is reversed. The nerve ring and excretory pore are distinct, the latter located halfway between the former and the union of the two portions of the œsophagus. Near the region where the vulva will later develop in the female, the anlage of the reproductive system appears in the form of an oval body consisting of a number of cells or a syncytium with several nuclei.

If an insect harboring these encysted larvæ is ingested by a proper vertebrate host, such as a rat, the latter are liberated from their capsules due no doubt to the action of the gastric juice, and on the following day they will be found to have penetrated into the mucous membrane of the stomach and sometimes also into that of the œsophagus and tongue. During the first ten days growth is rather slow, the larvæ only doubling their original length. They molt at about this time and their tails become simple like those of the adult worms. Then they grow more rapidly, and after two months the females begin to deposit eggs.

*References.*—4, 5, 19, 40, 43, 63.

Family RICTULARIIDÆ Railliet, 1916

Subfamily RICTULARIINÆ Hall, 1913

Genus RICTULARIA Froelich, 1802

*RICTULARIA WHARTONI* sp. nov. Fig. 18.

This nematode is named in honor of the late Mr. Lawrence D. Wharton, one of the early pioneers in the field of parasitology in the Philippine Islands.

*Description.*—Male unknown.

ter long. Anterior portion of œsophagus 0.4 millimeter long, posterior portion 2.4 millimeters; total length of œsophagus, therefore, about one-fourth of total body length. Distance from anterior end of worm to cervical papillæ 0.13 millimeter, to nerve ring 0.22 millimeter, to excretory pore 0.34 millimeter. Tail (fig. 17, a) slightly twisted on its long axis, provided with asymmetrical alæ, the left wing being usually longer than the right. Eight pairs of pedunculated caudal papillæ present, of which four pairs are slightly larger and preanal and four pairs postanal; last postanal pair very minute; at least a pair of sessile papillæ often present near tip of tail. Spicules very dissimilar; short one usually on the right, sword-shaped, 0.125 by 0.015 millimeter in size; left spicule filiform, 0.740 millimeter long, of nearly uniform thickness (0.006 millimeter) throughout except at proximal end, where it is dilated. Gubernaculum asymmetrical, 0.065 millimeter long.

Female 35.0 to 70.0 millimeters in length by 0.20 to 0.35 millimeter in thickness at middle of body. Posterior end behind anus formed into a pointed, ventrally curved tail (fig. 17, b). Pharynx 0.058 to 0.072 millimeter long. Anterior portion of œsophagus 0.46 to 0.78 millimeter long, posterior portion 4.0 to 7.6 millimeters; total length of œsophagus 4.5 to 8.4 millimeters or about one-eighth to one-ninth of total body length. Distance from anterior end of worm to cervical papillæ 0.13 to 0.16 millimeter, to nerve ring 0.23 to 0.25 millimeter, to excretory pore 0.60 to 0.66 millimeter. Vulva not prominent, behind middle of body. Distance from tip of tail to vulva 2.6 to 5.9 millimeters, and to anus 0.17 to 0.21 millimeter. Vagina short, directed anteriorly from vulva and followed by long ovejector. Uteri divergent; anterior uterus becomes receptaculum seminis near posterior end of œsophagus, the posterior uterus being similarly modified behind level of vulva. Ovaries much coiled. Eggs oval, embryonated at deposition, 54

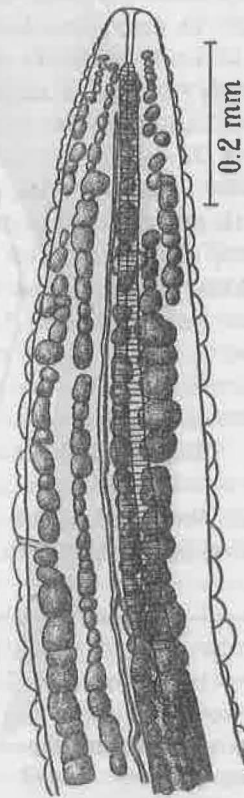


FIG. 16. *Gongylonema neoplasticum*, anterior end, lateral view.

