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Thiabendazole as an Anthelmintic Against *Ascaridia columbae* in Pigeons[1]

EVERETT E. WEHR[2] AND MERLE L. COLGLAZIER

Ascaridia columbae is a common intestinal nematode of pigeons. When present in large numbers, the parasite causes anemia and weakness. Often the affected birds are poor eaters and breeders (Levi, 1957). Attempts to control this parasite with piperazine were unsuccessful (Hwang et al., 1958) despite efficacy of the drug against *A. galli* of chickens (Colglazier et al., 1960; Horton-Smith and Long, 1956; and Shumard and Eveleth, 1955). Inasmuch as thiabendazole has demonstrated effectiveness against many intestinal parasites, including ascarids of livestock and poultry (Brown, 1961; Cuckler, 1961; and Long and Wakelin, 1964) it was tried against *A. columbae*. The results are reported herein.

Materials and Methods

The 57 White King pigeons used in this experiment were purchased from a commercial grower as 6-week-old squabs. They were housed in sterilized wire cages suspended from the ceiling of the poultry house, and fed unmedicated turkey-pigeon mash. Fecal examinations were made for a 2-week period to ascertain that the pigeons were free from extraneous parasites. Each bird was then inoculated experimentally with approximately 1,000 infective eggs of *A. columbae* from laboratory cultures.

About 50 days later, when the droppings contained eggs of *A. columbae*, each bird was put in a separate cage and given free access to turkey-pigeon mash containing 0.5% thiabendazole by weight, for the periods shown in Table 1.

The worms passed by each bird were counted daily. At the termination of treatment, the pigeons were necropsied and all worms remaining were counted.

Results and Discussion

The data are in Table 1. One hundred per cent of the *A. columbae* were removed by feeding mash medicated with 0.5% thiabendazole for a 10-day period. Failure of the drug to remove all worms from pigeons treated for 8 and 9 days reduced its overall efficacy to 96%. This reduced efficiency may be misleading because 47 of the 62 worms recovered in Trial 2 came from one pigeon; this bird failed to consume its allotment of medicated mash.

The drug removed immature as well as mature worms. The greatest number of worms was passed on the 3rd post-treatment day, but appreciable numbers were still being passed on the 6th day. Unfavorable effects were not observed in any of the birds.

Summary and Conclusions

Fifty-seven 15-week-old White King pigeons, experimentally infected with the intestinal roundworm, *Ascaridia columbae*, were used in four critical trials to assess the anthelmintic activity of a 0.5% thiabendazole-medicated mash fed *ad libitum*. Efficacies of 99, 84, 100, and 100% were obtained in birds fed the mash for 8, 9, 10, and 13 days, respectively. The average efficacy in the four trials was 96%. Both immature and mature *A. columbae* were removed. The drug produced no visible unfavorable effects.

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Table 1. Efficacy of 0.5% thiabendazole-medicated mash for the removal of *Ascaridia columbae* from pigeons.

Trial	Number of pigeons	Treatment period (days)	Parasites		Efficacy (per cent)
			No. removed	No. recovered at necropsy	
1	19	8	669	8*	99
2	15	9	318	62†	84
3	8	10	258	0	100
4	15	13	282	0	100
Total or average	57		1,527	70	96

* Worms recovered from one bird only.
† Worms recovered from five birds (47 from one bird).

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Helminths of Some Wild Mammals in the Southeastern United States[1]

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During our studies in recent years, some local native wild mammals have been examined for helminthic parasites. Some of these studies have been published including information on helminths of the raccoon (Harkema and Miller, 1964) and the mink (Miller and Harkema, 1964). Information is presented here on a limited number of four additional species of animals: the otter, *Lutra canadensis*; bobcat, *Lynx rufus*; grey fox, *Urocyon cinereoargenteus*; and red fox, *Vulpes fulva*.

When possible, host animals were obtained alive from trappers during the regular trapping season, but some were shot and others drowned in traps so that immediate examination was not always possible. All animals, however, were examined as soon as possible after capture. The trematodes, cestodes, and acanthocephalans were killed and fixed in AFA (alcohol, formalin, and acetic acid), stained and mounted for further study. The nematodes were killed in hot 70 per cent alcohol and stored in glycerin alcohol. Large nematodes were cleared in lacto-phenol.

[1] Supported in part by research grant AI05927 from the National Institutes of Health, U. S. Public Health Service.

Table 1. Incidence of helminths in 20 otters from North Carolina.

Species of parasite	Number infected
Trematoda	
Baschkirovitrema incrassatum (Diesing, 1850)	14
Enhydridiplostomum alarioides (Dubois, 1937)	7
Nematoda	
Capillaria plica (Rudolphi, 1819)	5
Crenosoma goblei Dougherty, 1945	1
Gnathostoma miyazakii Anderson, 1964	4

Results and Discussion

Twenty-eight species of helminths were recovered from 65 mammals. These are discussed in relation to the four species of hosts because most of the parasites encountered appeared to be fairly host specific.

Lutra canadensis (Table 1)

Twenty otters were collected from eight counties in North Carolina in the vicinity of the Northeast Cape Fear River. About one-third was from coastal counties, but there appeared to be no apparent differences in the helminths in hosts from coastal areas versus those from inland habitats. Two trematode and three nematode species were collected from the otter.

Baschkirovitrema incrassatum (Diesing, 1850) was the most common trematode found in the otter. It was present in 14 of the 20 hosts and varied in number from 1 to 89 per host. The measurements of our specimens compare favorably with those of Beverley-Burton (1960). This form is found in various species of otters from several parts of the world including Brazil (Diesing, 1850), the Sudan (Myers, Wolfgang, and Kuntz, 1960), and Southern Rhodesia (Beverley-Burton, 1960). More recently Miller and Harkema (1964) reported the mink in North Carolina as a new host. Specimens from the otter in New York deposited in the National Museum by W. J. Hamilton in 1953 and additional specimens from Georgia collected by McKeever and Sawyer in 1955 were obtained on loan through the courtesy of Dr. Allen McIntosh and compared with our specimens. All are similar. The only other record of this trematode in the United States is that of Sawyer (1961) from the otter in Georgia. Two of our specimens have been deposited in the National Museum as USNM Helm. Coll. No. 57415.

Enhydridiplostomum alarioides (Dubois, 1937) was the only other trematode found in the otter. It occurred in 7 of 20 hosts and varied from 1 to 400 per host. This species was reported from the mink, *Mustela vison*, in North Carolina by Miller and Harkema (1964). Specimens were collected by Pearson in 1951 from the otter in Chapleau, Ontario and catalogued as USNM Helm. Coll. No. 49045. Permission was obtained from the Museum to stain and mount these for detailed study. Our forms agree in all respects. Sawyer (1961) published the first report of this parasite in the United States. The type specimen of *Enhydridiplostomum fosteri* (McIntosh, 1940) also was compared, and we agree that it is a distinct and separate species. Specimens from North Carolina have been deposited as USNM Helm. Coll. No. 57429.

Capillaria plica (Rudolphi, 1819) was one of three nematodes collected from the otter. It occurred in 5 of 20 hosts and ranged from 1 to 30 per host. The urinary bladders of the raccoon, bobcat, and foxes also contained this parasite.

Crenosoma goblei Dougherty, 1945, was recovered from the respiratory tract of one host. Only one specimen, a female, was found, and, therefore, the specific identification is uncertain.

Gnathostoma miyazakii Anderson, 1964, was recovered from the kidneys of four otters. These hosts were from counties adjacent to the Northeast Cape Fear River. The total number of parasites was difficult to ascertain because it was practically impossible to remove an intact worm from the fibrous tissue of the kidney. Sufficient material was available, however, to confirm the identity of this species. The unusual location of these mature gnathostomes invites additional investigation. This is apparently the first record of this nematode in the United States. The only other gnathostome reported in mustelids in North America is *Gnathostoma sociale* (Leidy, 1858). The latter species was redescribed and compared with *G. miyazakii* by Anderson (1964).

Lynx rufus (Table 2)

Helminths were recovered from 16 bobcats, 12 hosts were from counties in eastern North Carolina and four from two counties in South

Table 2. Incidence of helminths in 16 bobcats from North Carolina and South Carolina.

Species of parasite	Number infected
Trematoda	
Alaria canis LaRue and Fallis, 1936	5
Paragonimus rudis (Diesing, 1850)	1
Cestoda	
Spirometra mansonoides (Mueller, 1935)	12
Mesocestoides variabilis Mueller, 1927	1
Taenia macrocystis Diesing, 1850	12
Taenia rileyi Loewen, 1929	4
Acanthocephala	
Centrorhynchus sp.	1
Nematoda	
Toxocara mystax (Zeder, 1800)	12
Ancylostoma caninum (Ercolani, 1859)	5
Ancylostoma braziliense Gomez de Faria, 1910	3
Capillaria plica (Rudolphi, 1819)	2
Anafilaroides rostrata Gerichter, 1949	2
Molineus barbatus Chandler, 1942	6
Dirofilaria striata (Molin, 1858)	2

Carolina. Thirteen species of helminths were recovered including two trematodes, four cestodes, one acanthocephalan, and seven nematodes.

Alaria canis LaRue and Fallis, 1936, was recovered from five hosts, all of which were collected in Brunswick County, North Carolina. The number of worms varied from 1 to 159 per host. Pearson (1956) gave a thorough description of the life cycle of *A. canis* and also the first report of its presence in bobcats. Most of the specimens in the bobcat are smaller than the ones recovered from the foxes in this area. Otherwise, they are similar.

Paragonimus rudis (Diesing, 1850 (= *P. kellicotti* Ward, 1908) was recovered from one host collected in Brunswick County, North Carolina. Four mature and two immature worms were found. There are scattered records of this trematode occurring in other states, but the only records in North Carolina are Hardcastle (1941), Harkema and Miller (1964), and Miller and Harkema (1964) reporting the house cat, raccoon, and mink respectively as hosts. Jordan and Byrd (1958) reported *Paragonimus* from the bobcat and cited other references to its presence in swine in Georgia. Stewart and Jones (1959) also reported it from the pig in Georgia and used the designation *P. rudis* as determined by Allen McIntosh.

Spirometra mansonoides (Mueller, 1935) was one of four species of cestodes recovered from the bobcat. It was present in 12 of the 16 hosts from both coastal and inland habitats, though more prevalent in hosts from coastal regions. It is interesting that both adults and spargana were not found in the same host even though often present in the raccoon and grey fox. It is known that young kittens can be infected with spargana by feeding them infected copepods. An excellent summary on the biology of *S. mansonoides* was recently presented by Mueller (1966).

Mesocestoides variabilis Mueller, 1927, was recovered from only one host taken from Pender County, North Carolina. These specimens were stained and compared with the descriptions of Voge (1955). Except for minor differences they compare favorably. The specific identification of members of the genus *Mesocestoides* is difficult. The genus was reviewed by Voge (1955) who regarded both *Mesocestoides manteri* Chandler, 1942, and *M. variabilis* as synonyms of *Mesocestoides corti* Hoeppli, 1925.

Taenia macrocystis Diesing, 1850, was one of two taenioids found in the bobcat. It was present in 12 of 16 hosts ranging from 2 to 48 specimens per host. In two hosts from South Carolina and two coastal North Carolina specimens there was a mixed infection of *T. macrocystis* and *T. rileyi* Loewen, 1929 (see below). Members of the cestode genus *Taenia* include a number of closely allied species, many of which are poorly defined and consequently difficult to identify. *Taenia macrocystis* was placed in the genus *Hydatigera* by Wardle and McLeod (1952), Yamaguti (1959), and others. *Taenia* is differentiated from *Hydatigera* on the basis of a nonsegmented neck region. There is no segmentation immediately behind the suckers on our specimens. Moreover, other authorities (Cameron, 1926) (Rausch and Williamson, 1959) (Esch and Self, 1965) advocate the synonymy of *Hydatigera* and *Multiceps* with *Taenia*. Recent authors have emphasized the character and size of the hooks, especially the smaller ones, as being the best features for specific identification. The study by Riser (1956) on the hooks of taenioid cestodes from North American felids was the basis for the identification of our specimens.

Taenia rileyi Loewen, 1929, was recovered

from 4 of 16 hosts, varying from 2 to 23 per host. As stated above they were found in mixed infections with *T. macrocystis*. They are differentiated from the latter on the basis of the larger size, having a more robust body, and with a strobilar configuration much like that of *Taenia pisiformis*. *T. macrocystis* is a rather small, slender member of the genus. Of significance too is the fact that the large hooks of *T. rileyi* are about 0.22–0.24 mm long, whereas those of *T. macrocystis* are 0.32–0.34 mm in length. Comparison of the large and small hooks of *T. rileyi*, *T. macrocystis*, and *T. pisiformis* (the latter collected locally from dogs) indicates that the size and shape of the small hooks provide the best diagnostic features for separating these forms. This is apparently the first report of *T. macrocystis* and *T. rileyi* from the southeastern United States.

One immature specimen of *Centrorhynchus* sp. was the only acanthocephalan recovered. Members of this genus are commonly found in birds, and it is presumed that this form is an accidental parasite of the bobcat.

Toxocara mystax (Zeder, 1800) was the most common nematode in the bobcat and was recovered from 12 of 16 hosts and varying from 1 to 40 per host. This species is cosmopolitan, having been reported many times from felids. Much of the biology on this and related species has been studied by Sprent (1956, 1958).

Ancylostoma caninum (Ercolani, 1859) was present in 5 of 16 hosts with 4 of 5 infected hosts being from South Carolina. There were from 1 to 23 per host with an average of about 7 indicating that the dog hookworm is not a common parasite of the bobcat.

Ancylostoma braziliense Gomez de Faria, 1910, was recovered from three hosts collected in the vicinity of Dorchester, South Carolina. The largest number from a single host was eight. The cat hookworm appears to be an even less of a problem than the dog hookworm.

Capillaria plica (Rudolphi, 1819) was found in the urinary bladders of only two hosts. Read (1949) stated that capillarids appear to have little host specificity though fairly specific for their location within the host. This seems to be the case with *C. plica* as we have found it in the bladders of the raccoon, bobcat, otter, red and grey foxes.

Anafilaroides rostrata Gerichter, 1949, was recovered from the lungs of two hosts. Klewer (1958) reported its presence in the lungs of 23 of 24 bobcats in Virginia. He also reported that its life cycle involves the slug *Limax maximus* as an intermediate host.

Table 3. Incidence of helminths in 24 grey foxes from North Carolina, South Carolina, and Georgia.

Species of parasite	Number infected
Trematoda	
Eurytrema procyonis Denton, 1942	3
Euryhelmis squamula (Rudolphi, 1819)	1
Sellacotyle mustelae Wallace, 1935	1
Alaria canis La Rue and Fallis, 1936	1
Procyotrema marsupiformis Harkema and Miller, 1959	1
Cestoda	
Taenia pisiformis (Bloch, 1780)	9
Mesocestoides variabilis Mueller, 1927	5
Spirometra (?) *mansonoides* (Mueller, 1935) spargana	2
Nematoda	
Physaloptera maxillaris Molin, 1860	9
Molineus patens (Dujardin, 1845)	2
Ancylostoma caninum (Ercolani, 1859)	17
Capillaria aerophila (Creplin, 1839)	1
Capillaria plica (Rudolphi, 1819)	5
Trichuris vulpis (Froelich, 1789)	1
Dirofilaria immitis (Leidy, 1856)	2

Molineus barbatus Chandler, 1942, was recovered from 6 of 16 hosts with from 1 to 23 per host. This form is commonly found in raccoons (Harkema and Miller, 1964) and has been reported from the skunk (Babero, 1960). Gupta (1961, 1963) studied the life history and biology of this species. Schmidt (1965) recently described a new species from the weasel and included a key to the genus. This is apparently the first report of the bobcat as a host for this species.

Dirofilaria striata (Molin, 1858) was recovered from two South Carolina hosts. One host contained two worms, the other one nine. Both sexes were recovered from the subcutaneous region of the thigh. Orihel and Ash (1964) reported this species in a bobcat from Louisiana. The average length of three females was 27.8 cm, of six males, 8.8 cm which compares favorably with the measurements given by Orihel and Ash (1964).

Urocyon cinereoargenteus (Table 3)

The 24 grey foxes were obtained as follows: 15 from North Carolina, 7 from Georgia, and

2 from South Carolina. The helminths recovered from this host appear to be similar in all three states, but there were some isolated instances as noted below. Fifteen species of helminths, including five trematodes, three cestodes, and seven nematodes, were collected from this host.

Eurytrema procyonis Denton, 1942, a trematode from the pancreatic duct, was recovered from three hosts from North Carolina. The number per host was 107 and 110 for two of the three hosts.

E. vulpis Stunkard, 1947, was described from a red fox as a provisional new species, but subsequently Stunkard and Goss (1950) placed it in synonymy with *E. procyonis*. This species has been found in the raccoon and in grey and red foxes from a number of localities. Denton (1944) reported on its life history. *E. procyonis* was transferred to the genus *Concinnum* by Travassos (1944) and Yamaguti (1958). However, as noted by Stunkard (1947), the validity of *Concinnum* is doubtful and features listed by Travassos to separate the two genera are inadequate.

Seventy-four specimens of *Euryhelmis squamula* (Rudolphi, 1819) were recovered from one fox collected in the vicinity of Millhaven, Georgia. This species was reported from Virginia (McIntosh, 1936), North Carolina (Parker, 1950; Harkema and Miller, 1964), Georgia (Babero and Shepperson, 1958), Oregon (Senger and Neiland, 1955), and more recently Anderson and Pratt (1965) contributed information on its life history. Adults were obtained in our laboratory by feeding cricket frogs, *Acris gryllis*, to white mice, both of which are new experimental hosts. Although Baer (1931) reported this helminth from the European fox, *Vulpes vulpes*, this is apparently the first report of a fox as host in the United States.

Sellacotyle mustelae Wallace, 1935, was recovered from the same fox from Georgia that contained *E. squamula*. Seventeen specimens were found. This is the most common trematode occurring in mink in North Carolina (Miller and Harkema, 1964), and this host appears to be the usual definitive host (Wallace, 1935; Erickson, 1946). *S. mustelae* has also been reported from the raccoon from Georgia (Sawyer, 1958) and from Georgia, Virginia, North and South Carolina (Harkema and Miller, 1964). Wallace (1934) reported an accidental infection in fox. A second species, *Sellacotyle vitellosa* Sogandares-Bernal, 1961, was described from mink collected in Louisiana.

Alaria canis LaRue and Fallis, 1936, was collected from one fox from Pender County, North Carolina with only five specimens present. These specimens from the grey fox are much larger and more robust than those from the bobcat. Size, however, appears to be the only difference. Pearson (1956) presented an excellent review of this species. The present report extends the geographical range distribution of this trematode.

Procyotrema marsupiformis Harkema and Miller, 1959, was recovered from the gall bladder of one fox from Hertford County, North Carolina, which is an endemic area for this parasite. Only two specimens were found. This form was described from specimens from the pancreatic duct of the raccoon. Miller and Harkema (1964) also reported this species in the gall bladder of the mink and commented on the locations in the hosts as being unique for strigeoid trematodes. More recently, Locke and Brown (1965) reported it from a raccoon collected in Maryland and discussed its pathogenicity. The life history of this species has been completed in our laboratory and will be published separately.

Taenia pisiformis (Bloch, 1780) was recovered from 9 of 24 hosts with 2 to 150 per host. This species is cosmopolitan in distribution and a common parasite of canine animals.

Mesocestoides variabilis Mueller, 1927, was recovered from five hosts and varied in number from 1 to 37 per host. Babero and Shepperson (1958) identified specimens from Georgia raccoons as *Mesocestoides lineatus*. Witenberg (1934) chose to include both the European and American representatives as forms of *M. lineatus*. However, the best summation of this group is by Voge (1955). Pending further definitive work the authors will retain the specific name *variabilis* for previously stated reasons (Harkema and Miller, 1964).

Spirometra mansonoides (Mueller, 1935) spargana were recovered from the subcutaneous tissues of two North Carolina hosts. Since adults were not obtained our specific identity is based on our previous findings of both spargana and adults in the raccoon.

Physaloptera maxillaris Molin, 1860, was recovered from nine hosts with 1 to 12 specimens per host. *P. rara* from the raccoon and *P. turgida* from the opossum appear to be the more common members of the genus in this region, but only *P. maxillaris* was recovered from the fox.

Molineus patens (Dujardin, 1845) was recovered from two hosts with four and nine specimens respectively. This was the second most abundant nematode in North Carolina mink (Miller and Harkema, 1964) although Morgan and Hawkins (1949) considered it to be rare in the mink. Since Skinker's (1932) first report of this species in North America it has been reported from a number of mustelid animals. To our knowledge this is the first report of its presence in the grey fox. Babero (1960) reported *M. patens* to be highly pathogenic to skunks in Louisiana. Schmidt (1965) recently described a new species, *M. mustelae*, from the long-tailed weasel in Montana and published a key to the species of *Molineus*.

Ancylostoma caninum (Ercolani, 1859) was the most commonly encountered nematode in this host being present in 17 of 23 hosts from all three states. It varied in number from 1 to 200 per host.

Capillaria aerophila (Creplin, 1839) was found in one North Carolina fox which contained three specimens. Commonly called the fox lungworm it has been reported a number of times from Europe and North America. Christenson (1938) discussed its life history and epidemiology and Read (1949) presented a key to the species of *Capillaria* in North American mammals.

Capillaria plica (Rudolphi, 1819) was collected from the urinary bladders of five foxes. As discussed above, we have found this species to be fairly common in this area.

Trichuris vulpis (Froelich, 1789), the dog whipworm, was recovered from one host and only two specimens were present. It is surprising that it was not encountered more often since the species is apparently cosmopolitan in distribution. Miller (1947) discussed the life history of this species.

Dirofilaria immitis (Leidy, 1856) was collected from two hosts, one in North Carolina with 13 specimens and one in South Carolina with one specimen. Although the dog is generally the recognized definitive host of the heartworm, this parasite has been reported from a wide range of mammalian species including the cat, wolf, coyote, coati mundi, muskrat, and others. The fox does not appear to be as susceptible as the dog. Erickson (1944) examined 120 red foxes, 26 grey foxes, 61 coyotes, and 18 timber wolves in Minnesota and found no heartworms. In the same paper he did report *D. immitis* from a single red fox in New York state. Walton, Glover, and Upham (1963) did not find heartworm microfilariae in the blood of 48 grey foxes and two red foxes whereas 41 of 61 dogs from the enzootic area were positive in a study at Fort Stewart, Georgia. They were led to postulate a possible physiologic resistance to the helminth by foxes. Schlotthauer (1964) found *D. immitis* in the heart of 4 of 83 red foxes and none in nine grey foxes. He remarked that wild mammal populations probably are not highly significant reservoirs of heartworm infection.

Table 4. Incidence of helminths in five red foxes from North Carolina and Georgia.

Species of parasite	Number infected
Cestoda	
Taenia pisiformis (Bloch, 1780)	3
Nematoda	
Physaloptera maxillaris Molin, 1860	1
Molineus patens (Dujardin, 1845)	2
Uncinaria stenocephala (Railliet, 1884)	3
Toxocara canis (Werner, 1782)	1
Capillaria plica (Rudolphi, 1819)	1

Vulpes fulva (Table 4)

Only five red foxes were examined during this study. Four of these were from North Carolina and one from Georgia. One species of cestode and five species of nematodes were recovered. With the exception of the hookworm, *Uncinaria stenocephala* (Railliet, 1884), the helminths were similar to those found in the grey fox. The species recovered and number of hosts infected were as follows: *Taenia pisiformis* (3), *Physaloptera maxillaris* (1), *Molineus patens* (2), *Uncinaria stenocephala* (3), *Toxocara canis* (1), and *Capillaria plica* (1).

Summary

Studies were conducted on the incidence and distribution of helminths in four species

of wild mammals. Sixteen bobcats, twelve from North Carolina and four from South Carolina, contained the following parasites: Trematoda: 2 species; Cestoda: 4 species; Acanthocephala: 1 species; Nematoda: 7 species. Twenty otters from North Carolina contained the following: Trematoda: 2 species; Nematoda: 3 species. Twenty-four grey foxes from North Carolina, South Carolina, and Georgia contained: Trematoda: 5 species; Cestoda: 3 species; Nematoda: 7 species. Five red foxes, four from North Carolina and one from Georgia, contained: Cestoda: 1 species; Nematoda: 5 species.

The 65 mammals harbored 28 different species of helminths. The bobcats collected from coastal counties contained more helminths, both in kinds and numbers, than did the otters or foxes. The otters contained the fewest parasites, and the foxes, although collected from widely distributed areas, never showed heavy infections.

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Digenetic Trematodes of Some Freshwater and Marine Fishes from Ghana[1]

JACOB H. FISCHTHAL AND J. D. THOMAS[2]

The trematodes of this report were collected in part by the junior author while a faculty member in the Department of Zoology, University of Ghana, Legon; additional collections were made by the senior author during 1965–66 while a Fulbright lecturer in Zoology at University College of Cape Coast, Cape Coast. Specimens have been deposited in the U. S. National Museum Helminthological Collection as noted. All measurements are in microns, unless otherwise indicated. The nomenclature of the hosts from Ghana and their identification are based primarily on the keys and descriptions given by Norman, by Norman and Irvine, and by Trewavas and Irvine, in the book by Irvine (1947).

Family Diplostomatidae
Metacercaria of *Posthodiplostomum nanum* Dubois, 1937

SYNONYM: *Posthodiplostomum antillanum* Pérez Vigueras, 1944.

HOSTS: *Epiplatys senegalensis* (Steindachner) (Cyprinodontidae); *Tilapia zillii* (Gervais), *Hemichromis fasciatus* Peters (Cichlidae); *Heterobranchus longifilis* Cuvier and Valenciennes (Clariidae).

HABITATS: Encysted in mesenteries and liver; free in small intestine of *H. longifilis*.

LOCALITIES: Kakum river estuary, Iture (*E. senegalensis*); stream near Ekotsi (*T. zillii*); tributary to Wynne river near Kwesemintin (*H. fasciatus, H. longifilis*); Ghana.

DATES: 2, 7, 9 November 1965.

SPECIMENS: USNM Helm. Coll. No. 63170 (*E. senegalensis*); No. 63171 (*T. zillii*); No. 63172 (*H. fasciatus*); No. 63173 (*H. longifilis*).

DISCUSSION: This species was originally described in the adult form from a heron from Brazil, and later was reported from Cuba. Williams and Chaytor (1966) and Williams (1967) reported that metacercariae found encysted in *Epiplatys senegalensis* and *E. sexfasciatus* (Steindachner) in Sierra Leone developed into *Posthodiplostomum nanum* when fed to day-old chicks and cattle egrets. The presence of an unencysted metacercaria in the small intestine of *Heterobranchus longifilis* probably represents an accidental infection resulting from the ingestion of a fish harboring the encysted stage. Five of 20 *E. senegalensis* were infected with one (in three), three, and eight metacercariae, respectively, one of two *T. zillii* with one, and one of eight *H. fasciatus* with one.

Family Maseniidae
Eumasenia ghanensis n. sp. (Figs. 1, 2)

HOST: *Heterobranchus longifilis* Cuvier and Valenciennes (Clariidae).

HABITATS: Duodenum and adjacent intestine.

LOCALITIES: Tributary to Pra river near Beposo; tributary to Wynne river near Kwesemintin; stream near Ekotsi; stream one-half mile east of Ekumfi; Ghana.

DATES: 2, 9, 22, 25 November 1965.

SPECIMENS: USNM Helm. Coll. No. 63174 (holotype); No. 63175 (paratypes).

DIAGNOSIS (based on 81 adult specimens; 15 measured): Body 543–1,044 by 177–350 at gonadal level, extremities rounded, lateral bulgings of body anteriorly caused by size and shape of oral sucker. Tegument spined as far posteriorly as midlength of posttesticular space, spines sparser posteriorly. Forebody 182–315 long, hindbody 288–605 long. Oral sucker subterminal ventral, 94–140 by 77–123, same length and width to longitudinally or transversely elongate, funnel-shaped; 56 circumoral spines in double row of 28 each, alternating, interrupted dorsally, wedge-shaped, oral row spines 10–16 long, aboral row spines 8–12 long. Acetabulum 73–134 by 72–136, round to very slightly transversely elongate, center at level of anterior two-fifths of body length. Sucker length ratio 1:0.69–0.96. Prepharynx 12–31 long; pharynx 33–49 by 34–54, round

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to transversely elongate, four-lobed anteriorly with dorsal lobe longer and ventral shorter than lateral ones; esophagus 5–37 long; cecal bifurcation 21–72 preacetabular; ceca cell-lined, extending to level of posterior margin of posterior testis (rarely) or short distance posttesticular (frequently).

Testes two, smooth, usually diagonal, in contact with one another, both or either one alone may be in contact with ovary, anterior testis sinistral and posterior testis tending to be median; rare amphitypy occurring; testes tandem in one specimen with anterior testis in median position wedged between ovary and posterior testis; in several specimens left testis displaced posteriorly, its anterior margin lying posterior to anterior margin of other testis. Anterior testis 52–111 by 64–122, 5–54 postacetabular; posterior testis 57–131 by 65–140, 28–125 postacetabular; posttesticular space 197–355 long. Cirrus sac 262–480 (longitudinal extent) by 46–87, thick-walled, muscular, widest at level of anterior chamber of seminal vesicle, commencing postacetabular and median to ovary, proximal part an elongated oval extending preacetabular, containing seminal vesicle, pars prostatica and prostate cells, distal part very long and narrow, with a posteriorly directed loop, containing ejaculatory duct and some prostate cells, opening into shallow genital atrium middorsally in region of interrupted circumoral spines. Seminal vesicle thick-walled, muscular, bipartite, both chambers oval, posterior chamber 60–114 by 23–59, anterior chamber 53–92 by 31–55. Pars prostatica 52–81 (longitudinal extent) by 15–38, an elongate, cell-lined, thick-walled vesicle; diverticulum lacking. Ejaculatory duct very long, with a posteriorly directed loop. Prostate cells surrounding anterior chamber of seminal vesicle, pars prostatica and proximal end of ejaculatory duct. Genital pore median, dorsal to oral sucker in region of interrupted circumoral spines.

Ovary 74–104 by 59–102, smooth, round to usually slightly longitudinally elongate, overlapping acetabulum. Mehlis' gland median to ovary. Seminal receptacle dorsal to portions of gonads. Laurer's canal not seen. Vitelline follicles relatively few, in lateral extracecal fields, invade intercecal space to variable extent without becoming confluent, anterior-posterior limits of extension from level of anterior margin of acetabulum to that of posterior testis, varying slightly within these limits; vitelline reservoir median to ovary. Uterus filling most of available space in hindbody, coils may enter forebody, ascending ventral to gonads and part of cirrus sac, metraterm undifferentiated, opening into genital atrium. Eggs numerous, yellow-brown, operculate, 25 measuring 21–26 by 13–18.

Excretory bladder I- to Y-shaped, few cells lining walls; stem wide, extending to posterior testis; arms short stubs or somewhat longer, on either side of posterior testis, sometimes one arm a short stub and other longer; narrow duct connecting stem to terminal excretory pore.

DISCUSSION: Seven of 14 fish examined harbored this species, being infected with one (in two), three, six (in two), 12 and 52 worms, respectively. Three species have been described: *E. moradabadensis* N. N. Srivastava, 1951 (India); *E. bangweulensis* Beverley-Burton, 1962 (Zambia); *E. ritai* Agrawal, 1964 (India). The first two are from clariid fishes and the third from a bagrid fish. Our species appears closest to *E. moradabadensis*, the latter differing in having 52 circumoral spines, a diverticulum from the pars prostatica, and the cirrus sac extending only to the posterior margin of the acetabulum. None of the previously described species were noted as having the pharynx lobed anteriorly, but this may have been overlooked.

Superfamily Plagiorchioidea

Orientocreadium indicum Pande, 1934

HOST: *Heterobranchus longifilis* Cuvier and Valenciennes (Clariidae).

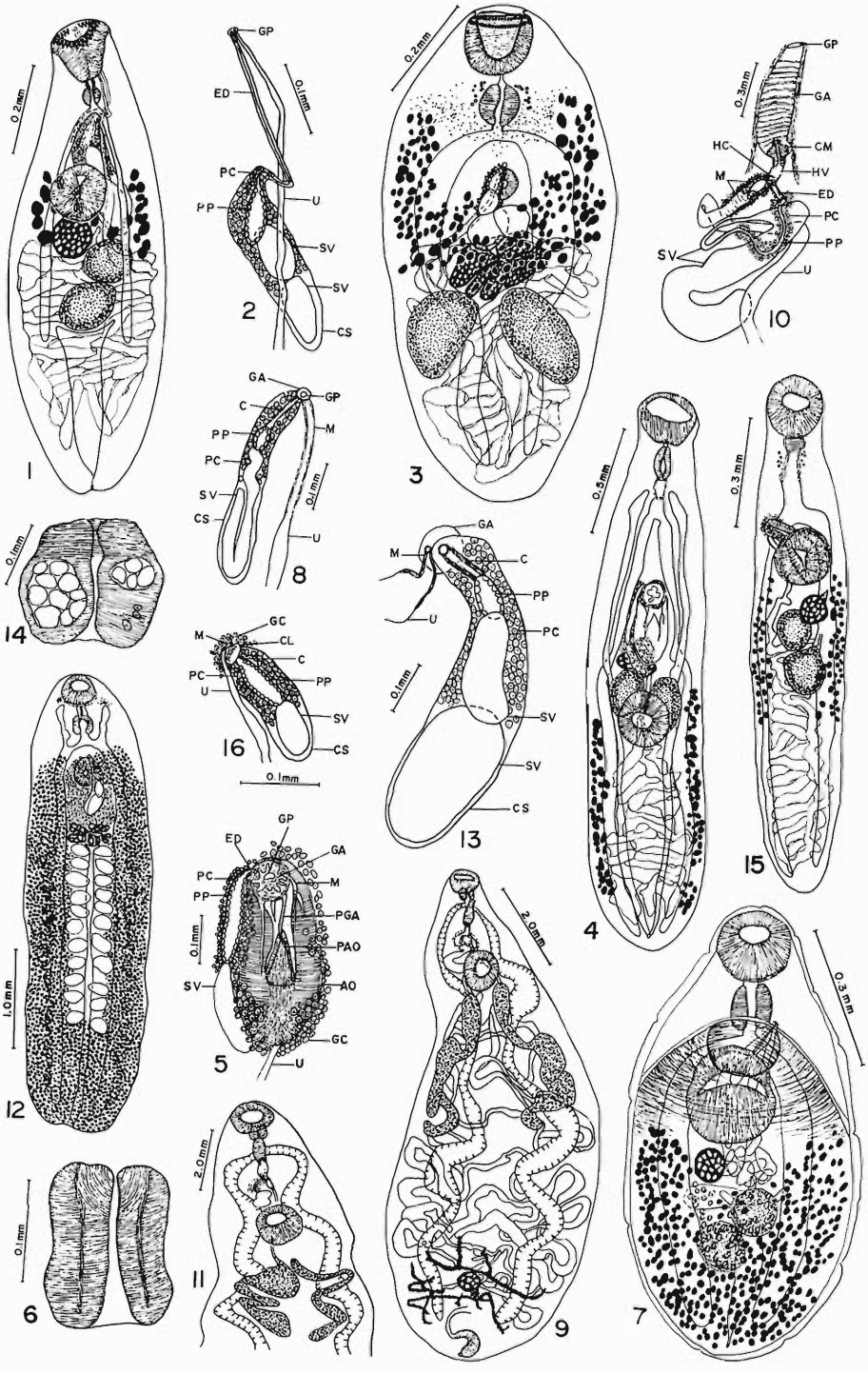
HABITATS: Small and large intestine.

LOCALITIES: Tributary to Wynne river near Kwesemintin; stream near Ekotsi; Ghana.

DATES: 7, 9, 22 November 1965.

SPECIMENS: USNM Helm. Coll. No. 63176.

DISCUSSION: Three of 14 fish examined harbored two adult, five adult, and 14 adult and 28 immature specimens, respectively. In life the forebody is extremely active, trembling, elongating greatly, and probing. Our specimens readily fit the description of *O. indicum*, except that in the former the pharynx is four-lobed anteriorly, the dorsal lobe being longer and ventral shorter than lateral ones; this



condition could have been overlooked in the original description of this species from *Rita buchanani* Bleeker (Bagridae) from India. Reexamination of specimens of *O. batrachoides* Tubangui, 1931, reported from Egypt by Fischthal and Kuntz (1963b) show that the pharynx is also four-lobed anteriorly. Agrawal (1964) declared *O. indicum* (cirrus and metraterm spined) a synonym of *O. batrachoides* (without such spination) probably because Fischthal and Kuntz (1963b) had placed *O. raipurensis* Saksena, 1958, and *O. dayalai* Saksena, 1958 (cirrus only spined) in synonymy with *O. batrachoides*; she indicated that the presence of a spined cirrus and metraterm are variable characters. Inexplicably, Fischthal and Kuntz overlooked the presence of a spiny cirrus in Saksena's species; the latter (1965) noted this fact. Because of the spiny cirrus and metraterm, the present authors recognize *O. indicum* as a valid species. Additionally, because the cirrus only is spined, we agree with Saksena (1965) that *O. raipurensis* is a valid species, but we regard *O. dayalai* and *O. umadasi* Saksena, 1960, as synonymous until such time as their life cycles are elucidated.

Family Cryptogonimidae
Paracryptogonimus ghanensis n. sp. (Fig. 3)

HOST: *Lutjanus guineensis* Bleeker, lagoon snapper (Lutjanidae).

HABITAT: Small intestine.

LOCALITY: Kakum river estuary, Iture, Ghana.

DATE: 26 November 1965.

SPECIMENS: USNM Helm. Coll. No. 63177 (holotype); No. 63178 (paratype).

DIAGNOSIS (based on one adult worm, two young adults just starting egg production, and 75 immature specimens from one of three fish examined; adult measured): Body 899 by 430, elongate oval. Tegument completely covered with fine spines. Forebody 276 long, hindbody 552. Gland cells in preacetabular parenchyma, primarily extra- and prececal. Eyespot pigment granules lying lateral and posterolateral to pharynx, rarely anterolateral to latter. Oral sucker 109 by 138, usually subterminal ventral, may be terminal when retracted into body; with single row of 70–75 circumoral spines, latter club-shaped, elongate, sharply pointed, length of seven 11–14. Acetabulum 71 by 74, embedded in body parenchyma, center at level of anterior one-third of body length. Sucker length ratio 1 : 0.65. Prepharynx 32 long; pharynx 74 by 80; esophagus 15 long (contracted); prepharynx and esophagus conspicuous even in immature specimens; cecal bifurcation 44 preacetabular; ceca conspicuously lined with large elongated cells, terminating 72 from posterior extremity, divergent in acetabular region, convergent at testicular level (even in immature specimens).

Testes two, symmetrical, longitudinal axis of each testis lying in anteromedian-posterolateral plane, mainly extracecal, anteromedian part dorsal to ceca, posttesticular space 230 long; right testis 205 by 119, left testis 174 by 121. Cirrus sac and cirrus lacking. Seminal vesicle tripartite (conspicuous in older immature specimens), overlapping ovary and acetabulum dorsally. Pars prostatica forming elongate, cell-lined vesicle 48 by 35. Ejaculatory duct very

←

Figures 1–16. 1. *Eumasenia ghanensis*, holotype, ventral view. 2. Same. Terminal genitalia, holotype, ventral view. 3. *Paracryptogonimus ghanensis*, holotype, dorsal view. 4. *Monodhelmis torpedinis*, ventral view. 5. Same. Terminal genitalia, ventral view. 6. Same. Pharynx, ventral view. 7. *Pycnadenoides ghanensis*, holotype, ventral view. 8. Same. Terminal genitalia, paratype, ventral view. 9. *Pelorohelmins ghanensis*, holotype, ventral view. 10. Same. Terminal genitalia, holotype, ventral view. 11. *Pelorohelmins palawanensis*, holotype, ventral view of anterior portion of body. 12. *Pleorchis ghanensis*, holotype, dorsal view. 13. Same. Terminal genitalia, paratype, dorsal view. 14. Same. Pharynx, paratype, dorsal view. 15. *Mesolecitha ghanensis*, holotype, ventral view. 16. Same. Terminal genitalia, holotype, ventral view.

Abbreviations: AO, accessory organ; C, cirrus; CL, cirrus lobe; CM, distal muscular portion of genital cone; CS, cirrus sac; ED, ejaculatory duct; GA, genital atrium; GC, gland cells; GP, genital pore; HC, proximal hermaphroditic chamber of genital cone; HV, middle hermaphroditic vesicle of genital cone; M, metraterm; PAO, projection of accessory organ; PC, prostate cells; PGA, plaited wall of genital atrium and accessory organ; PP, pars prostatica; SV, seminal vesicle; U, uterus.

short, opening into shallow genital atrium. Prostate cells surrounding anterior chamber of seminal vesicle, pars prostatica, and ejaculatory duct. Genital pore just preacetabular, median.

Ovary deeply multilobed, 123 by 189, median, mainly intercecal, may overlap ceca ventrally, in contact with both testes, lying 57 postacetabular. Seminal receptacle not seen. Vitelline follicles in adults and immature specimens distributed from pharyngeal or esophageal level to level of anterior margin of testes, lateral fields confluent or nearly so dorsally between acetabulum and testes; right and left vitelline ducts uniting dorsal to ovary. Uterus descending and ascending between testes to posterior extremity, slightly overlapping testes ventrally, filling posttesticular space inter- and extracecally, ascending further between right testis and ovary to right of latter, then proceeding across body at anterior margin of ovary to left side of latter, continuing ascent anteromedianly to genital atrium, windings on each side of ovary to lateral body walls, slightly overlapping ovary dorsally. Eggs numerous, yellowish, 10 measuring 14–19 by 8–13.

Excretory bladder Y-shaped, cell-lined; stem extending to ovary and arms to sides of pharynx; short, narrow duct connecting bladder to terminal excretory pore.

Discussion: The young adults measure 745 by 287 (17 eggs in uterus) and 715 by 255 (36 eggs), respectively. *P. ghanensis* is closest to *P. leilae* (Nagaty, 1957) Manter, 1963 (Red Sea) and *P.* sp. Manter, 1963 (Fiji). Manter (1963) noted that *P.* sp. is very close to, if not identical with, *P. leilae* (syn. *Metadena l.* Nagaty, 1957); his Fijian specimens differ from the latter in having the vitelline follicles confluent, or nearly so, near the acetabulum, and a slightly different sucker ratio. No description or illustration was given for *P.* sp. On the basis of the distribution of the vitelline follicles we do not believe *P.* sp. identical with *P. leilae*. The number of circumoral spines and seminal vesicle chambers are not recorded for the latter. Our species differs from the latter in having the vitelline follicles confluent, or nearly so, between the acetabulum and testes rather than being in separate lateral fields, and in the excretory arms extending to the pharyngeal level rather than to the oral sucker.

Family Fellodistomatidae
Markevitschiella sp.

Host: *Pagrus ehrenbergi* Cuvier and Valenciennes, golden-headed sea bream (Sparidae).

Habitat: Small intestine.

Locality: Tema, Ghana.

Specimens: USNM Helm. Coll. No. 63179.

Discussion: Three immature specimens were found in one host. They resemble *M. nakazawai* (Kobayashi, 1921) Skrjabin and Koval, 1957 (syn. *Steringotrema n.* Kobayashi, 1921), from sparid fishes from Japan, but specific identification can not be made. Kobayashi (1921) noted that *Steringotrema* Odhner, 1911, might be identical to *Pycnadena* Linton, 1911 (syn. *Didymorchis* Linton, 1910, preoccupied). Yamaguti (1958) listed them as separate genera. Skrjabin and Koval (1957) created the genus *Markevitschiella* for Kobayashi's species. Our specimens do not possess a postoral muscle ring, a significant feature of *Pycnadena*. The latter genus is transferred by us in this paper to the family Opistholebetidae.

Monascus typicus (Odhner, 1911) Looss, 1912

Synonyms: *Monascus monenteron* Looss, 1907 (nom. nud.); *Haplocladus typicus* Odhner, 1911.

Hosts: *Decapterus rhonchus* (Geoffroy St. Hilaire), mackerel scad, *Selar crumenophthalmus* (Bloch), goggle-eye scad, *Chloroscombrus chrysurus* (L.), bumper (Carangidae).

Habitat: Small intestine.

Localities: Tema (*Decapterus, Selar*), Cape Coast (*Chloroscombrus*); Ghana.

Dates: 1954 (Tema), 16 December 1965 (Cape Coast).

Specimens: USNM Helm. Coll. No. 63180 (*D. rhonchus*); No. 63181 (*S. crumenophthalmus*); No. 63182 (*C. chrysurus*).

Discussion: Our collection consists of two specimens from two *D. rhonchus*, one from *S. crumenophthalmus*, and two from one of 28 *C. chrysurus*. These represent new host and geographic distribution records. There are extensive variations in our present material as well as in specimens reported by Skrjabin and Koval (1957) and Fischthal and Kuntz (1963a). The redescription of *Monascus filiformis* (Rudolphi, 1819) Looss, 1907, by Dollfus (1947) indicates characteristics which

overlap those of *M. typicus*. The latter may be a synonym of the former, but final decision must await life cycle studies. Dawes (1946) indicated that some synonymy of species probably exists.

Family Hirudinellidae
Hirudinella ventricosa (Pallas, 1774) Baird, 1853

HOST: *Acanthocybium solandri* (Cuvier and Valenciennes), wahoo (Scombridae).

HABITAT: Stomach.

LOCALITY: Tema, Ghana.

DATE: 31 December 1964.

SPECIMENS: USNM Helm. Coll. No. 63183.

DISCUSSION: We are identifying our three specimens from one host as *H. ventricosa* as a result of the analysis of the genus by Nigrelli and Stunkard (1947). One flattened worm measured about 47 mm long. The testes are extracecal and symmetrical, one on each side of the acetabulum; the ovary is postacetabular; and the genital pore is submedian to the left at the level of the cecal bifurcation.

Family Monodhelminthidae
Monodhelmis torpedinis Dollfus, 1937 (Figs. 4–6)

HOST: *Arius heudeloti* Cuvier and Valenciennes, sea catfish (Ariidae).

HABITAT: Small intestine.

LOCALITIES: Tema, Cape Coast, Iture, Elmina; Ghana.

DATES: 13 January (Elmina), 21 February (Iture), 16 March (Cape Coast); 1966.

SPECIMENS: USNM Helm. Coll. No. 63184.

DESCRIPTION (based on 20 adult specimens; 10 measured): Body 2,353–2,615 by 550–640, widest at gonadal level, ends blunt. Tegument entirely covered with fine spines. Forebody 1,215–1,360 long; hindbody 926–1,045 long, shorter than forebody. Oral sucker subterminal ventral, somewhat funnel-shaped, 230–265 by 215–242, longer than wide, with wide opening into prepharynx; preoral lobe 6–24 long. Acetabulum 203–218 by 196–220, round to longitudinally elongate, center at level of anterior one-half to three-fifths of body length. Sucker length ratio 1:0.81–0.93. Prepharynx very short, thick-walled, muscular. Pharynx 121–138 by 96–116, longitudinally elongate, conspicuously constricted or with only very slight indication of constriction near midlength, unlobed anteriorly; entrance to pharyngeal lumen surrounded by cup-like modification composed of longitudinal muscles, some of lateral fibers of cup continuing posteriorly through center of each pharyngeal lobe, remainder of lobe with circular muscles. Esophagus thin-walled posteriorly and muscular anteriorly, latter with inner longitudinal and outer circular muscles, muscular part 61 (contracted)–176 (extended) long. Cecal bifurcation 680–800 preacetabular; ceca cell-lined, extending to posterior extremity (at level of excretory pore) or not so far, postcecal space 51–210 long.

Testes two, about same size, smooth, longitudinally elongate, intercecal, in contact with ceca or not, symmetrical or anterior margin of right testis slightly ahead of left, in contact or not, partly overlapping anterior part of acetabulum; right testis 242–270 by 138–191, left testis 242–270 by 140–187. Terminal male genitalia dextral, between accessory genital organ and right cecum. Cirrus sac and cirrus lacking. Seminal vesicle 167–246 by 52–100, saccular, undivided, thick-walled, muscular, commencing ventral to anterior part of right testis or in contact with latter, ventral to ovary. Pars prostatica an elongate vesicle, 146–218 by 37–68, thick-walled, muscular, cell-lined, surrounded by compact layer of prostate cells. Ejaculatory duct observed in two specimens, 22 by 11 and 29 by 15, very short, opening into right side of genital atrium. Latter 116–148 by 121–160, very large, cavity large, dorsoventrally oriented; in ventral view walls composed of outer moderately thick and inner thin dorsoventrally oriented muscle layers, very thick anteroposteriorly oriented ring of circular muscles between them, inner walls much plaited; muscles layers, plaited walls and lumen continuous with those of accessory genital organ. Latter 205–242 by 148–182, large, flask-shaped, very thick walled, anteroposteriorly oriented, may overlap left cecum ventrally, lumen 58–77 wide posteriorly; muscle layers of genital atrium change their orientation with regard to long axis of body as they bend sharply posteriorly and continue into accessory organ: outer and inner layers now longitudinal muscles, middle layer in dorsoventrally oriented ring; outer longitudinal muscles on one side continuous around posterior end of accessory organ and are longitudinal muscles of other side; at posterior end

a broad band of some of the outer longitudinal muscle fibers from each side turn anteriorly through the midcenter of solid concentric circular muscles which completely surround this band and continue into a large projection lying free in lumen, projection covered by thin, compact circular muscle layer, projection 100–145 by 51–60 (at base); a very thin band of muscle fibers extending from posterior limits of inner longitudinal muscles of one side of lumen to those of other side, passing through midcentral band of fibers entering projection; thick mass of gland cells externally capping posterior end of accessory organ, some cells on other parts of latter. Genital pore median, 335–420 preacetabular, 815–970 from anterior extremity, at level of anterior one-third to two-fifths of body length, half way between cecal bifurcation and acetabulum or slightly more anteriorly.

Ovary 172–201 by 160–196, trilobed, dextral, in contact with right testis or overlapping it and accessory organ dorsally, lying 23–70 preacetabular. Seminal receptacle and Laurer's canal not seen. Vitelline follicles in extracecal fields, some few overlapping ceca ventrally, extending from level of anterior part of testes or more posteriorly at acetabular level to 165–345 from posterior extremity, anteriormost as well as posteriormost levels of each field subequal; right and left vitelline ducts coursing anteriorly ventral to cecum on its side, arching medianly anterior to testis on its side, uniting in notch between testes to form vitelline reservoir. Uterus mainly intercecal in hindbody, posteriorly overlapping ceca and barely extending extracecally in some, descending and ascending between testes, dorsal to accessory organ, opening into genital atrium sinistrally. Eggs numerous, yellowish, moderately thick-shelled, operculate, 27 measuring 32–39 by 21–28.

Excretory bladder V-shaped, cell-lined, arms dorsal and intercecal in hindbody, ventral and extracecal in forebody, crossing ceca ventrally at ovarian level, extending anteriorly to esophageal level; excretory pore subterminal dorsal, 46–80 from posterior extremity.

Discussion: Our collection consists of six specimens from one host from Tema, and three, five and six, respectively, from three of five fish examined from the Cape Coast area (includes Iture and Elmina). *M. torpedinis* was inadequately described from a single worm from an electric ray, *Narcacion torpedo* Klein (probably a synonym of *Torpedo narke* Risso) (Torpedinidae), from Mauritania, by Dollfus (1937). We agree with Yamaguti (1952) that the ray probably is an accidental host, having ingested a teleost harboring the adult worm. The two other species in the genus, *M. arii* Yamaguti, 1952 (Borneo) and *M. philippinensis* Velasquez, 1961 (Philippines), as well as our specimens of *M. torpedinis*, are all from sea catfishes, *Arius* spp. Dollfus (1937) stated that the postcecal space in his specimen is 0.055 mm long, but his illustration shows that it is at least three times longer. We noted in our Tema specimens that the postcecal space is 100–210 long, resembling Dollfus' worm, whereas in the Cape Coast area specimens it is only 51–75 long; in our opinion these differences represent intraspecific population variations. While Dollfus does not state that the ovary is trilobed, his illustration appears to show this condition; we are unable to reconcile the difference in appearance of the oral sucker. Dollfus shows the pharynx partially projecting into the oral cavity. While this phenomenon was not noted in our specimens, the opening into the oral sucker is certainly wide enough to allow the pharynx to enter it. We believe that the constriction noted by us on the pharynx is the level to which it enters the oral cavity; it probably is then held in this position by the contraction of the oral sucker musculature around the pharynx. We also believe that the cup-like modification of the entrance to the pharynx assists in feeding when the pharynx is projecting into the oral cavity.

We have examined the holotype and a paratype specimen of *M. philippinensis* (USNM Helm. Coll. No. 39478), and find them much flattened and difficult to interpret. The illustration of this species by Velasquez (1961) shows the holotype specimen. In the explanation of the plate it is stated that the figure is a ventral view, whereas it actually is a dorsal view. The structure labeled SR is not the seminal receptacle, but the ovary which appears to be bi- or trilobed. A seminal receptacle was not seen. The structure labeled OV is not the ovary, but the seminal vesicle. The structure labeled VS is not the seminal vesicle, but some dark staining granules along the wall

of the lumen of the accessory genital organ; the seminal vesicle lies dextrally between the accessory organ, ovary, and right cecum. The accessory organ, as far as can be ascertained, is basically similar to that described by us for *M. torpedinis*. The excretory arms do not extend to the oral sucker, but only to the esophageal level. The eggs are operculate, 12 measuring 53–63 by 24–30. *M. philippinensis* differs from our specimens in having much longer eggs, a round oral sucker, and an entirely muscular esophagus, and in the vitelline follicles not extending as far posteriorly. *M. arii* differs from our specimens in having an unlobed ovary, a round oral sucker, the pharynx trilobed anteriorly, and an entirely muscular esophagus, and in the vitelline fields being relatively short. *M. philippinensis* differs from *M. arii* in being larger, in the greater length of the vitelline fields, the more posterior extension of the ceca, and in having the ovary lobed, and the pharynx bilobed anteriorly.

Family Opistholebetidae
Pycnadenoides ghanensis n. sp.
(Figs. 7, 8)

HOSTS: *Umbrina cirrosa* (L.) (type), *U. ronchus* Valenciennes, drum (Sciaenidae); *Pomadasys jubelini* (Cuvier and Valenciennes), burro (Pomadasyidae); *Drepane punctata* (L.), spadefish (Drepanidae).

HABITAT: Small intestine.

LOCALITIES: Tema (*U. ronchus*, *P. jubelini*), Cape Coast (*U. cirrosa*, *P. jubelini*, *D. punctata*); Ghana.

DATES: 16 December 1965 (*U. cirrosa*); 3, 25 March 1966 (*P. jubelini*, Cape Coast); 21 March 1966 (*D. punctata*).

SPECIMENS: USNM Helm. Coll. No. 63185 (holotype, *U. cirrosa*); No. 63186 (paratypes, *U. ronchus*); No. 63187 (paratype, *P. jubelini*); No. 63188 (paratype, *D. punctata*).

DIAGNOSIS (based on nine adult specimens; seven measured): Body 961–1,264 by 500–830, ovoid, flat to short distance preacetabular, remainder round and robust, ends blunt; tegument thick, unspined. Forebody 250–340 long, hindbody 460–730 long. Gland cells distributed throughout parenchyma. Oral sucker 145–191 by 152–230, usually transversely elongate, subterminal ventral; preceeded by very short preoral lobe. Postoral circular muscle ring present. Acetabulum 206–298 by 194–290, somewhat pyriform, longitudinally or transversely elongate, embedded in body fold containing radial muscles, facing anteroventrally on anterior robust part of body, opening transversely elongate, center at level of anterior three- to four-tenths of body length. Sucker length ratio 1 : 1.39–1.70. Prepharynx 32–48 long; pharynx 93–145 by 93–145, round to longitudinally or transversely elongate; esophagus 36–53 long, thick-walled, muscular; cecal bifurcation overlapping anterior part of acetabulum; ceca wide, conspicuously cell-lined, extending to posterior extremity, postcecal space 60–82 long.

Testes two, usually diagonal but may be tandem, in contact, smooth, round to longitudinally or transversely elongate; anterior (left) testis 116–180 by 107–222, 73–230 postacetabular; posterior (right) testis 115–177 by 121–232, 160–350 postacetabular; posttesticular space 92–235 long. Cirrus sac 304–542 by 70–136, thick-walled, muscular; commencing 39–152 postacetabular, sinistral or dorsal to ovary, extending anterosinistrally to open into shallow genital atrium lying sinistral to pharynx; containing convoluted seminal vesicle, short pars prostatica, prostate cells, and long, muscular, protrusible cirrus. Genital pore sinistral to pharynx, 36–90 posterior to oral sucker, 61–97 preacetabular.

Ovary 83–145 by 73–125, longitudinally elongate, smooth, dextral, separated from testes, overlapping acetabulum 10 to lying up to 125 postacetabular. Oviduct emerging from posteromedian margin of ovary. Mehlis' gland posterior and posteromedian to ovary. Seminal receptacle 75–90 by 145–222, transversely elongate, large, dorsal, overlapping right cecum, ovary and anterior testis. Laurer's canal not seen. Vitelline follicles extending extracecally and cecally from level of posterior margin of acetabulum to posterior extremity, filling posttesticular space, confluent dorsally from ovarian or anterior testis level posteriorly, may overlap lateral margins of testes and posterior margin of posterior testis ventrally; vitelline reservoir posteromedian to ovary, overlapping anterior testis. Uterus ventral, intercecal but may slightly overlap ceca, between anterior margin of posterior testis and acetabulum but may be entirely pretesticular; metraterm thick-walled, muscular, commencing dorsal to acetabulum, opening into genital

atrium. Eggs relatively few, yellow-brown, 15 measuring 67–80 by 32–41.

Excretory bladder Y-shaped, cell-lined, wide, dorsal, stem extending to about middle of anterior testis, arms extending to anterior margin of anterior testis; short, narrow duct connecting bladder to subterminal dorsal excretory pore.

Discussion: Our collection consists of three specimens from one of five. *U. cirrosa* examined, two from one *U. rhonchus*, one each from three of eight *P. jubelini*, and one from one of 15 *D. punctata*. Two species have been described: *P. pagrosomi* Yamaguti, 1938 (Japan); *P. calami* Manter, 1947 (Florida). Both are from sparid fishes. Our form appears closest to *P. pagrosomi*, the latter differing in the extension of the cirrus sac just posterior to the anterior margin of the acetabulum, the vitelline follicles being absent dorsal to the gonads, and the acetabulum being near midbody and transversely oval in shape.

Cable (1956) transferred the thick-bodied species of the genus *Pachycreadium* Manter, 1954, from the family Opecoelidae to the family Opistholebetidae because of the presence of a postoral ring, black pigment spots, and other features. Siddiqi and Cable (1960) noted that the two species of *Pycnadenoides* Yamaguti, 1938, show many similarities to species of *Pachycreadium*. They stated: "If, as seems very likely, a postoral ring is present in the two species, *Pachycreadium* should be reduced to synonymy with *Pycnadenoides* if, indeed, both genera are not synonymous with *Pycnadena*, a genus that differs from *Pachycreadium* only in the symmetrical arrangement of the testes." *Pycnadenoides ghanensis* n. sp. has a postoral ring. Examination by us of specimens of *Pachycreadium crassigulum* (Linton, 1910) Manter, 1954 (USNM Helm. Coll. Nos. 8461, 39350), *P. gastrocotylum* (Manter, 1940) Manter, 1954 (No. 9346), *P. lerneri* Sogandares, 1959 (No. 38872), *Pycnadenoides calami* Manter, 1947 (No. 37039), *Pycnadena lata* (Linton, 1910) Linton, 1911 (No. 8463), *P. piriformis* Price, 1934 (No. 38713), and *Propycnadenoides philippinensis* Fischthal and Kuntz, 1964 (No. 37888) show that a postoral ring is present in all of them. In light of the above we are transferring *Pycnadena* Linton, 1911, *Pycnadenoides*, and *Propycnadenoides* Fischthal and Kuntz, 1964, from the family Fellodistomatidae to the family Opistholebetidae. As a matter of convenience, we prefer at this time to recognize the above discussed genera as valid. Sogandares (1959) described *Pachycreadium lerneri* from a single specimen, stating that the ovary is smooth and globular; the holotype specimen shows the ovary as being deeply six-lobed.

Family Pelorohelminthidae
Pelorohelmins ghanensis n. sp. (Figs. 9, 10)

Host: *Arius latiscutatus* Günther, sea catfish (Ariidae).

Habitat: Swim bladder.

Locality: Tema, Ghana.

Date: 17 December 1964.

Specimens: USNM Helm. Coll. No. 63189 (holotype); No. 63190 (paratype).

Diagnosis (based on one adult worm, one young adult just starting egg production, and two immature specimens; adult measured): Body 11,015 by 4,370; tegument thick, unarmed; hindbody wide and bluntly rounded at extremity, forebody tapering slightly. Forebody 1,895 long, hindbody 8,285, forebody to hindbody ratio 1 : 4.37. Preoral lobe present. Oral sucker subterminal ventral, 580 by 667; acetabulum 975 by 798, center at about level of anterior one-fifth of body length; sucker length ratio 1 : 1.68 (1 : 1.30 in young adult measuring 6,020 in total body length). Prepharynx lacking; pharynx 287 by 353, anterior three-fifths overlapping oral sucker dorsally; esophagus 166 long (contracted anteriorly); cecal bifurcation 1,012 preacetabular, dorsal to level of anterior one-third of genital atrium; ceca conspicuously cell-lined, winding to within 897 of posterior extremity (closer to latter in other specimens).

Testes two, symmetrical, narrow, much longitudinally elongate, serpentine, anteriormost margin posterolateral to acetabulum, mainly extracecal; right testis 3,465 in longitudinal extent, varying in width from 130–498; left testis 2,990 in longitudinal extent, varying in width from 115–445. Vasa efferentia long, emerging from anterior margin of each testis. Seminal vesicle large, bipartite; proximal part long, relatively thin-walled, winding antero-

dextral to acetabulum, inflated with sperm; distal part much shorter, thick-walled, muscular, tubular, with single dextral loop. Pars prostatica thick-walled, muscular, cell-lined, sinuous, much shorter than seminal vesicle, distal part enlarged into a chamber, entirely surrounded by thick layer of prostate cells, sinistral to metraterm. Ejaculatory duct short, very muscular, with much enlarged muscular sphincters at each end, posterior sphincter projecting into chamber of pars prostatica, anterior sphincter projecting into proximal chamber of genital cone. Genital cone 298 by 74, considerably modified into three parts: proximal part round, muscular hermaphroditic chamber 74 in diameter into which ejaculatory duct and metraterm open independently; middle part 106 by 66, an elongate, thick-walled, muscular hermaphroditic vesicle; distal part a large, very muscular sphincter, 158 by 121, projecting considerably into genital atrium. Latter large, elongate, 628 by 175, muscular, with inner ladderlike arrangement of strong circular muscle bundles which are relatively widely spaced from one another, and outer thick layer of longitudinal muscles; entire atrium surrounded by thick layer of longitudinal muscle fibers lying free in parenchyma, fibers proceed posteriorly beyond genital cone. Genital pore a narrow, transverse slit, median to slightly submedian, prebifurcal, ventral to anterior part of esophagus, 107 from oral sucker.

Ovary 324 by 505, smooth, median, intercecal, 3,298 posttesticular, postovarian space, 1,588 long. Oviduct from ventral surface of ovary, enlarging into vesicle before narrowing and becoming surrounded by Mehlis' gland. Latter well developed, juxtaposed posterosinistral to ovary, sinistral to ootype. Laurer's canal not seen. Vitellaria dendritic, with multilobed branches, inter- and extracecal, 1,755 posttesticular, three vitelline ducts entering ootype complex. Uterus coiled in hindbody from level of cecal ends to acetabulum, dorsal to ceca and vitellaria, ascending dorsal to acetabulum; metraterm dextral to pars prostatica, composed of two muscular parts, distal 187 by 96, more muscular than proximal, a large, very muscular sphincter separates proximal and distal parts and projects into latter; few gland cells surrounding metraterm. Eggs small, numerous, 13 measuring 23–27 by 13–17.

Excretory bladder long, sinuous, thick-walled, cellular except for short, muscular part closest to excretory pore; short, narrow duct connecting bladder to subterminal dorsal excretory pore; arms uniting dorsally between anterior part of esophagus and pharynx.

Discussion: The type species of the genus, *P. palawanensis*, was described by Fischthal and Kuntz (1964) from a single specimen from the small intestine of *Gazza minuta* (Bloch) (Leiognathidae) from Palawan Island, Philippines. Without placing it in a family, but within the superfamily Hemiuroidea, they created the subfamily Pelorohelminthinae for the genus. Freitas and Kohn (1967) described *Dollfustravassosius moniliovatus* n. gen., n. sp., from the swim bladder of *Arius* (= *Tachysurus*) *grandicassis* Valenciennes (Ariidae) from Marambaia Island, Brazil, and placed it in a new subfamily Dollfustravassosiinae within the family Isoparorchiidae Poche, 1926. We declare *Dollfustravassosius* and Dollfustravassosiinae synonyms of *Pelorohelmins* and Pelorohelminthinae, respectively. For reasons discussed by Fischthal and Kuntz (1964), excluding the reference to symmetrical testes, the genus can not be placed in the family Isoparorchiidae. In light of the description of *Pelorohelmins moniliovatus* (Freitas and Kohn, 1967) n. comb., and *P. ghanensis*, we have reexamined the type species (USNM Helm. Coll. No. 60181), and find that the testes in the latter are symmetrical, narrow, much longitudinally elongate, and serpentine (Fig. 11) rather than tandem and dextral as originally described. The so-called "tandem testes" actually represents the right testis alone; a vas efferens was observed emerging from the anterior end of this testis, and was traced anteriorly to the acetabulum. Also, the seminal vesicle in the type species is preacetabular rather than being dextral to the acetabulum as originally described. The generic and subfamily diagnoses given by Fischthal and Kuntz (1964) need to be emended to state: Testes two, postacetabular, symmetrical, longitudinally elongate, serpentine. Immediately following, in the generic diagnosis only, it should state: Seminal vesicle extending anteriorly from acetabulum, bipartite.

P. ghanensis differs from *P. palawanensis* in having larger eggs, and the Mehlis' gland next to or in contact with the ovary rather than relatively far removed; further, in the former the ootype lies between the ovary and Mehlis' gland, the secretions of the latter flowing dextrally into the ootype, whereas in the latter the Mehlis' gland lies between the ovary and ootype, its secretions flowing sinistrally into the ootype. *P. ghanensis* and *P. palawanensis* differ from *P. moniliovatus* in having the eggs haphazardly arranged in the uterus rather than moniliform, the genital atrium (as defined by us) elongate rather than globular and appearing as a genital bulb, and the excretory pore subterminal dorsal rather than terminal. *P. palawanensis* differs further from *P. moniliovatus* in having the Mehlis' gland relatively far removed from the ovary rather than next to or in contact with the latter. The structural details of the terminal genitalia in *P. moniliovatus* either differ significantly from the other two species or, as is probable, are not presented.

With the presence of three species in the genus, we believe that the erection of a new family for them is warranted. Therefore, we are raising the subfamily to family status.

Pelorohelminthidae n. fam.

DIAGNOSIS: Hemiuroidea. Body large; tegument thick. Oral sucker subterminal ventral, followed directly by pharynx and esophagus. Ceca winding to near posterior extremity. Acetabulum in anterior body third. Testes two, symmetrical, serpentine, postacetabular. Seminal vesicle, pars prostatica and ejaculatory duct present. Genital cone in three parts: proximal hermaphroditic chamber into which ejaculatory duct and metraterm project and open independently; middle hermaphroditic vesicle; distal muscular part projecting into muscular genital atrium. Genital pore median to slightly submedian, between oral sucker and cecal bifurcation. Ovary round, posttesticular. Vitellaria dendritic, multilobed, between testes and cecal ends, inter- and extracecal. Uterus postacetabular, between acetabulum and cecal ends, inter- and extracecal. Metraterm of two muscular parts. Eggs small, numerous. Excretory bladder long, sinuous, part near excretory pore muscular. Includes only one genus, *Pelorohelmins* Fischthal and Kuntz, 1964.

Family Pleorchiidae
Pleorchis ghanensis n. sp. (Figs. 12–14)

HOSTS: Type, *Cynoscion macrognathus* (Bleeker), large-mouth weakfish (Sciaenidae); *Pomadasys jubelini* (Cuvier and Valenciennes), burro (Pomadasyidae).

HABITAT: Small intestine.

LOCALITY: Tema, Ghana.

SPECIMENS: USNM Helm. Coll. No. 63191 (holotype, *C. macrognathus*); No. 63192 (paratypes, *C. macrognathus*); No. 63193 (paratypes, *P. jubelini*).

DIAGNOSIS (based on 18 specimens; eight adults measured): Body 4,660–5,247 by 1,310–1,550, flat, elongate, sides nearly parallel, tapering slightly preacetabularly to rounded anterior extremity, posterior extremity more or less truncate and slightly emarginate at excretory pore. Tegument spined except for preoral lobe, spines scalelike ventrally and dorsally, long and pointed laterally and sublaterally. Gland cells in preacetabular parenchyma. Eyespots, or rarely scattered pigment granules, just posterior to oral sucker or on each side of pharynx. Forebody 878–1,235 long, hindbody 3,145–3,995 long; preoral lobe 13–32 long. Oral sucker 258–314 by 276–354, transversely elongate, subterminal ventral. Postoral circular muscle ring present. Acetabulum 224–298 by 218–310, round to slightly longitudinally or transversely elongate, center at level of anterior one-fifth to one-fourth of body length. Sucker length ratio 1 : 0.83–1.02. Prepharynx wide, 155–346 long, muscular; pharynx large, usually slightly wider than long, 165–250 by 195–236, with well-developed and conspicuous anterior circular muscle ring, remainder weakly muscular or muscles degenerated and replaced by vesicular cells, surrounded by gland cells; esophagus 110–165 long, slightly muscular; cecal bifurcation 103–272 preacetabular; ceca extending to posterior extremity, a single pair of large, elongate, saccular diverticula extend to prepharynx level, many smaller diverticula present on outer sides of ceca from postacetabular level to near cecal ends, ceca and diverticula conspicuously cell-lined.

Testes 44 in number in 17 specimens and 46 in one, lying in intercecal space on each

side of excretory bladder in two ventral and two superimposed dorsal longitudinal rows, extending from just postovarian to 820–960 from posterior extremity, 22 testis on right and 22 on left in 12 individuals, 20 and 24 in four, 24 and 20 in one, and 22 and 24 in one; testes measuring 132–220 by 140–254, usually transversely elongate but may be round to longitudinally elongate, smooth to slightly lobed. Cirrus sac 563–766 (longitudinal extent) by 133–177, relatively thick-walled, proximal extremity 242–416 postacetabular, curving dorsal to dextrolateral part of acetabulum, lying dorsal to uterus, separated from ovary by uterine coils, containing seminal vesicle, pars prostatica, cirrus, and prostate cells. Seminal vesicle bipartite, relatively thin-walled, posterior chamber 188–386 by 125–162, smaller anterior chamber 122–224 by 60–115. Pars prostatica relatively thin-walled, cell-lined, 106–168 by 24–67. Cirrus muscular, longer than par prostatica. Prostate cells surrounding anterior chamber of seminal vesicle, pars prostatica and part of cirrus. Genital atrium wide, shallow. Genital pore median, immediately preacetabular.

