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PROCEEDINGS OF THE
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Histochemical Enzyme Studies on *Pharyngostomoides adenocephala* Beckerdite, Miller, and Harkema, 1971 (Trematoda: Diplostomatidae)

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ABSTRACT: *Pharyngostomoides adenocephala*, a trematode parasitic in the small intestine of the raccoon, was studied histochemically for carboxylic esterase, and acid and alkaline phosphatase activity. Fresh-frozen material or specimens prefixed in 10% neutral buffered formalin, Baker's calcium-formalin, or 5% glutaraldehyde, were sectioned at 10 μ in a cryostat. Carboxylic esterase substrates employed with appropriate inhibitors were: 5-bromoindoxyl acetate, alpha-naphthyl acetate, acetylthiocholine iodide, and butyrylthiocholine iodide. Acetylcholinesterases were localized in the oral sucker and associated subtegumentary cells, pseudosuckers and associated glands, pharynx, ceca, acetabulum, holdfast organ, subtegument, nerve tissue, genital papilla, and excretory pore. No pseudocholinesterase was found. Nonspecific esterases were demonstrated in the oral sucker and associated subtegumentary cells, pseudosuckers and associated glands, acetabulum, holdfast organ, epithelial covering of the testes, and the ovary. Sodium alpha-naphthyl acid phosphate was used to test for both phosphatases, Gomori's lead method for acid phosphatase, and calcium cobalt (Gomori) for alkaline phosphatase. Acid phosphatase was indicated in the cecal cells and cecal content, and in the holdfast organ. Alkaline phosphatase was demonstrated in the epithelial covering of the testes, and the ovary.

One of the current trends in parasitological studies is the use of histochemical techniques to localize enzymes which may play an important role in the general physiology, feeding habits, and mode of attachment of the parasite to the host tissue.

A few trematodes of the families Strigeidae, Cyathocotylidae, and Diplostomatidae have been studied histochemically for carboxylic esterase activity (Lee, 1962, 1966; Erasmus, 1967; Erasmus and Öhman, 1963; Öhman, 1964a, b, 1965, 1966a, b; Bogitsh, 1966a; Reid and Harkema, 1970). *Fasciola hepatica* Linnaeus, 1758, has been examined extensively for carboxylic esterase activity (Halton, 1963, 1967a; Panitz and Knapp, 1967; Pantelouris, 1967; Krvavica et al., 1967; Thorpe, 1967, 1968; Barry et al., 1968).

Halton (1967c) compared the localization of phosphatases in eight trematodes. Lee (1962), Erasmus and Öhman (1963), Öhman (1965, 1966a, b), Bogitsh (1966b), and Johnson et al. (1971) examined several strigeoid trematodes for acid and alkaline phosphatase. Bečejac and Krvavica (1964), Berry et al. (1968), and Thorpe (1968) demonstrated acid and/or alkaline phosphatase in *F. hepatica*.

This histochemical study on *Pharyngostomoides adenocephala*, a strigeoid trematode found in the small intestine of the raccoon, was undertaken to aid in the clarification of the metabolism of this parasite and further elucidate the host–parasite relationship.

Materials and Methods

Live trematodes were removed from the intestine of naturally infected raccoons. All specimens were briefly washed in Tyrode's solution. Some were fixed in 4% formaldehyde in 0.2 M phosphate buffer, pH 7.0, or 4% formaldehyde containing 1% anhydrous calcium

chloride, pH 7.0 (4 C) for 18 hr, and stored in a 1:1 mixture of glycerine and water (Humason, 1967) at 4 C. Others were fixed in 2.5% glutaraldehyde in 0.2 M phosphate buffer, pH 7.0 (4 C) for 6 hr, and stored in a 0.2 M phosphate-buffered sucrose solution, pH 7.0. Unfixed specimens were either stored immediately in the 1:1 glycerine–water mixture at –20 C, or were quenched with Freon 20 and then held at cryostat temperature (–30 C) for short periods of time. Intestine with trematodes *in situ* was removed from the host, cut into 4-mm square pieces, and fixed and stored using one of the above methods. All sectioning was done in an Ames Lab Tek Cryostat (–30 C) at 10 μ utilizing O. C. T. (Lab Tek) as the mounting matrix.

Sections were affixed to gelatin-chromate coated ("subbed") slides, and allowed to air-dry for 30 min. Sections of unfixed specimens were postfixed in formalin vapor for 3 min. All sections were mounted in glycerine-gelatin after treatment. Rat pancreas was used as a positive control for pseudocholinesterase activity and rat tongue was used as positive control for nonspecific esterase activity and acetylcholinesterase activity. Host intestine served as a positive control for alkaline phosphatase, while rat prostate satisfied this criterion for acid phosphatase. Negative control was accomplished by incubating without substrate.

Histochemical tests

In all tests, sections to be inhibited were preincubated in the buffer of choice (see below) containing the appropriate inhibitor at 37 C for 30 min, prior to incubation in substrate and inhibitor. Sections not inhibited were preincubated in buffer only, prior to incubation in substrate.

General carboxylic esterase activity was demonstrated using the substrates 5-bromoindoxyl acetate in 0.1 M Tris buffer (Holt and Withers, 1952) at 37 C for 3 hr, and alpha-naphthyl acetate in 0.1 M Tris buffer (Gomori, 1952) at 37 C for 10 min. Eserine sulfate (10^{-5} M), a cholinesterase inhibitor, and sodium fluoride (7.5×10^{-2} M), a nonspecific esterase inhibitor, were used with these two substrates.

Acetylcholinesterase activity was determined by incubating with acetylthiocholine iodide (Koelle and Friedenwald, 1949) at 37 C for 1 hr. Eserine sulfate (10^{-5} M) and 10^{-5} M isoOMPA (tetraisopropylpyrophosphoramide) (K & K Laboratories), a pseudocholinesterase inhibitor, were used with this substrate. Butyrylthiocholine iodide (Koelle and Friedenwald, 1949) was employed with isoOMPA as inhibitor, to demonstrate any pseudocholinesterase that might be present, but none was found.

Naphthol AS-D acetate (Burstone, 1957), a substrate for general carboxylic esterase determination, was found to be variable within a test, and from test to test. The effects of 62C-47 (courtesy of Burroughs Wellcome and Co., Inc.), an acetylcholinesterase inhibitor, was also found to be variable. Copper sulfate (10^{-5} M) did not differentiate between the types of nonspecific esterases, if these types were present in this worm.

Sodium alpha-naphthyl acid phosphate was one of the substrates used to demonstrate acid phosphatase (Veronal-acetate buffer, pH 5)

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Abbreviations: A, acetabulum; C, ceca and/or contents; EP, excretory pore; GP, glands associated with pseudosuckers; H, holdfast organ; HT, host tissue; N, nerve; O, ovary; OS, oral sucker; Ph, pharynx; Ps, pseudosucker; S, subtegument; T, testis.

Figures 1–7. 1. Frontal section of anterior forebody. Alpha-naphthyl acetate. ×375. 2. Frontal section of anterior forebody. Alpha-naphthyl acetate inhibited by eserine sulfate showing nonspecific esterase in the oral sucker. ×250. 3. Frontal section of anterior forebody. Alpha-naphthyl acetate. ×250. 4. Frontal section of anterior forebody. Alpha-naphthyl acetate inhibited by eserine sulfate showing nonspecific esterase in subtegument associated with the oral region. ×250. 5. Sagittal section through the holdfast organ and acetabulum. 5-bromoindoxyl acetate. ×250. 6. Transverse section through holdfast organ while attached to host tissue. 5-bromoindoxyl acetate. ×80. 7. Transverse section of middle forebody. Alpha-naphthyl acetate. ×250.

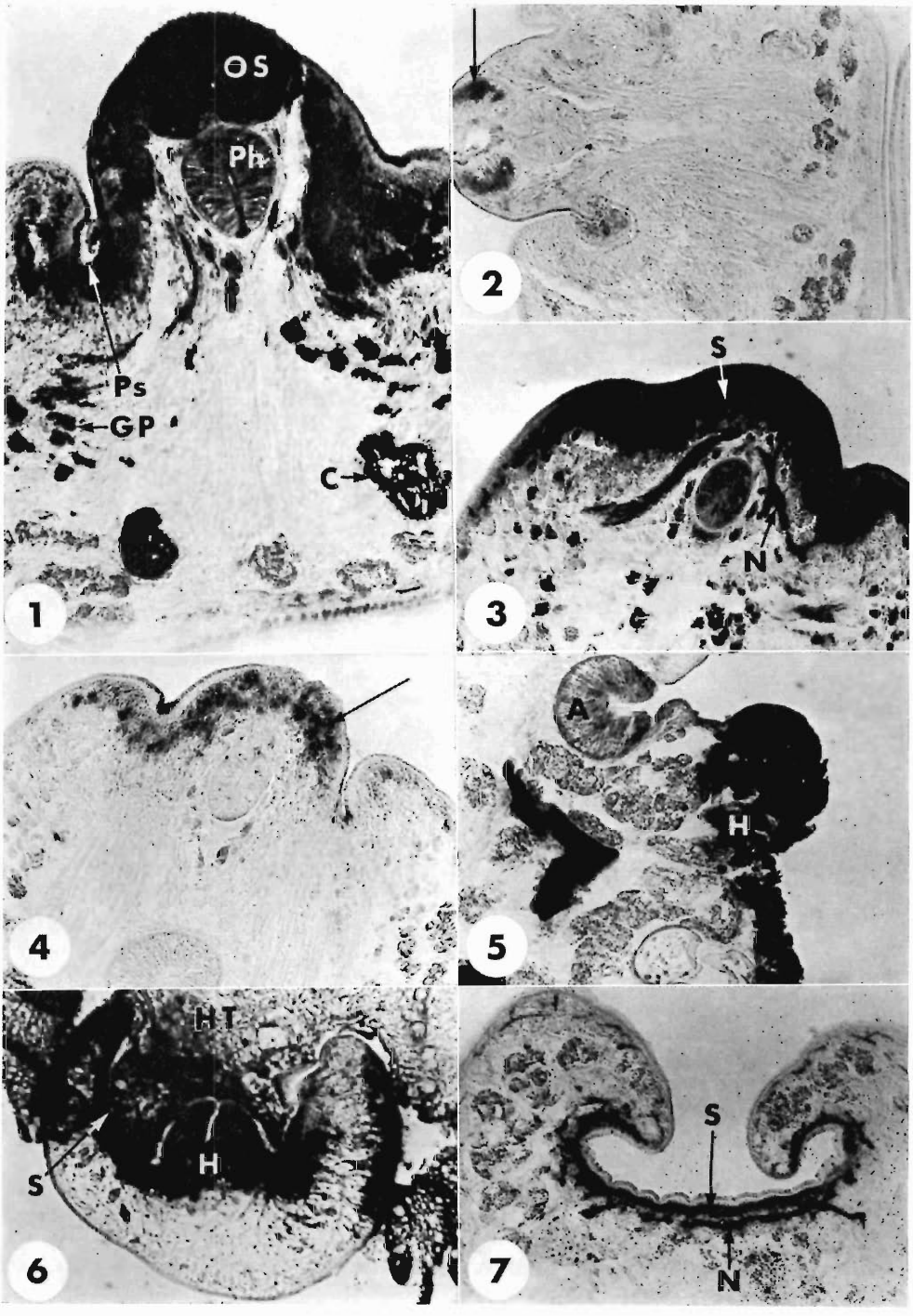

Table 1. Localization of esterases and phosphatases in *Pharyngostomoides adenocephala*.[1]

Tissue	Esterases		Phosphatases	
	AChE[2]	Simple	Acid	Alkaline
Oral sucker	3+	2+	0	0
Pseudosuckers and associated glands	3+	2+	0	0
Pharynx	2+	0	0	0
Cecal cells	3+	0	3+	0
Cecal contents	3+	0	3+	0
Acetabulum	2+	1+	0	0
Holdfast organ	3+	2+	3+	0
Subtegument	2+	0	0	0
Nerve tissue	3+	0	0	0
Excretory pore	2+	0	0	0
Genital papilla	2+	0	0	0
Covering of testes	0	3+	0	2+
Ovary	0	2+	0	2+

[1] 3+ = intense reaction; 2+ = moderate reaction; 1+ = slight reaction; 0 = no reaction.
[2] Acetylcholinesterase.

(Pearse, 1960) and alkaline phosphatase (0.1 M Tris buffer, pH 10) (Gomori, 1952). A lead method using 0.05 M acetate buffer, pH 5 (Gomori, 1952) was also used for acid phosphatase, as was calcium cobalt using sodium barbital buffer, pH 10 (Gomori, 1952) for alkaline phosphatase. Sodium fluoride (10^{-2} M) was used to inhibit acid phosphatase, potassium cyanide (10^{-2} M) for alkaline phosphatase. Both inhibitors yielded complete inhibition.

Results and Discussion

Carboxylic esterases

Acetylcholinesterase was the predominant carboxylic esterase localized in *P. adenocephala*. The activity was best demonstrated in the areas of presumably highest physiological and physical activity. Nonspecific esterase activity was also present in most structures, but in comparatively reduced amounts, usually occurring in conjunction with acetylcholinesterase, but occurring alone in the ovary and in the epithelial covering of the testes (see Table 1).

A comparison of the results using the two acetate substrates indicates that alpha-naphthyl acetate yields a more intense, but less sensitive, reaction than does 5-bromoindoxyl acetate. Pearson and Defendi (1957) found that there was less diffusion with 5-bromoindoxyl acetate, and that the colored product formed was smaller since it was part of the original substrate and not an incorporated azo dye added to the incubation medium.

ORAL SUCKER: This structure was the site of most intense carboxylic esterase activity (Fig. 1). Öhman (1966a) reported similar results in *Apatemon gracilis minor* Yamaguti, 1933. It is thought that this organ has a dual function, one of attachment and one of ingestion, as speculated by Bečejac et al. (1964). This structure may also be secretory, either for internal and/or extracorporeal digestion. Most of the activity is that of acetylcholinesterase. Nonspecific esterase activity is restricted to the outer portion of the structure (Fig. 2).

The subtegumental cells associated with the oral sucker yielded an intense reaction (Fig. 3). Some of this activity is due to the presence of nonspecific esterase, but the majority is that of acetylcholinesterase (Fig. 4). These cells apparently secrete the esterases which then accumulate in the overlying tegument and oral sucker (Halton, 1967b, 1968).

PSEUDOSUCKERS AND ASSOCIATED GLAND CELLS: The pseudosuckers are invaginated structures which show intense carboxylic esterase activity only along the margin of the invagination. The associated gland cells are arranged in a semicircular, narrow layer around the pseudosuckers (Fig. 1). Ducts connecting

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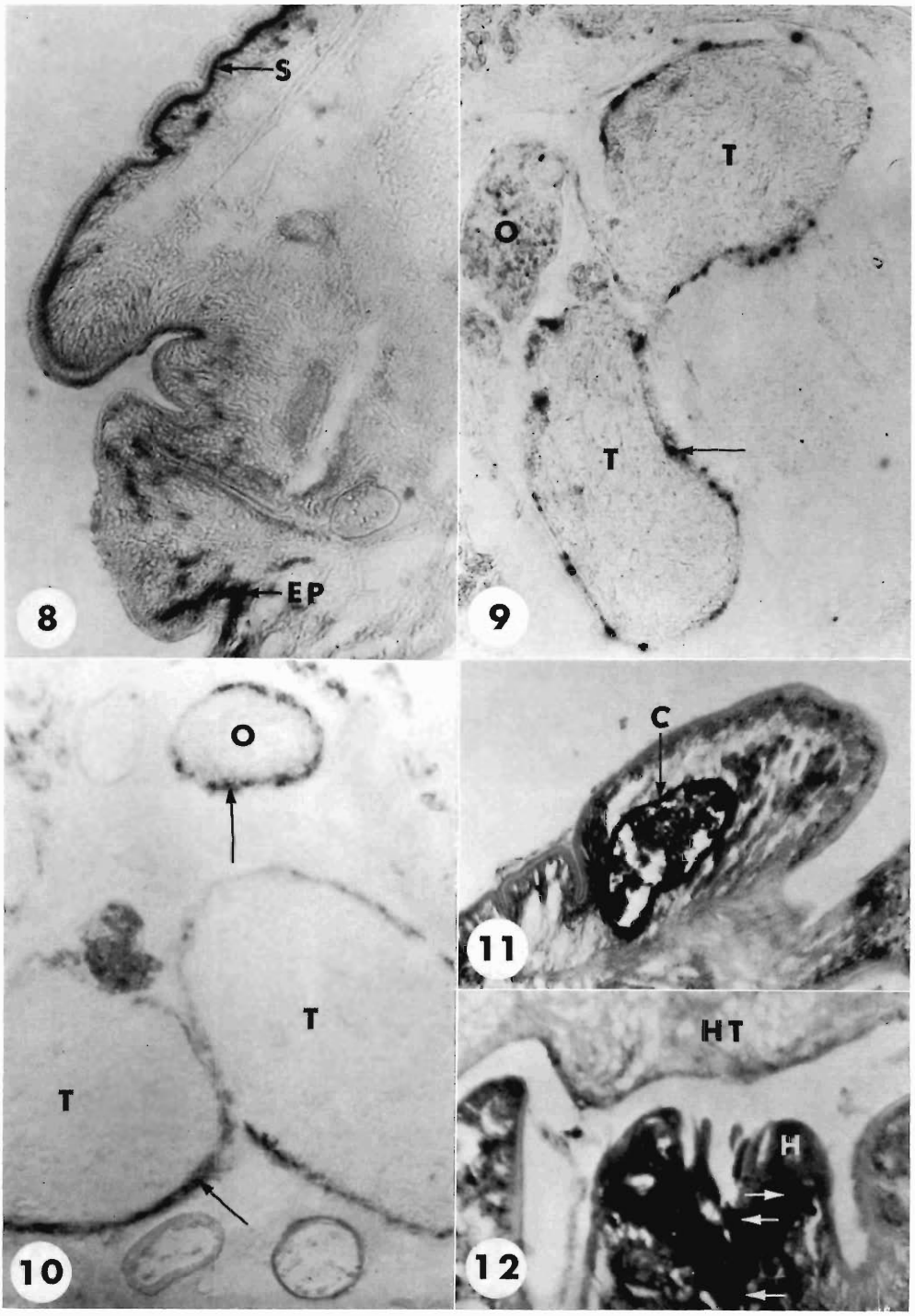
Figures 8–12. 8. Sagittal section of hindbody through the excretory pore. Alpha-naphthyl acetate. ×375. 9. Frontal section through the testes and ovary. 5-bromoindoxyl acetate inhibited by eserine sulfate. ×375. 10. Frontal section through the testes and ovary. Sodium alpha-naphthyl acid phosphate. ×375. 11. Tangential section of forebody through the ceca. Sodium alpha-naphthyl acid phosphate. ×250. 12. Transverse section of middle forebody while attached to the host tissue illustrating inner glandular regions of the holdfast organ. ×80.



the gland cells and the pseudosuckers were not enzymatically active.

The activity appears to be mostly acetylcholinesterase, with some nonspecific esterase. Host tissue showed only nonspecific esterase activity. However, when the pseudosuckers are in contact with the mucosal epithelium, there is considerable acetylcholinesterase activity of parasitic origin in the host tissue (Öhman, 1965, 1966a). Lee (1962) suggests that the enzymes secreted by the pseudosuckers are for extracorporeal digestion, and that an attachment function by these organs is a purely muscular one.

PHARYNX: This structure shows a moderate reaction with all substrates (Fig. 1). Inhibition studies revealed that all the activity was acetylcholinesterase. The fact that this organ showed a less intense reaction than did the oral sucker may indicate that it is a secondary structure for the ingestion of nutrients (Bečejac et al., 1964) or that it functions in a suction capacity only. Reid and Harkema (1970) have determined that the pharynx of *Procyotrema marsupiformis* Harkema and Miller, 1959, gives a more intense reaction than does the oral sucker.

Fripp (1967) reported finding acetylcholinesterase and pseudocholinesterase in the pharynx of adult schistosomes. Öhman (1965) examined *Diplostomum spathaceum* Braun, 1893, and reported finding only acetylcholinesterase in the pharynx.

CECA: The intestinal ceca and their contents exhibit an intense acetylcholinesterase reaction (Fig. 1). Since the host tissue contains only nonspecific esterase, the cecal cells are probably secreting acetylcholinesterase. It is also a possibility that the trematode is ingesting some of its own extracorporeal enzymes. The cecal cells are slightly more active than the subtegument, which may indicate that the ceca are more involved in the passage of nutrients into the worm (Barry et al., 1968). Öhman (1965, 1966a, b), working with three different strigeoid trematodes, reported results varying from no esterase activity to intense nonspecific esterase activity in the cecal cells. Halton (1967a) found nonspecific esterases and acetylcholinesterases in the cecal cells of *F. hepatica*.

ACETABULUM: The esterase activity in the acetabulum is moderate to intense, and is mostly acetylcholinesterase with some isolated areas of nonspecific esterase (Fig. 5). Bečejac et al. (1964) reported intense acetylcholinesterase activity in the acetabulum of *Dicrocoelium lanceatum* (Rudolphi, 1819) as did Krvavica et al. (1967) in *F. hepatica*. The esterases in this organ would seem to imply an attachment function and/or a secretory function (Halton, 1968). The less intense reaction in this sucker as compared to that of the oral sucker and the holdfast organ suggests a reduction in function.

HOLDFAST (ADHESIVE) ORGAN: This organ contains approximately equal amounts of nonspecific esterase and acetylcholinesterase, the quantities of each varying in different areas. Acetylcholinesterase is concentrated in the peripheral regions, while nonspecific esterase is in the inner, glandular regions, with both in between (Fig. 5).

Inhibition studies using eserine sulfate and the substrate 5-bromoindoxyl acetate indicate that this organ is more enzymatically active when in contact with the host tissue, and secretes acetylcholinesterase into the host tissue (Fig. 6). Öhman (1966b) found both nonspecific esterase and acetylcholinesterase in the holdfast organ of *Holostephanus luhei* Szidat, 1936. Erasmus and Öhman (1963) state that the holdfast organ in several genera of strigeid trematodes is primarily secretory in function, and these secretions seem to be histolytic and/or digestive.

SUBTEGUMENT: The entire subtegument, with the exception of the ventral hindbody, exhibits a well-defined reaction of acetylcholinesterase. When the trematode is not attached to the host tissue, the subtegument can be enzymatically differentiated from the nonreactive tegument (Figs. 7, 8). However, when the trematode is attached, the reaction is more intense, and is uniform from the base of the subtegument, through the tegument, and into the host tissue (Fig. 6). This indicates that acetylcholinesterase is being secreted by the subtegumental cells. Similar conclusions were drawn by Öhman (1965).

Carboxylic esterases secreted to the exterior of the worm may be associated with the trans-

port of metabolites through the tegument and/or have a lytic effect on the host tissue (Lee, 1962; Öhman, 1966b). Halton (1967a) suggests that the cholinesterase in the tegument of *F. hepatica* functions in some way for the passage of nutrients. Bogitsh (1966a) states that the subtegumentary cells help maintain intimate contact with the host tissue by secretory functions.

NERVE TISSUE: The nervous system reacts intensely with all three substrates and contains only acetylcholinesterase activity. No attempt was made to reconstruct the entire nervous system but nerve cords, commissures, and small nerve nets were localized throughout the trematode. The oral sucker, pseudosuckers, and pharynx are richly innervated by branches of the lateral nerve cords (Fig. 3). The lateral nerve cords give off many branches, especially in the forebody. The acetabulum and ventral forebody subtegument are innervated by branches from a commissure (Fig. 7). The lips of the excretory pore exhibit an intense reaction (Fig. 8), as do the lips of the genital papilla. This reaction could be that of nerve tissue, or could be that of subtegumental cells.

Bogitsh (1966a) used histochemical studies on the carboxylic esterase activity to reconstruct the nervous system of *Posthodiplostomum minimum* (MacCallum, 1921).

REPRODUCTION STRUCTURES: The cells of the ovary exhibit general, moderate nonspecific esterase activity throughout (Fig. 9). The epithelial covering of the testes shows intense nonspecific esterase activity, as well as heavy, localized areas within this epithelium (Fig. 9). Halton (1967a) reported identical findings in *F. hepatica*.

The testes and ovary were the only areas of pure nonspecific esterase activity. This activity was best demonstrated using the more sensitive 5-bromoindoxyl acetate method.

Phosphatases

Both acid and alkaline phosphatase have been reported in the holdfast organ of *Cyathocotyle bushiensis* Khan, 1962 (Erasmus and Öhman, 1963) and *H. luhei* (Öhman, 1966b). Only acid phosphatase has been determined in the holdfast organ of *D. spathaceum* (Öhman, 1965), *A. gracilis minor* (Öhman, 1966a), and *Alaria marcianae* (LaRue, 1917) (Johnson et al., 1971). Only alkaline phosphatase was reported in the holdfast organ of *Diplostomum phoxini* Faust, 1918 (Lee, 1962). We found only acid phosphatase in the holdfast organ of *P. adenocephala*, and this was strongly localized in the gland cells (Fig. 12). The above-mentioned authors suggest that both of these phosphatases are secreted to the exterior by the gland cells, and that these secretions are histolytic and play a part in extracorporeal digestion.

Acid phosphatase was intensely localized in the cecal cells, which agrees with the results of most researchers in trematode histochemistry. Halton (1967c) feels that this enzyme is functional in active transfer processes in the microvilli. We also found this enzyme in the cecal contents (Fig. 11) as did Erasmus and Öhman (1963) and Öhman (1966a, b). It is generally assumed that the cecal cells do not secrete acid phosphatase. Therefore, we feel that the trematode is ingesting some of the enzyme secreted by the gland cells of the holdfast organ, since the host tissue is negative for this phosphatase.

The presence of alkaline phosphatase was demonstrated only in the epithelial covering of the testes, and the periphery of the ovary (Fig. 10). Halton (1967c) obtained similar results in six of eight trematodes examined. The distinct similarity in location and the apparent similarity of these enzyme groups suggest that this alkaline phosphatase activity might be the nonspecific esterase discussed earlier.

Alkaline phosphatase was occasionally found in the cecal contents, but only if the trematode was feeding on the mucosal epithelium of the host intestine, which is rich in this enzyme.

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The Seasonal Abundance of the Ancyrocephalinae (Monogenea) on Largemouth Bass in Walter F. George Reservoir[1]

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ABSTRACT: Four species of Ancyrocephalinae were collected from largemouth bass in Walter F. George Reservoir from December 1967 to January 1969. The abundance of *Urocleidus principalis* and *U. furcatus* peaked at 28 C in June and mid-September, declined in the early fall, and then rose to another peak in December at 9 C. The abundance of *Actinocleidus fusiformis* peaked prior to the spring period of maximum temperature change in June and mid-September at 28 C and in December at 9 C. Abundance of *Clavunculus bursatus* peaked in the early spring and late fall at 9 C. The peaks of abundance seemed to be a water temperature-associated phenomenon.

The objective of this study is to describe seasonal changes in abundance of monogenean populations on the largemouth bass. Few studies of the population dynamics of Monogenea on North American fishes have been conducted. Mizelle and Crane (1964), working with largemouth bass, *Micropterus salmoides* (Lacépède), from a California pond found that *Actinocleidus fusiformis* (Muller, 1934) Mueller, 1937, comprised 7% of the branchial Monogenea present in June and 3% in August; that *Clavunculus unguis* (Mizelle and Cronin, 1943) Mizelle, Stokely, Jaskoski, Seamster, and Monaco, 1956, not collected in June, constituted 50% in August; that *Urocleidus furcatus* (Mueller, 1937) Mizelle and Hughes, 1938, comprised 23% in June and 32% in August; and that *U. principalis* (Mizelle, 1936) Mizelle and Hughes, 1938, remained at 60% of the sample during both months. Crane and Mizelle (1968) found that on the bluegill, *Lepomis macrochirus* Rafinesque, in a California pond the *U. ferox* Mueller, 1934, population "peaks of August and April showed a positive relationship with temperature, whereas that for January occurred when the annual temperature was low (8 C)." The population peaks of *A. fergusoni* Mizelle, 1938, occurred in July, January, and May but the peaks were not correlated with the annual temperature. Meyer (1970) found that *Dactylogyrus* sp. epizootics in fish ponds in the Southeast peaked in April but were common in the spring and early summer. Paperna (1963) found an optimum temperature for *Dactylogyrus* on carp to be between 24 and 28 C.

Materials and Methods

Biweekly collections of largemouth bass were made from 14 December 1967 to 6 January 1969 in a 20-acre cove 1.2 miles south of Cottonton, Russell County, Alabama, in Walter F. George Reservoir on the Chattahoochee River. Initially, 10 fish per sample were collected with the aid of an electrofishing device. Because of difficulty experienced in collected hosts, the sample number was reduced to five fish (187 total). Surface water temperature was recorded for each collection (Fig. 1). The fish were placed in a 1:4,000 solution of formalin as suggested by Putz and Hoffman (1963). After 1 hr, enough formalin was added to make a 5% solution. In the laboratory the fish were measured and grouped according to size. One side of the gill arch was removed and examined; the sediment remaining in the 5% formalin solution was concentrated by decantation and examined. Parasites collected were retained for later identification. Sample totals should be considered relative figures repre-

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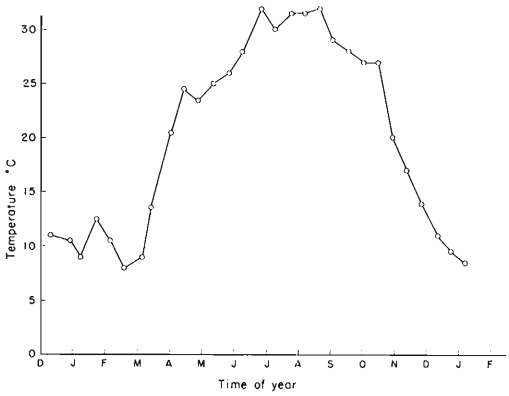

Figure 1. Surface temperature of Walter F. George Reservoir.

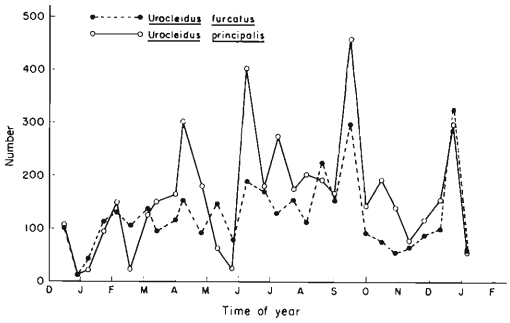

Figure 2. Seasonal abundance of *Urocleidus furcatus* and *U. principalis*.

sentative of the monogenean populations since only the gills on one side of the fish were examined. Because of variability in the number of fish per sample and mean length (4.7 to 12.5 inches) of the host a standard sample of five fish with standardized mean lengths of 8 inches was adopted and the data were adjusted to these standards.