Female 25 to 33 millimeters in length by 0.65 to 0.90 millimeter in thickness across middle of body. Cuticle transversely striated, often swollen anteriorly forming a pair of ventrolateral cuticular expansions 0.40 to 0.90 millimeter long (fig. 18, *a*). Anterior end bent ventrally in preserved specimens, the rest of body length turned towards opposite direction or rolled into a semicircle; posterior end conical, ending in a short fine point (fig. 18, *c*). Head 0.145 to 0.195 millimeter in thickness across base of buccal capsule, provided with two ventral papillæ. Buccal capsule well developed, 0.05 to 0.07 by 0.06 to 0.08 millimeter in size, with its aperture surrounded by a series of denticles (corona radiata) and its base armed with three conical teeth possessing serrated borders (fig. 18, *b*). Œsophagus 3.5 to 4.6 millimeters long. Nerve ring 0.30 to 0.35 millimeter from anterior end. Cervical papillæ not very conspicuous, 0.70 to 0.74 millimeter from anterior end. There are 42 to 43 pairs of "combs" extending from the head to the level of the vulva and measuring 0.045 by 0.015 to 0.200 by 0.145 millimeter; first pair of "combs" almost ridgelike, the rest bigger, more distinct and gradually becoming more spinelike (fig. 18, *a*). Behind the vulvar level there are 47 to 50 pairs of spines 0.05 to 0.16 millimeter long, the first three or five pairs being really of a transitional type and the most posterior pair shorter; last pair of spines immediately behind level of anal opening. Vulva moderately prominent, usually in front (0.3 millimeter) of level of posterior end of Œsophagus, occasionally directly opposite or even slightly behind this level. Vagina directed posteriorly from vulva. Uteri convergent. Eggs with smooth fairly thick shell, embryonated at time of deposition, measuring 44.2 to 47.5 by 34 microns. Anus 0.215 to 0.270 millimeter from tip of tail.

*Specific diagnosis.*—*Rictularia*: Male unknown. Female 25 to 33 millimeters in length by 0.65 to 0.90 millimeter in maximum thickness; with a pair of ventrolateral cuticular dilations in cervical region. Base of buccal capsule armed with three conical teeth possessing serrated borders. Œsophagus 3.5 to 4.6 millimeters long; distance from anterior end to nerve ring 0.30 to 0.35 millimeter; to cervical papillæ 0.70 to 0.74 millimeter. Forty-two to forty-three pairs of "combs" from head to level of vulva and forty-seven to fifty pairs of spines from immediately behind vulvar level to posterior end of body. Vulva usually in front of posterior end of Œsophagus. Anus 0.215 to 0.270 millimeter from tip of tail. Eggs 44.2 to 47.5 by 34.0 microns in size.

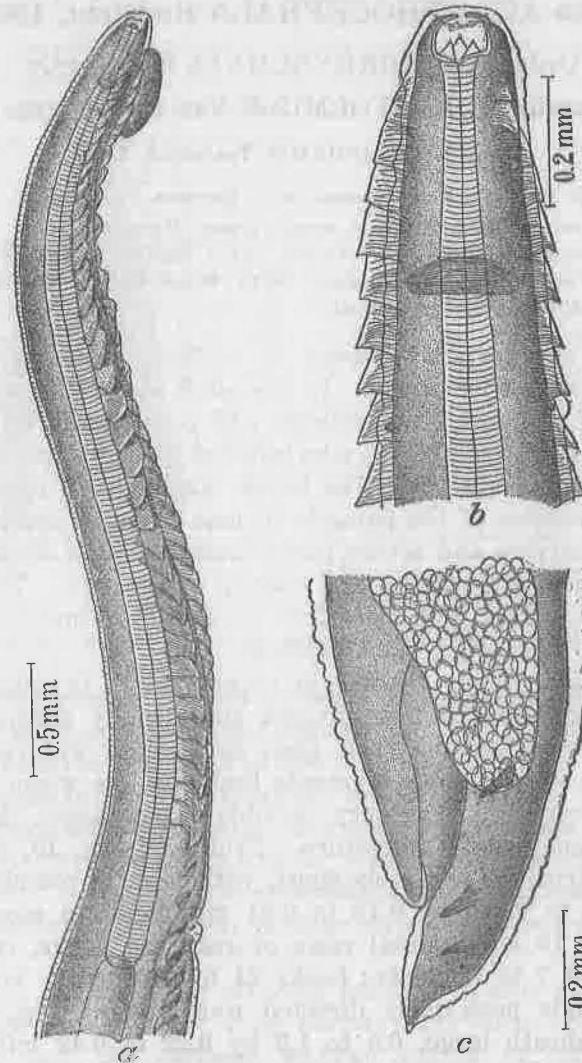


FIG. 18. *Rictularia whartoni* sp. nov. a, Anterior end of female, lateral view; b, anterior end of female, ventral view; c, posterior end of female, lateral view.