Ovary 246–416 by 391–525, deeply multilobed, wider than long, median, lying 331–452 postacetabular, intercecal, may partly overlap anteriormost testes. Oviduct thick-walled, muscular, arising from ovary dorsum. Laurer's canal thick-walled, muscular, sinuous, opening on dorsal surface over ovary. Seminal receptacle lacking; uterus containing sperm. Mehlis' gland poorly developed, lying anterodorsal to ovary. Uterus may fill intercecal space between ovary and acetabulum, occasionally overlapping both dorsally as well as lying sinistral to acetabulum. Metraterm short, commencing dorsal to acetabulum, surrounded by gland cells. Vitelline follicles small, numerous, extending from posterior extremity to level of cecal bifurcation or slightly more posteriorly, extending to body margins, filling posttesticular space, may be confluent ventral and dorsal to entire testicular field or more posterior part of this region, frequently present is a ladderlike arrangement of follicles ventrally and dorsally in testicular field as bridges of follicles extend from between testes across excretory bladder; right and left vitelline ducts unite posterodorsal to ovary to form small vitelline reservoir. Eggs thin-shelled, yellowish, with small operculum, 23 measuring 52–66 by 33–47 (averaging 61 by 39).

Excretory bladder I-shaped, elongate, tubular, extending between rows of testes to ovary; a pair of collecting tubules extend anteriorly to approximate level of posterior margin of oral sucker; excretory pore terminal.

Discussion: Our collection consists of 11 adult and five immature worms from *C. macrognathus*, and one adult and one immature worm from *P. jubelini*. The body spines appear to be easily lost. The gland cells in the preacetabular parenchyma were observed in a few specimens only. Five species of *Pleorchis* Railliet, 1896, are recognized: Type, *P. polyorchis* (Stossich, 1888) Railliet, 1896 (Adriatic Sea); *P. americanus* Lühe, 1906 (U. S. Atlantic); *P. sciaenae* Yamaguti, 1938 (East China Sea); *P. californiensis* Manter and Van Cleave, 1951 (U. S. Pacific); *P. magniporus* Arai, 1962 (Mexican Pacific). All are from sciaenid teleost fishes; an additional host for the last named species is a dasyatid sting-ray. The latter probably is an accidental host, having ingested the teleost harboring the adult stage. Examination of specimens of *P. americanus* (USNM Helm. Coll. No. 8400) and *P. californiensis* (No. 38872) reveal the presence of a postoral muscle ring, an inconspicuous circular muscle ring on the anterior end of the pharynx, and an operculum on the eggs; no mention was made of these features for any of the species in the genus. Our species appears closest to *P. sciaenae* and *P. magniporus*. *P. sciaenae* differs in having only the anterior part of the body spined, lacking a circular muscle ring on the anterior part of the pharynx (or if one is present, it probably is inconspicuous), the esophagus being practically absent, the ovary being shallowly lobed, the vitelline follicles not being partly confluent, or nearly so, ventral and dorsal to the testes, and the eggs being longer (69–72). *P. magniporus* differs from our species in lacking a circular muscle ring on the anterior part of the pharynx (or if one is present, it probably is inconspicuous), the ovary being rosette-shaped, the vitelline follicles extending anteriorly only to the level of the posterior margin of the acetabulum, and not being confluent, or nearly so, in the testicular region, and in the eggs averaging longer (75).

Family Proctoecidae
Mesolecitha ghanensis n. sp.
(Figs. 15, 16)

HOST: *Acanthurus monroviae* (Steindachner), surgeon-fish (Acanthuridae).

HABITAT: Small intestine.

LOCALITY: Cape Coast, Ghana.

DATE: 3 March 1966.

SPECIMENS: USNM Helm. Coll. No. 63194 (holotype); No. 63195 (paratypes).

DIAGNOSIS (based on four adult and three immature specimens from one of two fish examined; adults measured): Body 1,262–1,394 by 240–270, elongate, narrow, ends round. Tegument finely spined. Forebody 370–412 long, hindbody 735–825 long. Oral sucker 157–169 by 140–155, longitudinally elongate, subterminal ventral; preoral lobe present or not. Acetabulum 155–157 by 140–155, almost round to slightly longitudinally elongate; compact circular muscle band within lateral and anterior margins, absent posteriorly; opening a narrow, transverse slit, lumen very narrow and cryptlike; center at about level of anterior one-third of body length. Sucker length ratio 1 : 0.92–1.0. Prepharynx very short; pharynx 65–69 by 78–82; esophagus 85–99 long, longer than pharynx, thick-walled, muscular; cecal bifurcation preacetabular, in some bifurcation delayed for short distance which adds cell-lined, nonmuscular portion to length of esophagus; ceca wide, conspicuously cell-lined, unequal in length, terminating 133–293 from posterior extremity.

Testes two, smooth, tandem to very slightly oblique, contiguous, may overlap slightly, may overlap cecum ventrally; anterior testis 99–121 by 95–114, 13–98 postacetabular; posterior testis 116–133 by 93–116, 135–185 postacetabular; posttesticular space 415–535 long. Vas efferens emerging from anterior margin of each testis, contiguous for short distance before entering cirrus sac. Latter 165–215 by 65–78, widest at midlength, thin-walled; commencing postacetabularly or just anterior to its posterior margin, proximal end median or slightly sinistromedian, extending diagonally and terminating at genital atrium lying just anterodextral to acetabulum; containing seminal vesicle, pars prostatica, cirrus and prostate cells. Seminal vesicle 66–88 by 41–52, oval, thick-walled. Pars prostatica a straight, cell-lined, elongate vesicle, 78–112 by 30–36, longer than seminal vesicle. Cirrus short, muscular, lying lobelike in genital atrium or protruding lobelike through genital pore, with long, slender, blunt-tipped spines. Prostate cells surrounding anteriormost part of seminal vesicle and length of pars prostatica. Genital atrium large, transversely elongate, thick-walled muscular. Genital pore anterodextral to acetabulum.

Ovary 75–86 by 72–80, round to slightly longitudinally elongate, smooth; 17–76 postacetabular, anterosinistral to and contiguous with anterior testis, may slightly overlap latter or may be entirely ventral to level of contiguity of anterior and posterior testes. Seminal receptacle lacking. Laurer's canal opening dorsal to acetabulum. Mehlis' gland well developed, anterior to ovary, overlapping latter and acetabulum. Vitelline follicles relatively few, inconspicuous, extending in lateral extracecal and cecal fields from level of posterior margin of acetabulum to 22–109 posttesticular, posterior limit of fields in each specimen unequal, fields confluent dorsal to gonads; vitelline reservoir large, anterior to ovary, lying in space between latter and acetabulum to being entirely dorsal to acetabulum. Uterus filling most available space in hindbody, sperm in many uterine coils, ascending dextral to cirrus sac; metraterm with fine spines for short distance, opening into genital atrium. Eggs relatively few, yellow-brown, operculate, 15 measuring 39–58 by 20–27, all but three of latter between 47–54 long.

Excretory bladder Y-shaped, cell-lined; stem long, wide, extending to posterior part of acetabulum; arms extending to oral sucker; narrow duct connecting bladder to terminal excretory pore.

DISCUSSION: The genus contains a single species, *M. linearis* Linton, 1910, from *Acanthurus coeruleus* Bloch and Schneider from Florida, Puerto Rico and Jamaica. It was placed in a new family Proctoecidae by Caballero (1959). Nahhas and Cable (1964) reexamined the type of *Proctoeces neomagnorus* Siddiqi and Cable, 1960, declaring it a synonym of *M. linearis*. Siddiqi and Cable (1960) stated that in *P. neomagnorus* the vitelline follicles are distributed in two lateral fields from the ovary to the anterior testis; from an examination of their specimen (USNM Helm. Coll. No. 39337) and their illustration it was

noted that the left field extends beyond the midlength of the posterior testis, while the right field extends posterior to the posterior testis. Examination of the type specimen of *M. linearis* (USNM Helm. Coll. No. 8471) shows that the vitelline follicles completely encircle the body between the acetabulum and anterior testis; in Siddiqi and Cable's specimen the vitelline follicles are confluent ventrally between the ovary and anterior testis, and dorsally at the level of the anterior testis only. Our species differs in being much smaller, in having the vitelline follicles in separate fields ventrally, in the ovary being contiguous with the anterior testis or both testes, and in having an acetabulum with compact circular muscles within its lateral and anterior margins.

Family Zoogonidae
Diphtherostomum anisotremi Nahhas and Cable, 1964

HOST: *Pomadasys jubelini* (Cuvier and Valenciennes), burro (Pomadasyidae).

HABITATS: Small intestine and pyloric ceca.

LOCALITY: Cape Coast, Ghana.

DATE: 3 March 1966.

SPECIMENS: USNM Helm. Coll. No. 63196.

DISCUSSION: Our collection consists of one, three, and 21 adult worms, respectively, from three of seven fish examined. This species was described by Nahhas and Cable (1964) from *Anisotremus virginicus* (L.) (Pomadasyidae) from Jamaica, West Indies. They state that the hindbody is unspined, but examination of the holotype specimen (USNM Helm. Coll. No. 60279) shows spines, although sparse, to be present; our specimens are also entirely spined. In both the metraterm is enlarged distally. Our specimens differ from the original description in having a shorter hindbody, the cirrus sac always overlapping the acetabulum (as far as midacetabular level), the genital pore usually prebifurcal but sometimes bifurcal, and the sucker length ratio 1:1.46–2.0. We can not determine whether the differences noted are due to development in different hosts species or to two different species being involved; life cycle studies could supply the answer. The pharynx in our worms is four-lobed anteriorly, with the dorsal lobe longer and ventral shorter than the two lateral ones; we could not verify this feature in the holotype. In addition to the normal eggs, smaller, thick-shelled, yellowish abnormal eggs were noted in our specimens, 16 measuring 16–20 by 8–11; Manter (1947) found such eggs in his new species, *Diphtherostomum americanum*.

Zoogonus mirus Looss, 1901

HOST: *Brachydeuterus auritus* (Cuvier and Valenciennes), burrito (Pomadasyidae).

HABITAT: Small intestine.

LOCALITY: Cape Coast, Ghana.

DATE: 19 January 1966.

SPECIMENS: USNM Helm. Coll. No. 63197.

DISCUSSION: Two adult specimens were recovered from one of 29 fish examined. The pharynx is six-lobed anteriorly; there are two lateral lobes on each side as well as one dorsally and one ventrally. There has been much discussion in the literature regarding the synonymy of *Z. mirus* with *Z. rubellus* (Olsson, 1868) Odhner, 1902, but it is generally agreed that a completely satisfactory conclusion can not be reached until their life cycles are elucidated.

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Levinseniella hunteri sp. nov., a New Species of Microphallid Trematode from the Wilson's Plover, *Charadrius wilsonia* Ord[1]

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In June of 1966 during a parasitologic survey of shorebirds on Grand Terre Island, Louisiana, the ceca of one of three Wilson's Plovers examined harbored five specimens of an undescribed species of *Levinseniella* Stiles and Hassall, 1901. Living worms were examined with light and phase microscopy to determine details of the excretory and reproductive systems. They were then killed in hot saline under slight cover slip pressure and immediately fixed in AFA. Each specimen was stained with Harris' hematoxylin and mounted in Canada balsam via standard procedures. Measurements are given in microns; the size range first followed by the average in parentheses.

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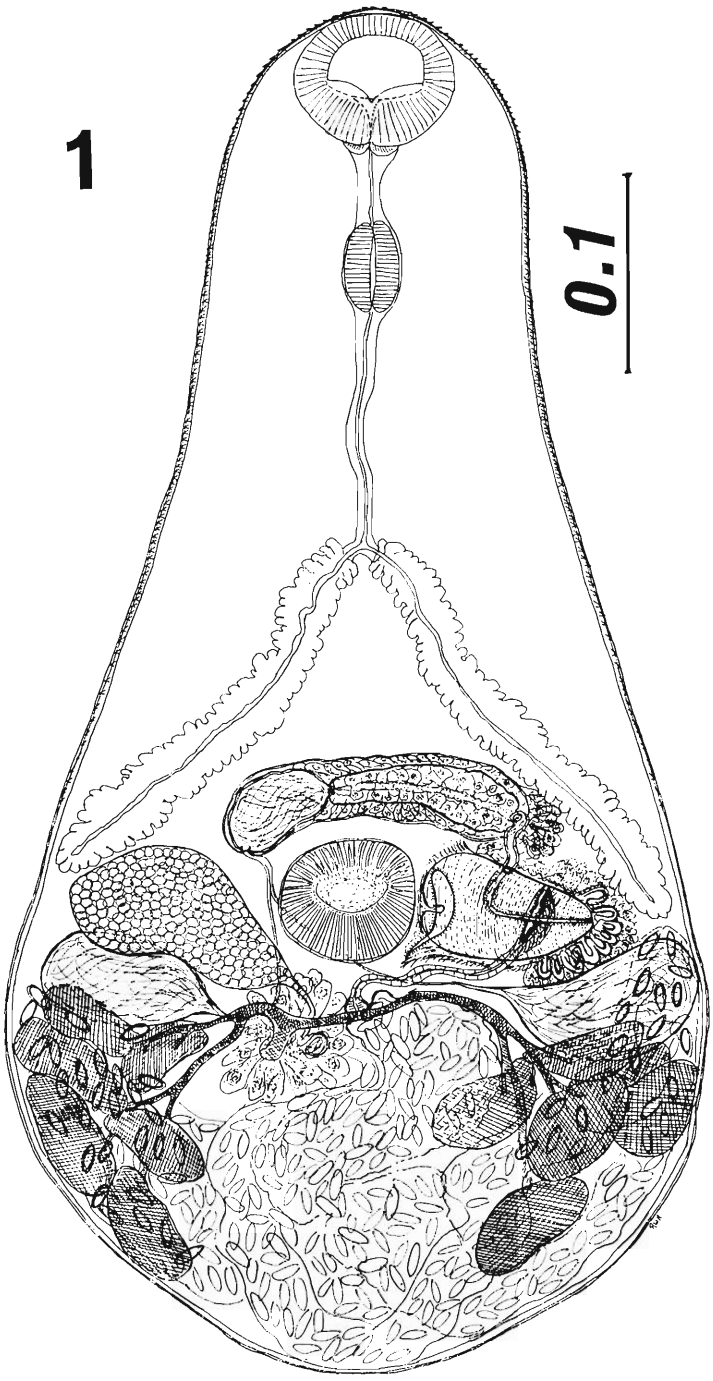

Figure 1. ***Levinseniella hunteri*** **sp. nov. drawn with microprojector (scale in mm). Ventral aspect of holotype; note position of large male papilla within genital atrium.**

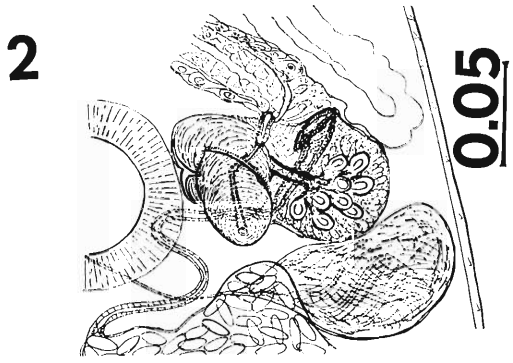

Figure 2. ***Levinseniella hunteri*** **sp. nov. drawn with microprojector (scale in mm). Terminal genitalia of paratype showing male papilla protruding through genital pore.**

mission for making available the facilities of the Marine Biological Laboratory on Grand Terre Island during the study. Special thanks are given Dr. S. Deblock for examining the specimens used in this study and confirming their taxonomic status. I would also like to thank Dr. E. E. Byrd for helpful suggestions on the preparation of the manuscript.

Levinseniella hunteri sp. nov. (Figs. 1–2)

DESCRIPTION (based on five specimens): Small linguiform distomes 620–730 (680) long by 280–370 (320) at widest point (level of testes). Cuticular spines largest in region of oral sucker, extending from anterior end to level of seminal vesicle. Oral sucker subterminal, 75–92 (85) wide by 70–80 (75) long, with postoral sphincter present. Acetabulum 62–75 (70) in diameter, located slightly less than two-thirds of body length from cephalic end. Prepharynx well developed, 30–50 (41) long. Pharynx well developed, 45–55 (48) long by 27–30 (29) wide. Esophagus 80–125 (111) long. Ceca 170–210 (190) long, "∧" shaped, extending posterolaterally to near body margins, ending at acetabular level. Seminal vesicle, 62–100 (88) long by 31–45 wide (38), kidney shaped, lying just anterior to acetabulum and slightly dextral to middle of body. Vasa efferentia joining just posterior to seminal vesicle to form greatly reduced vas deferens. Pars prostatica well developed, 70–110 (88) long, surrounded by numerous relatively small gland cells. A thin, nonmuscular membrane appears to surround seminal vesicle and pars prostatica complex. Genital pore a slack slit, lying immediately sinistral to the acetabulum. Genital atrium sinistral, and adjacent to acetabulum. Male genital papilla a relatively large blunt, muscular cone, with its broad base anchored in right wall of genital atrium directly adjacent to acetabulum and dorsal to genital pore. Ductus ejactulatoris penetrates male papilla anteriorly from side, approximately one-third the distance from papilla's base. Upon penetrating male papilla, ductus ejactulatoris turns distally, terminating in small opening at tip of papilla. When within genital atrium, male papilla is directed laterally and lies at right angle to long axis of body. In this position its rounded distal end is proximal to lateral glandular wall of genital atrium which bears 9 well defined atrial (male) pockets. No sclerotized "hooks" observed in atrial pockets. When male papilla protrudes through genital pore, portion of genital atrium containing pockets becomes constricted. Metraterm extending from intertesticular region to genital atrium; entering atrium from dorsal aspect, midway between base of male papilla and lateral wall of atrium. Metraterm ending in dilated opening with glandular lining. Ovary 85–90 (88) by 36–44 (41), lateral to acetabulum and anterior to right testis. Ootype and associated Mehlis' gland, Laurer's canal and fertilization chamber in intertesticular region. Vitellaria post-testicular, acenose, composed of a group of 6–7 large follicles (30–40 in diameter) on each side of body. Uterus post-acetabular, with lateral loops occasionally extending over anterior border of testes. Eggs brown, operculate, 15–17 long by 8–10 wide. Excretory pore subterminal. Bladder V or U shaped. Flame cell formula 2 [(2 + 2) + (2 + 2)] = 16.

HOST: *Charadrius wilsonia* Ord.

LOCALITY: Grand Terre Island, Jefferson Parish, Louisiana.

SITE OF INFECTION: Ceca.

HOLOTYPE (No. 70965) and Paratype (No. 70966) in USNM Helm. Coll., Beltsville, Maryland.

This species is named in honor of Dr. Wanda S. Hunter.

Levinseniella hunteri sp. nov. differs from all the other described species of *Levinseniella*

by possessing a massive conical male papilla penetrated from the side by the ductus ejaculatoris. It more closely resembles *L. indica* Lal, 1936, *L. polydactyla* Deblock and Rose, 1962, and *L. carteretensis* Coil and Heard, 1966, than any of the other members of the genus. Though the description for *L. indica* is vague, *L. hunteri* differs from it in having no female pouch and nine (rather than four or five) male pockets. *Levinseniella polydactyla* differs from *L. hunteri* by possessing a larger number of atrial (male) pockets (12) and by the ductus ejaculatoris penetrating its comparatively small male papilla through the base. *Levinseniella carteretensis*, also described from the Wilson's Plover, is differentiated from *L. hunteri* by possessing a rudimentary male papilla and a well-developed female pouch.

Heard (1968) divided the genus *Levinseniella* into four morphological groups based on the number of male pockets and the presence or absence of a female pouch. *Levinseniella hunteri* has "numerous male pockets" and no female pouch, and therefore, is placed in Group IV of this scheme with *L. polydactyla*.

Summary

Levinseniella hunteri sp. nov. is described from the Wilson's Plover, *Charadrius wilsoni* Ord., collected in Louisiana. It differs from all other described species of *Levinseniella* by possessing a massive conical male papilla penetrated from the side by the ductus ejaculatoris. *Levinseniella hunteri* has nine male atrial pockets and no female pouch, and therefore is placed in Group IV of the subgeneric scheme proposed by Heard (1968).

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Some Digenetic Trematodes of Marine Fishes of New Caledonia. Part I. Bucephalidae, Monorchiidae, and Some Smaller Families[1]

WALTER O. DURIO[2] AND HAROLD W. MANTER[3]

The trematodes were collected by H. W. Manter in June and July 1963. All the fishes were from near Noumea, New Caledonia, and most of them obtained from the city market where many fishes are sold alive each morning. Facilities and space for examination of the fishes were provided at the Noumea Aquarium. Special thanks are due Mrs. René Catala, Acting Director of the Aquarium, who aided in the procurement of fishes and in many other ways. About 40 species of fishes were examined and 46 species of Digenea collected.

One handicap in the work was the lack of a good authority for the identification of the fish hosts. In some cases, only the common, local name was ascertained. A number of fishes were preserved and later identified by Dr. M. Legand, Institut Français d'Océanie, Noumea.

The trematodes were killed in A. F. A. (50% alcohol, 100 parts; formalin, 6½ parts; glacial acetic acid, 2½ parts) under a cover glass. Specimens were stained with Delafield's or Ehrlich's hematoxylin.

Some of the species are recorded also from Australia. The Australian collections were made by H. W. Manter in 1963, unless otherwise indicated.

Holotypes of new species are deposited in the United States National Museum Helminthological Collection. Most paratypes and other specimens will be in the Manter Collection at the University of Nebraska.

All measurements are in millimeters, unless otherwise stated.

Names of new genera and new species are in boldface type, not italicized.

[1] Studies from the Department of Zoology, University of Nebraska, No. 386. Supported in part by National Science Foundation Grant No. GB 468.

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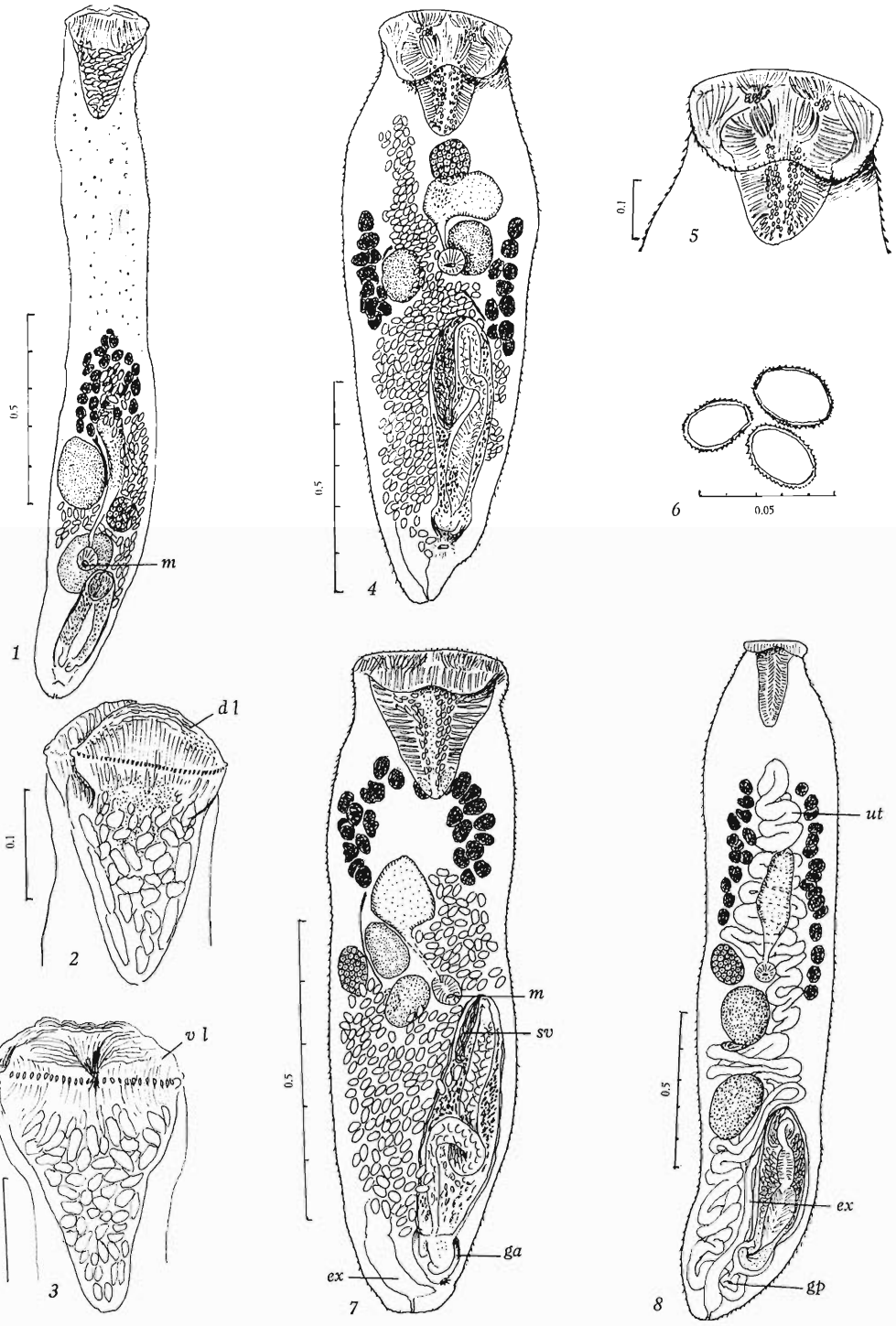
[3] University of Nebraska, Lincoln.



BUCEPHALIDAE Poche, 1907
Neidhartia coronata n. sp.
(Figs. 1–3)

HOST: Serranidae; probably *Epinephelus* sp.

LOCATION: Intestine.

NUMBER: Eight (two immature) from one host.

HOLOTYPE: USNM Helm. Coll. No. 63302.

DESCRIPTION (based on six somewhat macerated, extended specimens): Body elongate, truncate at anterior end; most body spines lost; length 1.392–1.949; width 0.193–0.287. Rhynchus conical, flattened at anterior end, with dorsal and ventral lobe; bearing single row of spines (lost on holotype) and spine-bearing ridge (Figs. 2–3). Anterior half of rhynchus with sublongitudinal muscles curving to become almost semicircular in side view near edge; tapered part of rhynchus with large, wide, thin-walled, irregularly spaced segments (muscles).

Mouth in posterior one-fourth to one-fifth of body length; pharynx subspherical, 0.058–0.065 in diameter; intestinal cecum long, extending anteriorly almost to midbody.

Testes tandem to slightly diagonal on right side of body, slightly separated, posterior testis dorsal to pharynx. Cirrus sac 0.226–0.229 by 0.074–0.099; overlapping posterior testis; containing ovoid seminal vesicle, straight pars prostatica, and numerous prostatic cells; wall rather thick, with diagonal muscles. Genital pore ventral, near posterior end of body.

Ovary subspherical, between testes but on left side of body. Uterus not extensive, extending anteriorly to about midbody, with loop between testes, then along left side of cirrus sac. Vitellaria immediately pretesticular extending anteriorly to near midbody, forming a broad band across body; 26 follicles in holotype. Intestinal cecum and uterus extending into zone of vitellaria; uterus may extend slightly anterior to vitellaria. Eggs 33–38 by 17–22 μ. Excretory pore terminal; anterior extent of vesicle not determined.

The name *coronata* is for the ring of rhynchal spines.

DISCUSSION: The small spines on the rhynchus are easily lost but in most specimens scars indicate the ridge or row where the spines had been located.

The genus *Neidhartia* Nagaty, 1937, has been distinguished from *Prosorhynchus* Odhner, 1905, chiefly on the basis of the ovary being at the intertesticular level rather than being pretesticular or opposite the anterior testis.

The genus *Dollfustrema* Eckmann, 1934, has three to six rows of rhynchal spines, and usually an intertesticular ovary. Thus, it seems to be a near relative of *Neidhartia*. The type species of *Dollfustrema*, *D. vaneyi* (Shen, 1930), has a cone-shaped rhynchus, and the ovary may be mostly anterior to the testes. It does have a distinctive three rows of spines on the rhynchus, and the rhynchus seems to have peculiar transverse bands of muscles. All other species in the genus have a more lenticular rhynchus.

Myorhynchus pritchardae n. gen., n. sp.
(Figs. 4–6)

HOST: Serranidae; commonly called "leche."

LOCATION: Intestine.

NUMBER: One specimen.

HOLOTYPE: USNM Helm. Coll. No. 63303.

DESCRIPTION: Body elongate, broad and truncate at anterior end, more tapered posteriorly; spined, except at flat anterior surface of rhynchus. Length 1.427; greatest width, just anterior to midbody, 0.470. Rhynchus

←

All figures were drawn with the aid of a camera lucida. The scale values are in mm. Abbreviations: *c*, cirrus; *dl*, dorsal lobe; *esv*, external seminal vesicle; *ex*, excretory vesicle; *ga*, genital atrium; *m*, mouth; *mt*, metraterm; *pph*, prepharynx; *prv*, prostatic vesicle; *sr*, seminal receptacle; *sv*, seminal vesicle; *to*, terminal organ; *ut*, uterus; *vl*, ventral lobe.

Figures 1–8. 1. *Neidhartia* coronata. Holotype. Ventral view. 2. Same. Anterior end. Dorsal view showing dorsal lobe and spines. 3. Same. Anterior end of a paratype. Lateral view. 4. Myorhynchus pritchardae. Holotype. Ventral view. 5. Same. Anterior end, showing musculature of the rhynchus. Ventral view. 6. Same. Eggs. 7. *Prosorhynchus* longisaccatus. Holotype. Ventral view. 8. *Prosorhynchus* serrani. Holotype. Ventral view.

(Fig. 5) with flattened anterior surface bearing ventral flap broadly incurved at posterior edge; 0.303 long by 0.303 wide; tapering posteriorly; strongly muscular and markedly bilateral; with six pairs of muscles on each side of median line as follows: (1) at anterior end a group of short diagonal fibers; (2) a small group of dorsoventral muscles; (3) curved, more or less longitudinal muscles; (4) a long row of dorsoventral muscles extending to posterior end of rhynchus where they intergrade with (5) transverse muscles along outer side of rhynchus; (6) curved, more or less longitudinal muscles along lateral sides of rhynchus. Longitudinal fibers in middle of ventral flap of rhynchus.

Mouth median, slightly anterior to midbody; pharynx 0.066 in diameter; esophagus present; cecum anterior to pharynx, extending more or less laterally to left, broadly rounded. Testes spherical, smooth, slightly diagonal; anterior testis to left, partly dorsal to pharynx; posterior testis near midbody. Cirrus sac 0.554 long by 0.140 wide; to left of midline; anterior end near midbody, just posterior to posterior testis. Seminal vesicle straight, elongate, extending about half-length of cirrus sac; pars prostatica extending anteriorly to near base of sac, then looping back and widening to form a terminal portion lined with microvilli. One ventral and two smaller atrial lobes. Genital pore ventral, 0.118 from posterior end of body. Ovary spherical, median, far anterior, immediately posterior to rhynchus, separated from anterior testis by intestinal cecum; Mehlis' gland immediately postovarian. Vitelline follicles lateral, in two widely separated rows; 10 on right side, 13 on left; entirely posterior to ovary; mostly at testicular level. Uterus with one slender loop extending anteriorly to level of base of rhynchus; mostly to right of cirrus sac; not extending appreciably posterior to genital pore. Eggs relatively wide, 25–30 by 20–22 μ; shell covered with small spines or pointed projections (Fig. 6). Excretory pore terminal; anterior extent of vesicle not determined.

GENERIC DIAGNOSIS OF **Myorhynchus:** Bucephalidae; Prosorhynchinae. Rhynchus conical, flattened anteriorly, with ventral fold or lobe; without tentacles or suckers; strongly bilateral, muscles in paired bilateral sets, mostly diagonal or dorsoventral. Mouth near midbody; cecum directed anteriorly. Testes slightly diagonal, near midbody; cirrus sac large. Ovary far anterior, near rhynchus. Vitellaria lateral, entirely postovarian. Egg shell covered with minute spines. Type species: *M.* **pritchardae** n. sp.

DISCUSSION: This genus is related to *Prosorhynchus*, but has three distinguishing characters: (1) the complex structure of the rhynchus; (2) the location of the ovary anterior to all vitellaria; and (3) the spiny eggs.

The name *Myorhynchus* is from *myo* = muscle and *rhynchos* = snout. The species is named for Mary Hanson Pritchard, University of Nebraska.

Prosorhynchus longisaccatus n. sp. (Fig. 7)

HOST: Serranidae; commonly called "leche."

LOCATION: Intestine.

NUMBER: Two from one host.

HOLOTYPE: USNM Helm. Coll. No. 63304.

DESCRIPTION: Body elongate, anterior end truncate, posterior end broadly rounded; length 1.096–1.201; almost uniformly wide; width 0.331–0.348. Rhynchus well developed, cone-shaped, with flattened top, 0.267–0.283 long by 0.267–0.271 wide at anterior end; anterior edge broadly indented ventrally. Muscles of rhynchus cone bilaterally arranged, with lateral transverse bands and two submedian, more or less diagonal or dorsoventral bands. Muscles of anterior edge of rhynchus more or less perpendicular to surface ventrally, but dorsally arranged in paired groups of diagonal muscles.

Mouth near midbody; pharynx 0.065–0.074 in diameter; cecum anterior to pharynx, short, wide, extending almost halfway between pharynx and rhynchus.

Testes ovoid, diagonal, close together; posterior testis to right of, or immediately posterior to, pharynx. Cirrus sac to left of midline, 0.477–0.552 long by 0.141–0.152 wide; thick-walled; extending to midlevel of posterior testis and to, or almost to, pharynx. Seminal vesicle tubular, extending about one-third length of cirrus sac, then bending directly forward as a sperm-free tube, joining pars prostatica near basal (proximal) end of cirrus sac; pars prostatica long, relatively narrow, with dorsoventral loop near middle of cirrus sac. Genital pore ventral, slightly to left of midline, near posterior end of body.

Ovary ovoid, to right of, or partly posterior to, anterior testis. Vitellaria in anterior third of body, mostly lateral, confluent at base of rhynchus; 13 follicles on each side; posterior follicles overlapping anterior part of cecum, not reaching testis. Mehlis' gland overlapping right posterior edge of ovary, or (in paratype) dorsal to left side of posterior testis. Uterus extending anteriorly along left side of cecum but not anterior to it, filling most of body to right of cirrus sac; not extending postatrially. Eggs 30–33 by 17–23 μ. Excretory pore terminal; vesicle along left side of atrium; anterior extent not determined.

The name *longisaccatus* refers to the long cirrus sac.

DISCUSSION: This is one of those species of *Prosorhynchus* with cone-shaped rhynchus, vitellaria forming an arc and ovary not anterior to testes. It seems most closely related to *P. epinepheli* Yamaguti, 1939. A species we consider to be *P. epinepheli* was collected (34 specimens) from *Epinephelus merra* Bloch at Heron Island, Australia. It agrees with *P.* **longisaccatus** in that the gonads are clustered close together in the region of the pharynx and cecum. The ovary may be anterior to both testes, but usually it overlaps the anterior testis. Yamaguti's (1939) figure shows one testis rather widely separated from the other, but this character was not mentioned in his description. In the Australian material, the testes are close together or separated only by a single coil of the uterus. Two characters separate *P.* **longisaccatus** from *P. epinepheli*: (1) the uterus does not extend even to midatrial level, whereas in all specimens of *P. epinepheli* it extends postatrially; (2) the rhynchus is wider, and the arrangement of muscles at its anterior edge gives a distinctive appearance. The cirrus sac is thick-walled in both New Caledonian and Australian material.

Prosorhynchus **longisaccatus** is also similar to *P. crucibulus* (Rud.), especially *P. crucibulus japonicus* Yamaguti, 1958, but has fewer vitellaria, the testes closer together, and a larger cirrus sac.

In most species of *Prosorhynchus*, the ovary is anterior to the anterior testis but in several of them it more or less overlaps, or may be directly opposite, this testis. In all six named species of *Neidhartia*, the ovary is at a level between the testes. At the present time, this difference seems to be the best character to separate the two genera.

Prosorhynchus **longisaccatus** occurred in the same host with **Myorhynchus pritchardae.**

Prosorhynchus serrani n. sp. (Fig. 8)

SYNONYM: *P. crucibulus* (Rud.) of Nagaty, 1937, nec Rudolphi, 1819, in *Serranus* (= *Variola*) *louti* (Forskål), Red Sea. New synonymy.

HOST: *Serranus louti* (Forskål); Serranidae.

NUMBER: Thirteen from one host.

HOLOTYPE: USNM Helm. Coll. No. 63305.

DESCRIPTION: Body elongate, about uniformly wide; anterior end truncate; posterior end broadly rounded; length 1.027–2.245; width 0.226–0.487. Rhynchus conical, flattened anterior fold with broad ventral indentation, 0.185–0.267 long by 0.156–0.217 wide; cone relatively narrow. Mouth median at midbody; pharynx 0.065–0.080 in diameter; esophagus short; cecum extending anteriorly, length variable, 0.096–0.301.

Testes rounded to ovoid, tandem to diagonal, to right of midline, separated by two coils of uterus; anterior testis immediately posterior to midbody. Cirrus sac to left of midline, 0.361–0.574 long by 0.092–0.174 wide; thick-walled; always reaching or overlapping level of posterior testis; separated from posterior testis by uterus and excretory vesicle; containing curved, tubular seminal vesicle about one-third length of cirrus sac; short but sometimes looped, sperm-free duct and pars prostatica often but not always constricted near middle to appear bipartite. Genital atrium spacious, with large atrial lobe. Genital pore ventral, about 0.15 from posterior end of body.

Ovary immediately pretesticular, near midbody, to right of midline, lateral to pharynx. Mehlis' gland and yolk reservoir near posterior end of anterior testis; sperm cells in proximal coils of uterus. Vitelline follicles large, in lateral rows, 13 to 18, usually 15 or 16, on each side; rows usually not meeting anteriorly, but forming an arc in two (of 13) specimens; posterior extent of vitelline follicles near ovarian level; anterior extent variable, rarely to base of rhynchus. Uterus extending anteriorly dorsal to pharynx and cecum; anterior

limit usually near anterior limit of vitellaria, sometimes anterior to vitellaria to base of rhynchus, in one specimen not anterior to cecum; descending uterus passing between testes and extending postatrially. Eggs 24–29 by 15–17 μ.

Excretory pore terminal; excretory vesicle extending to right of cirrus sac, curving to left of posterior testis, ending near anterior end of latter.

DISCUSSION: This species agrees well with Nagaty's (1937) "*P. crucibulus* (Rud., 1819)" from the same host from the Red Sea. It cannot be *P. crucibulus* because of the smaller size; smaller, more slender rhynchus; pretesticular ovary; and uterine coils lying between the testes. A related species is *P. tsengi* Tsin, 1933 (syn. *Gotonius platycephali* Yamaguti, 1934) which, however, has a cirrus sac not reaching the posterior testis, a longer excretory vesicle, and shorter rhynchus.

Some details of the cirrus sac of species of *Prosorhynchus* have not been well delineated in either descriptions or figures. In most, if not all, species the tubular seminal vesicle bends about 180° and becomes a fairly wide, thin-walled tube free of sperm cells. Such a tube is present in every specimen of 14 species of the genus in the Manter collection. Since it connects the seminal vesicle with the "pars prostatica" (actually in *Prosorhynchus* an elongate prostatic vesicle), it must at times contain sperm cells, probably only temporarily. The true condition in the type species, *P. squamatus* (Rud.) Odhner, 1905, is questionable. There is evidence that more than one species have been considered to be *P. squamatus*.

Prosorhynchus freitasi Nagaty, 1937

HOSTS AND LOCALITIES: *Epinephelus* sp.; Serranidae; New Caledonia. *Plectropomus maculatus* (Bloch); Serranidae; Heron Island; Queensland, Australia.

LOCATION: Ceca and intestine.

NUMBER: Twelve in one *Epinephelus*; one in one *Plectropomus*.

DISCUSSION: *P. freitasi* was first reported from *Serranus guttatus* Peters from the Red Sea. The present specimens agree in general morphology and measurements. New hosts and new geographical localities are thus recorded.

HAPLOSPLANCHNIDAE Poche, 1925
Hymenocotta mulli Manter, 1961

HOSTS AND LOCALITIES: Mullet; Mugilidae; New Caledonia and Fiji. *Mugil cephalus* Linn., at Heron Island, Queensland, Australia.

LOCATION: Intestine.

FELLODISTOMATIDAE Nicoll, 1913
Tergestia clonacantha Manter, 1963

HOST: *Hemirhamphus* sp.; halfbeak; Hemirhamphidae.

LOCATION: Intestine.

NUMBER: One in one host.

DISCUSSION: *Tergestia clonacantha* Manter, 1963, from *Hemirhamphus* sp. in Fiji, agrees in general morphology and measurements with this specimen from New Caledonia. The only marked difference is that the two specimens from Fiji show a long cirrus sac extending around the left side of the acetabulum and reaching halfway or more between the acetabulum and the ovary. The specimen from New Caledonia has a much shorter cirrus sac which does not reach the posterior edge of the acetabulum. However, the entire cirrus of this specimen is protruded from the body which is somewhat contracted; this may account for the difference in this character.

MICROSCAPHIDIIDAE Travassos, 1922
Synonym: Angiodictyidae Looss, 1902
Hexangium sigani Goto and Ozaki, 1929

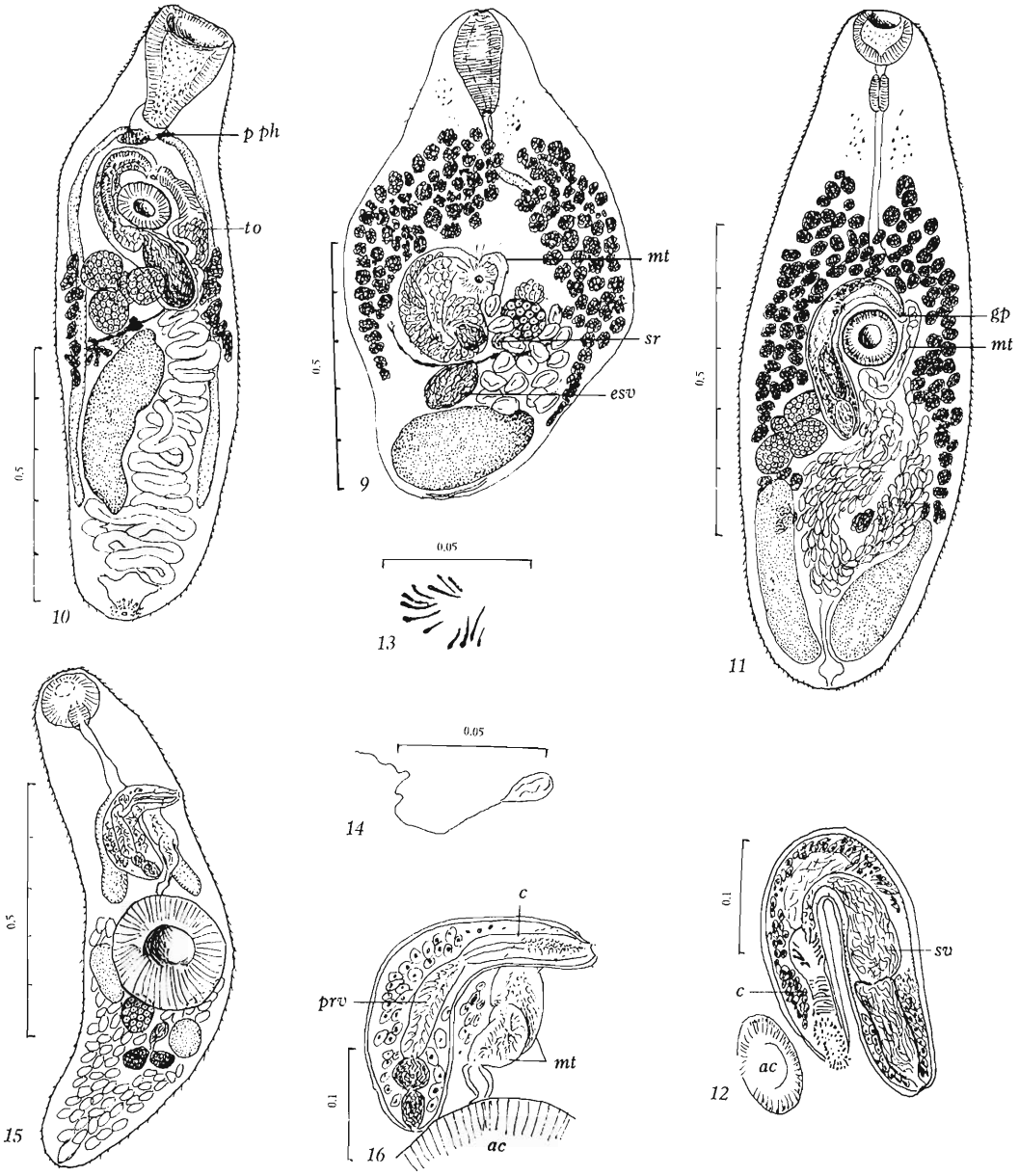
SYNONYMS (according to Razarihelisoa, 1960): *H. affinum* Tubangui and Masiluñgan, 1944; *H. secundum* Annereaux, 1947; *H. loossi* (Nagaty, 1954) Yamaguti, 1958; *Arthurloossia loossi* Nagaty, 1954.

HOSTS AND LOCALITIES: *Siganus* sp.; Siganidae; New Caledonia. *Siganus* sp. (six species); Heron Island and Green Island; Queensland, Australia. *Lutjanus vaigiensis* (Quoy and Gaimard); Lutjanidae; New Caledonia.

LOCATION: Intestine.

NUMBER: Numerous in *Siganus* sp.; one from *Lutjanus*.

DISCUSSION: This species is known, usually from *Siganus* spp., in Japan (Goto and Ozaki, 1929); Celebes (Yamaguti, 1953); Madagascar (Razarihelisoa, 1960); Philippines (Velasquez, 1961); Borneo (Fischthal and Kuntz, 1965). The Australian specimens show considerable variation in the arrangement of the



Figures 9–16. Bivesiculoides posterotestis. Holotype. Ventral view. 10. *Lasiotocus* **longitestis.** Holotype. Ventral view. 11. **Hysterorchis vitellosus.** Holotype. Ventral view. 12. Same. Frontal section through cirrus sac showing double spination. 13. Same. Spines from base of cirrus sac. 14. Same. Egg. 15. *Diphtherostomum* **tropicum.** Holotype. Ventral view. 16. Same. Terminal genital organs of paratype.

testes (usually diagonal, sometimes tandem, rarely symmetrical), but these variations were noted in Madagascaran specimens by Razarihelisoa.

BIVESICULIDAE Yamaguti, 1939
Bivesiculoides posterotestis n. sp. (Fig. 9)

HOST: Myctophidae; shiner; "pretre."

LOCATION: Intestine.

NUMBER: One specimen in one host.

HOLOTYPE: USNM Helm. Coll. No. 63301.

DESCRIPTION: Body ovoid, thin, widest near midbody; length 0.992; width 0.557. Cuticula with traces of spines mostly lost by maceration. Scattered eye-spot pigment near oral sucker. Mouth terminal; oral sucker elongate, funnel-shaped, 0.189 long by 0.103 greatest width. Ceca obscured by vitellaria.

Genital pore median, near midbody, more or less muscular. Testis large, transversely ovoid, at posterior end of body; 0.181 long by 0.316 wide. External seminal vesicle ovoid, between testis and cirrus sac. Cirrus sac thin-walled, about 0.256 long by 0.144 wide, oriented with base at posterior end, extending 0.064 anterior to genital pore; containing transversely ovoid internal seminal vesicle, very large prostatic gland, large prostatic vesicle, and short cirrus.

Ovary ovoid; to left of middle of cirrus sac; 0.078 long by 0.098 wide. Mehlis' gland just anterior to ovary; seminal receptacle just posterior to ovary; uterus entirely pretesticular, between ovary and testis. Metraterm thin-walled, extending slightly anterior to genital pore. Vitellaria follicular, filling sides of body from posterior end of oral sucker to anterior end of testis, almost confluent anteriorly. Eggs yellowish, mostly collapsed, 54–64 by 42–48 μ; some almost round; embryos undeveloped.

Excretory vesicle seen only as a trace between testis and posterior end of body.

The name *posterotestis* refers to the far posterior location of the testis.

DISCUSSION: The genus *Bivesiculoides* Yamaguti, 1938, differs from *Bivesicula* Yamaguti, 1934, in having the uterus entirely pretesticular. Only two species have been named hitherto: *Bivesiculoides atherinae* Yamaguti, 1938, from Japan and *B. otagoensis* Manter, 1954, from New Zealand. *Bivesiculoides* **posterotestis** differs from both of these in (1) orientation of the cirrus sac which lies posterior rather than anterior to the genital pore; (2) more posterior testis; and (3) vitellaria not overlapping the testis. It is most like *B. atherinae*, especially in egg size and shape of the oral sucker.

MONORCHIIDAE Odhner, 1911
The Genera *Proctotrema* Odhner, 1911, and *Lasiotocus* Looss, 1907 in Odhner, 1911

Bartoli and Prevot (1966) restudied the type species of *Proctotrema, P. bacilliovatum* Odhner, 1911, and decided this genus should be considered monospecific, all other species named in it to be moved to *Lasiotocus*. The chief generic characters of *Proctotrema* would then be as follows:

Seminal vesicle a coiled tube rather than saccular; "vagina" or terminal organ a simple enlargement of end of metraterm, armed with a single cluster of large spines; genital atrium unarmed; eggs long and narrow (length about three times width); ovary three- or four-lobed; acetabulum funnel-shaped. Type and only species: *P. bacilliovatum* Odhner, 1911.

The most distinctive of these generic characters is the tubular, rather than saccular, seminal vesicle.

Bartoli and Prevot also studied the type species of *Lasiotocus, L. mulli* (Stossich, 1883) Looss, 1907 in Odhner, 1911. The chief generic characters would be: seminal vesicle saccular; uterus entering side of terminal organ; atrium unspined, without atrial sac.

Bartoli and Prevot did not attempt to subdivide the remaining species of *Lasiotocus*, now containing several species formerly in *Proctotrema*. The result is a rather large genus (at least 23 species). Manter and Pritchard (1961) proposed separating these species on the basis of a distinctly lobed ovary in contrast with an unlobed or indistinctly lobed ovary. Such a division can be made without difficulty if based on published descriptions and figures. However, these species are often based on a small number of specimens so that individual variations are not certainly known. Some species of the related genus, *Genolopa* Linton, 1910, show great variation in indentations of the ovary. Pending more information on the various species involved, the genus *Lasiotocus* in the sense of Bartoli and Prevot (1966) is accepted here.

Lasiotocus longitestis n. sp. (Fig. 10)

HOST: *Plectorhynchus* sp.; Lutjanidae; "loche castex."

LOCATION: Intestine.

NUMBER: One.

HOLOTYPE: USNM Helm. Coll. No. 63306.

DESCRIPTION: Body truncate at anterior end; broadly rounded posteriorly. Length 1.253; width 0.365. Oral sucker funnel-shaped, 0.246 long by 0.176 wide. Forebody 0.348 long, contracted. Acetabulum 0.115 wide (0.070 long); sucker ratio 1 : 0.65. Prepharynx wide; pharynx about 0.056 long by 0.040 wide; esophagus probably about same length as pharynx; ceca extending to 0.214 from posterior end of body. Testis elongate, 0.342 by 0.128 greatest width, in posterior half of body, toward right side of body, more or less pointed at posterior end; posterior end near level of cecal ends. Cirrus sac large, bending around right side of acetabulum, base near midbody; containing saclike seminal vesicle, prostatic vesicle, and cirrus armed with broad-based spines. Genital atrium unspined; genital pore median.

Ovary deeply four-lobed; lobes spherical and connected only by narrow stalks; to right of midline; immediately anterior to testis. Seminal receptacle not observed. Vitellaria lateral at ovarian level, cecal and extracecal; seven to nine follicles on each side. Mehlis' gland and yolk reservoir posterior to ovary; uterus coiling to left of testis, extending nearly to posterior end of body, entering terminal organ near middle. Terminal organ 0.182 long by 0.080 greatest width, curving around left side of acetabulum; basal half unspined, filled with eggs; anterior half armed with slender spines. Eggs thin-shelled, collapsed, 24–28 by 14–15 μ. Excretory pore ventroterminal, glandular; excretory vesicle apparently short and wide.

DISCUSSION: This species is most similar to *L. plectorhynchi* (Yamaguti, 1934) Yamaguti, 1954 from a related host in Japan. *Lasiotocus* **longitestis** differs in its longer, more narrow testis reaching to within less than one-fourth body length of posterior end of body, as do the ceca; its cirrus sac relatively considerably longer; and four- rather than three-lobed ovary. *Lasiotocus himezi* Yamaguti, 1951, has a four-lobed ovary and a fairly long testis but it has a much longer esophagus, less elongate oral sucker, and longer posttesticular space. In *L. macrorchis* (Yamaguti, 1934) Yamaguti, 1954, the posttesticular space is almost half body length.

Hysterorchis vitellosus n. gen., n. sp. (Figs. 11–14)

HOSTS AND LOCALITIES: *Plectorhynchus* sp.; Lutjanidae; Noumea, New Caledonia. *Plectorhynchus pictus* (Thunberg); Heron Island, Queensland, Australia; parasite collected by Dr. John C. Pearson, University of Queensland.

LOCATION: Intestine.

NUMBER: Four from New Caledonia; one from Australia.

HOLOTYPE: USNM Helm. Coll. No. 63307.

DESCRIPTION (based on four specimens; one sectioned): Body entirely and strongly spined; 0.988–1.064 long; 0.362–0.442 greatest width; tapered and broadly rounded at each end. Remains of pigment spots in forebody. Oral sucker rounded; 0.080–0.093 in diameter; acetabulum near midbody, 0.080–0.093; sucker ratio 1 : 0.86–1.16. Forebody 0.435–0.523 long. Prepharynx short; pharynx 0.061–0.080 long by 0.032–0.038 wide; esophagus very long, thick-walled, muscular, 0.130–0.192 long; bifurcation about one-third body length from anterior end; ceca inconspicuous, hidden by vitellaria, ending slightly posterior to acetabulum.

Testes two, elongate, symmetrical or slightly diagonal, in posterior third of body, extending to posterior end of body. Cirrus sac (Fig. 12) large, curved, arcuate to U-shaped, base slightly posterior to midbody; with thick wall of longitudinal (outer) and circular (inner) muscles; length 0.272–0.448; width 0.054–0.070; partly dorsal to acetabulum, or curving around either side of acetabulum; extending anterior to genital pore, then recurving to genital pore. Genital pore slightly posterosinistral to anterior edge of acetabulum. Cirrus sac containing bipartite seminal vesicle, anterior chamber narrowing to tube, then entering a small sac armed with long spines with swollen bases (Fig. 13), followed by tube with circular muscles and cirrus armed with short spines. Prostatic cells around seminal vesicle and cirrus except for region of thin-walled, transparent cells adjacent to tube between seminal vesicle and cirrus.

Ovary deeply three-lobed or (in holotype) four-lobed; to right of cirrus sac; sometimes overlapping acetabulum dorsally; seminal receptacle lacking; sperm in uterus. Vitelline follicles large, numerous, from midesophagus level to testes level, surrounding ceca, confluent anterior to acetabulum, slightly overlapping uterus and testes dorsally. Uterus with a single large coil extending posteriorly between, or ventral to, testes to near posterior end of body. Metraterm thick-walled, about 0.240–0.256 long by 0.048 wide, extending along left side of acetabulum, posterior part usually bent toward midline and sometimes crossing cirrus sac; unspined; uterus entering posterior end of metraterm (i.e., terminal organ not differentiated). Eggs (Fig. 14) yellow, 26–32 by 16–19 μ, with long filament at one end.

Excretory vesicle extending between testes or flattened posterior to them, not distinctly Y-shaped but spreading at anterior end.

The name *hysterorchis* refers to the far posterior location of the testes. The name *vitellosus* refers to the vitellaria which are much better developed than in other monorchids.

DIAGNOSIS OF **Hysterorchis:** Monorchiidae. Testes two, near posterior end of body. Oral sucker round. Cirrus sac with bipartite, saccular seminal vesicle and spined cirrus. Ovary deeply three- or four-lobed. Vitellaria extensive in middle third of body. Eggs filamented. Uterus entering base of metraterm; metraterm muscular but unspined; atrium unspined. Type species: **Hysterorchis vitellosus.**

DISCUSSION: This genus is unusual in its bipartite seminal vesicle, extensive vitellaria, and unspined metraterm. The nearest related genus is *Diplohurleytrema* Nahhas and Cable, 1964, from *Echidna catenata* (Bloch), a moray eel, from the Caribbean. *Diplohurleytrema* has fairly extensive vitellaria, a bipartite seminal vesicle, two testes, and filamented eggs. However, it differs in its unlobed ovary, presence of a seminal receptacle, spined metraterm, median genital pore, and more anterior testes. *Diplolasiotocus* Yamaguti, 1952, from *Chaetodon* Linn. in the Celebes is somewhat similar in its long esophagus, bipartite seminal vesicle, two testes, and filamented eggs; but its vitellaria are reduced to a few tubular glands, the ovary is unlobed, the metraterm spined, the genital pore median. The double spination of the cirrus in **Hysterorchis** suggests the condition found by Bartoli and Prevot (1966) in *Lasiotocus mulli* (Stossich, 1883) Looss, 1907, in Odhner, 1911.

Hysterorchis has a number of characters which might be considered as primitive (or less specialized) in the family Monorchiidae; for example, the numerous vitelline follicles, simple oral sucker, and unspined metraterm.

ZOOGONIDAE Odhner, 1911
Diphtherostomum tropicum n. sp.
(Figs. 15–16)

HOSTS AND LOCALITIES: *Lethrinus* sp.; Lethrinidae; "bec de cane"; New Caledonia. *Lethrinus glyphodon* Günther; Green Island, Queensland, Australia.

NUMBER: Five in one of four hosts in New Caledonia; six in two of six hosts in Australia.

HOLOTYPE: USNM Helm. Coll. No. 63308.

DESCRIPTION: Body rather plump, entirely spined but spines more sparse posteriorly; tapered toward each end; length 0.783–1.190; width 0.199–0.300. Oral sucker 0.099–0.123 wide; acetabulum just posterior to midbody, 0.193–0.221 wide, usually somewhat wider than long. Sucker ratio 1 : 1.80–1.95. No prepharynx; pharynx 0.033–0.045 long by 0.033–0.045 wide; esophagus 0.164–0.185 long, extending almost halfway between suckers; bifurcation somewhat nearer to oral sucker; ceca short, extending to anterior border of acetabulum.

Genital pore sinistral, variously lateral, slightly dorsal, or slightly ventral, near level of bifurcation. Testes lateral, far apart, at posterior border of acetabulum. Cirrus sac (Fig. 16) large, arcuate, containing bipartite seminal vesicle, prostatic vesicle with length more than twice width, thick-walled cirrus, and prostatic cells. Cirrus with fine papillae (or microvilli ?) which sometimes appear spine-like.

Ovary globular, median, between testes, partially overlapping acetabulum. Seminal receptacle between ovary and left testis, rarely postovarian. Two globular vitelline masses, juxtaposed, immediately posterior to seminal receptacle. Uterus filling most of hindbody; short, thick-walled portion of uterus at anterior edge of acetabulum, entering well-developed metraterm. Metraterm bent dorsally once,

appearing somewhat shorter than cirrus sac but if straightened would be about same length (Fig. 16); less wide than cirrus sac; thick-walled; inner surface with fine, delicate papillae. Eggs with thin shells, containing developed embryos; 37–53 by 16–25 μ. Excretory vesicle small sac at posterior end of body.

DISCUSSION: *Diphtherostomum tropicum* is most similar to *D. brusinae* (Stossich, 1889) Stoss., 1904, but differs in (1) the shape of the prostatic vesicle which is much longer than wide; (2) the absence of a transparent flap or lip on the acetabulum; (3) its more anterior seminal receptacle; (4) the dorsally curved metraterm. The fine spines of the metraterm described for *D. brusinae* might be microvilli. *Diphtherostomum brusinae* is known from Labridae in the Mediterranean and from *Lethrinus* Cuvier in Japan.

Summary

Twelve species of Digenea, in seven families, are reported from fishes of New Caledonia. The following new genera (2) and new species (8) are described: New genera: **Myorhynchus** (Bucephalidae); **Hysterorchis** (Monorchiidae). New species: *Neidhartia* **coronata; Myorhynchus pritchardae;** *Prosorhynchus* **longisaccatus;** *P.* **serrani;** *Bivesiculoides* **posterotestis;** *Lasiotocus* **longitestis; Hysterorchis vitellosus;** *Diphtherostomum* **tropicum.** The *Prosorhynchus crucibulus* (Rud.) of Nagaty, 1937, is considered a synonym of *P.* **serrani.**

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Observations on *Hexatylus viviparus* and *Neotylenchus abulbosus* (Neotylenchidae: Nematoda)

W. R. NICKLE[1]

T. Goodey (1926a) described *Hexatylus viviparus* from potato in England as a new genus and species. He also found it in diseased gladiolus corms, and later, T. Goodey (1926b) expanded the description. In 1931 Steiner proposed *Neotylenchus abulbosus* as a new genus and species for nematode specimens found associated with strawberry plants in California. He also stated that he collected it from strawberry plants in Wisconsin and Germany; from potatoes in ships stores from England, Holland, Norway, and New Brunswick, Canada; and from carrots in England and Sweden. In 1932 Steiner and Buhrer described a single male specimen from carrots in Sweden as that of *N. abulbosus*. Both T. Goodey and Steiner accurately identified these nematodes, which lacked a valved median esophageal bulb, as not being the bulb and stem nematode, *Ditylenchus dipsaci* (Kühn), that required quarantine restrictions at that time.

Tylenchids lacking a valved median bulb have been known and studied for 42 years, and as a result of this study, the genus *Neotylenchus* has been designated as the type genus of the family Neotylenchidae. This family now includes about 75 nominal species.

A study of the esophageal morphology of the original specimens of Steiner's *N. abulbosus*, and *H. viviparus* of T. Goodey is basic to understanding the taxonomy of this large group of nematodes because various esophageal interpretations now appear in the literature (Fig. 1).

Materials and Methods

Female specimens of *Neotylenchus abulbosus*, the original collection from strawberry in California, were obtained from the USDA Nematode Collection. The male from carrot in Sweden and some females from the same collection were also available. Other original specimens, labeled by Steiner and others as *Neotylenchus abulbosus*, were studied. These included nematodes from potato in England, Holland, and Germany; from carrots in England; from sugarbeets in California; from iris in Holland; from turnip in Wales; from poppy in England; and from plantain in Oregon. D. J. Hooper of the Rothamsted Experiment Station kindly loaned me mounted syntype specimens of the original *Hexatylus viviparus* and *Neotylenchus consobrinus* (de Man, 1907) Filipjev, 1936, and a vial containing a mass collection of *H. viviparus* from potato in Ireland grown on a *Botrytis* culture. *Hexatylus viviparus* and other neotylenchids from the Thorne Collection also were thoroughly studied for relevant relationships. Paratype slides of *Hexatylus mulveyi* Das, 1964, were sent to me for study by R. H. Mulvey.

Steiner's slides of *Neotylenchus abulbosus* from strawberry in California were flooded with warm glycerine and remounted. Some specimens from the mass collection of *Hexatylus viviparus* were stained by the cottonblue-lactophenol technique, while others were stained in picric acid and mounted in dehydrated glycerine.

Results and Discussion

Studies of the original syntype material of *Neotylenchus abulbosus* revealed that the stylet was surrounded by strengthening rings (Fig. 2C), similar in arrangement to those illustrated for *Hexatylus viviparus*. The stylet knobs of *N. abulbosus* were not in the form of outward-pointing curved processes as described by Steiner, 1931, but appeared slightly bifid (Fig. 2C). The posterior part of the esophagus of *N. abulbosus* did not have the definitely set-off posterior bulb, as expected from previous descriptions, but had dorsally overlapping glands. Syntype specimens and a mass collection of *H. viviparus* from Rothamsted also were studied and other similarities between the two species were noted. There was a prominent junction of the esophageal and intestinal lumena (Fig. 2A), just anterior to the nerve ring in both *N. abulbosus* and *H. viviparus*. This eliminates the possibility of a definitely set-off posterior bulb. Previous

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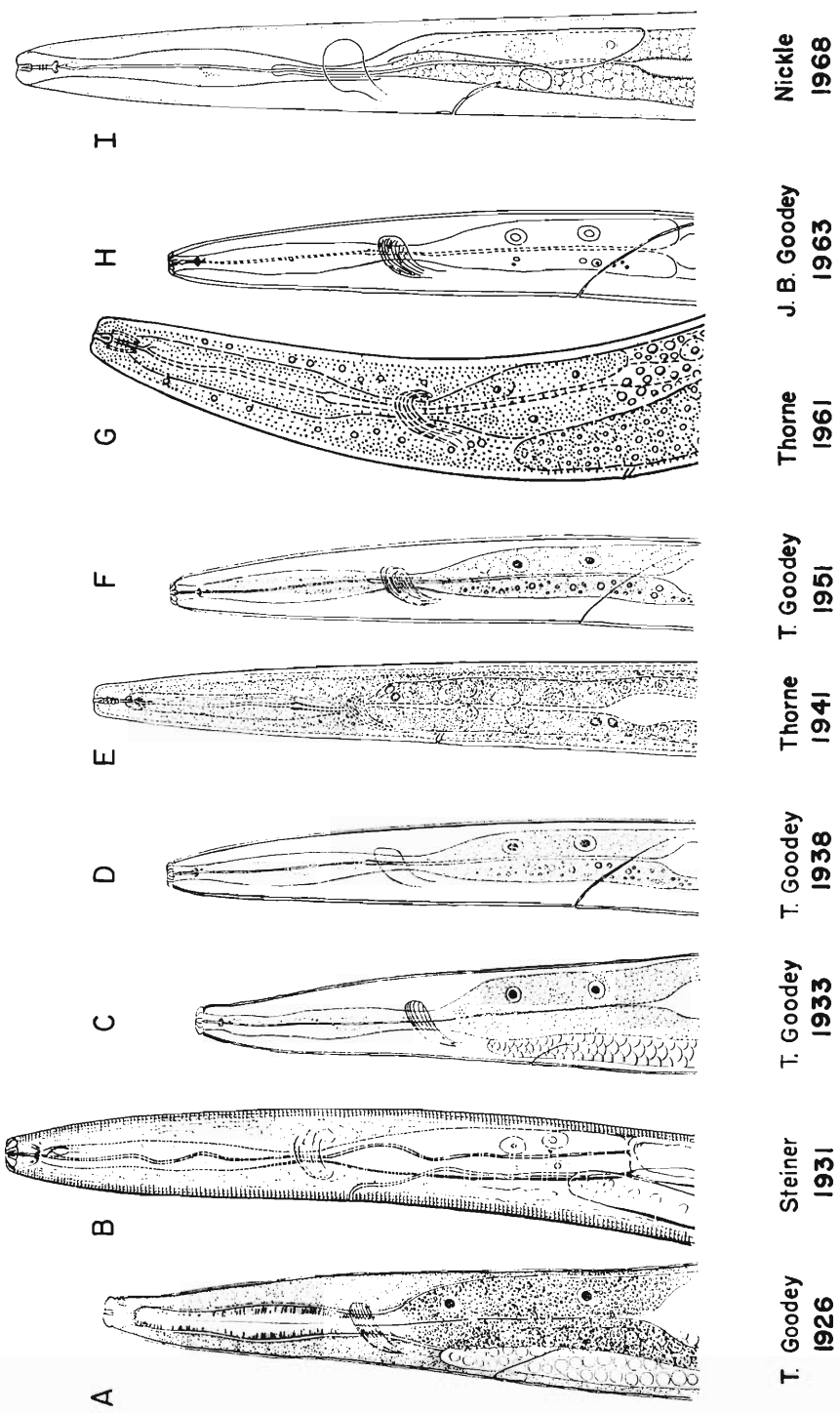

Figure 1. Drawings depicting the various interpretations of the esophageal area of *Hexatylus viviparus*.

workers considered the junction of the esophagus and intestine to be at the widening of the intestinal lumen at the level of the base of the overlapping esophageal glands (Fig. 1). The suggestion that the esophagus and intestine are fused, as stated in the diagnosis of the genus *Hexatylus*, was difficult to accept since fusion of two organ systems is not known to occur anywhere in the animal kingdom, and it would be unlikely to occur only in this nematode genus.

Both stained and glycerine mounted specimens of *H. viviparus* revealed that the esophageal glands overlap the intestine and lie dorsally in a diverticulum. Three esophageal gland nuclei and two large coelomocytes were present in the area (Fig. 2A). These coelomocytes may have been confused by earlier workers with the gland nuclei (Fig. 1). The overlapping esophageal glands were also observed in the original *N. abulbosus* and *H. viviparus* material. The posterior part of the esophagus did not vary from a posterior bulb to overlapping glands. Other differences previously thought to exist between *N. abulbosus* and *H. viviparus* were not found. Both nematodes were found to have the cephalic framework in eight sectors (Fig. 2B) as Steiner (1931) described and four lateral lines. The subventral gland orifices opened into the area where the median bulb would have been if it were present. The intestinal lumen widened broadly at a level just posterior to the base of the overlapping gland.

The male specimen from carrot in Sweden, described as the male of *N. abulbosus*, and some female nematodes from the same collection, were studied. These female nematodes were the same as *Hexatylus viviparus* as described in this paper. The male was not in good condition. It looked like it may have had a stylet, but the specimen gave the appearance of having decomposed before fixation rather than that of lacking a stylet as described by Steiner. *N. abulbosus* was described from female specimens taken from strawberry plants in California, and it appears unwise that the description of this male specimen from carrot in Sweden be given much credence in the taxonomy of *N. abulbosus*.

The esophageal area of *Hexatylus viviparus* has been illustrated differently nine times by five nematologists in the last 42 years (Fig. 1). Because this area is difficult to see, we are confronted by illustrations that depict the esophagus as being fused with the intestine, as having a definitely set-off posterior bulb, and now as having overlapping glands. T. Goodey's original drawing (Fig. 1A) showed a fusion of the esophagus with the intestine and no esophageal gland orifices. Steiner's drawing (Fig. 1B) may have been a dorsal or ventral view of the overlapping gland which made it appear as a definitely set-off posterior bulb. In 1933 T. Goodey redrew this nematode (Fig. 1C), and though he maintained the fusion of the esophagus with the intestine, he added the dorsal and subventral gland orifices. He redrew the nematode again in 1938 (Fig. 1D) and added the important junction of the esophageal and intestinal lumena. He also still considered the esophagus and intestine to be fused, but he changed the pattern on the ventral side of the esophagus to appear more like an intestine. Thorne made a drawing (Fig. 1E) of this nematode in 1941 and decided that the esophagus was fused with the intestine. He pointed out the strengthening rings around the stylet but did not differentiate between the subventral gland orifices and the junction of the esophageal and intestinal lumena. T. Goodey redrew the nematode with minor changes for his textbook of 1951 (Fig. 1F). Thorne redrew the front end of this nematode for his textbook in 1961 (Fig. 1G). It was similar to his earlier drawing, and he still considered the esophagus to fuse with the intestine. In 1963 J. B. Goodey rounded off the base of the overlapping esophageal gland (Fig. 1H) and mentioned that further work might show that *H. viviparus* and *N. abulbosus* are indistinguishable. Figure 1I depicts the present author's interpretation of the esophageal intestinal area.