Results and Discussion

Four species of Ancyrocephalinae normally occur on the largemouth bass in Walter F. George Reservoir: *Clavunculus bursatus* (Mueller, 1936) Mizelle, Stokely, Jaskoski, Seamster, and Monaco, 1956, *Urocleidus furcatus*, *U. principalis*, and *Actinocleidus fusiformis*. Specimens of *U. furcatus* and *U. principalis* constituted a major portion of the population. Mizelle and Crane (1964) noted that no more than four of the seven species of Ancyrocephalinae reported from largemouth bass occurred at any one locality. This may be because of competition within species groups or difficulty in separating three species groups—*C. bursatus* from *C. unguis*, *U. principalis* from *U. helicis* (Mueller, 1936) Mizelle and Hughes, 1938, and *U. furcatus* and *U. dispar*.

The abundance of *U. principalis* (Fig. 2) varied (14 to 150) during the winter months, but in the spring increased to a peak (302) in mid-April after the period of maximum change of the surface water temperature. Abundance declined until late May prior to increasing to a peak (394) in June when surface water temperature was 28 C. It then declined to a moderate level (167 to 276) and remained at this level during the summer. In September abundance (459) peaked at a temperature of 28 C then declined steadily during the fall period of maximum temperature change. In December at a water temperature of 9 C, abundance had again risen near the level (299) of the spring peak. In January the abundance had decreased to the low level (58) of the previous winter.

The abundance of *U. furcatus* (Fig. 2) was at the lowest level (14) in January then increased to a moderate level and remained at this level (79 to 156) until June. Abundance increased in June after the spring period of maximum temperature change then declined to the former levels. Abundance increased to a peak (301) in mid-September. As in the *U. principalis*, summer peaks in abundance seemed to be associated with a surface water temperature near 28 C then rose to its highest level (320) in December at a surface water temperature of 9 C. In October and November, during the period of maximum temperature change, abundance declined. In January abundance again decreased to a low level (60).

The abundance of *C. bursatus* (Fig. 3) declined after the initial December sample but gradually increased to a peak (67) in early February at a water temperature of 9 C. *C. bursatus* abundance was at a low level (8) in late March and early April and again in late September and October (8 to

13) during the periods of rapid temperature change but in the remaining spring and summer months it varied at a moderate level (13 to 53). In December the abundance again exhibited a peak (71) at a water temperature of 9 C.

The abundance of *A. fusiformis* (Fig. 3) increased during the winter months, reaching the highest level (60) in mid-March. During the spring period of maximum temperature change the abundance decreased, then expanded to a peak (77) in late June. Abundance in the summer remained at a moderate level (38 to 54) until a mid-September peak (101). In the fall abundance declined and then rose during the period of maximum temperature decline to its highest level (131). During November and December abundance varied (43 to 117) but seemed to indicate a slow decline.

The abundance of the four species of Ancyrocephalinae occurring on largemouth bass exhibited population trends which seemed to be water temperature-associated phenomena. The abundance of *U. principalis* and *U. furcatus* was at moderate to low levels during the winter. The abundance of *C. bursatus* and *A. fusiformis* demonstrated peaks prior to the spring period of maximum temperature increase. Declines in abundance were observed for all four species during this period of maximum temperature increase. These declines may be indicative of a period of acclimation for the parasites between the two periods of relative temperature stability during summer and winter. As the temperature rose to 28 C in late June and declined to 28 C in mid-September the abundance of all species except *C. bursatus* peaked indicating a temperature optimum. During the midsummer period when surface water temperature exceeded 30 C the abundance of the three species remained at a moderately high level. This high level of abundance may be a result of the tendency of bass to associate themselves with the temperatures (27 C; Dendy, 1948) close to the parasites' optimum. After a fall decline the abundance of all four species increased to extremely high levels as the temperature approached 9 C then declined. This phenomenon was experienced by Crane and Mizelle (1968)

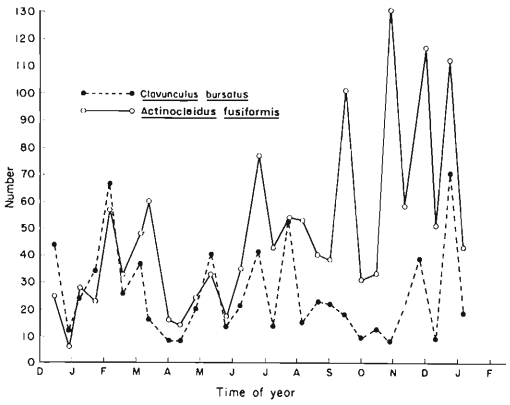

Figure 3. Seasonal abundance of *Clavunculus bursatus* and *Actinocleidus fusiformis*.

at a similar temperature with the ancyrocephalans of bluegill but no plausible explanation for it exists.

The phenomenon may have represented a period in which the water temperature was below that necessary for release of fish antibodies but above the minimum temperature required for ancyrocephalinaean reproduction. Bisset (1947) found the temperature below which cold-blooded vertebrates did not release antibodies to be 12 C. Water temperature is an important factor directly influencing the reproductive rate and life-span of Monogenea (Bychowsky, 1957); however, an equally important indirect influence of water temperature is exerted on the host's life history and antibody response to the parasite. Water temperature is not the only factor influencing parasite population (Bauer, 1969) but it is particularly critical to external parasites with direct life cycles and short life-spans, such as the ancyrocephalineans.

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Freshwater Larval Trematodes. XXX. Life Cycle of *Petasiger novemdecim* Lutz, 1928[1]

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ABSTRACT: The cercaria of *Petasiger novemdecim*, an echnostome larva of the Magnacauda group, with a dorsally uninterrupted row of 19–21, rarely 23, collar spines, including a group of four angle spines, parasitizes *Biomphalaria glabrata olivacea*, and encysts in the gills and internal layer of the esophagus of the fish, *Lebistes reticulatus*. These cysts, when fed to a short-billed grebe, *Podiceps dominicus speciosus*, develop into adult echinostomes in its small intestine with the same number of collar spines as the cercaria. Fourteen species are considered as synonyms of *P. pungens*. The diagnostic value of different characters is discussed.

Lutz (1928) described *Petasiger novemdecim* from the intestine of *Podiceps dominicus* (L.) in an unknown part of Venezuela, characterized by 19 cephalic spines. Apart from the diagram of this species, Lutz' description of the parasite is very fragmentary. Nasir and Scorza (1968) found a cercaria of the type Magnacauda Byrd and Reiber, 1940, from *Biomphalaria glabrata olivacea* (Say), which was experimentally connected with the adult *Stephanoprora denticulata* (Rudolphi, 1802) Odhner, 1910. During this research we came across a cercaria which, like that of *S. denticulata*, encysted in guppies, *Lebistes reticulatus* (Peters). These cysts, unlike those of *S. denticulata*, when fed to a domestic pigeon failed to develop into adult parasites. This appeared rather strange, and a search was made to find natural definitive hosts which might harbor the trematodes likely to correspond with the cercaria in question. Autopsy of a short-billed or least grebe, *Podiceps dominicus speciosus* (Lynch Arribalzaga), trapped from the same locality from which the snails were collected revealed the presence of several hundred echinostomes (with 19–21 collar spines) in its intestine. Guppies from the same locality were examined, and their gills were loaded with cysts similar to the ones obtained from the experimental infections.

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[2] Modified from data based on the graduate work of this author.

Accordingly, it was decided to elucidate the life cycle experimentally.

Materials and Methods

On different occasions 4,000 specimens of *Biomphalaria glabrata olivacea* were collected from a dyke, locally known as "dique de San Juan Bautista," on the Island of Margarita, Nueva Esparta State, Venezuela. The snails were transported in holed plastic bags, and maintained in the laboratory in continuously aerated enamel trays about three-fourths filled with pond water. These mollusks could not be kept alive for long periods. They have a habit of climbing out of the water onto the sides of the receptacle, but fail to return to the water again. Thus, most of the snails dried up. Some of those which survived emitted cercariae of *Petasiger novemdecim*, on the average for 2 days, and died within 3 days.

The second intermediate hosts, *Lebistes reticulatus*, for experimental purposes, were obtained from laboratory-raised stock kept for years in our laboratory. The fish were fed commercial fish food known as Tetramin.

Two young grebes, *P. dominicus speciosus*, were procured from a lake in Falcon State in which mollusks have never been found. One of the grebes died. It was dissected the same day, but no helminth infections were encountered. The stool of the other bird, on daily fecal examination for 5 days, proved negative for trematode eggs. It was administered orally an undetermined number of cysts pooled from the laboratory-infected guppies, but died 60 hr postinfection. On dissection, 50 immature worms of *Petasiger novemdecim* were recovered from its small intestine.

Only freshly emerged cercariae were studied, sometimes with the aid of intravital stains. The adult worms were fixed with hot (60–70 C) Gilson's fixative, and stained with acetocarmine. The diagrams have been drawn with the aid of a camera lucida, except certain details which were added freehand. All measurements are in millimeters.

Redia (Fig. 1)

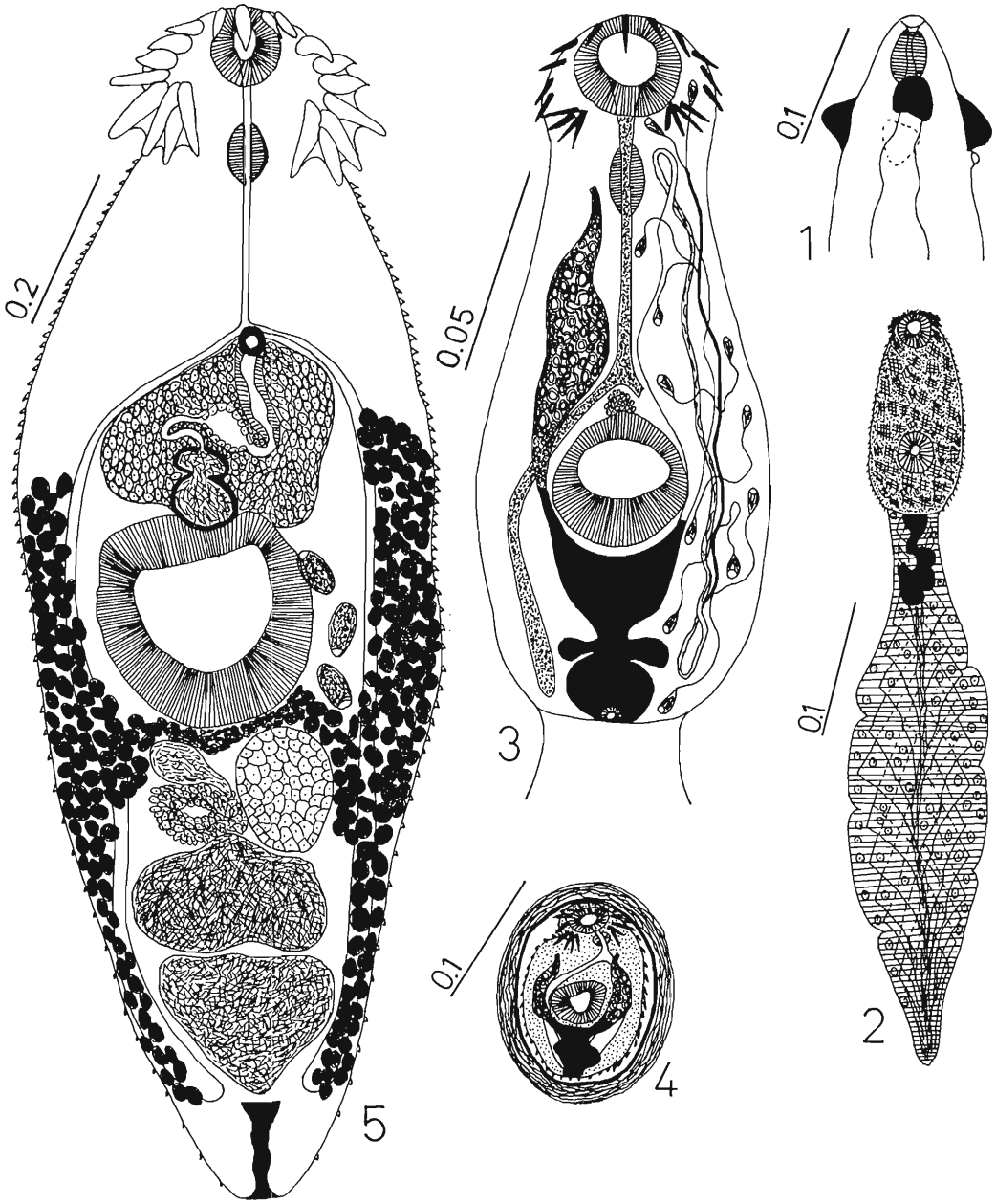
Body orange-yellow pigmented, bearing pair of posterior locomotor appendages. Pharynx anteroposteriorly elongated. Collar subdivided into four lobes: one dorsal, one ventral, and two lateral. Birth pore, when observable, behind one of lateral lobes. Gut saccate, tortuous, may reach posterior appendages, filled with yellowish material. Body cavity containing germinal masses in various stages of development. Six to 10 apparently fully developed cercariae in each redia. Measurements of 12 living rediae, haphazardly selected: body 0.376–0.846 by 0.094–0.141; pharynx 0.033–0.048 by 0.024–0.045.

Cercaria (Figs. 2–3)

Body spinose. Tail leaflike, aspinose, two to three times as long as body, traversed by longitudinal, diagonal, and circular muscle fibers. Brownish-yellow pigment posterior to pharynx along esophagus, around excretory vesicle, and proximal part of tail. Collar spines 19–21, rarely 23, dorsally uninterrupted, include a group of four angle spines. Ventral sucker larger than oral, equatorial or postequatorial. Pharynx longer than prepharynx. Esophagus long, extending almost to ventral sucker. Intestinal ceca extending to posterior division of excretory vesicle. Entire digestive tract containing granular material. Cystogenous glands with rhabditiform contents. Excretory system as in Figure 3. Anterior and posterior excretory loops present. Secondary excretory tubes ciliated internally. Main excretory tubes containing refractile excretory granules of double nature only in preacetabular region. Extension of excretory vesicle variable, occupying proximal region of tail. Excretory pore anterior to posterior border of body. Flame cell formula $2[(2+2+2+2+2+2)] = 24$. Swimming in snakelike fashion, i.e., describing a figure "S" and not "8." Measurements of 12 specimens: body 0.140–0.180 by 0.060–0.079; tail 0.394–0.451 by 0.047–0.117; oral sucker 0.024–0.028 in diam; ventral sucker 0.026–0.036 in diam; prepharynx 0.006–0.017 long; pharynx 0.010–0.016 by 0.007–0.010.

Metacercaria (Fig. 4)

Cercariae, due to their "fish lure" swimming behavior, fall easy prey to fish. Several times they have been observed to be actively in-



Figures 1–5. *Petasiger novemdecim* Lutz, 1928. 1. Anterior end of redia; note the subdivided collar. 2. Cercaria in general. 3. Body of cercaria, flame cells, and intestinal cecum shown on one side only. 4. Cyst. 5. Entire worm, ventral view.

gested by fish. The cysts, excluding the cyst wall of host origin, are 0.130–0.186 by 0.072–0.103, and are enclosed in a wall of double nature: an internal layer of parasite origin, and an external layer of host origin, the thickness of which varies with time.

Adult (Fig. 5)

HOST: Short-billed or least grebe, *Podiceps dominicus speciosus* (Lynch Arribalzaga) [= *Podiceps dominicus* (L.)]; also known as "patico zambullidor"; natural and experimental infections.

HABITAT: Small intestine.

LOCALITY: Dique de San Juan Bautista, State of Nueva Esparta, Venezuela.

DEPOSITED SPECIMEN: USNM Helm. Coll. No. 72003, neotype.

Tegumental spines completely or incompletely covering general body surface. Collar spines 19–21, seldom 23, including a group of four angle spines, arranged in dorsally uninterrupted series. Ventral sucker larger than oral, equatorial or slightly so. Prepharynx well developed. Pharynx smaller than oral sucker. Esophagus not extending to ventral sucker. Intestinal ceca reaching posterior end of body. Ovary smooth, anteroposteriorly or transversely elongated, pretesticular. Eggs operculate, only few, maximum three. Seminis receptaculum uterinum lateral to ovary, anterior to ootype complex. Vitelline glands mostly extracecal, confluent immediately posterior to ventral sucker, with anterior limits fluctuating from somewhat posterior to esophageal bifurcation, and posteriorly between posterior end of intestinal ceca and posterior end of body. Testes unlobed, irregular, mostly transversely elongated, tandem or diagonal, in posterior third of body. Cirrus sac large, irregular, preacetabular, including bipartite seminal vesicle, elongated pars prostatica, and abundant prostate glands. Common genital pore immediately postbifurcal, median or submedian. Excretory vesicle Y-shaped. Measurements of seven egg-bearing adults: body 1.211–1.577 by 0.448–0.564; transverse diameter of collar 0.224–0.286; angle spines 0.072–0.130 long; spines of dorsal series 0.047–0.074; oral sucker 0.072–0.084 in diam; prepharynx 0.023–0.047 long; pharynx 0.072–0.086 by 0.044–0.064; esophagus 0.156–0.780 long; ventral sucker 0.224–0.288 in diam; cirrus sac 0.197–0.248 by 0.224–0.289; ovary 0.120–0.159 by 0.110–0.122; anterior testis 0.140–0.168 by 0.200–0.249; posterior testis 0.168–0.179 by 0.160–0.186; intrauterine eggs 0.060–0.072 by 0.030–0.044.

Discussion

Beaver (1939) described a large-tailed cercaria with a collar of 19 spines from *Helisoma antrosum percarinatum* (Walker) and *H. campanulatum smithi* (Baker), in Douglas Lake, Michigan, which encysted in the esophagus and pharyngeal region of various fishes, *Ambloplites rupestris* (Rafinesque), *Ameiurus nebulosus* (Le Sueur), *Lebistes reticulatus* (Peters), *Lepomis pallidus* (Rafinesque), *Notropis hudsonius* (Clinton), *Perca flavescens* (Mitchill), *Umbra limi* (Kirtland), and an undetermined number of minnows. The cysts from these fishes when fed to canaries, duck, pigeons, cat, mice, and rat developed into adult worms only in the canaries. They were *Petasiger nitidus* Linton, 1928, a parasite described from the horned grebe, *Colymbus auritus* L., from Woods Hole, Massachusetts.

Abdel-Malek (1952) reported a new cercaria, *C. chandleri*, of the same type as that of *Petasiger nitidus*, in *Helisoma corpulentum* Say, from Lake Itasca, Minnesota, which differed from *P. nitidus* in the number of collar spines (21), the presence of an orange-yellow pigment instead of deep brown in the pharyngeal region, the smaller intestinal ceca which reached only the middle of the acetabulum, the larger gland cells, the shape of the excretory bladder, the number of excretory granules, and the larger redial gut. According to the same author (1953) the cercaria encysted in the submucosa of the gill lamellae, the branchial area, and the esophagus of various fishes, *Ameiurus nebulosus*, *Chrosomus eos* (Cope), *Fundulus* sp., *Notemigonus crysoleucas* (Mitchill), *Notropis* sp., *Perca flavescens*, *Poecilichthys exilis* (Girard), *Semotilus atromaculatus* (Mitchill), and tadpoles. The cysts were fed to canaries, chicks, ducklings, mice, and garter snake, but only the canaries yielded positive results. Of the different species of the birds examined from

Itasca region, the pied-billed grebe, *Podilymbus podiceps podiceps* (L.), harbored some adult worms which were considered as the corresponding egg-bearing counterparts of the immature flukes obtained experimentally. The natural and experimental infections were considered as *Petasiger chandleri* (Abdel-Malek, 1952). Abdel-Malek (1953) remarked that *P. chandleri* differs from *P. nitidus* in the following respects "shorter prepharynx, longer esophagus bifurcating immediately in front of the ventral sucker, shorter ceca reaching only to the level of the anterior testis, collar spines varying from 19–21 (19 in *P. nitidus*), and uterus with 12–15 ova instead of 6 as in *P. nitidus*."

The so-called differences between the cercariae of *Petasiger chandleri* and *P. nitidus* are too flimsy to make a clear-cut distinction, especially in the view of an identical flame cell formula, i.e., $2[(3+3+3)] = 18$. The same is true of the adult morphological characters. Just as adult *P. chandleri* possesses 19–21 collar spines, in the same way the cercaria probably is also provided with 19 or 20 collar spines. Some specimens, cercariae and adults, of *P. novemdecim* from the same individual host are furnished with 21, occasionally with 23, spines. From the foregoing observations, we are inclined to believe that *Cercaria chandleri* and *P. chandleri*, its corresponding adult, are in fact synonyms of *P. nitidus*.

The cercaria of *Petasiger novemdecim* also bears 19 collar spines, with a group of four angle spines, and thus is inseparable from that of *P. nitidus* in this respect; both species of cercariae swim in a snakelike fashion. The differences in the measurements of organs are of minor importance, but they differ substantially in the number of the flame cells: *P. nitidus*, 18; *P. novemdecim*, 24. The adult morphology is only a question of size differences.

Insofar as the number of cephalic spines is concerned, there are many representative species from different echinostome genera showing variable numbers: *Acanthoparyphium* sp. Yamaguti, 1934, 22–23 collar spines; *Aporchis segmentatus* Fuhrmann, 1915, 55–57; *Chaunocephalus panduriformis* Travassos, 1922, 23–26; *Echinochasmus elongatus* Miki, 1923, 30–34; *Echinostoma revolutum* (Frölich, 1802) Looss, 1899, 35–38; *Episthmium bursicola* (Creplin, 1837), 20–24; *Himasthla rigeadana* Dietz, 1909, 32–38; *Hypoderaeum conoideum* (Bloch, 1782), 47–53; *Patagifer bilobus* (Rudolphi, 1819) Dietz, 1909, 52–62; *Pegosomum saginatum* (Ratz, 1898) Ratz, 1903; *Petasiger brevicauda* (Ishii, 1935) Mendheim, 1943, 19–21; *P. parvispinosus* (Yamaguti, 1933) Ablasov and Ikasanova, 1959, 50–52; *P. pungens* (v. Linstow, 1894) Fuhrmann, 1928, 19–21; *P. magniovatum* (Stossich, 1898) Pande, 1939, 19–22; *Prionosoma serratum* (Diesing, 1850) Dietz, 1909, 44–48. Thus, it is not surprising that the members of the same echinostome species from the same or a different host happen to possess a variable number of collar spines. The same may be said of the cercarial stages. Johnson (1920) observed 43 spines in the cercaria of *Echinostoma revolutum*, but only 37 in the adult. He attributed this loss of spines due to the handling of the worms and simply there was not much space in the adult collar. Tubangui (1932) and Beaver (1937) were of the opinion that Johnson observed a cercaria different from that of *E. revolutum*. Had the difference in the number of spines been an isolated case some credence could be attached to the latter authors' opinion. *Cercaria essexensis* Khan, 1960, is provided with 47–49 collar spines, while the adult thereof, *Hypoderaeum essexensis* (Khan, 1960) Khan, 1962, has 49. Consequently, it is of little specific value that there are 19–21 spines in the adult *Petasiger chandleri* of Abdel-Malek, 1953, while its cercarial stage has 21.

Johnston and Angel (1941) described a new species, *Petasiger australis*, from grebes, *Podiceps ruficollis novaehollandiae* Stephans and *P. policephalus* Jardine and Selby, from South Australia, with 19 collar spines, including a group of four angle spines. Without experimental proof, it was considered to be the adult of a large-tailed echinostome cercaria, *C. gigantura* Johnston and Angel, 1941, from *Amerianna pyramidata* (Conrad). According to them the adult differs from *Petasiger nitidus* "in the dimensions of the body, organs and collar spines and in the sucker ratio"; from *P. pungens* in general form, the length of the esophageal region, and the arrangement of the

testes; from *P. lobatus* Yamaguti, 1933, in sucker ratio, and especially in the form and arrangement of the testes.

Prudhoe (1945) recognized *Petasiger pungens* (v. Linstow, 1894) Fuhrmann, 1928, as a valid species, reducing to synonymy the following: *Echinostomum pungens* Stossich, 1899, *E. pungens* of Odhner, 1910; *Petasiger megacanthus* (Kotlan, 1922) Pande, 1939, *P. neocomense* Fuhrmann, 1928, *P. neocomense* of Baylis, 1939, and *P. nitidus* Linton, 1928. The present authors are not only in agreement with Prudhoe, but also believe that other species, namely *P. australis*, *P. chandleri*, *P. brevicauda*, *P. floridus* Premvati, 1968, *P. grandivesicularis* Ishii, 1935, *P. lobatus*, *P. longicirratus* Ku, 1938, *P. parvispinosus*, and *P. spasskyi* Oschmarin, 1947, should be synonymized with *P. pungens*. In other words, the life history data of *P. nitidus* is in fact the life cycle of a previously known species, i.e., *P. pungens*. In the prevailing circumstances, it seems only reasonable to leave these species as conspecifics unless further life history studies provide concrete biological evidence as to their actual specific determination. Characters such as measurements, disposition of testes, position of cirrus sac in relation to ventral sucker, size of pars prostatica, position of genital pore, esophageal length, point of esophageal bifurcation, presence of seminal receptacle, cecal length, extent of vitelline glands, size of eggs, and number of eggs in uterus, frequently used to separate the adult parasites, are all subject to variations even in members of the same species.

A partial life cycle is known of another species, *Petasiger linguiformis* Kogame, 1945, in Japan. Cysts from the pericardium of *Viviparus malleatus* Reeve were fed to a white rat, and adults were recovered from its intestine. Yamaguti (1958) introduced a new genus, *Allopetasiger*, to accommodate this species which bears more than 40 collar spines in a double row.

Within the genus *Petasiger* Dietz, 1909, Baschkirova (1941) erected the subgenera *Petasiger*, species with tandem testes, and *Neopetasiger*, species with oblique, or symmetrical or nearly symmetrical testes. Mendheim (1943) established another genus, *Navicularia*, which was considered a synonym of *Petasiger* by Skrjabin and Baschkirova (1956). Gogate (1934), Ku (1938), Mendheim (1943), Nigam (1944), and Skrjabin and Baschkirova (1956) published keys for the identification of various species in *Petasiger*. Bisseru (1957), on the basis of the number of collar spines, divided *Petasiger* into two groups: one with 27 collar spines, e.g., *P. exaeretus* Dietz, 1909, the other with 19–21 spines, e.g., *P. pungens* or *P. megacanthus*. One wonders as to the justification of this subdivision. There are several species which, according to the number of collar spines, may be grouped as: (1) 19–22 spines, represented by *P. magniovatum*; (2) 23, *P. neocomense* (syn. of *P. pungens*), *P. minutissimus* Gogate, 1934, *P. skrjabini* Baschkirova, 1941; (3) 24, *P. coronatus* Mendheim, 1940; (4) 25, *P. aeratus* Oschmarin, 1947; (5) 33, *P. inopinatum* Baer, 1959; (6) 42, *P. indicum* (Bhalerao, 1931) Gogate, 1934.

Nasir and Scorza (1968) published a key for the separation of the magnacaudate cercariae, including the five species, i.e., *Petasiger pungens*, *Cercaria gigantura*, *C. paucispina* Faust and Hoffman, 1934, *C. rashidi* Nasir, 1962, and *C. titfordensis* Nasir, 1962, which like that of *Petasiger novemdecim* possess a total of 19 collar spines. The cercaria of *P. novemdecim* is readily identified from that of *P. pungens* in having 24 flame cells instead of 18, from *C. gigantura* with 30–36, and from *C. titfordensis* with 36 flame cells. *Cercaria paucispina* has a group of three angle spines in contrast to four of *P. novemdecim*. *Cercaria rashidi*, with 36 flame cells, describes a figure "8" while swimming and not an "S" as for *P. novemdecim*.

Within the Magnacauda group of cercariae, there are cercarial forms which belong to different adult genera, i.e., *Stephanoprora* Odhner, 1902, represented by *S. denticulata* (Rudolphi, 1802) Odhner, 1910 (Nasir and Scorza, 1968), and *Petasiger* represented by *P. novemdecim*. Now, there is *Stephanoprora paradenticulata* Nasir and Rodriguez, 1969, the cercaria of which lacks collar spines, but these are meticulously present from the metacercaria through adult. Had it not been for the life cycle of this species, it could have been erroneously

taken for a "gymnocephalic" larva. This alludes to the artificial value of cercarial classification.

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Sex Ratio of *Trichinella spiralis* in Guinea Pigs and Mice in Relation to Host Resistance[1]

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ABSTRACT: The male-to-female sex ratios of the larva and adult *Trichinella spiralis* in the guinea pig and mouse were examined in relation to host resistance and worm recovery. Five and 28% of infective larvae were recovered as adults from guinea pigs and mice, respectively. The female worm predominated in both species of hosts; the sex ratios of the larvae and adult worms were 0.6 and 0.4 of a male per female, respectively. No difference due to host was observed. There was an inverse relationship between the sex ratio and the adult worm distribution and the small intestine of guinea pigs. In the intestinal quarter with the highest worm density, the sex ratio of adult worms was as low as one male to three females while in the segment with the lowest worm density it approached that of larvae. This relationship also occurred in guinea pigs with a previous infection with this nematode.

The guinea pig has been observed in our laboratory to be more resistant than the mouse to *Trichinella spiralis* in terms of percentages of infective larvae recovered as adult worms in the small intestine. During the 1st week of infection, these percentages ranged from 5 to 10 and 15 to 30 for the guinea pig and mouse, respectively. Differences in worm recovery among the four quarters of the small intestine of the guinea pig also have been observed (Castro et al., 1967; Lin and Olson, 1970). The sex ratio of worms in the small intestine and skeletal muscle of these hosts was investigated to determine whether an association exists between the sex ratio and these differences in host resistance and worm recovery. Some animals were given a stimulating infection prior to the experimental infection in an attempt to increase the host resistance.

Materials and Methods

Infective larvae were recovered from 6- to 12-week-old infections in mice by pepsin digestion of the carcass (Olson et al., 1960), counted, and given to mice and guinea pigs as described by Castro and Olson (1967). Male albino mice (20 to 30 g) of the Yale Swiss strain purchased from Texas Inbred Mice Co., Houston, Texas, and male albino guinea pigs (200 to 255 g) obtained from Albino Farms, New Jersey, were employed.