*Location*.—Stomach and small intestine.

*Locality*.—Manila, P. I.

*Type specimens*.—Philippine Bureau of Science parasitological collection, No. 10.

*Life history*.—Unknown.

*Reference*.—6, 19, 63.

## Class ACANTHOCEPHALA Rudolphi, 1808

## Order ECHINORHYNCHATA Faust, 1929

## Family MONILIFORMIDÆ Van Cleave, 1924

## Genus MONILIFORMIS Travassos, 1915

MONILIFORMIS MONILIFORMIS (Bremser, 1811) Travassos, 1915. Fig. 19.

Synonyms: *Echinorhynchus moniliformis* Bremser, 1811; *Gigantorhynchus moniliformis* (Bremser, 1811) Railliet, 1893; *Hormorhynchus moniliformis* (Bremser, 1811) Ward, 1917; *Echinorhynchus cestodiformis* Linstow, 1904.

This is appropriately known in ordinary language as the beaded thorn-headed worm. In the adult stage it is a common parasite of rats and other rodents and occasionally of dog and man. Calandruccio (1888), who infected himself experimentally by ingesting several infective larvæ, was able to demonstrate that the presence of the parasite in man in large numbers may produce diarrhœa and severe gastrointestinal pain accompanied by exhaustion, somnolence, and ringing of the ears. The expulsion of the worms with male fern caused the symptoms to disappear two days after the treatment.

*Description.*—Body whitish or creamy-white in color, attenuated at both extremities, divided superficially except at extreme anterior and posterior ends by annular grooves into a series of beadlike pseudo-segments that give the worm a moniliform appearance. Size very variable in both sexes, the smallest specimens usually immature. Proboscis (fig. 19, *a*) cylindrical, protrusible, relatively short, with broadly rounded distal end; 0.425 to 0.670 by 0.15 to 0.21 millimeter in size, armed with 12 to 16 longitudinal rows of recurved hooks, each row composed of 7 to 12 hooks; hooks 24 to 30 microns long, each with a single posteriorly directed root process (fig. 19, *b*). Proboscis sheath large, 0.5 to 1.3 by 0.22 to 0.42 millimeters in size, its wall composed of two muscular layers, of which the outer is made up of diagonally wound fibers. Lemnisci filiform, 2.4 to 10.0 millimeters long, with few large nuclei.

Male 5.5 to 86.0 millimeters in length by 1.0 to 1.5 millimeters in maximum breadth at middle of body; posterior end expanded into small bell-shaped bursa copulatrix, which, however, is usually retracted within the body, being forced out only during the copulatory act or as the result of the contraction of the wall during the preservation of the specimen. Reproductive organs

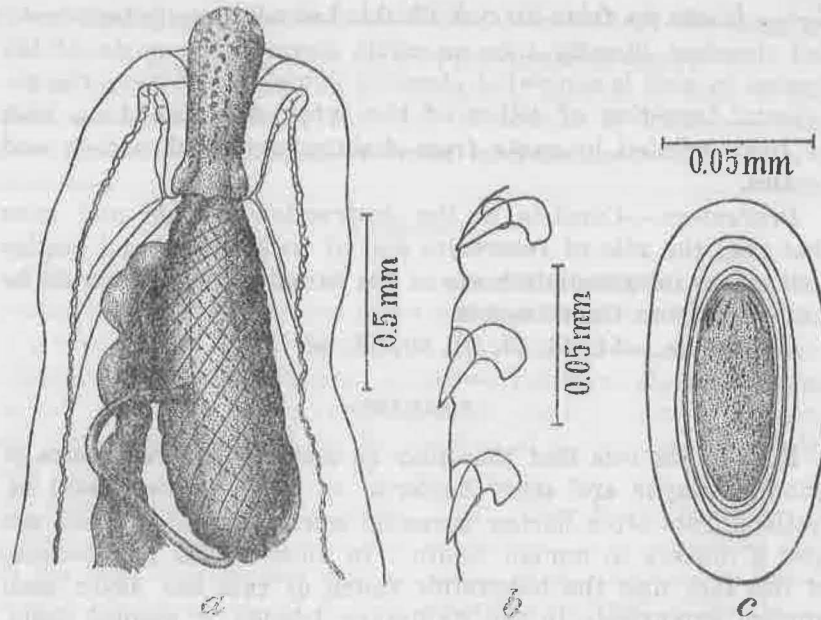


FIG. 19. *Moniliformis moniliformis*. a, Anterior end, lateral view; b, hooks; c, egg.

at posterior portion of body cavity. Testes, of which there are two, are oval, elongated, one immediately behind the other, 0.2 to 4.0 (usually 2.0) by 0.12 to 0.96 millimeters in size. Prostatic glands eight in number, roundish to oval in shape, compressed and crowded together behind testes, the entire mass measuring in mature worms 0.45 to 3.60 by 0.25 to 1.10 millimeters.