No differences could be found between syntype specimens of *H. viviparus*, the type species of *Hexatylus*, and *N. abulbosus*, the type species of *Neotylenchus*. They thus become conspecific, requiring the synonymy of the genus *Neotylenchus* under the genus *Hexatylus*. This synonymy has been proposed in the past, or suggested by several workers (T. Goodey, 1933, 1938; Christie, 1938; Andrassy, 1952; Meyl, 1954; J. B. Goodey, 1963). How-

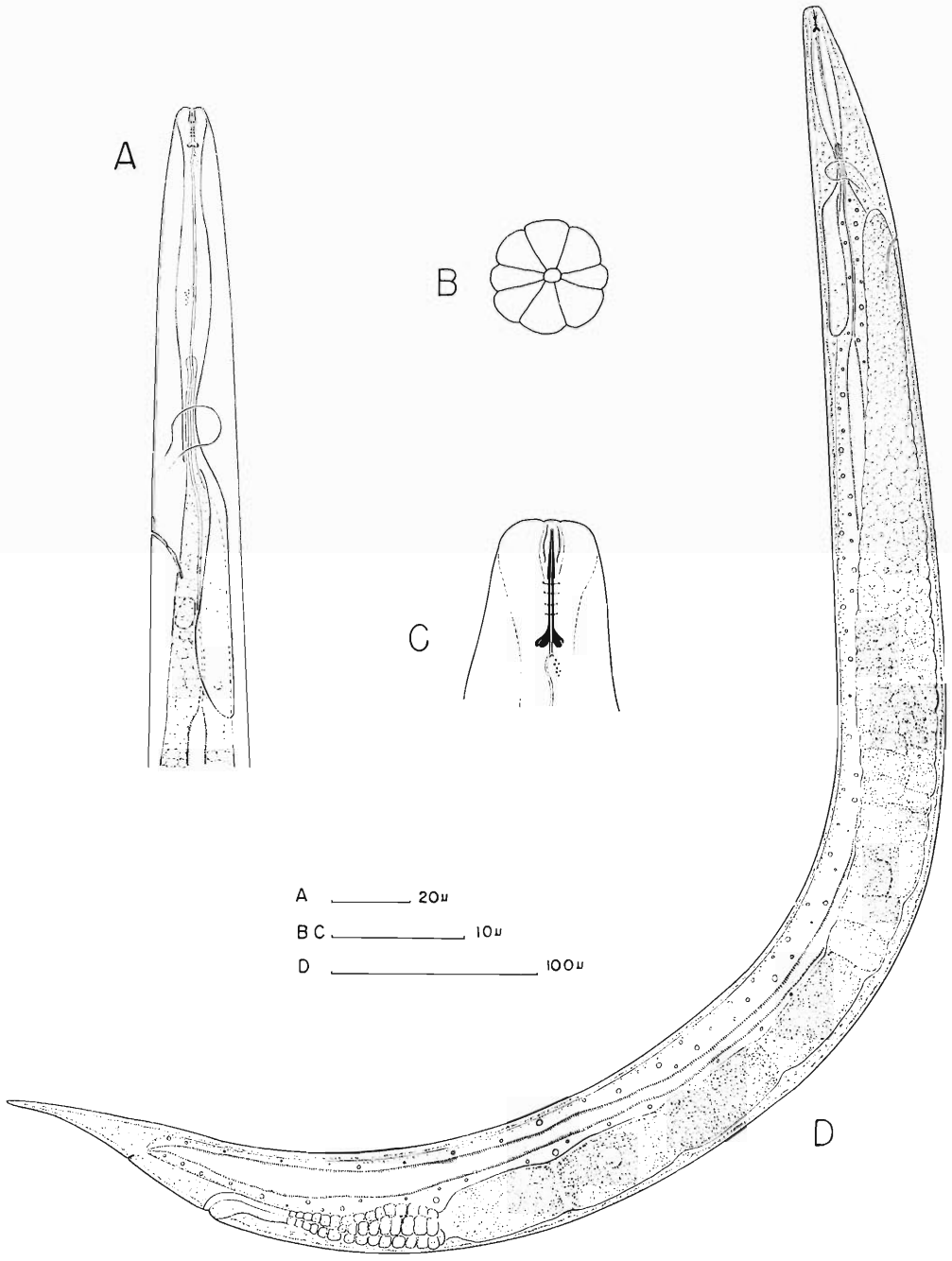

Figure 2. Drawings from *Hexatylus viviparus* and the original *Neotylenchus abulbosus* material. A. Anterior end of *H. viviparus* from gladiolus corm. B. *En face* view, from original *N. abulbosus* slide. C. Head and stylet of original *N. abulbosus* specimen, showing bifid knobs and strengthening rings. D. Female from an original specimen of *N. abulbosus*.

ever, this action seems justified by the present studies of the original material of Steiner and T. Goodey.

The results of this study of syntype material of *N. abulbosus* and *H. viviparus* require certain adjustments in the Neotylenchidae, some of which are beyond the scope of this paper. As the type species of the genus *Neotylenchus* becomes a junior synonym of the type species of the genus *Hexatylus*, the former generic name can no longer be used. The family name Neotylenchidae and the subfamily name Neotylenchinae are retained. Studies of the available specimens and literature of the remaining species of the old genus *Neotylenchus* do not reveal a suitable type species to represent them as a group. My observations require the transfer of *N. consobrinus* (de Man, 1907) Filipjev, 1936, to another genus in the Neotylenchidae, namely, *Paurodontus* Thorne, 1941, because of the presence in T. Goodey's specimens of a long stemlike projection of esophageal tissue into the intestine. *N. linfordi* Hechler, 1962, has a short stemlike projection at the base of the esophagus and is also placed in the genus *Paurodontus*. In making these changes, I agree with J. B. Goodey (1963) in reducing the taxonomic value placed on the number of sectors in the cephalic framework of members of this family. After a study of excellently preserved syntype material, I have transferred *Neotylenchus arcuatus* Thorne, 1941, to the genus *Nothanguina* Whitehead, 1959. *Neotylenchus velatus* (Bütschli, 1873) Skarbilovich, 1952, *N. obtusicaudus* (Stek., 1941) Skarbilovich, 1952, and *N. zeae* (Stek., 1941) Skarbilovich, 1952, are placed in *species inquirendae*. *N. acutus* Thorne, 1941; *N. beljaevae* (Atakhanov, 1959) Andrassy, 1961; *N. coprophagus* (T. Goodey, 1938) Thorne, 1941; *N. dendrophilus* Rühm, 1956; *N. intermedius* (Christie, 1938) Thorne, 1941; *N. latus* Thorne, 1935; *N. obesus* Thorne, 1934, and *N. serpens* Andrassy, 1961, require more study before they can be placed properly within the family Neotylenchidae. They are also considered as *species inquirendae*.

Hexatylus mulveyi Das, 1964, with six lines in the lateral field is retained as a valid species of the genus *Hexatylus*. The genus *Scytaleum* Andrassy, 1961, which he considered to be intermediate between the genus *Hexatylus* and the genus *Neotylenchus*, is placed as a synonym of *Hexatylus*. *Scytaleum vigissi* (Skarbilovich, 1952) Andrassy, 1961, the type species of the genus *Scytaleum*, with a shorter stylet and the presence of males, is also considered a valid species of *Hexatylus*, as originally proposed by Skarbilovich. The three remaining species in the genus *Scytaleum*: *S. italicum* (Meyl, 1954) Andrassy, 1961; *S. skarbilowiezae* (Atakhanov, 1959) Andrassy, 1961; and *S. thornei* (Meyl, 1954) Andrassy, 1961, are placed in *species inquirendae*. Other *species inquirendae* include: *Hexatylus boettgeri* Meyl, 1954; *H. brevicaudatus* Meyl, 1954; and *H. dipapillatus* Meyl, 1954. Future work, especially on the esophageal area, will undoubtedly reveal their exact status.

The following changes are therefore proposed at this time:

Hexatylus T. Goodey, 1926.
Syn. *Neotylenchus* Steiner, 1931.
Scytaleum Andrassy, 1961.
Hexatylus viviparus T. Goodey, 1926.
Syn. *Neotylenchus abulbosus* Steiner, 1931.
Hexatylus vigissi Skarbilovich, 1952.
Syn. *Scytaleum vigissi* (Skarbilovich, 1952) Andrassy, 1961.
Paurodontus linfordi (Hechler, 1962) n. comb.
Syn. *Neotylenchus linfordi* Hechler, 1962.
Paurodontus consobrinus (de Man, 1907) n. comb.
Syn. *Neotylenchus consobrinus* (de Man, 1907) Filipjev, 1936.
Nothanguina arcuatus (Thorne, 1941) n. comb.
Syn. *Neotylenchus arcuatus* Thorne, 1941.

Species inquirendae

The following species seem to belong in the Neotylenchidae but the details in their descriptions are inadequate for recognition by present-day standards. These species require more study, in the light of the basic changes imposed upon this group by the information presented in this paper.

Neotylenchus acutus Thorne, 1941.
Neotylenchus beljaevae (Atakhanov, 1959) Andrassy, 1961.

Neotylenchus coprophagus (T. Goodey, 1938) Thorne, 1941.
Neotylenchus dendrophilus Rühm, 1956.
Neotylenchus intermedius (Christie, 1938) Thorne, 1941.
Neotylenchus latus Thorne, 1935.
Neotylenchus obesus Thorne, 1934.
Neotylenchus obtusicaudus (Stek., 1941) Skarbilovich, 1952.
Neotylenchus serpens Andrassy, 1961.
Neotylenchus velatus (Bütschli, 1873) Skarbilovich, 1952.
Neotylenchus zeae (Stek., 1941) Skarbilovich, 1952.
Hexatylus boettgeri Meyl, 1954.
Hexatylus brevicaudatus Meyl, 1954.
Hexatylus dipapillatus Meyl, 1954.
Scytaleum italicum (Meyl, 1954) Andrassy, 1961.
Scytaleum skarbilowiczae (Atakhanov, 1959) Andrassy, 1961.
Scytaleum thornei (Meyl, 1954) Andrassy, 1961.

Genus: *Hexatylus* T. Goodey, 1926.
Syn. *Neotylenchus* Steiner, 1931.
Scytaleum Andrassy, 1961.

DIAGNOSIS (Emended): Neotylenchinae. Cephalic framework octagonal. Stylet knobs slightly bifid. Pharynx slightly sclerotized, with several strengthening rings surrounding stylet. Dorsal esophageal gland orifice near base of stylet. Subventral gland orifices open in area where median bulb would have been if it were present. Lumen of esophagus joins lumen of intestine near base of corpus, in region of nerve ring. Lumen becomes wider at this junction and widens again markedly at level of base of overlapping esophageal glands. Esophageal glands overlap intestine dorsally in a diverticulum. Intestinal lumen with prominent villae. Gonad prodelphic, well-developed, extending into esophageal area; vulva posteriorly located; postuterine sac absent. Tail short, more or less acuminated. Males rare or absent.

Type species: *Hexatylus viviparus* T. Goodey, 1926.
Syn. *Anguillulina* (*Hexatylus*) *vivipara* (T. Goodey, 1926) W. Schneider, 1939.
Iotonchium viviparum (T. Goodey, 1926) Filipjev and Stek., 1941.
Neotylenchus abulbosus Steiner, 1931.
Hexatylus abulbosus (Steiner, 1931) T. Goodey, 1933.
Anguillulina (*Neotylenchus*) *abulbosa* (Steiner, 1931) W. Schneider, 1939.
Iotonchium abulbosum (Steiner, 1931) Filipjev and Stek., 1941.

MALE: Unknown.

FEMALE: Length 0.67–1.5 mm; width 0.037–0.057 mm; a = 15–35; b = 13–16; c = 10–20; V% = 81–89; stylet = 9–11 μ.

Females with great variation in length and width between those not yet producing eggs and senile forms. Cuticle striated. Lateral field with four lines. Phasmids and deirids not observed. Cephalic framework slightly sclerotized. Stylet 9–11 μ. Excretory pore posterior to nerve ring. Hemizonid just anterior to excretory pore. Overlapping esophageal glands located dorsally in a diverticulum, later more degenerate, and pushed to side by developing ovary.

Bionomics. This species has worldwide distribution and has been found in various situations in which rotting plant material was present. It has been successfully cultured on fungal plates.

Other species:
Hexatylus mulveyi Das, 1964.
Hexatylus vigissi Skarbilovich, 1952.
Syn. *Scytaleum vigissi* (Skarbilovich, 1952) Andrassy, 1961.

I believe that members of the genus *Hexatylus* should be limited to those nematodes having the strengthening rings surrounding the stylet, bifid stylet knobs, the prominent junction of the esophageal and intestinal lumena, and overlapping esophageal glands.

Summary

Studies of syntype specimens of *Neotylenchus abulbosus* Steiner, 1931, and *Hexatylus viviparus* T. Goodey, 1926, revealed that they were conspecific. Because *N. abulbosus*, the type species of *Neotylenchus*, is now a junior synonym of the type species of the older genus *Hexatylus*, the genus *Neotylenchus* becomes unavailable.

The esophagus of *Hexatylus viviparus* was found to have dorsally overlapping esophageal glands instead of a fusion of the esophagus with the intestine. The descriptions of the

genus *Hexatylus* and its type species *H. viviparus* are emended. Illustrations of *H. viviparus* are presented.

Neotylenchus consobrinus (de Man, 1907) Filipjev, 1936, and *Neotylenchus linfordi* Hechler, 1962, are transferred to the genus *Paurodontus* Thorne, 1941. *Neotylenchus arcuatus* Thorne, 1941, is transferred to the genus *Nothanguina* Whitehead, 1959, and the genera *Scytaleum* Andrassy, 1961, and *Neotylenchus* Steiner, 1931, are considered to be synonyms of the genus *Hexatylus* T. Goodey, 1926. The following species are placed in *species inquirendae*: *Neotylenchus acutus* Thorne, 1941; *N. beljaevae* (Atakhanov, 1959) Andrassy, 1961; *N. coprophagus* (T. Goodey, 1938) Thorne, 1941; *N. dendrophilus* Rühm, 1956; *N. intermedius* (Christie, 1938) Thorne, 1941; *N. latus* Thorne, 1935; *N. obesus* Thorne, 1934; *N. obtusicaudus* (Stek., 1941) Skarbilovich, 1952; *N. serpens* Andrassy, 1961; *N. velatus* (Bütschli, 1873) Skarbilovich, 1952; *N. zeae* (Stek., 1941) Skarbilovich, 1952; *Hexatylus boettgeri* Meyl, 1954; *H. brevicaudatus* Meyl, 1954; *H. dipapillatus* Meyl, 1954; *Scytaleum italicum* (Meyl, 1954) Andrassy, 1961; S. *skarbilowiezae* (Atakhanov, 1959) Andrassy, 1961; S. *thornei* (Meyl, 1954) Andrassy, 1961.

Acknowledgment

The author wishes to express thanks to Miss Patricia A. McIntosh for providing technical assistance on this study.

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Report of the Brayton H. Ransom Memorial Trust Fund

Funds on Hand, 1 January 1967	$2,500.49
Receipts: Interest received in 1967	155.47
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Parasitic Development of *Filipjevimermis leipsandra* Poinar and Welch (Mermithidae) in *Diabrotica u. undecimpunctata* (Chrysomelidae)

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Introduction

In July 1967 Dr. F. P. Cuthbert sent the author some living mermithids which had developed in larvae of *Diabrotica balteata* and were subsequently described as a new species, *Filipjevimermis leipsandra* Poinar and Welch (in press). The life history of this species will be discussed by Cuthbert (in press).

F. leipsandra is unusual in several respects. Males are very rare and not necessary for the propagation of the species. Another interesting character of this nematode is its association with the central nervous system of the host during the early stages of parasitism.

After penetrating through the cuticle and entering the hemocoel of the host larva, the infective stage nematode seeks out and enters one of the ganglia of the central nervous system. The protocerebral lobes and subesophageal ganglion are most frequently attacked, but other ganglia may also be entered. The nematodes do not initiate development without first entering a ganglion, and those which remain in the hemolymph are encapsulated and eventually killed.

Further studies on the host range of this nematode and selection of ganglia will be presented by the author and Dr. Götz, a visitor in this laboratory for three months during the autumn of 1967.

The present paper discusses the parasitic development of *F. leipsandra* and its association to the central nervous system of *D. u. undecimpunctata*.

Materials and Methods

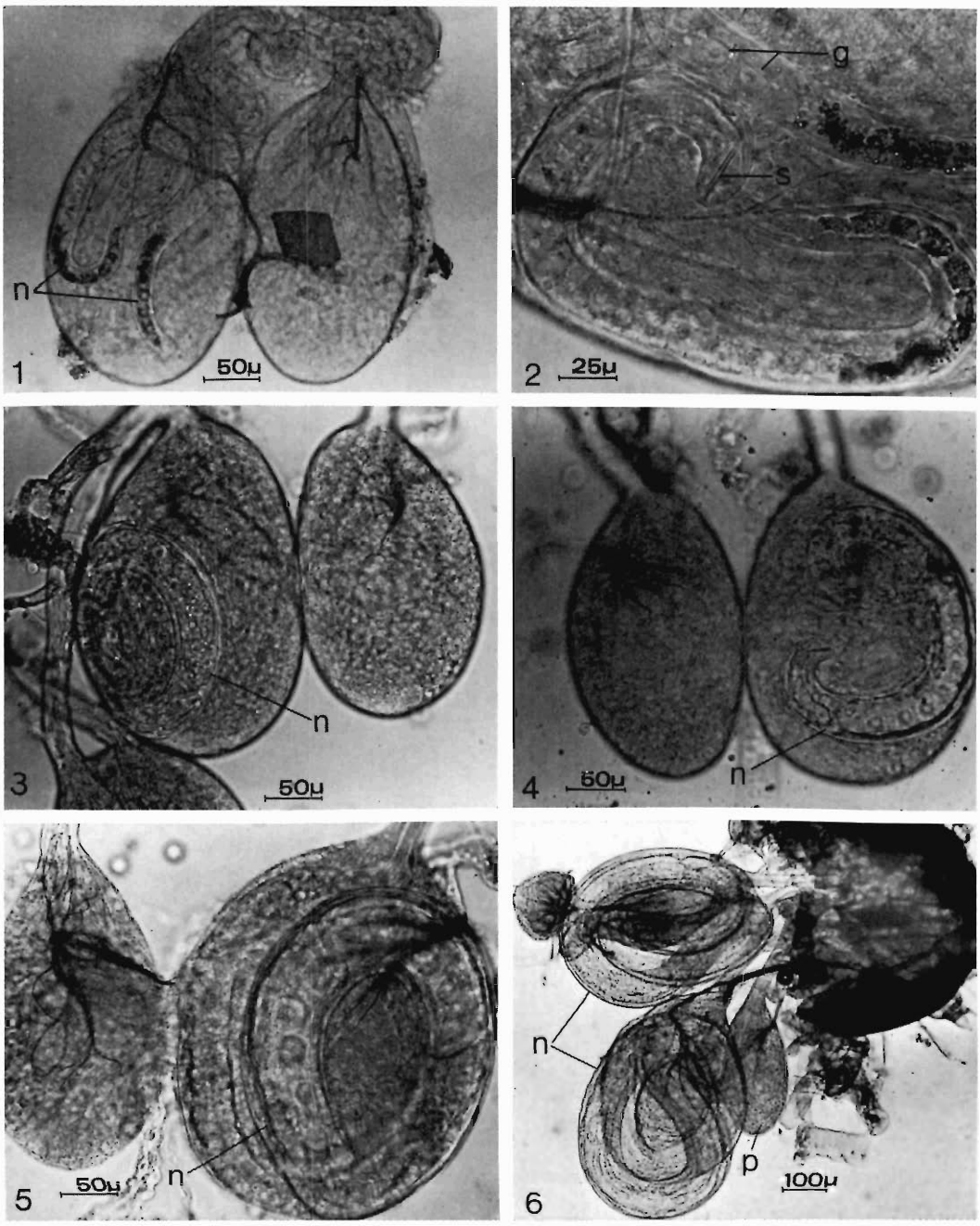
Adult mermithids oviposited in dishes of water. After the eggs hatched, the infective juveniles were held at 12 C for future infection experiments. Since *D. balteata* does not occur in Northern California, a local species, *D. undecimpunctata undecimpunctata* was successfully infected and served as a host for the nematode. Comparisons of this host with *D. balteata* showed that the parasitic development was similar in both insects. *Diabrotica u. undecimpunctata* was grown on corn seedlings using a modification of the method presented by Rimando et al. (1965). Larval development ranged from 18–25 days, with three instars.

One-day-old *Diabrotica* larvae were placed between two layers of moist filter paper in a small petri dish for laboratory infections. Infective stage nematodes were placed directly on the inner side of both pieces of filter paper. The edges of the paper were held together with a ring and the infection chamber left at 70 C for 80 minutes. The insects were then removed and kept on roots of germinating corn seedlings during the remainder of the experiment.

At regular intervals over a 4-week period, an infected host was dissected in Ringer's solution and nematode development noted. All observations, including photographs and drawings, were made by the author with fresh material lightly stained with cotton blue.

Results

The juvenile of *F. leipsandra* molted once within the egg before hatching. After hatching, the preparasitic stages were extremely active and entered the host by direct penetration through the cuticle. Observations indicated that both glandular secretions and stylet action aided penetration. When contact with the host was made, the nematode forced its head against the cuticle and began a succession of stylet movements. Occasionally, a quick movement of the host brushed off the nematode and viscous material could be seen coming from the mouth of the latter. In one instance after entering the hemocoel, the nematode migrated to the head end of the host and explored the periphery of the subesophageal ganglion for several seconds. It then forced its head through the neural lamella and perineurium and slowly entered the gan-



Figures 1–6. 1. Two juveniles of *F. leipsandra* 2 days after infection in one of the protocerebral lobes of a first instar *Diabrotica* larva. n = nematode. 2. Close-up of nematodes in figure 1 showing the gland cells or stichocytes (g) of 1 specimen and the stylet(s) of another. 3. *F. leipsandra* in a protocerebral lobe of a first instar *Diabrotica* larva 4 days after infection. n = nematode. 4. *F. leipsandra*

glion, following the inner contour of the neural lamella and eventually coming to rest in the neuropile. It appears that the cells and fibers in the ganglion are not broken, but just pushed aside as the nematode enters. Once inside the ganglion, the parasite remains still, only altering its position through subsequent growth.

The nematode may remain within the host from 12 to 22 days, depending on the state of the host and number of parasites present. After 22 days, the parasite may reach a size of 4.70 cm and a width of 0.26 mm. This is an enormous change from the average length (0.54 mm) and width (0.018 mm) of the infective juvenile.

The size of the parasite after 24 hours in the host did not differ significantly from that of the infective stage (Fig. 7). The well-developed stylet leads directly into the pharyngeal tube which runs the length of the pharynx. The anterior portion of the pharynx is narrow and consists of a cuticle lined tube surrounded by a layer of nucleated sheath tissue. The prominent nerve ring encircles this anterior portion of the pharynx, which gradually widens to its full width at the level of the atrophied gland reservoirs. These latter paired oval shaped bodies are what remains of the two long gland reservoirs of the infective juvenile.

In the infective stage, these reservoirs are filled with globules which are probably enzymes used in softening the host cuticle during penetration. The basal two-thirds of the pharynx, including the stichosome (Steiner, 1933) contains 16 gland cells or stichocytes. These cells are arranged in two rows forming the two subdorsal portions of the pharynx. The pharynx is attached to the intestine by a thin layer of connective tissue, however, this is only a physical, not a functional union and does not persist for long. The intestine proper is filled with globules, but a lumen in the anterior portion contains large crystals of unknown origin. These crystals are very distinct in the early parasitic stages, but gradually disappear and are absent in the postparasitic juvenile. The cellular structure of the gut is still obscure, but a distinct rectum and anus are present. The gonad rudiment lies on the ventral side of the body just behind the junction of the pharynx and intestine.

Figure 1 shows two nematodes in one of the protocerebral lobes of the host 2 days after infection. Although still no significant increase in length, the width was now 0.025 mm and the stichocytes were prominent (Fig. 2). Little noticeable change occurred after 3 days in the host except for an increase in width (0.034 mm). After 4 days, however, a significant increase in length (0.712 mm) as well as width (0.053 mm) produced a noticeable enlargement of the infested protocerebral lobe of the host (Fig. 3).

After 5 days within the protocerebral lobe of a first instar host, the nematode reached a length of 0.741 mm (Fig. 4, 8). The stylet and pharyngeal tube were distinct and the stichocytes increased greatly in size. Remnants of the paired gland reservoirs were still visible. Movement of the crystals within the intestinal lumen suggested that the lumen was filled with liquid. The cellular structure of the intestine proper is now evident and the rectum and anus are still distinct. Cells of the hypodermal cords are prominent. Increase in growth of the parasite after 6 days (L = 1.36 mm, W = 0.08 mm) forced it against the neural lamella of the protocerebral lobe in a second instar host (Fig. 5).

Most of the parasites broke out of the ganglion proper on the 7th day, but were still contained by the neural lamella which protected them from direct contact with the hemolymph (Fig. 9). The length increased greatly to 2.39 mm and the width to 0.11 mm. The structure of the stylet was obscure and the stichocytes began to elongate. The junction between the pharynx and intestine was severed and the gut grew forward. The gonad rudi-

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←

in a protocerebral lobe of a first instar *Diabrotica* larva 5 days after infection. n = nematode. 5. Greatly enlarged protocerebral lobe of a second instar *Diabrotica* larva containing a developing juvenile of *F. leipsandra* 6 days after infection. n = nematode. 6. Two specimens of *F. leipsandra* breaking out of a protocerebral lobe and the subesophageal ganglion, respectively, of a second instar *Diabrotica* larva 8 days after infection. Note that both specimens are still contained by the neural lamella which surrounds the ganglia. n = nematode; p = uninfected protocerebral lobe.

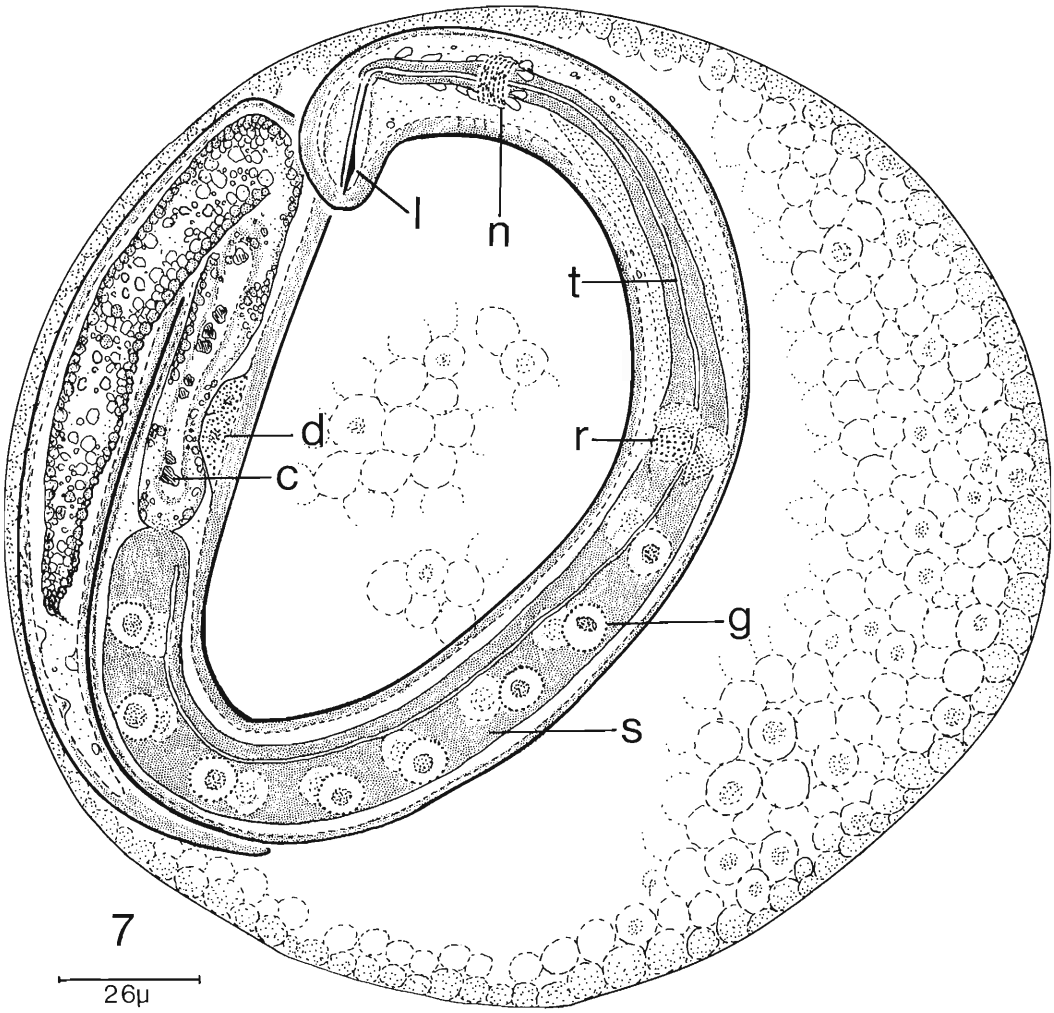

Figure 7. ***F. leipsandra*** **in the first thoracic ganglion of a first instar** ***Diabrotica*** **1 day after infection. s = stichosomal portion of pharynx; g = gland cell or stichocyte; r = gland reservoir; t = pharyngeal tube; n = nerve ring; l = stylet; d = gonad; c = crystals in anterior lumen of intestine.**

ment was still an undifferentiated mass of cells. After 8 days in the ganglia of a second stage host, the parasite reached a length of 2.7 mm (Fig. 6). The neural lamella continued to stretch, and on the 9th day still contained the parasite, which had reached a length of 5.00 mm and a width of 0.11 mm. The pharynx had now assumed a distinct tripartate structure with the ventral portion containing the pharyngeal tube, and the two subdorsal portions each with a row of eight large stichocytes. The intestine reached its definitive location in relation to the rest of the body and the gonad rudiment began to differentiate into vaginal and ovarial portions (Fig. 10).

The nematode remained within the pouch for two more days while the neural lamella stretched up to 3 mm in length. The membrane broke on the 12th day after infection and the parasites moved directly into the host hemocoel. The period the nematode remained inside the ganglia proper and the membrane,

respectively, varied depending on the rate of infection and age of the host. Growth in length continued at a phenomenal rate and on the 14th day, the nematode was 34.6 mm long and 0.20 mm wide.

When the nematode emerged from the host, in this case on the 22nd day, it had reached a length of 47.0 mm and a width of 0.26 mm. Although the intake of nourishment probably ceased even before the nematode made its exit from the host, sexual differentiation continued up to the postparasitic molts and ovarial development continued until the nematode expired.

Discussion

The parasitic development of *Filipjevimermis leipsandra*, as with mermithids in general, results in an extreme increase in length rather than width as is found in other entomogenous nematodes (Poinar, 1965). In one case, the length and width increased 87 and 14 fold respectively over a 22-day period in the host. No sign of a molt was noted during the parasitic period. One molt occurred within the egg just before hatching and the postparasitic juvenile molted twice before oviposition. The sensory papillae were obscure during parasitic development, although the nerve ring and associated cells were distinct at all stages.

An increase in length did not occur until the 4th day after infection. This may be typical of mermithid development since Christie (1936) also remarked that with *Agamermis decaudata* in *Melanoplus femur-rubrum*, there was little change in length of the parasite during the first three days in the host. However, internal development began immediately after entering the host. This was especially evident with the stichocytes of the pharynx.

Although Hyman (1951) considered the pharynx and stichosome as separate structures in the Mermithidae, it is obvious that they are part of the same organ and the stichosome is regarded here as a highly specialized part of the pharynx.

During parasitic development, the basal portion of the pharynx differentiates into three longitudinal divisions. The ventral part contains the remainder of the pharyngeal tube which ends blindly at the base of the organ. The two subdorsal portions each contain a row of eight gland cells or stichocytes and they may jointly be regarded as the stichosome (Steiner, 1933). The stichocytes are large clear cells with granular nuclei and are most prominent during the early stages of parasitism. They probably play an important role in the nutrition of the nematode, but their exact nature is unknown. In later parasitic and postparasitic stages the stichosome tissue breaks down and the posterior part of the pharynx consists of isolated stichocytes attached to the slender pharyngeal tube.

The number of stichocytes in *F. leipsandra* was constantly 16 which may be basic for mermithids since Christie (1936) also found 16 in developing juveniles of *Agamermis decaudata* and Götz (1964) recorded 16 in juveniles of *Gastromermis rosea*. However, other workers have found variable numbers; Johnson (1955) recorded from 15–17 in *Hydromermis contorta* depending on the age of the juvenile, and Couturier (1963) found up to 10 in *Tunicamermis melolonthae*. A bulblike enlargement of the pharynx as Christie (1936) reported in juveniles of *A. decaudata* was lacking in *F. leipsandra*.

The intestine, or trophosome as it is called in its modified form in mermithids, appears initially as a tube filled with globular inclusions. Intestinal cells become distinct by the 5th day and the intestine rapidly begins to elongate by the 7th day. The significance of the lumen in the anterior portion of the trophosome with its crystal contents is unknown.

A minute, nonfunctional anus and rectum are present throughout most of the parasitic development, but only a vestigial anus remains in the postparasitic juvenile. The cells forming the hypodermal chords are distinct during all stages of development and some appear to be binucleate or in process of division. Although cells of the gonad rudiment begin dividing early in the development, sexual differentiation was completed only after the parasites left the host. No sign of an excretory pore was seen during this study.

Most nematodes which develop exclusively in invertebrates are not known to invade specific tissues of the host, in contrast to the filarioid and spiruroid nematodes which utilize invertebrates as intermediate hosts. However, even in the latter two groups, a record of

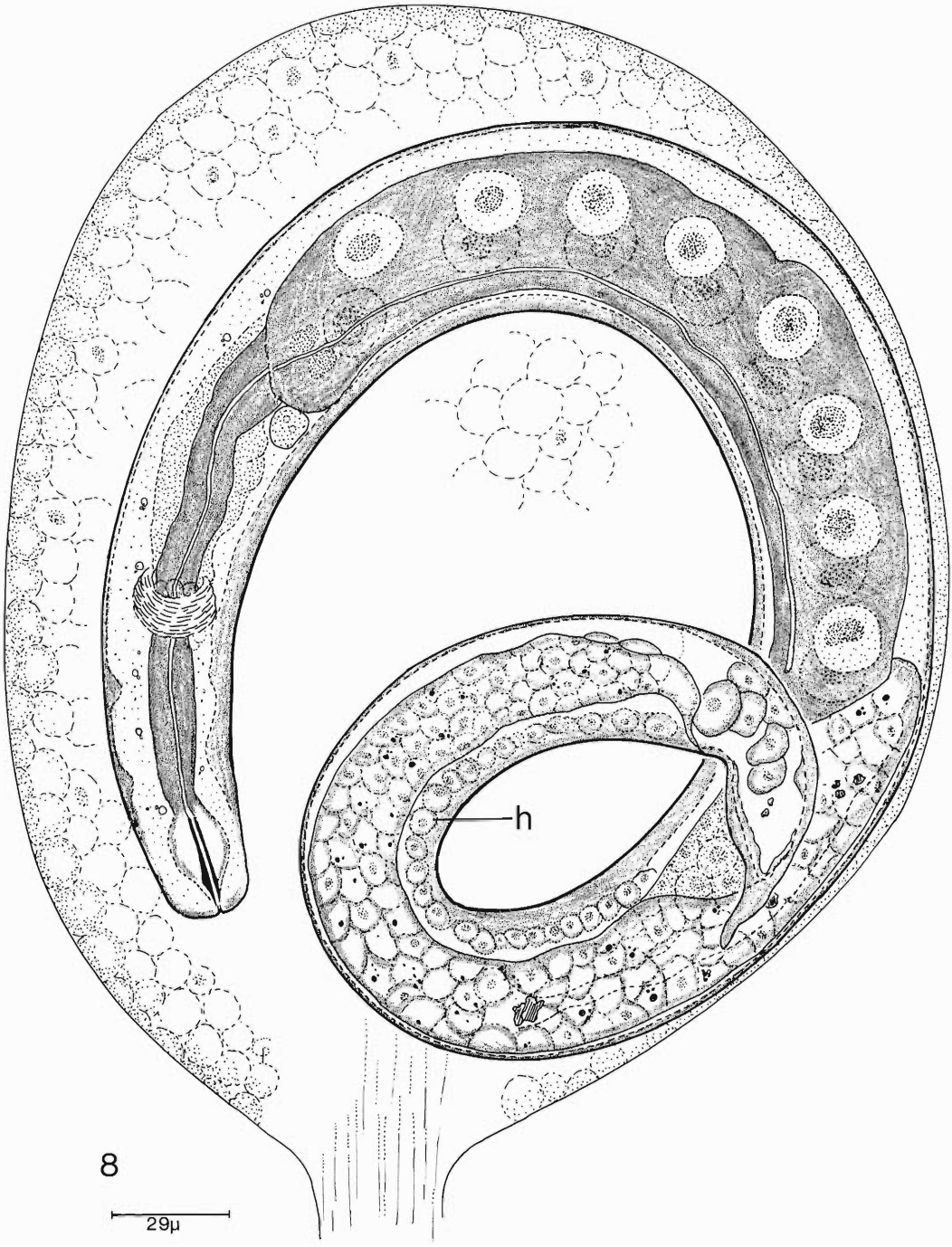

Figure 8. Developing juvenile of *F. leipsandra* 5 days after infection in a protocerebral lobe of a first instar *Diabrotica* larva. h = hypodermal cell.

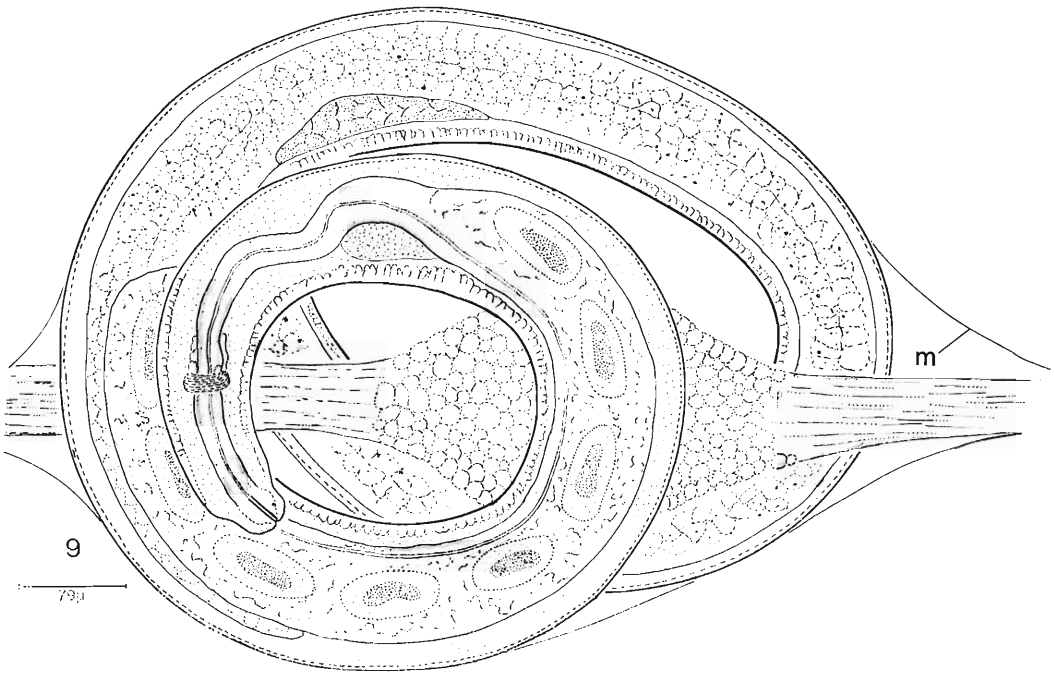

Figure 9. Developing juvenile of *F. leipsandra* which has just broken out of an abdominal ganglion of a second instar *Diabrotica* larva 7 days after infection. It is retained by the thin neural lamella (m).

development in the nervous system of the host could not be found, although Lavoipierre (1958) mentions once finding a juvenile of *Loa loa* partly embedded in the brain of the adult fly, *Chrysops silicea*.

Thus, it was surprising to discover a mermithid which showed an affinity to the ganglia of an insect host. Still, the affinity of mermithid nematodes to specific tissues of insects may be more widespread than imagined since Hagan and Hoopingarner (in press) found the early stages of an undetermined mermithid in the brain lobes of larvae of *Aedes stimulans*.

One of the most obvious reasons for *F. leipsandra* to enter the ganglia of *Diabrotica* would be to escape encapsulation and subsequent death. It is interesting that the parasite is not attacked by blood cells when it breaks out of the ganglion and neural lamella 9–12 days after infection. Whether the nematode is now too large or has acquired some attribute which makes it "acceptable" to the host is not known. A similar situation was reported by Strickland (1930) working with the tachinid *Gonia* and noctuid larvae. Upon entering the body cavity, the parasites were encapsulated unless they entered the supraesophageal ganglion of the host. After remaining there for a few days, they re-entered the body cavity and were not attacked by blood cells. Other mermithids occurred in a sheath within their hosts, but whether this protected them from an encapsulation reaction is not known (Rennie, 1925; Couturier, 1963).

The "normal" host of an entomogenous nematode is usually considered one in which the association supposedly has been of such long standing that the parasite is now "accepted" with a minimum of host reaction (Poinar, in press). The behavior of *F. leipsandra* could represent an intermediate step in adapting to a parasitic development free in the hemolymph of *Diabrotica*, or it could represent the end of a specialized line of selection, enabling the parasite to avoid the defense reaction of various hosts.

If the latter is true, and artificial infection studies with various hosts suggest this, then

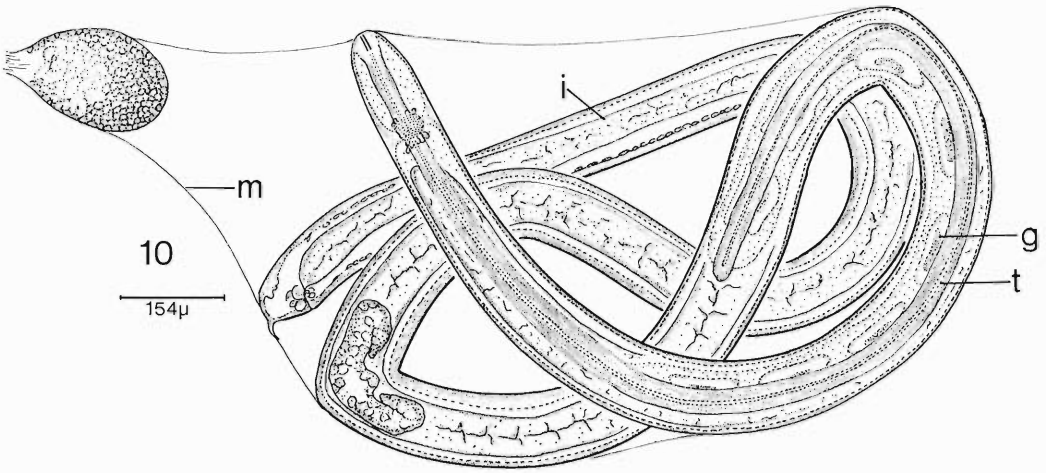

Figure 10. ***F. leipsandra*** **9 days in the host and held within the neural lamella (m) of the protocerebral lobe of a second instar** ***Diabrotica*** **larva. i = intestine or trophosome; g = gland cell or stichocyte; t = pharyngeal tube.**

the nematode may not be hindered by the defense reaction of new "unusual" hosts and would be able to expand its host range. In fact, *Diabrotica* may be a relatively "recent" host since it could easily destroy the parasites by encapsulation if they did not enter the ganglia. Of course, the possibility that the ganglia furnish developing juveniles of *F. leipsandra* some subtle nutritional factor necessary for development is still open for investigation.

Summary

First instar larvae of *Diabrotica u. undecimpunctata* were infected in the laboratory with juveniles of the mermithid nematode, *Filipjevimermis leipsandra*. The infective stage nematodes penetrated directly into the hemocoel and then entered one of the ganglia of the host. The protocerebral lobes and subesophageal ganglion were most frequently attacked. The parasites developed initially within the ganglia, then after outgrowing the latter, were retained by the neural lamella, which stretched a considerable distance before finally breaking and liberating the nematodes in the host hemolymph.

The growth and internal development of the parasite were studied by dissecting infected hosts at regular intervals. Parasitic development lasted from 12 to 22 days, a relatively short period for such a tremendous increase in length of the nematode.

Acknowledgments

The author expresses his sincere thanks to Dr. Cuthbert for providing the original supply of nematodes, to Mr. R. A. Corey of the Shell Development Company, Modesto, California, for his help in rearing methods of *Diabrotica* and to Mr. Carl Reiner who patiently maintained colonies of *D. u. undecimpunctata* for experimental use at the University. Grateful appreciation is also extended to Mr. Gerard Thomas who assisted in technical aspects of this study.

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A Revision of the Genus *Rotylenchulus* Linford and Oliveira, 1940 (Nematoda: Tylenchidae)[1]

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Species of the genus *Rotylenchulus* have been one of the most misidentified groups of all the tylenchs. As evidence, nematodes belonging to this genus have been described in at least four different genera. Also this genus has been variously assigned to three families: Tylenchidae (Linford and Oliveira, 1940; Thorne, 1949, 1961; Allen and Sher, 1967); Heteroderidae (Chitwood and Chitwood, 1950; Skarbilovich, 1960); Hoplolaimidae (Hopper and Cairns, 1959; Goodey, 1963; Husain and Khan, 1967) and five different subfamilies: Nacobbinae (Hopper and Cairns, 1959; Goodey, 1963); Pratylenchinae (Thorne, 1949, 1961; Baker, 1962); Tylenchulinae (Skarbilovich, 1960); Hoplolaiminae (Loof and Oostenbrink, 1962); Rotylenchulinae (Husain and Khan, 1967; Allen and Sher, 1967).

The genus *Rotylenchulus* was proposed by Linford and Oliveira in 1940 when they described *R. reniformis*. Yokoo and Tanaka (1954) described *Tetylenchus nicotiana* from Japan which was subsequently transferred to the genus *Rotylenchulus* by Baker (1962).

Three other species (*Helicotylenchus elisensis* Carvalho, 1957, 1959; *Spirotylenchus queirozi* Lordello and Cesnik, 1958, and *Helicotylenchus parvus* Williams, 1960) were transferred to the genus *Rotylenchulus* by Sher (1961). In 1960 Das proposed a new genus, *Leiperotylenchus*, which he considered to be closely related to *Tylenchus* and *Ditylenchus*. However, the position of the dorsal gland orifice and characters of male tail indicated a close relationship with *Rotylenchulus*. Indeed, Loof and Oostenbrink (1962) transferred *Leiperotylenchus leiperi* to the genus *Rotylenchulus*. Goodey (1963) synonymized *elisensis*, *parvus*, *leiperi* and *queirozi* with *R. reniformis*. Husain and Khan (1965) described

[1] A part of the thesis submitted by senior author in partial fulfillment of the requirements for the Ph.D. degree, University of California, Davis.

R. stakmani from India. Swarup, et al. (1967) considered it a synonym of *R. reniformis*.

The kidney-shaped mature females from which the common name, reniform nematodes, was derived, are described only in two species, *R. reniformis* and *R. borealis*. The descriptions of other species were based on immature females and males.

Representatives of the genus *Rotylenchulus* have world-wide distribution and their host records are numerous and diverse (Linford and Yap, 1940; Peacock, 1956; Martin, 1955). Their general occurrence and economically great potential as plant pathogens make it especially important that the taxonomy of this group be soundly established to assure accurate identification of species. For this purpose this study has been carried out.

Materials and Methods

Over 3,500 permanently mounted specimens of *Rotylenchulus* from more than thirty countries covering most parts of the world have been assembled for this generic revision. Type specimens for most of the nominal species of this genus were obtained.

For immature females two measurements of the esophagus, b and b′ (Sher, 1963), are included in the de Man formula. Also included in these measurements are: o (Perry, Darling and Thorne, 1959); c′ (Sher, 1966) and h (length of hyaline portion of tail in microns). The measurements given in parenthesis in descriptions of the holotype, allotype and neotype refer to population range.

An immature female was designated as holotype for *R. parvus* and mature females as holotype for *R. borealis* and neotype for *R. nicotiana*. The immature female is used as the holotype for the new species described here because many morphological characters are more easily seen in these than in swollen females. The swollen female is more difficult to collect, indeed is unknown for most species despite diligent search for them.

Type specimens are being deposited in five permanent institutional collections which are indicated by the following abbreviations: University of California Nematode Collection, Davis (UCNC, Davis); University of California Nematode Collection, Riverside (UCNC, Riverside); United States Department of Agriculture Nematode Collection, Beltsville, Maryland (USDANC, Beltsville); Nematology Department, Rothamsted Experimental Station, Harpenden, England (NDRES, England); Plantenziektenkundige Dienst, Wageningen, The Netherlands (PD, The Netherlands).

Morphology of *Rotylenchulus*

Rotylenchulus species are characterized by sexual dimorphism, mature females being swollen to kidney shape and males vermiform with not as well developed stylet and esophagus. Although detailed morphology of mature females is obscure, the overall shape and that part of the body posterior to the vulva provide useful taxonomic characters. Fixed specimens of males, immature females and larvae assume a spiral to open C shape upon fixation.

INCISURES: Immature females, males and larvae all have four incisures in the lateral field. Posteriorly on males these incisures extend varying distances from slightly anterior to the cloacal opening to about midway on the tail. The most ventral line always ends at the level of or anterior to the cloaca and on the caudal alae except in *R. macrodoratus* where that ventral line appears to merge with the edge of the caudal alae. The lateral field of mature females was not visible.

PHASMIDS: These are porelike and located slightly anterior to the middle of the tail.

EXCRETORY PORE: The excretory pore is located posterior to the median bulb in all species.

HEMIZONID: The hemizonid is two to three annules long and immediately anterior to the excretory pore.

LIP REGION: The lip region is continuous, not set off and varies in shape and annulation. Most species have either low and rounded lip region (*R. parvus*) or higher and conoid in shape (*R. macrodoratus* n. sp.). Some species appear to be intermediate between these two categories (*R. reniformis*).

Immature females of some species have three or more distinct annules (*R. reniformis*). In other species there is evidence of fine annulations, but these are difficult to count (*R. parvus*). There is still another group where annulation is entirely lacking or the annules are too fine to resolve (*R. leptus* n. sp.).

The shape and annulation of the lip region

of larvae in all species are similar to the immature females except *R. anamictus* n. sp. where the larvae have a conoid lip region in contrast to the low and rounded lip region of immature females. Males in general have a rounded lip region.

The labial framework of immature females is conspicuous. The cheilorhabdions are thickened anteriorly, extend laterally and in some species are thickened at both ends. The basal ring of the cephalic framework has the same thickness as that of the cheilorhabdions and arches posteriorly in a characteristic manner. The cephalic framework in males is weaker than that in immature females.

STYLET: Total length of the stylet and size and shape of the stylet knobs provide taxonomically important characters. Stylet length in immature females ranges from 10–26 μ. The stylet knobs slope backward except in *R. macrodoratus* n. sp. (Fig. 10, A and D) where the knobs are anchor-shaped in immature females and in larvae. The male stylet is smaller and less developed than the corresponding female stylet and knobs are much reduced.

DORSAL GLAND ORIFICE: One of the important characters of *Rotylenchulus* is the location of the dorsal esophageal gland orifice. Its position varies from 0.56–1.90 times the stylet length posterior to the stylet knobs and is diagnostic for different species.

ESOPHAGUS: The esophagus of immature females is long with a well-developed median bulb and valve, distinct long and narrow isthmus, and lobelike glandular region. The posterior region of the esophagus is usually hemispherical in shape but there is occasional intrapopulation variation in this character. The glandular region of the esophagus overlaps the intestine laterally and ventrally and is predominantly lateral. The lumen of the esophagus curves ventrally in the form of an open loop at the dorsal gland orifice. The tissue at the junction of esophageal lumen with the intestine appears to be more dense than the surrounding area. No distinct valve could be found at the junction. The esophageal gland nuclei are three in number.

The esophagus of mature females is irregular in shape. The median bulb of mature females is spheroid, more than twice the size of the median bulb of immature females. The esophagus in males is much reduced with almost no evidence of the median bulb, valve and lumen. The posterior part of the male esophagus overlaps the intestine laterally and ventrally, usually more ventrally.

The esophagus of the second-stage larva is not reduced like that of males. Often it is obscure in fixed specimens but when seen it is usually similar to the immature female. However, the posterior part of the esophagus of larvae is often asymmetrical.

REPRODUCTIVE SYSTEM: *Rotylenchulus* females have didelphic, amphidelphic ovaries. The ovaries of immature females are very small and undeveloped. Each ovary forms a double flexure near the distal end (Fig. 4, B) which is unique among tylenchs. The details of mature female reproductive systems could not be traced in their entirety due to the densely-packed granules and much coiling of the ovaries. One of the useful characters in distinguishing species is the postmedian position of the vulva. The value of V usually falls between 58–66 except for *R. reniformis* and *R. anamictus* n. sp. where it is more posteriorly located. Lips of the vulva of mature females usually protrude to varying degrees beyond the body contour. The transverse slit of the vulva widens about halfway across the body assuming a funnel shape. The uterus in mature females is distinctly convoluted. Nakasono (1966) reported recognizable sperms and spermatheca in egg-laying females in this genus. These structures have been observed in some species and the presence or absence of sperms and spermatheca might prove to be a useful taxonomic character. Unfortunately, these structures usually cannot be observed due to the coiling of the ovaries.

The male reproductive system is monorchic and outstretched. Gubernaculum and spicules are well-developed. Caudal alae are much reduced, adanal and annulated.

TAIL: Generally the tail shape of the larvae is rounded whereas it is more pointed in the immature females. There is considerable intraspecific variation in tail shape of immature females which limits the diagnostic value of this character. However, length of tail, ratio of anal body diameter to tail length (c′) and length of the hyaline portion of the tail (h) are important for distinguishing species. The

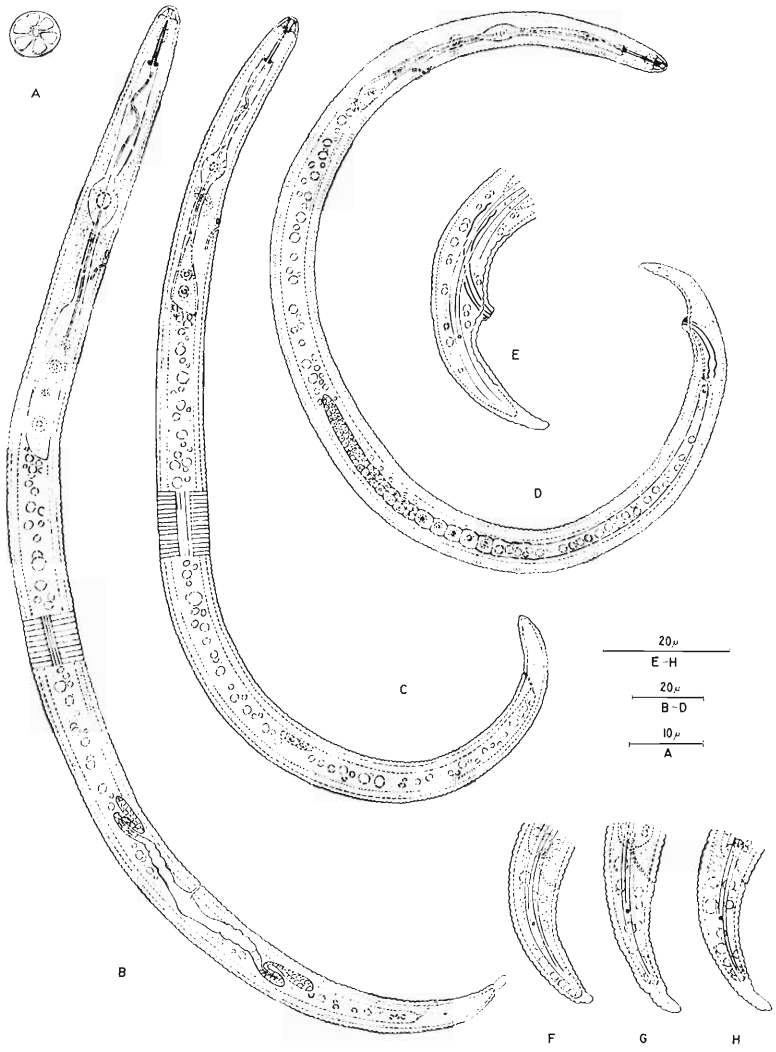

Figure 1. ***Rotylenchulus reniformis.*** **A—Immature female, face view; B—Immature female; C—Larva; D—Male; E—Male, tail; F–H—Immature female, tail.**

body content of the larvae reaches almost to the terminus and there is virtually no indication of a hyaline area.

The distal portion of the tail of mature females in some species is set off into a finger-like appendix. In other species the distal portion of the tail is in the shape of a short spike. Still in other species the tail is bluntly rounded with no indication of an appendix or projection.

Systematics
Subfamily Rotylenchulinae Husain and Khan, 1967

DIAGNOSIS EMENDED: Tylenchidae. There is only one genus in this subfamily and the characters of that genus, *Rotylenchulus*, constitute the characters of the subfamily.

Type genus *Rotylenchulus* Linford and Oliveira, 1940.

Genus *Rotylenchulus*

Rotylenchulus Linford and Oliveira, 1940, pp. 35–39; Thorne, 1949, pp. 41–42; Thorne, 1961, pp. 244–245; Goodey, 1963, pp. 87–88.

Spirotylenchus Lordello and Cesnik, 1958, p. 161; Sher, 1961, p. 159.

Leiperotylenchus Das, 1960, pp. 560–562.

DIAGNOSIS EMENDED: Rotylenchulinae. Mature female swollen, kidney-shaped, male vermiform. Lip region of immature female not set off, cephalic framework conspicuous. Dorsal gland orifice more than one-half stylet length posterior to base of stylet knobs. Esophagus long with narrow isthmus, glands overlapping intestine laterally, ventrally, more often laterally. Vulva post-median, ovaries didelphic, amphidelphic with two flexures in immature female, highly convoluted in mature female. Female tail usually more than twice anal body diameter. Larval tail more rounded than tail of immature female. Phasmid pore-like, anterior to middle of tail. Male with weak stylet and stylet knobs, reduced esophagus, indistinct median bulb and valve. Caudal alae adanal. Lateral field of male, immature female and larvae with four incisures, nonaerolated. Eggs deposited in gelatinous matrix.

Type species *Rotylenchulus reniformis* Linford and Oliveira, 1940.

Rotylenchulus reniformis Linford and Oliveira (Figs. 1, A–H; 2, A–H)

syn. *Tetylenchus nicotiana* Yokoo and Tanaka, 1954.
Rotylenchulus nicotiana (Yokoo and Tanaka, 1954) Baker, 1962. New Synonymy.
Rotylenchus elisensis Carvalho, 1957.
Helicotylenchus elisensis (Carvalho, 1957) Carvalho, 1959.
Spirotylenchus queirozi Lordello and Cesnik, 1958.
Rotylenchulus queirozi (Lordello and Cesnik, 1958) Sher, 1961.
Leiperotylenchus leiperi Das, 1960.
Rotylenchulus leiperi (Das, 1960) Loof and Oostenbrink, 1962.
Rotylenchulus stakmani Husain and Khan, 1965.

MEASUREMENTS: (16 mature ♀, Hawaii, population originally from type locality, reared on cowpea): L = 0.38–0.52 mm; width at vulva = 0.10–0.14 mm; a = 4–5; V = 68–73; length of swollen portion of body plus tail = 0.19–0.47 mm; stylet = ?; median esophageal bulb diameter = 18–22 μ.

(26 immature ♀ topotypes): L = 0.34–0.42 mm; a = 22–27; b = 3.6–4.3; b′ = 2.4–3.5; c = 14–17; c′ = 2.6–3.4; h = 4–8; V = 68–73; stylet = 16–18 μ; o = 81–106.

(10 ♂ topotypes): L = 0.38–0.43 mm; a = 24–29; b′ = 2.8–4.8; c = 12–17; h = 4–8; T = 35–45; stylet = 12–15 μ; gubernaculum = 7–9 μ; spicules = 19–23 μ.

(10 larvae topotypes): L = 0.35–0.41 mm; a = 20–24; b′ = 3.5–4.1; c = 12–16; stylet = 13–15 μ.

IMMATURE FEMALE (neotype): L = 0.40 mm; a = 24; b = 3.8; b′ = 2.8; c = 16; c′ = 2.9; h = 6; V = 72; stylet = 16 μ; o = 82. Lateral field slightly less than quarter of body width. Body in open C shape. Lip region high, conoid, rounded, not set off from body, with 5 annules (4–6). Stylet knobs rounded, slope backward. Excretory pore 77 μ from anterior end (73–90 μ) at the level of posterior end of isthmus below hemizonid. Metacorpus elongate, oval and valve massive 4 μ (4–6 μ) long. Esophageal glands overlap intestine laterally and ventrally, the longest overlap ventral. Tail 24 μ (19–26 μ) long, conoid, terminus rounded.

MATURE FEMALES: Anterior part of body contour irregular. Body curved ventrally. Esophagus irregular in shape. Metacorpus spherical, with large valve. Vulva with raised lips. Vagina funnel shaped. Spermatheca spherical to irregular in shape containing many sperms. Body swollen almost to terminus then round to grossly hemispherical shape. Spike-like process of tail short (5–8 μ).

MALES: More slender than immature females. Lip region high, rounded, cephalic sclerotization and stylet weaker than immature females. Esophagus reduced, lumen usually difficult to see. Caudal alae adanal and rudimentary.

LARVAE: Resembling immature females. Posterior part of esophagus asymmetrical. Esophageal glands overlap intestine laterally and ventrally. Dorsal gland orifice about one stylet length posterior to stylet knob base. Genital primordium four-celled, at the same

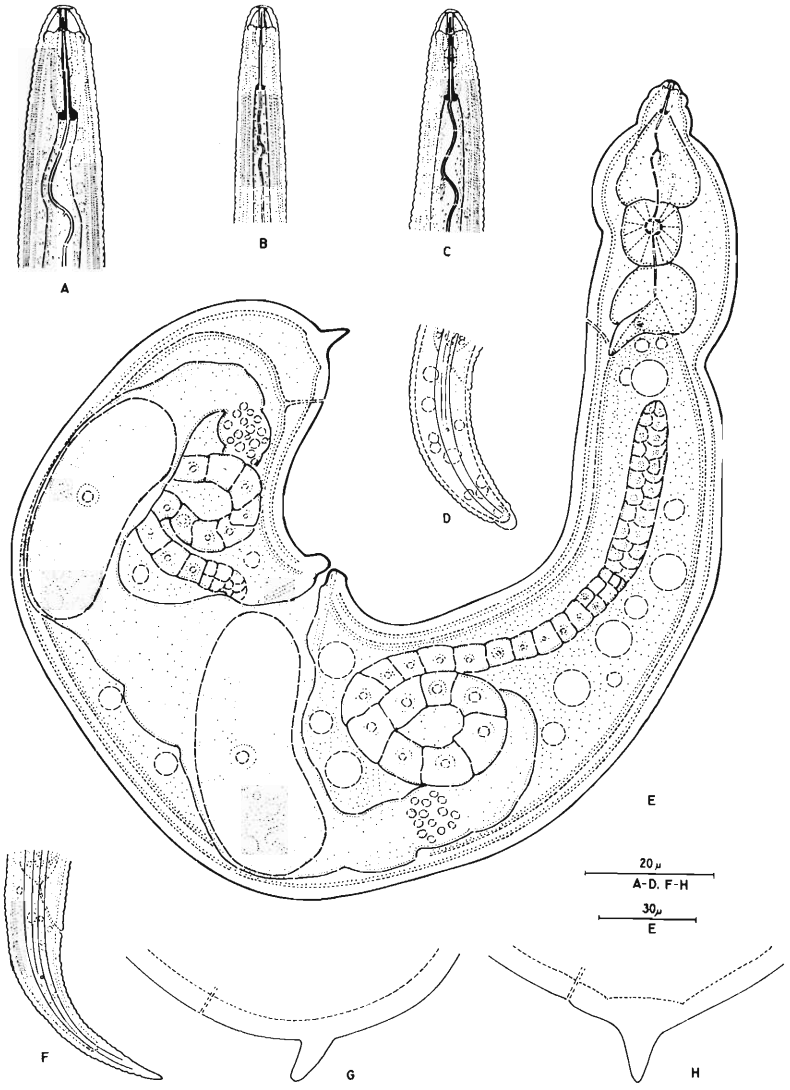

Figure 2. ***Rotylenchulus reniformis.*** **A—Immature female, anterior end; B—Male, anterior end; C—Larva, anterior end; D—Larva, tail; E—Mature female; F—Immature female (Ratnapura, Ceylon), tail; G–H—Mature female, tail.**

position as vulva. Tail more rounded than immature females.

NEOTYPE: Immature female, collected by J. Radewald, 24 February 1961, slide numbered 900, UCNC, Davis.

TOPOTYPES: 23 mature ♀, 75 immature ♀, 20 ♂, 21 larvae same data as neotype, distributed as follows: 12 mature ♀, 47 immature ♀, 16 ♂, 21 larvae on slides numbered 901–928, UCNC, Davis; 3 mature ♀, 7 immature ♀, 1 ♂, slides numbered R1–R3, UCNC, Riverside; 2 mature ♀, 9 *immature* ♀, 1 ♂, slides numbered T587–T590, USDANC, Beltsville; 2 mature ♀, 6 immature ♀, 1 ♂, slides numbered 60/1/10–60/1/13, NDRES, England; 2 mature ♀, 6 immature ♀, 1 ♂, slides numbered b66–69, PD, The Netherlands.

NEOTYPE HABITAT AND LOCALITY: Soil

around pineapple (*Ananus sativus*), Dole Corporation, Field 4522, Block C-9, County of Oahu, Hawaii, USA.

TOPOTYPES OF *R. elisensis* (4 immature ♀): L = 0.38–0.43 mm; a = 27–28; b = 3.7–3.9; b′ = 2.8–2.9; c = 13–14; c′ = 2.9–3.3; h = 8–9; V = 69–70; stylet = 17–18 μ; o = 79–81.

TOPOTYPES OF *R. elisensis* (4 ♂): L = 0.43–0.47 mm; a = 28–31; b′ = 3.9–4.1; c = 15–17; h = 7–8; T = ?; stylet = 12–13 μ; gubernaculum = 8–9 μ; spicules = 20–22 μ.

PARATYPES OF *R. stakmani* (5 ♀): L = 0.34–0.39 mm; a = 24–26; b = 3.6–3.7; b′ = 2.7–3.5; c = 14–16; c′ = 2.8–3.0; h = 5–7; V = 70–72; stylet = 16–18 μ; o = 100.

PARATYPES OF *R. stakmani* (3 ♂): L = 0.38–41 mm; a = 28–29; b′ = 3.8–4.2; c = 14–15; h = 4–6; T = ?; stylet = 14–15 μ; gubernaculum = 8–9 μ; spicules = 18–22 μ.

TOPOTYPES OF *R. nicotiana* (8 immature ♀): L = 0.36–0.44 mm; a = 24–31; b = 3.5–3.9; b′ = 2.7–3.1; c = 12–14; c′ = 3.1–3.8; h = 6–12; V = 69–72; stylet = 17–19 μ; o = 75–90.

TOPOTYPES OF *R. leiperi* (8 immature ♀): L = 0.35–0.41 mm; a = 23–26; b = 3.6–4.0; b′ = 2.5–3.5; c = 14–15; c′ = 2.8–3.0; h = 5–6; V = 70–73; stylet = 16–18 μ; o = 81–98.

TOPOTYPES OF *R. leiperi* (4 ♂): L = 0.39–0.43 mm; a = 26–28; b′ = 3.6–4.0; c = 13–14; h = 4–6; T = 30–32; stylet = 12–13 μ; gubernaculum = 7–8 μ; spicules = 18–21 μ.

22 immature ♀ (Ratnapura, collection no. 1, Ceylon): L = 0.43–0.53 mm; a = 27–32; b = 3.6–4.4; b′ = 3.0–3.5; c = 11–15; c′ = 3.9–5.0; h = 8–12; V = 68–71; stylet = 20–22 μ; o = 70–100.

8 immature ♀ (Ratnapura, collection no. 2, Ceylon): L = 0.33–0.46 mm; a = 21–33; b = 3.7–3.9; b′ = 2.9–3.5; c = 13–15; c′ = 2.9–3.7; h = 5–10; V = 69–72; stylet = 16–20 μ; o = 86–100.

6 ♂ (Ratnapura, collection no. 2, Ceylon): L = 0.35–0.46 mm; a = 25–34; b′ = 3.4–4.2; c = 14–16; h = 5–6; T = 29–40; stylet = 12–14μ; gubernaculum = 6–8 μ; spicules = 18–21 μ.

15 immature ♀ (Sherwood forest, Jamaica): L = 0.43–0.53 mm; a = 27–32; b = 3.6–4.7; b′ = 2.8–3.5; c = 13–17; c′ =3.8–4.6; h = 4–6; V = 67–72; stylet = 17–21 μ; o = 76–105.

6 immature ♀ (Kingston, Jamaica): L = 0.41–0.49 mm; a = 24–28; b = 3.9–4.5; b′ = 3.0–3.7; c = 11–14; c′ = 4.0–5.0; h = 5–9; V = 68–70; stylet = 18–21 μ; o = 75–105.

13 immature ♀ (San Miguel, Philippines): L = 0.42–0.44 mm; a = 27–32; b = 3.6–4.9; b′ = 2.9–3.5; c = 11–13; c′ = 4.1–4.6; h = 5–10; V = 67–70; stylet = 18–20 μ; o = 75–100.

4 mature ♀ (Florida, USA): L = 0.40–0.64 mm; width at vulva = 0.08–0.14 mm; a = 4–5; V = 66–72; length of the swollen portion plus tail = 0.26–0.46 mm; stylet = 14–15 μ; median esophageal bulb diameter = 19–24 μ.

10 mature ♀ (Hawaii, USA): L = 0.44–0.57 mm; width at vulva = 0.11–0.14 mm; a = 4–5; V = 67–70; length of the swollen portion plus tail = 0.25–0.40 mm; stylet = ?; median esophageal bulb diameter = 19–20 μ; eggs = 60–94 μ × 37–44 μ.

Mature females of *R. reniformis* also have been identified from the following habitats and localities: pineapple root, Columbia; soya (*Glycine max*) root, Gold Coast; tomato (*Lycopersicon esculentum*) root, Japan; tomato root, Nigeria; *Vigna sesquipedales* root, Philippines; *Yucca gloriosa* root, San Bernardino, USA.

DIAGNOSIS: *R. reniformis* can be identified by its high conoid and rounded lip region of the immature females, more posterior position of the vulva in the immature and mature females, hemispherical shape of body beyond anus ending in a short spikelike process in mature females.

R. reniformis is the most widely distributed species of the genus. Immature females and males have been examined and identified from the following habitats and localities: tomato soil, Sao Paulo, Brazil; cocoa (*Theobroma cacao*) soil, Kandy, Ceylon; tea (*Thea sinensis*) soil, Ratnapura, Ceylon; coconut (*Cocos nucifera*) and tea soil, Ceylon; jungle soil, Kahawatta, Ceylon; malanga (*Arum* sp.) soil, papaya (*Carica papaya*) soil, sweet potato (*Ipomoea batatas*) soil, Vinales, Cuba; banana (*Musa* sp.) soil, Kerala, India; rose (*Rosa* sp.) soil, Delhi, India; potato (*Solanum tuberosum*) soil, Aligarh, India; *Sorghum* sp. soil, Hyderabad, India; soil around unknown plant, Java, Indonesia; tobacco (*Nicotiana* sp.) soil, Java, Indonesia; tea soil, Java, Indonesia; coffee (*Coffea* sp.) soil, Indonesia; avocado (*Persea americana*) soil, Iraq; sugar cane (*Saccharum*

officinarum) soil, Basrah, Iraq; tobacco soil, Kogoshima, Japan; burdock (*Arctium lappa*) soil, Saitama, Japan; banana soil, Darlingford and Kingston, Jamaica; *Citrus* sp. soil, Kingston, Jamaica; fumigation plot soil, Spanish Town, Jamaica; sugar cane soil, Jamaica; papaya soil, Ganta, Liberia; tomato soil, Culican, Mexico; banana soil, Benin Province, Nigeria; banana soil, Abeokuta Province, Nigeria; general bush soil, Ondo Province, Nigeria; garden eggplant (*Solanum melongena*) plant soil, Nigeria; unknown grass soil, Ibadan Province, Nigeria; gravel field soil, Ibadan Province, Nigeria; corn (*Zea mays*) soil, Adamawa Province, Nigeria; corn soil, Benin Province, Nigeria; corn soil, Enugu Province, Nigeria; lettuce (*Lactuca sativa*) soil, Ondo Province, Nigeria; *Hyparrhenia rufa* soil, Ibadan Province, Nigeria; unknown tree soil, Ibadan Province, Nigeria; water leaf (*Talinum triangulare*) soil, Adamawa Province, Nigeria; soil around unknown plant, Dacca, Pakistan; soil around unknown plant, San Miguel, Philippines; *Vigna sesquipedales* soil, Laguna, Philippines; unknown weed soil, Somaliland; *Croton* sp. soil, Florida, USA; cotton soil (originally from a field population of Puerto Rico), North Carolina, USA; *Yucca gloriosa*, San Bernardino, USA; Texas, USA; tomato soil, Venezuela; naranja (*Citrus* sp.) soil, Venezuela; and weed soil, Western Panama.