Adult worms were recovered as described by Castro et al. (loc. cit.) and sexed by external morphology. Larvae were recovered by pepsin digestion of the entire carcass of the mouse or digestion of skeletal muscle proportionally taken from legs, trunk, and jaw in the case of the guinea pig. Larvae were fixed in 10% formalin and sexed under a compound microscope (100 and 400×) by the criteria of Hemmert-Halswick and Bugge (cited by Gould, 1945). Larvae were identified as males on the basis of (1) a long rectum (30–50 μ), (2) a gonad at its midportion filling the width of the body cavity, (3) an intestine displaced from ventral to dorsal side near the middle of the gonad, and (4) no genital crest; those lacking these four characteristics were taken as females. About 10% of the larvae examined could not be classified by these four characteristics and were discarded. Other investigators have confirmed the reliability of using the length of rectum (Ali Khan, 1966) and the position of intestine (Villella, 1966) to sex these larvae. Thirty per cent of the adult worms and 100 to 200 of the larvae recovered from each animal were examined. Statistical analysis was done with the Student's t test (Snedecor, 1956); differences were considered as significant when the P value was 0.05 or less.

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Table 1. Sex ratios of *Trichinella spiralis* larvae in the skeletal muscles and adult worms in the small intestine of the guinea pig and mouse.

Host		Parasite			
Species	Group*	Stage	Mean No. of adult worms recovered	Days (d) or weeks (w) after experimental infection	Sex ratio† (Mean ± SE)
Guinea pig	I	Adult	984	3 d	0.45 ± 0.02
	II	"	1,149	7 d	0.40 ± 0.03
	III	"	866	3 d	0.43 ± 0.02
	IV	"	1,115	7 d	0.44 ± 0.02
	V	Larva	—	7 w	0.62 ± 0.03
Mouse		Adult	142	3 d	0.40 ± 0.03
	—	Larva	—	10 w	0.67 ± 0.06

* Six animals per group. Each animal was infected with 20,000 (guinea pigs) or 400 to 500 (mice) larvae. Guinea pigs in groups III and IV were additionally given a stimulating infection with 2,500 larvae 4 weeks earlier.
† The number of males per female.

Experiments and Results

Two groups of mice were given 400 to 500 larvae per mouse (20 larvae per g body weight) and killed 3 days or 10 weeks later for the recovery of adult worms or larvae, respectively. Three groups of guinea pigs were infected with 20,000 larvae per animal (40 larvae per g body weight) and killed on days 3 (group I) and 7 (group II) for recovery of adult worms and after 7 weeks (group V) for recovery of larvae. In addition, two other groups of guinea pigs were given a stimulating infection of 2,500 larvae per animal 4 weeks prior to a challenge infection of 20,000 larvae per animal (40 larvae per g body weight) to note any effect of acquired resistance on sex ratios of adult worms recovered at 3 (group III) and 7 days (group IV) postchallenge.

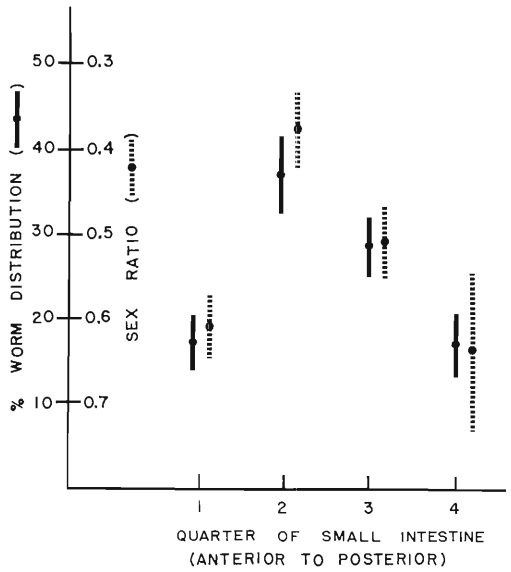

Figure 1. The inverse relationship between the per cent worm distribution and the male-to-female sex ratio of adult *Trichinella spiralis* in the four quarters of small intestine of group I guinea pigs. Mean and standard error are given.

This experiment showed that the male-to-female sex ratios for adult worms from the mouse and guinea pig were both about 0.4-to-1 while the sex ratios of larvae from these hosts were both about 0.6-to-1 (Table 1). Ratios (after conversion to arcsin values) for larvae from these two hosts were not significantly different nor were those for adults. The ratios for larvae were, on the other hand, significantly different from those for adults, regardless of host. About 5 and 28% of the infective dose were recovered as adults in guinea pigs and mice, respectively, despite the fact that the guinea pigs of groups III and IV had been given a stimulating infection. The number of adult worms recovered from guinea pigs on day 3 (groups I and III) was less than that on day 7 (groups II and IV) but this difference was not significant.

Analysis of the recovery and the sex ratio of adult worms from each quarter of small intestine was done on the guinea pigs killed on days 3 and 7. The results (Table 2) showed that the quarters with the higher percentages

Table 2. Worm recovery and sex ratio of *T. spiralis* in the four quarters of the small intestine of the guinea pig.

Group No. of host	Days after experimental infection	Quarter* of small intestine	Per cent worm† distribution (Mean ± SE)	Sex ratio‡ Mean ± SE)
I	3	2	36.7 ± 4.5	0.382 ± 0.044
		3	28.8 ± 3.3	0.510 ± 0.041
		1	17.3 ± 3.0	0.608 ± 0.038
		4	17.2 ± 3.9	0.635 ± 0.096
II	7	2	33.3 ± 5.2	0.336 ± 0.061
		3	25.7 ± 4.3	0.362 ± 0.084
		1	21.0 ± 4.7	0.470 ± 0.032
		4	20.0 ± 4.3	0.618 ± 0.111
III	3	2	38.4 ± 4.1	0.320 ± 0.070
		1	21.8 ± 1.9	0.372 ± 0.061
		4	21.8 ± 3.1	0.405 ± 0.100
		3	18.0 ± 2.7	0.592 ± 0.175
IV	7	3	32.0 ± 5.1	0.287 ± 0.055
		4	31.2 ± 4.8	0.573 ± 0.092
		2	20.0 ± 2.5	0.750 ± 0.146
		1	16.8 ± 7.6	0.494 ± 0.056

* The quarters are numbered from anterior to posterior but tabulated in the order of decreasing worm density.
† In terms of per cent of the total number of adult *T. spiralis* recovered from the small intestine.
‡ The number of males per female.

of total worm recovery also had the lower sex ratios; this relationship was more obvious in the nonstimulated (groups I and II) than in the stimulated groups (III and IV). This inverse relationship between the per cent worm distribution and the sex ratio can be seen more clearly in Figure 1. Statistical analysis showed that in the nonstimulated groups, the differences in percentages and sex ratios between quarters 2 and 4 on both days 3 and 7 and between quarters 1 and 2 on day 3 were significant. Since the stimulating infection rarely results in any adult worms being present after 4 weeks, these data for the stimulated groups pertain only to the challenge infection. In these groups, differences in percentages between quarters 2 and 3 were significant on both days 3 and 7; the differences in sex ratios between these two quarters on day 7 were also significant. Differences other than those cited above were not significant.

Discussion

The present study revealed that the sex ratio of adult worms in the guinea pig does not differ from that in the mouse—at least during the early infection. Sex ratios for the progeny of these adults, i.e., larvae in muscle, were also very similar for these two hosts and differed from the sex ratios for adult worms by having proportionally less females. Hence, factors other than a difference in sex ratio must be found to account for the relatively greater resistance of guinea pigs to this infection. Of additional interest to us is that in guinea pigs, a stimulating infection with 2,500 larvae did not cause any change in sex ratios of the adult worm population following challenge. Stimulation with 2,500 larvae produced a weak immunity against reinfection with 20,000 larvae which is manifested by an earlier shift in the numbers of worms to the posterior gut (Lin and Olson, 1970). This shift was seen in this study for group IV animals as compared to group II (Table 2). Shift of sex ratio in favor of the male under unfavorable conditions has been reported for plant nematodes (Ellenby, 1954; Viglierchio and Croll, 1968) and *Trichinella spiralis* (Campbell and Cuckler, 1966; Denham, 1968).

The unbalanced sex ratio in favor of females as shown in the present study has been previously reported for nematodes. Sex ratios of less than 0.6 have been reported for adult

hookworms in man and cats (Hurley, 1959; De Carneri, 1963) and adult pig ascaris in pigs (Galvin, 1968). Gursch (1939) reported that the sex ratio of adult trichinella in the rat during the first 12 days of infection was 0.43; Podhajecky (1963, cited by Villella, 1970) and Thomas (1965) found it to be 0.45 and 0.34, respectively, in the first few days of infections in mice. Although several investigators (cited by Villella, 1970) did not find such striking sex differences for trichinella adults in rats and mice, females still in general dominated the adult worm population. Hemmert-Halswick and Bugge (cited by Gould, 1945) and Roth (1938) observed that the sex ratios of muscle larvae were 0.6 and 0.5, respectively. The data of Berntzen (1966) on the development of trichinella in vitro showed a sex ratio of 0.55 for larvae at 48 hr and 5 days after cultivation. The pathological implications of unbalanced sex ratios in this infection are not known. In this connection, Beaver et al. (1964) have evidence, in the case of adult hookworms, that when females outnumber males, more intestinal pathology occurs. These authors suggested that mating in the presence of unbalanced sex ratios may be a significant factor in the disease in dogs.

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Helminths of the Florida Duck, *Anas platyrhynchos fulvigula*[1]

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ABSTRACT: Thirty-four species of helminths were found in 78 Florida ducks (*Anas platyrhynchos fulvigula*) from Alachua and Glades counties, Florida. These included 12 species of trematodes, seven species of cestodes, 14 species of nematodes, and one species of acanthocephalan. Thirty-three of these are new host records. *Porrocaecum crassum* is recorded for the first time from North America and *Strongyloides* is reported for the second time from wild ducks. Seasonal peaks in the incidence of some trematodes and cestodes appeared to be correlated with rainfall and the food habits of the host.

The Florida duck, *Anas platyrhynchos fulvigula*, is a nonmigratory race of the mallard which occurs only in peninsular Florida from the latitude of Gainesville (Alachua County) southward, reaching its greatest abundance in the vicinity of Lake Okeechobee. Until recently the Florida duck has been considered either as a full species, *Anas fulvigula*, or as a race of the mottled duck of southern Texas and Louisiana. The mottled duck is now considered a separate subspecies, *Anas platyrhynchos maculosa* (Johnsgaard, 1961).

Because of the above-mentioned taxonomic changes and because the Florida duck has been introduced into several parts of Europe, it is difficult to evaluate the early literature reports of helminths from the Florida duck. The following appear to be valid: *Cotylurus flabelliformis* (Faust, 1917) by Dubois (1953); *Dicranotaenia coronula* (Dujardin, 1845) and *Drepanidotaenia lanceolata* (Bloch, 1782) by Fuhrmann (1932); *Retinometra longicirrosa* (Fuhrmann, 1906) by Fuhrmann (1908); *Diploposthe laevis* (Bloch, 1782) by Fuhrmann (1908) and Bezubik (1956); and *Avioserpens taiwana* (Sugimoto, 1919) by Wehr (1934).

This report deals with helminths collected from Florida ducks from north-central and south Florida.

Materials and Methods

Seventy-eight ducks were collected by shotgun from July 1970 through June 1971 from freshwater marshes in Alachua County (Paynes Prairie) and Glades County (Fisheating Creek Refuge and Game Management Area and Lake Okeechobee) located in north-central and south Florida, respectively. Some birds were examined within a few hours after death, but most were frozen and examined at a later date.

The gastrointestinal tract, heart, and trachea were opened and the contents washed through a 100-mesh sieve. The intestinal mucosa was either scraped or sprayed with water to remove *Strongyloides*. In 60 of the 78 ducks, the esophagus was teased apart under a dissecting microscope to detect *Capillaria*. Lungs, liver, and kidneys were teased and washed into the sieve before examination. Helminths were fixed and preserved for study by standard techniques. Nematodes were cleared and studied in lactophenol. Cestodes and small trematodes were stained with Harris' hematoxylin. Large trematodes were stained with Ehrlich's hematoxylin in acetic acid (Chubb, 1962).

Results and Discussion

Thirty-four species of helminths were recovered from the 78 ducks, none of which were free of helminths. These included 12 species of trematodes, seven species of cestodes, 14 species of nematodes, and one species of acanthocephalan. All except *Dicranotaenia coronula* are new host records for the Florida duck (Table 1).

Trematoda

Two species of blood flukes were found. *Trichobilharzia* sp. was found most often in

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Table 1. Helminths of 78 Florida ducks from Alachua and Glades counties, Florida.

Helminth	No. ducks infected	No. worms/duck Mean	(Range)
Trematoda			
Apatemon gracilis (4, 5)*	49	13	(1–61)
Echinoparyphium recurvatum (4, 5, 7)	44	35	(1–575)
Zygocotyle lunata (6)	36	3	(1–21)
Trichobilharzia sp. (12)	33	—	—
Typhlocoelum cucumerinum (9, 10, 11)	30	4	(1–20)
Echinostoma revolutum (5)	26	9	(1–53)
Dendritobilharzia pulverulenta (12)	17	2	(1–5)
Hypoderaeum conoideum (8)	6	14	(1–62)
Prosthogonimus ovatus (8)	5	2	(1–5)
Psilochasmus oxyurus (4)	5	11	(5–25)
Eucotyle wehri (13)	1	2	—
Levinseniella sp. (6)	1	1	—
Cestoda			
Cloacotaenia megalops (8)	38	3	(1–16)
Hymenolepis sp. (5)	21	4	(1–15)
Hymenolepis hopkinsi (5, 6)	13	20	(1–123)
Dicranotaenia coronula (5)†	10	23	(4–100)
Fimbriaria fasciolaris (5)	8	6	(1–30)
Diorchis bulbodes (5)	7	29	(2–100)
Sobolevicanthus filumferens (5)	4	17	(1–30)
Nematoda			
Epomidiostomum uncinatum (3)	47	4	(1–19)
Capillaria sp. (6)	47	3	(1–9)
Amidostomum acutum (3)	46	3	(1–16)
Porrocaecum crassum (3, 5)	40	4	(1–30)
Strongyloides sp. (4, 5, 6, 7, 8)	35	4	(1–19)
Tetrameres crami (2)	32	4	(1–13)
Tetrameres spp. (2)	25	3	(1–19)
Capillaria contorta (1)	23	3	(1–10)
Echinuria uncinata (2)	11	13	(1–106)
Spirurid larvae (1, 2)	9	2	(1–5)
Streptocara crassicauda (3)	4	1	(1)
Sciadiocara rugosa (3)	3	1	(1–2)
Unidentified filariids (10)	2	1	(1)
Hadjelia neglecta (3)	1	1	—
Acanthocephala			
Corynosoma sp. (5)	2	1	(1–2)

* Numbers in parentheses indicate location in the host: (1) esophagus, (2) proventriculus, (3) gizzard lining, (4) duodenum, (5) lower small intestine, (6) ceca, (7) large intestine, (8) cloaca, (9) trachea, (10) lungs, (11) air sacs, (12) blood vessels, (13) kidneys.
† Previously recorded from *A. p. fulvigula*.

association with the liver. These fragile flukes were fragmented by the screening technique, making accurate counts and species identification impossible. *Dendritobilharzia pulverulenta* (Braun, 1901) was usually found in small numbers in association with the kidneys.

Macko and Busa (1960) state that all cyclocoelid trematodes of the Anatidae belong to one morphologically variable species, *Typhlocoelum cucumerinum* (Rudolphi, 1809). Gravid worms of this species occurred in the trachea of the hosts and immature forms were found in the lungs and air sacs.

Psilochasmus oxyurus (Creplin, 1825) and *Levinseniella* sp. are trematodes associated with brackish water marshes. Infections of these species were found only in a sample of eight ducks from Lake Okeechobee, which has a higher salinity than other marshes in the area, but is not considered brackish. The salinity is high enough apparently to support the mollusks needed for the life cycles of these flukes.

Cestoda

Cloacotaenia megalops (Nitzch, 1829) was the most common cestode encountered and was found only in the cloaca. This species is a common and cosmopolitan parasite of ducks (McDonald, 1969).

An undescribed species of *Hymenolepis* characterized by a strobila 2 to 5 mm in length and a scolex bearing 10 hooks (length 81 μ) occurred commonly in the duodenum of the ducks.

Nematoda

Although McDonald (1969) states that *Strongyloides* species are rare or accidental in wild ducks, this may not actually be the case since these minute nematodes can be easily overlooked unless they are searched for specifically (Little, 1966). In this study a species of *Strongyloides* occurred in 35 ducks in all parts of the lower digestive tract. Although measurements of these worms fall within the range of *S. avium* Cram, 1929, species identification cannot be positive without culturing and examining the free-living adult forms.

Capillaria contorta (Creplin, 1839) was found in the esophageal mucosa of 23 ducks. The actual incidence of this nematode may have been somewhat higher since the tissue was not teased in the first 18 ducks examined. A second species of *Capillaria* occurred in the ceca and is characterized by the absence of caudal alae, a spiny spicule sheath, and a spicule length of 550 to 675 μ in the male, and a simple vulva in the female. This species does not appear to be any of the described capillarids of waterfowl and may be new.

Epomidiostomum uncinatum (Lundahl,

1848) and *Amidostomum acutum* (Lundahl, 1848), occurring under the Koilon lining of the gizzard, were the most comon nematodes encountered.

Porrocaecum crassum (Deslongchamps, 1824) is a common Eurasian parasite of ducks, but to our knowledge has not been previously reported from North America. Larval stages of this species were found under the Koilon lining and adults in the small intestine. In several cases, the worms had apparently perforated the intestine after death and migrated into other organs such as the lungs. Representative specimens of *P. crassum* have been deposited in the USDA Para. Coll. No. 66313.

Three species of *Tetrameres* appear to be represented in our sample. The first, with spicule lengths of 295 to 325 μ and 130 to 162 μ, compares closely with *Tetrameres crami* Swales, 1933, a common parasite of ducks. The second, with spicule lengths of 575 to 800 μ and 105 to 140 μ, appears to be an undescribed species. The third, with spicule lengths of 210 to 240 μ and 55 to 70 μ, is closest to *T. ryjikovi* Chuan, 1961, but differs from that species in the absence of a well-chitinized cloaca.

Spirurid larvae found in the esophagus and proventriculus resemble third-stage larvae of *T. crami* as figured by Swales (1936), but could possibly be larvae of the other four spirurids encountered in this study.

In three of 11 ducks infected with *Echinuria uncinata* (Rudolphi, 1819), the characteristic nodules caused by this species were large enough to nearly block the lumen of the proventriculus. The literature on mortality in waterfowl due to this pathogenic nematode was summarized by Cornwell (1963).

A new species of *Sciadiocara* found under the Koilon lining of three ducks has been described elsewhere (Schmidt and Kinsella, 1972). A single specimen of *Hadjelia neglecta*, originally described from a domestic duck in Brazil by Lent and Frietas (1939), was found in a duck from Glades County. This is the first record of this nematode since the original description.

Acanthocephala

Two ducks were infected with immature forms of *Corynosoma* sp. Further identification was impossible since the proboscis was retracted on all specimens.

Host–parasite relationships

Since much of the literature on the fauna of the mallard in North America is scattered in numerous taxonomic papers, it is difficult to make a direct comparison with the Florida duck. Twenty-six of the 34 helminths found in this study are listed by McDonald (1969) as previously reported from *Anas platyhrynchos*. A comparison of the intestinal helminths of *A. p. fulvigula* with surveys of *A. platyrhynchos* in Poland (Bezubik, 1956) and England (Avery, 1966) reveals that while the nematode and trematode fauna is similar, only three cestodes are shared (*Dicranotaenia coronula*, *Cloacotaenia megalops*, and *Fimbriaria fasciolaris*). In addition, the number of cestode species in the Florida duck is reduced in comparison to these areas.

Although the sample size was not large, some patterns of seasonal dynamics in the helminth fauna could be seen. The incidence of cestodes and trematodes which require a second intermediate host in their cycles (e.g., *Echinoparyphium*, *Echinostoma*, *Typhlocoelum*, and *Cloacotaenia*) increased through the summer months to reach a peak in November and then fell to their lowest point in February and March. This pattern may be correlated with the annual rainfall in the collection areas, which are characterized by cool, dry winters and warm, wet summers. Beckwith and Hosford (1957) studied the food habits of the Florida duck in Glades County and found that the amount of animal matter in the diet reached a peak in summer and declined to a trace in fall and winter. This would explain the low incidence (in late winter) of helminths whose life cycle depends upon the ingestion of an intermediate host.

Blood flukes and nematodes with a direct cycle (*Strongyloides*, *Epomidiostomum*, and *Amidostomum*) also reached a peak in fall and winter, but did not show a sharp decline in spring.

Buscher (1965) found that the cestode and trematode faunas of three migratory ducks in Manitoba increased through the summer months to a peak in August and then declined sharply

during the migration to Texas in the fall. Buscher speculated that this decrease in infection rate was due to the unfavorable conditions of migration and the absence or limitation of new infection during migration. The continued increase of trematode and cestode infections in the fall in the nonmigratory Florida duck supports this theory. The Florida duck may act as a reservoir host for winter infections of such ducks as the mallard and black duck, which migrate to this area.

Acknowledgments

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Calcareous Corpuscles of *Glaridacris laruei* (Lamont) (Cestoidea: Caryophyllidea)

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ABSTRACT: Calcareous corpuscles, as demonstrated by alizarin red S, calcium red, and sodium rhodizonate, and by isolation techniques, are present in the monozoic tapeworm, *G. laruei*. These corpuscles are conspicuously smaller than and not as numerous as those from the cysticerci of *Taenia pisiformis*. While the greatest concentration is in the neck the greatest percentage occurred in the testicular region; their distribution in two gravid specimens is tabulated. Photographs illustrating the differences in size, spatial relationship to each other, and lamellar structure of corpuscles are presented. This is the first conclusive report that calcareous corpuscles are present in caryophyllidean cestodes.

Calcaereous corpuscles are conspicuous elements of the larval and adult stages of most cestodes (von Brand, 1966). These intracellular deposits of inorganic (chiefly calcium) and organic components have been demonstrated in a number of species of Cyclophyllidea and Pesudophyllidea by histochemical and isolation techniques (von Brand et al., 1960, 1967; Chowdhury et al., 1962; Nieland and von Brand, 1969; Waitz, 1963). They are readily seen in the plerocercoids of various species of *Diphyllobothrium* (Kuhlow, 1953). Furthermore, they have also been observed in the spathebothriids *Spathobothrium* (Yamaguti, 1943) and *Cyanthocephalus* (Wiśniewski, 1932), and in the cestodarians *Gyrocotyle* and *Amphilina* (Schneider, 1884). Von Brand et al. (1969), using isolation techniques, were unable to verify the presence of calcareous corpuscles in the latter two genera, however.

Despite the detailed anatomical studies of mature *Caryophyllaeus* by Will (1893), of *Archigetes* by Wiśniewski (1930), of various species by Hunter (1930), and descriptions of approximately 80 other species, the status of calcareous corpuscles in caryophyllidean cestodes remains confused. They are recorded as absent from *Archigetes* and *Caryophyllaeus* by Leuckart (1878), *Glaridacris catostomi* by Cooper (1920), *Balanotaenia bancrofti* by Johnston (1924), and the caryophyllideans as a group by Woodland (1923) and Subramanian (1939). On the other hand, Schneider (1884) and Zschokke (1884) reported them present in *Caryophyllaeus mutabilis* (= *C. laticeps*). The purpose of the present study, therefore is to reexamine the question of calcareous corpuscles in caryophyllids by using *Glaridacris laruei*, an intestinal parasite of the white sucker, *Catostomus commersoni*.

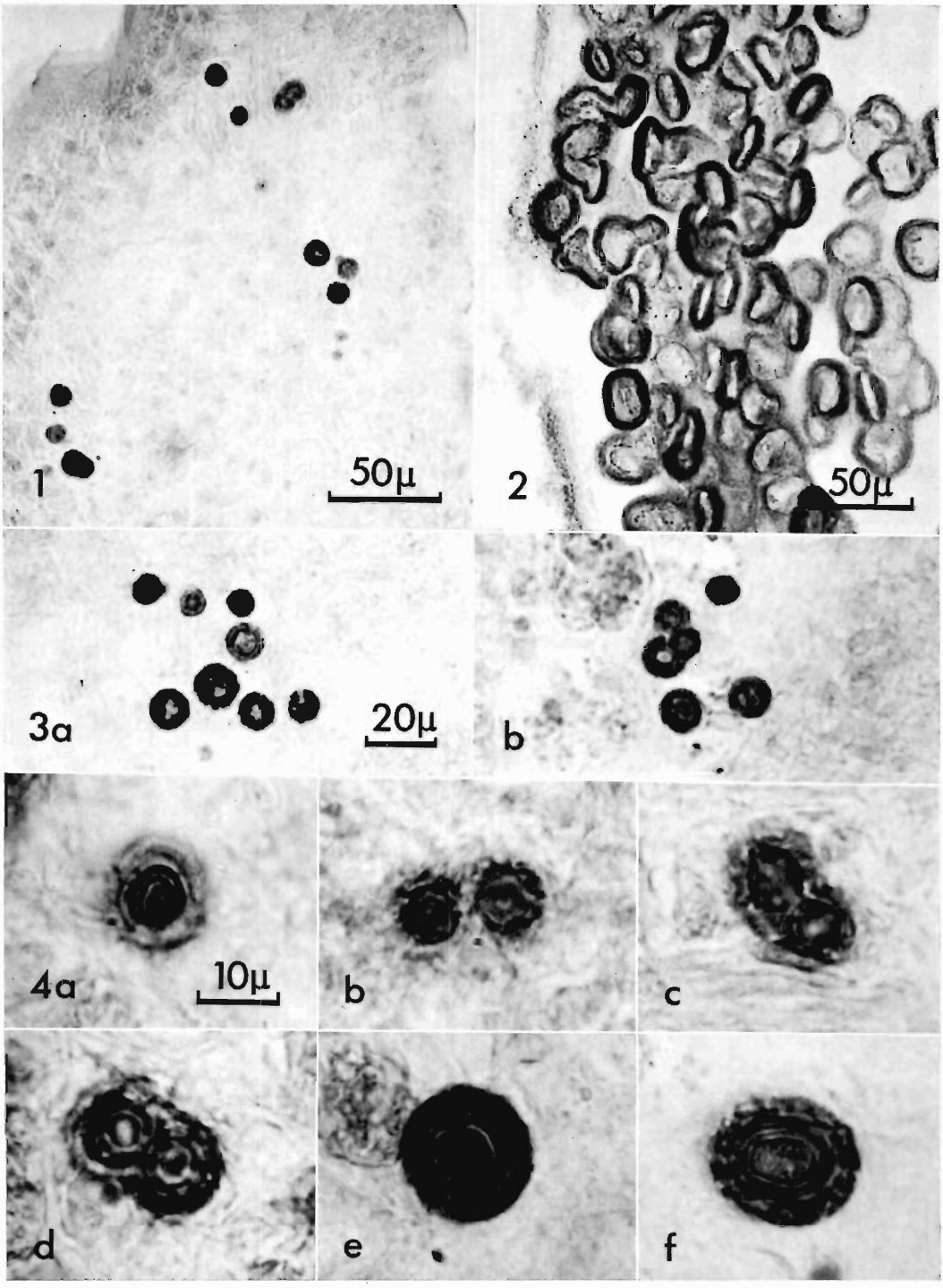
Materials and Methods

Gravid specimens of *Glaridacris laruei* (Lamont, 1921) were collected from the posterior intestine of freshly killed *Catostomus commersoni* (Lacépède) from Raquette Lake (Hamilton County), New York, in October of 1969 and 1970. *Taenia pisiformis* (Bloch) cysticerci from the viscera of the eastern cottontail, *Sylvilagus floridanus* (Allen), were used as controls.

All specimens were fixed in either absolute ethanol (von Brand et al., 1960) or ethanol–formalin (McGee-Russell, 1958), adjusted to a pH of 7.1 to 7.3 with 10% NaOH. Fixation of *G. laruei* was carried out at ambient temperature (0 to 5 C) and specimens were refrigerated until processed.

Specimens for the isolation of calcareous corpuscles were treated according to the methods of von Brand et al. (1960). The washed sediment was placed on a slide and stained with alizarin red S.

All other specimens were embedded in paraplast (Fisher Scientific) and sectioned at 5 to 10 μ; hydration and dehydration were according to McGee-Russell (1958). Hydration of sections was also accomplished using a xylene and a 100% 2-propanol step of two changes of 5 min each before the final step in distilled water. This latter method was eventually adopted as it required less time and



gave results comparable to the former method. Sections were mounted in Kleermount (Carolina Biological).

The following histochemical dyes were used to test for calcium localizations according to the methods of McGee-Russell (1958) and von Brand et al. (1960): alizarin red S (Allied Chemical Co., No. 58005), calcium red (Gurr, London, No. 3569), and sodium rhodizonate (British Drug House, No. 685364/540208). Sections were stained for 1 to 3 min with alizarin red S and calcium red, and 60 min with sodium rhodizonate.

As a control for nonspecific staining, sections were decalcified with either acetate buffer (pH 4.3 to 4.5) or 10% HCl for 20 min according to the methods of von Brand et al. (1960) and Chowdhury et al. (1955).

As a general stain for acidic protein, sections were exposed to a solution of 0.1% fast green dissolved in McIlvaine's citric acid phosphate buffer (0.1 M, pH 4) for 30 min.

The presence of nucleic acids was detected using a solution of methyl green–pyronin (0.5 g methyl green, 0.2 g pyronin Y, dissolved in 100 cc of distilled water at 80 C and cooled and filtered before use) for 30 min.

Specimens used for the distribution of calcareous corpuscles were serially sectioned and treated with alizarin red S. Direct counts were made in each of the following regions: scolex, from the anterior tip of the scolex to its junction with the neck; neck, from the base of the scolex to the most anterior testis; testicular region, from the anterior to posterior testis; and posttesticular region, from the posterior testis to the posterior tip of the worm. Except for the scolex, each of the other regions was further subdivided into an inner medullary and outer cortical parenchyma separated from each other by the inner longitudinal muscles.

The assistance of the New York Environmental Conservation Department in obtaining hosts, of Dr. Samuel McGee-Russell in obtaining some of the stains and interpreting the calcium staining reactions, and of Dr. Florian Muckenthaler for instruction in using the methyl green–pyronin technique and hydration procedures, is gratefully acknowledged.

Results

Small structures in the parenchyma of *G. laruei* were stained by the histochemical procedures for calcium localizations before but not after pretreatment with an acidic solution. They were also stained by methyl green and fast green indicating the presence of a highly polymerized nucleic acid moiety and protein moiety, respectively. When observed under phase contrast or oil immersion (Figs. 4a–f), these structures appeared to be similar to the calcareous corpuscles of *T. taeniaeformis*, i.e., with concentric rings as demonstrated by von Brand et al. (1960). Furthermore, isolation procedures for calcareous corpuscles yielded a washed sediment from *G. laruei* that was primarily composed of these structures. On the basis of histochemical tests and other observations, it would thus appear that these small structures are indeed calcareous corpuscles.