Female 7 to 270 by 1.5 millimeters in size. Ovary present only in larval stage, produces large numbers of ova which later are found free in the body cavity of the adult worm. Eggs ellipsoidal, 109 to 137 by 40 to 63 microns in size, and provided with three envelopes; in fully mature eggs outer shell slightly wrinkled and the inclosed embryo brown or dark-colored, striated and covered with minute spines (fig. 19, c).

*Location*.—Small intestine.

*Life history*.—Indirect, the intermediate hosts being species of beetles (*Blaps mucronata*), cockroaches (*Periplaneta americana*), and possibly other insects. If ingested by these insects the eggs develop into oval larvæ in their abdominal cavities. Each larva is inclosed in a very delicate cyst, which, according to Southwell (1922) is easily lost. The larva on being swallowed by a suitable mammalian host together with the insect har-



boring it escapes from its cyst (if this has not already been lost) and develops directly into an adult worm. The mode of infection in man is somewhat obscure; it may result from the accidental ingestion of either of the infected intermediate host or food polluted by cysts from disintegrated cockroaches and beetles.

*Prevention.*—Consists in the destruction of rats and mice that play the rôle of reservoirs and of cockroaches and beetles that act as intermediate hosts of the parasite. Foods should be protected from these insects.

*References.*—14, 46, 47, 51, 53, 54, 56.

#### SUMMARY

Besides the rôle that they play as carriers and reservoirs of bubonic plague and other bacterial as well as spirochætal infections, rats often harbor parasitic worms, some of which are also a menace to human health. In view of this and because of the fact that the helminthic fauna of rats has never been studied extensively in the Philippine Islands, it seemed desirable to undertake a systematic examination of these animals for the purpose of finding out if they are infested with parasites that are transmissible to man.

The examination of nine hundred fifty rats (*Mus norvegicus*) resulted in the identification of the following sixteen species of helminths: Trematodes: *Euparyphium ilocanum*, *E. guerreroi*, and *E. murinum* sp. nov.; cestodes: *Tænia tæniaformis* (larval form), *Raillietina garrisoni* sp. nov., *Hymenolepis diminuta*, and *H. nana*; nematodes: *Gongylonema neoplasticum*, *Hepaticola hepatica*, *Heterakis spumosa*, *Nippostrongylus muris*, *Protospirura muricola*, *Rictularia whartoni* sp. nov., *Strongyloides ratti* and *Trichosomoides crassicauda*; Acanthocephala: *Moniliformis moniliformis*.

The following parasites of rats have been reported from human beings: *Euparyphium ilocanum*, *Hymenolepis diminuta*, *H. nana*, *Syphacia obvelata*, *Hepaticola hepatica*, and *Moniliformis moniliformis*. The first four species mentioned in this paragraph have been reported to occur in man in the Philippine Islands.

It is also believed that *Raillietina garrisoni* should be included among the parasites of the rat that are transmissible to man because of its common occurrence and its close morphological

resemblance to the human tapeworm described by Garrison in 1911 from the Philippines as *Davainea madagascariensis*.

The morphology and the life history, if known, of each of the different parasites are given and, in the case of the forms that are transmissible to man, methods of avoiding infestation are discussed.

#### ADDENDUM

After the manuscript of the above paper was submitted for publication, I found in the literature a description by Hoeppli<sup>2</sup> of a new nematode, *Rictularia tani*, from the brown rat in Amoy, China, with which *Rictularia whartoni* Tubangui should be compared. The two forms resemble each other in several important characters, such as, in the number of their cuticular combs and spines, the length of the œsophagus, and the location of the nerve ring, vulva and anus. They differ in the presence of a pair of ventrolateral cuticular dilatations in *R. whartoni* and in the fact that the last pair of spines of *R. whartoni* is found behind the anus, that of *R. tani* occurring in front of that level. Because of these differences it is decided to maintain the Philippine *Rictularia* as a separate species.