Sher (1961) considered *H. elisensis* a synonym of *R. reniformis*. The opportunity to study the specimen supplied by Carvalho indicated that they are conspecific with immature females of *R. reniformis* and the synonymy is confirmed.

Sher (1961) synonymized the genus *Spirotylenchus* Lordello and Cesnik, 1958, with *Rotylenchulus* and by that action *S. queirozi* became *Rotylenchulus queirozi* (Lordello and Cesnik, 1958) Sher, 1961. Goodey (1963) synonymized *R. queirozi* with *R. reniformis*. The only character of *R. queirozi* which falls outside the range of *R. reniformis* is the short male tail of *queirozi* (c = 18.0–18.2). This variance is not considered to be great enough to represent a distinct species. In all other respects *R. queirozi* closely resembles *R. reniformis* in dimensions and descriptions. Therefore, the synonymy of Goodey is considered valid.

The illustration and description of *Leiperotylenchus leiperi* published by Das (1960) shows a monodelphic ovary, posterior bulb in the esophagus and six lines in the lateral field which do not conform with the generic characterization of *Rotylenchulus*. However, the male and the position of the dorsal gland orifice as well as other measurements of the female indicate a relationship with *R. reniformis*. Jones (as mentioned by Goodey, 1963) as well as Raski (personal communication) observed type specimens in Hyderabad. They considered the specimens to be immature females of *Rotylenchulus*. Five collections from soil taken in 1963 from the type locality also were examined. None of these samples contained nematodes as described by Das. Two of these samples contained immature females and males of *R. reniformis*. Goodey (1963) synonymized *L. leiperi* with *R. reniformis*. The additional evidence above supports the synonymy.

The differences judged by Husain and Khan (1965) to represent a different species, *R. stakmani*, are: dorsal gland orifice less than one stylet length behind the base of stylet knob, absence of caudal alae in males and shorter tail of males. Examination of paratype specimens sent by these authors revealed all the males have distinct but rudimentary, adanal alae which is typical of all known species of *Rotylenchulus*. The dorsal gland orifice and male tail show no differences when compared with specimens of *R. reniformis* from the type locality. Therefore, the placement of *R. stakmani* in synonymy with *R. reniformis* by Swarup et al. (1967) is confirmed.

Specimens from Ceylon, Jamaica, and Japan present a complex of morphological characters which are especially difficult to resolve. These widely variable characters include the measurements of L, stylet length, c′, h and o. In addition the presence or absence of males also must be considered.

At one extreme is a population from Ceylon (Ratnapura, collection no. 1) *in which* immature females have values for L, stylet length, c′ and h which are distinctly greater and do not overlap the measurements of specimens from the type locality. Also no males could be found in the Ceylonese collection. However, a second collection from the same locality

and habitat in Ceylon (Ratnapura, collection no. 2) had males in equal frequency to the females. Also the immature females had the values of L, stylet length and h which were intermediate and bridged the measurements of Ratnapura, collection no. 1 and type specimens of *R. reniformis*. Furthermore populations from Jamaica and Philippines give further evidence of values which bridge and overlap the differences in L, stylet length and h.

Recently Nakasono and Ichinohe (1967) redescribed *R. nicotiana* diagnosing it from *R. reniformis* on (1) absence of males, (2) lower value of o (81.3 ± 2.3% as against 91.1 ± 3.5% for *reniformis*) and (3) a higher value of h (8.5 as against 6 for *reniformis*). There is also evidence for a difference in the host preference between *reniformis* and *nicotiana*. However, the range of o (60.0–94.2) and h (6–12) in *nicotiana* overlaps considerably the values of each in *reniformis*. Also there are a number of collections from other parts of the world in which the o and h values for the immature females are similar to *reniformis* and *nicotiana* and males are frequent. These collections include San Bernardino, California (h = 5–9, o = 77–94); North Carolina (h = 4–6, o = 75–88); Western Panama (h = 6–10, o = 80–92); Mexico (h = 5–10, o = 83–100); and Brazil (h = 8–9, o = 79–81).

These data are suggestive of a polymorphic species with many local variations. The same could be true of host preferences for which there are many examples of variations between populations of the same species. Furthermore the immature females in these many collections resemble each other very closely in almost all other specific characters. The close relationship of all these specimens is still further emphasized by the close similarity of the adult females. Indeed where adult females are known for other species of *Rotylenchulus* they show marked differences in size and shape (Fig. 12, A–J).

There remains the significance of the perplexing presence or absence of males and their role in reproduction. Unfortunately there is not sufficient information on which to base firm conclusions. When judged from the generic level the similarities are more persuasive for a variable species or a group of sibling species rather than a multiplicity of distinct species. Further research should give a better understanding of the importance of males in this complex group of nematodes and also serve as a more reliable basis for distinguishing different species that may exist in the complex. In the meantime on the basis of the additional evidence presented here it is judged wiser to consider these collections as representing a single species, the most variable in the genus.

Rotylenchulus macrosomus n. sp. (Fig. 3, A–G)

MEASUREMENTS (21 immature ♀ paratypes): L = 0.52–0.64 mm; a = 30–38; b = 3.8–5.7; b′ = 2.9–4.3; c = 12–16; c′ = 3.7–5.0; h = 13–18; V = 63–68; stylet = 18–22 μ; o = 139–188.

(21 ♂ paratypes): L = 0.50–0.68 mm; a = 30–41; b′ = 3.7–5.7; c = 12–16; h = 15–23; T = 20–33; gubernaculum = 8–10 μ; spicules = 21–24 μ; stylet = 13–16 μ.

(7 larvae paratypes): L = 0.49–0.68 mm; a = 25–35; b′ = 4.3–5.3; c = 13–17; stylet = 14–16 μ.

IMMATURE FEMALE (Holotype): L = 0.64 mm; a = 37; b = 4.7; b′ = 3.7; c = 14; c′ = 3.9; h = 17; V = 64; stylet = 18 μ; o = 143. Lip region bluntly conoid, finely annulated. Stylet knobs sloping backwards. Excretory pore posterior to hemizonid, 106 μ from anterior end (90–106 μ). Metacorpus oblong, valve 5 μ (5–6 μ) long. Esophageal glands overlapping the intestine laterally and ventrally, more ventrally. Tail 39 μ (35–43 μ) long, annulation around the terminus prominent; terminus bluntly rounded.

MALE (Allotype): L = 0.56 mm; a = 37; b′ = 4.4; c = 14; h = 15; T = 22; stylet = 13 μ; gubernaculum = 9 μ; spicules = 22 μ. Sclerotization of the lip region weak. Stylet and esophagus reduced. Metacorpus and valve indistinct.

LARVAE: Similar to immature females. Tail more rounded than immature females.

HOLOTYPE: Immature female, collected by G. Minz, July 4, 1960, slide numbered 1010, UCNC, Davis.

ALLOTYPE: Male, same data as holotype, slide numbered 1011, UCNC, Davis.

PARATYPES: 48 immature ♀, 36 ♂, 7 larvae, same data as holotype, distributed as follows: 44 immature ♀, 31 ♂, 7 larvae, slides numbered 1012–1026, UCNC, Davis; 1 immature

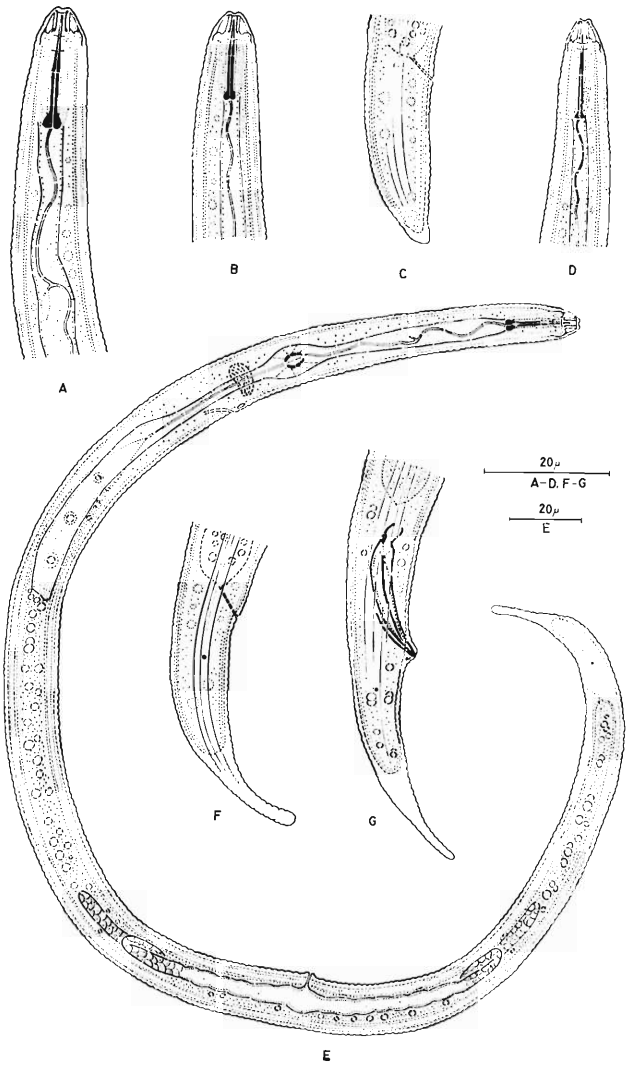

Figure 3. ***Rotylenchulus macrosomus*** **n. sp. A—Immature female, anterior end; B—Larva, anterior end; C—Larva, tail; D—Male, anterior end; E—Immature female; F—Immature female, tail; G—Male, tail.**

♀, 1 ♂, slide numbered R8, UCNC, Riverside; 1 immature ♀, 2 ♂, slides numbered T-587p–T-588p, USDANC, Beltsville; 1 immature ♀, 1 ♂, slide numbered 40/6/1, NDRES, England; 1 immature ♀, 1 ♂, slides numbered WT 1025–1026, PD, The Netherlands.

TYPE HABITAT AND LOCALITY: Olive (*Olea europaea*) soil, Hulda, Israel.

DIAGNOSIS: *R. macrosomus* is closely related to *R. borealis* from which it can be distinguished by its larger size of males (0.50–0.68 mm vs. 0.40–0.49 for *borealis*) and immature females (0.52–0.64 mm vs. 0.37–0.46); also larger stylet (18–22 μ vs. 13–16 μ) and longer hyaline portion of immature female tail (h = 13–18 vs. 9–13 for *borealis*).

Additional specimens of *R. macrosomus* have been identified from the following habitats and localities: peanut (*Arachis hypogaea*), Beit Dagan, Israel; bean (*Phaseolus vulgaris*)

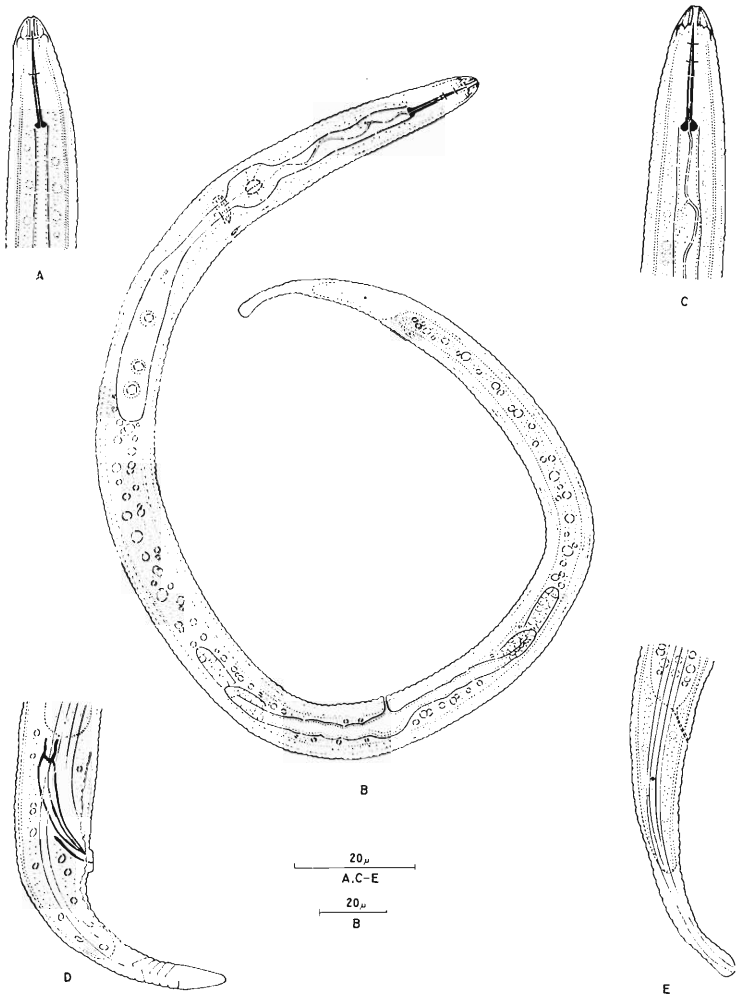

Figure 4. ***Rotylenchulus clavicaudatus*** **n. sp. A—Male, anterior end; B—Immature female; C—Immature female, anterior end; D—Male, tail; E—Immature female, tail.**

soil, Naven Yarr, Israel; banana soil, Karkur, Israel.

Rotylenchulus clavicaudatus n. sp. (Fig. 4, A–E)

MEASUREMENTS (4 immature ♀): L = 0.46–0.59 mm; a = 28–30; b = 4–5; b′ = 2.9–3.9; c = 12–16; c′ = 3.8–5.3; h = 16–23; V = 57–59; stylet = 17–20 μ; o = 75–85.

IMMATURE FEMALE (Holotype): L = 0.51 mm; a = 30; b = 4; b′ = 3.0; c = 12; c′ = 4.4; h = 23; V = 58; stylet = 19 μ; o = 82. Cheilorhabdions thickened at both ends. Lip region high, conoid, without any visible annulation. Metacorpus spheroid, valve 4 μ long. Esophageal glands overlapping intestine laterally. Tail 43 μ (35–50 μ) long, gradually tapering from the anus, terminus bluntly rounded to hemispherical.

MALE (Allotype): L = 0.54 mm; a = 29; b′ = 4.0; c = 15; h = 18; T = 30; stylet = 18 μ; gubernaculum = 9 μ; spicules = 20 μ. Similar to immature females. Esophagus reduced, metacorpus and valve indistinct.

HOLOTYPE: Immature female, collected by

J. Heyns, January, 1964, slide numbered 970, UCNC, Davis.

ALLOTYPE: Male, same data as holotype, slide numbered 970, UCNC, Davis.

PARATYPES: 3 immature females, same data as the holotype, slide numbered 971, UCNC, Davis.

TYPE HABITAT AND LOCALITY: Associated with *Strelitzia* sp., virgin soil, on beach front at Port St. John's, Transkei, South Africa.

DIAGNOSIS: *R. clavicaudatus* is closely related to *R. macrosomus* from which it can be distinguished by lower value of o; lack of annulation on lip region, more anterior position of the vulva and broader clavate shape of the tail. It can be distinguished from *R. borealis* by lack of annulation on lip region and lower value of o.

Rotylenchulus borealis Loof and Oostenbrink, 1962 (Fig. 11, A–C)

MEASUREMENTS (9 immature ♀ paratypes): L = 0.38–0.44 mm; a = 30–31; b = 3.5–4.2; b′ = 2.8–3.4; c = 11–13; c′ = 3.7–4.2; h = 8–13; V = 59–63; stylet = 14–16 μ; o = 140.

5 ♂ paratypes: L = 0.43–0.49; a = 34–39; b′ = 3.6–4.2; c = 13–14; h = 9–15; T = 26–32; stylet = 12–14 μ; gubernaculum = 7–8 μ; spicules = 21–22 μ.

8 immature ♀ (Monaco, France): L = 0.39–0.44; a = 27–29; b = 3.7–4.2; b′ = 2.3–3.4; c = 13–15; c′ = 2.9–3.4; h = 9–13; V = 60–64; stylet = 13–15 μ; o = 147–185.

8 ♂ (Monaco, France): L = 0.40–0.48 mm; a = 29–37; b′ = 3.5–4.9; c = 12–14; h = 9–15; T = 28–41; gubernaculum = 7–8 μ; spicules = 19–20 μ; stylet = 12–14 μ.

6 larvae (Monaco, France): L = 0.39–0.43 mm; a = 25–29; b′ = 3.5–4.1; c = 13–15; stylet = 12–13 μ.

2 immature ♀ (South Colombano, Italy): L = 0.34–0.44 mm; a = 25–29; b = 3.7–4.2; b′ = 3.0–3.5; c = 13–14; c′ = 3.0–3.5; h = 13; V = 60–63; stylet = 14 μ; o = 142–150.

3 ♂ (South Colombano, Italy): L = 0.44–0.47 mm; a = 28–34; b′ = 3.6–4.2; c = 14–16; h = 10–15; T = ?; stylet = 12–13 μ; gubernaculum = 8 μ; spicules = 20–22 μ.

1 ♂ (Pieve del Cairo, Italy): L = 0.44 mm; a = 27; b′ = 3.7; c = 13; h = 13; T = ?; stylet = 12 μ; gubernaculum = 7 μ; spicules = 20 μ.

IMMATURE FEMALES: Following is an addition to the original descriptions. Esophageal glands overlapping intestine laterally and ventrally, usually more laterally. Each ovary with two flexures. Dorsal gland orifice more than one stylet length posterior to stylet knob base.

LARVAE: Resembling immature females. Lip region conoid, finely annulated, not set off. Esophageal glands overlapping intestine laterally and ventrally. Tail bluntly rounded.

Specimens of *R. borealis* have been identified from the following habitats and localities: grass and weed soil, 2 miles below Venice, France; grass and weed under Pine Grand Cornice above Monaco, France; grape vine soil (*Vitis* sp.) Castelnaudary, France; orchard nursery soil, Pieve del Cairo, Italy; vine soil, South Colombano, Italy; vine soil, Bresciano, Italy.

Rotylenchulus leptus n. sp. (Fig. 5, A–G)

MEASUREMENTS (23 immature ♀ paratypes): L = 0.31–0.37 mm; a = 28–33; b = 3.4–4.0; b′ = 2.6–3.3; c = 11–14; c′ = 3.4–4.5; h = 3–7; V = 58–64; stylet = 12–14 μ; o = 140–160.

(10 larvae, paratypes): L = 0.30–0.36 mm; a = 24–26; b′ = 3.5–3.9; c = 13–15; stylet = 12–14 μ.

IMMATURE FEMALE (Holotype): L = 0.36; a = 29; b = 3.4; b′ = 2.8; c = 13; c′ = 4.0; h = 5; V = 62; stylet = 12 μ; o = 162. Body in open C shape, slender. Lip region high, conoid, annules not visible. Stylet knobs small, sloping backwards. Excretory pore 71 μ from the anterior end (65–76 μ), below hemizonid. Metacorpus oblong, esophageal glands overlapping the intestine laterally (some paratypes more ventrally). Tail 27 μ (22–28 μ) long, slender, conoid, terminus rounded.

MALE: Unknown.

LARVAE: Resembling female, tail more rounded than the immature female.

HOLOTYPE: Immature female, collected by G. Martin, 1957, slide numbered 972, UCNC, Davis.

PARATYPES: 30 immature ♀, 15 larvae, same data as holotype, distributed as follows: 26 immature ♀, 15 larvae, slides numbered 973–981, 986–987, UCNC, Davis; 1 immature ♀, slide numbered R6, UCNC, Riverside; 1 im-

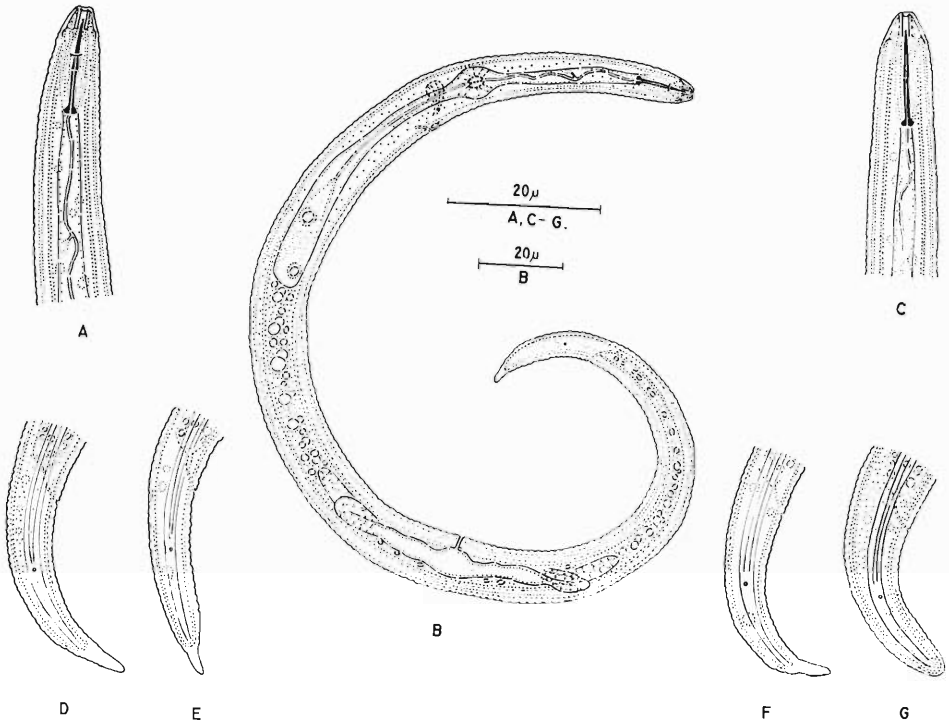

Figure 5. ***Rotylenchulus leptus*** **n. sp. A—Immature female, anterior end; B—Immature female; C—Larva, anterior end; D–F—Immature female, tail; G—Larva, tail.**

mature ♀, slide numbered T-589p, USDANC, Beltsville; 1 immature ♀, slide numbered 40/4/1, NDRES, England; 1 immature ♀, slide numbered WT 1022, PD, The Netherlands.

TYPE HABITAT AND LOCALITY: Soil around bamboo (*Bamboos vulgaris*), unknown grass, and weed soil, Gwelo, Southern Rhodesia.

ADDITIONAL COLLECTIONS: 20 immature ♀ (Chipinga, Southern Rhodesia): L = 0.29–0.33 mm; a = 27–31; b = 3.2–3.8; b′ = 2.3–3.1; c = 11–13; c′ = 3.6–4.7; h = 3–7; V = 57–63; stylet = 11–13 μ; o = 123.*

DIAGNOSIS: *R. leptus* is most closely related to *R. parvus* from which it can be distinguished by its high conoid lip region, lack of annulation in the lip region, longer and more slender tail, and larger hyaline portion of immature female tail (h = 3–7 vs. less than 3 for *parvus*).

* Measurement of one specimen.

Rotylenchulus variabilis n. sp. (Figs. 6, A–H; 7, A–C)

MEASUREMENTS (16 mature ♀ paratypes): L = 0.38–0.53 mm; width at the vulva = 0.07–0.12 mm; a = 4–6; V = 58–64; swollen portion of the body plus tail = 0.20–0.35 mm; stylet = ?; median esophageal bulb diameter = 17–22 μ; eggs = 50–52 μ × 22 μ (within uterus).

(22 immature ♀ paratypes): L = 0.30–0.37 mm; a = 22–26; b = 3.3–3.9; b′ = 2.4–3.1; c = 13–16; c′ = 2.6–3.2; h = 3–6; V = 59–66; stylet = 13–15 μ; o = 120–138.

(21 ♂ paratypes): L = 0.34–0.41 mm; a = 22–33; b′ = 3.1–4.1; c = 14–20; h = 3–7; T = 29–51; stylet = 10–12 μ; gubernaculum = 7–9 μ; spicules = 19–23 μ.

(2 larvae paratypes): L = 0.36–0.37 mm; a = 22–23; b′ = 3.6–3.7; c = 14–15; stylet = 12–13 μ.

IMMATURE FEMALE (Holotype): L = 0.36

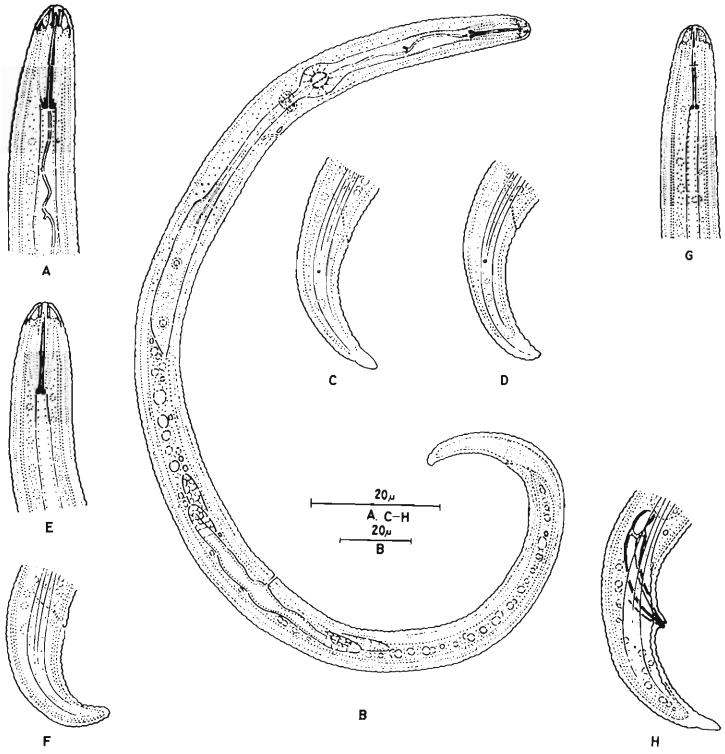

Figure 6. ***Rotylenchulus variabilis*** **n. sp. A—Immature female, anterior end; B—Immature female; C–D—Immature female, tail; E—Larva, anterior end; F—Larva, tail; G—Male, anterior end; H—Male, tail.**

mm; a = 26; b = 3.7; b′ = 2.8; c = 16; c′ = 2.6; h = 3; V = 63; stylet = 13 μ; o = 122. Body in open C shape. Lip region hemispherical with 5 annules (4–6). Cheilorhabdion thickened at both ends. Stylet knobs sloping backwards. Excretory pore 76 μ from the anterior end (72–82 μ). Metacorpus oblong, valve 4 μ (4–6 μ) long. Esophageal glands overlapping intestine laterally. Tail 21 μ (20–24 μ) long, terminus bluntly rounded, annulations around the terminus prominent.

MALE (Allotype): L = 0.37 mm; a = 28; b′ = 3.5; c = 17; h = 6; T = 44; gubernaculum = 8 μ; spicules = 21 μ. Stylet and esophagus much reduced. Metacorpus and valve indistinct. Tail rounded. Stylet 10 μ.

MATURE FEMALE: Body strongly curved, tail often crosses the neck. Body shape posterior to vulva intermediate between *R. reniformis* and *R. parvus*, narrows to anus. Posterior to anus most specimens have rounded shape more strongly curved on ventral side setting off small projection (4–6 μ long) more gross and cylindrical than in *R. reniformis*. Metacorpus spheroid, valve large. Vulva with prominent raised lips.

LARVAE: Resembling immature females. Lip region bluntly conoid. Tail more rounded than immature females.

HOLOTYPE: Immature female, collected by G. Martin, March 1962, slide numbered 988, UCNC, Davis.

ALLOTYPE: Male, same data as holotype, slide numbered 989, UCNC, Davis.

PARATYPES: 17 mature ♀, 33 immature ♀, 31 ♂, 2 larvae same data as holotype, distributed as follows: 17 mature ♀, 26 immature ♀, 26 ♂, 2 larvae, slides numbered 990–999, 1007–1009, UCNC, Davis; 3 immature ♀, 1 ♂, slide numbered R7, UCNC, Riverside; 2 immature ♀, 2 ♂, slides numbered T-590p–

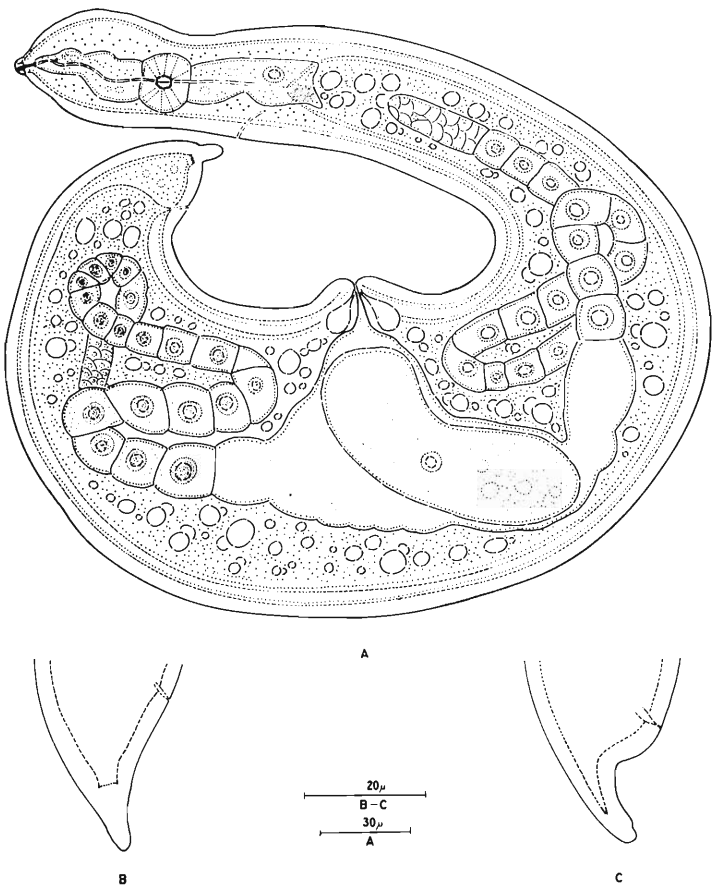

Figure 7. ***Rotylenchulus variabilis*** **n. sp. A—Mature female; B–C—Mature female, tail.**

T-591p, USDANC, Beltsville; 1 immature ♀, 1 ♂, slides numbered 40/5/1–40/5/2, NDRES, England; 1 immature ♀, 1 ♂, slides numbered WT 1023–1024, PD, The Netherlands.

TYPE HABITAT AND LOCALITY: Soil around *Rumex* sp., Inyanga Orchard area, Southern Rhodesia.

DIAGNOSIS: *R. variabilis* is most closely related to *R. parvus* and distinguished by the distinct annulation of the lip region, longer hyaline tail portion (h = 3–6 vs. less than 3) and longer valve in metacorpus of immature females, and by large mature female with terminal projection. It can be distinguished from *R. leptus* by the presence of annulation in lip region.

Additional specimens of *R. variabilis* have been identified from the following habitats and localities: bean (*Phaseolus vulgaris*) soil, corn soil, Machakos district, Kenya; bean soil, sweet potato soil, Kiambu Hill, Kenya; corn soil, banana hill, Kenya; cowpea soil (*Vigna sinensis*), Ondo Province, Nigeria; spear grass (*Imperata cylindrica*) soil, oil palm (*Elaeis guineensis*) soil, Oyo Province, Nigeria; soil around the roots of unknown vegetables, Niger Province, Nigeria.

R. variabilis shows variation in certain characters to a remarkable degree within the same population. Most of the immature females of paratypes and other collections have a long esophagus measuring up to 80 μ from the valve to the end of the esophageal glands. In some specimens this distance may be as low

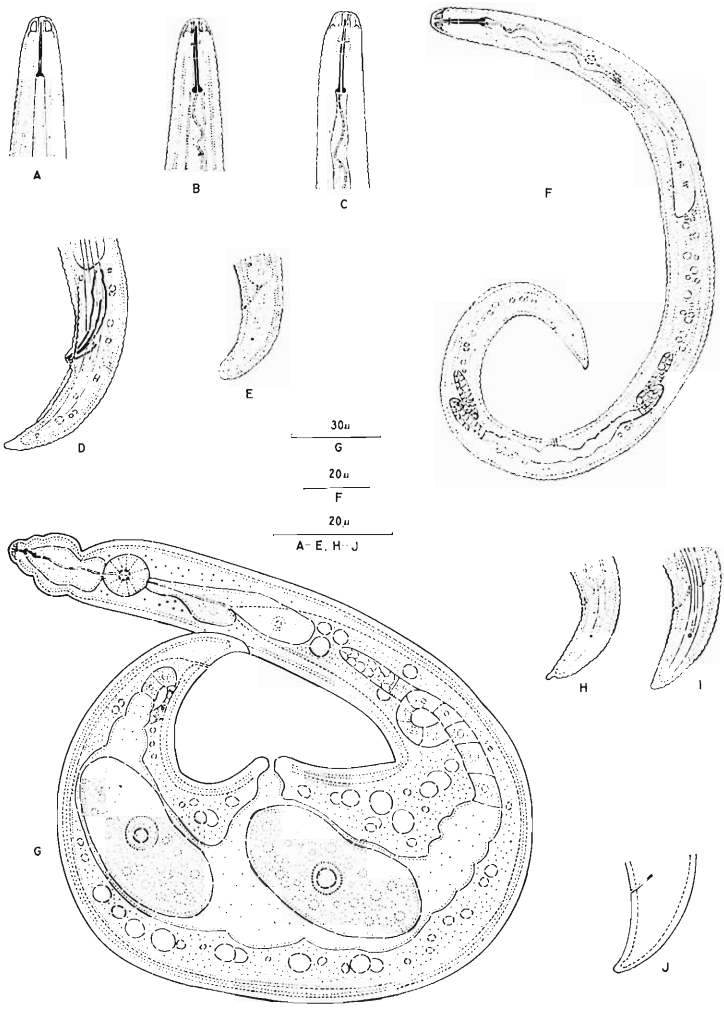

Figure 8. ***Rotylenchulus parvus.*** **A—Male, anterior end; B—Larva, anterior end; C—Immature female, anterior end; D—Male, tail; E—Larva, tail; F—Immature female; G—Mature female; H–I—Immature female, tail; J—Mature female, tail.**

as 56 μ. In most of the immature females the annulation is pronounced around the tail terminus but there are some individuals in which the tail terminus is smooth. Some male specimens from corn soil, Kiambu Hill, Kenya have a very pointed tail.

Rotylenchulus parvus (Williams, 1960) Sher, 1961
Helicotylenchus parvus Williams, 1960 (Fig. 8, A–J)

Williams described this species from immature females collected from sugarcane soil in Mauritius. Goodey (1963) judged it to be a synonym of *R. reniformis.* Type specimens sent by Williams were studied together with a population originally from soil of a cotton field in Imperial Valley, California. That field population was maintained in the greenhouse at Davis and used for life history and host range studies. Large numbers of specimens were available from roots of barley in those greenhouse cultures. No males were seen in these Davis cultures. The 3 males described

below were provided by Dr. D. E. Konicek who collected 2 from the field population and one from his greenhouse culture. It was found both immature and mature females have morphological characters distinctly different from *R. reniformis* which made possible a diagnosis clearly indicating its status as a separate species.

MEASUREMENTS (10 immature ♀ paratypes): L = 0.23–0.27 mm; a = 18–25; b = 3.5–3.8; b′ = 2.4–3.1; c = 16–19; c′ = 2.1–2.7; h = less than 3; V = 61–65; stylet = 12–13 μ; o = ?.

40 immature ♀ (Imperial Valley, California): L = 0.25–0.34 mm; a = 20–26; b = 3.1–3.7; b′ = 2.1–3.0; c = 16–20; c′ = 2.0–2.7; h = less than 3; V = 60–66; stylet = 12–14 μ; o = 90–107.

15 mature ♀ (Greenhouse culture, Davis; originally from Imperial Valley, California): L = 0.25–0.36 mm; width at vulva = 0.04–0.08 mm; a = 4–7; V = 61–66; swollen portion of the body plus tail = 0.15–0.25 mm; stylet = 12–15 μ; median esophageal bulb diameter = 12–15 μ; eggs = 56–69 μ × 30–38 μ.

2 ♂ (Imperial Valley, California): L = 0.38–0.46 mm; a = 28–32; b′ = 3.6–4.0; c = 18–23; h = less than 3; T = 32–34; stylet = 10 μ; gubernaculum = 5 μ; spicules = 16 μ.

1 ♂ (Greenhouse culture, Sacramento; originally from Imperial Valley, California): L = 0.39 mm; a = 29; b′ = 4.0; c = 14; h = 3; T = 41; stylet = ?; gubernaculum = 7 μ; spicules = 16 μ.

10 larvae (Greenhouse culture, Davis; originally from Imperial Valley, California): L = 0.25–0.34 mm; a = 21–25; b′ = 2.5–3.5; c = 14–18; stylet = 12–13 μ.

IMMATURE FEMALES: Body in an open C to loose spiral. Lip region low rounded, finely annulated; stylet knobs sloping backwards. Excretory pore 60–75 μ from anterior end. Metacorpus spheroid, valve length 3 μ. Esophageal glands overlapping intestine laterally and ventrally, frequently laterally. Tail short, 13–18 μ; terminus in form of a short ventral projection.

MATURE FEMALES: Posterior part of the body often crosses the neck. Body contour beyond the vulva tapers abruptly, postanal part slender, not hemispherical, similar to immature females but wider. Body width at the anus 10–16 μ. Vulva with prominent raised lips. Vagina funnel-shaped extending half across the body. Tail without spikelike process or projection.

MALES: Lip region high, hemispherical. Cephalic sclerotization weak. Prorhabdion not pronounced, difficult to see. Esophagus reduced. Lumen of the esophagus, metacorpus and valve difficult to resolve. Tail rounded.

LARVAE: Resembling immature females. Tail bluntly rounded, without projections.

Specimens identified as *R. parvus* have been examined from the following habitats and localities: papaya soil, Nairobi, Kenya; corn soil, Southern Rhodesia; fallow soil, Penhalonga, Southern Rhodesia; munga (*Pennisetum typhoides*) soil, Salisbury, Southern Rhodesia; sunhemp (*Crotalaria juncea*) soil, Southern Rhodesia; Turkish tobacco soil, Natoba farm, Pimba, Northern Rhodesia.

The original description of *R. parvus* shows the esophageal gland as overlapping the intestine more dorsally and the ovaries as outstretched. The paratype specimens show that the esophageal glands overlap the intestine ventrally and laterally and the ovaries typical with two flexures. The stylet could be seen only in one specimen of three males examined.

Rotylenchulus anamictus n. sp. (Fig. 9, A–H)

MEASUREMENTS (31 immature ♀ paratypes): L = 0.27–0.33 mm; a = 22–26; b = 3.0–3.9; b′ = 2.1–3.0; c = 13–17; c′ = 2.3–2.9; h = 4–7; V = 67–72; stylet = 12–14 μ; o = 107–141.

(12 ♂ paratypes): L = 0.33–0.40 mm; a = 26–30; b′ = 3.3–4.3; c = 14–17; h = 3–6; stylet = 10–12 μ; gubernaculum = 6–7 μ; spicules = 18–20 μ.

(5 larvae paratypes): L = 0.31–0.36 mm; a = 23–26; b′ = 3.1–3.5; c = 13–15; stylet = 12 μ.

IMMATURE FEMALE (Holotype): L = 0.30; a = 23; b = 3.4; b′ = 2.6; c = 15; c′ = 3.0; h = 4; V = 70; stylet = 13 μ; o = 140. Body in open C shape. Lip region low, rounded, with 3 annules (3–4). Stylet knobs rounded, sloping backwards. Excretory pore posterior to hemizonid, 69 μ from the anterior end (69–83 μ). Metacorpus spheroid, valve length 3 μ (3–4 μ). Esophageal glands overlapping the intestine laterally and ventrally, slightly more

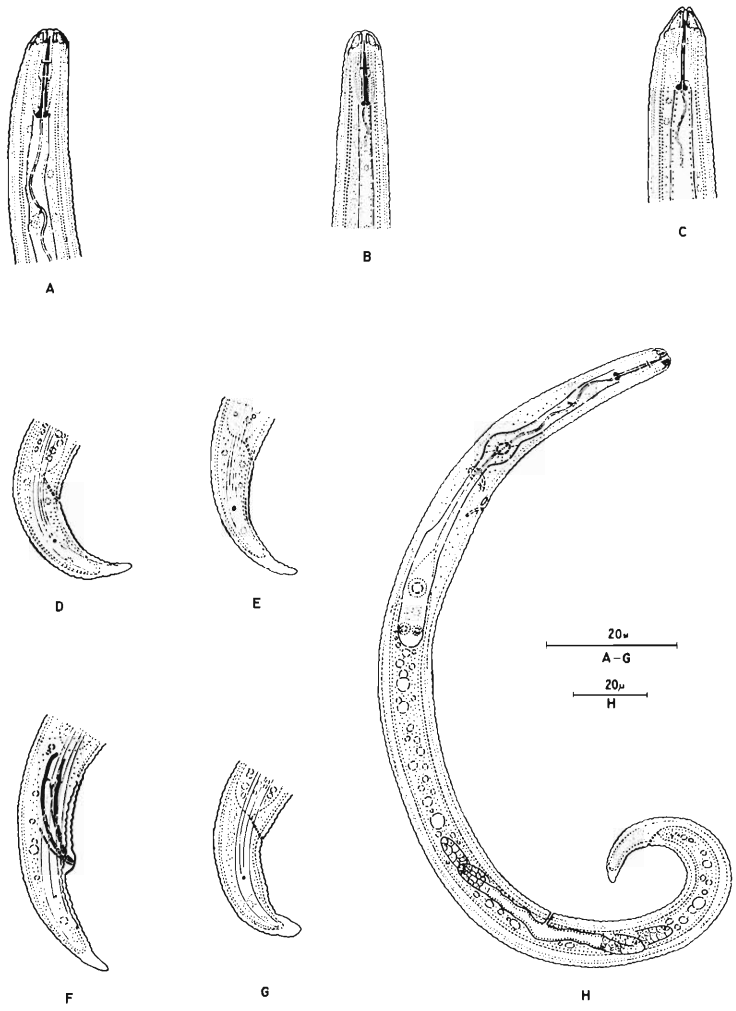

Figure 9. ***Rotylenchulus anamictus*** **n. sp. A—Immature female, anterior end; B—Male, anterior end; C—Larva, anterior end; D–E—Immature female, tail; F—Male, tail; G—Larva, tail; H—Immature female.**

ventrally. Tail conoid, 21 μ (18–23 μ) long, terminus rounded.

MALE (Allotype): L = 0.34 mm; a = 26; b′ = 3.4; c = 17; h = 3; T = 29; gubernaculum = 7 μ; spicules = 19 μ. Lip region hemispherical, annulated. Cephalic sclerotization weaker than immature females. Stylet reduced, 10 μ. Excretory pore 74 μ from anterior end (69–75 μ). Lumen of esophagus, metacorpus and valve difficult to resolve. Tail conoid, terminus rounded.

LARVAE: Lip region conoid. Lumen of esophagus not distinct. Tail more rounded than immature females.

HOLOTYPE: Immature female, collected by F. Lamberti, July 1964, slide numbered 944, UCNC, Davis.

ALLOTYPE: Male, same data as the holotype, slide numbered 945, UCNC, Davis.

PARATYPES: 38 immature ♀, 12 ♂, 10 larvae, same data as holotype, distributed as follows: 30 immature ♀, 8 ♂, 10 larvae, slides numbered 946–962, UCNC, Davis; 3 immature ♀, 1 ♂, slides numbered R4–R5, UCNC,

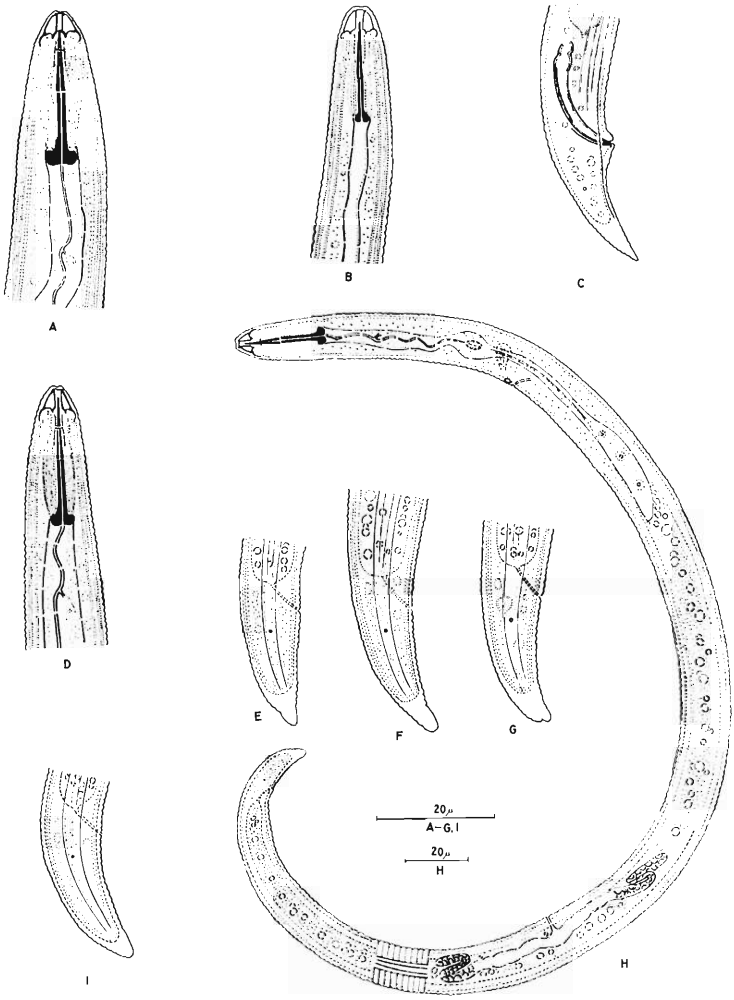

Figure 10. ***Rotylenchulus macrodoratus*** **n. sp. A—Immature female, anterior end; B—Male, anterior end; C—Male, tail; D—Larva, anterior end; E–G—Immature female, tail; H—Immature female; I—Larva, tail.**

Riverside; 3 immature ♀, 1 ♂, slide numbered T-592p, USDANC, Beltsville; 1 immature ♀, 1 ♂, slides numbered 40/3/1–40/3/2, NDRES, England; 1 immature ♀, 1 ♂, slides numbered WT 1020–1021, PD, The Netherlands.

TYPE HABITAT AND LOCALITY: Soil around *Acacia* sp. about 2 miles south of Merca, Somaliland.

DIAGNOSIS: *R. anamictus* is most closely related to *R. parvus* and can be distinguished on the more posterior position of the vulva (V = 67–72 vs. 60–66 for *parvus*), larger hyaline portion of immature female tail (h = 4–7 vs. less than 3), different shape of the immature female tail, conoid shape of larval head and usually longer tail of immature female. It can be distingiushed from *R. reniformis* by the short body length, smaller stylet, and low rounded lip region.

Rotylenchulus macrodoratus n. sp. (Figs. 10, A–I; 11, D–F)

MEASUREMENTS (25 immature ♀ paratypes): L = 0.40–0.49 mm; a = 22–28; b = 3.2–4.7;

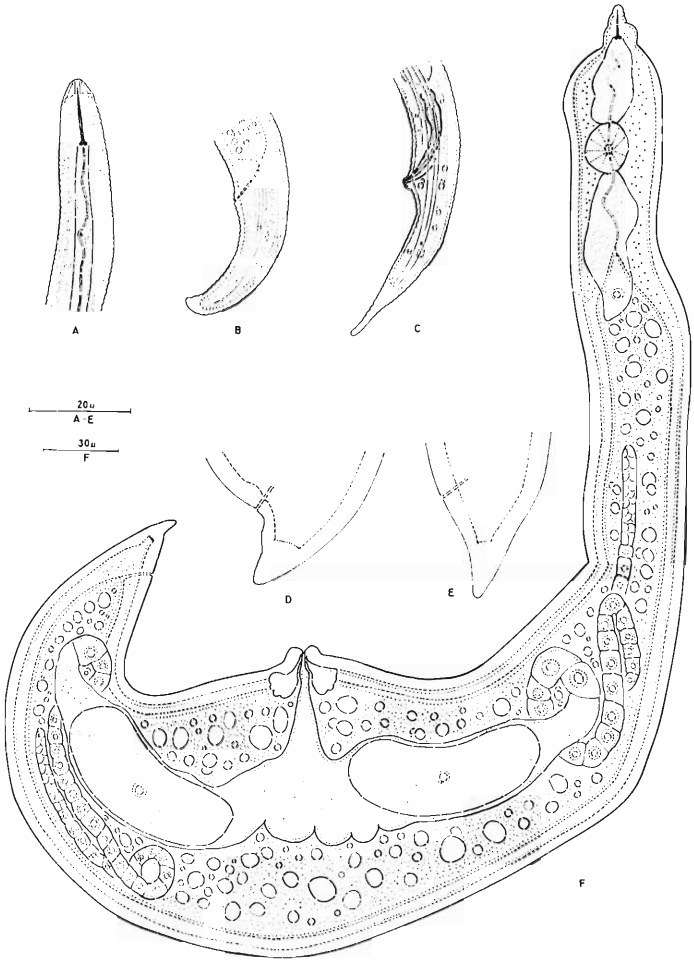

Figure 11. ***Rotylenchulus borealis.*** **A—Larva, anterior end; B—Larva, tail; C—Male, tail.** ***Rotylenchulus macrodoratus*** **n. sp. D–E—Mature female, tail; F—Mature female.**

b′ = 2.8–3.6; c = 16–24; c′ = 1.8–2.4; h = 6–12; V = 64–72; stylet = 22–26 μ; o = 56–82.

(12 ♂ paratypes): L = 0.45–0.53 mm; a = 27–32; b′ = 3.8–4.6; c = 21–28; h = 6–10; stylet = 17–20 μ; gubernaculum = 7 μ; spicules = 20 μ.

(12 mature ♀ paratypes): L = 0.41–0.53 mm; width at vulva = 0.06–0.19 mm; a = 4–6; V = 64–71; length of the swollen portion plus tail = 0.17–0.34 mm; stylet = ?; median esophageal bulb diameter = 13–16 μ.

(10 larvae paratypes): L = 0.40–0.50 mm; a = 21–28; b′ = 3.0–4.7; c = 15–20; stylet = 20–22 μ.

IMMATURE FEMALE (Holotype): L = 0.46 mm; a = 28; b = 4.2; b′ = 3.3; c = 20; c′ = 2.4; h = 6; V = 71; stylet = 25 μ; o = 64. Lip region conoid with fine annulation. Second and third incisures in lateral field lighter than the 2 outer lines, gradually disappearing near level of flexure of posterior ovary. Cephalic sclerotization heavy, arches downwards strongly. Spear knobs large, anchor-shaped. Excretory pore 100 μ (91–101 μ) from anterior end. Metacorpus oblong, valve 3 μ (3–5 μ)

long. Esophageal glands overlapping intestine ventrally. Tail 21 μ (20–23 μ) long, terminus bluntly rounded.

MALE (Allotype): L = 0.46 mm; a = 29; b′ = 3.9; c = 23; h = 6; T = 42; stylet = 18 μ; gubernaculum = ?; spicules = ?. Lip region high, hemispherical. Stylet knobs and esophagus much reduced, metacorpus and valve indistinct. First lateral line from the ventral side merging with edge of caudal alae.

MATURE FEMALES: Body ventrally curved, tail sometimes crossing the neck. Slope of the body contour anterior and posterior to vulva abrupt. Body contour behind vulva tapers to a degree intermediate between *R. reniformis* and *R. parvus*. Metacorpus spheroid. Vulva with raised, pronounced lips. Tail terminus with spikelike process.

LARVAE: Resembling immature females. Tail more rounded than immature females.

HOLOTYPE: Immature female, collected by A. Ciccarone, March 1962, slide numbered 929, UCNC, Davis.

ALLOTYPE: Male, same data as holotype, slide numbered 930; UCNC, Davis.

PARATYPES: 15 mature ♀, 85 immature ♀, 24 ♂, 28 larvae, same data as holotype, distributed as follows: 15 mature ♀, 70 immature ♀, 19 ♂, 27 larvae, slides numbered 931–943, 963–969, 982–985, 1027–1032, UCNC, Davis; 7 immature ♀, 1 ♂, 1 larva, slide numbered R9, UCNC, Riverside; 4 immature ♀, 1 ♂, slide numbered T-593p, USDANC, Beltsville; 3 immature ♀, 2 ♂, slide numbered 40/7/1, NDRES, England; 1 immature ♀, 1 ♂, slides numbered WT 1027–1028, PD, The Netherlands.

TYPE HABITAT AND LOCALITY: Soil around grape (*Vitis* sp.), Bari, Italy.

DIAGNOSIS: *R. macrodoratus* is distinguished from all other species of *Rotylenchulus* by its robust stylet and knobs with forward directed processes, acute conoid lip region, and heavy sclerotization of the cephalic framework; shorter tail which is sometimes less than twice the anal body diameter.

Esophageal glands in some paratype specimens of immature females are in the form of hemispherical lobes and overlap intestine laterally. It was not possible to take measurements of spicules and gubernaculum in toto mounts because all the male tails of the paratypes as well as from other collections were in a latero-ventral position. However, these measurements could be taken accurately by mounting the tail end in proper position in glycerin jelly.

Mature females of *R. macrodoratus* also have been identified from the roots of *Laurus nobilis*, Bari, Italy. Additional specimens of immature females, males and larvae, of *R. macrodoratus* have been identified from the following habitats and localities: grape (*Vitis* sp.) soil, Lazzaretto, Italy; almond (*Prunus amygdalus*) soil, Torre Tresca, Italy.

Key to the Species of *Rotylenchulus**

1. Stylet knobs anchor-shaped, stylet 22 μ or more ..... *macrodoratus* n. sp.
   Stylet knobs spheroid, stylet usually less than 22 μ 2
2. h = 14 or more; 15 or more in male, L of male 0.5 mm or more 3
   h = 13 or less; 15 or less in male; L of male when present 0.49 mm or less 4
3. o = < 100 ..... *clavicaudatus* n. sp.
   o = > 100 ..... *macrosomus* n. sp.
4. V = 66 or less 5
   V = 67 or more 8
5. h = > 8; > 9 in male ..... *borealis*
   h = < 7; < 7 in males when present 6
6. c′ = 3.3 or more, lip region conoid without visible annulation, males unknown ..... *leptus* n. sp.
   c′ = 3.2 or less, lip region hemispherical or rounded, annulations present, males common or rare 7
7. h = < 3; lip annulation very fine, not distinct, swollen female tail without spikelike process ..... *parvus*
   h = > 3; lip annulations distinct; swollen female tail with spikelike process ..... *variabilis* n. sp.
8. Lip region high; stylet 15 μ or more; L = 0.34 mm or more; o = < 106 ..... *reniformis*
   Lip region low; stylet 14 μ or less; L = 0.33 mm or less; o usually > 110 ..... *anamictus* n. sp.

Discussion

Husain and Khan (1967) indicated a close relationship between *Rotylenchulus* and the Hoplolaiminae when they proposed the sub-

* Characters mentioned hereafter refer to immature females unless and otherwise mentioned.

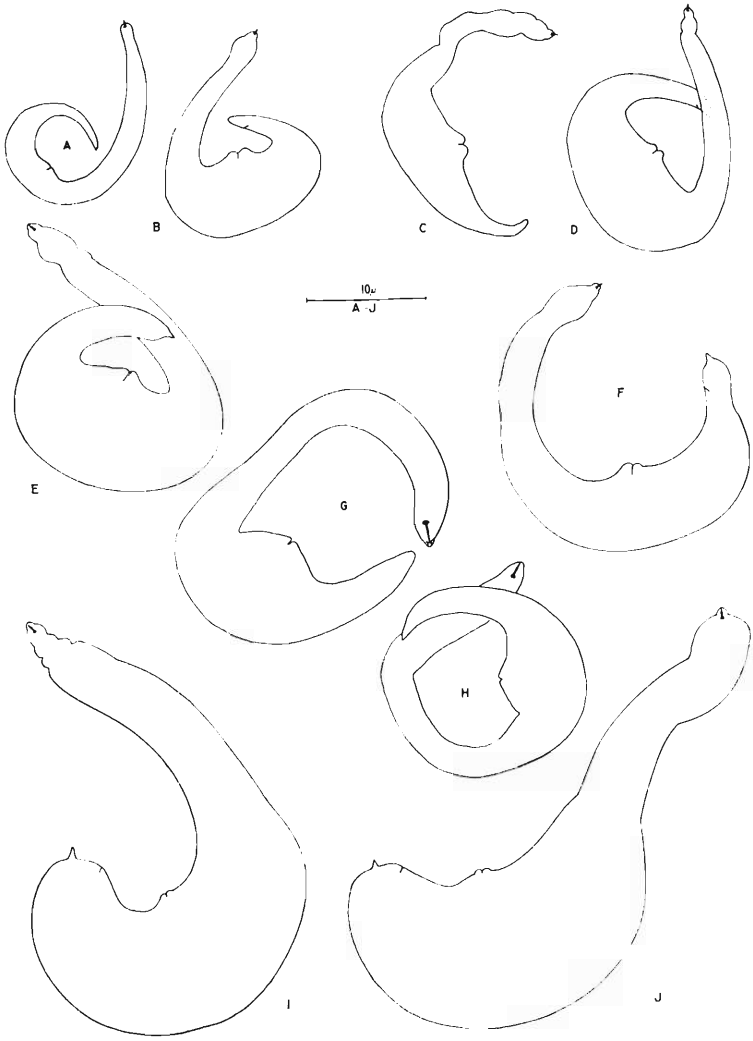

Figure 12. ***Rotylenchulus*** **spp. Mature females. A–D—*R. parvus*; E–F—*R. variabilis* n. sp.; G–H—*R. macrodoratus* n. sp.; I–J—*R. reniformis*.**

family Rotylenchulinae within the family Hoplolaimidae. The present study supports this conclusion of relationship principally by the immature females of *R. macrodoratus* which bear many characters similar to species of *Helicotylenchus*.

Some of the characters of Hoplolaiminae as emended by Sher (1961) are: "ovaries outstretched, amphidelphic, and didelphic, female tail short, not more than twice the anal body diameter . . . caudal alae enveloping male tail." *Rotylenchulus* females all have double flexures in the ovaries. In most species the female tail is more than twice the anal body diameter, even in *R. macrodoratus* where the female tail is short, many individuals have a tail more than twice the anal body diameter. The males of *Rotylenchulus* have adanal caudal alae. Considering these differences it is judged most appropriate to place *Rotylenchulus* in Rotylenchulinae.

The characters of immature females which

are considered useful in separation of the species are: shape of the lip region, annulation in lip region, stylet length, knob shape, position of the dorsal gland orifice, position of the vulva and the length of the hyaline portion of the tail. Although males are known in all species except *R. leptus*, the male morphology does not usually provide useful diagnostic characters. Generally the same is true with the larvae.

Mature females are known in only five of the nine species of *Rotylenchulus*. This stage has considerable importance in distinguishing species but will be limited in application until mature female specimens are available for all species. In the meantime, the relationship between species perhaps is best judged on the basis of the lip region in combination with tail characters of immature females. Such an examination reveals several groupings: Group I—species with lip region low, rounded to hemispherical, annulated; h less than 8—represented by *parvus, variabilis*, and *anamictus*; Group II—species with lip region high and conoid, without visible annulation; h less than 8—represented by *leptus*; Group III—species with lip region high, conoid, rounded with annules, h less than 13—represented by *reniformis*; Group IV—species with lip region high, conoid, with or without annulation; h is 8–24—represented by *borealis, macrosomus,* and *clavicaudatus*; Group V—species with lip region acutely conoid, with annules; h less than 13—represented by *macrodoratus*.

Immature females of *macrodoratus* show the least relationship with any other group. Lip region, stylet size and knob shape of this species show complete departure from all the species of this genus. The closer relationships of *parvus*-group and *reniformis* is exhibited by *anamictus* which shares characters of both *parvus* and *reniformis*. Its total size, stylet length, lip region are similar to those of *parvus* but the vulva position, tail and frequency of occurrences of males bring this species closer to *reniformis*. *R. leptus* stands in between Group I and Group III and comes closer to the *parvus*-group. Whereas in gross morphology this species is similar to the *parvus*-group its conoid lip region, lack of annulation in lip region, slender and long tail do not certainly fit this species in Group I. The *borealis*-group is more closely related to Group III than any other groups. The lip region of *R. borealis* is similar to that of *reniformis* and the lower limit of h comes within the range of *reniformis*. Collections of mature females are needed for all species for comparative studies with immature females, larvae, and males to gain a better understanding of the relationship of the species.

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Summary

The genus *Rotylenchulus* Linford and Oliveira, 1940 is reviewed and the generic diagnosis is emended. The morphology of *Rotylenchulus* and key to the species is given. The nominal species of *Rotylenchulus* now total nine, six of which are described here as new. *Rotylenchulus nicotiana* (Yokoo and Tanaka, 1954) Baker, 1962 and *Rotylenchulus stakmani* Husain and Khan, 1965 are synonymized with *R. reniformis*. Description of neotype and redescriptions of various stages are made for the genotype, *R. reniformis*. Males and mature females of *R. parvus* and larva of *R. borealis* are described for the first time.

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Isoglaridacris hexacotyle comb. n. (Cestoidea: Caryophyllidea) from Catostomid Fishes in Southwestern North America

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Glaridacris hexacotyle (Linton, 1897) is known only from the superficial description of Linton (1897) and the more detailed account of Hunter (1930); both descriptions were based on the same eight specimens from "*Catostomus* sp." from the Gila and Salt Rivers in Arizona. This paper presents additional descriptive data and proposes nomenclatorial changes based upon a restudy of the original material and of new collections from the Salt River.

Materials and Methods

A total of 160 cestodes from 15 of 16 sonora suckers, *Catostomus insignis* Baird and Girard, and 17 from 7 of 29 gila suckers, *Catostomus* (*Pantosteus*) *clarki* Baird and Girard, was collected in December 1964, at Coons Bluff on the Salt River in Tonto National Forest near Tempe, Arizona (Mariocopa County). The sonora suckers ranged in total length from 225–494 mm (mean: 359 mm) whereas the gila suckers ranged from 213–375 mm (mean: 260 mm). Living cestodes were fixed in steaming AFA or 5 per cent formalin and stained with Semichon's carmine.

Only 108 cestodes (82 gravid) from the sonora sucker and 16 (nine gravid) from the gila sucker were stained and mounted; two gravid individuals from the sonora sucker were sectioned. Measurements were made on a selected sample of 30 gravid worms from 12 sonora suckers and five from three gila suckers. Host nomenclature is according to the recent treatment of Smith (1966).

Comparative material included: *Glaridacris hexacotyle* (Linton, 1897), USNM Helm. Coll. No. 49727 (label: USNM Helm. Coll. 49727 from 4793) consisting of a vial with three posterior regions, two scolexes, and darkly stained fragments of the testicular region; 19 of Hunter's original slides of this species (his numbers: 584.1 a–g, .2 to .4 a–b, .5 to .7 a–d, and .8 to .9); *Isoglaridacris folius* Fredrickson and Ulmer, 1967, paratype, USNM Helm. Coll. No. 60301; *I. longus* Fredrickson and Ulmer, 1967, holotype, USNM Helm. Coll. No. 60302; and *I. bulbocirrus* Mackiewicz, 1965, topotypes, 136 whole mounts of gravid and immature worms from the author's collection.

Isoglaridacris hexacotyle comb. n. (Figs. 1–8)

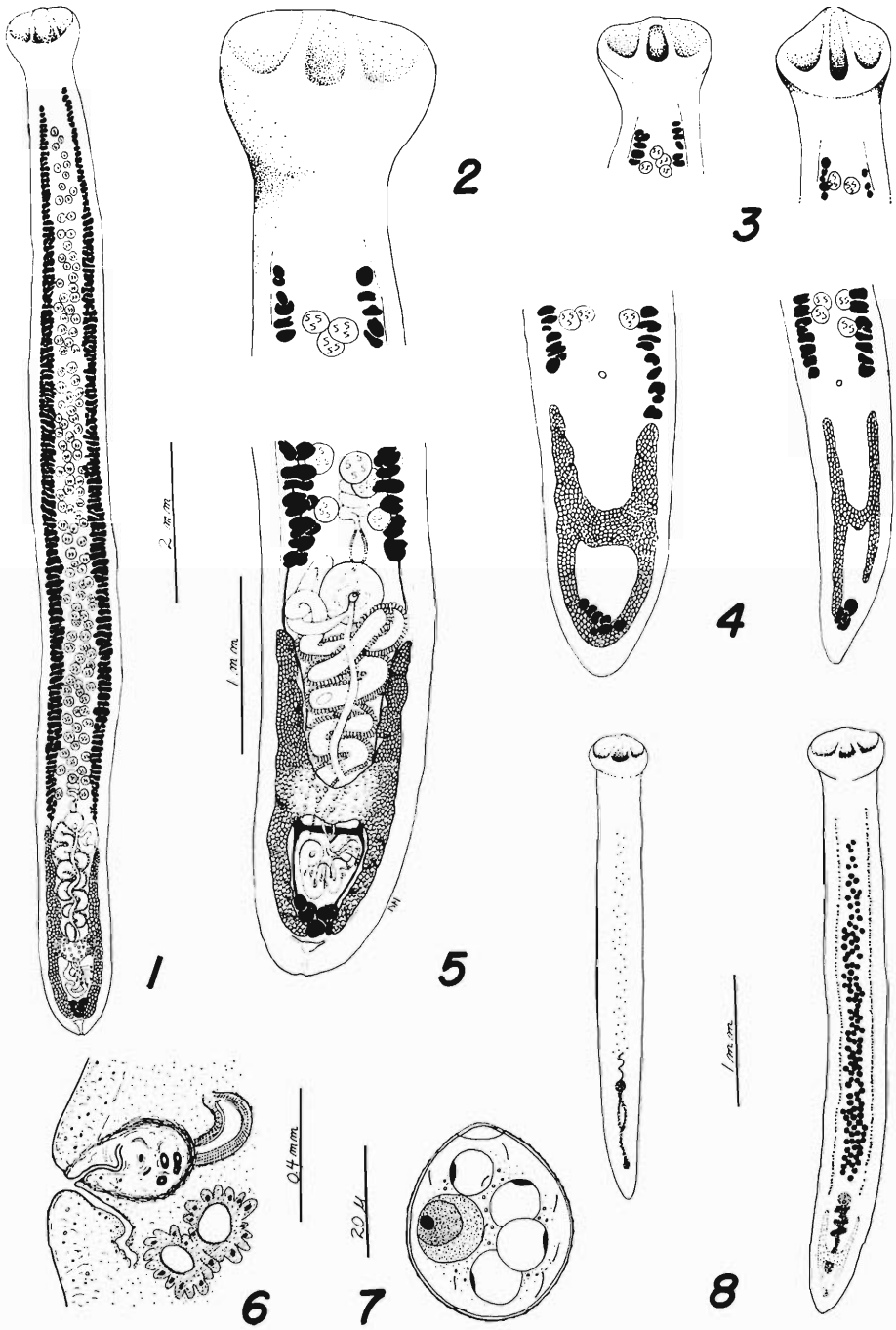
SYNONYMY: *Monobothrium hexacotyle* Linton, 1897; *Caryophyllaeus hexacotyle* (Linton, 1897) Woodland, 1923; *Glaridacris hexacotyle* (Linton, 1897) Hunter, 1927.

HOSTS AND DISTRIBUTION: *Catostomus* sp., Gila and Salt River, Arizona (Linton, 1897); White River, 8 km W. Meeker, Rio Blanco County, Colorado (collected by G. Schmidt). *Catostomus insignis* Baird and Girard, Gila River, Tonto National Forest, Mariocopa County, Arizona. *Catostomus* (*Pantosteus*) *clarki* Baird and Girard, same as *C. insignis* as well as Birch Creek, a tributary of the Virgin River, Zion National Park, Washington County, Utah.

HABITAT: Small intestine, weakly attached or free.

TYPE: Lectotype USNM Helm. Coll. No. 4793, paralectotypes USNM Helm. Coll. No. 4793. Supplementary material includes USNM Helm. Coll. No. 70927, 3 whole mounts from *C. clarki,* USNM Helm. Coll. No. 70928, 10 whole mounts from *C. insignis,* and British Museum (Natural History) Helm. Coll. No. 1967.12.29. 1–3, 3 whole mounts from *C. insignis.*

MORPHOLOGY: There appears to be some confusion regarding the number of gonopores found in this species. According to Hunter (1930: 66), "The cirrus sac opens flush with the ventral surface of the parasite, and the female system empties in a similar fashion just behind that of the male." In his specific diagnosis, however, he seems to imply that there is one gonopore since the terms "common genital atrium" are used. Linton (1897), on the other hand, mentioned *a* genital aperature and clearly pictured one in his figure 3, plate



Figures 1–8. ***Isoglaridacris hexacotyle.*** **1. Gravid individual. 2. Scolex. 3. Scolex variations. 4. Variations in ovarian shape. 5. Posterior region. 6. Midsagital section through the gonopore. 7. Operculate egg with ovum and vitelline cells. 8. Immature individuals.**

XXVIII. That the cirrus joins the uterovaginal canal that in turn opens on the surface as a single gonopore is borne out by a reexamination of the fragments in Linton's vial, of Hunter's slides, particularly numbers 584.7c and 584.9 and examination of 108 cestodes in the present study. Sections on Hunter's slide, that includes the one used for his figure 41, have the cirrus partially everted through a single gonopore. Since *Glaridacris* Cooper, 1920, has two gonopores, it is necessary to make the nomenclatorial changes indicated above.

My other data are in general agreement with Hunter's (1930) detailed description but indicate that there is a greater variation in the species. Mean measurements (in mm, ranges in parentheses) of a selected sample of 30 gravid worms from sonora suckers are: length 10.4 (7–15.5), width at gonopore 0.74 (0.5–1.1), and number of testes 162 (132–205). Measurements of five specimens from gila suckers are: length 10.1 (8.7–12), width at gonopore 0.54 (0.5–0.6), and number of testes 174 (143–223). Immature worms resembled adults and lacked a cercomer (Fig. 8). The characteristic hexagonal scolex, from which the species derives its name, is found only on contracted specimens that have the apex of the scolex thrust forward. Normally the scolex is much like that of *Glaridacris catostomi* Cooper, 1920 (Fig. 2); some of the variations are shown in figure 3. In all cases (91) the vitellaria extended more anteriorly than the testes (Fig. 1) and posteriorly to the cirrus; postovarian vitellaria were always present. Two vitelline ducts connect the postovarian vitellaria with the vitelline reservoir; Hunter (1930) reported only one.

Two types of ovarian variation were observed: unequal arm lengths (Figs. 1, 4) and fusion of the posterior arms to form an inverted A-shaped ovary. This latter variation was found in 8 of the 82 gravid worms from only the sonora sucker.

Ten ova dissected from the distal part of the uterus and measured in water were 35 (32–40) μ long and 29 (28–30) μ wide. The shell is rough, being covered with what appears to be excess shell-material globules; there is a small operculum and there are three to five vitelline cells per egg (Fig. 7).

Additional data on variation growth and incidence have been presented by Chandra (1966) and Amin (1968).