Calcareous corpuscles of *G. laruei* are much less numerous and are smaller than those from *T. pisiformis* cysticerci (Figs. 1, 2); 17 from different parts of *G. laruei* were from 6.3 to 18 μ in greatest diameter while those of *T. pisiformis* ranged from 19 to 36 μ ($N = 19$). They are round to oval (Figs. 4e, f) and many of various sizes exhibited a conspicuous lamellar structure (Figs. 4a, d–f). While most of them appeared as single corpuscles, some were adjacent to each other (Fig. 4b) or joined to form double structures (Figs. 4c, d). Clusters of corpuscles of various sizes appeared more common in the scolex and neck (Figs. 1, 3a); some clusters occurred near vitelline follicles, however (Fig. 3b).

←

Figures 1–4f. Calcareous corpuscles of *Glaridacris laruei*, except as indicated; stained with alizarin red and photographed using a green filter. 1. Portion of neck and scolex showing general distribution of corpuscles. 2. Corpuscles from cysticercus of *Taenia pisiformis*. 3. a. Cluster of corpuscles in neck, b. cluster near two vitelline follicles. 4a–f. Oil immersion photographs illustrating the differences in size, relationship to each other, and lamellar structure of corpuscles.

Table 1. Number and per cent (in parentheses) of calcareous corpuscles in indicated regions of gravid *Glaridacris laruei*.

Length (mm)	Region							
		Neck		Testicular		Posttesticular		
	Scolex	M*	C†	M	C	M	C	Totals
9	16 (19)	5 (6)	3 (3.6)	46 (55)	1 (1.2)	10 (12)	3 (3.6)	84
11	21 (5.3)	123 (31)	1 (0.3)	181 (45.5)	25 (6.3)	39 (9.8)	8 (2)	398
Totals	37 (7.7)	128 (27)	4 (0.8)	227 (47)	26 (5.4)	49 (10)	11 (2.3)	482

* Medullary parenchyma.
† Cortical parenchyma.

Although serial sections were made of a number of worms, sections of only two were complete enough to allow for distributional counts (Table 1). Calcareous corpuscles were present in all regions of *G. laruei* with greatest proportion in the medullary parenchyma of the extensive testicular region. That they were more common in the medullary than cortical parenchyma was also evident from scattered sections of four other gravid worms ranging in length from 13 to 19 mm. No corpuscles were found in the testis, vitellaria, ovary, or uterine glands.

Discussion

Calcareous corpuscles, demonstrable by both histochemical and isolation techniques, were found in *G. laruei*. Results with fast green and methyl green–pyronin procedures indicate that like those of some cyclophyllidean cestodes (Chowdhury et al., 1960; Waitz, 1963), the corpuscles contain protein and nucleic acid. These corpuscles are conspicuously smaller and not as abundant as those of *T. pisiformis* cysticerci (Figs. 1, 2). In size they are closer to those of the cyclophyllidean *Inermicapsifer madagascariensis* as recently reported by Swiderski et al. (1970).

The distributional pattern shown in Table 1 indicates a considerable variation in the number of corpuscles per worm. Furthermore, they were generally more common in the medullary than in the cortical parenchyma (Table 1). This pattern is thus like that in the anterior segments of *T. taeniaeformis* (Figs. 1, 2 of Nieland and von Brand, 1969). On the other hand, Chowdhury et al. (1962) found more corpuscles in the cortical parenchyma of *T. saginata*, but unfortunately they failed to indicate from what part of the strobila the proglottids had been taken. Many more corpuscles were found in the cortical than in the medullary parenchyma of pleroceroids of *D. latum*, judging from figure 9 of Kuhlow (1953); this did not appear to be the case with other species of *Diphyllobothrium*, however. These data would suggest, therefore, that the distribution of calcareous corpuscles within the parenchyma may vary greatly from species to species.

There is also considerable variation in the number of corpuscles in different regions of *G. laruei*. The greatest number of corpuscles was found in the 55 to 65% portion of the cestode forming the testicular region while the greatest concentration was generally in the 5 to 10% portion forming the neck. In comparing the distribution of corpuscles along the strobila of *T. taeniaeformis*, von Brand et al. (1960) found that on a weight basis there was no gradient from anterior to middle to gravid regions. However, because the larger gravid proglottids contained more corpuscles than the smaller, middle ones did, von Brand et al. (1960: 208) concluded that, "This observation seems to indicate that the deposition of calcareous corpuscles rather closely parallels the formation of new living tissue." While it is not known how a caryophyllid grows, i.e., whether there is a zone of proliferation in the neck as is characteristic of strobilate tapeworms or whether growth is diffuse, studies by Hunter (1930) and Amin (1969) on the growth of two species of caryophyllids showed that the greatest increase in length (growth) occurred behind the neck. The fact that 65%

of the corpuscles of two gravid *G. laruei* occurred below the neck suggests that their formation in monozoic tapeworms may also be associated with the formation of new tissue. No histological zone of proliferation has been described for the neck or any other parts of caryophyllids, yet the apparent increased concentration of calcareous corpuscles in the neck suggests that this region may be physiologically different from other parts of the tapeworm.

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Survival and Development of *Leucochloridiomorpha constantiae* (Trematoda) in the Chick Coelom[1]

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ABSTRACT: To determine the adaptability of *Leucochloridiomorpha constantiae* to a nonintestinal site, metacercariae and adults were surgically implanted into the chick coelom. Sixteen (44.4%) of 36 implanted adults and 42 (24.0%) of 175 implanted metacercariae were recovered live on various surfaces of the viscera from 18 hr to 15 days postimplantation. Crural contents varied and consisted of transparent or refractile material in worms recovered from the peritoneum or adipose tissue and dark-brown material in those obtained from the liver. Metacercariae became ovigerous in the coelom within 4 days and by 10 days contained amber eggs with fully developed pear-shaped miracidia.

Although the small intestine of the raccoon, *Procyon l. lotor*, has been experimentally infected with *Leucochloridiomorpha constantiae* (Mueller, 1935), in naturally or experimentally infected birds this parasite appears to live exclusively in the bursa of Fabricius (Gower, 1938; Allison, 1943). To determine the adaptability of *L. constantiae* to nonintestinal sites, adults and metacercariae were implanted into the chick coelom and results are reported herein.

Materials and Methods

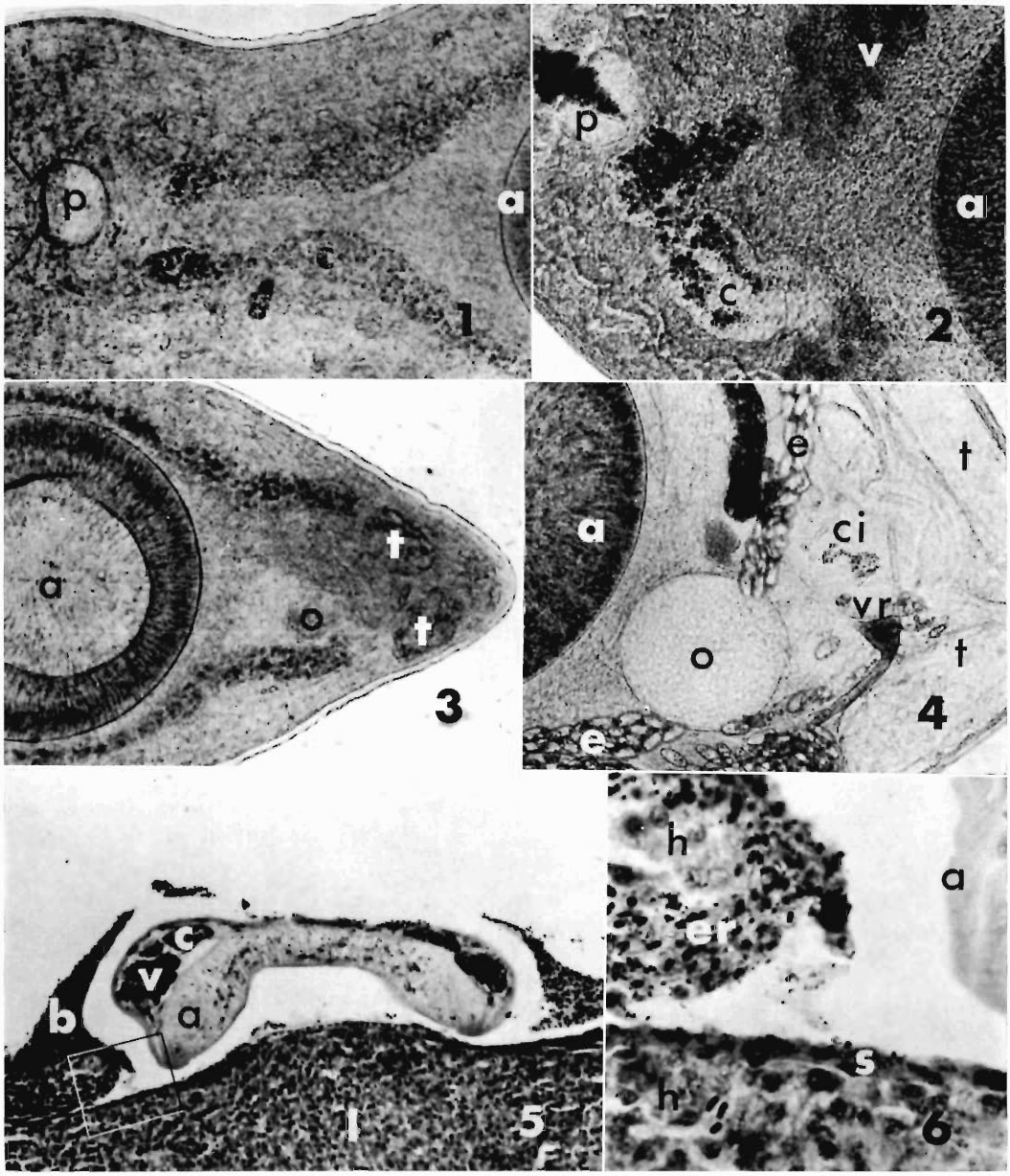
Adults, 14 to 21 days old, obtained from the bursa of Fabricius of chicks previously infected with metacercariae by the "cloacal drop" method of Allison (1943), and metacercariae dissected from the uteri of *Campeloma decisum* snails (Fried and Harris, 1971) were washed in three changes of Locke's (Paul, 1960) solution prior to coelomic implantation into uninfected 7-day-old white Leghorn chicks. Recipient chicks were starved overnight prior to surgery, anesthetized with Equi-Thesin (Fried and Berry, 1961), and a 1-cm incision was made through the ventral body wall behind the sternum. Each chick received either six adults or 25 metacercariae pipetted into the coelom in a drop of Locke's. The incision was sutured with cotton thread and chicks were necropsied from 18 hr to 15 days postimplantation. Most flukes recovered from the coelom were examined live under light coverslip pressure (Figs. 2, 4). An *in situ* preparation of a 2-week-old coelomic fluke attached to the serosa of the liver was prepared as paraffin sections fixed in AFA and stained with Heidenhain's iron alum hematoxylin (Figs. 5, 6).

Results

Sixteen (44.4%) of 36 implanted adults were recovered live from the coelom between 18 hr and 15 days postimplantation. Worms were attached by their acetabula to the liver serosa, peritoneum, pericardium, adipose tissue, and intestinal and air sac surfaces. Four days after implantation adults still contained sperms in the seminal receptacle and eggs with fully developed miracidia. The fact that adult implants were live and looked essentially like bursal worms led to studies with metacercariae.

Forty-two (24.0%) of 175 implanted metacercariae were recovered live on various surfaces of the viscera from 3 to 14 days postimplantaion. Egg development was first seen in 4-day-old worms, sperms were present in the seminal receptacle, and except for a day lag in development these worms appeared essentially as those observed in the bursa (Allison, 1943; Fried and Harris, 1971). Seven-day-old worms recovered from the surface of the liver contained hepatic cells in the crura and eggs with well-developed embryos (Figs. 2, 4). Ten-day-old worms contained amber eggs with fully developed pear-shaped miracidia. Crural contents varied and consisted of transparent or refractile material in worms recovered from the peritoneum or adipose tissue, and dark-brown material in those obtained from the liver.

[1] Supported in part by a research grant from the Lafayette College Committee on Advanced Study and Research.



Figures 1–6. Development of *L. constantiae* in the chick coelom. Abbreviations: (a) acetabulum, (b) blood clot, (c) crura, (ci) cirrus, (e) eggs, (er) erythrocytes, (h) hepatic cells, (l) liver, (o) ovary, (p) pharynx, (s) serosa of the liver, (t) testis, (v) vitellaria, (vr) vitelline reservoir. 1. Anterior aspect of live metacercaria stained intravitally with neutral red. 2. Anterior aspect of an adult 7 days after metacercarial inoculation into the coelom. Note liver tissue in the pharynx and crura of this fluke which was recovered from the liver surface. 3. Posterior aspect of metacercaria seen in Figure 1. 4. Posterior aspect of fluke seen in Figure 2. 5. *In situ* histologic preparation of metacercaria cultivated for 2 weeks in the coelom and recovered on the liver surface. Note blood clot associated with the fluke. 6. Enlarged view of bracketed area in Figure 5.

Sections of a 2-week-old coelomic worm attached to the liver revealed the presence of a clot containing erythrocytes and some entrapped hepatic cells (Figs. 5, 6).

Discussion

L. constantiae metacercariae contain genital primordia (Mueller, 1935; Fig. 3), and Allison (1943) reported lipoidal material in the crura. Unpublished studies on cryostat sections of metacercariae stained with Oil Red O (Lillie, 1944) have confirmed Allison's findings. Although further studies are needed to elucidate differences in the ingesta of metacercariae and adults this fluke appears nonspecific in its feeding habits, ingesting blood, columnar epithelium, and lymphoidal follicles in the bursa (Fried and Lang, 1971) and at least hepatic and peritoneal tissue in the coelom.

Gross observations on metacercariae cultivated for 10 days in the chick coelom indicate that such worms appear morphologically similar to 7-day-old bursal worms obtained from double-worm infections in chicks (Fried and Harris, 1971). Further studies are needed to determine why the chick coelom is suitable for the cultivation of this fluke. Other coelomic implantation studies on hermaphroditic digenes revealed nonsurvival of gorgoderids in the frog coelom (Goodchild, 1954, 1955) and philophthalmids in the chick coelom (Fried, 1964), survival of adult *Fasciola hepatica* and adults of *Paragonimus westermani* and *P. ohirai* in the rat coelom (Lienert, 1959; Ōmura, 1960), suboptimal development of *Echinostoma revolutum* in the chick coelom (Fried and Fink, 1968), and sexual maturation of *Clinostomum complanatum* in the mouse coelom (Dowsett and Lubinsky, 1966).

Acknowledgments

The authors are grateful to Mr. Kevin R. Harris, Institute for Pathobiology, Lehigh University, Bethlehem, Pa., for the use of unpublished material on the histochemistry of *Leucochloridiomorpha constantiae*.

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A Review of the Status of the Trematode Genera *Lechriorchis* Stafford, 1905, and *Zeugorchis* Stafford, 1905 (Digenea: Plagiorchiidae)

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ABSTRACT: It was proposed, and supporting evidence offered, that the genus *Zeugorchis* Stafford, 1905, be considered a synonym of *Lechriorchis* Stafford, 1905. Taxonomic revisions at the species level were made; the genus *Lechriorchis* is now represented by *L. primus* Stafford, 1905, *L. megasorchis* (Crow, 1913), *L. aequatus* (Stafford, 1905), and *L. boscii* (Cobbold, 1859).

Stafford (1905) described two genera of trematodes, *Lechriorchis* and *Zeugorchis*, from snakes in Canada. *Lechriorchis primus* and *Zeugorchis aequatus* were designated the type species of their respective genera. *L. primus* was recovered from the lung and *Z. aequatus* from the esophagus and stomach of the garter snake, *Thamnophis sirtalis* L.

Nicoll (1911) and Talbot (1934) stated that Stafford did not adequately describe either genus. Nicoll revised the generic diagnosis of *Lechriorchis*, redefining the position of the genital pore as midway between the edge of the body and the pharynx, rather than close behind the intestinal bifurcation. His revision also stated that the intestinal diverticula extended a short distance beyond the testes. He also noted that a well-developed metraterm was present. This redefinition of the genus was not accepted by subsequent workers since it excluded the type species, *L. primus*.

Based on his 1911 revision Nicoll (1914) described the genus *Mediorima* which he considered to be closely related to *Lechriorchis*. He stated that *Mediorima* differed from *Lechriorchis* only in that the position of the genital pore was posterior to the intestinal bifurcation. Since the genital pore in *Lechriorchis* was originally described as medially and postbifurcal and Nicoll's original suggestion was not accepted by subsequent workers, *Mediorima* is now considered a synonym of *Lechriorchis*.

Talbot (1934), in attempting to differentiate the two genera, considered the intestinal ceca the most important generic character of *Lechriorchis*. He stated, "The intestinal ceca of the members of this genus may reach only to the testes or they may be clasped between them, but in either case their ends definitely turn toward the center of the body which is a characteristic not found in the members of any other genera of the Reniferinae." He further stated that the most important diagnostic character of the genus *Zeugorchis* was the metraterm, noting that it was much longer and more muscular than in *Lechriorchis* and contained numerous glands.

Price (1935, 1936) redefined the two genera on the basis of their respective types. Byrd and Denton (1938) reviewed the characters of the two genera and stated that *Zeugorchis* should be characterized by two prominent features, the position of the genital pore and the testes located in the posterior fourth of the body.

These workers proposed a new genus, *Paralechriorchis*, based on two morphological features. The species of this genus differed from closely related genera in the presence of a short, stout cirrus sac that extended from acetabulum to the genital pore and the presence of a well-developed and muscular metraterm that equaled the cirrus sac in length. Yamaguti (1958) considered *Paralechriorchis* a synonym of *Zeugorchis*.

The intent of this paper is to demonstrate that there are insufficient criteria for considering *Lechriorchis* and *Zeugorchis* discrete genera.

Materials and Methods

The present material consisted of 100 carefully measured specimens selected at random

Table 1. Comparison of Z. *aequatus* and L. *primus* and the present material.

	Z. *aequatus*	L. *primus*	Present material
Body			
Length	1.9–2.29	4.9–5.5	3.04–7.90 (5.54)
Width	0.61–0.63	1.4–1.9	0.87–2.28 (1.66)
Oral sucker			
Length	0.225	0.39–0.51	0.33–0.59 (0.46)
Width	0.24	0.39–0.47	0.32–0.59 (0.48)
Acetabulum			
Length		0.63–0.68	0.32–0.65 (0.48)
Width	0.18–0.22	0.63–0.78	0.30–0.62 (0.47)
Pharynx			
Length	0.13	0.2	0.15–0.31 (0.24)
Width		0.185	0.19–0.33 (0.24)
Ovary			
Length	0.170	0.17–0.2	0.14–0.48 (0.35)
Width	0.170		0.11–0.47 (0.29)
Testis (anterior)			
Length	0.270	0.56–0.72	0.26–1.65 (0.87)
Width	0.170	0.35	0.19–0.64 (0.47)
Testis (posterior)			
Length	0.425		0.31–1.55 (0.86)
Width	0.120		0.17–0.68 (0.48)
Cirrus pouch			
Length		1.0	0.49–1.30 (0.87)
Width		0.34	0.20–0.46 (0.20)
Egg			
Length	0.048–0.044	0.052–0.055	0.027–0.045 (0.038)
Width	0.022–0.024	0.024–0.029	0.013–0.025 (0.018)

from an infection of several hundred from one water snake, *Natrix sipedon sipedon* L. Material from other infected snakes was also used to determine variability of characters not measurable as was the type material from the United States National Museum Helminth Collection.

The numerical data appear in Table 1. All measurements are in millimeters unless otherwise indicated. Numbers in parentheses are averages.

Discussion

Talbot (1934), in considering the intestinal ceca the most important generic character of *Lechriorchis*, was dealing with extremely variable structures. He stated that the cecal ends may very in length but they definitely turn toward the center of the body. Cecal length in the present material ranged from the anterior testicular margin to slightly posterior to the testes. The ends turned medially in 33, coursed laterally in 55, were ventral to the testes in five, and seven specimens had one cecum turned medially and one laterally. He further stated that the most important diagnostic character of the genus *Zeugorchis* was the metraterm, noting that it was much longer and more muscular than in *Lechriorchis*. This organ, in the present material, ranged in length from 0.2 to 1.43 with an average of 0.76 (Table 1) which was from one-fourth to slightly longer than the cirrus sac. In a separate publication (1933) he described the genus *Caudorchis* which was later considered a synonym of *Zeugorchis* by Price (1936).

Price (1935, 1936), in redefining the two genera, pointed out differences in the size of the body, suckers, cirrus sac, testes, and eggs. *Lechriorchis primus*, the type species, was consistently larger than *Zeugorchis aequatus*. The most conspicuous differences, other than general body size, were the position of the testes and the extent of the cirrus sac. He stated that the cirrus sac of *Zeugorchis* was slightly oblique to the long axis of the body with its base posterior to the acetabulum, while the cirrus sac of *Lechriorchis* had its base at the level of the midline of the acetabulum. Material used in the present study varied considerably, four specimens had the cirrus sac extending and overlapping the upper right margin of the acetabulum, 15 overlapping the upper right quadrant, while 29 had the cirrus sac extending posterior to the acetabulum. The remaining 52 terminated in the posterior right quadrant of the acetabulum. Cirrus sac length ranged from 0.49 to 1.3 with an average of 0.87 (Table 1). Cirrus sac length and extent are too variable to be reliable generic characters.

The testes of *Zeugorchis* were said to be near the posterior end while those of *Lechriorchis* were in the middle third of the body. Sumwalt (1926), in her description of Z. *syntomentera*, figured and commented on the

fact that the testes of young worms were near the posterior end of the body while in older worms they tended to be in the middle third.

The two morphological features used by Byrd and Denton (1938) appear to be too variable to be reliable generic characters. The position of the genital pore is quite variable as evidenced by the present material. Thirty-eight specimens had the genital pore located medially at, or slightly posterior to, the cecal bifurcation, 26 had the pore situated postbifurcal and to the right of the body midline, 36 had the pore ventral to, or to the outside of, the intestinal ceca.

It would appear that characters as variable as the aforementioned are poor features upon which to base a generic diagnosis. Characters such as cirrus sac length and position relative to the acetabulum, relative position of the cecal ends, and position of the genital pore, within limits, might vary as a result of differences in fixing procedures. The position of the testes is a function of worm age.

Based on the above data there appear to be insufficient criteria for separating these two genera. Since *Lechriorchis* has priority it is proposed that *Zeugorchis* be considered a synonym of *Lechriorchis*. The latter is emended as follows.

Lechriorchis Stafford, 1905, emend.

With the characters of the subfamily Styphlodorinae. Body dorsoventrally flattened, elongate. Body spinulate. Oral sucker subterminal, well developed. Phraynx moderate to well developed. Acetabulum in anterior half of body; slightly larger than oral sucker. Esophagus moderate in length. Intestinal cecae may extend to or beyond testes, terminal portion turning either medially or laterally. Testes opposite or oblique, may be lobed or smooth. Cirrus pouch with base at anterior right margin of acetabulum, or ranging slightly beyond the posterior right half; enclosing seminal vesicle, prostatic complex, and a protrusible cirrus. Genital pore in region of cecal bifurcation and anterior margin of acetabulum, median or submedian, often ventral to intestinal ceca. Ovary dorsodextral or median to posterior margin of acetabulum, pretesticular, anterior half may overlap acetabulum. Uterus intercecal, reaching to posterior extremity, ascending and descending limb passing between testes, ascending limb may or may not be greatly distended. Metraterm well developed, length variable, half to full length of cirrus pouch. Vitellaria lateral, may or may not extend the full length of the cecae. Excretory stem bifurcating behind acetabulum into short arms. Parasitic in lung, alimentary canal, or uterus of snakes.

Yamaguti (1958) lists nine species in the genus *Lechriorchis*; of these six have been subsequently considered synonyms of some other taxon. Byrd and Denton (1938) considered *L. secundus* a synonym of *Zeugorchis natricis*. Dubois and Mahon (1959) proposed that *L. abduscens* and *L. inermis* be considered synonymous with *Ochetosoma elongatum* and *L. insignis* and *L. proprius* with *L. megasorchis* and *L. tygarti* with *L. primus*. These alterations left three species in the genus: *L. primus*, *L. plesientera*, and *L. megasorchis*.

Sumwalt (1926), in describing *L. plesientera*, stated, "It is conceivable that in the event of a more detailed description of the type species, *L. primus*, *L. plesientera* may prove to be identical with it." With redescriptions of *L. primus*, increased knowledge of the variability of specific characters, and a careful study of the type material involved, it seems likely that both authors have described the same worm and *L. plesientera* should become a synonym of *L. primus*.

This leaves two species, *L. primus* and *L. megasorchis*, to be considered. It appears that they are distinct species in spite of the variability of the characters used to separate them. The testes in a 5-mm *L. megasorchis* measured 0.98 by 0.61 compared to 0.5 by 0.35 for a specimen of *L. primus* 7 mm in length. The ovary in a worm the same size is approximately twice as large as that of a 7-mm *L. primus*. The eggs of *L. megasorchis* are smaller, 0.031 by 0.016, than those of *L. primus*, 0.053 by 0.034.

On close examination it apears that many of the species now assigned to the genus *Zeugorchis* are conspecific with previously described forms. The differences between *L. aequatus* (= *Z. aequatus*) and *Z. snytomentera* as described by Sumwalt (1926) are so slight and variable that one cannot distinguish

between the two. Sumwalt in her description stated, "The differences between *Z. syntomentera* and the type (*Z. aequatus*) species are so slight that if the latter should be more adequately described the former may prove to be identical to it."

Parker (1941) described *Paralechriorchis syntomenteroides* which was subsequently transferred to the genus *Zeugorchis*. He distinguished this species from *Z. syntomentera* by its proportionally larger acetabulum, longer cirrus sac, larger testes and ovary, larger pharynx, and more posterior vitellaria. These are extremely variable characters and the magnitude of the differences are so small that they are more probably due to fixation or intraspecific variation. Since *Z. syntomentera* has been considered conspecific with *L. aequatus* above, it is proposed that *Z. syntomenteroides* be considered a synonym of *L. aequatus*.

L. megasorchis and *Z. natricis* are very similar morphologically. The difference in testes size is probably the most striking variation, 0.98 by 0.61 for *L. megasorchis* and 0.46 by 0.47 for *Z. natricis*. Measurements from 100 specimens in the present study (Table 1) show a size range of 0.26 to 1.65 (0.87) for testes length and 0.19 to 0.64 (0.47) for width. The present material varied sufficiently to encompass all of the morphological differences used to distinguish these two species. Based on these data it is proposed that *Z. natricis* be considered a synonym of *L. megasorchis*.

Stewart (1960) described *Z. megacystis* based on characters which are known to be variable and not reliable at the specific level. She considered a difference of 0.1 in body length a sufficient criterion to differentiate *Z. megacystis* from *Z. eurinus*. She used other variable characters as the position of the genital pore and sucker ratios to distinguish this species. These characters are easily influenced by the state of contraction at fixing and the method of fixation and cannot be considered reliable specific characters. It is proposed that *Z. megacystis* be considered a synonym of *L. aequatus*.

There appears to be no significant difference in *Z. eurinus* (Talbot, 1933) and those forms which, above, have been considered conspecific with *L. aequatus*. This species was differentiated from other forms on the same variable characters.

Based on the above discussion those forms which were considered members of the genus *Zeugorchis* are all reduced to synonymy except *Z. aequatus* and *Z. boscii*. *Z. boscii* is a poorly described taxon and cannot be dealt with because of the lack of information concerning this form.

Since *Zeugorchis* was considered above to be congeneric with *Lechriorchis*, the two species remaining in the original taxon should be *L. aequatus* (Stafford, 1905) and *L. boscii* (Cobbold, 1859). These along with *L. primus* Stafford, 1905, and *L. megasorchis* (Crow, 1913) represent the genus as emended.

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Nematode Parasites of Oceanica. XVIII. *Caenorhabditis avicola* sp. n. (Rhabditidae) Found in a Bird from Taiwan[1]

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ABSTRACT: *Caenorhabditis avicola* sp. n. is described from one male and three female nematodes from the intestine of a plumbeous water redstart, *Rhyacornis fuliginosus* (Passeriformes, Turdidae), from Taiwan. It is characterized by the extension of the anterior margins of the peloderan bursa into sharp points, giving the male posterior end an arrowheadlike shape in ventral view, and by the spicules, which are 95 μ long. It is postulated that the worms were pseudoparasites, possibly symbionts of an insect ingested by the bird.

This paper is based on specimens collected in February 1959 by the second author and his associates of Naval Medical Research Unit No. 2 during field operations in Taiwan. They were killed in hot alcohol and stored in 70% alcohol and glycerine. Clearing for study was by dehydration in glycerine. All measurements are in microns unless otherwise indicated.

Caenorhabditis avicola sp. n.

One male and three females were found in the intestine of a plumbeous water redstart near Chien-shih, Hsin-chu Hsien. These specimens differ markedly from known species and form the basis for the following description.

Description

Body very small, delicate. Mouth (Fig. 1) surrounded by six rudimentary lips, each with a single, inconspicuous papilla. Four cephalic papillae present at same level as amphids. Stoma (Fig. 2) cylindrical, sclerotized, with three-lobed glottoid apparatus; each lobe bears two needlelike anteriorly directed teeth. The esophageal cuff is short. Esophagus muscular, with anterior corpus, median pseudobulb, slender isthmus and terminal, valvulated bulb. Nerve ring near center of isthmus. Excretory pore slightly anterior to level of terminal bulb.

MALE: 720 long, 30 greatest width. Stoma 16 long. Nerve ring 120, excretory pore 130, pseudobulb 80 from anterior end. Pseudobulb 15 long, 15 wide. Terminal bulb 20 long, 20 wide. Total length of esophagus 150. Tail (Figs. 3–5) 80 long; genital cone sclerotized. Bursa peloderan, 130 long with pedunculate papillae arranged as follows: three pairs preanal with middle pair shortest; three pair postanal, followed after a space by three more pairs; for a total of nine pairs. Tail spike slender. Spicules not fused, simple, equal, 95 long. Gubernaculum slender, simple, 70 long.