Very recently there also came to hand a paper by Lopez-Neyra<sup>3</sup> that has an important bearing on the discussion of *Raillietina garrisoni*. I described this as a new species of rat tapeworm for, while recognizing its close alliance to *Raillietina celebensis* (Janicki) Meggitt and Subramanian, 1927, it differs from the latter in the number of its testes and uterine egg capsules and in the size of its cirrus pouch. I also gave reasons for suspecting its possible identity with Garrison's *Davainea madagascariensis* which, according to Joyeux and Baer, differs from the specimens described under the same name by other observers. Now, according to Lopez-Neyra, the following represent one and the same species of parasite that should be known as *Kotlania madagascariensis* (Davaine, 1869): the collections in the Parasitological Laboratory of the University of Paris denominated as Type No. 108 (Davaine), No. 109 (Davaine), No. 8 (Blanchard, Port-Louis) and No. 33 (Nossi-Bè, 1873); *Taenia madagascariensis* Leuckart, 1891; *Davainea madagascariensis* Garrison, 1911; *D. formosana* Akashi, 1916; *Raillietina*

<sup>2</sup> Centralbl. f. Bakteriolog. u. Parasitenk. 1 Abt. Orig. 110 (1929) 75-78.

<sup>3</sup> Ann. Parasit. Hum. et Comp. 9 (1931) 162-184.

*celebensis* (Janicki) Meggitt and Subramanian, 1927; *R. funebris* Meggitt and Subramanian, 1927; and possibly *R. fluxa* Meggitt and Subramanian 1927. If Lopez-Neyra's hypothesis is accepted, then *Raillietina garrisoni* will have to fall in line with the above synonymy.

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## ILLUSTRATIONS

[Drawn by V. V. Marasigan under the direction of the author.]

### TEXT FIGURES

- FIG. 1. *Euparyphium ilocanum*. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view. (After Tubangui, 1931.)
2. *Euparyphium guerreroi*. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view. (After Tubangui, 1931.)
3. *Euparyphium murinum* sp. nov. *a*, Entire worm, ventral view; *b*, anterior end, showing arrangement of spines on cephalic collar, ventral view.
4. *Tænia tæniaformis*. *a*, Entire larva (after Sambon, 1924); *b*, scolex, anterior view; *c*, rostellar hooks.
5. *Raillietina garrisoni* sp. nov. *a*, Rostellar hooks; *b*, scolex; *c*, mature segment; *d*, gravid segment; *e*, egg.
6. *Hymenolepis diminuta*. *a*, Head; *b*, mature segment, dorsal view; *c*, gravid segment; *d*, egg.
7. *Hymenolepis nana*. *a*, Entire worm (from Ransom, 1904); *b*, rostellar hooks.
8. *Hymenolepis nana*. *a*, Head; *b*, mature segment, ventral view; *c*, gravid segment; *d*, egg.
9. *Strongyloides ratti*, entire worm. *a*, Anus, *oe*, œsophagus; *ov*, ovary; *v*, vulva.
10. *Trichosomoides crassicauda*. *a*, Mature female with male in uterus (after Hall, 1916), *m*, male worm; *v*, vulva; *b*, anterior end of mature male (after Thomas, 1924); *c*, egg.
11. *Hepaticola hepatica*. *a*, Anterior end of mature female (after Nishigori, from Yorke and Maplestone, 1926); *oe*, œsophagus; *v*, vulva; *b*, egg.
12. *Nippostrongylus muris*. *a*, Anterior end, lateral view; *b*, bursa, dorsal view.
13. *Syphacia obvelata*. *a*, Anterior end of female, lateral view; *b*, male, lateral view; *c*, posterior end of male, ventral view; *d*, posterior end of female, lateral view; *e*, egg. (All from Yorke and Maplestone, 1926.)
14. *Heterakis spumosa*. *a*, Anterior end of female, ventral view; *b*, posterior end of female, lateral view; *c*, posterior end of male, ventral view.
15. *Protospirura muricola*. *a*, Anterior end of female, ventral view; *b*, mouth, anterior view; *c*, posterior end of male, lateral view; *d*, posterior end of female, lateral view.
16. *Gongylonema neoplasticum*, anterior end, lateral view.
17. *Gongylonema neoplasticum*. *a*, Posterior end of male, ventral view; *b*, posterior end of female, lateral view.
18. *Rictularia whartoni* sp. nov. *a*, Anterior end of female, lateral view; *b*, anterior end of female, ventral view; *c*, posterior end of female, lateral view.
19. *Moniliformis moniliformis*. *a*, Anterior end, lateral view; *b*, hooks; *c*, egg.