HOST-PARASITE RELATIONSHIPS: There were striking differences in the incidence and worm burden between sonora and gila suckers collected from the same pool. While a mean of 10.7 (3–20) cestodes occurred in 15 of 16 sonora suckers only 2.4 (1–6) were found in 7 of 29 gila suckers. Using the chi square contingency test, the probability is less than 0.005 per cent that the two hosts are infected to the same degree. Such a significant difference may be associated with the different feeding habits of the hosts as reflected in the structure of their mouths. For example, the sonora sucker has thick, fleshy papillose lips that aid in sucking material from mud, sand, or the surface of rocks. The gila sucker, on the other hand, has the same soft, papillose lips but with a tough cartilaginous inner edge that aids in scraping or tearing material from the surface of rocks. Sonora suckers are, therefore, more apt to ingest the probably intermediate host of *I. hexacotyle*, tubificid worms, which normally live in mud.

In August 1964, an average of three (1–12) cestodes were found in four of seven gila suckers, ranging in size from 8.5–18 cm, from Birch Creek in Zion National Park, Utah. Fish were observed scraping and tearing algae and other growths from the surface of large rocks.

SYSTEMATICS: This species is placed in the genus *Isoglaridacris* Mackiewicz, 1965, primarily on the basis of its having a single gonopore; *Glaridacris* has two gonopores and, therefore, cannot receive this species. All of the other characters, such as vitellaria in lateral rows, cuneiform scolex, and type of ovary, are clearly those of *Isoglaridacris*. There are three other species of *Isoglaridacris*: *I. bulbocirrus* Mackiewicz, 1965, from *C. commersoni* (Lacépède) (Mackiewicz, 1965), and *I. longus* Fredrickson and Ulmer, 1967, from *Moxostoma macrolepidotum* (LeSueur) and *I. folius* Fredrickson and Ulmer, 1967, from *M. erythrurum* (Raf.) (Fredrickson and Ulmer, 1967).

According to Linton (1897: 426) the type is USNM No. 4793 with the label "From sucker (*Catostomus* sp.) inhabiting the Gila and Salt River, Arizona; E. Palmer." This number, since recatalogued as No. 49727, consists of a vial with only fragments of worms; no specimen has been designated as

the type. The only other specimens from the original collection are the 19 slides (all sections) found in Hunter's caryophyllaeid collection. Since there is no type specimen, I propose to designate slides 584.7a–d of the Hunter Collection (now USNM Coll. No. 4793) as lectotype; they consist of serial saggital sections of a whole worm. All of the other slides of this species from the same collection are designated as paralectotypes and are now catalogued as USNM Helm. Coll. No. 4793.

Discussion

This nomenclatorial change reduces the number of nearctic *Glaridacris* species to four; Kennedy (1965) has recently considered the palearctic species, *G. brachurus* (Mrázek, 1908) and *G. limnodrili* Yamaguti, 1934, as synonyms of *Archigetes* Leuckart, 1878. The nearctic species fall into two dissimilar groups: one represented by *G. catostomi*, which is long and filiform, has a cuneiform scolex, annularly arranged vitellaria and widely separated gonospores; and the other by *G. laruei* (Lamont, 1921), *G. oligorchis* Haderlie, 1953 and *G. confusa* Hunter, 1927, which are relatively short forms having a terminal disc on the scolex, vitellaria in two lateral rows and gonopores close together.

Such a grouping strongly suggests that the genus *Glaridacris* should be revised to include forms more similar to each other. Indeed, the type of the genus, *G. catostomi*, more closely resembles *Caryophyllaeus terebrans* (Linton, 1893) than it does any other species of *Glaridacris*. Not only do both species have a similar general morphology but study of living and preserved *C. terebrans* from *Catostomus ardens* Jordan and Gilbert in Wyoming clearly confirms the presence of loculi on a weakly developed cuneiform scolex. The scolex of palearctic *Caryophyllaeus* Mueller, 1787, is basically of another type, however, being expanded with apical folds or fimbriae and completely lacking loculi. Comparative studies of the cirrus complex of *G. catostomi* and *C. terebrans* are now in progress; hopefully they should further elucidate the relationship of the nearctic and palearctic *Caryophyllaeus* to each other and to *Glaridacris*.

Acknowledgments

Thanks are extended to Mr. Richard Koehn, graduate student at Arizona State University, for his generous help in collecting hosts from the Salt River; to the National Park Service for permission to examine fish from Zion National Park; to Dr. G. W. Hunter III for loan of the *Glaridacris* part of his collection; and to Dr. G. Smith for his opinion regarding the identity of the Birch Creek fish.

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Echinostome Trematodes from Florida Birds

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Two new species of trematodes of the subfamily Echinostomatinae were recovered from two birds obtained from Leon County in Florida. Also, 25 worms of an already known species of *Echinochasmus donaldsoni* Beaver, 1941 were found in the intestine of two pied billed grebes, *Podilymbus podiceps* Linnaeus. The worms were fixed in hot AFA under slight coverglass pressure and stained in Semichon's carmine.

Measurements are in microns unless otherwise indicated.

Euparyphium anhingae n. sp. (Fig. 1)

HOST: *Anhinga anhinga* Linnaeus.
LOCATION: Intestine.
LOCALITY: Leon County, Florida.
NUMBER OF WORMS: Twelve from one host.
TYPE SPECIMENS: Holotype and two paratypes in USNM Helm. Coll. Nos. 71148, 71149.
DESCRIPTION: Body large, spiny, measures 2.54–4.83 mm in length, and 540–600 in width in the region of ventral sucker, and 610–640 in the region of testes. Body curved at ventral sucker in all specimens. Head collar with 24 spines; four spines on each ventral angle of crown and sixteen spines in a continuous single dorsal row. Size of largest spine 90–110 by 20–25. Oral sucker small, measures 70–85 by 70–90. Ventral sucker large, diameter 340–440, and lies in one-fourth anterior part of body. Distance from anterior end of body to ventral sucker 540–810. Prepharynx absent, pharynx 135–160 by 80–110. Esophagus long, bifurcates anterior to ventral sucker; ceca long, terminating at posterior end of body.

Testes elongated, lobed, tandem, in midbody region. Anterior testis 400–580 by 250–340; posterior testis 370–580 by 230–310. Distance from posterior border of posterior testis to posterior end of body 0.870–1.81 mm. Cirrus sac elongated, posterior border near the middle of ventral sucker; anteriorly cirrus sac extends to intestinal bifurcation and opens at genital pore. Seminal vesicle moderately developed, pars prostatica small. Ovary entire, pretesticular, postacetabular, submedian, 100–260 by 100–120. Seminal receptacle present. Uterus small, pretesticular, has 10 to 15 eggs. Vitellaria follicular; extends from anterior border of anterior testis, along sides of body, to posterior end of body; the two lateral fields join posterior to hind testis. Eggs measure 60–70 by 40–45.

DISCUSSION: The genus *Euparyphium* Dietz, 1909 has a number of species, but only two species, namely, *E. inerme* (Führmann, 1904) Odhner, 1910 and *E. melis* (Schrank, 1788) Railliat, 1919 have been reported from mammals from North America. From the host *Anhinga*, one species, *E. capitaneum* Dietz, 1909, is reported from Brazil and Habana.

Euparyphium anhingae resembles *E. capitaneum* considerably, but differs from it in the following: (1) in having 24 collar spines (not 27); (2) in the absence of prepharynx; (3) in having genital pore at level of intestinal bifurcation (not posterior to intestinal bifurcation), and (4) in the shape of testes.

The shape of testes in *E. anhingae* resembles that of *E. inerme*, but the position of testes in the former is in midbody while in the latter it is in anterior half of body. Further, *E. anhingae* differs from *E. inerme* in the number and size of collar spines and in the absence of prepharynx.

Petasiger floridus n. sp. (Figs. 2, 3)

HOST: Pied billed grebe, *Podilymbus podiceps* Linnaeus.
LOCATION: Intestine.
LOCALITY: Leon County, Florida.
NUMBER OF WORMS STUDIED: Four from one host.
TYPE SPECIMENS: Holotype and one paratype in USNM Helm. Coll. Nos. 71150, 71151.
DESCRIPTION: Body fusiform, broadest at level of ventral sucker; spiny in preacetabular region. Body measures 1.58–2.08 mm in length and 530 to 640 in maximum width. Width of

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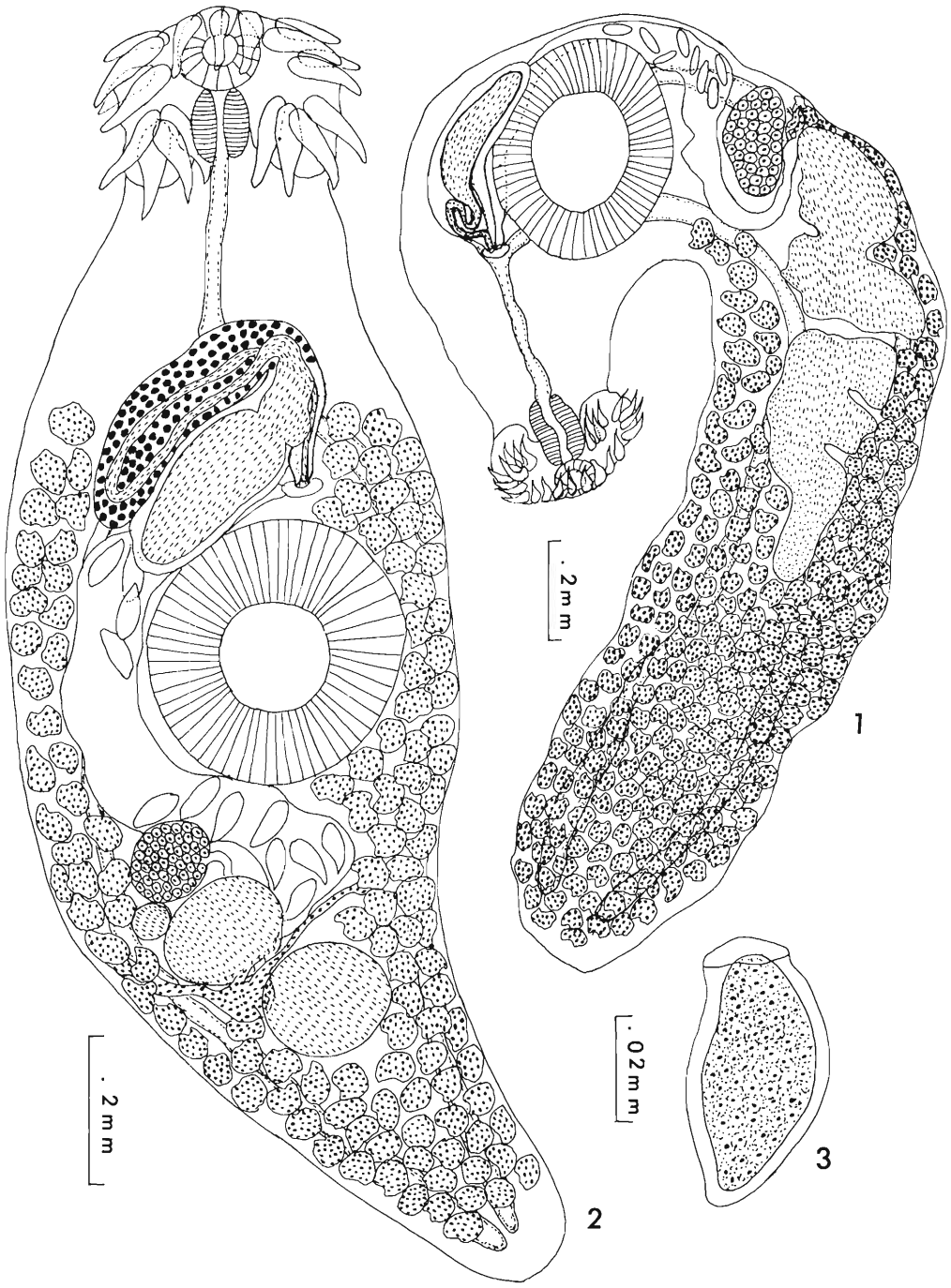

Figures 1–3. 1. *Euparyphium anhingae* from *Anhinga anhinga*. Holotype: Dorsal view. 2. *Petasiger floridus* from *Podilymbus podiceps*. Holotype: Ventral view. 3. *Petasiger floridus*. Egg.

body at oral crown region is 270–330 and at neck region 240–250. Preacetabular length varies from 700–810 and postacetabular from 770–940.

Oral sucker small, diameter 100; ventral sucker large, diameter 370–400; ratio of two suckers 1:3–1:4. Oral crown has nineteen spines; four spines on each ventral angle and four on lateral sides are larger than the three spines on the dorsal side. Largest collar spine measures 135 in length, and the smallest 90. Pharynx oval, measures 90 by 50. Esophagus long; ceca long and terminate at posterior end of body.

Testes oval, oblique in position, may be contiguous or slightly apart; anterior one more toward the right. Both testes measure 200–270 by 170–200. Cirrus sac large, slightly dextral, completely preacetabular, and crowds the intestinal bifurcation. Seminal vesicle divided into a larger posterior portion and a smaller anterior one; pars prostatica very long; prostate glands very massive. Genital pore preacetabular, far behind the intestinal bifurcation.

Ovary submedian, postacetabular and pretesticular, measures 130 by 120. Seminal receptacle and Laurer's canal present. Shell gland dorsal and lies either above or posterior to anterior testis. Uterus short, dextral, with ascending limbs only. Vitellaria follicular, extend from intestinal bifurcation or level of cirrus sac into two lateral fields which join posterior to hind testis, and fill entire posterior body space. Eggs few in number, and measure 60–70 by 40–45.

Discussion: Bashkirova (1941) divided the genus *Petasiger* Dietz, 1909 into two subgenera: (*Petasiger*), type *Petasiger* (*Petasiger*) *exaeretus* Dietz, 1909 for species having tandem testes; and (*Neopetasiger*), type *Petasiger* (*Neopetasiger*) *skrjabini* Bashkirova, 1941 for species having oblique, or symmetrical or nearly symmetrical testes. Skrjabin (1956) followed the classification proposed by Bashkirova and included all the species of the genus *Petasiger* under either of the two subgenera.

Bisseru (1957) does not mention anything regarding the classification given by Bashkirova. On the other hand, he has divided the genus into two groups on the basis of number of collar spines. He named the group with 27 collar spines as *P. exaeretus* Dietz, 1909, and the other with 19–21 spines from grebes as *P. pungens* (Von Linstow, 1894) Führmann, 1928 or *P. megacanthus* Kotlan, 1922. Since then, *P. inopinatum* Baer, 1959 has been reported with 33 collar spines from *Hagedashia hagedash* Latham, 1790. This species does not fall into either of the groups formed by Bisseru.

Of the 33 species of the genus *Petasiger* so far described from different parts of the world, only two, namely, *P. nitidus* Linton, 1928 [described in detail by Beaver (1939)], and *P. chandleri* Abdel-Malek, 1953, have been described from North America, both from grebes. Both the species are included by Skrjabin under the subgenus (*Neopetasiger*). *Petasiger floridus* differs from both these in the following: (1) in having cirrus sac entirely preacetabular; (2) pars prostatica very long; (3) genital pore far behind the intestinal bifurcation and immediately preacetabular; (4) presence of seminal receptacle, and (5) in the size and shape of eggs.

Summary

Two new and one known species of Echinostome trematodes are described from Florida birds.

Echinochasmus donaldsoni Beaver, 1941 were obtained from the intestine of two pied billed grebes, *Podilymbus podiceps* Linnaeus.

Euparyphium anhingae n. sp. from intestine of *Anhinga anhinga* Linnaeus is characterized by the number of collar spines, absence of prepharynx, shape of testes, and position of genital pore.

Petasiger floridus n. sp. from the intestine of *Podilymbus podiceps* is characterized by the position of cirrus sac and genital pore, presence of seminal receptacle, long pars prostatica, and by the size and shape of eggs.

Acknowledgment

I express my sincere thanks to Professor Robert B. Short for the use of his personal library.

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Onchobdella n. gen. New Genus of Monogenetic Trematodes (Dactylogyridae, Bychowski 1933) from Cichlid Fish from West Africa

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Introduction

In the course of parasitological examination of fresh water fishes from different habitats in Ghana (Paperna, 1965), fish of the genus *Hemichromis* were found parasitized with several allied forms of dactylogyrid monogenea whose common morphological affinities separate them from all hitherto known genera of the family Dactylogyridae. Fish caught by hand net or seine net were placed alive into vials containing 0.5–1% solution of formalin. After a few hours, when the fish had died, the concentration of the formalin solution was increased to about 4% by the addition of a few drops of formaldehyde.

The worms were collected from the skin and the gills of the fish as well as from the bottom of the vials. Worms so treated were usually fully relaxed, and were immediately mounted in Glycerine Gelatin for examination. Only mounted specimens were measured. All measurements given are in millimeters.

Onchobdella n. gen.

GENERIC DIAGNOSIS: Body elongated or stout. Prohaptoral anterior lobes are poorly demarcated and head organs are present. Eyes, two or four; if four, they may be arranged in one transverse row in front of the round pharynx. Intestinal crura are united posteriorly. The single testis is in the posterior position within the intestinal loop, while the single ovary is located anteriorly to the testis. Copulatory organ consists of tubiform cirrus and an accessory piece, consisting of two elongate flattened pieces, attached to each other along one or two of their edges and between these two planks the distal part of the cirrus is protruded. Seminal vesicles and 2–3 prostate glands follow the distal part of the male genital system. Vagina present.

Anchors unequal in size and shape, one, usually the larger pair, is followed by one common solid bar, frequently curved, while each anchor of the second pair, which is usually the smaller and hook-shaped, is followed by one club-shaped bar. Each of the anchors is accompanied by complicated sclerotized filaments which are attached to the anchor's shaft as well as lining the outer margins of the aperture in the skin through which the anchors are drawn out.

Hooklets, 5–6 pairs, each consists of rudimentary base, delicate long needle-shaped shaft and solid spike with delicate posterior projecting process. The large anchors in the opisthaptor are arranged distal-laterally with their tips pointed inward, one against the other. Such position is relatively rare among *Dactylogyridae*. More often anchors are located with their tips toward the lateroventral side of the opisthaptor.

TYPE SPECIES: *Onchobdella voltensis* n. sp.

TYPE HOST: *Hemichromis fasciatus*.

LOCALITY: Afram sector, *Volta Lake*.

REMARKS: Anchors located in similar position as in *Onchobdella* n. gen., i.e. lateral-distally with tips pointed inward are characteristic also of few other "ancyrocephalid" genera such as *Bifurcohaptor* Jain 1958, *Hamatopeduncularia* Yamaguti, 1953, *Hargitrema*

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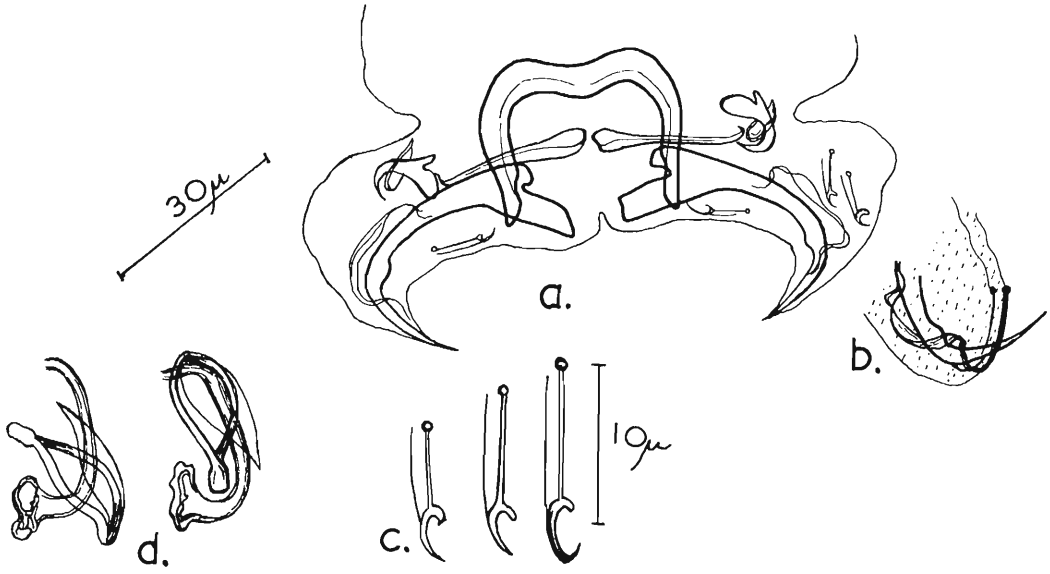

Figure 1: ***Onchobdella voltensis.*** **a: Opisthaptor, anchors and bars. b: Additional sclerites associated with the erection mechanism of the anchors. c: Hooklets. d: Copulatory organ.**

(Hargis, 1955) and a few species of the genus *Dactylogyrus*. Each of these forms, however, differs from *Onchobdella* in the details of the morphological structures of the opisthaptor and its anchors, bars and hooklets.

Onchobdella voltensis n. sp. (Figures 1 and 3b)

DESCRIPTION: Small stout worms 0.20–0.35 long, 0.10–0.15 wide. Two to four eyes are present. Opisthaptor occupies the whole posterior end of the body, 0.05–0.12 wide, 0.02–0.04 long. The pair of the larger anchors are 0.06–0.09 long with 0.01–0.015 long inner root. The bar associated with these anchors is horseshoe-shaped, 0.07–0.10 long and 0.002–0.005 thick. The second pair of anchors are 0.015–0.020 long and have well demarcated inner and outer roots.

The attached bars are 0.02–0.04 long, their proximal thin end is not filiform as in the other species (see further). In the copulatory organs the cirrus is a heavy short tube 0.03–0.05 long with wide thick walled basal funnel. The accessory piece consists of two solid 0.025–0.030 elongate sclerotized pieces and an additional median filamentous piece, attached together form an ellipsoidal shape through which the cirrus is protruded.

HOST AND LOCALITIES: Gills of *Hemichromis fasciatus*, Afram sector, Volta Lake. Gills of *Hemichromis bimaculatus*, Afram sector and Kete Krachi, Volta Lake and Adutor Lagoon in the Volta river "delta."

SPECIMENS STUDIED: Six, from *H. fasciatus* and one from *H. bimaculatus*.

TYPE SPECIMENS: Type and paratype in the British Museum, London; other paratypes in the author's collection.

Onchobdella spirocirra n. sp. (Figures 2 and 3a)

DESCRIPTION: Body stout, 0.28–0.50 long, 0.15–0.25 wide. Only two eyes are present. Opisthaptor is narrower than the entire body, 0.09–0.11 long, 0.08–0.09 wide.

The large anchors are 0.13–0.15 long with 0.02–0.25 long inner root. The horseshoe-shaped bar of the large anchors is 0.11–0.16 long, 0.010–0.012 wide. The anchors of the small pair are 0.02–0.03 long with well-demarcated inner and outer roots.

Their attached club-shaped individual bars

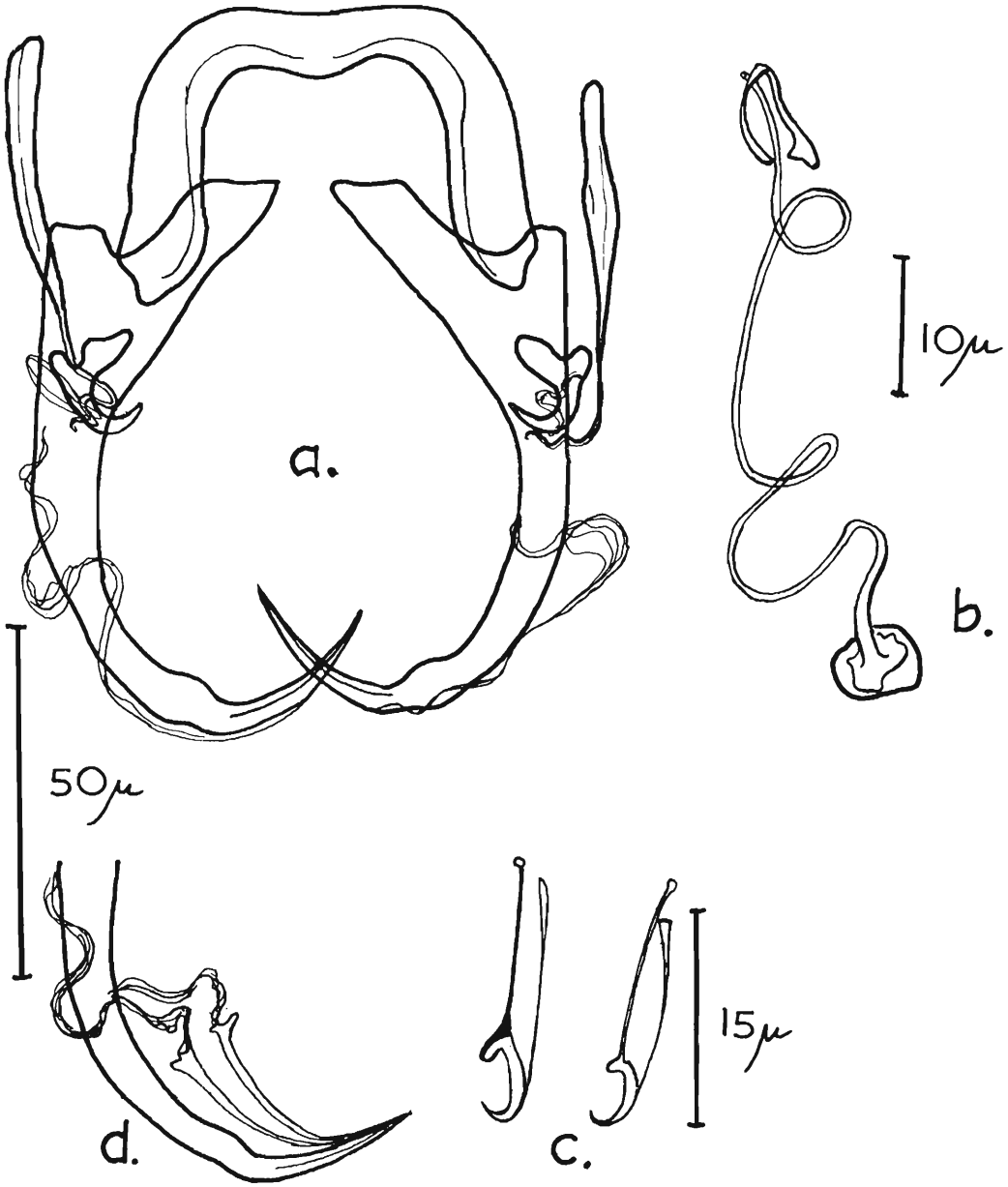

Figure 2. ***Onchobdella spirocirra.*** **a: Anchors and bars. b: Copulatory organ. c: Hooklets. d: Additional sclerites of the large anchors.**

end proximally with a filiform process. Their solid part is 0.05–0.07 long. Hooklets are 0.017–0.019 long with 0.008–0.009 long spike.

Copulatory organ consists of 0.05–0.07 long filiform spirally coiled cirrus, originating from a thin walled, round funnel and two elongated, triangular accessory pieces, 0.007–0.008 long, located at the tip of the cirrus.

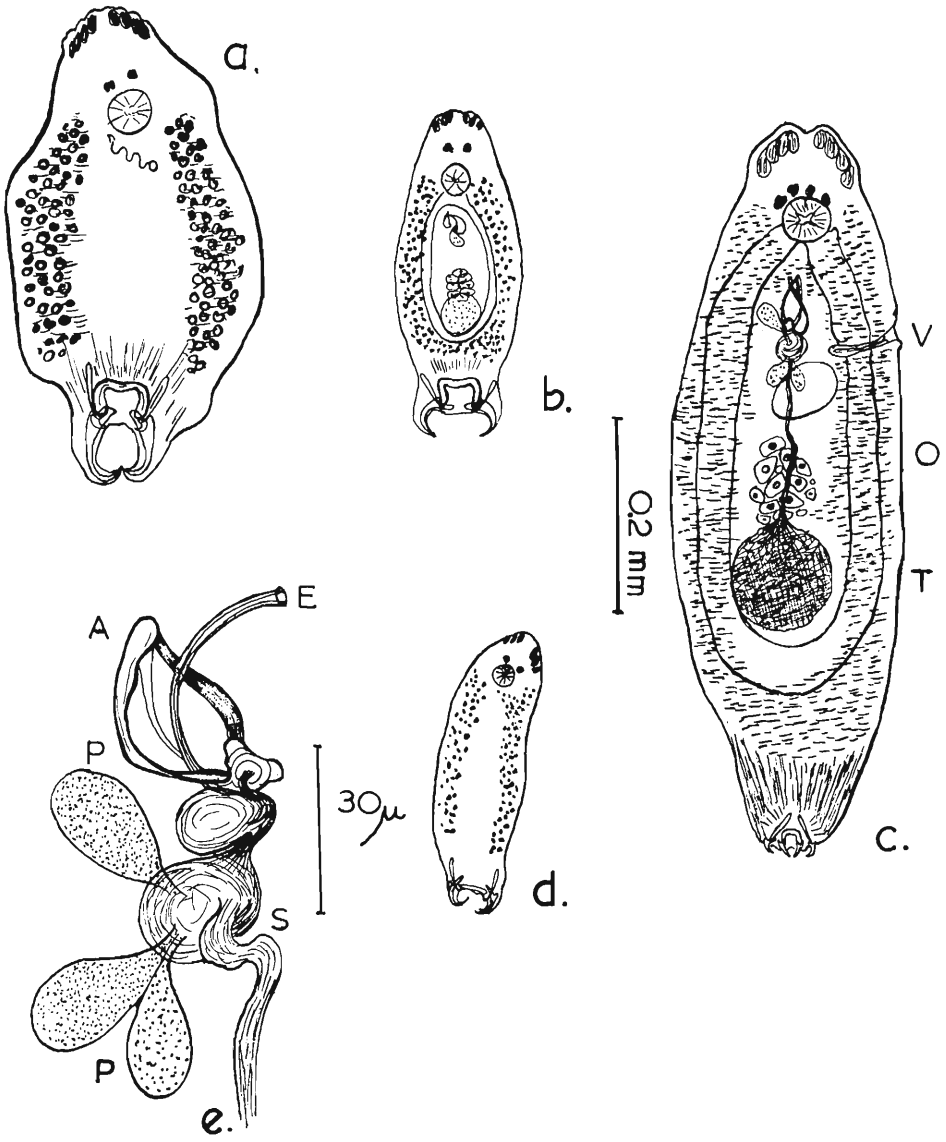

Figure 3. a: ***Onchobdella spirocirra*** **(Dorsal view).** b: ***O. voltensis*** **(Dorsal view).** c: ***O. pterigyalis*** **(Dorsal view, O—ovary, T—testes, V—vaginal pore).** d: ***O. krachii.*** **e: Terminal male genital system of** ***O. pterigyalis*** **(A—Accessory piece, E—Cirrus, P—Prostate glands, S—Seminal vesicle).**

HOST AND LOCALITIES: Gills of *Hemichromis bimaculatus*, from Mamahuma stream, east of Accra, and Afram sector, Volta Lake.

SPECIMENS STUDIED: Three.

TYPE SPECIMENS: Type in the British Museum, London. Paratype in author's collection.

Onchobdella pterigyalis n. sp. (Figures 3c, e, 4a, b)

DESCRIPTION: Large worms 0.50–0.75 long, 0.20–0.25 wide. Opisthaptor rudimentary, inserted into the posterior end of the body, 0.02–0.04 long, 0.03–0.04 wide. Four eyes

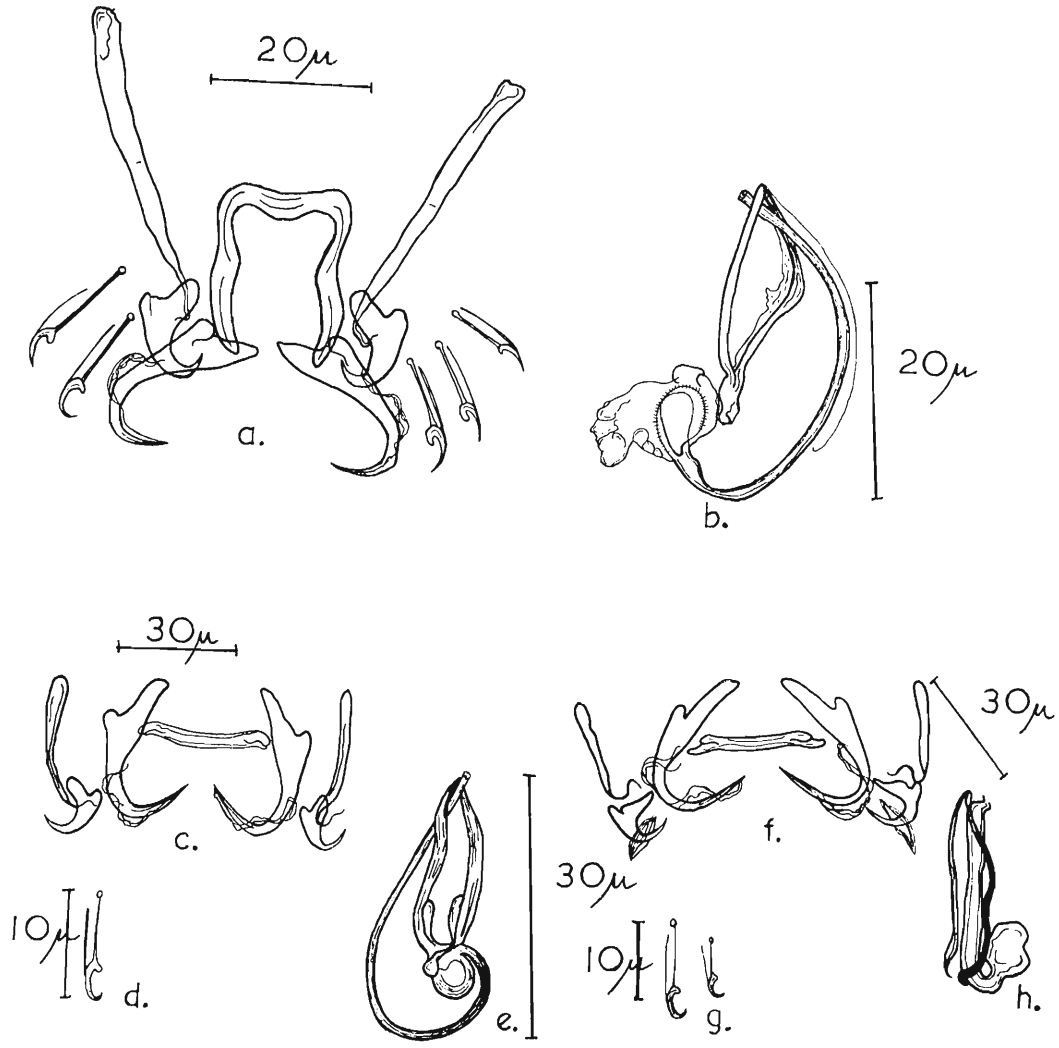

Figure 4. ***Onchobdella pterigyalis:*** **a: Anchors, bars and hooklets. b: Copulatory organ.** ***O. krachii*****: c: Anchors and bars. d: Hooklet. e: Copulatory organ.** ***O. aframae*****: f: Anchors and bars. g: Hooklets. h: Copulatory organ.**

are present, located in one transverse row in front of the pharynx. The "large" pair of anchors is greatly reduced, 0.035–0.045 long with 0.005–0.008 long inner roots, only slightly larger than the second "small" pair.

Their attached horseshoe-shaped bar is 0.05–0.06 long. The anchors of the second pair are 0.025–0.030 long, their inner and outer roots are well demarcated. Their individual bars are 0.032–0.040 long, their filiform prominal end is short. Hooklets are about 0.02 long with 0.005 long spike.

In the copulatory organ the cirrus is 0.08–0.09 long, elongated tube with wide, thick-walled funnel. The rim of the funnel is strengthened by solid sclerotized processes. The 0.02–0.03 long accessory piece consists of two plates meeting at both ends, enclosing an ellipsoidal space. At one edge the accessory piece is attached to the funnel. Vagina, with-

out sclerotized walls, opens on the left side of the body (when worm is placed on its dorsal side).

HOST AND LOCALITY: Fins of young *Hemichromis bimaculatus*, Collected in Nungua dam and Mamahuma stream, east of Accra. The parasites were found only after the fish host were kept one month in the laboratory aquarium.

SPECIMENS STUDIED: Five.

TYPE SPECIMENS: Syntypes in the British Museum, London. Paratypes in author's collection.

The following two species differ from the ones described above in having straight and not bent bar, attached to the large anchors. It is not certain whether this type of bar can be accepted as a specific character in these species as they may be rather an immature form of the normal horseshoe-shaped bar. In the collected worms all the genital organs were fully developed. However, only the presence of fully developed egg in the worms could safely indicate a fully mature stage of development.* These forms are, however, described as separate species in view of the specific morphology of the copulatory organs.

Onchobdella krachii n. sp. (Figures 3d, 4c, d, e)

DESCRIPTION: Small, elongated worm, 0.3 long, 0.09 wide. Opisthaptor 0.06 wide, 0.04 long, simple, poorly demarcated from the rest of the body. The anchors of the "large" pair are 0.045–0.060 long, while their inner root is 0.015–0.020 long. Their attached bar, is straight 0.032 long, 0.004 wide. The anchors of the small pair are 0.025–0.030 long, their individual bars are 0.03–0.04 long, with only short filiform proximal processes. Hooklets are 0.01–0.012 long. In the copulatory organ, the cirrus is a long and delicate tube, 0.08 long, arising from round, thin-walled funnel. Its accessory piece, 0.02 long, consists of two sclerotinoid pieces attached to the funnel and another filamentous piece. All the three pieces are jointed distally enclosing a triangular space.

HOST AND LOCALITY: Gills of *Pelmatochromis guentheri*, Kpandu and Kete Krachi, Volta Lake.

SPECIMENS STUDIED: Two.

TYPE SPECIMENS: Type in the British Museum, London. Paratype in author's collection.

Onchobdella aframae n. sp. (Figures 4f, g, h)

DESCRIPTION: Body elongated, 0.30–0.35 long, 0.05–0.10 wide. Only two eyes are present. Opisthaptor is 0.05–0.06 wide and 0.01–0.02 long. The large anchors are 0.06–0.07 long with 0.012–0.015 long inner roots. The associated straight bar is 0.03–0.04 long. The small anchors are 0.02–0.03 long with well demarcated inner and outer roots. Their individual bars are 0.02–0.03 long, their proximal filiform processes are short. Hooklets are about 0.01 long.

In the copulatory organ, the cirrus is a heavy straight tube, 0.05–0.06 long with a large round funnel. The 0.03–0.05 long, accessory piece consists of two parallel rodlike sclerites usually not jointed distally.

HOST AND LOCALITY: Gills of *Hemichromis fasciatus*, Afram sector, Volta Lake.

SPECIMENS STUDIED: Three.

TYPE SPECIMENS: Type, in the British Museum, London. Paratype in author's collection.

REMARKS: The divergence of the species in this genus as evidenced by the morphological variability is apparently not only associated with adaptation to the different hosts but is rather more frequently associated with the adaptation to the different micro habitats occupied within the organs of a single or few closely related host species. *O. pterigyalis*, parasitizing the fins can serve as a significant example, showing reduction in the size of the opisthaptor and its sclerotinoid armature compared with those of the gill parasites.

As can be seen from the table of ratios below, the ratio between the lengths of the two groups of anchors, the ratio between the total length of the large anchor and the length of its inner root, as well as the ratio between the size of the worm and the size of the opisthaptor are of importance in the diagnosis distinguishing the different species of this genus. Of these ratios, the large anchors to small anchors ratio is the most variable. With the reduction in the size of the large anchors, there is also a parallel decrease in the size of the opisthaptor, which becomes very reduced

* Recently mature specimens of *O. aframae* were collected containing egg in the uterus, but still having a straight bar as in the juvenile specimens.

Table 1. The ratio between the size of the different organs in species of *Onchobdella*.

Ratio: in:	*O. voltensis*	*O. spirocirra*	*O. pterigyalis*	*O. krachii*	*O. aframae*
Body length to opisthaptor length	9–10 / 1	3–4.5 / 1	20–25 / 1	7.5 / 1	15 / 1
Body width to opisthaptor width	1–2 / 1	2–2.5 / 1	6–7 / 1	1.33 / 1	0.8–1.7 / 1
Large anchors to small anchors	3–3.5 / 1	5–7 / 1	1.5 / 1	1.8–2 / 1	2–3 / 1
Small anchor's bar to large anchors	1 / 2–3.5	1 / 3.5–5	1 / 1.1–1.2	1 / 1.9	1 / 3–4.9
Root of large anchors to large anchors	1 / 7–8	1 / 6	1 / 6–7	1 / 3	1 / 4–5
Cirrus to accessory piece	1.2–1.6 / 1	6–7 / 1	3–4 / 1	4 / 1	1.2–1.5 / 1

in *O. pterigyalis*. In addition, as in most of the groups of Dactylogyridae, the morphology of the copulatory organ is also characteristic of each species. Here, the relative size of the cirrus decreases from *O. spirocirra*, through *O. pterigyalis* and *O. krachii* to *O. voltensis* and *O. aframae* (Table 1).

Summary

Five new species of monogenetic trematodes (Dactylogyridae) included into a new genus *Onchobdella* are described (*O. voltensis, O. spirocirra, O. pterigyalis, O. krachii, O. aframae*). The hosts are cichlid fish of the genera *Hemichromis* and *Pelmatochromis* collected in Ghana in small water reservoirs in the coastal plain and in several sectors of the Volta Lake.

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New Host Records of Intestinal Nematodes of Maryland Rodents and Suppression of *Capillaria bonnevillei* Grundmann and Frandsen, 1960 as a Synonym of *C. americana* Read, 1949[1]

J. Ralph Lichtenfels[2] and A. James Haley[3]

Introduction

Major surveys of nematode parasites of rodents of the United States have been conducted in the southwest by Hall (1916), North Carolina by Harkema (1936), Minnesota by Erickson (1938), and the north central states by Rausch and Tiner (1948, 1949). More recently, studies have been done in Utah by Grundmann and Frandsen (1960a) and Grundmann et al. (1961), Colorado and Idaho by Leiby (1961, 1962), Alaska by Rausch (1952, 1957, and others), and Nevada by Babero and Matthias (1967). In Maryland, the nematode parasites of rodents have not been extensively surveyed. Hall et al. (1955) examined six species of Maryland rodents for helminths and Price (1960) studied the filar-

[1] Adapted from a thesis presented by the senior author to the Department of Zoology, University of Maryland, in partial fulfillment of the requirements for the degree of Master of Science.

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Table 1. Intestinal nematodes found in a survey of some rodents of Maryland (1963–1964). New host records are indicated by an asterisk (*).

Host	No. examined	No. infected	Nematodes collected
CRICETIDAE			
Peromyscus leucopus	73	2	*Capillaria americana*
		23	*Rictularia coloradensis*
		1	*Syphacia* sp.
		1	*S. peromysci*
		1	*Aspiculuris tetraptera*
		1	*A. americana*
Neotoma magister	3	2	**Capillaria americana*
		2	**Trichuris* sp.
Clethrionomys gapperi	17	1	**Capillaria americana*
		6	*Heligmosomum carolinensis*
		1	*Syphacia* sp.
Microtus pennsylvanicus	15	6	*Trichuris opaca*
		7	*Longistriata dalrymplei*
		4	*Syphacia* sp.
ZAPODIDAE			
Zapus hudsonius	5	3	**Longistriata dalrymplei*
		2	*Citellinoides zapodis*
SCIURIDAE			
Tamias striatus	3	1	**Rictularia coloradensis*
Tamiasciurus hudsonicus	15	3	**Strongyloides robustus*
		11	**Capillaria americana*
		7	*Citellinema bifurcatum*
		1	*Syphacia thompsoni*
MURIDAE			
Rattus norvegicus	3	1	*Mastophorus muris*
		3	*Heterakis spumosa*
Mus musculus	35	3	*Mastophorus muris*
		22	*Syphacia obvelata*
		23	*Aspiculuris tetraptera*

ioid nematodes of some small mammals of Maryland. In the present study, nine species of rodents from nine localities in five counties of Maryland were examined for intestinal nematodes. Seven of the nine rodent species were collected entirely from three western counties where apparently no previous surveys had been conducted.

Materials and Methods

Collections were made with snap and box traps in the summers of 1963 and 1964. Red squirrels were shot in March of 1964. The identification of rodents was aided by museum specimens of the Inland Resources Division, Natural Resources Institute, University of Maryland. Two-thirds of the rodents were examined the day of capture; the others were stored in a deep freeze. The digestive tracts of the rodents were opened in water, scraped with a curved glass rod, and examined with transmitted light under a dissection microscope. The nematodes were fixed in hot alcohol-glycerine and cleared for study in a solution of 80% phenol and 20% absolute alcohol. Measurements are presented only when they provide new information and are given in microns unless otherwise indicated.

Results and Discussion

Sixteen species of nematodes representing six superfamilies were collected from 100 of 169 rodents and seven new host records are reported (Table 1). Brief discussions are given of new data that supplement or correct descriptions of species or establish new host records.

Superfamily Rhabditoidea
Strongyloides robustus Chandler, 1942

HOST: *Tamiasciurus hudsonicus* (Erxleben), red squirrel.

HABITAT: Small intestine.

LOCALITY: Northeastern Garrett County, Maryland.

INTENSITY OF INFECTION: One host harbored 60 nematodes, two others harbored one each.

SPECIMENS: USNM Helm. Coll. No. 65585.

MEASUREMENTS (based on 13 specimens): As published by Chandler (1942) except: tail length 77–103 instead of 60–80; uterus to anus 240–473 instead of 100–260.

DISCUSSION: *Strongyloides robustus* was described from *Sciurus niger* (type host) and *S. carolinensis* from southeast Texas. Dozier and Hall (1944) found it in *S. niger* from Dorchester County, Maryland. The present report from *Tamiasciurus hudsonicus* is the third of this species and a new host record.

Superfamily Trichuroidea
Capillaria americana Read, 1949

HOSTS: *Tamiasciurus hudsonicus*, Red squirrel; *Neotoma magister* Baird, woodrat; *Peromyscus leucopus* (Rafinesque), whitefoot mouse; *Clethrionomys gapperi* (Vigors), redback vole.

HABITAT: Posterior half, small intestine.

LOCALITY: Northeastern Garrett County, Maryland.

INTENSITY OF INFECTION: One to six specimens per host.

SPECIMENS: USNM Helm. Coll. Nos. 65586 (red squirrel), 65587 (wood rat), 65588 (whitefoot mouse), 65589 (redback vole).

MEASUREMENTS: Table 2.

DISCUSSION: *Capillaria americana* was described from *Glaucomys volans* (type host), *Sciurus carolinensis, Peromyscus maniculatus*, and *P. leucopus* from the north central USA (Read, 1949). The present report of *C. americana* from the red squirrel, wood rat, and redback vole constitutes three new host records.

In the course of identification the senior author studied the type specimens of both *Capillaria americana* and *Capillaria bonnevillei* Grundmann and Frandsen, 1960. It became apparent that differences between the descriptions of the two species were due to errors in both descriptions. The spicule sheath of *C. americana* was described as smooth and the vulva as dividing the body 1:2.4 to 1:2.7. However, an examination of the cotypes disclosed that the spicule sheath is spined and the vulva divides the body 1:3.4. The specimens from the present collection agree with the characters found in the cotypes of *C. americana*.

Grundmann and Frandsen (1960b) described *C. bonnevillei* from *Dipodomys ordii* from Utah and separated it from *C. americana* by the presence of spines on the spicule sheath, bilobate papillae on the caudal lobes of the male, and the apparent absence of bacillary bands. However, bacillary bands are present in the holotype and allotype of *C. bonnevillei* and, as pointed out above, the spicule sheath of *C. americana* is spined. The papillae on the caudal lobes of the males do appear to be bilobate but are very similar in the two species. Therefore, a comparison of the measurements and morphological characteristics of *C. americana* and *C. bonnevillei*, supplemented with data obtained from the present collection (Table 2), leaves no doubt that *C. bonnevillei* is a synonym of *C. americana*.

Trichuris sp.

HOST: *Neotoma magister*, woodrat.

HABITAT: Caecum.

LOCALITY: Northwestern Allegany County, Maryland.

INTENSITY OF INFECTION: Fragments of three females from one rat; one male from another.

SPECIMENS: USNM Helm. Coll. No. 66277.

DISCUSSION: This is a new host record for *Trichuris* sp. The limited material and its fragmented condition made determination difficult. The single male specimen differs in several characters from its most similar forms, *T. muris* (Schrank, 1788) and *T. madisonensis* Tiner, 1950. Additional specimens are necessary for a proper description.

Superfamily Strongyloidea
Longistriata dalrymplei Dikmans, 1935

HOSTS: *Microtus pennsylvanicus* (Ord), meadow vole; *Zapus hudsonius* (Zimmerman), meadow jumping mouse.

HABITAT: Small intestine.

Table 2. A comparison of *Capillaria americana* Read, 1949 and *C. bonnevillei* Grundmann and Frandsen, 1960 including data from the original descriptions of the species, a restudy of the type specimens (data in parentheses), and specimens of *C. americana* from Maryland rodents. All measurements are in microns unless otherwise indicated.

	C. americana Read, 1949		*C. bonnevillei* Grundmann and Frandsen, 1960		*C. americana* from Maryland rodents (12 specimens of each sex)	
Sex	male	female	male	female	male	female
Body length	12.2–15.4 mm	23.0–28.4 mm	12.3–16.0 mm	19.8 mm	9.3–12.7 mm	24.0–32.5 mm
Esophagus length	5.4–6.5 mm	6.8–7.5 mm	4.3–4.7 mm	4.6 mm	3.7–5.0 mm	4.7–7.8 mm
Number of paraesophageal nuclei	41–45	36–39	36	36	38–47	37–50
Anterior end to first paraesophageal nucleus	(418)	(486)	(370)	(360)	300–384	328–520
Body diameter at base of esophagus	(76)	(100)	(89)	(129)	56–77	72–117
Maximum body diameter near middle of body	84–103	121–144	(113)	(149)	65–110	115–144
Spicule length	209–258		240–300		182–234	
Spicule width at base	11–14		(14)		12–17	
Vulva to posterior end of esophagus		(113)		(50)		48–132
Egg length × width		46–52 × 23–27		41–59 × 20–29		50–62 × 24–30
Spined spicule sheath	(yes)		yes		yes	
Bacillary band	yes		(yes)		yes	

LOCALITY: Northeastern Garrett County, Maryland.

INTENSITY OF INFECTION: Voles—30, 23, 7, 1 or 2 in each of four others; Jumping mice—5, 1 in each of two others.

SPECIMENS: USNM Helm. Coll. Nos. 65591 (*Microtus*) and 65592 (*Zapus*).

DISCUSSION: This species was described from *Ondatra zibethica* and *Microtus pennsylvanicus*. Rausch and Tiner (1949) found it in voles from a single locality—a marsh in Wisconsin. In the present study the hosts were trapped in the edge of a meadow bordering a swamp. The present report of *L. dalrymplei* from *Zapus hudsonius* is a new host record.

Heligmosomum carolinensis (Dikmans, 1940)

HOST: *Clethrionomys gapperi*, redback vole.

HABITAT: Small intestine.

LOCALITY: Western and northeastern Garrett County, Maryland.

INTENSITY OF INFECTION: One host harbored 15 specimens; the other five harbored one to three specimens each.

SPECIMENS: USNM Helm. Coll. No. 65593.

MEASUREMENTS: Esophageal length 600–653; body diameter at base of esophagus 72–91; greatest diameter of esophagus 34–52.

Male: Body length 5.02–5.43 mm; spicule length 1.90–2.01 mm; body diameter in prebursal region, 91–120.

Female: Vulva to posterior end body 137–192; tail length, excluding spine, 62; tail spine length 10; ovejector length 173–259; body diameter, region of ovejector, 107–166; egg length 60–65; egg width 36–47; ovejector to posterior end of body 657–735.

DISCUSSION: The present collection is only the third record of *H. carolinensis*, and it provides supplemental data on the characteristics of the species. The original collection by Dikmans (1940) from *Clethrionomys gapperi* in North Carolina included a single entire male and no entire females. An examination of the cotypes revealed the entire male to be a fourth-stage larva. It is not surprising, there-

fore, that males of this species collected by Schad (1954) from the redback vole in Canada were longer with normally (instead of weakly) sclerotized spicules and longer bursal branches than the type material. The present collection contained a fourth-stage larva and other specimens intermediate in size between the type material and that collected in Canada by Schad.

Superfamily Oxyuroidea
Aspiculuris americana Erickson, 1938

HOSTS: *Peromyscus leucopus*, whitefoot mouse.

HABITAT: Large intestine.

LOCALITY: Allegany County, Maryland.

INTENSITY OF INFECTION: Nine females and one male from the single host.

SPECIMENS: USNM Helm. Coll. No. 65603.

MEASUREMENTS: Male: Body length 2.73 mm; esophagus length 341; esophageal bulb length 115; esophageal bulb width 55; body diameter, base of esophagus 89; termination of cervical alae to base of esophagus 144; tail length 233; most posterior papillae to cloacal opening 72.

Female: Body length 4.00–4.30 mm; esophageal length 415–456; esophageal bulb length 139–154; esophageal bulb width 65–72; body diameter, base of esophagus 106–113; cephalic expansion length 84–91; termination of cervical alae to base of esophagus 194–238; tail length 676–784; egg length 79–86; egg width 29–36; vulva to anterior end of body 1.56–1.68 mm; excretory pore to anterior end of body 800.

DISCUSSION: This is the third report of *Aspiculuris americana*. It was described from both *Peromyscus leucopus* and *P. maniculatus* in Minnesota by Erickson (1938). The next report was from *P. floridanus* in Florida by Layne (1963) who included no description of his specimens. The present report, therefore, provides additional information about the range and measurements of *A. americana*.

Superfamily Spiruroidea
Rictularia coloradensis Hall, 1916

HOSTS: *Peromyscus leucopus*, whitefoot mouse; *Tamias striatus* (Linnaeus), eastern chipmunk.

HABITAT: Anterior region, small intestine.

LOCALITY: Montgomery, Washington, Allegany, and Garrett Counties, Maryland.

INTENSITY OF INFECTION: One to six specimens per whitefoot mouse (including two male worms) and one female from the single chipmunk host.

SPECIMENS: USNM Helm. Coll. Nos. 65598 (*P. leucopus*) and 65599 (*T. striatus*).

DISCUSSION: The single female *Rictularia coloradensis* from an eastern chipmunk represents a new host record. All specimens obtained in this collection conformed with the redescription of *R. coloradensis* given by Tiner (1948). However, the status of Tiner's redescription is unsettled. It was based on males with precloacal fans, but the type male of the species (Hall, 1916) has no precloacal fans and has much larger spicules than Tiner's males. In this connection, McPherson and Tiner (1952) reported both kinds of males from a single whitefoot mouse and Oswald (1958) reported both types of males in experimental infections in *Mus musculus*. Experiments using eggs from a single female worm may be necessary to solve this perplexing problem of two types of males for one nematode species. Efforts are underway to provide additional information.

Other Helminths

Very few Platyhelminthes were encountered in this study. One unidentified trematode was recovered in a deteriorated condition from a whitefoot mouse. Cestodes were found in one of three Norway rats, *Rattus norvegicus* (Berkenhout), from Allegany County and in two of 15 meadow voles from Garrett County. Those from the Norway rat were identified as *Hymenolepis diminuta* (Rudolphi, 1819) and those from the vole as *Aprostatandrya macrocephala* (Douthitt, 1915).

Summary

Sixteen species of intestinal nematodes were found in nine species of rodents collected in five counties of Maryland. Seven new host records are reported. *Capillaria bonnevillei* Grundmann and Frandsen, 1960 is placed in synonymy with *C. americana* Read, 1949 and errors in the description of *C. americana* are corrected.

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Ultrastructure of the Metacercarial Cyst of *Ascocotyle chandleri* Lumsden, 1963 (Trematoda: Heterophyidae)[1]

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Heterophyid trematodes of the genus *Ascocotyle* Looss, 1899, utilize various brackish water fishes and, in some instances, larval anurans as second intermediate hosts. The trematode larvae exhibit marked specificity for a particular organ, and are nearly always found in close proximity to the circulatory system of the host. The cercariae penetrate the subendothelial tissues where they encyst and undergo development to the preadult (metacercaria).

Light microscopy studies on the encystment of *Ascocotyle* spp. in their second intermediate hosts have been described by Sogandares and Lumsden (1963, 1964), Timon-David (1961), and Schroeder and Leigh (1965). During the present investigation, the ultrastructure of the cyst wall of *Ascocotyle chandleri* and surrounding host tissues has been examined by electron microscopy as an initial step in determining the mechanism of the encystment process and the nature of the mature cyst. Previous electron microscope studies on metacercarial cyst structure and formation include those of Dixon and Mercer (1964, 1967) and Mercer and Dixon (1967) on *Fasciola hepatica* Linn., 1758, and that of Macy et al. (1968) on *Sphaeridiotrema globulus* (Rud., 1814).

Methods and Materials

Livers of naturally infected *Cyprinodon variegatus* Lacépède were scanned with a dissecting microscope to locate the metacercarial cysts. Areas of tissue containing the cysts of *A. chandleri* were excised and prepared for microscopic study by a variety of methods, including fixation with buffered glutaraldehyde, acrolein, and osmic acid, and embedment in epoxy resins or methacrylates. Considerable difficulty was encountered infiltrating intact cysts with sufficient plastic adequate to obtain thin sections of the material for electron microscopy; best results were obtained when the cysts were mechanically ruptured during fixation, thus allowing simultaneous access of the monomer mixture to the inner and outer surfaces of the cyst wall.

The material illustrated in the present paper was fixed in 3 per cent glutaraldehyde buffered at pH 7.3 in 0.12 M monobasic sodium phosphate-sodium hydroxide, saturated with calcium chloride, and containing 3 per cent sucrose. After fixation for 2–4 hours at ice water temperatures, the tissue blocks were washed in cold phosphate buffer, postfixed 1 hour with 1 per cent osmium tetroxide (Millonig, 1961), dehydrated with ethanol and propylene oxide, and embedded in epon (Luft, 1961). Thin sections (displaying silver interference colors) were cut on diamond knives with a Sorvall MT-2 ultramicrotome, collected on uncoated copper grids, double stained with uranyl acetate and lead citrate, and examined in a Siemens Elmiskop 1A electron microscope operated at an accelerating voltage of 80 kv. Thick (1 μ) sections for light microscopy were mounted on microslides and stained with azure B.

Results and Discussion

Encystment of *Ascocotyle chandleri* in the liver of *Cyprinodon variegatus* is, as noted by Lumsden (1963), immediately subadjacent to the endothelium of the hepatic sinusoids (Figs. 1–5). The metacercaria is surrounded by a cyst wall approximately 15 μ thick, consisting of a finely granular matrix of moderate electron density (Figs. 5 and 9). This primary cyst wall is bordered on its inner surface by a layer of more coarsely filamentous material with adherent membrane-limited vesicles (Fig. 7). The periphery of the cyst is marked by an electron opaque, bilamellate cortex (Fig. 6) in direct contact with a lamina consisting of an amorphous matrix of variable thickness containing occasional collagen fibers (Figs. 6 and 8). Adjacent to this lamina are one or more layers of endothelial cells (Figs. 1–6) joined to one another by desmosomal junctions

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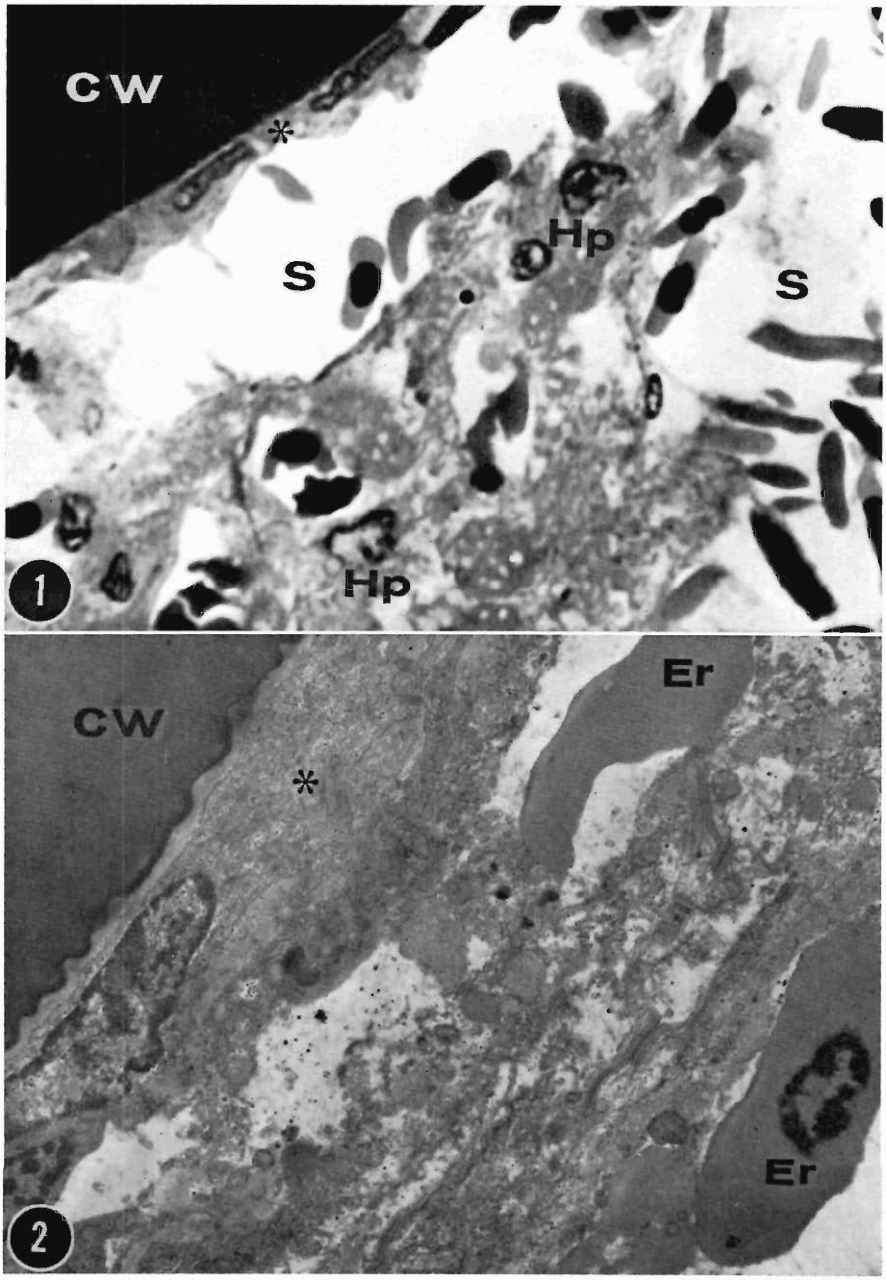
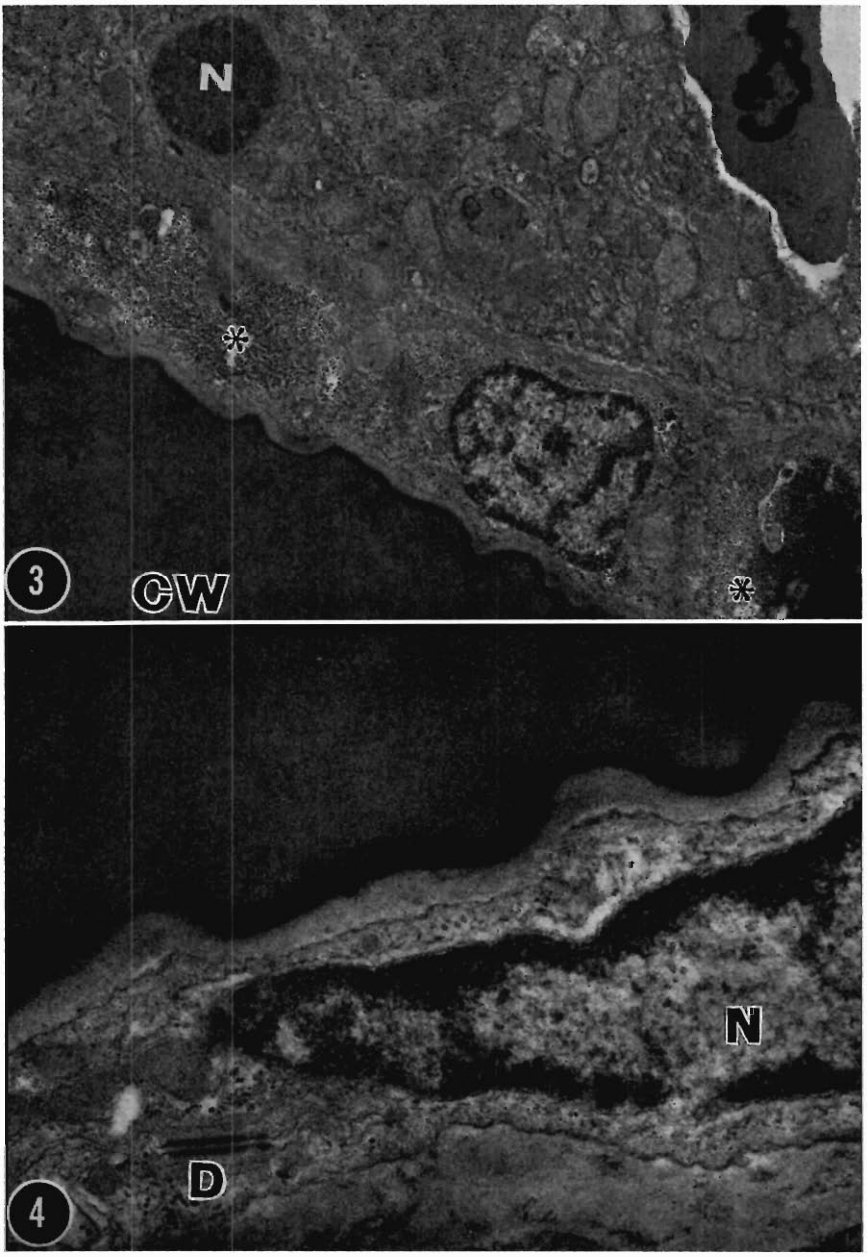


Figures 1–2. Survey images of *Ascocotyle chandleri* metacercarial cyst and adjacent hepatic tissues. 1. Photomicrograph illustrating the cyst wall (CW) lined by a layer of endothelial cells (*). These endothelial cells border sinusoidal spaces (S) surrounding the hepatocytes (Hp). The sinusoids contain numerous ovoid erythrocytes with densely stained nuclei. × 2,000. 2. Corresponding electron micrograph of the tissue shown in Figure 1, illustrating part of the cyst wall (CW), endothelium (*), some erythrocytes (Er) and cellular debris in the sinusoidal space. × 5,400.



Figures 3–4. Electron micrographs illustrating the relationship of host tissues and the metacercarial cyst of *A. chandleri*. 3. Cells peripheral to the cyst wall (CW) frequently contain significant quantities of glycogen (*). The upper half of this picture is occupied largely by a hepatocyte, whose tangentially sectioned nucleus appears at N. An erythrocyte can be seen in the upper right corner of this micrograph. × 6,100. 4. The junction of two endothelial cells lining the periphery of the cyst wall is marked by a prominent desmosome (D). Part of the fusiform nucleus of the cell on the right is illustrated at N. × 24,000.