FEMALE: 1.1–1.28 mm long, 50–60 greatest width. Stoma 16 long. Nerve ring 113–125, excretory pore 140–165, pseudobulb 80–85

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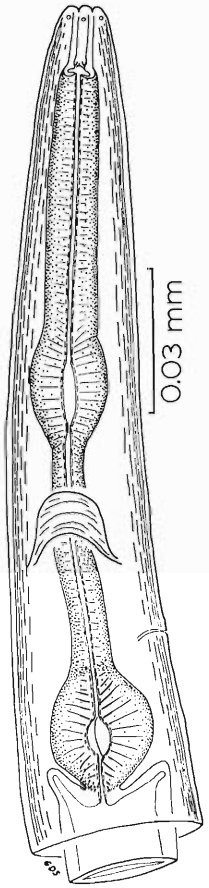

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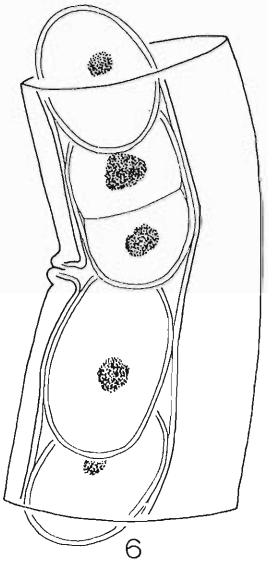

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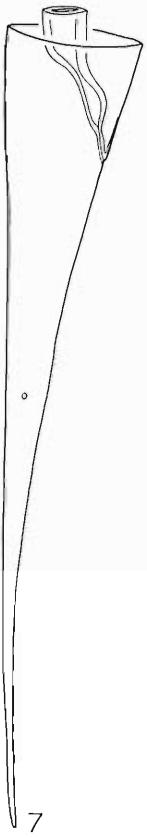

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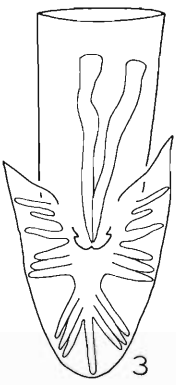

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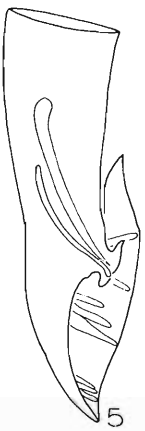

5

from anterior end. Pseudobulb 18–20 long, 18–20 wide. Terminal bulb 22–28 long, 22–28 wide. Total length of esophagus 165–180. Vulva (Fig. 6) equatorial, 540–590 from anterior end, slightly salient; vagina short. Uteri simple, containing two eggs each. Eggs 40–45 by 26–30. Tail (Fig. 7) long, slender, conical, 170–190 long. Phasmidial pores about midway between anus and tip of tail.

LOCATION: Small intestine of plumbeous water redstart, *Rhyacornis fuliginosus affinis* (Ogilvie-Grant) (Passeriformes, Turdidae).

TYPE LOCALITY: Chien-shih, Hsin-chu Hsien, Taiwan.

TYPE SPECIMENS: USNM Helm. Coll. holotype male No. 72133, allotype female No. 72134, paratype females No. 72135.

Remarks

The following 10 species have been placed in *Caenorhabditis* and are accepted by recent authors (Osche, 1952; Dougherty, 1955): *C. elegans* (Maupas, 1900); *C. dolichura* (Schneider, 1866); *C. pseudodolichura* Körner in Osche, 1952; *C. kowalewsky* (Golovin, 1901); *C. briggsae* (Dougherty et Nigon, 1949); *C. clavopapillata* (Kreis et Faust, 1933); *C. perrieri* (Maupas, 1900); *C. carpathica* (Soós, 1941); *C. debilicauda* (Fuchs, 1937); and *C. rara* Körner in Osche, 1952. Of these only *C. elegans* and *C. briggsae* have the anterior ends of the bursae extended anteriad to give a heart-shaped appearance in ventral view. In both of these species, however, the anterior bursal margins are rounded, rather than pointed as in the present species. Further, the spicules of *C. elegans* and *C. briggsae* are 32–39 long, compared to 95 in *C. avicola*. Thus, the shape of the bursa and size of spicules, two characters unlikely to vary a great deal within a species, will serve to distinguish this species from all others in *Caenorhabditis*.

The occurrence of this worm in a bird probably represents a case of pseudoparasitism, for no species in the genus has previously been demonstrated to be parasitic. *Caenorhabidtis dolichura* is known to be a symbiont of ants (Wahab, 1962), so a similar association may obtain with *C. avicola*, explaining its presence in a bird.

Osche (1952) proposed the new subgenus *Caenorhabditis*, which Dougherty (1953) elevated to generic status. The assignment of authorship as "*Caenorhabditis* (Osche, 1952) Dougherty, 1953," by Dougherty (1955) is in violation of Article 43 of the International Code of Zoological Nomenclature, which states that the categories in the genus group are of coordinate status in nomenclature and that change in category does not affect the original date and author for a taxon based on the same type species.

Acknowledgments

We wish to thank the technicians of the Parasitology Department of Naval Medical Research Unit No. 2 for assistance in procurement and examination of hosts, and to acknowledge Mr. H. B. Deignan (deceased), U. S. National Museum, for identification of the bird.

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Figures 1–7. ***Caenorhabditis avicola*** **sp. n. (Scale on Figure 2 applies to all figures). 1. En face. 2. Anterior end, lateral view. 3. Posterior end of male, ventral view. 4. Posterior end of male, lateral view. 5. Posterior end of male, optical section of lateral view, showing spicule and gubernaculum. 6. Vulvar region, lateral view. 7. Tail of female, lateral view.**

Zoogeography of Digenetic Trematodes from West African Marine Fishes[1]

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ABSTRACT: Of the 107 species of trematodes found in West African (Mauritania to Gabon) marine fishes, 100 are allocated to 64 genera in 24 families while seven are immature didymozoids. Many of these genera are located in most of the world's seas with the exception of the polar seas; only five are endemic to West Africa. The data for the 41 species known from West Africa and elsewhere, and those morphologically closest to the 55 endemic species, indicate that they are very widely distributed, particularly in the Western and North Atlantic, and Mediterranean. Historical and present-day events concerning physical and biological environmental factors and their effects on actual and potential hosts as well as on life cycle stages of the trematodes have resulted in the geographical distribution reported. The distribution of marine fishes has been emphasized to explain in part the trematode distribution.

Studies on the geographical distribution of digenetic trematodes of marine fishes in various seas have been presented by Manter (1955, 1963, 1967), Szidat (1961), and Lebedev (1969), but West African waters were not included as sufficient data were not available until more recently. The digenetic trematodes of West African marine fishes (mainly shore and shelf inhabitants) have been reported by Dollfus (1929, 1937a, b, 1946, 1951, 1960), Dollfus and Capron (1958), Thomas (1959, 1960), Nikolaeva (1965), Fischthal and Thomas (1968a, b, c, 1969, 1970a, b, 1971, 1972a, b, c), and Fischthal and Williams (1971).

According to Ekman (1953) the West African tropical marine fauna in general is poorer than any other tropical coastal fauna (Western Atlantic, Indo-West Pacific, Eastern Pacific) because of lower water temperatures, the considerably shallower layer of tropical water, the sandy sea floor which is unsuitable for coral reef formation, and the open coast which provides little or no shelter from the surf. He further noted that the region contains only an insignificant number of endemic genera, although endemic species are much more numerous and represent a fairly high percentage of the total number in several groups. Data on the oceanography of tropical West Africa (Gulf of Guinea from 5° S to 15° N) and warm temperate Mauritania have been presented by Ekman (1953), Buchanan (1958), Longhurst (1962), and Ingham (1970).

Zoogeographical Distribution

Of the 107 species of trematodes found in West African fishes, 100 are allocated to 64 genera in 24 families while seven are immature didymozoids of unknown generic status (Appendix I). A list of the host species and the trematodes found in each is given in Appendix II. The data on the geographical distribution of the genera (Table 1) indicate that many are located in most of the world's seas with the exception of the Arctic and Antarctic, and that only five (7.8%) are endemic to West Africa (Table 2). The latter figure is comparable to that for the North Atlantic (7.5%). The data for the species (Tables 1, 3) indicate that the 41 species elsewhere known and those morphologically closest to the 55 endemic species are very widely distributed, but with much larger numbers occurring in the Western Atlantic, North Atlantic, and Mediterranean, and mostly in tropical and warm temperate waters. Intermediate numbers occur in the tropical Eastern Pacific, Japanese region, and Red Sea.

Discussion

Explanations for the geographical distribution of the trematodes noted above relate in

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Table 1. Summary of geographical distribution of 58 genera[1] and 96 species of digenetic trematodes from West African marine fishes. Under No. spp. the first column of numbers indicates how many of 41 West African species are also known from the locality stated; the second column indicates how many species morphologically most like the 55 endemic species are known from the locality stated.

Locality	No. genera	No. spp.
N. Europe	21	9— 3
British Isles		8— 2
Belgium, Norway		3— 0
Baltic Sea		5— 1
Eastern N. Atlantic	15	11— 2
Europe		10— 2
Morocco		1— 0
Madeira Isl.		1— 0
Iceland		1— 0
Western N. Atlantic	38	20—11
Canada		2— 1
U. S.		14— 9
Bimini		7— 3
Bermuda		7— 2
Bahama		2— 0
Azores	3	2— 0
Eastern S. Atlantic	18	8— 2
South-West Africa		8— 2
Western S. Atlantic	17	6— 1
Brazil		3— 1
Argentina		3— 0
Mediterranean–Black Sea	31	17— 6
Mediterranean		17— 6
Black Sea		7— 3
Caribbean	35	19—10
Gulf of Mexico	42	20—17
Arctic	9	1— 1
Barents Sea		1— 1
N. Pacific	25	6— 8
Bering Sea		2— 0
Okhotsk Sea		3— 1
Alaska		1— 0
Canada		1— 1
U. S.		5— 6
Tropical E. Pacific	31	12—10
Mexico		8—10
Panama		6— 3
Ecuador		4— 1
Galápagos Isl.	11	4— 7
Central Pacific	31	3— 4
Hawaii		3— 4
Line Isl.		1— 0
Japan	39	13—21
Japan		9—16
Korea		0— 2
Yellow Sea		2— 0
E. China Sea		1— 3
Taiwan		1— 2
East Indies	31	5— 8
S. China Sea		4— 0
Philippines		3— 7
Mariana Isl.		1— 0
Celebes		2— 3
Borneo		0— 1
Indian Ocean	26	9— 7
India		4— 6
Ceylon		0— 1
Madagascar		1— 1
Gulf of Aden		5— 0
Red Sea	24	12— 4
New Zealand–Australia	30	8— 8
Australia		1— 3
Tasmania		1— 0
New Zealand		5— 0
New Caledonia		2— 2
Fiji Isl.		0— 3
Antarctic	4	0— 0

[1] Endemic genera excluded are: *Diplomonorcheides* Thomas, 1959; *Elopsium* Fischthal and Thomas, 1972; *Neochoanodera* Fischthal and Thomas, 1970; *Neolepocreadium* Thomas, 1960; *Pedunculotrema* Fischthal and Thomas, 1970. *Palaeorchis* Szidat, 1943, has only freshwater fishes from Japan and Europe as hosts.

great part to historical and present-day events concerning physical and biological environmental factors (geological occurrences, climates, temperatures, currents, salinity, bottom conditions, shore configurations, animal and plant populations, food chain, etc.) and their effects on actual and potential hosts as well as on stages in the life cycles of the trematodes. Migrations have been accomplished by adult fishes and mollusks and their pelagic larvae; mollusks probably have moved long distances via currents while attached to floating vegetation or debris.

Ekman (1953) noted that an immense Tethys Sea, already existing in the Lower Cambrian and continuing into the late Tertiary, included the Eastern Pacific, tropical Atlantic, Mediterranean, and Indo-West Pacific. The fauna of this sea was part of one major unit, the Tethys fauna, and was essentially tropical and more homogeneous than the present-day tropical–subtropical shelf fauna. This probably applied to the trematodes as well. Valentine (1967) noted that fluctuating climates act as a sort of diversity pump, enhancing species diversity during climatic deterioration and retaining some fraction of the new lineages during climatic improvement. He indicated that the Tethyan fauna was enriched by this process acting within the Tethys and also by recruitment of lineages from the extra-Tethyan provincial margins, especially during improving climatic phases. Trematodes probably were similarly affected.

During the course of geological time various barriers arose to divide the Tethys Sea into more or less separate seas. Other seas were also affected by the appearance or removal of

Table 2. Number of genera and per cent endemic of digenetic trematodes of marine fishes from various geographical regions.[1]

Locality	No. genera	% genera endemic
N. Atlantic	58	7.5
Tropical W. Atlantic	145	25
Mediterranean–Atlantic	69	23
Red Sea–Gulf of Aden	38	25
India	55	24
East Indies	84	31
Japan	168	32
New Zealand–Australia	76	17
Hawaii	169	40
Tropical E. Pacific	78	11
W. Africa	64	7.8

[1] Figures for Hawaii based on data by Yamaguti (1970); others, except W. Africa, from Lebedev (1969).

Table 3. Summary of geographical distribution in littoral provinces (Hedgpeth, 1957) of digenetic trematodes of West African marine fishes.

Province	No. of 41 spp. elsewhere known	No. of spp. morphologically closest to 55 endemic spp.
Arctic	3	2
Boreal	8	2
Antiboreal	4	1
Boreal–Antiboreal	6	1
Warm temperate	33	27
Tropic	32	36

barriers. Ruggieri (1967) noted that the separation of the Mediterranean from the Indian Ocean occurred during the Miocene, but Tortonese (1964) indicated the Pliocene. The former author further noted that towards the end of the Miocene the two straits connecting the Mediterranean with the Atlantic disappeared and the Mediterranean was transformed into a series of lagoons which either dried up or became gradually desalinified, thus decimating its marine fauna. During the Pliocene the Gibraltar straits formed and the Atlantic flowed anew into the Mediterranean, reestablishing truly marine conditions. Those elements of the Miocene fauna that had persisted in the Atlantic outside Gibraltar were reintroduced (with their trematodes) to the Mediterranean together with new species previously absent from the area; some of the latter may have been from West Africa. Ruggieri indicated that the Atlantic facing the Gibraltar straits probably was the true asylum for the Indo-Pacific relicts (with their trematodes) during the Miocene salinity crisis in the Mediterranean; some of these relicts along with other Mediterranean fishes may have migrated southward to West Africa during this time.

Ekman (1953), Briggs (1966, 1970), and Ruggieri (1967) reported that during the late Tertiary and early Quaternary there was a considerable change in the tropical nature of the North Atlantic and Mediterranean due primarily to the advent of colder climates. The northern fauna (with their trematodes) migrated southward when possible and simultaneously the tropical fauna disappeared in part. Much of the displaced Mediterranean fauna (with their trematodes) migrated to West Africa which still supports some of them. On the American side of the Atlantic (Florida, Georgia, neighboring states) colder climates of the Miocene also affected the tropical fauna but not as catastrophically as in the North and Eastern Atlantic and the Mediterranean. The major difference was that during the Pliocene and Quaternary the tropical climate and fauna reappeared on the American side, whereas only an insignificant part reappeared in tropical West Africa and especially the Mediterranean. Tortonese (1964) noted that the largest group comprising the present-day Mediterranean fish fauna (about 550 species) is Atlantic (boreal, West African, or amphi-Atlantic); other species are endemic (about 70 or 13%), cosmopolitan, or Indo-Pacific. In great part it is because of the historical events related above that significantly low percentages of endemic genera generally occur in the fauna of West Africa, the Mediterranean, and the North Atlantic, and also why many identical as well as closely related species of trematodes and other groups are found in these regions.

Ben-Tuvia (1966) indicated that at least 24 of about 800 species of fishes have migrated from the Red Sea to the Mediterranean since the opening of the Suez Canal in 1869, some as far west as Lampedusa near Sicily; no reliable records exist of a reverse migration although a few are found in the Suez Canal. Some 18 of the Red Sea species are now among the more common forms along the Mediterranean coast of Israel and nine are sufficiently abundant to be commercially exploited. Some of the trematodes from Red Sea fishes possibly have become established in closely related

Mediterranean fishes or in other fishes which feed on the same intermediate hosts. Wide-ranging Mediterranean fishes then may have moved into the Atlantic and to West Africa.

Briggs (1970) reported that during the Oligocene some boreal species (including fishes and their trematodes) north of the Bering Land Bridge moved out of the Arctic Basin to the North Atlantic. During the Miocene and again in the Pliocene the Bering Land Bridge disappeared, opening a seaway between the North Pacific and Arctic. The movement of species (including trematodes) was (and still is) predominantly northward from the Pacific to the Arctic Ocean to the North Atlantic. These events explain in great part Manter's (1963) observation that of 54 species of digenetic trematodes of marine fishes from the British Columbian region of Canada, 21 (40%) also occur in the North Atlantic. Briggs also noted that present-day species in the North Atlantic have broad latitudinal ranges. Some, with their trematodes, occur in West Africa.

Briggs (1967) observed that the Mid-Atlantic Barrier is a broad, deepwater expanse of ocean separating the West African tropics from those of the Western Atlantic. About 380 species of tropical shore fishes are found in the Eastern Atlantic and 900 species in the Western Atlantic, giving a total of 1,280. About 118 (9.2%) of this total are trans-Atlantic species, making the barrier about 91% effective. The migration has been and still is from west to east. The 118 trans-Atlantic species comprise 31% of the tropical West African shore fish fauna; many genera are also in common. Briggs noted further that West African invertebrate groups also show appreciable percentages of the species as being trans-Atlantic (6% of the prosobranch mollusks). These facts serve greatly to explain why such a large number of trematodes species from West African fishes are identical with or closely related to those in the tropical Western Atlantic and its neighboring warm temperate zones.

Briggs (1961, 1967) and Rosenblatt (1967) have discussed the New World Land Barrier. The former author noted that of the total number of shore fish species (about 1,000) that probably occur on both sides of Central America, only about 12 are identical (excluding 13 circumtropical and a few euryhaline species); this barrier is about 99% effective. Rosenblatt reported that the shore fish fauna of both sides of the Americas show great similarity at the family, subfamily, and generic levels, but not at the species level; however, there are a large number of pairs of sibling species. He further noted that a fair number of genera in the Western Atlantic are found also in the Indo-West Pacific. About 10 genera (2%) of the total for the Western Atlantic are common to and limited to the tropical Atlantic. The historical events relating to the continuous Tethys Sea and subsequent formation of the South and Central American land bridges during the Pliocene to separate the Atlantic and Pacific account in great part for the present-day distribution of fishes in this region. This also explains in part Manter's (1963) observation that of 226 species of digenetic trematodes from Caribbean fishes, about 18% also occur in the tropical Eastern Pacific. It also explains in part why many trematodes from West African fishes occur in the Eastern Pacific and Indo-West Pacific since, as noted above, about 31% of the West African shore fish species also occur in the tropical Western Atlantic and a fair number of genera from the latter locality also are found in the Indo-Pacific.

The Old World Land Barrier has been 98% effective in separating the shore fishes of the Indo-West Pacific from the Atlantic. Briggs (1967) indicated that the fish fauna of tropical Southeast Africa in the area between Mozambique and Algoa Bay numbers about 1,000 species and in tropical West Africa about 380, a total of 1,380. Migration has been from east to west around the Cape of Good Hope, involving only 31 species (8 to both sides of the Atlantic; 4 confined to West Africa; 3 to St. Helena Island; 16 circumtropical); however, many genera are in common. This distribution of fishes has to some extent affected the distribution of their trematodes.

Briggs (1961, 1964, 1967) noted that the East Pacific Barrier is a vast stretch of about 3,000 miles of deepwater lying between Polynesia and America. He reported 62 trans-

Pacific species of shore fishes (13 of which are circumtropical) out of a total of about 1,037 species for both regions (about 387 species assumed to be in the Line Islands lying at easternmost Polynesia in the Equatorial Countercurrent; about 650 species between southern Mexico and Peru); many common genera are in the two regions. This barrier is 94% effective. The successful migrations were recent or current invasions, and were almost exclusively from west to east via the countercurrent. Briggs (1967) related that 18 species of mollusks are trans-Pacific. Some of the trematodes probably moved across this barrier with their vertebrate and molluscan hosts.

Briggs (1960) reported that at least 107 species of marine fishes form homogeneous worldwide circumtropical species populations. Additional species are worldwide but form subspecific populations in parts of their range. Other species are nearly circumtropical but have not been found in the Eastern Pacific. A majority of the 107 fish species can be considered to be typical of the open seas (90 pelagic, 14 littoral, 3 benthic). In West Africa five of these 107 species were found infected with at least one species of trematode which occurs in the same host species elsewhere. The circumtropical (or nearly so) distribution of many genera and species of fishes has aided considerably the wide distribution of their trematodes; additionally, new and more localized hosts have been acquired by some.

Briggs (1967) summarized the information concerning tropical marine fishes and invertebrates as follows: "There is no doubt that the Indo-West Pacific Region has served as *the* evolutionary and distributional center for the entire marine tropics. Its fauna is almost unbelievably rich with, for example, more than 3,000 species of shore fishes. It seems clear that the unusually stable ecosystems and high level of competition provide the proper environment for the evolution of dominant species that can successfully invade the other regions. From the Indo-West Pacific, dominant species migrate eastward across the open ocean to America, westward around the Cape of Good Hope into the Atlantic, and northward through the Suez Canal into the Mediterranean. Successful reciprocal migrations are, at least, very rare and may be completely lacking. Furthermore, judging from the general indications of relationship among the four great tropical faunas, this process has been going on for many millions of years. Some of the dominant species are so successful that they have been able to establish and maintain circumtropical distributions (indicating more or less regular migrations across the East Pacific, Old World land, and mid-Atlantic barriers). The Western Atlantic tropics may be considered a secondary center of evolutionary radiation. Many species produced in this area have proved capable of migrating eastward to colonize the Eastern Atlantic region. However, species originating in the Eastern Atlantic are apparently incapable of successfully invading the western side. Again, the advantage seems to lie with the area that possesses the richer fauna and higher level of competition." The distributions exhibited by the digenetic trematodes of marine fishes from West Africa and from other regions are in agreement with Briggs' observations and conclusions.

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Appendix I

List of digenetic trematodes from West African marine fishes, and other localities from which known

Acanthocolpidae. *Stephanostomum africanum* Fischthal and Williams, 1971. *S. bicoronatum* (Stossich, 1883) Manter, 1940—also Mediterranean, Tyrrhenian, Adriatic, Black, Yellow, E. China Seas. *S. casum* (Linton, 1910) McFarlane, 1934—also Bermuda; Bahama; Caribbean; Gulf of Mexico; U. S. Atlantic; Mexican, Canadian Pacific; Galápagos; Philippines; New Caledonia; Red Sea. *S. coryphaenae* Manter, 1947—also Bimini; Caribbean; Gulf of Mexico. *S. ghanense* Fischthal and Thomas, 1968. *S. megacephalum* Manter, 1940—also Caribbean; Gulf of Mexico; Mexican, Panama, Ecuador Pacific; Red Sea. *S. sierraleonense* Fischthal and Williams, 1971. *S. trachinoti* Fischthal and Thomas, 1968. Azygiidae. *Otodistomum veliporum* (Creplin, 1837) Stafford, 1904—also Mediterranean, Black Seas; European, Moroccan, U. S., Canadian Atlantic; Iceland; British Isles; North, Baltic Seas; Argentina; New Zealand; Sea of Japan; Alaska; U. S., Mexican Pacific. Bucephalidae. *Bucephaloides ghanensis* Fischthal and Thomas, 1968. *B. gracilescens* (Rudolphi, 1819) Hopkins, 1954—also Mediterranean, Adriatic Seas; British Isles; South-West Africa; Barents Sea; Far Eastern Seas of Siberia. *B. ovatus* (Linton, 1900) Hopkins, 1954—also U. S. Atlantic; Panama Pacific. *Prosorhynchus aculeatus* Odhner, 1905, metacercaria—also Mediterranean, North, Baltic Seas; British Isles; Japan; Galápagos. *P. caudovatus* Manter, 1940—also Suez. *Rhipidocotyle ghanensis* Fischthal and Thomas, 1968. *R. senegalensis* Fischthal and Thomas, 1972. Cryptogonimidae.[1] *Paracryptogonimus ghanensis* Fischthal and Thomas, 1968. Didymozoidae. *Allonematobothrium ghanense* Fischthal and Thomas, 1968. Didymozoidae (*Monilicaecum*) larvae I Nikolaeva, 1965—also South-West Africa. Didymozoidae gen. sp. larvae V Nikolaeva, 1962—also Red Sea. Immature Didymozoid B Fischthal and Kuntz, 1964—also Philippines. Immature Didymozoid D Fischthal and Thomas, 1968. Immature Didymozoid E Fischthal and Thomas, 1968. Immature Didymozoid F Fischthal and Thomas, 1968. Immature Didymozoid G Fischthal and Thomas, 1968. Enenteridae. *Cadenatella brumpti* (Dollfus, 1946) Nahhas and Cable, 1964—also Bimini. *C. cadenati* (Dollfus, 1946) Nagaty, 1948. *Enenterum pimelepteri* Nagaty, 1942—also Red Sea. Fellodistomatidae. *Elopsium ghanense* Fischthal and Thomas, 1972. *Markevitschiella* sp. Fischthal and Thomas, 1968. *Monascus typicus* (Odhner, 1911) Looss, 1912—also Mediterranean, Adriatic, Black, Red Seas; Gulf of Aden; India. *Steringotrema divergens* (Rudolphi, 1809) Odhner, 1911—also Mediterranean, Tyrrhenian, Baltic Seas; British Isles. Gorgoderidae. *Nagmia africana* Fischthal and Thomas, 1972. *N. senegalensis* Fischthal and Thomas, 1972. Halipegidae. *Gonocercella trachinoti* (MacCallum, 1913) Yamaguti, 1954—also U. S. Atlantic; Gulf of Mexico. Haploporidae. *Megasolena hysterospina* (Manter, 1931) Overstreet, 1969—also U. S. Atlantic; Caribbean; Gulf of Mexico. Hemiuridae. *Adinosoma robusta* (Manter, 1934) Manter, 1947—also Gulf of Mexico. *Aponurus lagunculus* Looss, 1907—also Mediterranean, Tyrrhenian, Adriatic, Black Seas; South-West Africa; Gulf of Mexico; U. S., Mexican Pacific; Celebes; S. China Sea; Gulf of Aden; Red Sea. *Dinurus barbatus* (Cohn, 1903) Looss, 1907—also European Atlantic; Caribbean; Gulf of Mexico; Mexican, Panama Pacific. *D. breviductus* Looss, 1907—also

[1] *Siphodera ghanensis* described by Fischthal and Thomas (1968c) is from freshwater fishes from Ghana and Gabon, but the two other species in the genus, *S. vinaledwardsii* (Linton, 1901) Linton, 1910, and *S. cirrhiti* Yamaguti, 1970, are from marine fishes.

European, U. S. Atlantic; Caribbean; Gulf of Mexico; Argentina; Red Sea. *D. tornatus* (Rudolphi, 1819) Looss, 1907—also European, U. S. Atlantic; Azores; Caribbean; Gulf of Mexico; Gulf of Aden; Red Sea. *Ectenurus lepidus* Looss, 1907—also Mediterranean, Tyrrhenian, Adriatic, Black Seas; South-West Africa; Caribbean; Brazil; Hawaii; New Zealand; Gulf of Aden. *E. virgulus* Linton, 1910—also Bimini; Bermuda; Bahama; U. S. Atlantic; Caribbean; Gulf of Mexico; Argentina; Gulf of Aden; Red Sea. *Lecithaster africanus* Fischthal and Thomas, 1971. *L. ghanensis* Fischthal and Thomas, 1971. *Lecithochirium ghanense* Fischthal and Thomas, 1972. *L. microstomum* Chandler, 1935—also U. S. Atlantic; Caribbean; Gulf of Mexico; Brazil; Mexican, Panama Pacific; Galápagos; Taiwan; Madagascar. *Lecithocladium augustiovum* Yamaguti, 1953—also Philippines; Celebes; Red Sea. *L. excisum* (Rudolphi, 1819) Lühe, 1901—also Mediterranean, Adriatic, Black, Irish, North, Baltic Seas; European, U. S. Atlantic; South-West Africa; Gulf of Mexico; Japan; S. China Sea; New Zealand. *L. mecoderum* Fischthal and Thomas, 1971. *L. unibulbolabrum* Fischthal and Thomas, 1971. *Parahemiurus merus* (Linton, 1910) Woolcock, 1935—also South-West Africa; U. S. Atlantic; Bimini; Bermuda; Caribbean; Gulf of Mexico; Brazil; U. S., Ecuador Pacific; Bering, Okhotsk, S. China Seas; Japan. *Prosorchis ghanensis* Fischthal and Thomas, 1972. *Sterrhurus ghanensis* Fischthal and Thomas, 1972. *S. fusiformis* (Lühe, 1901) Looss, 1907—also Mediterranean, Adriatic Seas; British Isles; Azores; European, U. S. Atlantic; Bermuda; Caribbean; Gulf of Mexico; Ecuador Pacific; Japan. *S. musculus* Looss, 1907—also Mediterranean, Adriatic, Black Seas; Bimini; Bermuda; U. S. Atlantic; Caribbean; Gulf of Mexico; Japan. *Tubulovesicula lindbergi* (Layman, 1930) Yamaguti, 1934—also Madeira Isl.; Canadian, U. S., Panama Pacific; Bering, Okhotsk, S. China, Red Seas; Japan. Hirudinellidae. *Hirudinella ventricosa* (Pallas, 1774) Baird, 1853—also Bimini; Bermuda; Caribbean; Gulf of Mexico; Mexican, Panama, Ecuador Pacific; Galápagos; Hawaii; Line Isl.; Mariana Isl. Lepocreadiidae. *Aephnidiogenes africanus* Fischthal and Thomas, 1972. *A. senegalensis* Dollfus and Capron, 1958 also India. *Diploproctodaeum ghanense* (Fischthal and Thomas, 1970) Fischthal and Thomas, 1972. *D. haustrum* (MacCallum, 1918) LaRue, 1926—also Bimini; U. S. Atlantic; Caribbean; Hawaii. *Holorchis legendrei* Dollfus, 1946—also Mediterranean; European Atlantic. *Homalometron senegalense* Fischthal and Thomas, 1972. *Lepidapedon ghanense* Fischthal and Thomas, 1970. *Lepocreadioides cynoglossi* Fischthal and Thomas, 1970. *Lepocreadium ghanense* Fischthal and Thomas, 1970. *Neochoanodera ghanensis* Fischthal and Thomas, 1970. *Neolepocreadium caballeroi* Thomas, 1960. *Opechona bacillaris* (Molin, 1859) Looss, 1907—also Adriatic, Black, Baltic, Red Seas; European Atlantic; South-West Africa; British Isles India; New Zealand–Australia region. *O. ghanensis* Fischthal and Thomas, 1970. *O. pseudobacillaris* Fischthal and Thomas, 1970. *Pseudocreadium ghanense* Fischthal and Thomas, 1970. Monodhelminthidae. *Monodhelmis torpedinis* Dollfus, 1937. Monorchiidae. *Diplomonorcheides magnacetabulum* Thomas, 1959. *Lasiotocus accraensis* Fischthal and Thomas, 1969. *L. attenuatus* Fischthal and Thomas, 1969. *L. chaetodipteri* Thomas, 1959. *L. cynoglossi* Thomas, 1959. *L. ghanensis* Fischthal and Thomas, 1969. *L. synapturae* Fischthal and Thomas, 1969. *Palaeorchis senegalensis* Fischthal and Thomas, 1972. *Parahurleytrema trachinoti* (Thomas, 1959) Nahhas and Powell, 1965. *Proctotrema amphitruncatum* Fischthal and Thomas, 1969. *Proctotrematoides ophichthi* Fischthal and Thomas, 1969. Opecoelidae. *Coitocaecum cadenati* Dollfus, 1960. *Helicometra fasciata* (Rudolphi, 1819) Odhner, 1902—also Mediterranean, Black Seas; N. Atlantic; South-West Africa; Caribbean; Mexican Pacific; Japan; New Caledonia; Tasmania; Red Sea. *Pedunculotrema capecoastense* Fischthal and Thomas, 1970. *P. ghanense* Fischthal and Thomas, 1970. *Plagioporus gerridis* Fischthal and Thomas, 1970. *Podocotyle temensis* Fischthal and Thomas, 1970. *Podocotyloides chloroscombri* Fischthal and Thomas, 1970. *Poracanthium ghanense* Fischthal and Thomas, 1970. *Pseudopecoelus ghanensis* Fischthal and Thomas, 1970. *P. tortugae* von Wicklen, 1946—also Caribbean; Gulf of Mexico. *P. vulgaris* (Manter, 1934)

von Wicklen, 1946—also Gulf of Mexico; New Zealand. Opistholebetidae. *Pycnadena africana* Fischthal and Williams, 1971. *Pycnadenoides ghanensis* Fischthal and Thomas, 1968. *P. senegalensis* Fischthal and Thomas, 1972. Pelorohelminthidae. *Pelorohelmins ghanensis* Fischthal and Thomas, 1968. Pleorchiidae. *Pleorchis ghanensis* Fischthal and Thomas, 1968. Proctoecidae. *Mesolecitha ghanensis* Fischthal and Thomas, 1968. Ptychogonimidae. *Ptychogonimus megastomus* (Rudolphi, 1819) Lühe, 1900—also Mediterranean, Tyrrhenian, Adriatic Seas; British Isles; European Atlantic; North Sea; Bermuda; Caribbean; Japan; New Zealand. Sclerodistomatidae. *Sclerodistomum italicum* (Stossich, 1893) Looss, 1912—also Adriatic Sea. Syncoeliidae. *Syncoelium katuwo* Yamaguti, 1936 —also U. S. Pacific; Japan. Zoogonidae. *Diphtherostomum anisotremi* Nahhas and Cable, 1964—also Caribbean; Gulf of Mexico. *Zoogonus mirus* Looss, 1901—also Adriatic Sea; Gulf of Marseille.