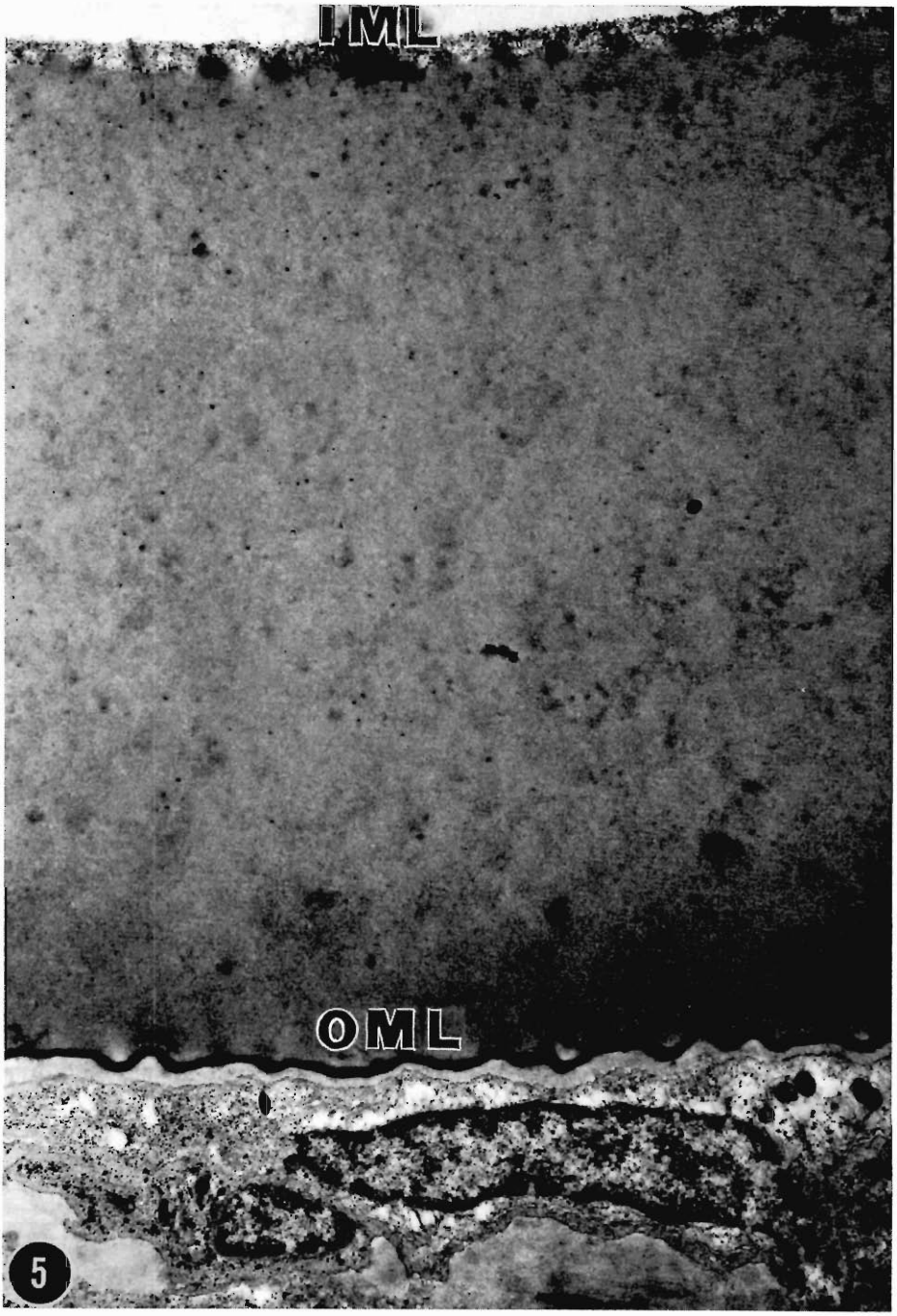
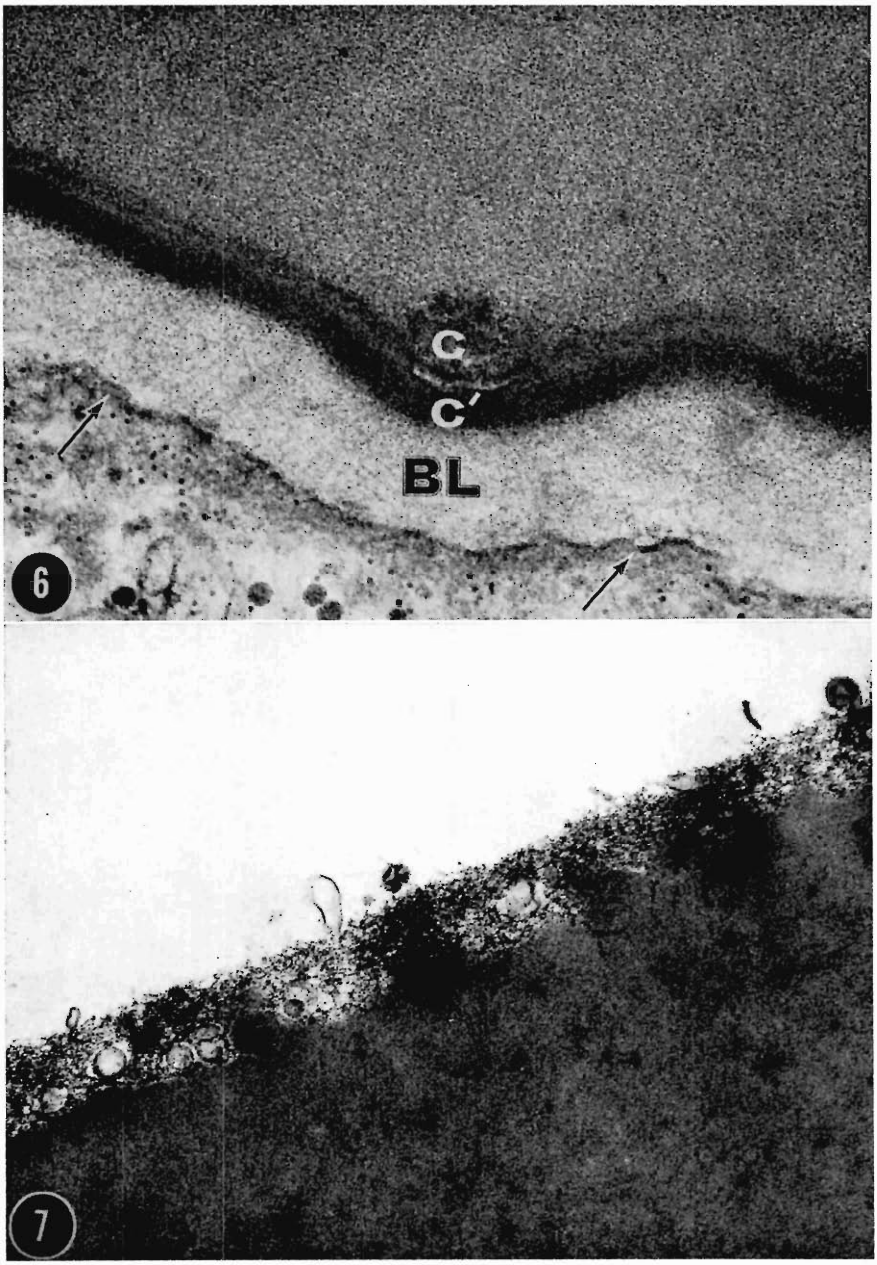
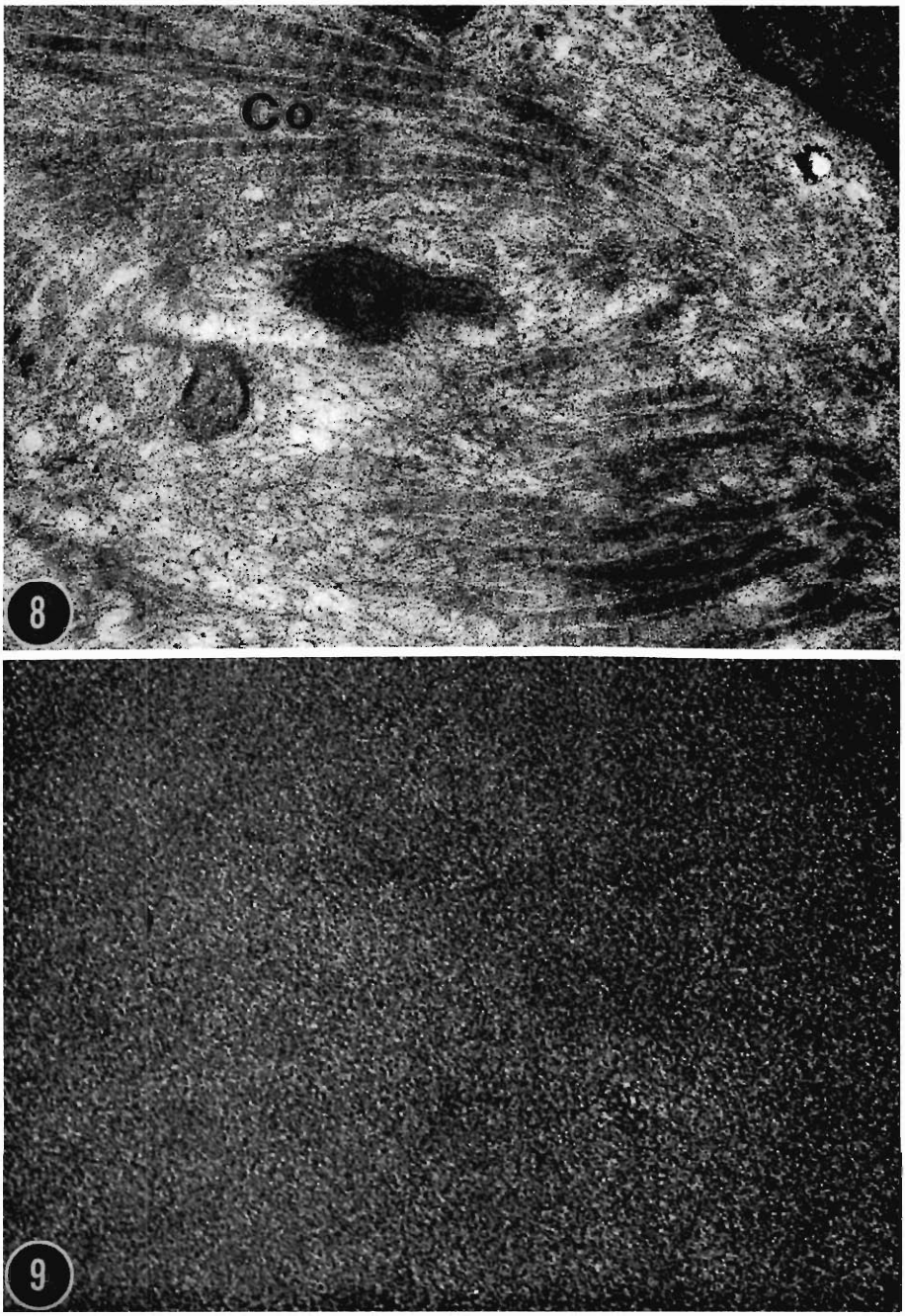


Figure 5. A section through the metacercarial cyst of *A. chandleri*. Illustrated are the inner marginal layer (IML) which borders the cavity occupied by the metacercaria, the outer marginal layer (OML), and bordering hepatic tissue. × 7,200.



Figures 6–7. Details of the marginal structure of the metacercarial cyst of *A. chandleri*. 6. The outer marginal layer, defined by a bilamellate, electron opaque cortex (C and C′), and bordered by a basal lamina (BL) probably of endothelial origin. The plasmalemma of an adjacent endothelial cell is indicated by the arrows. × 80,000. 7. The inner marginal layer, consisting of a meshwork of filamentous material in which membrane bound vesicles (V) are embedded. These vesicles and the blebbed appearance of the marginal matrix (*) suggest that material of parasite origin is being added to the structure of the primary cyst wall. × 24,600.



Figures 8–9. 8. Collagen fibers (Co) in the basal lamina and adjacent tissue space proximal to the metacercarial cyst of *A. chandleri*. Part of an endothelial cell is visible in the upper right corner of this micrograph. × 66,600. 9. High magnification image of the matrix of the metacercarial cyst wall illustrating its finely granular texture. × 93,300.

(Fig. 4). These cells typically contain significant quantities of particulate glycogen (Fig. 3), a few small mitochondria, and a fusiform nucleus (Figs. 2, 4 and 5). The hepatic tissues surrounding these trematode cysts do not contain an abnormal number of leukocytes or other cell types associated with inflammatory-immunological response mechanisms.

Collagenlike proteins have been indicated as components of metacercarial cysts of certain *Ascocotyle* spp. by staining properties of light microscope preparations (Sogandares and Lumsden, 1963, 1964), and chromatographic analysis of cyst wall hydrolysates (Lenhoff et al., 1960). Results of the present study, however, indicate that the cyst wall of *A. chandleri* does not contain morphologically identifiable collagen fibers, though such are sometimes present in the surrounding host tissue, including the basal lamina adjacent to the outer surface of the primary cyst wall (Fig. 8). The possibility that the cyst matrix contains a tropocollagenlike protein which is not polymerized into the familiar 1,000 Å thick, cross-striated collagen fibers cannot be evaluated at this time.

The majority of the host cells immediately adjacent to the metacercarial cyst of *A. chandleri* seem to be derived from the hepatic endothelium, though occasional fibroblasts have also been identified in the tissues peripheral to the primary cyst wall.

The structure of the metacercarial cyst of *A. chandleri* thus differs from that described for cysts of certain other *Ascocotyle* species, notably *A. leighi* Burton, 1956, and *A. pachycystis* Schroeder and Leigh, 1965, which at the level of light microscopy appear to be multilayered, perhaps in part collagenous, and surrounded by layers of fibroblasts (Sogandares and Lumsden, 1964; Schroeder and Leigh, 1965). The ultrastructure of the metacercarial cyst of *A. chandleri* differs significantly from that previously described for other trematodes. The metacercarial cyst of *Fasciola hepatica*, as described most recently by Dixon and Mercer (1967), consists of tanned proteins and a keratinized protein, plus a carbohydrate-protein complex, arranged in 4 distinct layers. Metacercariae of *Sphaeridiotrema globulus* are similarly enclosed by a cyst wall composed of four distinct layers or envelopes (Macy et al., 1968).

Summary

Metacercariae of *Ascocotyle chandleri* encyst beneath the endothelium of the hepatic sinusoids of *Cyprinodon variegatus*. The primary cyst wall consists of a finely granular matrix, bordered internally by a meshwork of fibers and vesicles and peripherally by an electron opaque, bilamellate cortex. The latter is in contact with a lamina of amorphous ground substance containing occasional collagen fibers. A layer of endothelial cells line the periphery of this cyst complex and border the adjacent sinusoidal space. The structure of *A. chandleri* metacercarial cysts is briefly compared with that previously reported for other trematodes.

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Revision of the Genus *Radopholus* Thorne, 1949 (Nematoda: Tylenchoidea)

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The genus *Radopholus* Thorne, 1949 was proposed in order to include those Pratylenchinae most closely resembling the genus *Pratylenchus* Filipjev, 1934 but which have two ovaries. *Radopholus similis* (Cobb, 1893) was named the type species, and one other species *R. oryzae* (van Breda de Haan, 1902) was included in the genus *Radopholus* at that time. In 1955, Allen transferred three species from the genus *Tylenchorhynchus* Cobb, 1913 to the genus *Radopholus* [*R. gracilis* (de Man, 1880), *R. behningi* (Micoletzky, 1927), and *R. zostericola* (Allgén, 1934)]. Two species, *R. neosimilis* Sauer, 1958 and *R. inaequalis* Sauer, 1958, were described from a native habitat in Australia.

In 1962, Luc and Goodey proposed the genus *Hirschmannia* for the large species in *Radopholus* with long overlapping ventral esophageal glands. This left the type species, *R. similis* and the two species of Sauer from Australia in *Radopholus*. An additional species was proposed, *R. williamsi* Siddiqi, 1964, using a population described from the Mauritius by Williams (1960) as *R. similis*.

This study is based on over 5,000 preserved specimens fixed usually in formalin (2–5%); FAA (formalin, alcohol, glacial acetic acid, and water); or TAF (formalin, triethylamine, and water); then transferred to diluted glycerine, allowed to dehydrate slowly, and mounted in dehydrated glycerine. The rapid glycerine technique of Baker (1953) was used for some specimens.

All the specimens studied are in the Nematode Collection of the Department of Nematology, University of California, Riverside, or as indicated in this paper.

Morphology

Species of *Radopholus* are typically cylindrical in shape and vary in length as adults from 0.4–0.9 mm. In at least one species (*R. similis*) some females from the roots of plants appear larger and fatter than specimens collected from soil around these roots. Morphological differences are seen between the females, males, and juveniles of most of the species. This is most marked in the lip and esophageal region of the female and male. The latter having a higher, rounder, distinctly set off lip region with reduced labial framework, stylet, stylet knobs, and esophagus. The female and juvenile have a hemispherical to flattened lip region with the labial framework well developed, strong stylet and stylet knobs with rounded, flattened anteriorly or forward pointed projections. The glandular posterior portion of the esophagus overlaps the intestine dorsally and laterally and is well developed and conspicuous in the female and juvenile, extending almost to the center of the body in some species with the three lobes often distinctly visible (b′ = length of the body divided by the length of esophagus to the end of the esophageal glands). The median bulb and posterior part of the esophagus are reduced and often indistinct in the male. In face view, the female and juvenile are round with six similar lips, the lateral lips set off by longitudinal striations in some species. The male face view is squarish, the lips are set off

and the lateral lips are greatly reduced. In addition to being smaller, the juveniles usually differ from the adults in having a shorter hyaline area between the cuticle and the body contents in the tail terminus. This hyaline area is conspicuous in all the adult specimens except one. The length of the hyaline area is given in the measurements of each species as the letter H (c′ = the length of the tail divided by the body width at the anus or cloaca). Juveniles also often have fewer incisures in the lateral field than adult specimens. The number of incisures vary from three to seven in this genus; a variation in number of incisures also occurs in some of the species. The incisures themselves may vary, being incomplete and/or irregular in some species. Incomplete areolation of the posterior part of the lateral field has been observed in many of the species.

The female reproductive system consists of opposed gonads with the vulva located at 50–70%. The ovaries are usually outstretched but in some large females obtained from roots, the anterior ovary extends to the esophageal region, and the posterior ovary to the tail where they can be reflexed. The ovary occupies from 12–50% of the body length. A spermatheca with rodlike sperms is seen in most species, one described species has round sperms in the spermatheca, and in three species the spermatheca is inconspicuous or absent and no sperms are visible. The rodlike sperms can also be observed in the testes.

Dense spherical granules and irregularly looping lateral canals are usually seen in the intestinal region. They are often overlapping the rectum into the tail.

The excretory pore is opposite the region of the esophageal intestinal valve and the hemizonid immediately anterior to the excretory pore. The hemizonion, cephalids and caudalid are inconspicuous or not seen in most specimens.

Genus *Radopholus* Thorne, 1949

Radopholus Thorne, 1949, p. 53; Luc and Goodey, 1962, p. 199.

DIAGNOSIS EMENDED: Radopholinae Allen and Sher, 1967. Labial framework and stylet well developed in female and juveniles. Sexual dimorphism marked; the male has higher rounder lip region and lateral lips, labial framework, stylet, and esophagus reduced. Anterior portion of stylet as long or longer than posterior portion. Deirids absent. Esophageal glands overlapping intestine dorsally. Gonads amphidelphic. Phasmids usually in anterior part of tail. Tail tapering to a rounded or almost pointed terminus, usually 2–4 times as long as the body width at the anus or cloaca. Gubernaculum protruding from cloaca.

TYPE SPECIES: *Radopholus similis* (Cobb, 1893).

Key to the Species of *Radopholus*

1. Phasmids in posterior part of tail; hyaline area in terminus 3 μ or less ..... *nigeriensis* n. sp.
   Phasmids in anterior part of tail; hyaline area in tail terminus 3 μ or longer 2
2. Spermatheca with round sperms ..... *rotundisemenus* n. sp.
   Spermatheca with rod-shaped sperms or sperms absent 3
3. Lateral field with 5 or more incisures ..... *inaequalis*
   Lateral field with 4 or less incisures 4
4. Female tail without annules around terminus ..... *williamsi*
   Female tail with annules around terminus 5
5. Esophageal glands of females terminating in anterior third of the body (b′ = 3.2–5.2) 7
   Esophageal glands terminating posteriorly to one-third of the body length (b′ = 2.2–3.2) 6
6. Adult lateral field with three incisures; vulva at 64% or more anterior ..... *trilineatus* n. sp.
   Adult lateral field with four or more incisures; vulva at 65% or more posterior ..... *magniglans* n. sp.
7. Female stylet 20 μ or longer; 4 or more annules on lip region ..... *nativus* n. sp.
   Female stylet 20 μ or shorter; 4 or less annules on lip region 8
8. Female terminus with short hyaline area (5 μ or less) and broadly rounded with distinct annulation ..... *neosimilis*
   Female terminus with conspicuous hyaline area (6 μ or longer) and narrowly rounded or almost pointed

with indistinct and/or irregular annulation 9

9. Female stylet 17 μ or less; sperms absent in spermatheca ..... *vertexplanus* n. sp.
   Female stylet 17 μ or longer; sperms present in spermatheca 10
10. Female tail 3.2 times as long as the body width at anus or longer with hyaline area 9 μ or longer ..... *similis*
    Female tail 3.1 times as long as the body width at anus or shorter with hyaline area 9 μ or shorter ..... *vangundyi* n. sp.

Radopholus similis (Cobb, 1893) Thorne, 1949 (Fig. 1 A–N)

Tylenchus similis Cobb, 1893, p. 301; Cobb, 1915 pp. 563–567; Bally and Reydon, 1931, pp. 80–86; Steiner and Buhrer, 1933, pp. 415–416.

Tylenchus granulosus Cobb, 1893, pp. 300–301, new synonymy.

Tylenchus acutocaudatus Zimmermann, 1898, pp. 42–43.

Tylenchus biformis Cobb, 1909, pp. 63–66.

Anguillulina similis: Goodey, 1932, pp. 38–40.

Anguillulina granulosa: Goodey, 1932, p. 92, new synonymy.

Tylenchus (*Chitinotylenchus*) *similis*: Micoletzky, 1922, pp. 543–547.

Tylenchorhynchus similis: Filipjev, 1934, p. 142.

Tylenchorhynchus acutocaudatus: Filipjev, 1934, p. 142.

Bitylenchus granulosus: Filipjev, 1934, p. 152, new synonymy.

Rotylenchus similis: Filipjev, 1936a, p. 545; Filipjev and Sch. Stekhoven, 1941, p. 211.

Tetylenchus granulosus: Filipjev, 1936b, p. 81; Filipjev & Sch. Stekhoven, 1941, p. 258, new synonymy.

Radopholus similis: Thorne, 1949, pp. 53–54; van Weerdt, 1958, pp. 191–193; Thorne, 1961, pp. 226–227.

MEASUREMENTS: 12 ♀ topotypes: L = 0.69 mm (0.52–0.88); a = 27 (22–30); b = 6.5 (4.7–7.4); b′ = 4.5 (3.5–5.2); c = 10.6 (8–13); c′ = 3.4 (2.9–4.0); H = 12 μ (9–16); V = $^{29\ (19-41)}$ 56 (55–61) $^{27\ (17-38)}$; stylet = 19 μ (17–20); O = 18 (12–20).

5 ♂ topotypes: L = 0.63 mm (0.59–0.67); a = 35 (31–44); b = 6.4 (6.1–6.6); b′ = 4.8 (4.1–4.9); c = 9 (8–10); c′ = 5.7 (5.1–6.7); H = 9 μ (7–11); stylet = 14 μ (12–17); gubernaculum = 9 μ (8–12); spicules = 20 μ (19–22).

SUGAR CANE, HAWAII: 13♀♀: L = 0.68 mm (0.59–0.82); a = 26 (22–35); b = 6.9 (5.7–7.8); b′ = 4.6 (3.9–6.5); c = 9.7 (8–11); c′ = 3.6 (2.9–4.1); H = 13 μ (10–17); V = $^{29\ (18-50)}$ 56 (52–60) $^{26\ (19-41)}$; stylet = 19 μ (17–20); O = 20 (15–25).

4♂♂: L = 0.62 mm (0.60–0.64); a = 35 (30–43); b = 5.8 (4.7–6.8); b′ = 4.6 (3.9–5.0); c = 9 (8–10); c′ = 5.5 (4.8–6.3); H = 9 μ (7–11); stylet = 14 μ (12–17); gubernaculum = 11 μ (9–12); spicules = 21 μ (18–23).

FEMALE: Lip region hemispherical, slightly or not set off with three to four annules; six similar lips, lateral lips slightly set off (face view). Stylet knobs rounded to slight projections anteriorly. Spermatheca with rodlike sperms. Lateral field with four incisures, coalescing to three incisures near middle of tail. Lateral field sometimes incompletely areolated on tail. Intestine indistinctly overlapping rectum into tail. Tail tapering, rounded variable terminus with or without annulation.

MALE: Lip region high, hemispherical, distinctly set off, with three to five annules in the posterior region; lateral lips distinctly smaller (face view). Tail tapering to rounded or almost pointed terminus; caudal alae not enveloping tail. Distal ends of spicules pointed. Gubernaculum with small titillae.

JUVENILE: Similar to female except for three incisures in the lateral field (Fig. 1 G–H) and shorter hyaline area in tail terminus (2–4 μ).

TYPE HOST AND LOCALITY: Soil about diseased banana plants, Fiji.

DIAGNOSIS: *R. similis* can be identified by the female with three to four annules on the lip region, stylet 17–20 μ, long hyaline area in tail terminus (H = 9–17 μ), and male with long narrow tail (c′ = 4.8–6.7).

The description, illustrations and measurements are based on specimens collected from the type host and type locality (topotype) of *R. similis* and from the roots and soil of sugar cane, Oahu, Hawaii (type host and near type locality of *T. biformis*).

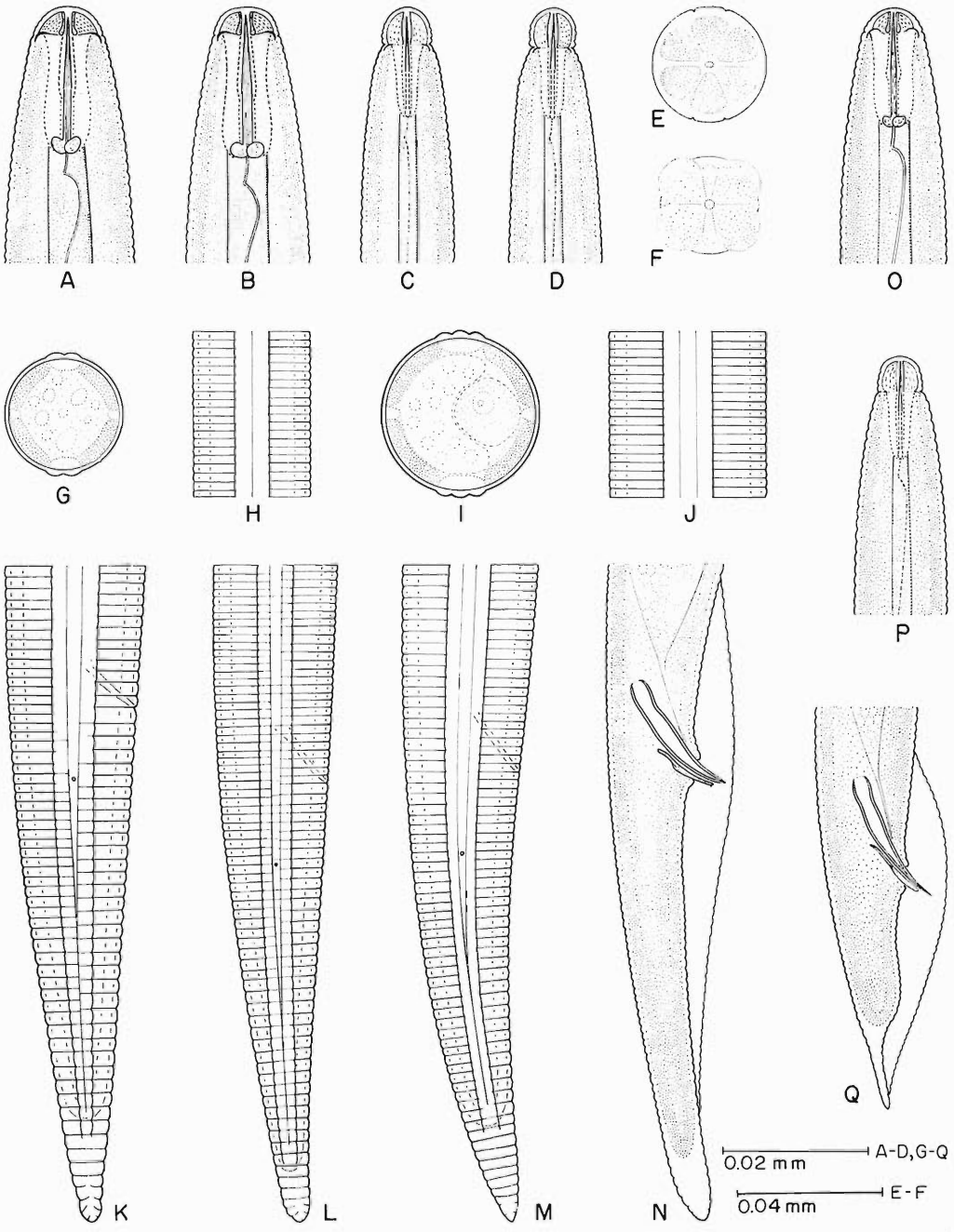

Figure 1. ***Radopholus similis:*** **A–B. Female, anterior ends. C–D. Male, anterior ends. E. Female, face view. F. Male, face view. G. Juvenile, cross-section near center of body. H. Juvenile, lateral view near center of body. I. Female, cross-section near center of body. J. Female, lateral view near center of body. K–M. Female, posterior regions. N. Male, posterior region.** ***Radopholus williamsi:*** **O. Female, anterior end. P. Male, anterior end. Q. Male, posterior region.**

Because of the original descriptions, measurements, and habitat and after an examination of specimens from the type host and locality, there is no doubt that *Tylenchus similis* Cobb, 1893 and *Tylenchus granulosus* Cobb, 1893 are the same taxon. Cobb's 1893 publication contained a description of *Tylenchus granulosus*, based on female specimens from diseased banana roots and adjacent soil, on page 300 and 301 (without an illustration); on page 301, the name *T. similis* was proposed on male specimens found around diseased banana plants (without a description but with illustrations). On the basis of page priority, *T. granulosus* is the older name for this taxon. Although *T. granulosus* has been placed in a number of genera, there is no evidence that this was done on identifying actual specimens with this name, and this taxon is now recorded as *Tetylenchus granulosus* (Cobb, 1893) Filipjev, 1936. To preserve the well-known name of an important, widely distributed economic pest, it is necessary to regard *T. granulosus* as a senior synonym or nomen oblitum (forgotten name). *Radopholus similis* is therefore considered in this paper as a valid name and *T. granulosus* a senior synonym.

Tylenchus acutocaudatus Zimmermann, 1898 described from coffee roots in Java was synonymized with *T. similis* by Menzel (1929) after studying specimens from tea (*Thea sinensis*) in Java. Steiner and Buhrer (1933) confirmed the synonymy of this species after an examination of specimens received from Menzel from the same host and locality. Additional reports of *R. similis* in Indonesia, where it is the cause of yellows disease of pepper, have been made by Thorne (1949, 1961), van der Vecht (1950), and Christie (1957). Although specimens of *R. similis* from Indonesia have not been available for study, there is no reason to doubt the synonymy of *T. acutocaudatus*.

Specimens of *R. similis* have been examined from the soil or roots of banana (*Musa* sp.) from the following localities: Government House, Suva and Viti Suva, Fiji; Selangor, Malaya; Malifanua Hill, Western Samoa; Hilo, Hawaii; Bundaberg, Queensland, Australia; Quezon City, The Philippines; Ilogbo Village, Colony Province, Nigeria; Kade, Ghana; Kisimaio, Somaliland; Spanish Town, Jamaica; Roseau Valley, St. Lucia; St. Vincent; Sinceretz Estate and Ashenden, Grenada; Neba Valley, Newfoundland and Woodford Hill, Dominica; Vinales, Cuba; Tiquisate, Guatemala; Santa Tecla, El Salvador; Perez, Dominican Republic; Golfito, Costa Rica; Bluefield, Nicaragua; Santa Marta, Colombia; São Paulo, Brazil; Los Angeles, California; and Oslo, Florida.

Additional specimens have been examined from the following habitats and localities: citrus (*Citrus* sp.) roots, Lake Alfred, Orlando and Alturas, Florida; avocado (*Persea americana*) roots, Lake Placid and Avon Park, Florida; anthurium (*Anthurium* sp.) roots, Hilo, Pohoa and Manoa Valley, Hawaii; *Sterlitzia reginae* roots, Hilo, Hawaii; *Zingiber officinale* roots, Kurtistown, Hawaii; *Hedychium flavum* roots, Keaau, Hawaii; Shell ginger (*Alpinia mutans*) roots, Nuuanu Valley, Hawaii, sugar cane (*Saccharum officinarum*) roots, Oahu, Hawaii; and *Philodendron haustatum* roots, Puerto Rico.

Radopholus williamsi Siddiqi, 1964 (Fig. 1 O–Q)

Radopholus similis: Williams, 1960, pp. 14–15 (in part).

Radopholus williamsi Siddiqi, 1964, pp. 207–208.

MEASUREMENTS: 6 ♀ paratypes: L = 0.42 mm (0.40–0.44); a = 21 (19–23); b = 5.1 (4.6–6.5); b′ = 3.0 (2.8–3.6); c = 13 (11–16); c′ = 2.4 (2.2–2.7); H = 7 μ (5–10); V = $^{16\ (14\text{-}18)}$ 64 (62–69) $^{16\ (14\text{-}18)}$; stylet = 15.5 μ (15–16); O = 15 (11–21).

6 ♂ paratypes: L = 0.41 mm (0.37–0.43); a = 25 (21–27); b = 6.0 (5.5–6.8); b′ = 4.0 (3.9–4.3); c = 12 (11–13); c′ = 3.2 (3.0–3.5); H = 11 μ (9–13); stylet = 10 μ (9–11); gubernaculum = 10 μ (8–11); spicules = 18 μ (17–20).

FEMALE: Lip region hemispherical, not set off with three to four annules; similar to type species in face view. Stylet knobs rounded to slightly flattened anterior surfaces. Spermatheca with rodlike sperms. Lateral field with three or four incisures. Intestine indistinctly overlapping rectum into tail. Tail tapering, rounded terminus without annulation.

MALE: Lip region spherical, distinctly set off, with four to five annules; similar to type species in face view. Tail narrowing to a

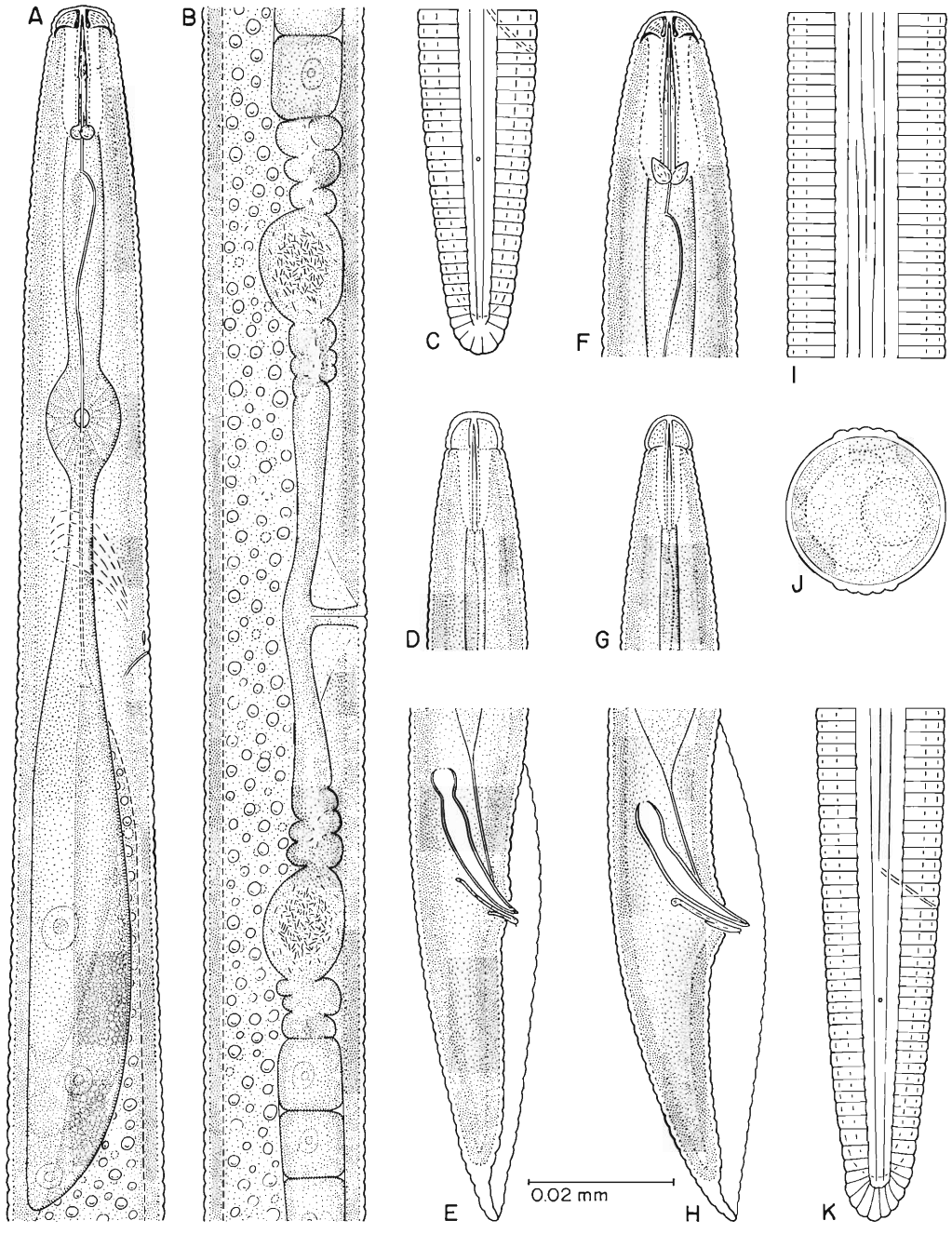

Figure 2. *Radopholus neosimilis:* A. Female, anterior region. B. Female, longitudinal section at center of body. C. Female, tail region. D. Male, anterior end. E. Male, posterior region. *Radopholus inaequalis:* F. Female, anterior end. G. Male, anterior end. H. Male, posterior end. I. Female, surface view near center of body. J. Female, cross-section near center of body. K. Female, tail region.

slender posterior portion; caudal alae almost enveloping tail. Distal ends of spicules needle-like. Titillae not seen on gubernaculum.

JUVENILE: Similar to female except for shorter hyaline area in tail terminus.

TYPE HOST AND LOCALITY: Sugar cane (*Saccharum officinarum*) roots, L'Etoile, Mauritius.

TYPE SPECIMENS: Female holotype and male allotype collected by J. R. Williams, 1959; deposited at Rothamsted Experimental Station, Harpenden, England. Paratypes (6 ♀♀, 4 ♂♂) are in the personal collection of R. Siddiqi (1964) and in the collection of the Department of Nematology, University of California (9 ♀♀, 5 ♂♂).

DIAGNOSIS: *R. williamsi* can be distinguished from the type species, *R. similis*, by the smaller body size, shorter stylet, shorter tail, and caudal alae almost enveloping the tail.

In addition to the paratypes studied (supplied by J. R. Williams), specimens of *R. williamsi* have been examined from sugar cane soil in the Fiji Islands.

Radopholus neosimilis Sauer, 1958 (Fig. 2 A–E)

Radopholus neosimilis Sauer, 1958, pp. 103–106.

MEASUREMENTS: 17 ♀ topotypes: L = 0.66 mm (0.60–0.74); a = 30 (26–33); b = 7.1 (6–8); b′ = 4.5 (3.4–4.9); c = 15 (12–17); c′ = 2.5 (2.0–3.1); H = 4 μ (3–5); V = $^{25\ (21-28)}$ 58 (55–60) $^{22\ (20-26)}$; stylet = 17 μ (16–19); O = 16 (14–18).

4 ♂ topotypes: L = 0.56 mm (0.51–0.65); a = 31 (26–35); b = 7.7 (6.4–8.4); b′ = 5.0 (4.7–5.3); c = 14 (12–15); c′ = 3.2 (2.9–3.7); H = 7 μ (5–11); stylet = 14 μ (12–16); gubernaculum = 10 μ (8–12 μ); spicules = 20 μ (19–23).

FEMALE: Lip region flattened anteriorly, rounded edges, slightly set off, with three or four annules; six similar lips without longitudinal striations in face view. Stylet knobs rounded, often with flattened anterior surfaces. Rodlike sperms (not seen in all specimens) incompletely filling spermatheca. Lateral field with four incisures. Intestine extends into tail. Tail tapering slightly to rounded, annulated terminus.

MALE: Lip region high, slightly flattened anteriorly, distinctly set off, with four or five annules; similar to type species in face view. Tail tapering to a rounded or almost pointed terminus. Caudal alae enclosing tail. Distal ends of spicules pointed. Gubernaculum with small titillae.

JUVENILE: Similar to female except for three incisures in lateral field and slightly shorter hyaline area in tail terminus (2–4 μ).

TYPE HOST AND LOCALITY: Soil around roots of *Codonocarpus cotinifolius* in virgin area near Lake Mournpoul, Hattah, Victoria, Australia.

TYPE SPECIMENS: Female holotype slide *Radopholus* 3, male allotype slide *Radopholus* 4, collection of Commonwealth Research Station, Merbein, Australia.

DIAGNOSIS: *R. neosimilis* can be distinguished from closely related *R. williamsi* by the more anterior position of the vulva, flattened lip region, shorter hyaline area in tail terminus and usually longer stylet and greater body length.

Radopholus inaequalis Sauer, 1958 (Fig. 2 F–K)

Radopholus inaequalis Sauer, 1958, pp. 100–103.

MEASUREMENTS: 10 ♀ topotypes: L = 0.64 mm (0.53–0.78); a = 25 (20–31); b = 7.5 (5–10); b′ = 5.2 (3.1–6.3); c = 17 (15–18); c′ = 2.3 (1.8–2.9); H = 8 μ (5–10); V = $^{29\ (18-34)}$ 59 (55–64) $^{24\ (17-28)}$; stylet = 22 μ (21–23); O = 15 (12–19).

8 ♂ topotypes: L = 0.59 mm (0.52–0.64); a = 30 (28–33); b = 7.2 (6.1–8.6); b′ = 5.1 (3.5–5.7); c = 14 (12–16); c′ = 2.9 (2.6–3.3); H = 8 μ (6–10); stylet = 14 μ (13–16); gubernaculum = 12 μ (11–13); spicules = 23 μ (21–25).

FEMALE: Lip region hemispherical, slightly or not set off, with three annules; similar to type species in face view. Stylet knobs with pointed anterior surfaces, often unequal in size. Rodlike sperms (not seen in all specimens) incompletely filling spermatheca. Lateral field with five to seven incisures, sometimes incompletely aerolated on tail. Intestine extends into tail. Tail tapering slightly to rounded, annulated terminus.

MALE: Lip region oblate, distinctly set off without annulation; similar to type species in face view. Lateral field with five or usually

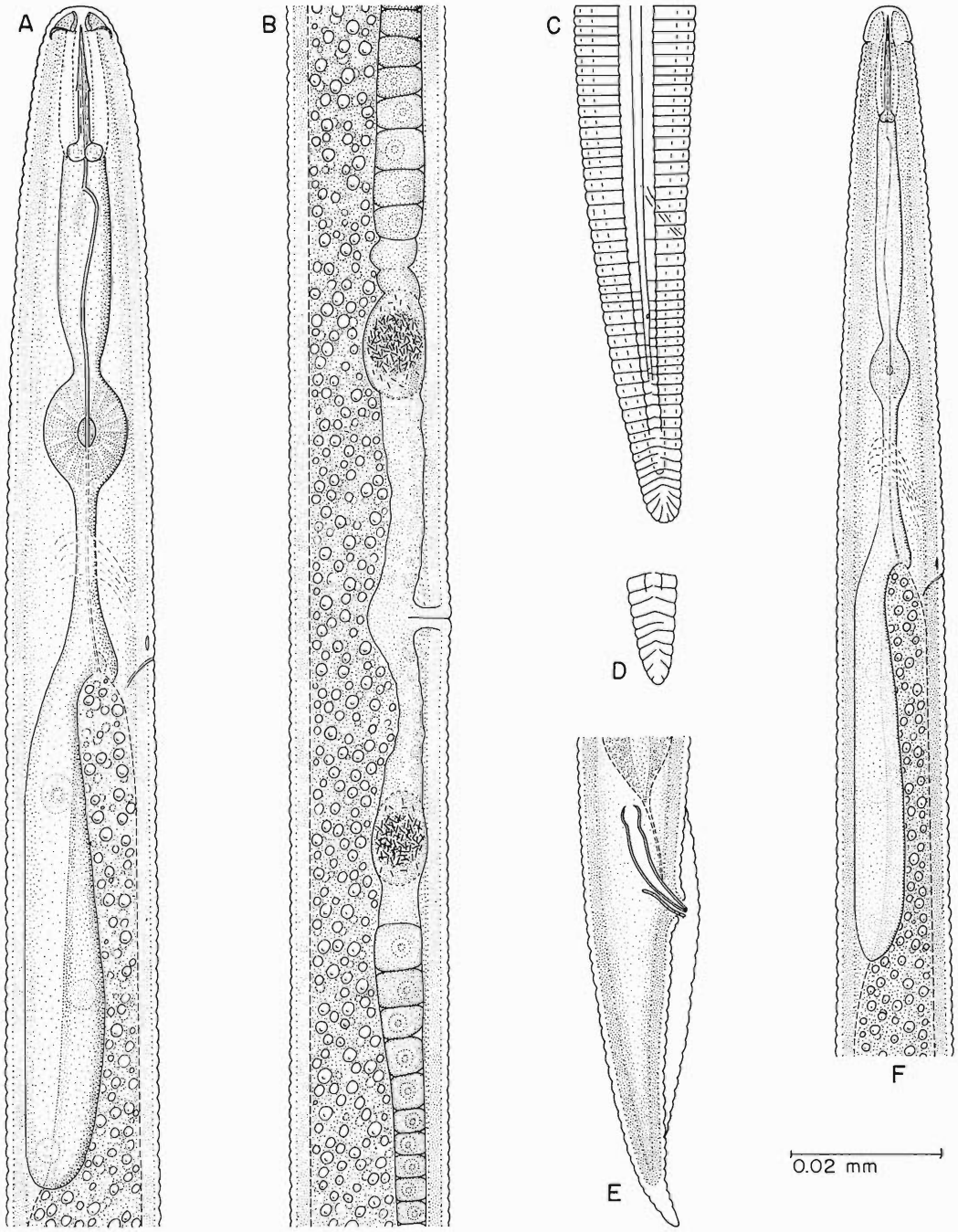

Figure 3. ***Radopholus vangundyi*** **n. sp.: A. Female, anterior region. B. Female, longitudinal section at center of body. C. Female, tail region. D. Female, terminus. E. Male, tail region. F. Male, anterior region.**

six incisures. Tail tapering to a rounded or almost pointed terminus. Distal ends of spicules pointed. Caudal alae enclosing tail. Gubernaculum with small titillae.

JUVENILE: Similar to female except for three or four incisures in lateral field and shorter hyaline area in tail terminus (2–7 μ).

TYPE HABITAT AND LOCALITY: Soil around roots of *Codonocarpus cotinifolius* in virgin area near Lake Mournpoul, Hattah, Victoria, Australia.

TYPE SPECIMENS: Female holotype slide *Radopholus* 1, male allotype slide *Radopholus* 2, collection of Commonwealth Research Station, Merbein, Australia.

DIAGNOSIS: *R. inaequalis* can be distinguished from *R. similis* and *R. williamsi* by the longer stylet with pointed anterior projections on the stylet knobs and five or more lateral incisures in the lateral field.

In a collection from the type locality of *R. inaequalis* and *R. neosimilis* (supplied by M. R. Sauer) there appears to be two additional undescribed species of *Radopholus*. These additional species in the same collection, the sexual dimorphism of the species and the scarcity of males (only two and three specimens of each species reported by Sauer in 1958) makes the specific identification of males for these species a more difficult problem than usually encountered. Although Sauer's identification of the males appears to be correct, additional data would be desirable.

Radopholus vangundyi n. sp. (Fig. 3 A–F)

MEASUREMENTS: 15 ♀ paratypes: L = 0.54 mm (0.47–0.65); a = 27 (22–30); b = 7.0 (6.3–8.1); b′ = 3.7 (3.3–4.0); c = 14 (12–16); c′ = 2.7 (2.4–3.2); H = 6.5 μ (5–9); V = $^{24\ (20-30)}$ 59 (57–62) $^{21\ (18-24)}$; stylet = 18 μ (17–19); O = 15 (11–24).

10 ♂ paratypes: L = 0.52 mm (0.41–0.63); a = 31 (28–35); b = 7.3 (6.1–7.7); b′ = 4.2 (3.6–4.6); c = 13 (11–15); c′ = 3.1 (2.7–3.6); H = 9 μ (6–12); stylet = 13 μ (12–15); gubernaculum = 7 μ (6–10); spicules = 16 μ (14–18).

FEMALE (holotype): L = 0.52 mm; a = 26; b = 6.3; b′ = 3.5; c = 15; c′ = 2.7; H = 6 μ; V = $^{22}60^{20}$; stylet = 18 μ; O = 16. Lip region hemispherical, not set off, with three annules. Stylet knobs round. Rodlike sperms incompletely filling spermatheca. Lateral field with four incisures. Intestine indistinctly overlapping rectum into tail. Tail tapering to almost pointed, annulated terminus.

MALE (allotype): L = 0.50 mm; a = 29; b = 6.1; b′ = 3.8; c = 12; c′ = 3.6; H = 10 μ; stylet = 13 μ; gubernaculum = 8 μ; spicules = 15 μ. Lip region oblate, distinctly set off, without annulation. Stylet knobs with sloping anterior surfaces. Median bulb with valve. Caudal alae narrow, not enveloping tail.

JUVENILE: Similar to female except for a shorter hyaline area in tail terminus (2–3 μ).

HOLOTYPE: Female collected by S. D. Van Gundy, 20 February 1966, catalog number 1, U.C.R. Nematode Collection, Riverside, California.

ALLOTYPE: Male, same data as holotype, catalog number 2.

PARATYPES: 37 ♀ ♀, 30 ♂ ♂, 9 juveniles same data as holotype distributed as follows: 3 ♀ ♀, 3 ♂ ♂, Department of Nematology, University of California, Davis; 25 ♀ ♀, 17 ♂ ♂, 8 juveniles, Department of Nematology, University of California, Riverside; 3 ♀ ♀, 4 ♂ ♂, USDA Nematode Collection, Nematology Investigations, Beltsville, Maryland; 3 ♀ ♀, 3 ♂ ♂, 1 juvenile, Nematology Department, Rothamsted Experimental Station, Harpenden, England; and 3 ♀ ♀, 3 ♂ ♂, Plantenziektenkundige Dienst, Wageningen, The Netherlands.

TYPE HABITAT AND LOCALITY: *Eucalyptus* sp., *Acacia* sp. and unknown grass soil in native habitat, bank of the Mt. Williams River (near Dadswells Bridge), Victoria, Australia.

DIAGNOSIS: *R. vangundyi* can be distinguished from the closely related *R. neosimilis* by the hemispherical female lip region shape, more tapering female tail, usually smaller female body size and the higher lip region without annulation in the male.

In face view the female has six similar lips, the lateral lips slightly set off (similar to the type species); amphid apertures are seen on the lateral lips. In the male face view the lips are set off with the lateral lips distinctly smaller (similar to the type species). The female lip region has three to four annules. The stylet knobs are round to slightly flattened anteriorly. Incomplete aerolation of the lateral field in the tail region is seen on some of the females. The tail is tapering to a rounded (often almost pointed) terminus.

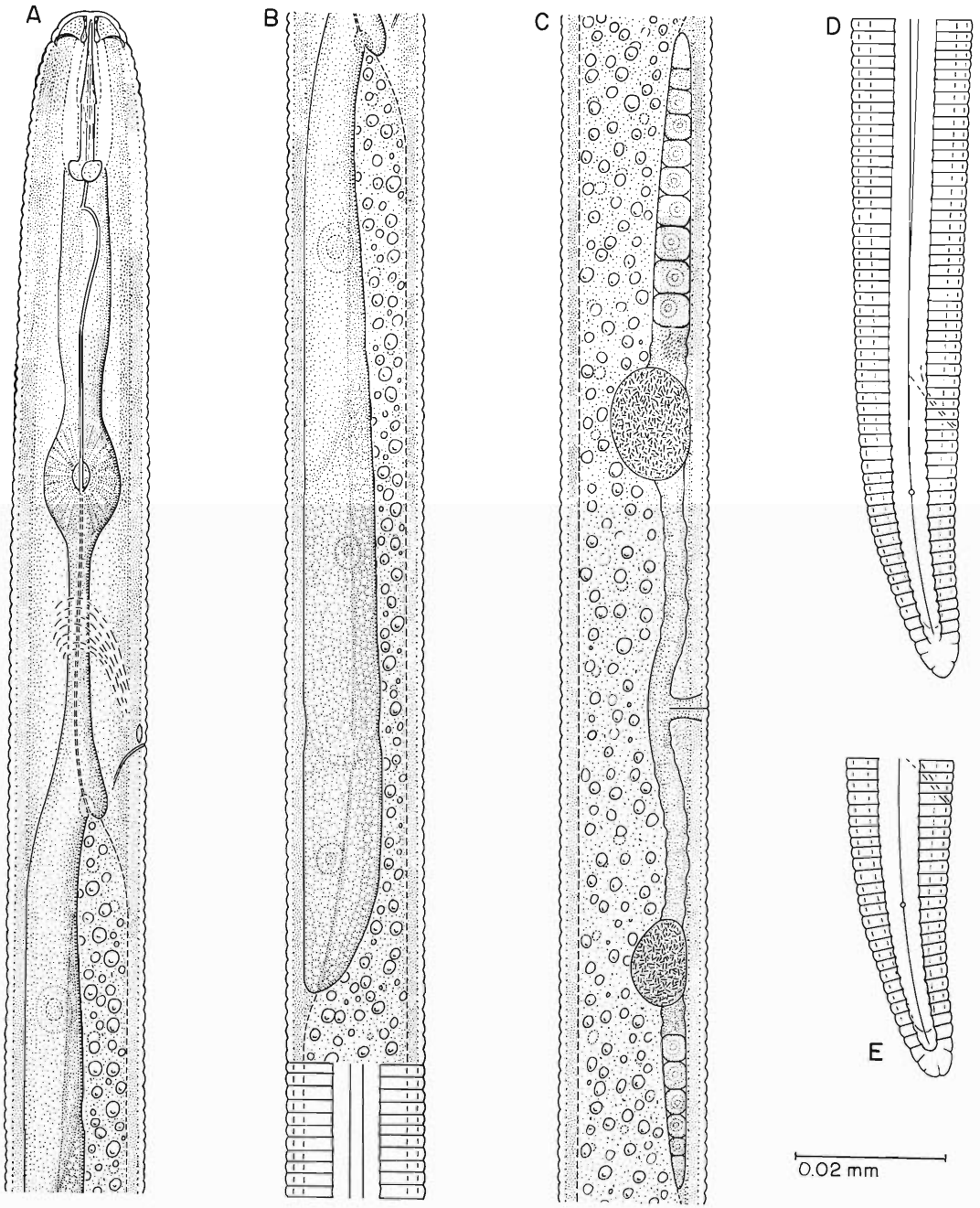

Figure 4. *Radopholus magniglans* n. sp.: A. Female, anterior region. B. Female, esophageal region. C. Female, longitudinal section at center of the body. D. Female, posterior region. E. Female, tail region.

Radopholus magniglans n. sp. (Fig. 4 A–E)

MEASUREMENTS: 20♀♀: L = 0.53 mm (0.47–0.57); a = 27 (24–29); b = 5.5 (4.9–6.1); b′ = 2.6 (2.3–3.2); c = 16 (14–18); c′ = 2.6 (2.4–2.9); H = 7 μ (6–8); V = $^{18\ (15-20)}$ 67 (64–71) $^{13\ (11-14)}$; stylet = 22 μ (21–23); O = 16 (11–23).

FEMALE (holotype): L = 0.56 mm; a = 27; b = 5.6; b′ = 3.1; c = 15; c′ = 2.8; H = 7 μ; V = $^{17}68^{12}$; stylet = 21 μ; O = 19. Lip region hemispherical, slightly set off, with two distinct annules. Stylet knobs rounded, slightly flattened surfaces. Two posterior esophageal glands coarser appearing than anterior esophageal gland; anterior gland with large nucleus, each posterior gland with one smaller nucleus. Rodlike sperms filling spermatheca. Posterior ovary and spermatheca distinctly smaller than anterior ovary. Lateral field with four incisures, inner lines closer together, coalescing to three incisures just anterior to level of anus. Tail tapering, rounded terminus with annulation.

MALE: Unknown.

JUVENILE: Unknown.

HOLOTYPE: Female, collected by S. D. Van Gundy, 3 November 1965, catalog number 3, U.C.R. Nematode Collection, Riverside, California.

PARATYPES: 167♀♀, same collection as holotype distributed as follows: 7♀♀, Department of Nematology, University of California, Davis; 133♀♀, Department of Nematology, University of California, Riverside; 8♀♀, USDA Nematode Collection, Nematology Investigations, Beltsville, Maryland; 6♀♀, Nematology Department, Rothamsted Experimental Station, Harpenden, England; 7♀♀, Plantenziektenkundige Dienst, Wageningen, The Netherlands; and 6♀♀, Canadian National Collection, Ottawa, Canada.

TYPE HABITAT AND LOCALITY: Unknown grass and *Eucalyptus* sp. soil in native habitat, bank of the Onkaparinga River (above Mylor), South Australia.

DIAGNOSIS: *R. magniglans* can be distinguished from the preceding species by the long conspicuous esophageal glands, usually two lip region annules and absence of male specimens.

The face view is similar to the type species with the lateral lips distinctly set off from the other lips. The lip region usually has two annules, three annules are seen in a few specimens. Stylet knobs are flattened anteriorly or with slightly anterior projections. The intestine appears to extend into the tail region. Annulation around the tail terminus is often irregular and indistinct.

Additional specimens of *R. magniglans* have been identified from the following native habitats and localities in Australia: bank of the Onkaparinga River (above Mt. Bold Reservoir), South Australia; Tyrendarra, Victoria and bank of the Murray River, about 10 miles above Renmark, South Australia.

Radopholus trilineatus n. sp. (Fig. 5 A–F)

MEASUREMENTS: 20 ♀ paratypes: L = 0.59 mm (0.53–0.66); a = 31 (28–34); b = 6.2 (5.5–6.6); b′ = 2.7 (2.5–3.1); c = 15 (13–18); c′ = 2.7 (2.1–3.1); H = 6 μ (5–7); V = $^{15\ (14-16)}$ 61 (59–64) $^{14\ (13-16)}$; stylet = 20 μ (18–21); O = 20 (16–24).

FEMALE (holotype): L = 0.60 mm; a = 30; b = 6.0; b′ = 2.7; c = 15; c′ = 2.7; H = 5 μ; V = $^{15}61^{13}$; stylet = 20 μ; O = 16. Lip region hemispherical, slightly set off, with two distinct annules. Stylet knobs round. Rodlike sperms filling spermatheca. Lateral field with three incisures. Tail slightly tapering, rounded terminus, annulated.

MALE: Unknown.

JUVENILE: Unknown.

HOLOTYPE: Female, collected by S. D. Van Gundy, 19 May 1966, catalog number 4, U.C.R. Nematode Collection, Riverside, California.

PARATYPES: 95♀♀, same data as holotype distributed as follows: 7♀♀, Department of Nematology, University of California, Davis, 62♀♀, Department of Nematology, University of California, Riverside; 6♀♀, USDA Nematode Collection, Nematology Investigations, Beltsville, Maryland; 7♀♀, Nematology Department, Rothamsted Experimental Station, Harpenden, England; 7♀♀ Plantenziektenkundige Dienst, Wageningen, The Netherlands; and 6♀♀, Canadian National Collection, Ottawa, Canada.

TYPE HABITAT AND LOCALITY: *Eucalyptus* sp., unknown sedge, fern and grass soil in

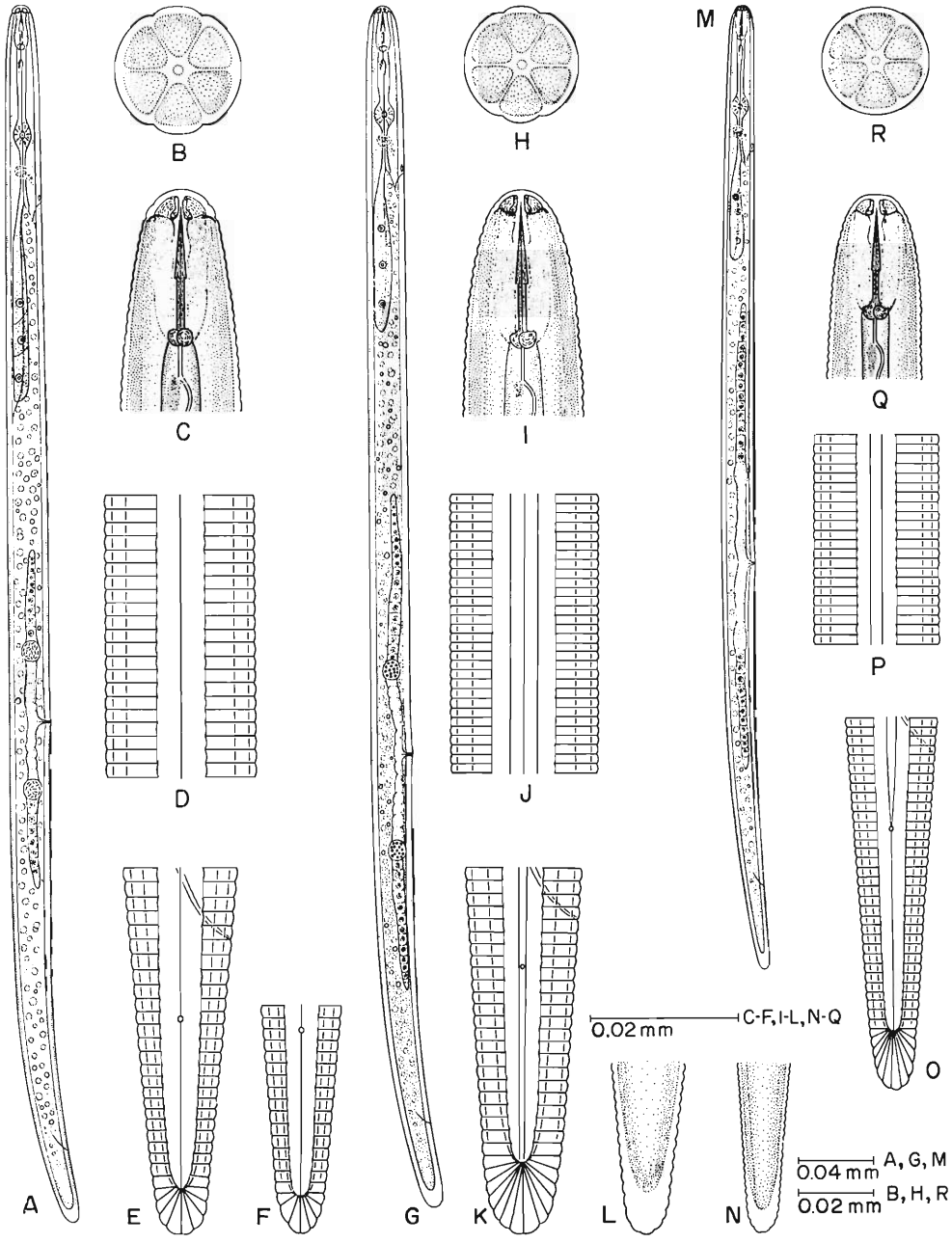

Figure 5. *Radopholus trilineatus* n. sp.: A. Female. B. Female, face view. C. Female, anterior end. D. Female, lateral view near center of body. E–F. Female, tail regions. *Radopholus rotundisemenus* n. sp.: G. Female. H. Female, face view. I. Female, anterior end. J. Female, lateral view near center of body. K. Female, tail region. L. Juvenile, tail terminus. *Radopholus vertexplanus* n. sp.: M. Female. N. Juvenile, tail terminus. O. Female, tail region. P. Female, lateral view near center of body. Q. Female, anterior end. R. Female, face view.

native habitat; bank of Scrubby Creek, near Narrarba, New South Wales, Australia.

DIAGNOSIS: *R. trilineatus* can be distinguished from the closely related *R. magniglans* by the three incisures of the lateral field in the female, more anterior position of the vulva (59–63) and the usually shorter stylet length. It can be distinguished from *R. williamsi* by the longer stylet, fewer annules on the lip region and longer esophageal glands.

In face view *R. trilineatus* is similar to *R. magniglans*. The lip region usually has two annules, some specimens without annulation. Stylet knobs are usually round, sometimes slightly flattened anteriorly. The intestine appears to extend into the tail region. The annulation on the tail termination is irregular and usually incomplete.

Additional specimens of *R. trilineatus* have been identified from *Eucalyptus* sp. and unknown grass soil in a native habitat west of Murray Bridge (Monarto South), South Australia.

Radopholus rotundisemenus n. sp. (Fig. 5 G–L)

MEASUREMENTS: 15 ♀ paratypes: L = 0.58 mm (0.54–0.61); a = 27 (24–33); b = 6.4 (5.6–7.2); b′ = 3.9 (3.6–4.5); c = 14 (13–16); c′ = 2.8 (2.4–3.6); H = 9 μ (7–11); V = $^{22\ (16-27)}$ 58 (56–61) $^{20\ (16-26)}$; stylet = 20 μ (19–22); O = 16 (12–20).

FEMALE (holotype): L = 0.58 mm; a = 32; b = 6.8; b′ = 4.0; c = 15; c′ = 3.3; H = 8 μ; V = $^{19}61^{19}$; stylet = 21 μ; O = 17. Lip region hemispherical, slightly set off, with three indistinct annules. Stylet knobs with flattened anterior surfaces. Spermatheca with round sperms. Lateral field with four incisures in anterior and posterior part of body, five and six incisures near center of body to three incisures on tail; incompletely aerolated on tail. Tail tapering slightly to rounded, annulated terminus.

MALE: Unknown.

JUVENILE: Similar to female except for usually fewer incisures in center of body and slightly shorter hyaline area in tail terminus (4–8 μ).

HOLOTYPE: Female collected by S. D. Van Gundy, 21 May 1966, catalog number 5, U.C.R. Nematode Collection, Riverside, California.

PARATYPES: 18 ♀ ♀, 4 juveniles same data as holotype distributed as follows: 2 ♀ ♀, USDA Nematode Collection, Nematology Collection, Beltsville, Maryland; 3 ♀ ♀, Plantenziektenkundige Dienst, Wageningen, The Netherlands; and 12 ♀ ♀, 4 juveniles, Department of Nematology, University of California, Riverside.

TYPE HABITAT AND LOCALITY: *Eucalyptus* sp., *Acacia* sp. and unknown native grass and fern soil in native habitat; Tyrendarro East, Victoria, Australia.

DIAGNOSIS: *R. rotundisemenus* can be distinguished from the closely related *R. inaequalis* by the round sperms in the spermatheca, fewer incisures in the lateral field and usually shorter stylet.

The face view is similar to the type species. Stylet knobs are flattened or usually with anterior projections (often pointed). Four to six, usually irregular incisures are in the lateral field near the center of the body. The intestine overlaps the rectum into the tail but is indistinct on most specimens. The annulation around the tail terminus is distinct but sometimes irregular.

Radopholus vertexplanus n. sp. (Fig. 5 M–R)

MEASUREMENTS: 15 ♀ paratypes: L = 0.51 mm (0.42–0.56); a = 30 (27–32); b = 5.8 (4.9–6.8); b′ = 3.6 (3.2–4.0); c = 12 (11–15); c′ = 3.8 (2.8–4.5); H = 9 μ (7–11); V = $^{24\ (22-27)}$ 58 (56–60) $^{18\ (16-22)}$; stylet = 16 μ (15–17); O = 20 (16–25).

FEMALE (holotype): L = 0.47 mm; a = 31; b = 5.4; b′ = 3.4; c = 11; c′ = 3.9; H = 10 μ; V = $^{25}58^{19}$; stylet = 16 μ; O = 21. Lip region flattened anteriorly with rounded edges, not set off from body, annulation indistinct. Stylet knobs with slightly flattened anterior surfaces. Spermatheca without sperms. Lateral field with four incisures narrowing to three incisures just anterior to level of anus. Tail tapering to irregularly rounded annulated terminus.

MALE: Unknown.

JUVENILE: Similar to female except for shorter hyaline area in tail terminus (4–6 μ).

HOLOTYPE: Female collected by S. D. Van Gundy, 21 May 1966, catalog number 6, U.C.R. Nematode Collection, Riverside, California.

PARATYPES: 24 ♀ ♀, 11 juveniles, same data

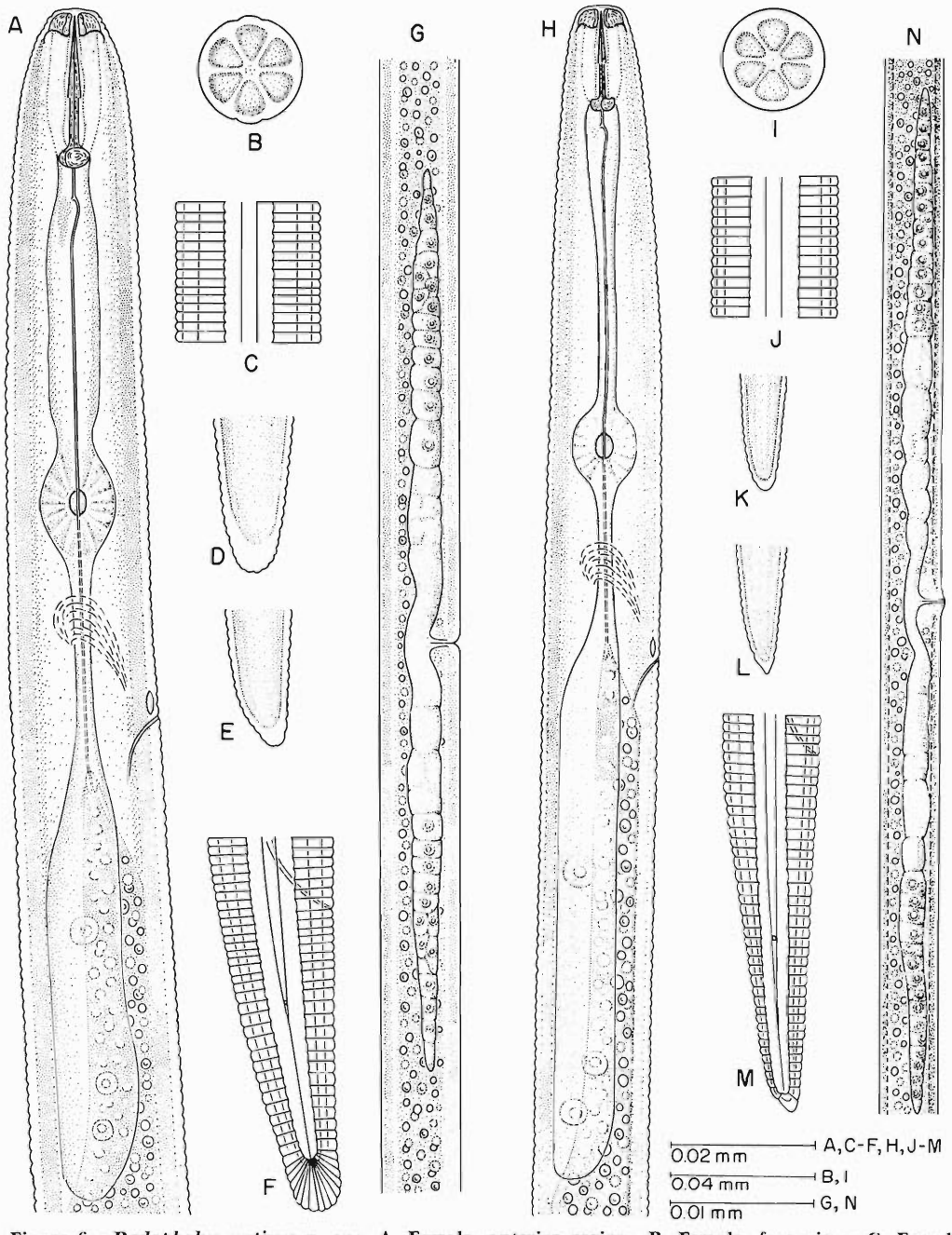

Figure 6. *Radopholus nativus* n. sp.: A. Female, anterior region. B. Female, face view. C. Female, lateral view near center of body. D. Female, terminus. E. Juvenile, terminus. F. Female, tail region. G. Female, longitudinal section at center of body. *Radopholus nigeriensis* n. sp.: H. Female, anterior region. I. Female, face view. J. Female, lateral view near center of body. K–L. Female, tail termini. M. Female, tail region. N. Female, longitudinal section at center of body.

as holotype distributed as follows: 3♀♀ USDA Nematode Collection, Nematology Section, Beltsville, Maryland; 3♀♀ Plantenziektenkundige Dienst, Wageningen, The Netherlands; 18♀♀, 11 juveniles, Department of Nematology, University of California, Riverside.

TYPE HABITAT AND LOCALITY: *Eucalyptus* sp., *Acacia* sp. and unknown native grass and fern soil in native habitat; Tyrendarra East, Victoria, Australia. Same collection as *R. rotundisemenus*.

DIAGNOSIS: *R. vertexplanus* can be distinguished from the most closely related species *R. williamsi* by the longer tail with annulation around the terminus, higher position of the vulva, the absence of sperms in the spermatheca and males and the flatter lip region.

Six similar lips without longitudinal striations are seen in face view (Fig. 5 R). The lip region is slightly or not set off with two or three faint often indistinct annules. Stylet knobs are rounded to usually flattened anteriorly. The intestine indistinctly overlaps the rectum. The spermatheca is often inconspicuous and without sperms. The tail tapers to a rounded or irregularly rounded, sometimes almost pointed terminus.

Radopholus nativus n. sp. (Fig. 6 A–F)

MEASUREMENTS: 15 ♀ paratypes: L = 0.56 mm (0.50–0.69); a = 26 (23–30); b = 5.8 (5.0–7.3); b′ = 4.2 (3.3–5.0); c = 15 (13–17); c′ = 2.8 (2.1–3.3); H = 6 μ (4–8); V = $^{23\ (20-27)}$ 60 (57–63) $^{22\ (19-30)}$; stylet = 20 μ (19–22); O = 16 (12–22).

FEMALE (holotype): L = 0.55 mm; a = 28; b = 5.2; b′ = 3.5; c = 12; c′ = 3.4; H = 7 μ; V = $^{23}58^{21}$; stylet = 21 μ; O = 17. Lip region hemispherical, slightly set off, with four annules. Stylet knobs with anterior projections. Spermatheca without sperms. Lateral field with four incisures, inner incisures coalescing at level of anus to three incisures on tail, incompletely areolated. Intestine indistinctly overlapping rectum. Tail tapering slightly to rounded, distinctly annulated terminus.

MALE: Unknown.

JUVENILE: Similar to female except for three incisures in lateral field and shorter hyaline area in tail terminus (3–4 μ).

HOLOTYPE: Female collected by W. C. Clark, 29 March 1958, catalog number 7, U.C.R. Nematode Collection, Riverside, California.

PARATYPES: 30♀♀, 5 juveniles, same collection as holotype distributed as follows: 3♀♀, 1 juvenile, USDA Nematode Collection, Nematology Investigations, Beltsville, Maryland; 3♀♀, Plantenziektenkundige Dienst, Wageningen, The Netherlands; and 24♀♀, 4 juveniles, Department of Nematology, University of California, Riverside.

TYPE HABITAT AND LOCALITY: Soil around the native plants *Carmichaelia monroi*, *Celmisia* sp., *Danthonia* sp., *Dracophyllum* sp., and *Senecio bellidioides* in a native habitat, Porters Pass (3,100′), about 10 miles west of Springfield, South Island, New Zealand.

DIAGNOSIS: *R. nativus* can be distinguished from the closely related species *R. neosimilis* and *R. vangundyi* by the longer stylet and absence of sperms in the spermatheca and males. It can be further distinguished from *R. vangundyi* by the four lip region annules.

The face view is similar to the type species (Fig. 6B). The lip region is slightly or not set off, hemispherical or sometimes slightly flattened anteriorly. Stylet knobs are flattened anteriorly or with anterior projecting processes. Areolation of the lateral field varies from almost complete areolation to incomplete areolation only in the tail region.

Additional specimens of *R. nativus* have been identified from soil around native plants in a native habitat at Burkes Pass (1,650′) about 10 miles east of Omarama, South Island, New Zealand.

Radopholus nigeriensis n. sp. (Fig. 6 H–N)

MEASUREMENTS: 20 ♀ paratypes: L = 0.59 mm (0.49–0.71); a = 29 (25–34); b = 6.6 (5.0–7.5); b′ = 3.9 (3.4–4.4); c = 11 (10–14); c′ = 3.7 (2.9–4.3); H = 2.5 μ (2–4); V = $^{26\ (24-29)}$ 54 (50–58) $^{26\ (22-30)}$; stylet = 15 μ (14–16); O = 13 (10–16).

FEMALE (holotype): L = 0.52 mm; a = 28; b = 5.8; b′ = 3.5; c = 11; c′ = 3.9; H = 4 μ; V = $^{28}55^{28}$; stylet = 14 μ; O = 16. Lip region flattened anteriorly, not set off, with 2 indistinct annules. Stylet knobs rounded, slightly flattened anterior surfaces. Anterior ovary extends to esophageal glands. Spermatheca without sperms. Vulva with prominent lips.

Lateral field with four and five indistinct incisures. Intestine not overlapping rectum. Phasmids in posterior portion of tail. Tail tapering to slight ventral nipplelike terminus, without annulation.

MALE: Unknown.

JUVENILE: Similar to female.

HOLOTYPE: Female, collected by F. E. Caveness, 30 May 1960, catalog number 8, U.C.R. Nematode Collection, University of California, Riverside.

PARATYPES: 50 ♀ ♀, 94 juveniles, same data as holotype distributed as follows: 2 ♀ ♀, 8 juveniles, Department of Nematology, University of California, Davis; 42 ♀ ♀, 62 juveniles, Department of Nematology, University of California, Riverside; 2 ♀ ♀, 7 juveniles, USDA Nematode Collection, Nematology Investigations, Beltsville, Maryland; 2 ♀ ♀, 6 juveniles, Nematology Department, Rothamsted Experimental Station, Harpenden, England; and 2 ♀ ♀, 11 juveniles, Plantenziektenkundige Dienst, Wageningen, The Netherlands.

TYPE HABITAT AND LOCALITY: Sandy loam soil in native habitat around southern gamba grass (*Andropogon tectorum*) and spear grass (*Imperata cylindrica*), 3 mile marker south of Igboora, Ibadan Province, western Nigeria.

DIAGNOSIS: *R. nigeriensis* can be distinguished from the previous species by the short hyaline area in tail terminus, phasmids in the posterior part of the body, usually shorter stylet and the prominent vulval lips. Slightly protruding vulval lips have been seen in a few specimens of *R. similis* from the roots.

In face view six similar lips without longitudinal striations are seen (Fig. 6 I). The lip region has two to three annules. Stylet knobs are flattened anteriorly to slightly projecting anteriorly. Incisures of the lateral field vary from usually four or five to sometimes six near the center of the body. The phasmids are often inconspicuous. The tail varies from almost pointed to irregularly rounded, sometimes with a slight nipplelike terminus.

Additional specimens have been seen from the following habitats and localities in northern Nigeria: soil around unknown native plants, ground nut (*Arachis hypogaea*) and guinea corn (*Sorghum margaritiferum*), 2.5 miles north of Katsina, Katsina Province; and corn soil (*Zea mays*), 2 miles north of Katsina, Katsina Province.

At least nine additional undescribed species of *Radopholus* have been identified from native habitats in Australia and New Zealand. Because of insufficient and/or poorly preserved specimens they are not described.

Discussion

The genus *Radopholus* is especially interesting because of its distribution, sexual and usually juvenile dimorphism, rod-shaped sperms in most species, and the apparent absence of males in some species which have spermatized females. In addition, at least one species is known to be widespread and of great economic importance and contains physiological races.

Nine of the eleven nominal species now in the genus *Radopholus* are known from Australia and New Zealand, and seven of these are from native habitats in Australia. Because of this, and the fact that six additional undescribed species are from native habitats in Australia, the genus *Radopholus* is considered to be indigenous to this area. The small number of samples taken (75) in a limited area of Australia (Victoria, Queensland and New South Wales), comprising 13 native species, is unique and quite remarkable for the Tylenchoidea. Four species (one described, three undescribed) were identified in over 450 samples collected from native habitats in New Zealand. In contrast, over 1,000 soil samples from uncultivated areas in western and eastern Nigeria contained only one new species (*R. nigeriensis*). *Radopholus* species indigenous to other areas in the world are not known. The native habitats of *R. williamsi* and *R. similis* are not known but their distribution suggests they could have originated in Australia.

R. nigeriensis, from a native habitat in Africa, shows the least affinity to the other species. The absence of males in this species is regrettable since their presence would further indicate the relationship of this species to the rest of the genus. Such information would be most interesting for a species that shows morphological differences from the other species and is native to an area so far removed from the habitats of the other species.

Although males are known for only five of the eleven nominal species of *Radopholus*, they are all similar in having a reduced stylet, esophagus, lateral lips and a higher, distinctly set off lip region. Morphological differences

are seen between the juvenile specimens and the adults in all species where juveniles are known except in *R. nigeriensis*. These differences, in addition to the normal smaller size of the juveniles, include the shorter hyaline area in the tail terminus and fewer lateral field incisures in four of the species.

The rod-shaped sperms observed in most *Radopholus* species are known only in the closely related genus *Radopholoides* de Guiran, 1967. The genus *Schistonchus* (Cobb, 1927), which is in the Aphelenchoidea, contains similar but longer flagellate sperms (Thorne, 1961). These rod-shaped sperms were first illustrated for *R. similis* in Cobb's 1915 paper, which gives a detailed description of this species and contains excellent illustrations.

The apparent absence of males in *R. magniglans*, *R. trilineatus*, and *R. rotundisemenus*, and presence of spermatized females, cannot be satisfactorily explained. In closely related genera, *Pratylenchus* Filipjev, 1934 and *Hirschmanniella* Luc and Goodey, 1963, as reported by Loof (1960) and Sher (1968) and in a closely related subfamily (Sher, 1965, Sher, 1966), there is a good correlation between the presence of males and sperms in the spermatheca, and the absence of males and no sperms in the spermatheca. Genera, in the more distantly related family Criconematidae, have been recorded with spermatized spermathecas and absence of males, as well as no sperms in the spermatheca and presence of males (Raski and Golden, 1965).

Brooks and Perry (1962) report the apparent reproduction of *R. similis* for three generations without males. It was not noted if sperms were present in the spermatheca in these specimens.

Steiner and Buhrer (1933) in a discussion of the sexual dimorphism of *T. similis* Cobb, 1893, speculated that, "Unless disproved, then, the sexual dimorphism may be considered an adaptation to the life-long endoparasitism of *T. similis*, to its possible habit of copulation within the host tissue, to the possible cessation of nutrition by the adult male and its death shortly after copulation." This is apparently not true for *Radopholus similis*, as numerous juveniles, females, and males are found in the soil around roots parasitized by this species. *R. magniglans*, and the closely related species, *R. trilineatus*, might fit the speculations of Steiner and Buhrer, since the only stage found thus far in the soil is the spermatized female.

More than 200 spermatized females but no males or juveniles of *R. magniglans* have been found in four localities (during November and December 1965). Over 100 spermatized females but no males or juveniles of *R. trilineatus* were found in two localities (during May 1966). In addition, the ovaries in these specimens appeared uniform in size and development. This suggests that these species may have a more formal or restrictive life cycle, and that the other stages might be found in the soil during different times of the year and/or the other stages might be in the roots of plants. The rather short ovaries and absence of well-developed oocytes or eggs might be further evidence that these species undergo further development in the roots of the plants.

R. rotundisemenus also has spermatized females and no males but only 18 females are known from one locality. In addition, juveniles of *R. rotundisemenus*, two additional species of *Radopholus* and a few male *Radopholus*, that could not be identified as to species, were found in this collection. The ovaries in *R. rotundisemenus* are variable, well-developed, and the spermatheca contains round sperms. Round sperms are also seen in one of the species of *Radopholus* that is not described because of insufficient specimens.

The best known, most widely distributed and only known pathogen in this genus, *Radopholus similis*, has been recorded as parasitizing 244 different plants (Poucher, et al., 1967). Bally and Reydon (1931) first reported the possibility of biological strains in this species when they were unable to infect *Gigantochloa apus* with specimens from *Coffea robusta*. Other workers have reported the inability of *Radopholus similis* from *Musa* spp. to infect *Citrus* spp. (DuCharme and Birchfield, 1956; Blake, 1961; van Weerdt, 1957). A study of specimens (races) from banana and citrus has been made and no consistent morphological differences can be seen between specimens from banana or citrus roots; this confirms the observations of DuCharme and Birchfield (1956) and van Weerdt (1958). Specimens from Java have been unavailable for study.

Morphological variation in single female progeny of *Radopholus similis* was reported by van Weerdt in 1958. Similar polymorphism was seen within the many populations of *R. similis* examined during the present study. The most common variations are in the female lip region shape and stylet knob shape (Fig. 1 A–B), as well as areolation of the posterior portion of the lateral field of the female (Fig. 1 K–M). Van Weerdt (1958) considered the areolation of the lateral field "an artifact as a result of the fixation in formalin . . ."

Summary

The genus *Radopholus* Thorne, 1949 is diagnosed. The four nominal species [*R. similis* (Cobb, 1893), *R. inaequalis* Sauer, 1958, *R. neosimilis* Sauer, 1958 and *R. williamsi* Siddiqi, 1964] are redescribed from type specimens. Seven new species are proposed; five from Australia, one from New Zealand and one from Nigeria; all from native habitats in these areas. A key to the species and illustrations of the species are presented. The distribution and some morphological characters of *Radopholus* are discussed.

Acknowledgments

Helpful assistance in the preparation of nematode slides, measurements, and illustrations was received from: A. H. Bell, K. W. Brown, and L. Wang.

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Digenetic Trematodes of Marine Fishes from Ghana: Families Acanthocolpidae, Bucephalidae, Didymozoidae[1]

JACOB H. FISCHTHAL AND J. D. THOMAS[2]

This paper is the second in a series by the authors on the digenetic trematodes of marine fishes from Ghana. Specimens have been deposited in the U. S. National Museum Helminthological Collection as indicated. All measurements are in microns, unless otherwise noted.

Family Acanthocolpidae

Stephanostomum casum (Linton, 1910) McFarlane, 1934

HOST: *Lutjanus modestus* Blecker, red snapper (Lutjanidae).

HABITAT: Rectum.

LOCALITY: Tema, Ghana.

DATE: 22 December 1964.

SPECIMEN: USNM Helm. Coll. No. 63330.

DISCUSSION: Our collection consists of two specimens from one host. Seven spines in the oral row of circumoral spines measure 72–93 by 17–22, while nine in the aboral row are 68–82 by 19–26. The body spines end just short of the posterior extremity. Fifteen eggs measure 66–74 by 42–47; they contain 8–16 cell embryos measuring 38–52 by 29–33. Our specimens compare favorably with specimens of *S. casum* in the U. S. National Museum Helminthological Collection from Florida (no. 8743), Massachusetts (no. 8211), North Carolina (no. 37101), and Puerto Rico (no. 39341).

Stephanostomum ghanensis n. sp. (Figs. 1, 2)

HOST: *Trachinotus goreensis* Cuvier and Valenciennes, pampano (Carangidae).

HABITAT: Stomach.

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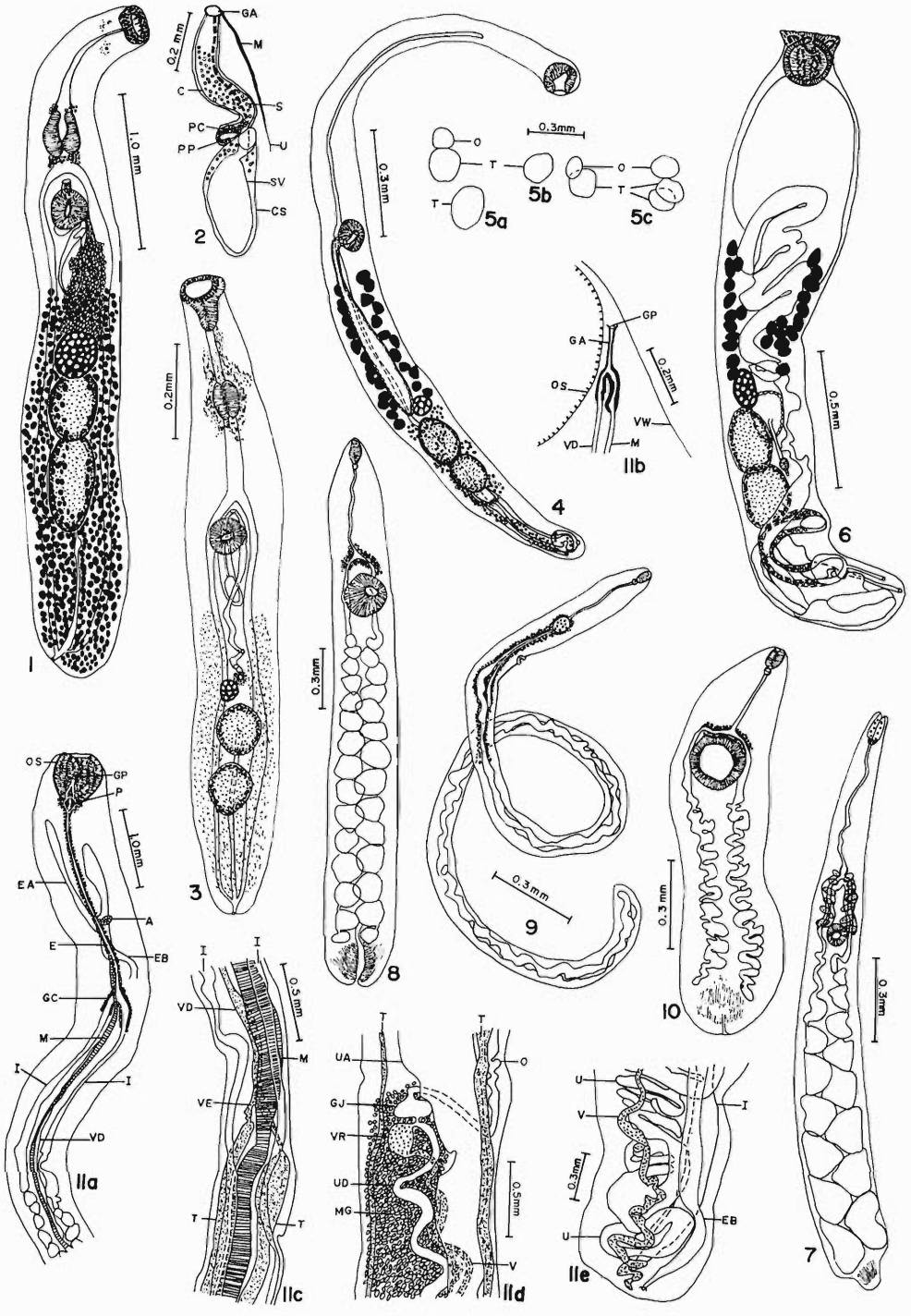

LOCALITY: Iture, Ghana.

DATE: 21 February 1966.

SPECIMEN: USNM Helm. Coll. No. 63331 (holotype).

DIAGNOSIS (based on one adult and two immature specimens; adult measured): Body 4,498 by 630 at testicular level. Tegument annulated preacetabularly, spined to level of posterior testis. Eyespot pigment present. Forebody 1,365 long, hindbody 2,858 long. Oral sucker 172 by 230, truncate posteriorly. Circumoral spines 34–36 in number, in two alternating, uninterrupted rows; ventral oral spines 45–57 by 22–23, dorsal 61–63 by 19–24; ventral aboral spines 33–41 by 16–19, dorsal 65–75 by 21–23. Acetabulum 275 by 255, center at level of anterior one-third of body length. Sucker length ratio 1:1.60. Prepharynx 655 long, thick-walled, muscular; pharynx 300 by 245, pyriform, glands anterolaterally and posteriorly; esophagus 152 long, thick-walled, muscular, glands along length; cecal bifurcation just preacetabular; ceca conspicuously cell-lined, extending to posterior extremity, opening into excretory bladder.

Gonads tandem, contiguous, filling intercecal space, may overlap ceca ventrally. Testes two, smooth; anterior testis 440 by 330, dorsally overlapping ovary 51; posterior testis 605 by 295; posttesticular space 955 long, also long in immature specimens. Cirrus sac winding, 700 (longitudinal extent) by 152 at seminal vesicle, commencing 425 postacetabular (three-fifths of distance from latter to ovary), just contacting vitellaria medianly. Internal seminal vesicle 375 (longitudinal extent) by 145, sacular, somewhat winding anteriorly. Pars prostatica short, just posterodorsal to acetabulum, surrounded by few prostate cells. Cirrus long, winding, proximal part spined. Cirrus sac uniting with metraterm at anterior margin of acetabulum, forming short genital atrium. Genital pore median, just preacetabular.

Ovary 218 by 232, smooth, lying 700 postacetabular. Ootype complex dorsal to ovary. Uterus extensively coiled between acetabulum and ovary, slightly overlapping latter dorsally, sperm in proximal portion. Metraterm thick-walled, shorter than cirrus sac, spines not observed. Vitellaria extensive, commencing 340 postacetabular; follicles ventral, lateral and dorsal to ceca, invading intercecal space dorsal to gonads but not confluent, filling posttesticular space except medianly, confluent dorsal to proximal half of uterus between anteriormost margin of vitellaria to just preovarian. Eggs yellow, thin-shelled, operculate, eight measuring 62–66 by 37–45, zygote undivided.

Excretory bladder long, narrow, extending to ovarian level, ducts reaching posterolateral margins of oral sucker before turning back on themselves and running posteriorly at least to vitellaria (probably beyond), pore terminal.

DISCUSSION: Our species could not be keyed to any species listed in the keys given by Manter and Van Cleave (1951) and Caballero (1952). The closest species appear to be *S. sentum* (Linton, 1910) Manter, 1947, and *S. anisotremi* Manter, 1940, but it differs from them in having a much longer posttesticular space, in the cirrus sac extending more than halfway to the ovary, and in the vitelline

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Figures 1–11. 1. ***Stephanostomum ghanensis*, holotype, ventral view.** 2. **Same. Terminal genitalia, holotype, ventral view.** 3. ***Stephanostomum trachinoti*, holotype, ventral view.** 4. ***Bucephaloides ghanensis*, holotype, anterior part of body in dextrolateral view, from pharynx posteriorly in dorsal view.** 5a. ***Prosorhynchus caudovatus*, relative position of gonads, ventral view; b. dorsal view of second specimen; c. dextrolateral view of third specimen.** 6. ***Rhipidocotyle ghanensis*, holotype, ventral view.** 7. **Immature Didymozoid D, ventral view.** 8. **Immature Didymozoid E, from *Scyris alexandrinus*, ventral view.** 9. **Immature Didymozoid F, dextrolateral view.** 10. **Immature Didymozoid G, ventral view.** 11a. ***Allonematobothrium ghanensis*, paratype, anterior extremity, dorsal view; b. terminal genitalia, holotype, dextrolateral view; c. region of anterior part of testes, holotype; d. region of genital junction (intestinal ceca omitted), holotype; e. posterior extremity, paratype.**

Abbreviations: A, acetabulum; C, cirrus; CS, cirrus sac; E, esophagus; EA, excretory arm; EB, excretory bladder; GA, genital atrium; GC, gland cells; GJ, genital junction chamber; GP, genital pore; I, intestinal cecum; M, metraterm; MG, Mehlis' gland; O, ovary; OS, oral sucker; P, pharynx; PC, prostate cells; PP, pars prostatica; S, spine; SV, seminal vesicle; T, testis; U, uterus; UA, ascending uterus; UD, descending uterus; V, vitellarium; VD, vas deferens; VE, vas efferens; VR, vitelline reservoir; VW, ventral body wall.

follicles being confluent dorsal to the proximal half of the uterus; it differs further from S. *anisotremi* in having fewer circumoral spines.

Stephanostomum megacephalum Manter, 1940

HOSTS: *Caranx hippos* (L.), jack or horse mackerel (Carangidae); *Myxus curvidens* (Valenciennes), mullet (Mugilidae).

HABITAT: Small intestine.

LOCALITIES: Cape Coast (*Caranx*), Tema (*Myxus*); Ghana.

DATE: 27 April 1966 (*Caranx*).

SPECIMENS: USNM Helm. Coll. No. 63332 (from *Caranx*); No. 63333 (*Myxus*).

DISCUSSION: Our specimens readily keyed to S. *megacephalum* in the keys given by Manter and Van Cleave (1951) and Caballero (1952). This species has been reported from *Caranx hippos* from the Pacific coast of Mexico, Panama and Ecuador, and from the Gulf of Mexico (Florida); it has also been found in *C. latus* Agassiz from Tortugas (Florida) and Jamaica (West Indies). Our collection consists of four adults and one immature specimen, with 28–30 circumoral spines, from one *C. hippos*, and four adults, with 31–32 spines, from one *M. curvidens*. The circumoral spines in specimens from the latter host average smaller (46–75 by 7–11) than those originally described; we believe this to be host influenced.

Stephanostomum trachinoti n. sp. (Fig. 3)

HOST: *Trachinotus glaucus* (L.), palometa (Carangidae).

HABITAT: Small intestine.

LOCALITY: Cape Coast, Ghana.

DATE: 20 April 1966.

SPECIMEN: USNM Helm. Coll. No. 63334 (holotype).

DIAGNOSIS (based on single immature specimen): Body 1,344 by 210 (preacetabular), extremities round. Tegument spined to anterior testis level, extending anteriorly up to circumoral spines. Eyespot pigment abundant, scattered from oral sucker to midlength of esophagus. Forebody 505 long, hindbody 745 long. Oral sucker 125 by 94, elongate, funnel-shaped. Circumoral spines numbering 80–84, in two alternating, uninterrupted rows, 5–7 by 4–5, oral spines smaller than aboral. Acetabulum 94 by 102, center at level of anterior two-fifths of body length. Sucker length ratio 1:0.75. Prepharynx 118 long, thick-walled, muscular; pharynx 60 by 54, oval, four-lobed anteriorly; esophagus 184 long, lined with cells continuous with those of ceca, longer than prepharynx or pharynx; cecal bifurcation 12 preacetabular; ceca long, cell-lined, terminating 46 from posterior extremity, opening into excretory bladder.

Gonads tandem, 4–5 apart, filling intercecal space, may overlap ceca ventrally. Testes two, smooth; anterior testis 118 by 93, posterior testis 115 by 103; posttesticular space 203 long. Cirrus sac 198 by 46, median, commencing 82 postacetabular, 48 previtellarian, 168 preovarian; containing small seminal vesicle, short pars prostatica surrounded by prostate cells, and long, spined cirrus. Cirrus sac uniting with metraterm preacetabularly, forming short genital atrium. Genital pore median, just preacetabular.

Ovary 45 by 38, smooth, lying 250 postacetabular. Ootype complex anterodextral to ovary. Uterus with little coiling, ascending ventral to proximal part of cirrus sac. Metraterm 140 by 20, thick-walled, muscular, appearing spined, shorter than and dextral to cirrus sac, commencing 31 postacetabular. Vitellaria commencing 130 postacetabular, 120 preovarian; follicles very small, ventral, lateral and dorsal to ceca, invading interceal space slightly, filling posttesticular space.

Excretory bladder long, narrow, extending dorsally to midlength of anterior testis, pore terminal.

DISCUSSION: This form could not be keyed to any species given in the keys by Manter and Van Cleave (1951) and Caballero (1952). The unique combination of characteristics prompted us to describe it as a new species even though immature. It differs from all species, except S. *multispinosum* Manter, 1940, in having 80–84 circumoral spines. The latter species differs in the oral sucker being cupuliform and smaller than the acetabulum, in having a pyriform pharynx and a short esophagus, in the vitellaria extending to the acetabulum, and in the cirrus sac extending a considerable distance postacetabular.

Family Bucephalidae
Bucephaloides ghanensis n. sp.
(Fig. 4)

HOST: *Scomberomorus tritor* (Cuvier and Valenciennes), Spanish mackerel or kingfish (Scombridae).

HABITAT: Small intestine.

LOCALITY: Iture, Ghana.

DATE: 21 February 1966.

SPECIMEN: USNM Helm. Coll. No. 63335 (holotype).

DIAGNOSIS (based on one complete specimen, and one with previtellarian body missing): Body 2,277 by 175 at ovarian level, elongate, narrow, extremities round. Tegument entirely spined. Anterior sucker 85 long, 77 deep, subterminal ventral. Mouth ventral to pharynx, at midbody length; pharynx 92 by 86, lying 1,110 from anterior extremity; esophagus muscular, very short, directed dorsally; intestine 560 by 46, very long, cell-lined, directed posteriorly to level of ovary or anterior testis.

Gonads smooth, tandem, may be contiguous or slightly separated from one another, extending posteriorly from posterior part of middle third of body. Testes two, median; anterior testis 123–145 by 102–114, posterior testis 116 by 94–97; posttesticular space 219–320 long. Cirrus sac 257–340 by 52–58, thick-walled, muscular, straight to slightly sinuous, terminating 30–38 from posterior extremity. Seminal vesicle 88–102 by 40–48, elongate oval. Pars prostatica 155–195 by 23–31, cell-lined, surrounded by dense mass of prostate cells. Genital lobes unequal, projecting into genital atrium. Latter 65–80 by 47–71; short duct leading to subterminal ventral genital pore.

Ovary 72–73 by 68–72, round, submedian dextral, lying 440 postpharyngeal and 1,622 from anterior extremity (holotype). Oviduct muscular, from posterodextral margin of ovary, extending posteriorly dorsal to anterior testis. Vitelline follicles in narrow lateral fields, extending from postpharyngeally (53 in holotype) to level of ovary or anterior testis, follicles (right–left) numbering 16–16, 16–17; vitelline duct from each field extending posteriorly dorsal to ovary and anterior testis, uniting at posterior part of latter to form short common duct. Uterus with few coils, extending from ovarian level to posterior margin of genital atrium. Eggs few, thick-shelled, yellow-brown, operculate, 10 measuring 16–21 by 10–15; many abnormal eggs present.

Excretory bladder very long, narrow, commencing 232 from anterior sucker, 320 from anterior extremity; pore terminal.

DISCUSSION: Our species most closely resembles *Bucephaloides philippinorum* Velasquez, 1959, from a sphyraenid fish from Luzon Island, Philippines, and *B. tenuis* (Yamaguti, 1952) Hopkins, 1954, from a platycephalid fish from Celebes. Both these species differ from ours in having a much longer posttesticular space and cirrus sac, and in the uterus extending considerably previtellarian and prepharyngeal. *B. tenuis* differs further in having a much shorter intestine, a larger ovary which is about the same size as the testes, and the anterior tip of the excretory bladder being much nearer the pharynx.

Prosorhynchus caudovatus Manter, 1940
(Figs. 5a–c)

SYNONYM: *Prosorhynchus crucibulus* of Eckmann, 1932, nec Rudolphi, 1819.

HOSTS: *Epinephelus goreensis* (Cuvier and Valenciennes), sea perch or grouper (Serranidae); *Lutjanus maltzani* (Steindachner), snapper (Lutjanidae).

HABITATS: Small intestine, stomach.

LOCALITY: Tema, Ghana.

DATE: 18 December 1964.

SPECIMENS: USNM Helm. Coll. No. 63336 (from *Epinephelus*); No. 63337 (*Lutjanus*).

MEASUREMENTS AND SOME PERTINENT DATA (based on two specimens from *E. goreensis*, and four from *L. maltzani*; five measured): Body 1,715–2,245 by 465–675, entirely spined; rhynchus 285–330 by 205–245, wedge- to funnel-shaped; pharynx 77–100 by 95–120, wider than long; narrow esophagus may be present; intestine 222–435 by 125–170; testes 167–232 by 150–196, their position in relation to each other and to ovary showing considerable variation as illustrated in Figs. 5a–c; cirrus sac 655–760 by 143–170, thick-walled, muscular, may overlap posterior testis or may be entirely posttesticular; genital atrium 186–300 by 167–200; ovary 124–198 by 111–155, overlapping testis dorsally; ootype complex dorsal to testis; Laurer's canal extending posteriorly beyond testis to dorsal surface of body; sperm

in proximal part of uterus, uterine coils may extend previtellarian; vitelline follicles in five specimens numbering (right–left) 8–12, 11–13, 11–14, 12–14, 14–14, usually in separate lateral fields, forming inverted U in two; vitelline reservoir small; eggs thick-shelled, operculate, yellow to yellow-brown, 20 measuring 32–43 by 21–25, usually with anopercular filament which may be up to 30 long, some with anopercular knob only; some abnormally shaped eggs present in all specimens.

DISCUSSION: This species was originally described from *Epinephelus* sp. from the Suez. The extreme variation in the relative positions of the gonads raises some question regarding the assignment of some species to the genus *Neidhartia* Nagaty, 1937, as they are based on only one or a very few specimens. Had we encountered our specimen illustrated in Figure 5b by itself, we probably would have described it as a new species of *Neidhartia* rather than recognizing it as a variant of *Prosorhynchus caudovatus*. An anopercular process has been described for at least some of the eggs in several species of bucephalids: *Paurorhynchus hiodontis* Dickerman, 1954, possesses a "knob"; *Bucephalus kathetostomae* (Manter, 1934) Manter, 1940, an "irregularly shaped cap"; *Bucephalus fragilis* Velasquez, 1959, a "protuberance."

Rhipidocotyle ghanensis n. sp. (Fig. 6)

HOST: *Psettodes belcheri* Bennett (Psettodidae).

HABITAT: Small intestine.

LOCALITY: Tema, Ghana.

SPECIMENS: USNM Helm. Coll. No. 63338 (holotype and two paratypes on same slide).

DIAGNOSIS (based on five specimens; four measured): Body 1,770–2,510 by 290–450 at postvitellarian or testicular level, dorsoventrally flattened anterior to midlength of vitellaria, much rounded posteriorly, anterior extremity truncate, posterior round. Tegument entirely spined, anterior spines more scalelike. Anterior sucker 190–205 by 143–175, subterminal ventral, opening round to elongate oval, with seven-lobed polygonal hood measuring 82–107 by 220–242, lobes may show muscular papilla when extended. Mouth 1,060–1,670 from anterior extremity, well posterior to midlength of body, posterior to pharynx; latter 61–76 by 58–77, round to longitudinally elongate, at level of anterior testis; esophagus long, 97–152 by 42–58, muscular, passing anteriorly from pharynx to ovarian level; intestine 196–272 by 126–150, oval, conspicuously cell-lined, dorsomedian, extending very slightly anterodorsal before looping posteriorly, terminating anterior to or at pharyngeal level, may overlap median parts of ovary and anterior testis.

Gonads smooth, tandem, usually overlapping adjacent one, dextral, posterior to midbody length. Anterior testis 220–278 by 157–198, posterior testis 222–240 by 150–193; posttesticular space 405–585 long. Cirrus sac 518–720 by 78–95, thick-walled, muscular, C-shaped to straight, extending from level of posterior testis to 100–240 from posterior extremity. Seminal vesicle 114–170 by 60–78, elongate oval. Pars prostatica 276–392 by 45–53, cell-lined, surrounded by dense mass of prostate cells. Genital lobes muscular, unequal, projecting into genital atrium. Latter 114–140 by 100–125; narrow, very thick-walled, muscular duct leading to subterminal ventral genital pore.

Ovary 138–182 by 116–129, pretesticular, lying 715–1,380 from anterior extremity. Oviduct muscular, from posterior or dextrolateral margin of ovary, extending posteriorly dorsal to anterior testis. Vitelline follicles in narrow lateral fields, extending from 505–840 from anterior extremity to ovarian level; follicles numbering (right–left) 8–14, 13–16, 13–17, 15–18 in four specimens, respectively; vitelline duct from each field extending long distance posteriorly, dorsal to ovary and anterior testis, uniting to form short common duct at overlap of anterior and posterior testes. Uterus extensive, extending from 495–640 from anterior extremity (previtellarian) to level of posterior margin of genital atrium or more posteriorly. Eggs numerous, yellow-brown, thick-shelled, operculate, 20 older ones measuring 23–27 by 16–18; younger eggs nearest ovary thin-shelled, larger and rounder.

Excretory bladder very long, narrow posteriorly, considerably expanded anteriorly and filling most of body width, extending almost to anterior sucker to slightly overlapping latter dorsally; pore terminal.

DISCUSSION: Our species appears closest to *Rhipidocotyle longleyi* Manter, 1934, from serranid and lutjanid fishes from Florida and

Japan, and to *R. laruei* Velasquez, 1959, from a psettodid fish from Luzon Island, Philippines. Both these species differ from ours in having the mouth near midbody length, lacking an esophagus or having only a very short one, and the excretory bladder extending anteriorly only to the level of the digestive tract. *R. longleyi* differs further in the intestine extending both anterior and posterior to the mouth, and in possessing a papilla on the posterior margin of the genital pore. *R. laruei* differs further in the intestine extending anteriorly from the pharynx, having the gonads at midbody length, the cirrus sac comprising almost one-half of the body length, the seminal vesicle being coiled, and the uterus extending anteriorly only to the level of the anterior vitelline follicles.

Family Didymozoidae

Fischthal and Kuntz (1964) and Nikolaeva (1964, 1965) have reviewed previously described immature didymozoids in addition to describing some new ones. Subsequently, Fischthal and Kuntz (1965) reported *Torticaecum nipponicum* Yamaguti, 1942, from a colubrid snake from North Borneo, and Parukhin (1966) illustrated, without describing, "Didymozoidae gen. sp. larvae" from carangid fishes from the South China Sea; the latter form is *Torticaecum*-like.

Immature Didymozoid B Fischthal and Kuntz, 1964

HOSTS: *Euthynnus alleteratus* (Rafinesque), false albacore or little tunny (Scombridae); *Brachydeuterus auritus* (Cuvier and Valenciennes), burrito (Pomadasyidae).

HABITAT: Small intestine.

LOCALITIES: Tema (*E. alleteratus*), Cape Coast (*B. auritus*); Ghana.

DATES: 23 October, 17 December 1964; 6 December 1965.

SPECIMENS: USNM Helm. Coll. No. 63339 (from *Euthynnus*); No. 63340 (*Brachydeuterus*).

DISCUSSION: Two albacore harbored four and 12 specimens, respectively; one worm was recovered from the burrito. This immature didymozoid was originally described from *Euthynnus yaito* Kishinouye from Palawan Island, Philippines.

Didymozoidae (*Monilicaecum*) larvae I Nikolaeva, 1965

HOSTS: *Vomer setapinnis* (Mitchill), moonfish (Carangidae); *Brachydeuterus auritus* (Cuvier and Valenciennes), burrito (Pomadasyidae); *Scomberomorus tritor* (Cuvier and Valenciennes), Spanish mackerel or kingfish (Scombridae).

HABITAT: Small intestine.

LOCALITY: Cape Coast, Ghana.

DATES: 29 November, 6 December 1965; 4 March 1966.

SPECIMENS: USNM Helm. Coll. No. 63341 (from *Vomer*); No. 63342 (*Brachydeuterus*); No. 63343 (*Scomberomorus*).

DESCRIPTION (based on three specimens; all measured): Body 1,748–2,030 by 213–280, elongate, anterior part narrow, gradually widening to rounded posterior extremity; body 7.2–8.8 times longer than wide. Forebody 395–452 long, hindbody 1,280–1,490 long. Body filled with vesicular parenchyma. Parenchymal glands conspicuous, filling entire body in zone beneath tegument. Oral sucker 156–167 by 61–66, 59–73 of it protruding from anterior body opening, elongate; composed of outer thin layer of longitudinal and inner thicker layer of circular muscles, and much greater inner area of vesicular parenchymatous cells, combined thickness of muscle layers 5–8. Acetabulum 73–99 by 80–93, muscular, center at level of anterior one-fourth of body length. Sucker length ratio 1:0.44–0.63. Distance between suckers 266–342, its ratio to body length being 1:5.9–6.6. Pharynx 22–27 by 23–27, round, inner part non-muscular and composed of vesicular cells, contiguous with center of posterior part of oral sucker; esophagus 186–276 long, sinuous, thick-walled, muscular, lumen much enlarged at distal end just before cecal bifurcation; latter 38–72 preacetabular; one cecum ascending very short distance before descent, ceca lined internally to acetabular level with very thick layer of amber-colored, large glands with free ends projecting into small lumen, length of glandular part of right cecum 120–127, left cecum 114–140, no nuclei visible in glands, walls 6–23 thick; indistinct, somewhat diffuse, large, very granular, multinucleate glands external to thick part of ceca; 7–8 narrow, elongate chambers along postacetabular length of each cecum, most cham-

bers with amber-colored amorphous contents; ceca terminating subequally, one 114–191 from posterior extremity, other 275–360. No reproductive fundaments. Excretory bladder elongate, narrow, followed anteriorly as far as acetabulum, but probably extends preacetabular; pore terminal.

DISCUSSION: This form was originally described from the small intestine of *Sardinops ocellata* (Clupeidae) and *Zeus faber* L. (Zeidae) from the Atlantic coast of Southwest Africa. We are referring our specimens to it even though some differences occur. Nikolaeva (1965) studied much smaller specimens than ours, but inasmuch as they are immature size alone may not be significant for differentiation. For the same reason and because of differences in the state of extension or contraction of the body following fixation, the ratios of width and of distance between suckers to body length are also unreliable as criteria for differentiation. Nikolaeva described a strongly muscular oral sucker for her specimens, but her illustration appears to show that the inner part is nonmuscular. Should our interpretation of the illustration be incorrect, then our specimens represent a different species. The only other immature didymozoid with a glandular stomachlike structure at the cecal bifurcation is *Monilicaecum ventricosum* Yamaguti, 1942, from the flesh and body cavity of *Cololabis saira* (Brevoort) (Scomberesocidae) from the Japanese Pacific. The latter species differs from Didymozoidae (*Monilicaecum*) larvae I in having the stomachlike structure confined to the cecal bifurcation rather than extending posteriorly on the ceca to acetabular level, and in lacking glands external to the stomach. The presence of glands surrounding the anterior part of the digestive tract has not been noted for any other immature didymozoid; they have been described for adults of *Nematobothrium sardae* MacCallum and MacCallum, 1916, and species in the genera *Paragonapodasmius* Yamaguti, 1938; *Allonematobothrium* Yamaguti, 1965; *Metanematobothrioides* Yamaguti, 1965; *Nematobothrioides* Yamaguti, 1965; and *Neonematobothrium* Yamaguti, 1965.

Immature Didymozoid D (Fig. 7)

HOST: *Lagocephalus laevigatus* (L.), smooth puffer or globe-fish (Tetraodontidae).

HABITAT: Small intestine.

LOCALITY: Cape Coast, Ghana.

DATE: 4 March 1966.

SPECIMEN: USNM Helm. Coll. No. 63344.

DESCRIPTION (based on single specimen): Characteristics as for Didymozoidae (*Monilicaecum*) larvae I, except as noted below. Body 2,085 by 240, abruptly narrowing postcecally to papillalike termination; body 8.7 times longer than wide. Forebody 750 long, hindbody 1,245 long. Oral sucker 119 by 50, within body, combined thickness of muscle layers 4–5. Acetabulum 90 by 87, strongly muscular, center at level of anterior 38 per cent of body length. Sucker length ratio 1: 0.76. Distance between suckers 615, its ratio to body length being 1:3.4. Pharynx 20 by 37, contiguous with entire width of truncated posterior end of oral sucker; esophagus 440 long; cecal bifurcation 148 preacetabular; ceca not ascending at beginning, winding, with very thick, amber-colored glands internally to acetabular level, length of glandular part of right cecum 205, left cecum 198, walls 10–22 thick; 15 distinct, isolated, large, multinucleate, agranular glands distributed dorsally and ventrally external to thick parts of ceca, some glands bipartite, varying in size from 24 by 26 to 29 by 55; ceca continuing to within 90 of posterior extremity, with 10 enlarged chambers along postacetabular length of each cecum, chambers for short distance small and conspicuously cell-lined. Excretory bladder commencing prebifurcal, 130 posterior to oral sucker, arms postpharyngeal.

DISCUSSION: This new form differs significantly from *Monilicaecum ventricosum* Yamaguti, 1942, and Didymozoidae (*Monilicaecum*) larvae I Nikolaeva, 1965, in having considerably more of the ceca internally lined with glands, a differently shaped pharynx, and an oral sucker distinctly longer than the acetabulum. It differs further from the latter form in that the ceca do not ascend the body before extending posteriorly, and in having a different type of gland external to the thick part of the ceca.

Immature Didymozoid E (Fig. 8)

HOSTS: *Scyris alexandrinus* (Geoffroy St. Hilaire), thread-fin horse mackerel; *Caranx africanus* Steindachner, African horse mackerel

(Carangidae); *Cynoscion macrognathus* (Bleeker), large-mouth weakfish (Sciaenidae); *Scomberomorus tritor* (Cuvier and Valenciennes), Spanish mackerel or kingfish (Scombridae); *Pomadasys jubelini* (Cuvier and Valenciennes), burro; *Brachydeuterus auritus* (Cuvier and Valenciennes), burrito (Pomadasyidae); *Psettodes belcheri* Bennett (Psettodidae); *Cynoglossus goreensis* Steindachner, *C. senegalensis* (Kaup), tongue soles (Cynoglossidae); *Rhinobatus albomaculatus* Norman, white-spotted guitarfish (Rhinobatidae); *Pteroplatea micrura* (Schneider), butterfly ray (Trygonidae).

HABITATS: Stomach, small intestine.

LOCALITIES: Tema, Cape Coast, Iture; Ghana.

DATES: 19 December 1964; 31 March, 2 April 1965; 21 February, 10 March 1966.

SPECIMENS: USNM Helm. Coll. No. 63345 (from *Scyris*); No. 63346 (*Caranx*); No. 63347 (*Cynoscion*); No. 63348 (*Scomberomorus*); No. 63349 (*Pomadasys*); No. 63350 (*Brachydeuterus*); No. 63351 (*Psettodes*); No. 63352 (*Cynoglossus goreensis*); No. 63353 (*C. senegalensis*); No. 63354 (*Rhinobatus*); No. 63355 (*Pteroplatea*).

DESCRIPTION (based on 19 specimens; 10 measured): Characteristics as for Didymozoidae (*Monilicaecum*) larvae I, except as noted below. Body 1,500–3,501 by 165–510, posterior extremity round; body 5.8–12.5 times longer than wide. Forebody 385–663 long, hindbody 1,015–2,830 long. Oral sucker 51–111 by 37–80, usually longitudinally elongate but may be round, entirely but weakly muscular. Acetabulum 100–222 by 98–218, center at level of anterior 17–29 per cent of body length. Sucker length ratio 1:1.71–2.52. Distance between suckers 270–542, its ratio to body length being 1:4.5–8.6. Pharynx 18–48 by 14–36, round to longitudinally elongate, entirely muscular, contiguous with center of posterior part of oral sucker; esophagus 191–404 long, straight or sinuous, lumen not much enlarged at distal end; cecal bifurcation 46–123 preacetabular, no glandular thickening of walls; ceca winding to within 27–190 of posterior extremity, each cecum with 12–16 chambers. Glands in compact mass externally surrounding posterior 78–189 of esophagus, cecal bifurcation and 53–140 of ceca (to acetabular level or nearly so). Excretory bladder commencing pre- to slightly postbifurcal.

DISCUSSION: The distribution of the glands external to the anterior part of the digestive tract is distinctive for this new form, differentiating it from all other known immature forms of the family. The distribution is somewhat similar to that reported for the adult of *Nematobothrioides kalikali* Yamaguti, 1965, from Hawaii; however, the latter lacks an acetabulum. The glands in specimens from the guitarfish and ray were sparser and more diffuse than those from the other hosts possibly because they, as selachians, are not suitable paratenic hosts.

Immature Didymozoid F (Fig. 9)

HOST: *Cypsilurus heterurus* (Rafinesque), flying-fish (Exocoetidae).

HABITAT: Small intestine.

LOCALITY: Tema, Ghana.

DATE: 2 June 1965.

SPECIMEN: USNM Helm. Coll. No. 63356.

DESCRIPTION (based on one complete specimen in dextrolateral view, hence measurements are length by depth; also, two fragments of postacetabular part of body of two other specimens): Characteristics as for Didymozoidae (*Monilicaecum*) larvae I, except as noted below. Body 3,597 by 116, very long. Forebody 515 long, hindbody 3,060 long. Oral sucker 45 by 39, entirely but weakly muscular, within body. Acetabulum 22 by 26, center at level of anterior 15 per cent of body length. Sucker length ratio 1:0.49. Distance between suckers 465, its ratio to body length being 1:7.7. Pharynx 27 by 21, entirely muscular; esophagus 252 long, lumen not enlarged distally; stomach at cecal bifurcation, 45 by 33, lying 150 preacetabular, lined internally with very thick, amber-colored glands; ceca 9–10 wide at exit from stomach, straight to short distance postacetabular, then sinuous with some small, elongate chambers, extending to within 32 of posterior extremity. Glands in compact mass external to stomach and ceca for distance of 1,045, terminating 620 postacetabular. Excretory bladder commencing prebifurcal, arms to 63 postpharyngeal.

DISCUSSION: The present new form appears closest to *Monilicaecum ventricosum* Yamaguti, 1942, but the latter differs in possessing non-

muscular elements in the oral sucker, in the retracted oral sucker being smaller than or the same size as the acetabulum, and in lacking glands external to the anterior part of the digestive tract. The distribution of the latter glands in our form is somewhat similar to that occurring in adults of *Paragonapodasmius managatuwo* Yamaguti, 1938, and *Metanematobothrioides opakapaka* Yamaguti, 1965.

Immature Didymozoid G (Fig. 10)

HOST: *Larimus peli* Bleeker (Sciaenidae).
HABITAT: Small intestine.
LOCALITY: Cape Coast, Ghana.
DATE: 19 January 1966.
SPECIMEN: USNM Helm. Coll. No. 63357.
DESCRIPTION (based on single specimen): Characteristics as for Didymozoidae (*Monilicaecum*) larvae I, except as noted below. Body 1,350 by 360, 3.8 times longer than wide. Forebody 340 long, hindbody 815 long. Oral sucker 83 by 64, entirely but weakly muscular, within body. Acetabulum 195 by 200, center at level of anterior 32 per cent of body length. Sucker length ratio 1:2.35. Distance between suckers 260, its ratio to body length being 1:5.2. Pharynx 27 by 27, entirely muscular; esophagus 255 long, straight, lumen not enlarged distally; cecal bifurcation overlapping anteriormost part of acetabulum; ceca thick-walled, muscular at acetabular level for distance of 103, with outer thin longitudinal and inner thick circular muscle layers which are continuous with those of esophagus, walls 3–5 thick, lumen narrow; glands in compact mass external to muscular part of ceca; beyond latter ceca conspicuously cell-lined, with 12 chambers along length of each cecum, amber-colored material absent from chambers, terminating 125 from posterior extremity. Excretory bladder followed anteriorly as far as acetabulum, but probably extending preacetabular; pore terminal.
DISCUSSION: This new form differs from all known immature didymozoids in having the ceca muscular at their beginning.

Allonematobothrium ghanensis n. sp. (Figs. 11a–e)

HOST: *Epinephelus aeneus* (Geoffroy St. Hilaire), sea perch or grouper (Serranidae).
HABITAT: Encysted in subepidermal tissue of buccal cavity.
LOCALITY: Tema, Ghana.
SPECIMENS: USNM Helm. Coll. No. 63358 (holotype, acetabulum prebifurcal); No. 63359 (paratypes).
DIAGNOSIS (based on fragments of seven specimens): Body very long, extremities round; anterior part of body (prebifurcal) wide, gradually becoming narrower postbifurcally, then gradually widening again to slightly greater width than prebifurcally; in one specimen 1,000 wide at pharyngeal level and 300 at distance 7,570 postbifurcal; in another 1,250 wide at pharyngeal level and 400 at distance 5,355 postbifurcal; may be up to 1,300 wide more posteriorly. Oral sucker 540–677 by 510–630, terminal, within body, well developed, muscular, 12–30 from anterior extremity. Acetabulum 80–105 long, 104–108 wide (in four), 65–70 deep (in three), transversely oval; in four lying 180 prebifurcal (1,010 posterior to oral sucker), 218 (625), 465 (915), and 795 (1,065), respectively; in three lying 180, 395, and 805 postbifurcal, respectively. Sucker length ratio 1:0.14–0.19. Pharynx 127–208 by 109–140, muscular, inverted bell-shaped, contiguous with posteromedian part of oral sucker, overlapping latter 19–100; esophagus 900–2,350 long, straight to slightly sinuous, thick-walled, muscular; ceca very long, narrow, extending to posterior extremity. Glands surrounding pharynx, esophagus, and ceca for distance of 265–475.

Testes two, symmetrical, tubular, unbranched, sinuous, commencing posterior to genital junction, usually slightly subequal anteriorly, anteriormost extent 11.6–14.7 mm from anterior extremity of body. Vas efferens from anterior tip of each testis, slightly swollen. Vas deferens very long, ascending next to metraterm, distalmost end thick-walled, muscular for very short distance. Genital atrium short, relatively narrow, thick-walled, muscular, protruding from genital pore in one specimen. Genital pore median, ventral to approximate midlength of oral sucker.

Ovary median, tubular, unbranched, winding considerably, 18.5–28.7 mm in longitudinal extent (in three), commencing 1.2–7.4 mm posterior to anteriormost tip of testes, lying 12.8–21.6 mm from anterior extremity of body. Genital junction 40.1–43.7 mm from anterior

extremity (in three); forming enlarged chamber 97–150 by 126–250 (in four), ovary emerging from anteromedian surface, single duct emerging from posteromedian surface; latter duct receiving vitellarium 15–30 (in four) from its origin, winding to posterior extremity as uterus after receiving vitellarium. Latter tubular, winding considerably, commencing near posterior extremity, enlarging into vitelline reservoir 165–220 by 77–175 (in four) just before joining duct from genital junction. Seminal receptacle absent. Mehlis' gland extensively developed, surrounding genital junction and continuing posteriorly around uterus for distances of 1,805 and 2,275 in two, respectively, filling much of body width. Metraterm very long; especially thick-walled and muscular before entering genital atrium. Eggs numerous, yellow-brown, oval, 43 measuring 15–20 by 10–13.

Excretory bladder elongate, narrow, sinuous, extending prebifurcal, arms extending anteriorly as far as level of posterior margin of oral sucker; pore terminal.

Discussion: *Allonematobothrium epinepheli* Yamaguti, 1965, the type and only species in the genus, was found encysted in pairs in the fins and underside of the operculum of *Epinephelus quernus* Seale from Hawaii. Our form differs from the type species in possessing oval eggs, and a considerably larger oral sucker and slightly smaller acetabulum, and in the genital junction forming an enlarged chamber. In *A. ghanensis* four specimens had the acetabulum lying prebifurcal, and three postbifurcal. No other difference was noted between them. Therefore, in spite of the extensive variation in the position of the acetabulum (795 prebifurcal to 805 postbifurcal), we are listing them as a single species until such time as life history studies may determine otherwise. Yamaguti (1965) noted the acetabulum as being 250–800 postbifurcal in the seven specimens of *A. epinepheli* studied.

Examination of the holotype specimen of *A. epinepheli* (USNM Helm. Coll. No. 63526) has made it possible to slightly amplify Yamaguti's description. The oral sucker measures 245 by 257 and the acetabulum 115 by 196; sucker length ratio 1:0.47. The pharynx is 77 by 87, slightly overlapping the oral sucker dorsally; the anterior end is shaped like an inverted bell with the clapper protruding slightly, while the posterior end is broad and truncate. A vitelline reservoir is present; this is not indicated in a paratype illustrated (Fig. 10D) by Yamaguti. The Mehlis' gland is 1,060 long, whereas it is illustrated in the same paratype as being considerably shorter. Finally, the distalmost ends of the vas deferens and metraterm as well as the genital atrium are thick-walled and muscular as described for our species.

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Five New Species of Belondiroidea (Nematoda) from Sibsagar, India, with a Revised Classification of the Superfamily

MOHAMMAD RAFIQ SIDDIQI*

Soil samples collected on 25 July 1966 by Mr. Ajai Kumar of the Oil and Natural Gas Commission of India around roots of various plants at Sibsagar, Assam State, contained 15 different species of belondiroid nematodes, five of which were previously undescribed. These species are listed below, together with the names of the associated plants; the first name against a new species is that of the type plant with which it is associated; botanical names are mentioned only once.

Axonchium amplicolle Cobb, 1920—Coconut (*Cocos nucifera* L.), Elephant-foot yam (*Amorphophallus campanulatus* (Roxb.) Blume ex Dcne.).

A. asacculum n. sp.—Sweet orange (*Citrus sinensis* (L.) Osbeck), banana (*Musa paradisiaca* L.), bottle gourd (*Lagenaria siceraria* (Mol.) Standl.), chillie (*Capsicum frutescens* L.), cotton (*Gossypium arboreum* L.), jack tree (*Artocarpus heterophyllus* Lamk.).

A. elegans Jairajpuri, 1964—Elephant ear (*Colocasia esculenta* (L.) Schott).

A. nitidum Jairajpuri, 1964—Lemon (*Citrus limon* (L.) Burm.), jack tree, litchi (*Litchi chinensis* Sonn.).

A. saccatum Jairajpuri, 1964—Chillie.

Belondira caudata Thorne, 1939—Bermuda grass (*Cynodon dactylon* (L.) Pers.), lemon; date palm (*Phoenix dactylifera* L.), areca nut (*Areca catechu* L.), cotton.

B. clavicaudata (Williams, 1958) Andrássy, 1963—Lemon, jack tree.

B. murtazai n. sp.—Litchi, date palm, coconut, areca nut.

B. neortha Siddiqi, 1964—Jack tree, lemon.

B. nepalensis Siddiqi, 1964—Elephant ear, litchi.

Dorylaimellus belondirelloides n. sp.—Bottle gourd.

D. discocephalus Siddiqi, 1964—Bermuda grass.

D. paraclavatus n. sp.—Rose (*Rosa* sp.).

D. parvulus Thorne, 1939—Rose, banana.

D. salvus n. sp.—Banana.

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Axonchium asacculum n. sp. (Fig. 1, A–F)

Measurements

FEMALES (12) (Paratypes): L = 0.97–1.17 mm; a = 38–49; b = 1.9–2.4; c = 51–65; V = 53–57.

FEMALE (Holotype): L = 1.05 mm; a = 40; b = 2.2; c = 57; V = 53^{-12}.

DESCRIPTION: Female: Lip region amalgamated, rounded, continuous with body contour. Spear well developed, 7–8 μ long. Hemizonid 92 μ from anterior end in holotype, near anterior edge of nerve ring. Esophagus 400–530 μ; anterior part 170–210 μ; esophagointestinal valve large, oval. Esophagus-vulva distance usually 100–190 μ (in one young female this distance is only 30 μ). Vagina elongate, longitudinal to body axis. Anterior uterine branch absent. Ovary with multiple rows of oocytes. Prerectum 103–140 μ long; rectum equal to or longer than anal body width. Tail obtusely rounded, equal to or a little less than anal body width. Male not found.

TYPE MATERIAL: Holotype and two paratypes at Nematology Department, Rothamsted Experimental Station, Harpenden, England; six paratypes at Commonwealth Bureau of Helminthology, St. Albans, England; two paratypes in Zoology Museum, Aligarh Muslim University, Aligarh, India; two paratypes at Crops Research Branch, USDA, Beltsville, Maryland, USA.

RELATIONSHIP: *A. asacculum* n. sp. comes close to *A. amalgans* Thorne, 1939 and *A. indicum* Siddiqi, 1964 from both of which it differs in the absence of the anterior uterine branch. From *A. amplicolle* Cobb, 1920; *A. bulbosum* Williams, 1958 and *A. nitidum* Jairajpuri, 1964 it can easily be differentiated by its smaller body size, continuous lip region, and the absence of an anterior uterine branch.

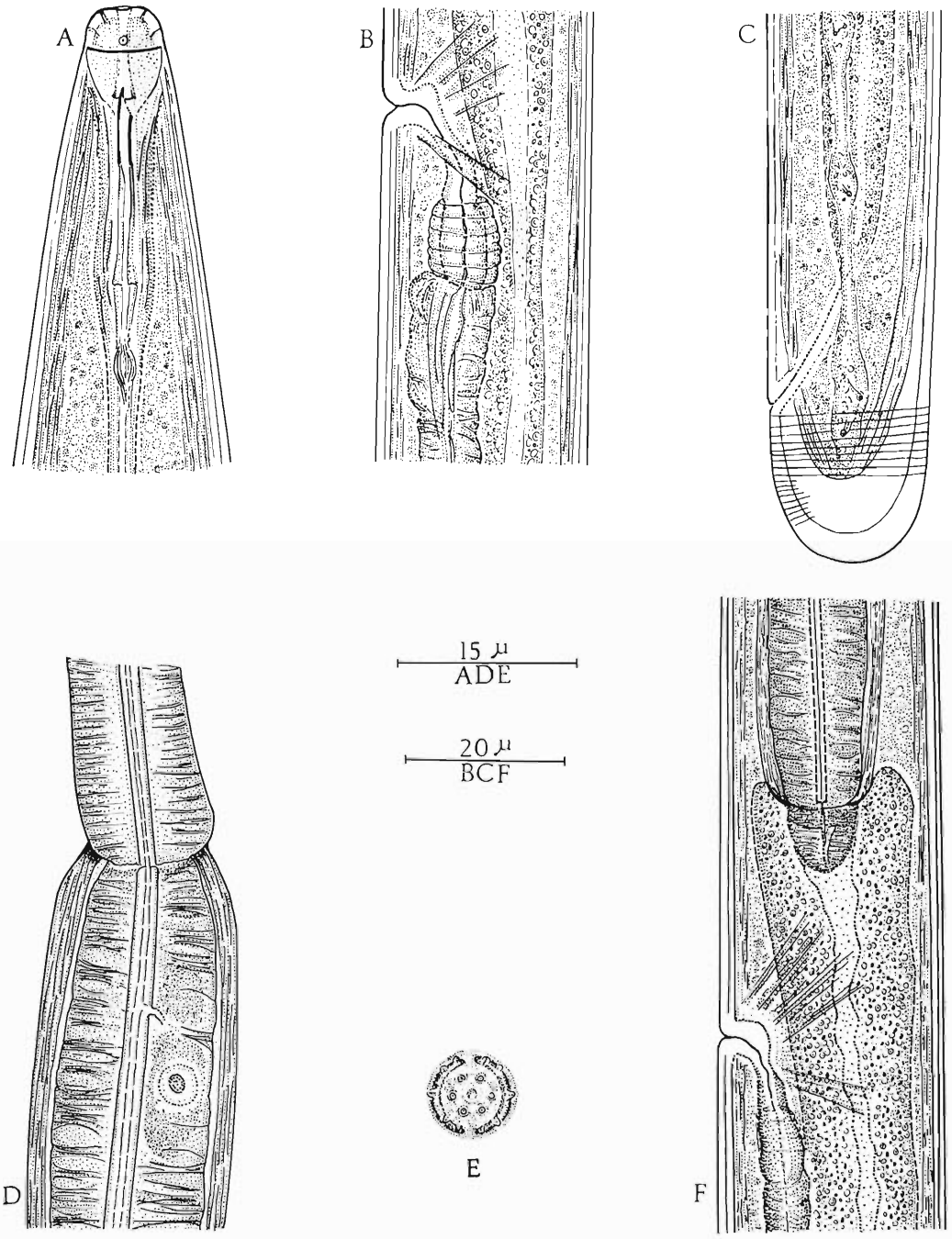


Figure 1, A–F. ***Axonchium asacculum*** **n. sp. A. Head end of female. B. A portion of female reproductive organs. C. Tail end of female. D. Junction of two parts of esophagus. E. *En face* view of female. F. Vulva near esophageal base in immature female.**

Belondira murtazai n. sp.* (Fig. 2, A–D)

Measurements

FEMALES (12) (Paratypes): L = 0.85–1.06 mm; a = 40–50; b = 4.3–4.9; c = 50–55; V = 36–38.

MALES (12) (Paratypes): L = 0.75–0.99 mm; a = 43–50; b = 4.3–5.1; c = 47–55; T = 33–48; spicules = 19–22 μ.

FEMALE (Holotype): L = 0.98 mm; a = 43; b = 4.9; c = 54; V = $^{6}37^{14}$.

DESCRIPTION: Female: Body slightly arcuate ventrally, tail end clavate. Inner layer of cuticle distinctly striated; striae fine. Spear 3–4 μ long, aperture one-third its length; extension in two parts, 12–16 μ long. Esophagus enlarging just behind its middle. Vagina straight, leading two-fifths to halfway into body. Anterior uterine sac 2⅓ to 3 times body width. Prerectum 2½ to 3 times body width. Tail rounded, about one anal body width long; its inner mass convex-conoid, about 10 μ long.

MALE: Spicules robust, ventrally bent near middle; copulatory muscles strongly developed. First supplementary, ventro-median papilla 42–47 μ from anus and the second 51–60 μ from the first. Body with a sharp depression behind anus.

TYPE MATERIAL: Holotype and two pairs of paratypes (2 ♂, 2 ♀) at Nematology Department, Rothamsted Experimental Station, Harpenden, England; two pairs of paratypes (2♂, 2♀) distributed to each of the following centers: Commonwealth Bureau of Helminthology, St. Albans, England; Plantenziektenkundige Dienst, Wageningen, The Netherlands; Department of Zoology, Aligarh Muslim University, Aligarh, India; and USDA, Beltsville, Maryland, USA.

RELATIONSHIP: *B. murtazai* n. sp. is very closely related to *B. nepalensis* Siddiqi, 1964 from which it differs in having a clavate tail end, straight and shorter vagina (vagina open S-shaped, more than half body width long in *B. nepalensis*), longer anterior uterine sac and a little more posterior vulva. Also its males have shorter and differently shaped spicules.

* Named after Mr. Murtaza Ali Quadri, Lecturer, S.N.I. College, Pilibhit, U.P., India who arranged and supplied this collection.

Belondira nepalensis Siddiqi, 1964 (Fig. 2, E–H)

Male and female specimens of *Belondira nepalensis* Siddiqi, 1964 were found in these samples. Measurements and diagrams of these are provided here and compared with those of the holotype. Males of this species are being reported for the first time.

Measurements

FEMALES (4): L = 0.83–0.95 mm; a = 36–43; b = 4.7–5.1; c = 44–54; V = 32–35; spear = 3–4 μ; anterior uterine sac = 1½–1⅔ body width.

MALES (3): L = 0.84–0.92 mm; a = 43–55; b = 4.2–4.7; c = 49–52; T = 40–46; spicules = 30–32 μ.

FEMALE (Holotype, after Siddiqi, 1964): L = 0.89 mm; a = 42; b = 5.1; c = 56; V = 33.6; spear = 3 μ (spear length was misprinted as 7 μ in the original description).

MALE: Body slightly arcuate ventrally in posterior half. Cuticle and subcuticle marked by transverse striae which are more prominent towards extremities. Testes dorylaimoid, with few spermatocytes. Spicules slender, ventrally arcuate but not sharply bent, poorly cephalated. Supplementary papillae consist of a preanal pair and two ventromedians: the first located 42–60 μ from anus and the second 50–60 μ from the first. Tail bluntly rounded, equal to or a little longer than anal body width; its inner layer of cuticle is more thickened than the outer.

Dorylaimellus belondirelloides n. sp. (Fig. 2, I–K)

Measurements

FEMALE (Holotype): L = 0.76 mm; a = 40; b = 4; c = 23; V = $^{6}47.5^{6}$.

FEMALE (Paratype): L = 0.73 mm; a = 37; b = 4.5; c = 21; V = 48.

JUVENILE (I): L = 0.44 mm; a = 27; b = 3.4; c = 18; (II): L = 0.53 mm; a = 33; b = 3.1; c = 18.

DESCRIPTION: Female: Body slightly arcuate ventrally. Cuticle with faint transverse striae; hypodermis coarsely striated; lateral hypodermal chords one-fourth body width. Lip region rounded, slightly offset, with raised papillae; inner papillae forming six-lobed, nonrefractive disc; pharyngeal sclerotization around

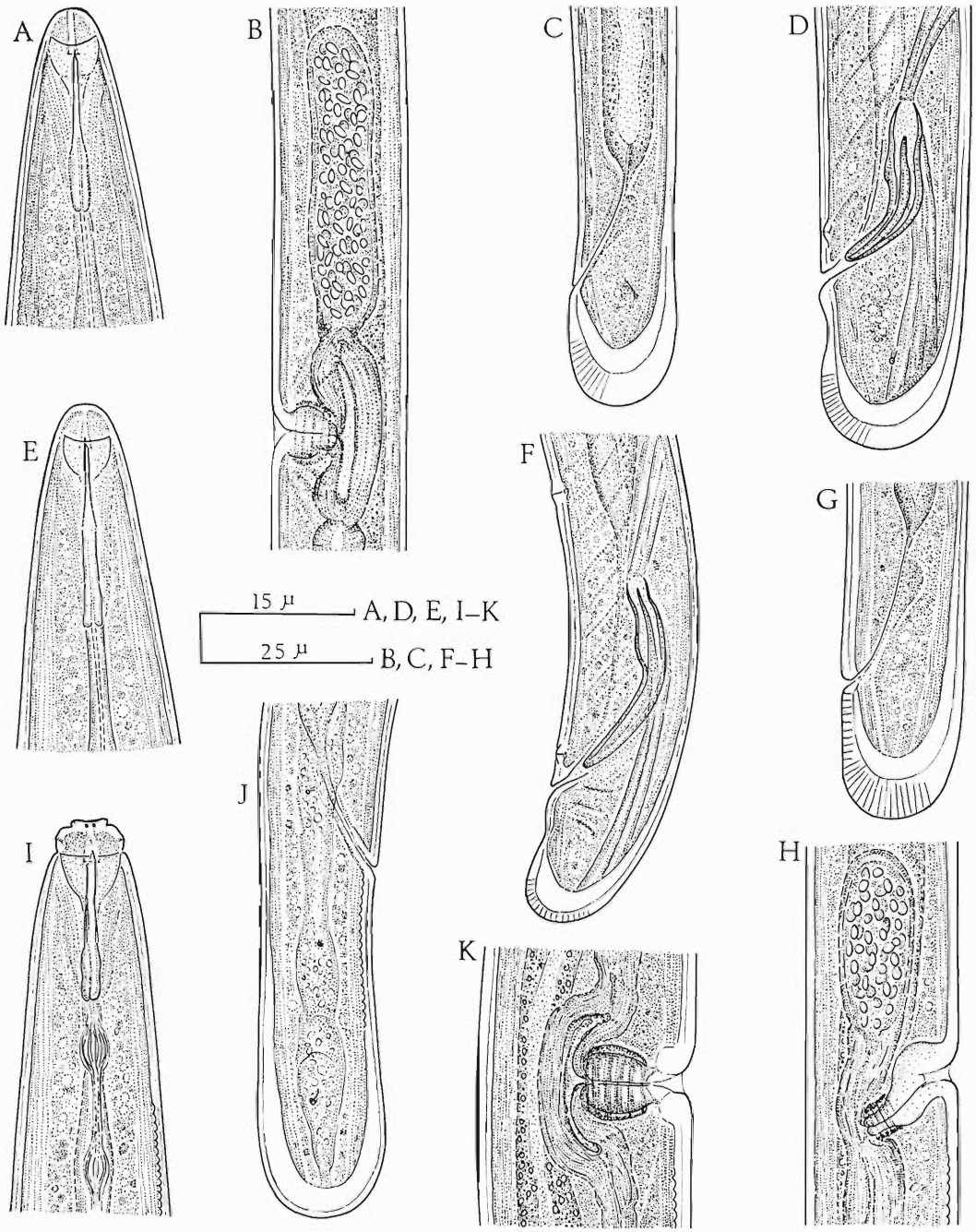


Figure 2, A–D. ***Belondira murtazai*** **n. sp. A. Head end of female. B. Vulval region. C. Tail end of female. D. Tail end of male. E–H.** ***B. nepalensis*** **Siddiqi, 1964. E. Head end of female. F. Tail end of male. G. Tail end of female. H. Vulval region. I–K.** ***Dorylaimellus belondirelloides*** **n. sp. I. Head end of female. J. Tail end of female. K. Vulval region.**

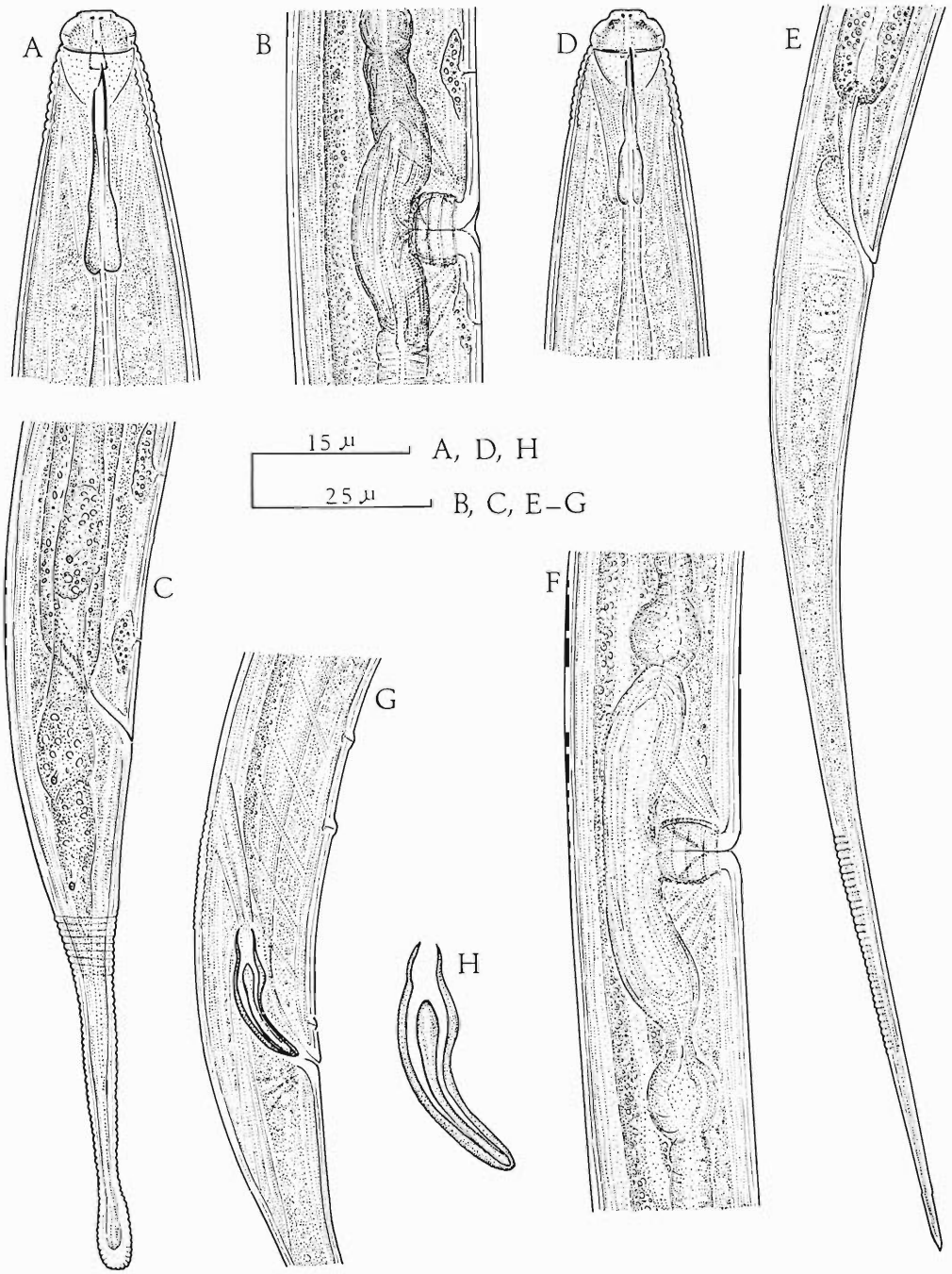


Figure 3, A–C. ***Dorylaimellus paraclavatus*** **n. sp. A. Head end of female. B. Vulval region. C. Tail end of female. D–H.** ***D. salvus*** **n. sp. D. Head end of female. E. Tail end of female. F. Vulval region. G. Spicular region. H. Spicule.**

mouth easily seen. Spear 5–6 μ long, aperture a quarter of its length; extension poorly flanged. Amphidial pouches large. Esophageal enlargement muscular, 46 per cent of neck length; esophago-intestinal valve large, heart-shaped. Nerve ring 67 μ from anterior end; hemizonid near its anterior edge. Ovaries paired, short. Prerectum 115 μ long; rectum a little longer than anal body width. Tail cylindroid-subclavate, thrice anal body width long; cuticle at terminus thickened. Male not found.