Appendix II

Alphabetical list of host species with trematodes found in each[1]

Acanthocybium solandri (Cuv. and Val.), Scombridae
  Hirudinella ventricosa (G)
Acanthurus monroviae (Steind.), Acanthuridae
  Mesolecitha ghanensis (G)
  Prosorchis ghanensis (G)
Alutera punctata Cuv., Monacanthidae
  Diploproctodaeum haustrum (S)
Antennarius commersonii (Lac.), Antennariidae
  Immature Didymozoid E (S)
  Rhipidocotyle senegalensis (S)
Arius heudeloti Cuv. and Val., Ariidae
  Monodhelmis torpedinis (G)
Arius latiscutatus Günther
  Pelorohelmins ghanensis (G)
Arnoglossus imperialis (Raf.), Bothidae
  Lecithocladium excisum (S)
Bathygobius soporator (Cuv. and Val.), Gobiidae
  Helicometra fasciata (G)
Batrachoides liberiensis (Steind.), Batrachoididae
  Sterrhurus ghanensis (G)
Blennius sanguinolentus Pallas, Blenniidae
  Prosorhynchus aculeatus, metacercaria (S)
Brachydeuterus auritus (Cuv. and Val.), Pomadasyidae
  Didymozoidae (*Monilicaecum*) larvae I (G)
  Immature Didymozoid B (G)
  Immature Didymozoid E (G)
  Zoogonus mirus (G)
Caesiomorus glaucus (L.), Carangidae
  Lecithocladium excisum (G)
  Opechona ghanensis (G)
  Opechona pseudobacillaris (G)
Capros aper (L.), Caproidae
  Pycnadenoides senegalensis (S)
Caranx africanus Steind., Carangidae
  Ectenurus virgulus (G)
  Immature Didymozoid E (G)
Caranx crysos (Mitchill)
  Ectenurus virgulus (G)
Caranx hippos (L.)
  Parahemiurus merus (G)
  Poracanthium ghanense (G)
  Stephanostomum megacephalum (G)
Cephalacanthus volitans (L.), Dactylopteridae
  Lecithocladium unibulbolabrum (G) (S)
  Sterrhurus ghanensis (G)
  Sterrhurus musculus (G)
Chaetodipterus lippei Steind., Ephippidae
  Lasiotocus chaetodipteri (G)
  Megasolena hysterospina (SL)
  Neochoanodera ghanensis (G)
Chloroscombrus chrysurus (L.), Carangidae
  Ectenurus lepidus (G)
  Monascus typicus (G)
  Podocotyloides chloroscombri (G)
Clupisudis niloticus (Ehrenberg),[2] Osteoglossidae
  Sterrhurus musculus (G)
Corvina nigra Val., Sciaenidae
  Stephanostomum bicoronatum (S)
Coryphaena hippurus L., Coryphaenidae
  Dinurus barbatus (G)
  Dinurus breviductus (G) (S)
  Dinurus tornatus (G)
  Stephanostomum coryphaenae (G)
Cynoglossus canariensis Steind., Cynoglossidae

[1] Trematodes indicated by (C) are from Cameroon, (G) Ghana, (M) Mauritania, (S) Senegal, and (SL) Sierra Leone.

[2] Freshwater fish.

Diplomonorcheides magnacetabulum (G)
Cynoglossus goreensis Steind.
Diplomonorcheides magnacetabulum (G)
Immature Didymozoid E (G)
Lasiotocus cynoglossi (G)
Lepocreadioides ghanensis (G)
Parahemiurus merus (G)
Cynoglossus senegalensis (Kaup)
Diplomonorcheides magnacetabulum (G)
Immature Didymozoid E (G)
Lasiotocus cynoglossi (G) (SL)
Lepocreadioides ghanensis (SL)
Cynoscion macrognathus (Bleeker), Sciaenidae
Immature Didymozoid E (G)
Pleorchis ghanensis (G)
Pseudocreadium ghanense (G)
Pseudopecoelus ghanensis (G)
Cypselurus heterurus (Raf.), Exocoetidae
Immature Didymozoid F (G)
Cypselurus lutkeni Jordan and Evermann
Lecithaster ghanensis (G)
Decapterus rhonchus (Geoff.), Carangidae
Ectenurus lepidus (G)
Monascus typicus (G)
Dentex canariensis Steind., Sparidae
Sclerodistomum italicum (S)
Diagramma mediterraneum Guichenot, Pomadasyidae
Holorchis legendrei (S)
Drepane punctata (L.), Drepanidae
Pseudocreadium ghanense (G)
Pycnadenoides ghanensis (G)
Elops lacerta Cuv. and Val., Elopidae
Elopsium ghanense (G)
Engraulis encrasicholus (L.), Engraulidae
Parahemiurus merus (G)
Ephippion guttifer (Bennett), Tetraodontidae
Diploproctodaeum ghanense (G)
Epinephelus aeneus (Geoff.), Serranidae
Allonematobothrium ghanense (G)
Lepidapedon ghanense (G)
Sterrhurus musculus (G)
Epinephelus goreensis (Cuv. and Val.)
Podocotyle temensis (G)
Prosorhynchus caudovatus (G)
Ethmalosa dorsalis (Cuv. and Val.), Clupeidae
Parahemiurus merus (G)
Euthynnus alleteratus (Raf.), Scombridae
Immature Didymozoid B (G)
Lecithochirium microstomum (G)
Syncoelium katuwo (S)
Fodiator acutus (Val.), Exocoetidae
Neolepocreadium caballeroi (G)
Galeoides decadactylus (Bloch), Polynemidae
Ectenurus lepidus (G)
Lecithaster africanus (G)
Lecithochirium ghanense (G)
Lecithocladium excisum (G)
Lecithocladium mecoderum (G)
Poracanthium ghanense (G) (SL)
Stephanostomum sierraleonense (SL)
Sterrhurus musculus (G)
Galeorhinus mustelus (L.), Carcharhinidae
Ptychogonimus megastomus (M)
Gephyroberyx darwini (Johnson), Trachichthyidae
Adinosoma robusta (S)
Gerres melanopterus Bleeker, Liognathidae
Pedunculotrema ghanense (G)
Gerres nigri Günther
Plagioporus gerridis (G)
Glyphisodon saxatilis (L.), Pomacentridae
Helicometra fasciata (G)
Gymnothorax vicinus (Castelnau), Muraenidae
Sterrhurus fusiformis (G)
Hydrocyon brevis Günther,[2] Characidae
Tubulovesicula lindbergi (G)
Hyporhamphus calabaricus (Günther), Hemirhamphidae
Lecithaster ghanensis (G)
Ilisha melanota Derscheid, Clupeidae
Helicometra fasciata (G)
Lecithocladium excisum (G)
Kyphosus sectatrix (L.), Kyphosidae
Cadenatella brumpti (S)
Cadenatella cadenati (S)
Enenterum pimelepteri (S)
Labrax punctatus (Bloch), Serranidae
Acphnidiogenes senegalensis (S)
Labrisomus nuchipinnis (Quoy and Gaimard), Clinidae
Helicometra fasciata (G)
Lagocephalus laevigatus L., Tetraodontidae
Diploproctodaeum ghanense (G)
Immature Didymozoid D (G)
Lecithochirium ghanense (G)
Parahemiurus merus (G)
Larimus peli Bleeker, Sciaenidae
Helicometra fasciata (G)
Immature Didymozoid G (G)
Pseudopecoelus tortugae (G)

[2] Freshwater fish.

Lethrinus atlanticus Cuv. and Val., Lethrinidae
Lasiotocus accraensis (G)
Lobotes surinamensis (Bloch), Lobotidae
Bucephaloides ovatus (C)
Lophius sp., Lophiidae
Bucephaloides gracilescens (S)
Lutjanus guineensis Bleeker, Lutjanidae
Paracryptogonimus ghanensis (G)
Lutjanus maltzani (Steind.)
Prosorhynchus caudovatus (G)
Lutjanus modestus Bleeker
Helicometra fasciata (G)
Pycnadena africana (SL)
Stephanostomum casum (G)
Melanoglaea ventralis Barnard, Ateleopidae
Coitocaecum cadenati (S)
Mustelus canis (Mitchill), Carcharhinidae
Ptychogonimus megastomus (S)
Myxus curvidens (Val.), Mugilidae
Stephanostomum megacephalum (G)
Narcacion torpedo Klein, Torpedinidae
Monodhelmis torpedinis (M)
Ophichthus semicinctus (Richardson), Ophichthyidae
Proctotrematoides ophichthi (G)
Otolithus brachygnathus (Bleeker), Sciaenidae
Stephanostomum africanum (S)
Pagellus bogaraveo (Brünnich), Sparidae
Parahemiurus merus (S)
Pycnadenoides senegalensis (S)
Steringotrema divergens (S)
Pagrus ehrenbergi Cuv. and Val., Sparidae
Markevitschiella sp. (G)
Paraconger notialis Kantor, Congridae
Sterrhurus ghanensis (G)
Parakuhlia boulengeri Pellegrin, Kuhliidae
Holorchis legendrei (S)
Pentanemus quinquarius (L.), Polynemidae
Poracanthium ghanense (G)
Periophthalmus koelreuteri (Pallas), Gobiidae
Lecithaster ghanensis (G)
Phyllogramma regani Pellegrin, Muraenesocidae
Sterrhurus ghanensis (G)
Tubulovesicula lindbergi (G)
Pomadasys jubelini (Cuv. and Val.), Pomadasyidae
Aephnidiogenes senegalensis (G) (SL)
Diphtherostomum anisotremi (G)
Immature Didymozoid E (G)
Lasiotocus attenuatus (G)
Lasiotocus chaetodipteri (G)
Paracryptogonimus ghanensis (G)
Pedunculotrema capecoastense (G)
Pleorchis ghanensis (G)
Proctotrema amphitruncatum (G)
Pycnadenoides ghanensis (G)
Pomadasys suillus (Val.)
Palaeorchis senegalensis (S)
Psettodes belcheri Bennett, Psettodidae
Immature Didymozoid E (G)
Parahemiurus merus (G)
Rhipidocotyle ghanensis (G)
Sterrhurus ghanensis (G)
Pseudotolithus senegalensis (Günther), Sciaenidae
Stephanostomum africanum (SL)
Pseudupeneus cyclostomus (Lac.), Mullidae
Didymozoidae gen. sp. larvae V (G)
Pteroplatea micrura (Schneider), Trygonidae
Immature Didymozoid E (G)
Rhinobatus albomaculatus Norman, Rhinobatidae
Immature Didymozoid E (G)
Poracanthium ghanense (G)
Rhinoptera marginata (Geoff.), Myliobatidae
Nagmia africana (S)
Rupiscartes atlanticus (Val.), Blenniidae
Prosorhynchus aculeatus, metacercaria (S)
Sardinella cameronensis Regan, Clupeidae
Parahemiurus merus (G)
Sargus cervinus Val., Sparidae
Aephnidiogenes africanus (S)
Sciaena sp., Sciaenidae
Sterrhurus ghanensis (G)
Scomber colias Gmelin, Carangidae
Lecithocladium excisum (G)
Lepocreadium ghanense (G)
Opechona bacillaris (G)
Scomberomorus tritor (Cuv. and Val.), Scombridae
Bucephaloides ghanensis (G)
Didymozoidae (*Monilicaecum*) larvae I (G)
Immature Didymozoid E (G)
Lecithochirium ghanense (G)
Lecithocladium excisum (G)
Scorpaena scrofa L., Scorpaenidae
Helicometra fasciata (S)
Pseudopecoelus vulgaris (S)
Scorpaena senegalensis Steind.
Sterrhurus musculus (G)
Scyris alexandrinus (Geoff.), Carangidae
Immature Didymozoid E (G)

Selar crumenophthalmus (Bloch), Carangidae
Ectenurus virgulus (S)
Lecithochirium ghanense (S)
Monascus typicus (G) (S)
Parahemiurus merus (G)
Sterrhurus musculus (G)
Seriola dumerili (Risso), Carangidae
Sclerodistomum italicum (S)
Smaris melanurus Val., Maenidae
Holorchis legendrei (S)
Solea hexophthalma Bennett, Soleidae
Homalometron senegalense (S)
Sparisoma cretense (L.), Sparisomidae
Prosorhynchus aculeatus, metacercaria (S)
Syacium micrurum Ranzini, Bothidae
Sterrhurus ghanensis (G)
Synaptura lusitanica Capello, Soleidae
Lasiotocus cynoglossi (G)
Lasiotocus ghanensis (G)
Lasiotocus synapturae (G)
Temnodon saltator Val., Pomacentridae
Sclerodistomum italicum (S)
Tetraodon pustulus Murray, Tetraodontidae
Diploproctodaeum ghanense (G)
Torpedo narce Risso, Torpedinidae
Otodistomum veliporum (M)
Trachinocephalus myops (Schneider), Synodidae
Lecithochirium ghanense (G)
Sterrhurus ghanensis (G)
Trachinotus glaucus (L.), Carangidae
Aponurus lagunculus (G)
Ectenurus virgulus (G)
Lecithaster ghanensis (G)
Lecithochirium ghanense (G)
Lecithocladium augustiovum (G)
Neolepocreadium caballeroi (G)
Parahemiurus merus (G)
Stephanostomum trachinoti (G)
Sterrhurus ghanensis (G)
Trachinotus goreensis (Cuv. and Val.)
Gonocercella trachinoti (G)
Lecithochirium ghanense (G)
Lecithocladium augustiovum (G)
Neolepocreadium caballeroi (G)
Parahemiurus merus (G)
Parahurleytrema trachinoti (G)
Stephanostomum ghanense (G)
Trichiurus lepturus L., Trichiuridae
Lecithochirium ghanense (G)
Lecithochirium microstomum (G)
Pseudopecoelus tortugae (G)
Trygon marmorata (Steind.), Dasyatidae
Nagmia senegalensis (S)
Umbrina canariensis Val., Sciaenidae
Stephanostomum bicoronatum (S)
Umbrina cirrosa (L.)
Pycnadenoides ghanensis (G)
Umbrina ronchus Val.
Pleorchis ghanensis (S)
Pycnadenoides ghanensis (G)
Stephanostomum bicoronatum (S)
Umbrina steindachneri Cadenat
Stephanostomum bicoronatum (S)
Upeneus prayensis Cuv. and Val., Mullidae
Lecithocladium augustiovum (S)
Vomer setapinnis (Mitchill), Carangidae
Didymozoidae (*Monilicaecum*) larvae I (G)

Redescription of *Trichuris fossor* Hall, 1916 (Nematoda: Trichuridae) from the Northern Pocket Gopher, *Thomomys talpoides*[1]

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Trichuris fossor Hall, 1916, was described from the northern pocket gopher, *Thomomys talpoides* (syn. *fossor*), from Colorado on the basis of measurements of two males and one female specimen. Chandler (1945) briefly described *Trichuris fossor* from *Thomomys bottae* from California. During a survey of the parasites of *Thomomys talpoides* from

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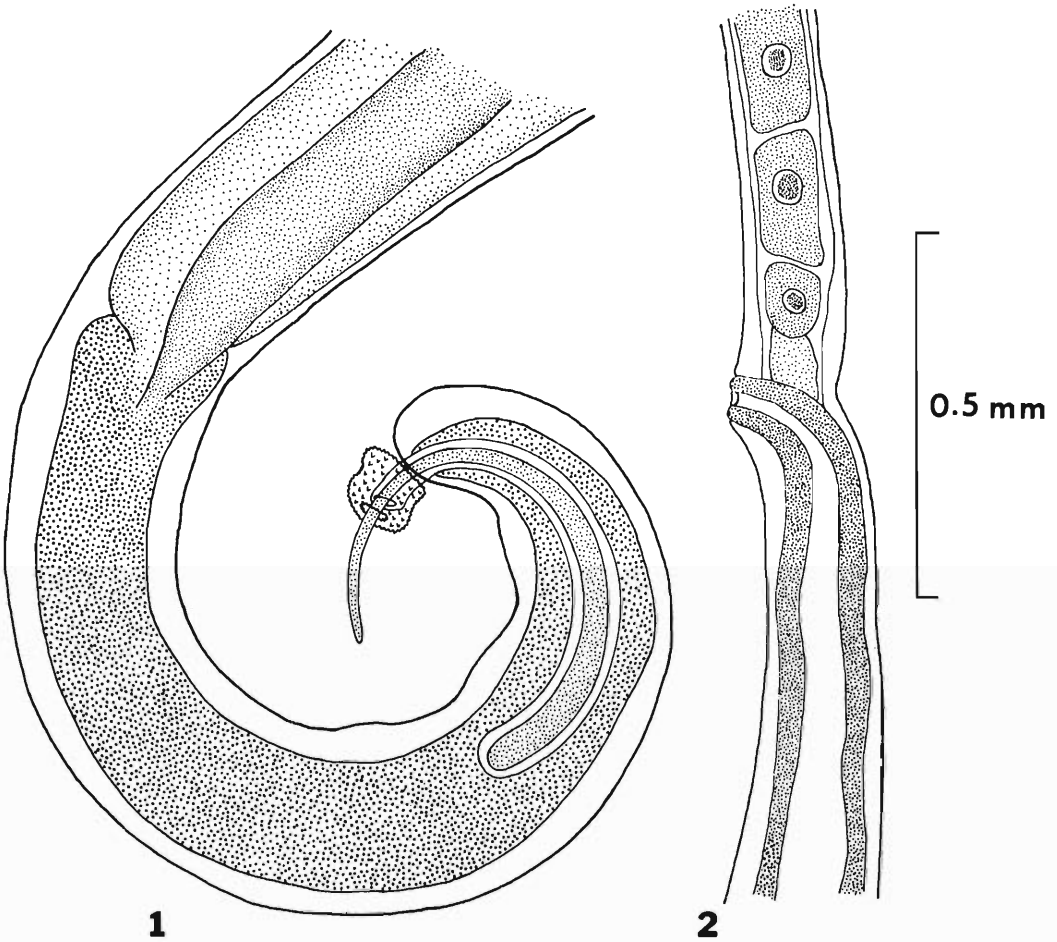

Figure 1. Posterior end of *T. fossor* male.

Figure 2. Vulvar region of *T. fossor* female.

Wyoming, *Trichuris fossor* was found in 65% of 46 animals (Todd, Lepp, and Tryon, 1971). Because these parasites differed somewhat from those described by Hall (1916) and Chandler (1945), a redescription of the parasite is presented.

Materials and Methods

The materials and methods used for collecting the animals and processing the specimens were presented by Todd, Lepp, and Tryon (1971). The following description is based on measurements of 25 females and 16 males. Drawings were made with the aid of a camera lucida.

Description

Trichuris fossor Hall, 1916

(Figs. 1, 2)

DESCRIPTION: Male 22 to 35 mm (mean 29 mm) long, esophagus 12 to 21 mm (mean 16 mm); body length: esophagus length—1:0.51 to 1:0.61 (mean 1:0.56); maximum body width 300 to 425 μ (mean 376 μ); width of midportion of esophagus 78 to 104 μ (mean 99 μ); spicule 0.97 to 1.35 mm long

Table 1. Measurements of *Trichuris fossor*.

Author	Total length ♂	Total length ♀	Esophagus length ♂	Esophagus length ♀	Maximum body width ♂	Maximum body width ♀	Spicule length	Eggs
Hall (1916)	17.5–20 mm	24 mm	10.8–10.9 mm	12.4 mm	516 μ	380 μ	1.7 mm	
Chandler (1945)	28–30 mm	28–33 mm					1.5 mm	64–68 μ × 35–38 μ
Present study	22–35 mm	25–47 mm	12–21 mm	14–25 mm	300–425 μ	300–625 μ	0.97–1.35 mm	69–77 μ × 30–37 μ

(mean 1.17 mm); extruded spicule sheath bell-shaped or cylindrical and covered with conical spines.

Female 25 to 47 mm (mean 37 mm) long; esophagus 14 to 25 mm (mean 20 mm); body length: esophagus length—1:0.48 to 1:0.62 (mean 1:0.54); maximum body width 300 to 625 μ (mean 474 μ); width of midportion of esophagus 104 to 130 μ (mean 118 μ); ovejector 98 to 195 μ (mean 139 μ) long; vulva 37 to 87 μ (mean 59 μ) from posterior end of esophagus; anus subterminal, 39 to 67 μ (mean 50 μ) from posterior end; eggs 69 to 77 μ by 30 to 37 μ (mean 72 by 34 μ).

LOCATION: Cecum of 30 of 46 animals and single specimens in the small intestine and large intestine of one animal.

HOST: *Thomomys talpoides* (northern pocket gopher).

LOCALITY: Park County, Wyoming.

Discussion

In addition to the reports of Hall (1916) and Chandler (1945) *T. fossor* has been found in *T. bottae* from California (Voge, 1956), *T. talpoides* from Alberta (Lubinsky, 1957), and *T. talpoides* and *T. umbrinus* from Utah (Frandsen and Grundmann, 1961).

Table 1 compares the measurements of *T. fossor* that have been previously reported (Hall, 1916; Chandler, 1945) with those found during the present study. The only obvious difference is that the spicule length of the specimens we examined was less than that reported by Hall (1916) and Chandler (1945); however, this does not in our opinion justify considering the specimens examined to be a new species.

Acknowledgments

The figures were prepared by Carole C. Whiteside. We wish to thank C. Arch Tryon, Jr., and Gary L. Brown for collecting the pocket gophers.

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A Review of the Genus *Zeldia* Thorne, 1937 (Nematoda: Cephalobidae) with Descriptions of Seven New Species

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ABSTRACT: The diagnosis of the genus *Zeldia* Thorne, 1937, is emended to include species having one, two, or three teethlike structures associated with the cheilorhabdions. *Zeldia minor*, *Z. feria*, *Z. tridentata*, *Z. solata*, *Z. spinula*, *Z. acuta*, and *Z. neoacuta* are described as new species. *Zeldia glyphra*, *Z. serrata*, and *Z. paucipunctata* are proposed as new synonyms of *Z. punctata*. *Zeldia punctulata* and *Z. setosa* are placed in *species inquirenda*. *Zeldia trifurcata* is transferred back to the genus *Chiloplacus*. Males are described for the first time in *Zeldia*; these occurred in populations of *Z. punctata* and *Z. solata*. In *Z. punctata* adults, second-, third-, and fourth-stage larvae the margins of the labial probolae vary from rounded to setose. First-stage larvae of *Z. punctata* and *Z. odontocephala* have three low rounded lips with no evidence of cephalic probolae, and the terminus of the tail is bluntly rounded. A key to the species is included.

The nematode genus *Zeldia* was proposed by Thorne in 1937. *Acrobeles punctata* Thorne, 1925, was designated as the genotype and three additional species were transferred to the genus. Our interest in this group of nematodes resulted from the examination of the cheilorhabdions of an undescribed species of *Zeldia*, collected in Florida by J. R. Christie in 1952. Subsequent examination of the type species and specimens from many localities in the U. S. and other countries indicated that the generic diagnosis needed modification in order to accommodate species having teeth or teethlike structures associated with the cheilorhabdions. These were first noted by Steiner (1938) when he described *Z. odontocephala*. However, the description and illustrations did not clearly indicate the nature of the structures he designated as teeth.

The syntype series of *Z. punctata* from the type locality in Indio, California (Thorne, pers. comm.) was available for study. These specimens are in poor condition but it was possible to observe variation in the shape of the labial probolae in the type series. Fourteen specimens were in good enough condition to determine that nine had labial probolae with pointed margins as illustrated by Thorne (1925) for *Z. punctata* and five had labial probolae with rounded margins similar to those illustrated for *Z. punctulata* (Thorne, 1925) Thorne, 1937, and *Z. serrata* Heyns, 1962. The variation among specimens in the type series of *Z. punctata* and the occurrence of similar variation in the labial probolae in other naturally occurring populations of this species seemed indicative of within-species variation, particularly in the absence of other distinguishing morphological characters. Anderson (1968) has reported similar variations in the labial probolae of *Acrobeloides nanus* (de Man, 1880) Anderson, 1968, and Anderson and Hooper (1970) for *Cephalobus persignis* Bastian, 1865.

Labial Probolae of *Z. punctata*

Soil collected by Dr. S. A. Sher near the Date Gardens at Indio, California, the type locality of *Z. punctata*, was found to contain specimens with rounded and pointed labial probolae, the latter being identifiable as *Z. punctata*. Single females from this collection were used to establish cultures of the nematode and associated bacteria on agar media. The shape of the probolae of each female was determined before it was placed in culture. Subsequently progeny of these females were examined and the probolae shape recorded. The results are shown in Table 1.

The number of progeny in the cultures originating from single females was variable and not correlated with the number of days the culture was maintained. The adult female

Table 1. Labial probolae shape in the female progeny of *Z. punctata* in cultures established with single females having either pointed or rounded probolae.

Temp	Probolae parent ♀	Probolae ♀ progeny		♂ Probolae	Days in culture	Total population
		Round	Pointed			
30 C	1 round (1)	896	0	0	27	4,080
	2 round	532	0	0	30	4,440
	3 round	497	3	0	64	8,518
25 C	1 round	551	10	0	45	8,161
	2 round	314	186	9 rd, 1 pt.	52	47,510
	3 round	506	0	0	56	56,949
	4 round	494	6	0	70	6,153
	5 round	511	0	0	71	5,461
30 C	1 pointed	64	493	0	41	5,957
	2 pointed	70	323	0	49	29,252
25 C	1 pointed	3	491	1 pt.	42	2,295
	2 pointed	3	516	0	50	60,082
	3 pointed (VI)	70	430	3 pt.	71	4,653

progeny examined were collected at random from water after the nematodes had been extracted from the agar in a modified Baermann funnel.

The progeny (adult females) of single females exhibited a range of variability in their labial probolae, from rounded to very pointed setose margins (Fig. 2, A). There was also a difference between individual females in the percentage of their progeny that exhibited variability in probolae shape. Males were found in three of the cultures (Table 1) and in one culture there was a mixture of males with rounded and pointed probolae. Prior to finding these males in cultures only a single male of *Z. punctata* had been collected, and that in South Africa.

Subcultures using 25 females per culture were established from several of the initial single female cultures. Populations produced by these females were examined for variability in the shape of their probolae. The results obtained from subculturing the populations marked I and VI in Table 1 are shown in Table 2. Subcultures were incubated at constant temperatures of 30, 25, 20, and 15 C. The females examined from the subcultures were collected at random from the total population of each plate.

In subculture I females with pointed probolae were not present in the 30 C culture, but they were present at the lower temperatures; no males were found in these subcultures. In subculture VI, which had its origin from a female with pointed probolae, only 8% of the females reared at 30 C had pointed probolae; at 25 and 20 C, 23 and 39% of the females had pointed probolae. These changes may be associated with temperature, but they may also be related to changes in the bacterial fauna of the cultures at the different temperatures. In this subculture I, 31 males were found, 16 with pointed probolae and 15 with rounded probolae.

Observations were also made on the configuration of the probolae of larvae from single females. The larval progeny of female number 2, 25 C (Table 1) were examined. Female progeny had a ratio of 314 round to 186 pointed. Second-stage larvae were 42 rounded and 52 pointed; third-stage larvae, 93 rounded and 7 pointed; fourth-stage larvae, 64 rounded and 7 pointed. These ratios among larvae differ from those of the adult females. However, it was observed that the shape of the probolae is not constant throughout the developmental stages of individual larvae. First-stage larvae have three low rounded lips and no evidence of cephalic probolae (Fig. 2, B). They also have a bluntly rounded tail terminus. Second-stage larvae have variable labial probolae, cephalic probolae are present, and the tail has a pointed terminus. Molting larvae were observed with the molted labial probolae rounded and the newly formed next stage with pointed probolae (Fig. 2, F). It is our conclusion that individual females of *Z. punctata*, whether with rounded or pointed probolae, may produce progeny in agar culture that have labial probolae differing in shape from the parent. Similar variability has been observed in naturally occurring populations of

Table 2. Labial probolae configuration of populations resulting from subculturing cultures I and VI (Table 1).