TYPE MATERIAL: Holotype at the Nematology Department, Rothamsted Experimental Station, Harpenden, England; rest at Commonwealth Bureau of Helminthology, St. Albans, England.

RELATIONSHIP: *D. belondirelloides* n. sp. differs from *D. caffrae* Kruger, 1965 and *D. projectus* Heyns, 1962 in having a more anteriorly located vulva and longer prerectum and tail.

Dorylaimellus paraclavatus n. sp. (Fig. 3, A–C)

Measurements

FEMALE (Holotype): L = 1.1 mm; a = 40; b = 4.5; c = 15; V = ^{6}48^{6}.

FEMALES (2) (Paratypes): L = 1.02–1.10 mm; a = 37–38; b = 4.3; c = 15; V = 47–49.

JUVENILE (I): L = 0.8 mm; a = 36; b = 3.6; c = 14.

DESCRIPTION: Female: Body slightly arcuate ventrally. Cuticle and subcuticle coarsely striated; striae more prominent over extremities. On one side, about 10 lateral body pores in neck region, 9 in esophagus-vulva and 17 in vulva-anus region, and 2 on tail. A ventral series of prominent body pores including 9 in region of esophagus, 10 in esophagus-vulva, and 18 in vulva-anus region. Lip region rounded, offset; papillae prominent. Amphid pouches almost as wide as body at that region. Spear well developed, with wide lumen and aperture about one-third its length, 7 μ long; extension well developed, twice its length. Hemizonid opposite nerve ring, which lies 70 μ from anterior end. Esophago-intestinal valve rounded. Posterior 53–56 per cent of esophagus enlarged. Esophagus-vulva distance 115 per cent of neck length. Vagina extending one-third into body. Ovaries short, symmetrical. Prerectum about four body widths long; rectum shorter than anal body width. Tail dorsally convex-conoid at first, then elongate-clavate, 4.3 times anal body width long (tail end in paratype female less clavate than that in holotype as depicted in Fig. 3, C).

JUVENILE: Cuticle and subcuticle distinctly striated. Spear 6 μ long; developing spear 7 μ long. Esophagus enlarged at 53 per cent of its length. Tail as in female but less clavate.

TYPE MATERIAL: Holotype at Nematology Department, Rothamsted Experimental Station, Harpenden, England; rest at Commonwealth Bureau of Helminthology, St. Albans, England.

RELATIONSHIP: In tail shape, *D. paraclavatus* n. sp. resembles *D. clavatus* Thorne, 1964, *D. nygellurus* Loof, 1964; *D. spicatus* Loof, 1964 and *D. virginianus* Cobb, 1913. *D. clavatus* and *D. spicatus* are smaller and have a smaller value for "b" ratio (3.2 or less), a postequatorial vulva and vulva-esophagus distance being 75 per cent or less of neck length. *D. nygellurus* is smaller, has a smaller spear extension, relatively longer tail and smooth cuticle. *D. virginianus* as redescribed by Thorne (1939), is larger and has a more posterior vulva and shorter tail.

Dorylaimellus salvus n. sp. (Fig. 3, D–H)

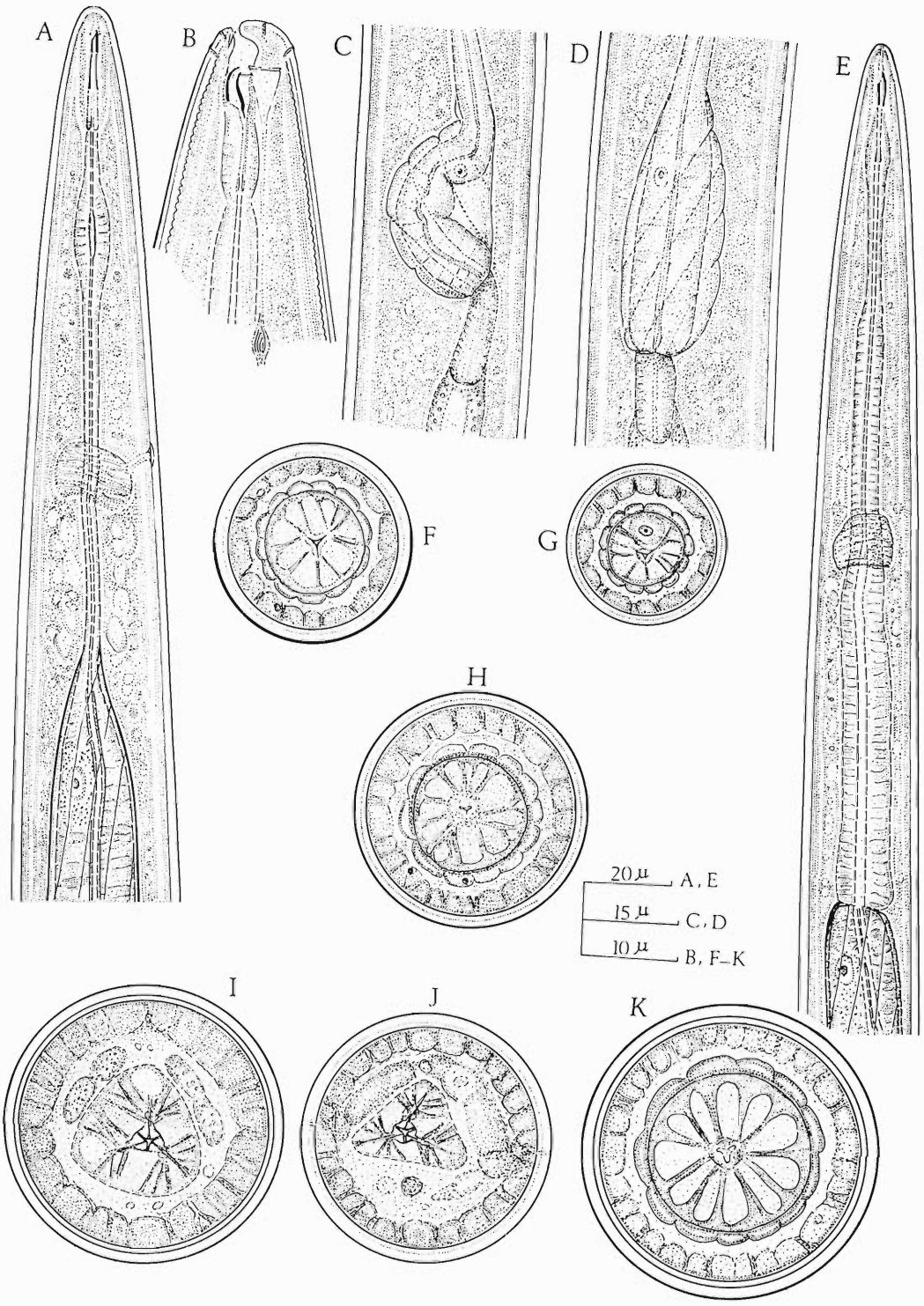
Measurements

FEMALES (3) (Paratypes): L = 1.17–1.23 mm; a = 47–53; b = 6.5–7.5; c = 8–10; V = 47–49.

MALES (3) (Paratypes): L = 1.10–1.17 mm; a = 46–51; b = 6.5–7.0; c = 8.5–9.5; T = 37–47.

FEMALE (Holotype): L = 1.23 mm; a = 53; b = 7.2; c = 9.2; V = ^{10}47.4^{8}.

DESCRIPTION: Female: Body slightly arcuate ventrally. Cuticle and subcuticle marked by distinct transverse striae. Lateral chords with prominent glandular bodies. Lip region rounded; inner margins forming a pseudolabial disc. Amphids large. Spear with narrow lumen, 5 μ long; extension 10–12 μ long, poorly flanged. Esophagus enlarging in its posterior third. Esophago-intestinal valve rounded. Vagina straight, extending halfway into body. Ovaries paired, symmetrical. Prerectum 5–6 times body width long; rectum a little longer



than anal body width. Tail elongate-conoid to a finely rounded terminus, 9–10 times anal body width long.

Male: Essentially similar to female. Spicules stout, 24–26 μ long. Besides a pair of submedian papillae near anus there are five ventro-median papillae spaced from anus at a distance of 29–44 μ, 46–50 μ, 73–80 μ, 92–99 μ, and 102–110 μ.

TYPE MATERIAL: Holotype and a pair of paratypes (1 ♂, 1 ♀) at Nematology Department, Rothamsted Experimental Station, Harpenden, England; a pair of paratypes (1♂, 1♀) at Commonwealth Bureau of Helminthology, St. Albans, England; a pair of paratypes (1♂, 1♀) at USDA, Beltsville, Maryland, USA.

RELATIONSHIP: In tail shape, *D. salvus* resembles *D. dorylaimoidurus* Siddiqi, 1966; *D. salimi* Siddiqi, 1966; *D. filicaudatus* Thorne, 1964; and *D. filiformis* Jairajpuri, 1964. The first two are smaller, have an attenuated spear, fewer supplementary papillae in male and spicules 17 μ long. The third has a longer esophagus and tail (b = 3, c = 5) and esophagus enlarged in its posterior two-thirds, and the fourth is smaller, has smooth cuticle and subcuticle, angular lip region devoid of labial disc and vulva at 43 per cent of body.

A revised classification of the Belondiroidea

The classification of the superfamily Belondiroidea (Thorne, 1939) Thorne, 1964 is mainly due to Thorne (1964). The major character of this superfamily is the presence of a conspicuous sheath of spiral muscles around the enlarged basal part of the esophagus. Clark (1961) was doubtful of the muscular nature of this sheath as he mentioned a "sheath of connective tissues" in diagnosing the family Belondiridae. Yeates (1967) considers that the muscular esophageal sheath of belondirids is "a fixation artifact" and regards Belondiridae and Nygellidae as synonymous with Dorylaimidae and Nygolaimidae respectively.

In certain species of *Discolaimus* and *Discolaimium* of the family Dorylaimidae the esophageal enlargement is covered with a thick sheath of connective tissue which, in *Discolaimus bicorticus*, is double-layered and appears thickened at three points in cross-section (Furstenberg and Heyns, 1966). However, such a sheath is not muscular and should not be confused with the muscular spiral sheath of the Belondiroidea. Yeates' (1967) conclusions are based mainly on his examination of *Dorylaimellus tahatikus* Yeates, 1967a, in which this sheath is not recognizable in living worms but a slight indication of it appears after fixation. I have examined the types of *D. tahatikus* and consider that this species belongs to *Tylencholaimus* of the family Dorylaimidae because of the shape and structure of its cuticle, head, spear, esophagus, and gonads. Accordingly I propose that it be redesignated as *Tylencholaimus tahatikus* (Yeates, 1967) n. comb.

Evidence for the muscular nature of the sheath around the esophageal enlargement of Belondiroidea seems to be limited to that of Hopper (1961), who reported six conspicuous spiral muscles capable of changing the length of the esophageal enlargement by their contraction or relaxation in *Swangeria bisexualis* Hopper, 1961. Likewise, in *Falcihasta palustris* Clark, 1964, I found six bands of strong muscles around the esophageal enlargement which, in most of the specimens examined, were apparently responsible for the dorsally bent condition of the esophageal enlargement (Fig. 4, c). I have also examined a number of transverse sections of the esophageal enlargement in *Belondira*, *Dorylaimellus*, and *Axonchium*, in all of which about 12 muscles were found surrounding the basal part of the esophagus (Fig. 4, F–H, K). These

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Figure 4. A–K. A. *Belondira neortha* Siddiqi: Anterior portion of esophagus (Belondirid type). B–D. *Falcihasta palustris* Clark: B. Head end of female, C, D. Basal region of esophagus. E. *Axonchium asacculum* n. sp.: Anterior portion of esophagus (Axonchiid type). F–K. T.S. through esophagus: F. *Belondira murtazai* n. sp.: Near middle of esophageal enlargement. G. *Dorylaimellus parvulus* Thorne: Through dorsal esophageal gland. H. *Axonchium asacculum* n. sp.: Near middle of esophageal enlargement. I–K. *Axonchium nitidum* Jairajpuri: I. Near base of anterior part of esophagus. J. Just behind nerve ring. K. Near middle of esophageal enlargement.

muscles are similar to somatic muscles in consistency. With this evidence at hand and the fact that the group is also recognizable by other subsidiary characters, I recognize Belondiroidea as proposed by Thorne (1964) and differ from Yeates (1967) who considers Belondiridae and Nygellidae as junior synonyms of Dorylaimidae and Nygolaimidae respectively.

Thorne (1964) recognized the following families under Belondiroidea: Belondiridae Thorne, 1939 (subfamilies Belondirinae Jairajpuri, 1964; Axonchiinae* Thorne, 1964); Oxydiridae** Thorne, 1964; Roqueidae Thorne, 1964; Dorylaimellidae (Jairajpuri, 1964) Thorne, 1964; Mydonomidae Thorne, 1964; Nygellidae Jairajpuri, 1964 (subfamilies Nygellinae Jairajpuri, 1964; Nygolaimellinae Clark, 1961). I feel that the proposal of Dorylaimellidae is unjustified, as the structure of the esophagus, buccal armature, and the number of muscles around the enlarged part of the esophagus are the same in *Belondira* and in *Dorylaimellus*. In many species of *Belondira*, for example *B. clavicaudata*, *B. bulbosa*, *B. nepalensis*, the spear extension, like that in *Dorylaimellus*, is divisible into two parts, the basal part bearing flanged swellings. The other feature, the presence of three or four sclerotized platelets around the vestibule, is sometimes hard to detect and in *D. parvulus* these pieces are hardly discernible even when viewed *en face*.

The esophagus in *Axonchium* (Fig. 4, E) is so different from that in Belondiridae (Fig. 4, A) that the subfamily Axonchiinae is here given a familial status, necessitating the suppression of Belondirinae and the redefinition of Belondiridae. A new family, Falcihastidae, is proposed to contain *Falcihasta* Clark, 1964, which has an asymmetrical head, mural spear, and six spiral esophageal muscles.

Jairajpuri (1964) proposed the family Nygellidae in which he included Nygellinae Jairajpuri, 1964 and Nygolaimellinae Clark, 1961. According to Article 36 of the International Code of Zoological Nomenclature, Nygellidae would be invalid as the family-group name, since Nygolaimellinae was already available. Nygolaimellinae is here raised to family rank as Nygolaimellidae (Clark, 1961) n. rank. Moreover, since the bibulbar appearance of the esophagus in *Nygolaimellus abnormis* Loos, 1949 is considered less important because another species, *N. capitivitatus* Andrássy, 1962, has almost a normal esophageal enlargement, Nygellidae Jairajpuri, 1964, as well as Nygellinae Jairajpuri, 1964, are here suppressed as synonyms of Nygolaimellidae.

Family Belondiridae Thorne, 1939
Syn. Belondirinae Jairajpuri, 1964
Belondirinae de Coninck, 1965
Dorylaimellinae Jairajpuri, 1964
Dorylaimellidae (Jairajpuri, 1964) Thorne, 1964
Dorylaimellinae de Coninck, 1965
Opailaimidae Kirjanova, 1951

DIAGNOSIS: Belondiroidea: Spear usually small with narrow lumen; spear extension appearing in two parts. Esophagus with a spindle-shaped swelling often with visible radial musculature following spear extension, becoming extremely thin and nonmuscular as it passes through the nerve ring, gradually enlarging into a cylindrical bulb enveloped by narrow bands of spiral muscles, about twelve in number. Esophago-intestinal valve simple, conoid rounded. Intestine two to four cells in circumference. Spicules well developed; supplements few.

TYPE GENUS: *Belondira* Thorne, 1939.

OTHER GENERA: *Belondirella* Thorne, 1964
Dorylaimellus Cobb, 1913
Yunqueus Thorne, 1964
Bullaenema Sauer, 1968
Axonchoides Thorne, 1967.

Family Axonchiidae (Thorne, 1964) n. rank
Syn. Axonchiinae Thorne, 1964

DIAGNOSIS: Belondiroidea. Moderately long (1 to 5 mm). Lateral chords narrow. Spear asymmetrical, rather spindle-shaped, axial, with wide lumen. Anterior part of esophagus narrower towards cephalic end, comparatively wider posteriorly with distinct radial musculature and lumen, offset from the posterior enlarged part by a constriction or a short isthmus; enlarged part usually greatly developed, enveloped by about 12 bands of spiral muscles. Dorsal esophageal gland large, with

* Original spellings of Axonchinae and Swangerinae amended as Axonchiinae and Swangeriinae respectively.

** Thorne's (1964) citation of this family as Oxydiridae (Jairajpuri, 1964) n. rank is an error, as this family-group name was not proposed by Jairajpuri (1964) or any other worker before Thorne (1964).

prominent nucleus near beginning of esophageal enlargement. Esophago-intestinal valve usually elongate-conical. Spicules with internal stiffening piece; spicular guiding pieces present; supplements numerous.

TYPE GENUS: *Axonchium* Cobb, 1920.

No other genus.

This family is at once recognized by the anterior part of the esophagus being very muscular and offset from the posterior part (Fig. 4, E). The genus *Axonchoides* Thorne, 1967, which is somewhat similar to *Axonchium*, has a belondirid type of esophagus and thus belongs to Belondiridae.

Family Swangeriidae (Jairajpuri, 1964) n. rank
Syn. Swangeriinae Jairajpuri, 1964

DIAGNOSIS: Belondiroidea. Medium-sized (1–2 mm), with slender body. Vestibule moderately wide and thick-walled in type genus. Spear symmetrical, elongate, axial. Esophagus slender with poor musculature, extending back to spindle-shaped, muscular, basal enlargement which is enveloped by six spiral muscles. Esophago-intestinal valve large, elongate-cylindrical, with intestine attached to its posterior end in fixed specimens. Ovaries paired. Males with large, slender spicules with lateral guiding pieces. No gubernaculum. Supplements few, widely spaced. Tail elongate, filiform in both sexes.

TYPE GENUS: *Swangeria* Thorne, 1939.

OTHER GENUS: *Qudsiella* Jairajpuri, 1967.

This family is recognized by the structure of the esophagus, esophago-intestinal valve and few supplements in the male. From Falcihastidae n. fam. it differs, besides the structure of the esophagus, in having a symmetrical lip region and axial spear.

Family Falcihastidae n. fam.

DIAGNOSIS: Belondiroidea. Medium-sized (1–2 mm). Few body pores. Lip region asymmetrical, lower ventrally than dorsally. Pharynx broad, not sclerotized, carrying an asymmetrical spear on its subventral sector. Esophagus in three almost equal parts as in Mydonomidae, basal part not marked off by a constriction, enveloped by six bands of muscles. Esoghago-intestinal valve large, cylindrical. Sensillar sacs of amphids rather far behind. Tails filiform in both sexes. Large spicules, with lateral guiding pieces. No gubernaculum. Supplements few.

TYPE GENUS: *Falcihasta* Clark, 1964.

No other genus.

Falcihastidae has a subventrally located mural spear as in Nygolaimellidae (Clark, 1961) n. rank but differs from this family in the form of the head, spear and pharynx and the absence of three esophago-intestinal glands.

Family Nygolaimellidae (Clark, 1961) n. rank
Syn. Nygolaimellinae Clark, 1961
Nygellidae Jairajpuri, 1964
Nygellinae Jairajpuri, 1964

DIAGNOSIS: Belondiroidea. Pharynx wide, long and tapering posteriorly, evertible; spear located on its left subventral sector. Esophagus narrow, gradually enlarging to a well-developed cylindrical portion which may appear bibulbar due to disintegration of tissue in midregion. Esophago-intestinal valve small, with three glandular organs. Tail bluntly rounded.

TYPE GENUS: *Nygolaimellus* Loos, 1949.

OTHER GENUS: *Nygellus* Thorne, 1939.

An outline classification of the Belondiroidea

- Belondiroidea
  - Belondiridae
    - *Belondira* Thorne, 1939
    - *Belondirella* Thorne, 1964
    - *Dorylaimellus* Cobb, 1913
    - *Yunqueus* Thorne, 1964
    - *Bullaenema* Sauer, 1968
    - *Axonchoides* Thorne, 1967
  - Axonchiidae — *Axonchium* Cobb, 1920
  - Mydonomidae — *Mydonomus* Thorne, 1964
  - Roqueidae — *Roqueus* Thorne, 1964
  - Oxydiridae — *Oxydirus* Thorne, 1939
  - Swangeriidae
    - *Swangeria* Thorne, 1939
    - *Qudsiella* Jairajpuri, 1967
  - Falcihastidae — *Falcihasta* Clark, 1964
  - Nygolaimellidae
    - *Nygolaimellus* Loos, 1949
    - *Nygellus* Thorne, 1939

Summary

Fifteen species of Belondiroidea have been reported from soil around roots of various plants in Sibsagar, India. New species described are: *Axonchium asacculum, Belondira murtazai, Dorylaimellus belondirelloides, D. paraclavatus,* and *D. salvus.* Males of *B. nepalensis* Siddiqi are also described.

Comments are made on the spiral muscular sheath around the esophageal enlargement of Belondiroidea disapproving of Yeates' (1967) action in regarding it a fixation artifact. *Dorylaimellus tahatikus* Yeates, 1967, on which Yeates based his discussion in suppressing Belondiridae is redesignated as *Tylencholaimus tahatikus* (Yeates, 1967) n. comb. *Falcihasta palustris* Clark has been shown to possess six spiral muscles around esophageal enlargement which are apparently responsible for the dorsally bent condition of the latter in many fixed specimens. Transverse sections of the esophageal enlargement in *Belondira*, *Dorylaimellus* and *Axonchium* show 12 muscles around it, similar in consistency to the somatic muscles.

Following families have been recognized under Belondiroidea: Belondiridae Thorne, 1939; Axonchiidae (Thorne, 1964) n. rank; Mydonomidae Thorne, 1964; Roqueidae Thorne, 1964; Oxydiridae Thorne, 1964; Swangeriidae (Jairajpuri, 1964) n. rank; Falcihastidae n. fam. and Nygolaimellidae (Clark, 1961) n. rank. Belondirinae Jairajpuri, 1964; Belondirinae de Coninck, 1965; Dorylaimellinae Jairajpuri, 1964; Dorylaimellinae de Coninck, 1965, and Dorylaimellidae (Jairajpuri, 1964) Thorne, 1964, have been synonymised with Belondiridae. Swangeriinae Jairajpuri, 1964, and Axonchiinae have been given family rank and described. Falcihastidae n. fam. has mural, asymmetrical spear; esophagus in three almost equal parts and large, cylindrical esophago-intestinal valve. Nygellidae Jairajpuri, 1964, is regarded as invalid owing to the availability of coordinate name Nygolaimellinae Clark, 1961, which is raised to the rank of a family and the former as well as Nygellinae Jairajpuri, 1964, have been put down as synonyms of the latter.

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Studies on the Freshwater Cercariae of Northern Colorado

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Introduction

Cercariae emerging from their molluscan hosts, serve as a clue to the digenetic trematode fauna of a region. More often than not, a cercaria and its corresponding adult are described and named separately and independently. It is not until the link between them is connected by life history studies that the identity of the former is recognized.

Very little previous work has been done on the cercariae of Colorado. The earliest significant work is that of Hurst (1923), who described *Cercaria gunnisoni* as a new species of xiphidiocercaria from *Lymnaea stagnalis appressa* Say and *L. proxima* Lea. He stated that the former host harbored three different species of cercariae simultaneously. Of the three, he described only *C. gunnisoni*. *Lymnaea* Lamarck, *Physa* Draparnaud, and *Planorbis* Guettard were abundantly represented in his area of study, and cercariae were found in all of them; he stated, "I am confident that many of these cercariae are undescribed species." Another significant work is that of Crawford (1939, 1940, 1943), who conducted studies on the life cycle of Colorado trematodes at Rocky Mountain Biological Laboratory, Gothic, Gunnison County, Colorado. The only other report on cercariae in Colorado is that of Hunter and Birkenholz (1961), who worked on the larval trematodes of Gunnison County. They found a high incidence of cercariae distributed in six major groups, with the echinostome type being predominent.

The present study was undertaken in order to add to the meager knowledge on the larval trematodes of Colorado and gain an insight into the digenetic trematode fauna of this state.

Materials and Methods

Mollusks were collected between the springs of 1962–1964 from rivers, lakes, creeks, ponds, and irrigation canals which abound in northern Colorado.

In the laboratory, water from the location where each snail collection was made was strained through four layers of cheesecloth to filter out larger particles of debris. Widemouth 50 cc bottles were filled to the three-quarter level with this water. About 5 to 10 snails of the same species were put into each bottle and the mouth was covered with a double-folded cheesecloth held in position by a rubber band to prevent the snails from crawling out. The bottles were placed in the part of the laboratory best lighted and allowed to stand for a maximum of 14 days. Snails which died during this period were crushed and examined for infection. The water in the bottles was checked daily for cercariae by viewing the contents against a light source and changed every other day. The snails in a bottle showing cercariae were isolated into individual bottles to determine which were infected and to provide a source of cercariae for morphological studies and information on emergence rate. At the end of 14 days, snails which had not shed any cercariae were crushed, examined for infection, and the incidence of infection tabulated. Some shed cercariae were transferred to a stender dish to study the swimming habits, tropisms, and longevity (Holliman, 1961). Unless otherwise stated, descriptions are based on shed cercariae.

For microscopic study, live cercariae were transferred in a drop of water to a glass slide and a No. 1 coverslip placed over it. Different kinds of media used by various investigators were tried, especially those said to facilitate the visibility of flame cells, such as intravitam stains combined with normal saline (Lundahl, 1941) and Amphibian Ringer's solution (Hall, 1959). With echinostome cercariae, collar spines were studied by the method of Abdel-Malek (1952). The genital anlage was best studied from stained specimens. Cercariae were studied alive, both unstained and stained with intravitam dyes of neutral red and nile blue sulfate, which proved very helpful in determining the number of penetration glands. Details of penetration glands and the excretory system were obtained

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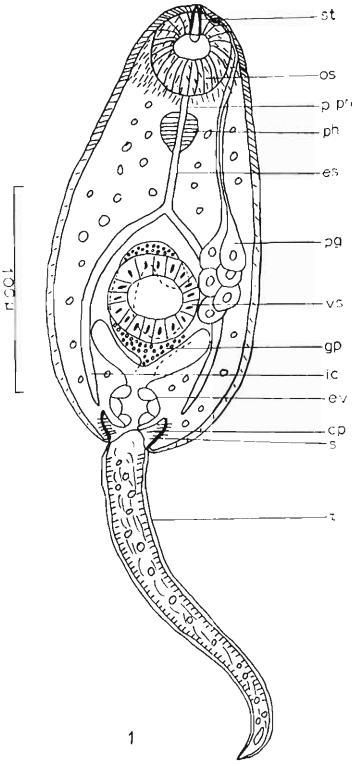

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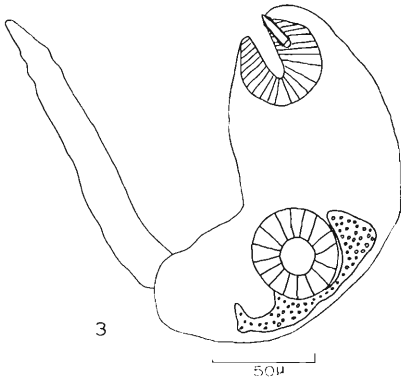

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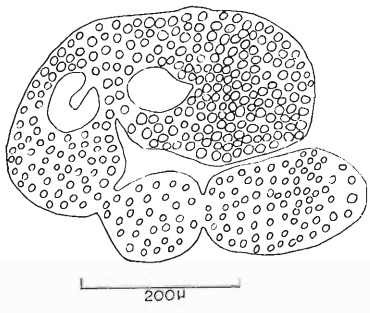

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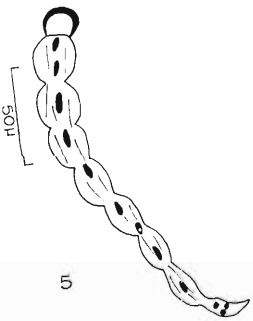

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by quickly compressing living cercariae with a coverslip (Burns, 1961). Cercarial reaction to intravitam dyes was sometimes checked by the method used by Holliman (1961).

Coverslip pressure was controlled by the addition of water to its edge or by absorption of water from under it with blotting paper. The evaporation of mounting solution was prevented (or controlled) by sealing the margins of the coverslip with vaseline.

Different methods were used to slow down the activity of living cercariae under a coverslip for study. The use of intravitam stains produced some effect. Coverslip pressure was helpful as well as the application of a drop of chloretone solution at the concentration of 1 to 10 parts of water. Cercariae were fixed by adding 10% formalin of equal volume to the water in a stender dish containing cercariae, a method similar to that used by Talbot (1936) and Holliman (1961). Sporocysts and rediae were fixed in the same manner.

For toto mounts, preserved materials were stained with either Mayer's acid carmine or Harris' alum haematoxylin. Fast green was sometimes used as a counter stain, and proved to be especially good for sporocysts and rediae.

All the drawings of cercariae were made to scale from preserved material with the aid of a projection prism. Measurements, in microns, of preserved material, unless otherwise specified, represent the average for five to ten well-extended or fairly well-extended specimens. The minima and maxima are recorded in the descriptions, with the average being in parentheses. Cercariae obtained from crushed snails were identified only to the major groups to which they belong, and were designated with letters for the ease of differentiation.

Results

A total of 2,189 mollusks was examined over the 2-year period. Of these, 150 were pelecypods (*Pisidium* Pfeiffer), and the remainder gastropods. None of the pelecypods were infected. A total of 778 snails, representing 37.2% of the 2,039 examined, were infected with larval trematodes; 116, or 14.9% of the infected snails, shed cercariae which were identified.

The mollusks were infected with four major groups of cercariae, viz., echinostome, furocercous, monostome, and xiphidiocercaria (see Table I), including apparently 26 species. Nine species were studied in detail, with four described as new.

An examination of the data on molluscan infection with larval trematodes studied in this survey brings out some interesting aspects of this work. Of all the cercarial species studied, that of *Notocotylus urbanensis* (Cort, 1914) appeared to be distributed more widely than the others in terms of locality. Table II shows the percentage of cercarial infections for each host species from northern Colorado.

Description of new species and statements concerning identified ones

A. Xiphidiocercaria

1. *Cercaria alganeshi* n. sp. (Plate I, Figs. 1–5)

Diagnosis

Belongs to Armatae group of Xiphidiocercaria. Body 198–231 (209) long, 67–110 (87) wide at level immediately preacetabular. Tail 168–209 (185) long, 19–24 (22) wide at base. Oral sucker 43–48 (47) in diameter; mouth subterminal; pharynx 14–17 (16) in diameter; esophagus longer than prepharynx, bi-

←

Abbreviations for all figures: bp, birth pore; cg, cystogenous gland; cp, caudal pocket; cs, collar spine; e sp, eyespot; es, esophagus; ev, excretory vesicle; fc, flame cell; g, gut; gd, gland duct; gp, genital primordium or genital anlage; ic, intestinal cecum; la, locomotor appendage; os, oral sucker; p ph, prepharynx; pg, penetration gland; ph, pharynx; s, spine; st, stylet; t, tail; vs, ventral sucker or acetabulum.

Explanation of Plate I

Figures 1–5. 1. *Cercaria alganeshi* n. sp. Ventral view showing body and tail structures. 2. Stylet of same, ventral view. 3. Side view of cercaria showing position of genital anlage and stylet. 4. Sporocyst. 5. Tail of cercaria shed under coverslip pressure showing crenate appearance and rounded mass at its base.

Table 1. List of cercariae studied.

	Cercarial type	Host	Locality
I.	*Echinostome*		
	1. *C. coloradensis* n. sp.	*Physa gyrina*	Ft. Collins
	2. *C. denverensis* n. sp.	*Physa integra*	Denver
	3. Echinostome cercaria A	*Physa gyrina*	Bellvue
	4. " " B	*Psysa* sp.	1 mi S of Bellvue
	5. " " C	*Psysa* sp.	Ft. Collins
	6. " " D	*Psysa* sp.	Ft. Collins
	7. " " E	*Psysa* sp.	Ft. Collins
	8. " " F	*Psysa* sp.	Buckhorn Mt.
	9. *C. olseni* n. sp.	*Lymnaea palustris*	Chambers Lake area, 42 mi W of Ft. Collins
II.	*Furcocercous*		
	1. *C.* of *Cotylurus flabelliformis*	*Lymnaea auricularia*	Dixon Lake, near Ft. Collins
	2. Furcocercous cercaria A	*Physa* sp.	Ft. Collins
	longifurcous pharyngeate monostome	*Gyraulus* sp.	Ft. Collins
III.	*Monostome*		
	1. *C.* of *Notocotylus stagnicolae*	*Lymnaea auricularia*	Dixon Lake, near Ft. Collins
	2. *C.* of *N. urbanensis*	*Physa gyrina*	Ft. Collins, Laporte
	3. Monostome cercaria A	*Physa gyrina*	Ft. Collins
IV.	*Xiphidiocercaria*		
	1. *C. alganeshi* n. sp.	*Physa gyrina*	Ft. Collins
	2. *C.* of *Plagiorchis micracanthos*	*Physa gyrina*	Laporte
	3. *C.* of *P. vespertilionis parochis*	*Lymnaea auricularia*	Dixon Lake, near Ft. Collins
	4. Xiphidiocercaria A	*Physa gyrina*	Bellvue
	5. " B	*Helisoma trivolvis*	Dixon Lake, near Ft. Collins
	6. " C	*Helisoma trivolvis*	Dixon Dam, near Ft. Collins
	7. " D	*Lymnaea palustris*	Ft. Collins
	8. " E	*Physa* sp.	Ft. Collins
	9. " F	*Stagnicola caperata*	Ft. Collins
	10. " G	*Physa gyrina*	Ft. Collins
	11. " H	*Stagnicola caperata*	Greeley
	12. " I	*Lymnaea palustris*	Chambers Lake area, 42 mi W of Ft. Collins

furcates about midway between pharynx and acetabulum; ceca extending almost to posterior end of body. Stylet (Fig. 2) elongate, sharply pointed and wider at base; 22 long and 5 wide; with basal bulb. Acetabulum 41–48 (46) in diameter, subequatorial in position. Tegument with minute spines concentrated anteriorly and sparse at posterior part of body, tail smooth. Penetration glands six pairs; located anterolateral to acetabulum. Excretory bladder consists of cornua located close to posterior margin of ventral sucker and posterior circular vesicle composed of a single layer of large cells. With alternate filling and emptying of anterior arms (cornua) and posterior vesicle, excretory bladder sometimes assumes Y-shape. Excretory tubules and flame cells obscured by numerous cystogenous glands. Body with scattered refractile concretions. Spines present in caudal pocket. Tail inserted in caudal pocket; circular muscles more prominent than in body, giving it striated appearance; filled with 30–35 small central cells; when shed (in specimens under coverslip pressure) a rounded mass seen at base (see Plate I, Fig. 5). Genital rudiment represented by large mass of small cells extending from anterior to posterior level of acetabulum presenting G-like appearance. Development in sporocysts bearing constrictions; sporocysts 627–814 (759) long, 176–220 (194) wide, containing one or two immature embryos, suggestive that cercariae emerge while yet immature and complete development in digestive gland of snail host.

HOST: *Physa gyrina* Say.

INCIDENCE OF INFECTION: One of 45 snails shed cercariae.

LOCALITY: Pond at tree dump, Fort Collins, Larimer County, Colorado.

Table 2. Percentage of cercarial infection for each species of molluscan host.

Host	Collected	Infected with any larval form		Positive with cercaria	
		Number	Percentage	Number	Percentage
Gyraulus sp.	26	6	23.1	4	15.4
Helisoma trivolvis	94	4	4.26	3	3.9
Lymnaea auricularia	668	595	89.1	28	4.18
Lymnaea palustris	60	8	13.3	5	8.33
Lymnaea sp.	46	0	0	0	0
Physa gyrina	546	99	18.1	48	8.80
Physa integra	46	9	19.6	3	6.52
Physa sp.	453	34	7.51	12	2.65
Pisidium sp.	150	0	0	0	0
Stagnicola caperata	100	23	23.0	13	12.0
Total	2,189	778	35.5%	116	14.9%

Cercariae emerge from their snail host a few at a time, during the morning hours up to noon. Their longevity is about 10 hours. Neutral red stain is mildly toxic, while nile blue sulfate is toxic, killing the cercariae in short time. The cercariae swim with the body flexed ventrally and the tail lashing in a figure-eight motion. They swim intermittently, alternating this with creeping on the substrate. Swimming is mostly vertical. From the substrate, they swim up until they reach the top of the water in the container. Here they stop wriggling and start sinking to the bottom of the container with the body half flexed and the tail bent forward over it. The rate of sinking may be slow or comparatively fast. The tail is longer than the body when swimming but is contracted to about half the length of the body when creeping. When subjected to coverslip pressure, the body contracts, the anterior region becoming much wider with a consequent reduction of the posterior region and the tail.

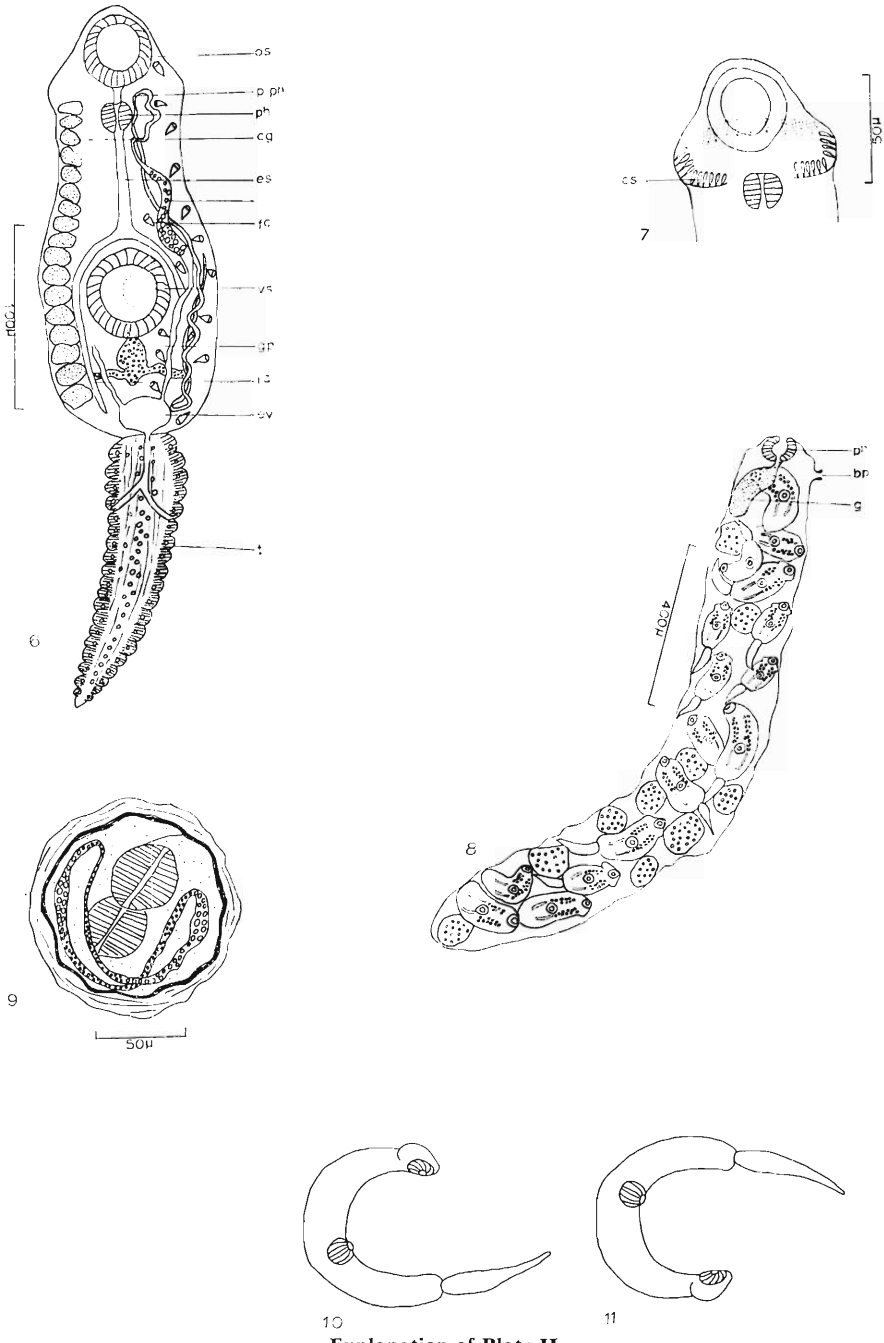
C. alganeshi resembles *C. goodmani* Najarian, 1952, the cercaria of *Telorchis robustus* Krull, 1936, and *C. concavocorpa* Sizemore, 1936. It resembles *C. goodmani* by the nature and operation of the excretory bladder and possession of caudal pocket spines. *C. goodmani* can be distinguished from *C. alganeshi* by its stylet which is devoid of a basal bulb, its short intestinal ceca, possession of eight pairs of penetration glands and tegumental spines which cover the entire body and tail. *C. alganeshi* appears to be closely related to the cercaria of *T. robustus* in the two having stylets wider at the base and with a basal bulb (mucilagenous plug), caudal pocket with spines, and intestinal ceca extending to almost the posterior end of the body. Cercaria of *T. robustus* differs from *C. alganeshi* by its possession of nine penetration glands (four on one side and five on the other), less pronounced genital anlage, and shorter esophagus bifurcating farther preacetabular. *C. alganeshi* is similar to *C. concavocorpa* with respect to the decaudation process of specimens under coverslip pressure, leaving the base of the tail with an accumulation of a rounded mass of tissue (Fig. 5) and the presence of a basal bulb on the stylet. The presence of eight pairs of penetration glands in *C. concavocorpa*, intestinal ceca extending almost to the level of posterior part of acetabulum, and spines covering the body and anterior half of the tail serve to separate it from *C. alganeshi*.

2. Cercaria of *Plagiorchis micracanthos* McMullen, 1937

Five of 20 *Physa gyrina* Say, collected from a pond opposite Laporte Lions Park, Laporte, were parasitized by xiphidiocercariae identified as those of *Plagiorchis micracanthos*. The general features of body and dimensions as reported by McMullen (1937) agree so closely with mine that I do not hesitate considering the two identical. This is a new host and new locality record.

3. Cercaria of *Plagiorchis vespertilionis* parorchis Macy, 1960

This species was found infecting one of 131 *Lymnaea auricularia* (L.) collected from Dixon Lake, near Fort Collins, The specimen agrees



Explanation of Plate II

Figures 6–11. 6. *Cercaria denverensis* n. sp. Ventral view showing details of body and tail, 7. Cephalic region from ventral view showing collar spines. 8. Redia. 9. Metacercaria. 10. Lateral view showing occasional posture on substrate. 11. Lateral view showing a different posture on substrate.

with the description given by Macy (1960). A new host and new locality record is established for this cercaria.

B. Echinostome cercaria

1. *Cercaria denverensis* n. sp. (Plate II, Figs. 6–11)

Diagnosis

Body 187–253 (238) long, 83–110 (98) wide at level of acetabulum; collar 62–84 (73) with about 34 spines in single row; tail 130–220 (155) long, 43–46 (44) wide at base. Oral sucker 35–41 (37) in diameter, mouth subterminal, prepharynx 10–12 (11) long, pharynx 14–22 (18) long, esophagus 14–22 (16) long, bifurcating just preacetabular, ceca extending to near posterior margin of body. Acetabulum 43–58 (46) in diameter, with small superficial and spherical concretions. Body devoid of spines; with row of about 17 large and conspicuous cystogenous glands extending along each lateral margin from pharynx to posterior end of body, those located posteriorly being larger; smaller glands fill enclosed area in random arrangement. Tail devoid of spines; crenate along margin; with numerous nuclei of parenchyma, visible in stained material. Cercariae decaudate readily. Excretory bladder small, and oval; from its anterior part two primary collecting tubules extend in wavy manner to posterolateral margins of acetabulum enlarge and undergo three or four undulations, then taper as they extend to the level of prepharynx where each makes an almost deltoid loop, passing under itself and descending to the level of excretory vesicle as the secondary tubule, loops again passing under itself as the tertiary duct and is seen as far anterior as level of ventral sucker. Primary collecting tubules filled with concretions, extending from ventral sucker anteriorly to the midlevel of esophagus. Tuft of cilia in the secondary tubule from level of anterior part of acetabulum to excretory vesicle, beat rapidly in living specimens flattened under coverslip pressure. Excretory tubule in tail forks at about posterior part of first fourth of length of tail into branches which open laterally to outside. About 16 flame cells observed on each side of body. Reproductive primordium consists of two irregular anterior and posterior masses of cells connected by thin strand of cells. The posterior mass shows vitelline duct rudiment. Development in colorless rediae (Fig. 8), spotted with yellowish-brown pigment, latter less numerous in anterior one-fifth. Redia 682–1,650 (1,265) long, 132–264 (205) wide; with only posterior locomotor appendages which tend to be less pronounced in mature redia. Appendages located at about three-fifths distance from anterior end. Pharynx 41–62 (48) long, 41–53 (45) wide, leading to short gut. Birth pore lateral and just posterior to collar. Tegument thin. Usually 14–16 cercariae in mature redia.

Metacercaria (Fig. 9) found in the same snail as cercariae. Some cercariae encysted in vials containing snails. Cysts spherical, 101–113 (109) in diameter, with thick, irregular outer layer and thin inner membrane. Metacercaria has more concretions in primary excretory tubules than cercaria, primary tubules arranged in a loop and crossing each other.

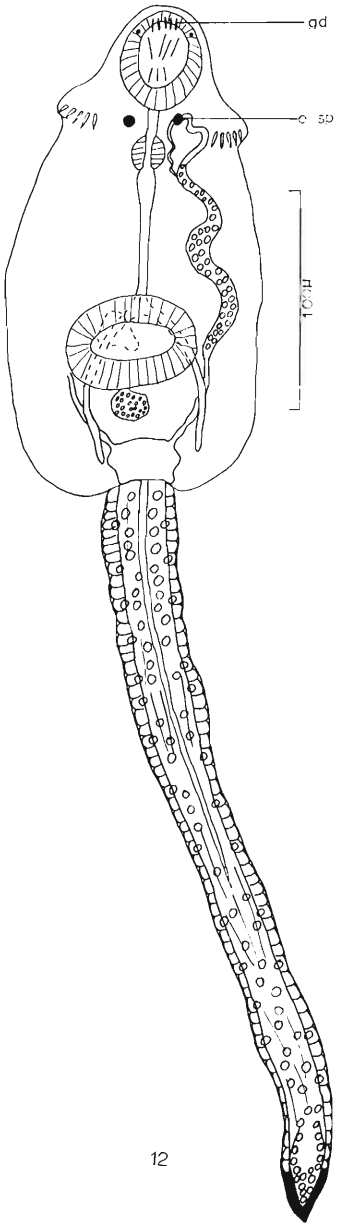
HOST: *Physa integra* Hald.

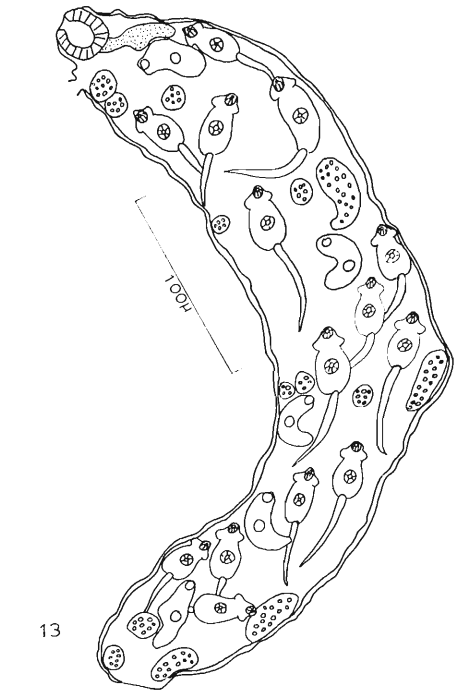
INCIDENCE OF INFECTION: One of 46 snails shed cercariae.

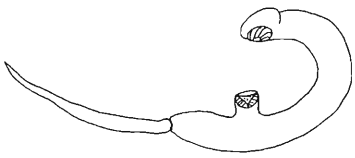
LOCALITY: Cherry Creek, Denver, Colorado.

This larva emerges from its snail host during the daytime, between 9:00 AM and 4:00 PM. Only a few are shed at a time. The life span of the cercaria is about 12–14 hours if encystment does not occur. No phototropism was observed. Neutral red stain used for the study of live cercariae was mildly toxic. The cercaria is not an active swimmer. Swimming is accomplished by the vigorous wriggling of the tail with the body flexed. However, it mostly stays at the bottom of the container with the anterior part bent up or down, but most commonly up (Figs. 10 and 11). In either of these positions, movement is from side to side accompanied by a slight wriggling of the tail. An attempt to infect leghorn chicks with metacercariae was unsuccessful.

Cercaria denverensis bears some resemblance to the cercaria of *Echinoparyphium flexum* as described by Najarian (1954) with respect to its digestive system, genital anlage, and excretory system. These two species, however, differ in the following respects: *C. denverensis* is smaller in size; it has 34 collar spines, while cercariae of *E. flexum* have 45; the flame cells are 32 (16 in each side), but 40 for the cercariae of *E. flexum*; the bifurcation of the caudal excretory tubule is about one-fourth of the length of the tail from its







Explanation of Plate III

Figures 12–14. 12. *Cercaria coloradensis* n. sp. 13. Redia. 14. Lateral view of cercaria showing occasional posture on substrate.

base, but one-eighth for the cercariae of *E. flexum*; it is devoid of tegumental spines which are present in the cercariae of *E. flexum*. The arrangement of cystogenous glands in conspicuous lateral row on each side is not mentioned for cercariae of *E. flexum*.

2. *Cercaria coloradensis* n. sp. (Plate III, Figs. 12–14)

Diagnosis

Body 242–286 (257) long, 88–138 (108) wide at level of acetabulum. Tail 297–385 (341) long, 26–36 (32) wide; mouth subterminal; prepharynx 7–17 (12) long; pharynx 14–19 (16) long, 11–14 (12) wide; esophagus bifurcating just below anterior margin of acetabulum; ceca end near posterior margin of body. Acetabulum 43–60 (50) long, 46–65 (52) wide; located just posterior to midbody. Body and tail devoid of tegumental spines. Collar 74–84 (78) wide with spines of undetermined number obscured by numerous cystogenous glands. Seven gland ducts observed dorsal to oral sucker; two spherical ducts laterally located, five elongate ducts medially located (Fig. 12). Excretory vesicle bulbous; from anterior part two primary collecting tubules extend in wavy form to lateral margins of acetabulum, dilate and undergo three or four undulations, then taper as they extend to level of prepharynx, here each forms an almost triangular anastomosis; rest of tubule obscured by cystogenous glands; primary collecting tubules filled with numerous concretions which extend from ventral sucker to level of pharynx. No bifurcation of caudal excretory tubule observed. Two eyespots lateral to prepharynx. Tail with numerous nuclei of parenchyma (seen in stained material), especially crowded in posterior tip. Genital primordium represented by two unconnected anterior and posterior masses of small cells. Development in fairly large rediae, measure 935–1,925 (1,247) long, 209–352 (271) wide just above posterior locomotor appendage. Pharynx 38–86 (54) in diameter. Birth pore lateral, just posterior to short collar; tegument comparatively thick; locomotor appendages not very prominent in either young or mature rediae; gut short. About 16–20 cercariae in various stages of development.

HOST: *Physa gyrina* Say.

INCIDENCE OF INFECTION: Ten of 47 snails shed cercariae.

LOCALITY: Pond on highway No. 14 in Fort Collins, Larimer County, 1 mile NE of Colorado State University.

Cercariae are shed during the day. Their swimming habit is characteristic of echinostome cercariae, being with body flexed and tail expanded and lashing vigorously. The cercaria folds over itself intermittently with the ventral sucker protruding like a short tube (Fig. 14) after creeping for a while on the substrate. Neutral red is mildly toxic.

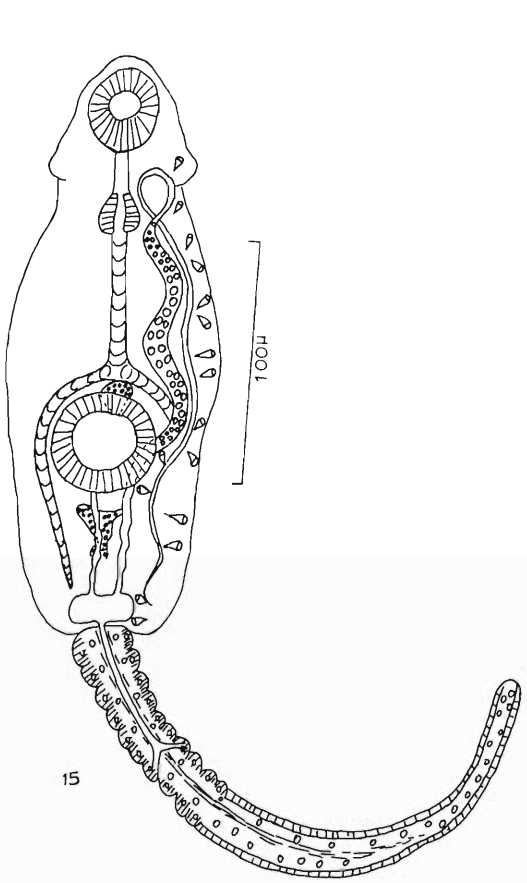
Cercaria coloradensis is similar to *C. rebstocki* McCoy, 1929, in some respects. While the esophagus of *C. coloradensis* bifurcates just posterior to the anterior margin of the acetabulum that of *C. rebstocki* bifurcates anterior to the acetabulum. It has a total of seven gland ducts, while *C. rebstocki* has eight. By possessing two eyespots which *C. rebstocki* lacks, *C. coloradensis* resembles a marine cercaria, *C. fuscata* Holliman, 1961.

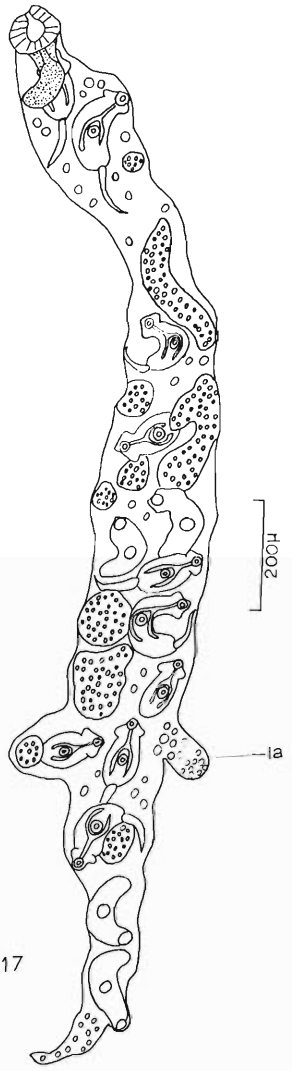
3. *Cercaria olseni* n. sp. (Plate IV, Figs. 15–17)

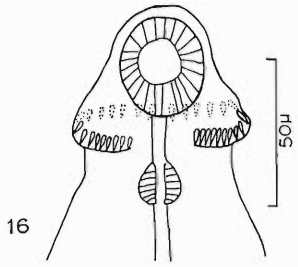
This species is named after Dr. O. Wilford Olsen, who helped in working out the flame cell pattern of this cercaria.

Diagnosis

Body 170–215 (189) long, 83–99 (90) wide at level just above acetabulum. Tail 187–242 (223) long, 19–22 (20) wide at base. Oral sucker 29–31 (30) long, 26–31 (29) wide; mouth subterminal; prepharynx 5–8 (6) long; esophagus long, bifurcating just preacetabular; ceca extending to level of excretory vesicle; esophagus and ceca filled with single row of spherical bodies with posterior part of each overlapping anterior part of adjacent one. Acetabulum 35–43 (39) long, 36–43 (40) wide; located subequatorial. Body and tail devoid of spines. Collar 53–60 (58) wide, with about 32–36 spines in single row (Fig. 16). Excretory vesicle comparatively small, oval. From anterior part of vesicle two primary collecting tubules extend to level of prepharynx in wavy manner; here each makes circular loop and continues posteriorly as secondary tubules; latter obscured by cystogenous glands filling body; from acetabular level each primary duct increases in diameter and under-







Explanation of Plate IV

Figures 15–17. 15. *Cercaria olseni* n. sp. Ventral view showing details of body and tail structures (cystogenous glands omitted). 16. Cephalic region of same, ventral view showing collar spines. 17. Redia.

goes three or four undulations, then tapers to level of prepharynx. Primary tubule with spherical concretions extending from the ventral sucker to level of pharynx. Caudal excretory duct bifurcates at about one-fourth length of tail into branches opening laterally to outside. About 16 flame cells observed on each side of body. Tail crenate at anterior two-fifths; stained specimen with numerous nuclei in parenchyma. Genital primordium represented by a mass of small cells lying posterior to acetabulum and a smaller mass lying anterodorsal and close to the latter. Development in elongate redia with prominent posterior locomotor appendages seen in both young and mature specimens. Redia (Fig. 17), 1,760–2,354 (2,110) long, 154–209 (183) wide at level just above locomotor appendages. Birth pore not observed; tegument thin. Fourteen to 18 embryos per mature redia in various stages of development.

HOST: *Lymnaea palustris* (Müll.).

INCIDENCE OF INFECTION: One of three snails shed cercariae.

LOCALITY: Pond near Chambers Lake, 42 miles west of Fort Collins, Larimer County, Colorado.

Neutral red was mildly toxic to cercariae. The swimming habit is characteristic of echinostome cercariae, being with body flexed and tail extended to about two times body length and lashing vigorously in a figure-eight motion. This tail movement helps to propel the cercaria rapidly. Attempts to infect leghorn chicks with metacercariae were unsuccessful.

Cercaria olseni is similar in some respects to *Cercaria equispinosa* Brown, 1926, and *C. indicae* XXIII Sewell, 1922, but differs from them by its smaller size, arrangement of collar spines, number of flame cells, genital rudiment and bifurcation of the caudal excretory duct. The digestive and excretory systems of *C. olseni* and *C. equispinosa* have striking resemblances. The genital anlage of *C. olseni* is dissimilar to that of *C. equispinosa*, being represented by only a mass of cells postacetabularly. While the number of flame cells in *C. olseni* is about 16 pairs, they are said to be several (4) on each side of the posterior region of the body of *C. equispinosa*. *C. indicae* XXIII differs from *C. olseni* by possession of a double ring of collar spines, 18 pairs of flame cells, bifurcation of the tail excretory duct at about one-fifth of the length of the tail from the base.

Discussion

At the initial stage of this investigation snail collections were maintained in 50 cc widemouth bottles filled three-quarters full with tap water and closed with regular bottle covers. The frequently observed outcome of this method was the death of all the snails within 2 or 3 days. Later, the writer adopted a method which involved putting the snails in filtered water, obtained from the respective bodies of water where collections were made and covering the bottles with cheesecloth. This was found very advantageous. It increased to a considerable extent the longevity of the snails. Many uninfected and slightly infected snails lived up to the set limit of 14 days, after which they were crushed for examination. Some snails which shed cercariae lived up to 5 or 6 days. This better result could be attributed to the following reasons: (1) Water, filtered with cheesecloth in order to remove large particles of debris, still contains some plankton and food particles on which the snails may feed. (2) By maintaining snails in the water from which they are collected, they are left in a condition close to their natural habitat. (3) This water, usually with dissolved salts (e.g. calcium carbonate) which the snails require for shell construction, is more propitious than tap water for their maintenance. (4) Covering the bottles with cheesecloth not only prevents the snails from crawling out, but allows more aeration than the regular bottle covers, thus increasing the dissolved oxygen content of the water which may be a limiting factor for most snails; some snail species require a high concentration of dissolved oxygen. (5) Changing of the water every other day prevents "souring" which is often caused by the defecation of the snails. It is thus advisable for investigations of this nature to maintain the snails in the water from which they are collected and change it regularly.

Of the nine species of shed cercariae studied in detail, four are described as new ones, augmenting the list of United States cercariae awaiting life history study. The similarities and differences of these species to their most closely related forms are given. Although

three of the new species are echinostomes and the other a xiphidiocercaria, the overall result of the study indicates that xiphidiocercariae are more abundant than those of the other groups represented here. This observation is not in agreement with that of Hunter and Birkenholz (1961), who reported a greater abundance of echinostome cercariae. The difference (3) in the number of species of xiphidiocercaria and echinostome cercariae is, however, too small to be considered very significant.

The percentage of infection (35.5%) indicated in Table II apparently shows that the trematode fauna in northern Colorado is rather meager, as might be expected in a region of limited precipitation (Gittings 1941). Table II shows the interesting fact that the snail *Lymnaea auricularia* (L.) had the highest percentage of infection (89.1%). It is a European species previously introduced into the eastern part of the United States and now found in Colorado.

A considerable decrease in larval trematode infection of snails was noted during the late fall and winter seasons. Some of the snails collected during these periods were infected with larval annelids (Oligochaeta). Such snails had no larval trematode infections. Snails, especially *Lymnaea auricularia* (L), harbored mostly the metacercarial stage during the winter. However, from the latter part of March to the summer months there was a significant increase in the other larval stages in the snails. This observation is in agreement with that of Faust (1922) and Ulmer (1957) with respect to *Tetracotyle flabelliformis* (Faust, 1917).

The inadvisability of crushing infected snails to obtain larval trematodes for study has been emphasized by various investigators. Stunkard (1930) said: "When infected snails are crushed, the larval trematodes are freed, but the cercariae are usually immature and frequently differ, even in morphological features, from those which emerge normally. Many published descriptions of cercariae are based on the study of such immature specimens, and consequently the observations, although accurate for that stage of development are misleading." Dunagan (1960) also pointed out that "the very common practice of cracking snails to obtain and study different stages of the parasite has undoubtedly led to the description of cercariae that would look much different if they had been allowed to emerge naturally." While the practice of describing cercariae obtained from crushed snails is discouraged, it is advisable to crack and examine for infection, snails which did not shed cercariae instead of discarding them, as is commonly done by some investigators. This has the advantage of giving an insight into the trematode fauna of the locality or region being surveyed. Moreover, there have been reported cases of precocious development of metacercariae inside the sporocyst or redia without the cercarial stage emerging from the snail (Stunkard, 1934; Ingles, 1935; Cort and Brackett, 1937; McMullen, 1937, 1938; and Acholonu, 1965). Cases of this nature will escape the notice of an investigator who discards snails that did not shed cercariae. It is advisable, therefore, to crush and examine such snails.

Summary

Cercariae falling into four main groups and 26 apparent species, including four undescribed species, were collected; nine species were shed by the snail hosts; the remainder were obtained from crushed snails, and were identified only to major group. They include *Cercaria denverensis* n. sp. from *Physa integra* Hald., *C. coloradensis* n. sp. from *P. gyrina* Say, and *C. olseni* n. sp. from *Lymnaea palustris* (Müll.) of the echinostome group; cercaria of *Cotylurus flabelliformis* (Faust, 1917) from *L. auricularia* (L.) and one unidentified species of the furcocercous group; cercaria of *Notocotylus stagnicolae* Herber, 1942, from *L. auricularia* (L.) and cercaria of *N. urbanensis* (Cort, 1914) from *P. gyrina* Say of the monostome group; cercaria of *Plagiorchis micracanthos* McMullen, 1937, from *L. auricularia* (L.), *C. alganeshi* n. sp. from *P. gyrina* Say and eight unidentified species of the xiphidiocercaria group, the most prevalent.

The 2,189 mollusks collected represent six recoznized species and several identified only to genus; 35.5% were infected with larval trematodes of one stage or another; 14.9% of the infected snails contained cercariae.

Acknowledgments

A dissertation submitted to the Graduate School, Colorado State University, in partial

fulfillment of the requirements for the degree of Doctor of Philosophy.

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MINUTES

Four Hundred Twenty-ninth Through Four Hundred Thirty-sixth Meetings

429th Meeting: Adult Education Center, University of Maryland, College Park, Maryland, 11 October 1967. Presentation of Helminthological Society Anniversary Award to Dr. Gerard Dikmans (*in absentia*). Announcement of Eighth International Congress of Tropical Medicine to be held in September 1968. Slate of officers for 1968 presented: D. R. Lincicome (President), A. C. Pipkin (Vice-President), E. J. L. Soulsby (Recording Secretary) and E. M. Buhrer (Corresponding Secretary-Treasurer). Papers presented: "The filaria, *Macacanema formosana* of the Taiwan monkey, *Macaca cyclopis*," by J. F. Bergner; "Morphological variation in the rat nematode, *Nippostrongylus brasiliensis*," by R. Lichtenfels "Effects of concurrent infections of *Nippostrongylus brasiliensis* and *Hymenolepis nana*," by J. Poiley; "Blood protozoan parasites of the redwing blackbird and the common grackle: A survey of two populations of Kent Island, Maryland," by R. G. Bagley; "Studies on the biology and life history of *Hepatozoon grisesciuri*, a haemogregarine of the gray squirrel," by B. Redington; "*Nippostrongylus brasiliensis* in castrates and normal male rats," by R. Salerno.

430th Meeting: Beltsville Parasitological Laboratory, Beltsville, Maryland, 17 November 1967. Letter of thanks from Dr. Dikmans read. Illness of senior member, Dr. J. R. Christie, announced. W. R. Nickle, J. H. Fischthal, and J. T. Lucker elected to Editorial Board. Slate of officers presented at 429th meeting elected by unanimous vote. Papers presented: "Continuous flow flotation process for separating oocysts from fecal debris," by J. M. Vetterling; "Host–parasite relations: Infection of cattle with *Oesophagostomum columbianum*, a parasite of sheep," by H. Herlich; "The development of a system of classification of the Nematoda," by M. Chitwood; "The esophago-intestinal sphincter of *Rictularia lucifigus* (Nematoda: Thelaziidae)," by F. Douvres; "Time-lapse photographs of equine Babesias," by W. M. Frerichs.

431st Meeting: Plant Industry Station, Beltsville, Maryland, 18 December 1967. Formalities of installation of new officers completed. Papers presented: "A nematode parasite of the face fly of cattle and horses," by W. R. Nickle; "Reproduction in *Diploscapter coronata*," by H. C. Hechler; "Plant growth regulators and resistance to root knot nematodes," by V. Dropkin; and a voluntary paper from the floor: "Metabolic differences in isolates of *T. lewisi* from different parts of the world," by D. R. Lincicome.

432nd Meeting: National Institutes of Health, Bethesda, Maryland, 19 January 1968. Papers presented: "Genetic aspects of the susceptibility of *Biomphalaria glabrata* to infection with *Schistosoma mansoni*," by D. S. Richards; "Activity of Lincomycin analogs against *Plasmodium cynomolgi* in Rhesus monkeys," by K. G. Powers; "Studies on antigens from axenically cultured *Entamoeba histolytica*," by M. N. Lunde and L. S. Diamond; "Studies on parasitic gastroenteritis of cattle in Germany," by J. Eckert and H. J. Bürger, "Infection of *Meriones unguiculatus*, *M. hurrianae*, *Mesocricetus auratus*, and *Cricetulus griseus* with *Dipetalonema witei*," by G. Pacheco.

433rd Meeting: Patuxent Wildlife Research Center, Laurel, Maryland, 9 February 1968. Report on the progress of the Program Committee of the Second International Congress of Parasitology given. Papers presented: "Mechanism of red cell destruction in *Leucocytozoon simondi* infections," by R. M. Kocan; "Breeding sites and collections of immature stages of black flies in Michigan (Diptera: Simuliidae)," by I. B. Tarshis; "Epizootiology of *Plasmodium circumflexum* in birds: Host and geographical distribution," by C. M. Herman and E. Snyder; "Comparative mitotic activity in two species of slime mold-like Ameboid Protozoa," by T. K. Sawyer.

434th Meeting: Naval Medical Research Institute, Bethesda, Maryland, 22 March 1968. The Auditors' report was read and approved.

Report on the progress of the organization of the Second International Congress of the World Federation of Parasitologists was given. Papers presented: "Oxygen uptake by *Trypanosoma lewisi* grown in young and old rats," by J. K. Adaramola; "Oxygen uptake by *Trypanosoma lewisi* grown in albino and black rats," by M. S. El Helu; "Electron-microscopic study of kinetoplastic DNA from *Trypanosoma cruzi*," by G. Riou; "A look at tropical medicine in Central America and Mexico," by B. Fried.

435th Meeting: Naval Medical Research Institute, Bethesda, Maryland, 17 April 1968. Summary of business executed by Executive Committee given to members. Papers presented: "Drug studies on the exoerythrocytic stages of malaria," by R. L. Beaudoin; "Experimental infections of malaria in a natural population of sparrows," by J. E. Applegate; "The sporogonous cycle of *P. vivax* as a system for evaluation of anti-malarial drugs," by L. A. Terzian; "Culture of *Trypanosoma rangeli* in an insect cell culture system," by A. C. Pipkin; "Histology of cercariae of *Schistosoma mansoni*: A demonstration," by M. A. Stirewalt.

436th Meeting: University of Pennsylania's New Bolton Center, Kennett Square, Pennsylvania, 25 May 1968. Papers presented: "The early histotropic stages of *Obeliscoides cuniculi* in the rabbit," by T. J. Hayes; "*Ascaris lumbricoides* in the unnatural host," by S. R. Sylk; "A parasitological fairy tale," by G. L. Graham; "Storage of *Ascaris* larvae at low temperatures," by D. Post; "The ultrastructure of cells reacting with antibody-sensitized *Ascaris* larvae," by D. J. Morseth; "Lymphocyte transformation in helminth infection," by E. J. L. Soulsby. Cocktails were served in Allam House, courtesy of the School of Veterinary Medicine, University of Pennsylvania, followed by dinner enjoyed by members and guests.

The following were elected to membership at the meetings indicated: *429th:* D. Gershon, C. L. Heagle, P. Krupa, F. Lamberti, D. H. MacDonald, R. D. Romanowski, K. S. Todd, F. G. Whittacker, G. W. Yeates. *430th:* J. C. Burke, B. L. Duncan, R. J. Gee, E. Panitz, D. Quigley. *433rd:* J. K. Adaramola, M. El Helu, J. Parris, D. K. Sen, W. B. Willers. *434th:* E. G. Bergquist, L. R. Crawley, S. Draggan, S. J. Edwards, B. Fried, J. S. Keithly, H. C. King, R. M. Kocan, C. M. Lee, R. D. McAnnally, W. E. Martin, E. O. Morrison, B. J. Muirhead, C. A. Porter. *435th:* K. Daib, G. Germani, H. H. Kreis, G. Merny, C. Netscher, G. A. Wells, D. Williams.

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