	I			VI		
	Original ♀ round probolae Progeny at 30 C, 890 round probolae			Original ♀ pointed probolae Progeny at 25 C, 60 round, 430 pointed probolae		
	Subculture progeny[1]			Subculture progeny		
Temp C	Round	Pointed	% Pointed	Round	Pointed	% Pointed
30	1,024	0	0.0	460	40	8.0
25	977	23	2.3	382	118	23.6
20	948	52	5.2	304	196	39.2
15	551	28	4.8	—	—	—

[1] Total number examined.

this species. With data from the laboratory and examinations of naturally occurring populations we believe that the taxonomic changes proposed in the following section are appropriate.

Taxonomy

Zeldia glyphra (Steiner, 1935) Thorne, 1937, was described from a single adult female from Mexico. It was differentiated from Z. *punctata* by the absence of cuticular punctation, more annules in the region of the buccal cavity, and the position of the nerve ring. The presence or absence of cuticular punctation is not a reliable character, because we have observed, in cultures and in naturally occurring populations, individuals with and without punctation. We believe Dr. Steiner was in error in showing the nerve ring encircling the isthmus of the esophagus. We have not encountered any individual in the genus which did not have the nerve ring surrounding the corpus of the esophagus, about opposite the excretory pore. The increased number of annules in the region of the esophagus probably resulted from shrinkage during fixation. We have observed specimens exhibiting similar shrinkage when procedures for killing and fixation were not properly carried out. Because of the absence of distinguishing morphological characters this species is made a synonym of Z. *punctata*.

Zeldia serrata Heyns, 1962. This species is similar in all respects to the form of Z. *punctata* with rounded labial probolae. We have been unable to discover any character that would make this a valid species. The serrate margins of the labial probolae described for this species are not consistently present in the paratype series that we have examined. It appears likely that the observed serrations are artifacts. In the absence of any distinguishing morphological characters the species is considered to be a synonym of Z. *punctata*. Evidence to support this conclusion also comes from a South African collection of three specimens; a male and one female had rounded probolae and a third female had pointed probolae.

Zeldia paucipunctata Andrássy, 1967, was described from a single immature female, which appears to be a fourth-stage larvae. The labial probolae fall within the range of those of Z. *punctata*; the posterior position of the phasmid and the forward position of the excretory pore were given as distinguishing characters. The specimen is distorted by shrinkage which accounts for the forward position of the excretory pore, and the phasmid is within the variation observed for Z. *punctata*. Because of the shrinkage of the cuticle in the anterior part of the body and the fact that the specimen is immature, it is impossible to determine the significance of the punctations

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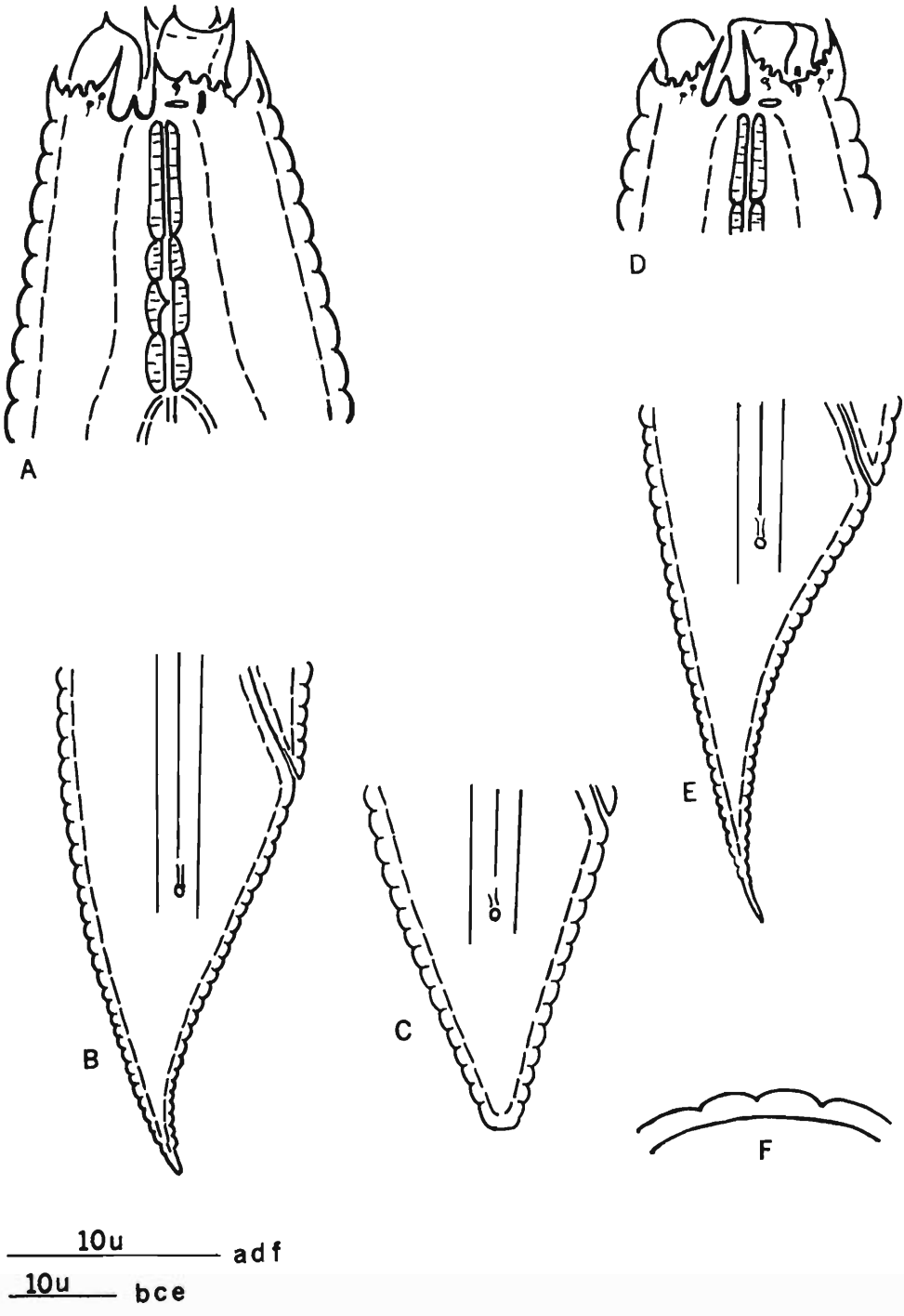
Figure 1. *Zeldia punctata*. A, D—Female heads; B, C, E—Female tails; F—Cross section of lateral field.



in that part of the body. We conclude that *Z. paucipunctata* is best regarded as a synonym of *Z. punctata*.

Zeldia acrobeles Andrássy, 1967, has been transferred to the genus *Nothacrobeles* Allen and Noffsinger, 1971, and becomes *Nothacrobeles acrobeles* (Andrássy, 1967) Allen and Noffsinger, 1971.

Zeldia punctulata (Thorne, 1925) Thorne, 1937. This species is placed as *species inquirenda*. The punctation illustrated by Thorne is very similar to that of *Z. odontocephala*. Thorne's syntypes are in very bad condition and no details of probolae or the cuticular punctation are visible. Two collections made by G. Griffin at the type locality in Utah did not contain specimens of *Zeldia*.

Zeldia setosa (Cobb, 1914) Thorne, 1937, described from a single young specimen is placed as a *species inquirenda*. Four collections made by W. R. Nickle from near the type locality in Virginia did not contain specimens of this species.

Zeldia trifurcata (Thorne, 1925) Goodey, 1963, is transferred back to the genus *Chiloplacus*, where Thorne placed it in 1937. It differs from *Zeldia* in the shape of the labial and cephalic probolae and in the shape of the female tail.

Systematics

Genus *Zeldia* Thorne, 1937

DIAGNOSIS EMENDED: Acrobelinae. Body cylindrical, tapering anteriorly. Tail short, conoid to elongate conoid, terminus acute or rounded. Cuticle usually punctate. Lateral fields two, marked by three incisures, the outer ones sometimes crenate. Labial probolae low and rounded to elongate, bifurcate. Cephalic probolae flaplike with three dentate cephalic axils. Axils and dentate point sometimes strongly cuticularized. Margins of axils rounded or attenuated, pointed. The anterior margins of the cephalic probolae usually bearing small membranous projections. Amphids elongate oval. A circle of 10 papillae on cephalic probolae. Cheilorhabdions without associated teeth or with one, two, or three teeth. These teeth appear to be connected to the cheilorhabdions. Pro-, meso-, meta-, and telorhabdions forming a narrow buccal cavity surrounded by esophageal tissue. Esophagus with a long cylindrical corpus, short isthmus, and a valvated posterior bulb. Nerve ring posterior to middle of corpus. Excretory pore about opposite the nerve ring, hemizonid near to and posterior to excretory pore. Deirid present near end of corpus. Gonad single, prodelphic, reflexed at juncture of uterus and ovary. Spermatheca absent. Distal end of ovary sometimes with a double flexure. Posterior uterine sac present. Rectal glands present. Phasmid present.

Males, rare. A single anteriorly directed gonad with a distal flexure. Spicules arcuate, gubernaculum linear. Preanal and postanal subventral papillae present, sometimes a subdorsal papillae near tail terminus.

TYPE SPECIES: *Zeldia punctata* (Thorne, 1925) Thorne, 1937.

Zeldia punctata (Thorne, 1925) Thorne, 1937

(Fig. 1, A–F; Fig. 2, A–G; Fig. 6, A)

SYN: *Acrobeles punctatus* Thorne, 1925; *Zeldia glyphra* (Steiner, 1935) Thorne, 1937, new synonymy; *Zeldia serrata* Heyns, 1962, new synonymy; *Zeldia paucipunctata* Andrássy, 1967, new synonymy.

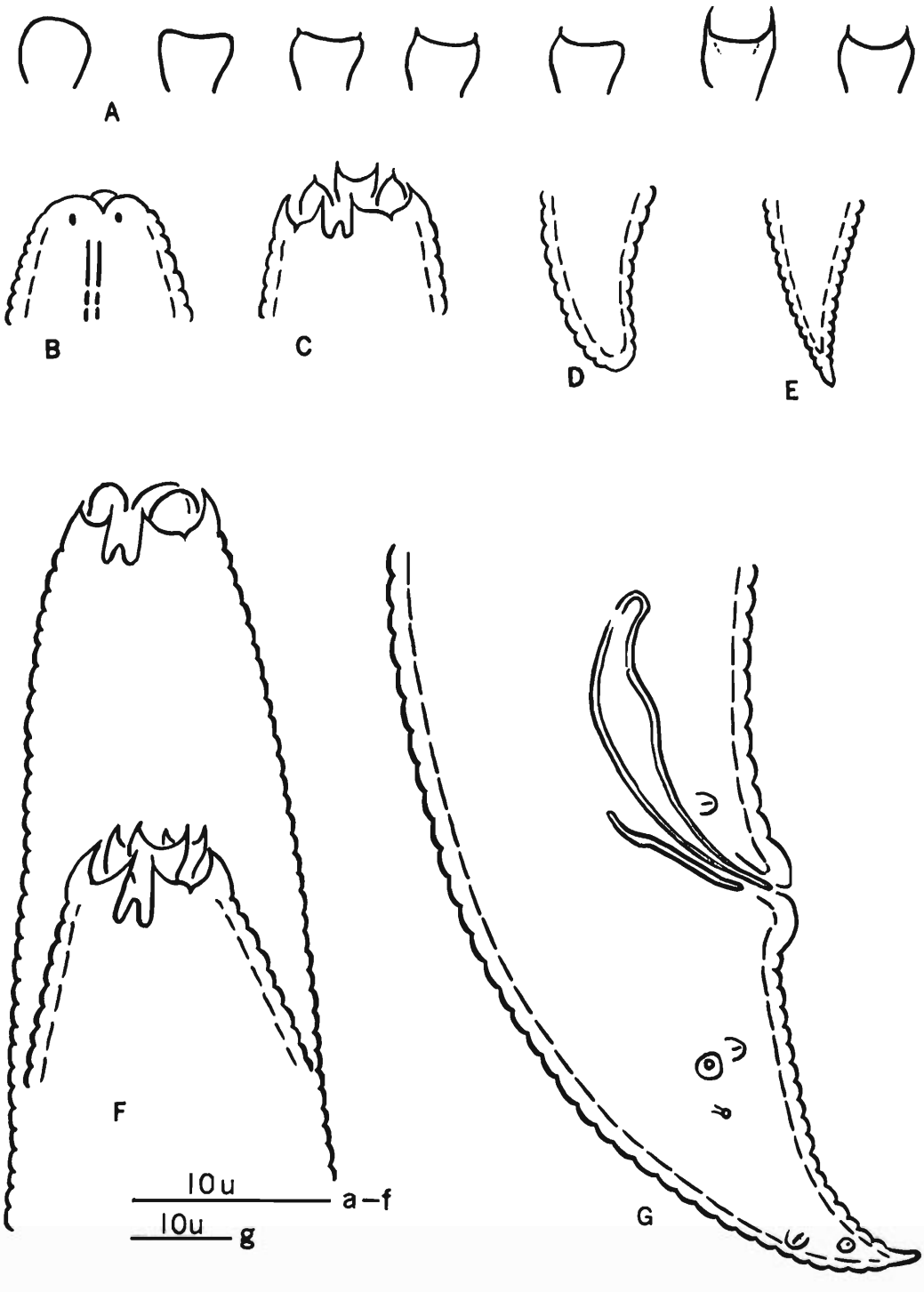
74 FEMALES: L = 0.80 (0.60–0.94) mm; a = 21.8 (15.8–27.3); b = 3.9 (3.3–4.5); c = 18.7 (13.2–23.6); V = 66 (62–68); T/abd = 1.9 (1.5–2.9); Ex. pore = 134 (100–159) μ.

17 MALES: L = 0.93 (0.82–1.01) mm; a = 25.7 (19.1–33.6); b = 4.3 (3.9–4.8); c = 17.5 (16.5–19.0); T = 46 (33–57); Spic. = 35 (29–40) μ; Gub. 17 (13–21) μ; T/abd = 1.7 (1.4–1.9); Ex. pore = 156 (129–172) μ.

LECTOTYPE (♀): L = 0.72 mm; a = 15.3

→

Figure 2. *Zeldia punctata*. A—Configuration of labial probolae; B—Head of first-stage larva; C—Head of second-stage larva; D—Tail of first-stage larva; E—Tail of second-stage larva; F—Molting larva showing change in labial probolae; G—Male tail.



(flattened); b = 3.6; c = 19.9; V = 67; T/abd = 1.5; Ex. pore = 120 μ.

Labial probolae variable in contour, with margins setose to rounded (Fig. 2, A). Cephalic probolae six, flaplike, anterior margin with a series of anteriorly projecting membranous points. Cephalic axils dentate, the dentation and posterior margins moderately cuticularized. Margins of cephalic axils pointed, extending forward a distance of three-fourths to equal to the anterior margins of the labial probolae (Fig. 1, A and D). Cephalic probolae with a circle of 10 papillae. Amphids elongate oval. Cheilorhabdions not modified with accessory teeth (Fig. 6, A). Cuticle annulated. Punctations, if present, not conspicuous, two transverse rows per annule in esophageal and tail region. Lateral field beginning three body widths from lip region extending to phasmids. Deirid near level of end of corpus. Excretory pore, hemizonid, and nerve ring about three-fourths length of esophagus from anterior end. Female reproductive system typical of genus (Fig. 7). A pair of obscure pores located dorsal to lateral field one and one-half body widths posterior to vulva. Phasmid near to or anterior to middle of tail. Terminus of tail pointed, or occasionally rounded.

MALE: Rare in nature, similar to female. Testis single, a flexure near distal end. Spicule arcuate, gubernaculum linear. Three pairs of subventral preanal papillae, four pairs of caudal papillae, one pair subdorsal papillae.

LECTOTYPE: Female collected 22–25 June 1925 by G. Thorne. Catalog number T-197-t, USDA Nematode Collection, Beltsville, Maryland.

PARALECTOTYPES: Thirty females, same data as lectotype, USDA Nematode Collection, Beltsville, Maryland.

TYPE HABITAT: Sandy soil around the roots of date palm.

TYPE LOCALITY: Date Gardens, Indio, California. Collected by Gerald Thorne, 22–25 June 1925.

DIAGNOSIS: *Z. punctata* most closely resembles *Z. minor*, *Z. feria*, and *Z. punua*. It differs from *Z. minor* in having wider cephalic axils, with more conspicuous dentation and heavier cuticularization; from *Z. feria* by the lighter punctations of the cuticle, the longer tail, and the more heavily cuticularized excretory tube; from *Z. punua* by the shorter bifurcations of the labial probolae, longer tail, and position of the phasmid (level of anus in *Z. punua*).

Z. punctata is a widely distributed species and is commonly found in warm sandy soils in many areas of the world.

Zeldia feria sp. n.
(Fig. 3, D–F)

11 FEMALES: L = 0.91 (0.77–0.98) mm; a = 22.6 (20.0–27.4); b = 3.8 (3.5–4.3); c = 24.3 (20.5–29.3); V = 66 (65–67); T/abd = 1.5 (1.3–1.7); Ex. pore = 145 (123–155) μ.

HOLOTYPE (♀): L = 0.97 mm; a = 24.9; b = 3.8; c = 25.6; V = 66; T/abd = 1.6; Ex. pore = 155 μ.

Labial probolae rounded to slightly concave at anterior margins. Cephalic probolae similar to those of *Z. punctata*. The cephalic axils are moderately cuticularized, dentate point small. Excretory tube obscure, lightly cuticularized. Cheilorhabdions without teeth as in *Z. punctata* (Fig. 6, A). Cuticle annulated, width at neck 1.8 μ, middle 2.5 μ, posterior 2.1 μ. Each annule with two rows of prominent punctations. Punctations about equal in size over entire body. Phasmid near middle of tail. Tail conoid, terminus rounded.

MALE: Not known.

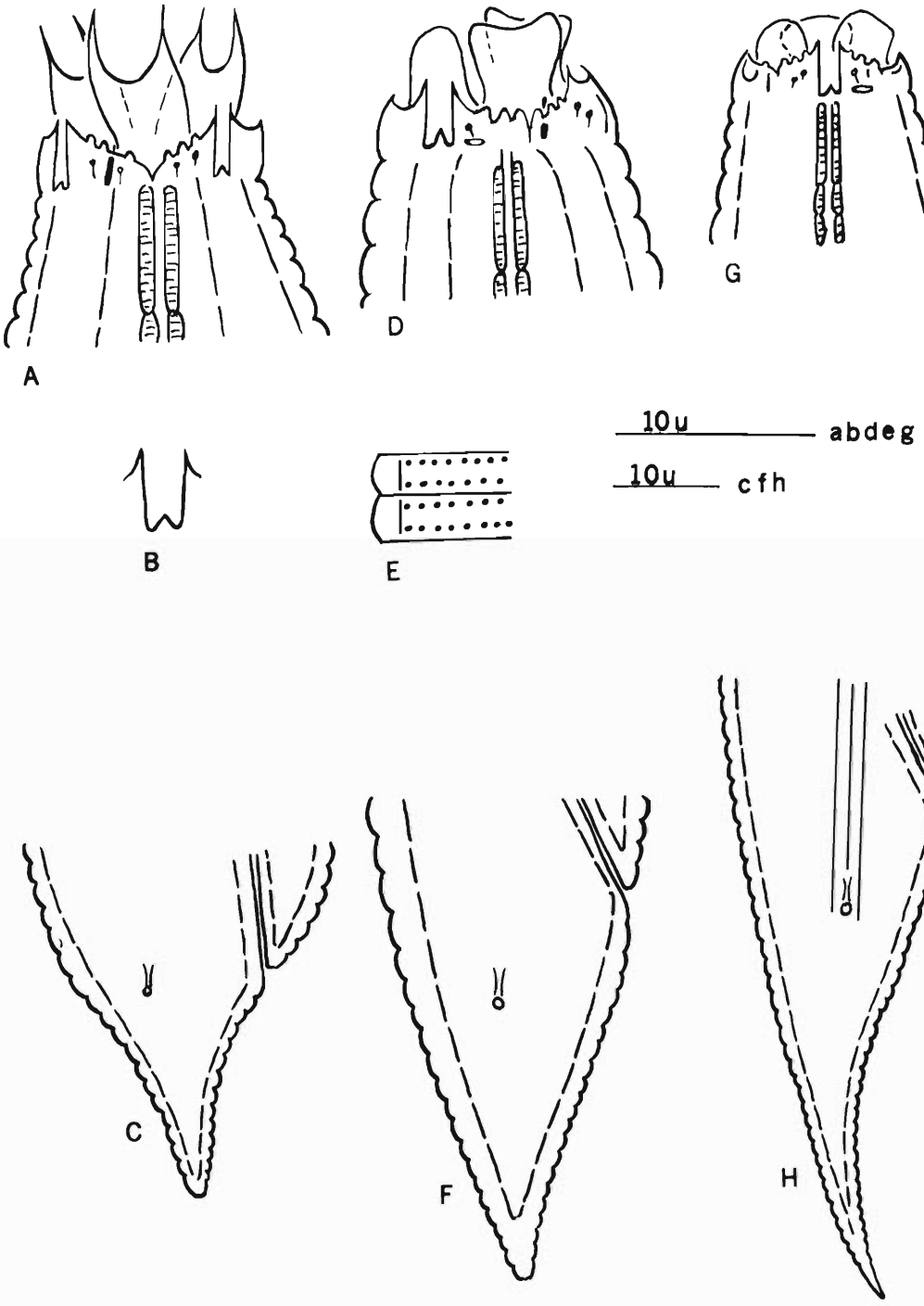
HOLOTYPE (♀): Collected May 1967 by P. A. A. Loof. Catalog number UCNC 1291, University of California, Davis.

PARATYPES: Four females, same data as holotype. Distributed as follows: 2 females, University of California, Davis; 2 females, Wageningen, The Netherlands.

TYPE HABITAT: Soil.

→

Figure 3. *Zeldia punua*. A—Female head; B—Cephalic axil; C—Female tail. *Zeldia feria* sp. n. D—Female head; E—Punctation of cuticle; F—Female tail. *Zeldia minor* sp. n. G—Female head; H—Female tail.



TYPE LOCALITY: Scheveningen, The Netherlands.

DIAGNOSIS: *Z. feria* is nearest to *Z. punctata* from which it differs in having conspicuous punctation, particularly large and prominent in the posterior part of the body, and the conoid tail with a rounded terminus. From *Z. punua*, it differs in the shape of the labial probolae and the position of the phasmid.

This species has also been examined from Goeree, Terschelling, and Westerbork, The Netherlands; Australia; and one young from India.

Zeldia minor sp. n.
(Fig. 3, G–H)

31 FEMALES: L = 0.81 (0.72–0.90) mm; a = 19.1 (16.6–25.7); b = 3.8 (3.3–4.1); c = 18.5 (15.4–23.2); V = 66 (65–67); T/abd = 1.8 (1.5–2.2); Ex. pore = 140 (130–163) μ.

HOLOTYPE (♀): L = 0.84 mm; a = 20.0; b = 3.7; c = 20.0; V = 67; T/abd = 1.7; Ex. pore = 143 μ.

Labial probolae rounded. Cephalic probolae similar to those of *Z. punctata*. The cephalic axils and the dentate point are very lightly cuticularized and narrow, their width being less than 1 μ and the dentate point very small. The cheilorhabdions are without teeth as in *Z. punctata* (Fig. 6, A). Cuticle annulated, width of annules anteriorly 1.3 μ, middle of body 2.3 μ, near tail 1.6 μ. Faint punctations, two rows per annule. Deirid near posterior end of corpus. Body pore about one body width behind vulva. Phasmid in anterior half of tail. Tail concave, conoid.

MALE: Not known.

HOLOTYPE (♀): Collected 3 August 1964 by F. E. Caveness. Catalog number UCNC 1259, University of California, Davis.

PARATYPES: Nineteen females, same data as holotype. Paratypes distributed as follows: 12 females, University of California, Davis; one female deposited at each of the following: USDA Nematode Collection, Beltsville, Maryland; University of California, Riverside; Wageningen, The Netherlands; Department of Zoology, Randse Afrikaanse University, Johannesburg, Republic of South Africa; CSIRO, Merbein, Victoria, Australia; I. Andrássy, Budapest, Hungary; Department of Scientific and Industrial Research, Entomology Division, University of Nelson, Nelson, New Zealand.

TYPE HABITAT: Soil around the roots of vegetables.

TYPE LOCALITY: Niger Province, Nigeria (7½ miles W of Bida and 3 miles N of Badeggi).

DIAGNOSIS: *Z. minor* is similar to *Z. punctata* from which it differs in the width of the cephalic axil (less than 1 μ, more than 1.5 μ for *Z. punctata*). Axils lightly cuticularized and the dentate point small and obscure.

This species is known only from Nigeria, where it has been collected in six provinces.

Zeldia punua Yeates, 1967
(Fig. 3, A–C)

HOLOTYPE (♀): L = 0.88 mm; a = 21.3; b = 3.1; c = 38.0; V = 63; T/abd = 1.1; Ex. pore = 119 μ.

Labial probolae bifurcate, with long setose margins. Bifurcations about one-half total length of the probolae. Cephalic probolae similar to those of *Z. punctata*. Cheilorhabdions without accessory teeth. Cuticle annulated, width of annules, esophageal region 1.9 μ, middle of body 2.3 μ, dorsal to anus 2.0 μ. Lateral field with three incisures, the outer ones crenate. Punctation conspicuous, two rows per annule, very large punctations in the posterior one-fifth of body. Phasmid slightly posterior to level of anus. Tail short, tapering rapidly to the bluntly rounded terminus.

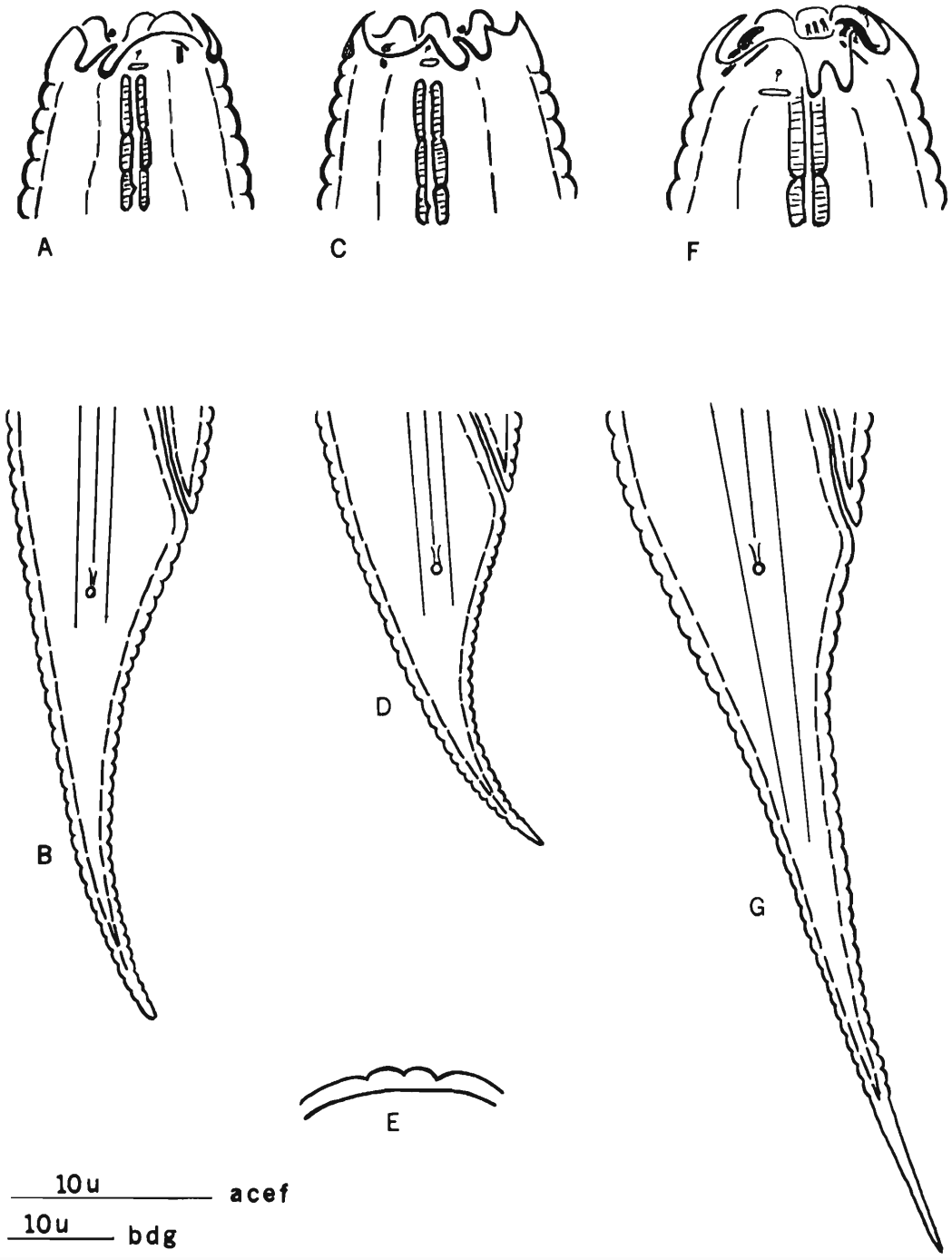
MALE: Not known.

HOLOTYPE (♀): Nematode Collection, Department of Scientific and Industrial Research, Entomology Division, University of Nelson, Nelson, New Zealand.

TYPE HABITAT: Sand around the roots of *Ammophilia arenaria* (L.) Link.

→

Figure 4. *Zeldia neoacuta* sp. n. A—Female head; B—Female tail. *Zeldia acuta* sp. n. C—Female head; D—Female tail; E—Cross section of lateral field. *Zeldia tridentata* sp. n. F—Female head; G—Female tail.



TYPE LOCALITY: Himatangi Beach, Manawater, N.Z.M.S.I., N148,751323.

DIAGNOSIS: *Z. punua* is distinguished from *Z. punctata*, *Z. minor*, and *Z. feria* by the longer setose margins of the labial probolae, crenate margins of outer incisures, short tail, and position of the phasmid. It differs from the other species by the absence of teeth associated with the cheilorhabdions.

The measurements, description, and diagnosis are based upon examination of the holotype and paratypes, loaned by Dr. W. C. Clarke, Zoology Department, University of Canterbury, Christchurch, New Zealand.

Zeldia odontocephala Steiner, 1938 (Fig. 5, D–E; Fig. 6, D)

22 FEMALES: L = 0.79 (0.72–0.86) mm; a = 22.3 (18.0–26.6); b = 3.7 (3.0–4.6); c = 16.5 (14.2–20.3); V = 64 (61–66); T/abd = 2.3 (1.8–2.8); Ex. pore = 130 (114–143) μ.

Labial probolae rounded, without setose points. Cephalic probolae similar to those of *Z. punctata*, their anterior margins with triangular flaps which are very obscure in fixed specimens, but easily observed in living specimens. Cheilorhabdions each with two accessory teeth (Figs. 5, D and 6, D). Cuticle annulated, each annule usually with two rows of punctations, sometimes three rows at midbody. Lateral field with three incisures, the outer ones usually crenate. Tail conoid, ventrally concave. Phasmid near middle of tail. Terminus of tail usually pointed, occasionally rounded.

MALES: Not known.

LECTOTYPE (♀): Collected 27 November 1937 by C. B. Henderson. Catalog number T-196-t, USDA Nematode Collection, Beltsville, Maryland.

TYPE HABITAT: Warty disease lesion on Irish potato.

TYPE LOCALITY: Greer, South Carolina.

DIAGNOSIS: *Z. odontocephala* can be distinguished from other species by the presence of a pair of teeth associated with each cheilorhabdion.

The syntype series of Dr. Steiner was made available for study. These specimens are in very poor condition and with the exception of one female are not identifiable. The single visible character on the best of the specimens is the teeth associated with the cheilorhabdion. In the specimen designated as a lectotype two teeth are visible, similar to those illustrated (Fig. 5, D). Dr. Steiner in his description indicates the presence of three teeth, one in the interspace between each of the labial probolae. However, the fact that two are visible in the specimen we have selected as the lectotype leads to the conclusion that Dr. Steiner was not correct in stating that a single tooth was present. We have been able to see the triangular projections on the anterior margins on all but two of the species described in this paper and conclude that this is not a useful character for identification of species. Mr. Gerald Thorne loaned a *Zeldia* species collected from soil in Bishopville, South Carolina. These specimens have two teeth as in the lectotype and although the collection site is some distance from Greer, South Carolina, it is established that *Z. odontocephala* occurs in another locality in the state.

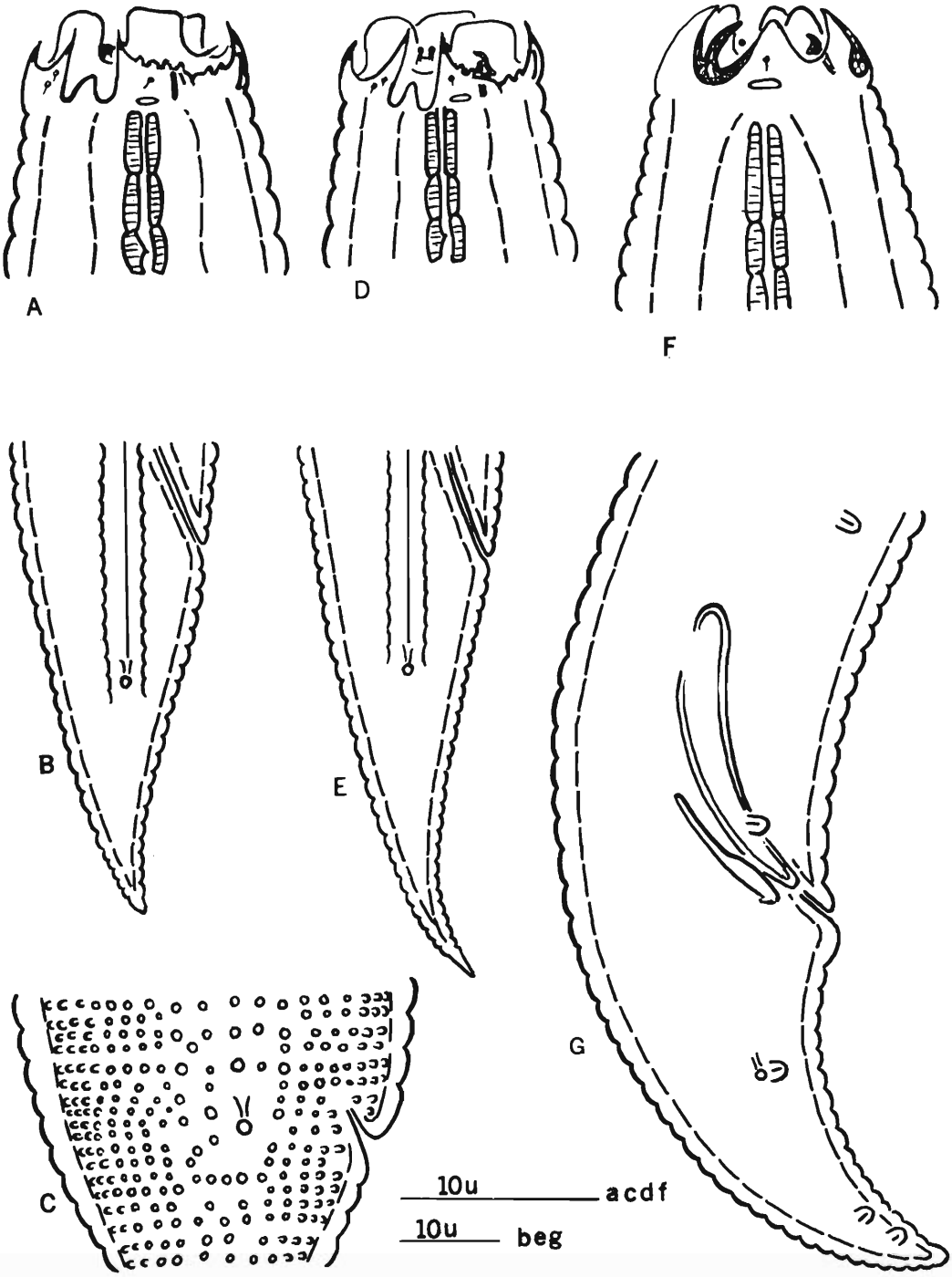
Specimens of *Z. odontocephala* have been collected in Alabama, Arkansas, California, Florida, and Georgia and from Australia, Chile, and Israel. We have maintained cultures of *Z. odontocephala* in agar–bacteria cultures for more than 1 year. We have not observed variations in the labial probolae or the number of teeth. No males have been found in the cultures, which contained 91,400 adult females. The lip region of the first-stage larvae is similar to that of first-stage larvae of *Z. punctata*, with no evidence of labial and cephalic probolae or the teeth which are present in second-stage larvae.

Zeldia tridentata sp. n. (Fig. 4, F–G; Fig. 6, E)

24 FEMALES: L = 0.73 (0.61–0.87) mm; a = 24.1 (18.5–35.1); b = 3.8 (3.2–4.6); c =

→

Figure 5. ***Zeldia spinula*** **sp. n. A—Female head; B—Female tail.** ***Zeldia odontocephala.*** **D—Female head; E—Female tail.** ***Zeldia solata*** **sp. n. F—Female head; G—Male tail; C—Phasmid and punctation, female tail.**



10.6 (8.1–14.6); V = 62 (59–64); T/abd = 3.8 (2.8–4.9); Ex. pore = 115 (84–136) μ.

HOLOTYPE (♀): L = 0.87 mm; a = 21.7; b = 4.6; c = 11.4; V = 63; T/abd = 3.6; Ex. pore = 136 μ.

Labial probolae low, rounded. Cephalic axils and dentate point moderately cuticularized. Anterior borders of cephalic axils rounded. Each cheilorhabdion associated with a structure having three teeth (Figs. 4, F and 6, E). In toto mounts the three teeth are seen behind the cephalic axils and between the labial probolae. Width of annules, esophagus 1.4 μ, midbody 2.3 μ, dorsal to anus 1.6 μ. Cuticle moderately punctate, two rows of punctations per annule. Outer incisures not crenate. Tail conoid, elongate. Phasmid slightly posterior to level of anus.

MALES: Not known.

HOLOTYPE (♀): Collected 8 September 1962 by R. B. Valdez. Catalog number UCNC 1256, University of California, Davis.

PARATYPES: Eight females collected by C. Calica, A. G. Newhall, and R. B. Valdez, from same habitat as holotype, differing only in dates and locations on Luzon Island. Distributed as follows: 4 females, University of California, Davis; 1 female deposited at each of the following: USDA Nematode Collection, Beltsville, Maryland; University of California, Riverside; Wageningen, The Netherlands; Department of Zoology, Randse Afrikaanse University, Johannesburg, Republic of South Africa.

TYPE HABITAT: Soil around the roots of coconut.

TYPE LOCALITY: Baao, Luzon Island, Philippine Islands.

This species has also been collected from Ceylon, India, Jamaica, Taiwan, Thailand, and Venezuela.

Z. *tridentata* is distinguished from other species of the genus by the presence of three teeth associated with each cheilorhabdion and the longer tail.

Zeldia spinula sp. n.
(Fig. 5, A–B; Fig. 6, B)

19 FEMALES: L = 0.78 (0.67–0.88) mm; a = 23.4 (21.0–28.7); b = 4.0 (3.3–4.9); c = 20.7 (19.1–22.3); V = 65 (64–69); T/abd = 1.8 (1.6–2.0); Ex. pore = 132 (114–152) μ.

HOLOTYPE (♀): L = 0.80 mm; a = 27.5; b = 3.7; c = 19.5; V = 65; T/abd = 2.0; Ex. pore = 141 μ.

Labial probolae blunt with rounded margins. Cephalic probolae flaplike with three moderately cuticularized dentate cephalic axils, their margins attenuated, pointed. A single toothlike structure associated with each cheilorhabdion (Figs. 5, A and 6, B). Cuticle annulated, two rows of obscure transverse punctations per annule. Lateral field with outer incisures crenated. Width of annules, neck 1.8 μ, midbody 2.2 μ, opposite anus 1.7 μ. Tail ventrally concave, conoid. Terminus bluntly rounded. Phasmid near middle of tail.

MALE: Not known.

HOLOTYPE (♀): Collected July 1969 by R. D. Riggs. Catalog number UCNC 1255, University of California, Davis.

PARATYPES: Five females, same data as holotype. Distributed as follows: 4 females, University of California, Davis; 1 female deposited USDA Nematode Collection, Beltsville, Maryland.

TYPE HABITAT: Soil around the roots of soybean.

TYPE LOCALITY: North Little Rock, Arkansas.

Specimens of this species have been collected from Louisiana, USA; The Netherlands; and one immature female from Australia.

DIAGNOSIS: Z. *spinula* is most closely related to Z. *odontocephala* from which it differs in having a single tooth associated with each cheilorhabdion (two in Z. *odontocephala*). It differs from Z. *solata*, Z. *acuta*, and Z. *neoacuta* in having prominent labial probolae and having the margins of the cephalic probolae attenuated and pointed.

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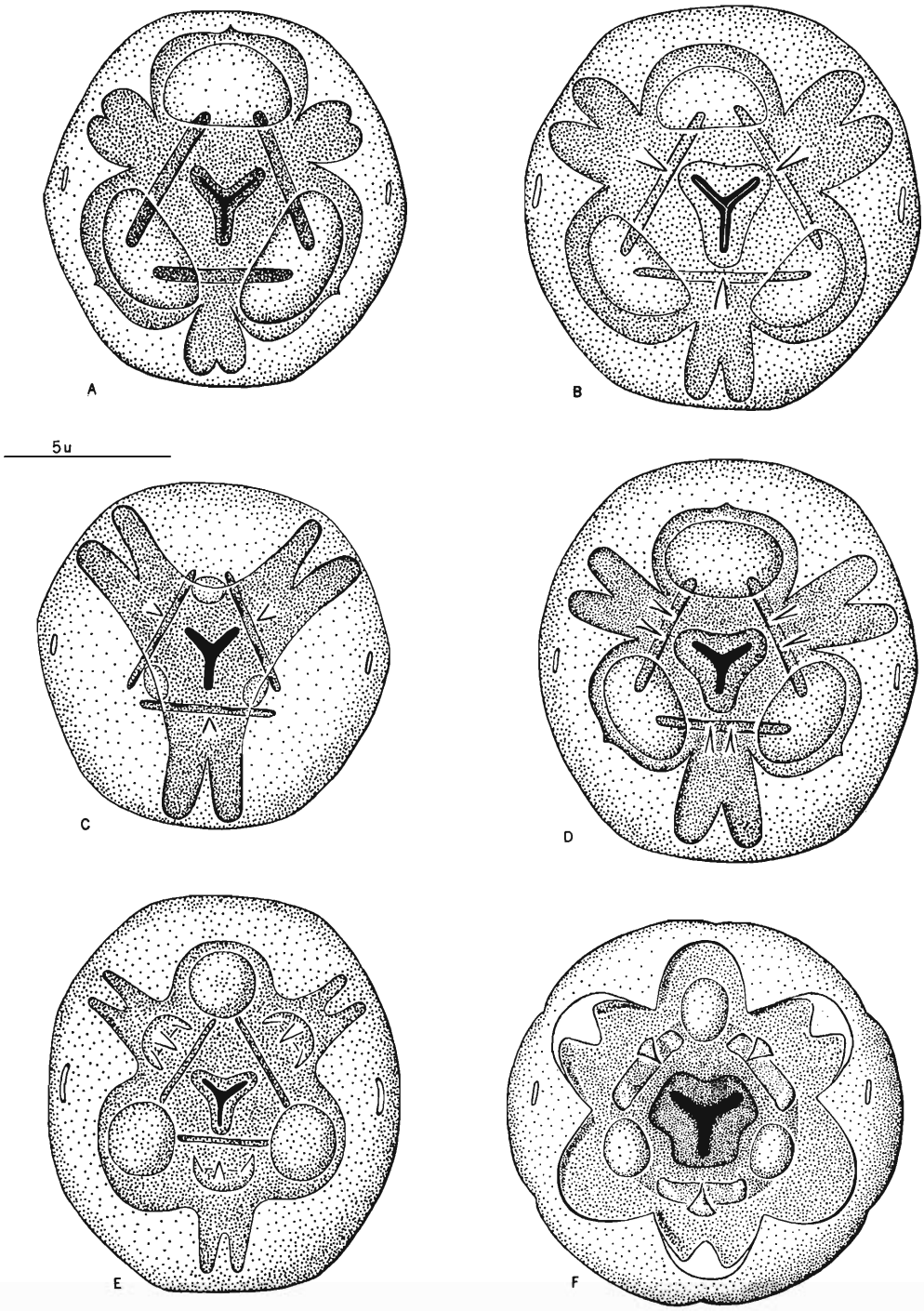
Figure 6. Face views. A—*Zeldia punctata*; B—*Zeldia spinula* sp. n.; C—*Zeldia neoacuta* sp. n.; D—*Zeldia odontocephala*; E—*Zeldia tridentata* sp. n.; F—*Zeldia solata* sp. n.



Zeldia acuta sp. n.
(Fig. 4, C–E)

30 FEMALES: L = 0.68 (0.56–0.78) mm; a = 22.9 (17.4–28.8); b = 3.7 (3.5–4.1); c = 16.3 (14.2–19.7); V = 65 (64–66); T/abd = 2.3 (2.1–2.6); Ex. pore = 116 (100–131) μ.

HOLOTYPE (♀): L = 0.65 mm; a = 22.2; b = 3.7; c = 15.0; V = 64; T/abd =2.6; Ex. pore = 111 μ.

Labial probolae low, rounded, obscure. Cephalic probolae flaplike. Cephalic axils and dentate point heavily cuticularized. The dentate point large, conspicuous. In profile view the axils and dentate point have the appearance of a curved tooth (Fig. 4, C). Margin of cephalic axils not attenuated, not acutely pointed. A single toothlike structure associated with each cheilorhabdion (Fig. 6, B–C). Cuticle annulated, width of annules, neck 1.6 μ, midbody 1.9 μ, opposite anus 1.4 μ. Outer incisures not crenate. Cuticular punctation not present or very obscure. Phasmid in anterior third of tail. Tail ventrally concave, conoid. Terminus acute, sometimes rounded.

MALES: Not known.

HOLOTYPE (♀): Collected 14 May 1964 by F. E. Caveness. Catalog number UCNC 1260, University of California, Davis.

PARATYPES: Five females, same data as holotype. Distributed as follows: 4 females, University of California, Davis; 1 female, USDA Nematode Collection, Beltsville, Maryland.

TYPE HABITAT: Soil around the roots of stylo.

TYPE LOCALITY: Port Harcourt Province, Nigeria (38 miles S of Port Harcourt and 2¼ miles SW of Ogoni).

This species has been examined from five other provinces in Nigeria, and from the following countries; India, Puerto Rico, and Sierra Leone.

DIAGNOSIS: *Z. acuta* is most closely related to *Z. neoacuta* from which it differs in having the margins of the cephalic axils pointed and a shorter tail.

Zeldia neoacuta sp. n.
(Fig. 4, A–B; Fig. 6, C)

29 FEMALES: L = 0.66 (0.59–0.79) mm; a = 22.4 (19.8–28.6); b = 3.7 (3.4–4.2); c = 14.5 (12.0–17.2); V = 65 (62–66); T/abd = 2.8 (2.2–3.5); Ex. pore = 115 (105–127) μ.

HOLOTYPE (♀): L = 0.76 mm; a = 24.4; b = 3.8; c = 14.5; V = 64; T/abd = 3.0; Ex. pore = 125 μ.

Labial probolae low, rounded, obscure. Cephalic probolae obscure. Cephalic axils with conspicuous cuticularization, dentate point large, heavily cuticularized. The anterior margins of the cephalic axils rounded (Figs. 4, A and 6, C). Anterior margins of cephalic probolae convex, rounded, obscure. Cheilorhabdions, each with one accessory tooth. Cuticle with transverse annulation, width of annules posterior to lip region 1.7 μ, midbody 2.3 μ, dorsal to anus 1.7 μ. Punctation usually present, two transverse rows per annule. Tail ventrally concave, conoid, terminus usually rounded. Phasmid opening in anterior one-third of tail.

MALES: Not known.

HOLOTYPE (♀): Collected 22 July 1964 by F. E. Caveness. Catalog number UCNC 1258, University of California, Davis.

PARATYPES: Ten females, same data as holotype. Distributed as follows: 4 females, University of California, Davis; 1 female at each of the following: USDA Nematode Collection, Beltsville, Maryland; University of California, Riverside; Wageningen, The Netherlands; Department of Zoology, Randse Afrikaanse University, Johannesburg, Republic of South Africa; I. Andrássy, Budapest, Hungary; Department of Scientific and Industrial Research, Entomology Division, University of Nelson, Nelson, New Zealand.

TYPE HABITAT: Soil around the roots of yam.

TYPE LOCALITY: Benue Province, Nigeria (5½ miles NE of Gboko Township and 52 miles W of Makurdi Township).

This species has been collected in 15 other provinces of Nigeria, and also in Jamaica and Sierra Leone.

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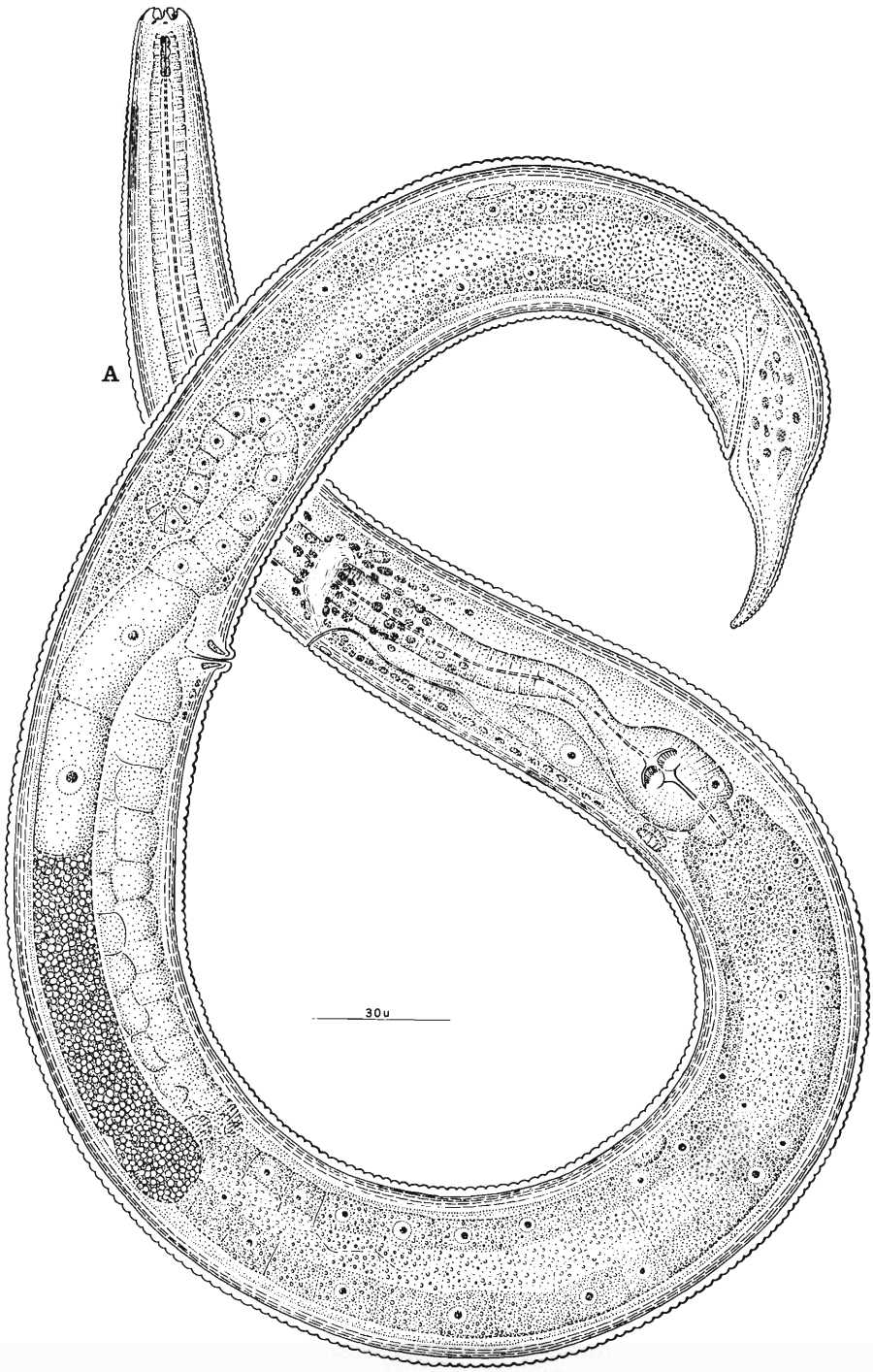
Figure 7. *Zeldia solata* sp. n. A—Female.



DIAGNOSIS: *Z. neoacuta* is most closely related to *Z. acuta* from which it differs in having the anterior margins of the cephalic axils rounded and the anterior margins of the cephalic probolae convexly rounded.

Zeldia solata sp. n.

(Fig. 5, C, F–G; Fig. 6, F; Fig. 7)

28 FEMALES: L = 0.85 (0.75–1.03) mm; a = 21.9 (17.3–28.4); b = 3.9 (3.6–4.4); c = 22.9 (19.0–28.4); V = 65 (64–68); T/abd = 1.9 (1.6–2.1); Ex. pore = 138 (126–170) μ.

HOLOTYPE (♀): L = 0.89 mm; a = 22.1; b = 3.8; c = 20.6; V = 67; T/abd = 2.0; Ex. pore = 143 μ.

Labial probolae low, rounded, obscure. Cephalic probolae flaplike. Cephalic axils and dentate point heavily cuticularized, the dentate point large (Fig. 5, F). Cheilorhabdions massive, a toothlike structure associated with each cheilorhabdion (Fig. 6, F). Cuticle with transverse annulation, width behind lip region 2.0 μ, midbody 2.3 μ, opposite anus 2.4 μ. Cuticle with conspicuous punctation, two rows per annule. Punctations large, very prominent on and near tail (Fig. 5, C). Tail ventrally convex conoid, terminus bluntly rounded (Fig. 7). Phasmid opening near level of anus.

MALE (1 paratype): L = 0.79 mm; a = 27.4; b = 3.5; c = 16.5; T = 43; Spic. = 35 μ; Gub. = 18 μ; T/abd = 1.8; Ex. pore = 140 μ.

Similar to female. Testis single, a flexure at distal end. Spicule arcuate. Gubernaculum linear, wider in distal portion. Two pairs of subventral preanal papillae, three subventral pairs on tail. Terminus of tail bluntly rounded.

HOLOTYPE (♀): Collected 25 October 1955 by D. J. Raski. Catalog number UCNC 1261, University of California, Davis.

PARATYPES: Fourteen females, same data as holotype. One male collected 28 January 1952 by J. R. Christie, Fort Meyer, Florida. Distributed as follows: 7 females and 1 male, University of California, Davis; 1 female deposited at each of the following: USDA Nematode Collection, Beltsville, Maryland; University of California, Riverside; Wageningen, The Netherlands; Department of Zoology, Randse Afrikaanse University, Johannesburg, Republic of South Africa; CSIRO, Merbein, Victoria, Australia; I. Andrássy, Budapest, Hungary; Department of Scientific and Industrial Research, Entomology Division, University of Nelson, Nelson, New Zealand.

TYPE HABITAT: Soil around the roots of oak (*Quercus virginiana*).

TYPE LOCALITY: Moore Haven, Florida (7 miles NW on Highway 27).

Specimens of this species have been collected in Texas.

DIAGNOSIS: *Z. solata* can be distinguished from *Z. acuta*, *Z. neoacuta*, and *Z. spinula* by its larger size, shape of the tail, position of the phasmid, and the prominent punctations on the tail.

Key to the Species of *Zeldia*

1. No teeth associated with cheilorhabdions 2
   Teeth associated with cheilorhabdions 5
2. Labial probolae bifurcate about one-half their length, tail short, less than 1.5× anal body diameter, terminus bluntly rounded ..... *punua* Yeates, 1967
   Labial probolae bifurcate less than one-third their length, or bluntly round 3
3. Cephalic axils less than 1 μ wide, lightly cuticularized, inconspicuous, dentate point very small, lightly cuticularized ..... *minor* sp. n.
   Cephalic axils more than 1 μ wide, moderately cuticularized, dentate point conspicuous 4
4. Tail conoid, terminus rounded, cuticle heavily punctate, probolae with rounded margins ..... *feria* sp. n.
   Tail ventrally concave conoid, terminus usually pointed, cuticle without or with light to moderate punctation, labial probolae bifurcate to bluntly rounded ..... *punctata* (Thorne, 1925)
5. Cheilorhabdions with two or three accessory teeth 6
   Cheilorhabdions with one accessory tooth 7
6. Cheilorhabdions with two accessory teeth, tail less than 3× anal body diameter ..... *odontocephala* Steiner, 1938
   Cheilorhabdions with three accessory teeth, tail more than 3× anal body diameter ..... *tridentata* sp. n.

7. Tail terminus bluntly rounded, phasmid at or anterior to anus, cuticular punctation on tail large, cephalic axils heavily cuticularized ..... *solata* sp. n.
   Tail terminus pointed, phasmid posterior to anus, punctation faint to moderate .. 8
8. Labial probolae large, bluntly rounded, margins of cephalic axils elongate, setose ..... *spinula* sp. n.
   Labial probolae small, rounded, margins of cephalic axils not elongate or setose 9
9. Margins of cephalic axils pointed ..... *acuta* sp. n.
   Margins of cephalic axils rounded ..... *neoacuta* sp. n.

Acknowledgments

The authors thank the following persons for furnishing many of the specimens used in this study: I. Andrássy, F. E. Caveness, W. C. Clark, R. P. Esser, A. M. Golden, J. Heyns, P. A. A. Loof, D. J. Raski, R. D. Riggs, M. Sauer, S. A. Sher, G. Thorne, and R. B. Valdez.

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Prosthodendrium volaticum sp. n. (Trematoda: Lecithodendriidae) from Two Species of Iowa Bats[1]

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ABSTRACT: *Prosthodendrium volaticum* sp. n. is described from the red bat, *Lasiurus borealis* (Müeller), and the big brown bat, *Eptesicus fuscus* (Beauvois), in Iowa. Eleven of 55 big brown bats and one of four red bats were infected. *P. volaticum* appears to exhibit seasonal periodicity, largest populations occurring during late summer and fall.

In a survey of parasites of chiropterans, 59 bats of two species from seven Iowa counties were examined for helminths during 1966–68. From 11 of 55 *Eptesicus fuscus* (big brown bat) and one of four red bats, *Lasiurus borealis*, 16 specimens of an undescribed species of Lecithodendriidae were recovered. Data relating to this new species of trematode from a study of helminths from six species of Iowa bats (Blankespoor and Ulmer, 1970) are included in this investigation. A single fluke was recovered from every infected host except for a big brown bat which harbored five adults.

Materials and Methods

Bats were collected from their roosts or in flight with the use of a 22-caliber rifle and were examined for helminths immediately after death. Flukes were fixed with A.F.A. under slight coverslip pressure, and Mayer's paracarmine, Erhlich's acid hematoxylin, Harris' hematoxylin, fast green, and eosin were used in the preparation of whole mounts and serial sections. Measurements of holotype and size ranges (in parentheses) of nine additional specimens are recorded in millimeters.

Gilford (1952), in an unpublished Master's Thesis, was the first to record this species and suggested the name *P. volaticum*. He did not, however, publish his findings. As a result of correspondence with Dr. Gilford, he suggested that we proceed with the publication of the species description based on Iowa specimens, and recommended that we include any of his data needed to supplement ours. The following description of *P. volaticum* includes certain findings based on his studies, particularly with reference to the position of the oviduct and associated female reproductive structures. We wish to acknowledge his cooperation in providing us with these additional data.

[1] This investigation was supported in part by NSF grant GB 5465X.
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Prosthodendrium volaticum sp. n.

Description

(Fig. 1)

Body oval, length 0.96 (0.56–1.46) by 0.78 (0.60–0.98); flattened dorsoventrally, rounded posteriorly, broadly pointed anteriorly; greatest width in area between testes and acetabulum; tegument aspinose, approximately 0.003 thick; oral sucker terminal, 0.07 (0.05–0.07) long, 0.09 (0.07–0.10) wide; acetabulum 0.08 (0.07–0.11) long, 0.09 (0.07–0.12) wide, immediately caudal to prostate gland complex; prepharynx absent; muscular pharynx 0.05 (0.04–0.05) long by 0.06 (0.05–0.06) wide; esophagus narrow, 0.22 (0.13–0.33) long, 0.01 (0.01–0.02) wide, extending to posterior level of vitellaria, then dividing to form two V-shaped intestinal crura; one arm of each crus extending posterolaterad to anterior level of testis, then bending to right angles and continuing anterolaterally between testes and vitellaria. Esophagus and proximal fourth of crura lined with tegument; distal three-fourths lined with darkly staining, apparently glandular epithelial cells. Vitellaria lateral to esophagus and anterior to intestinal crura, composed of 30 to 40 follicles in grapelike clusters. Right and left vitelline ducts extending posteriad, passing parallel to each side of prostate gland complex and fusing at its right posterolateral margin. Common vitelline duct short and not readily seen in whole mounts. Testes triangular to quadrangular, preovarian and preacetabular, in middle third of body. Right testis 0.23 (0.14–0.25) by 0.21 (0.15–0.30);

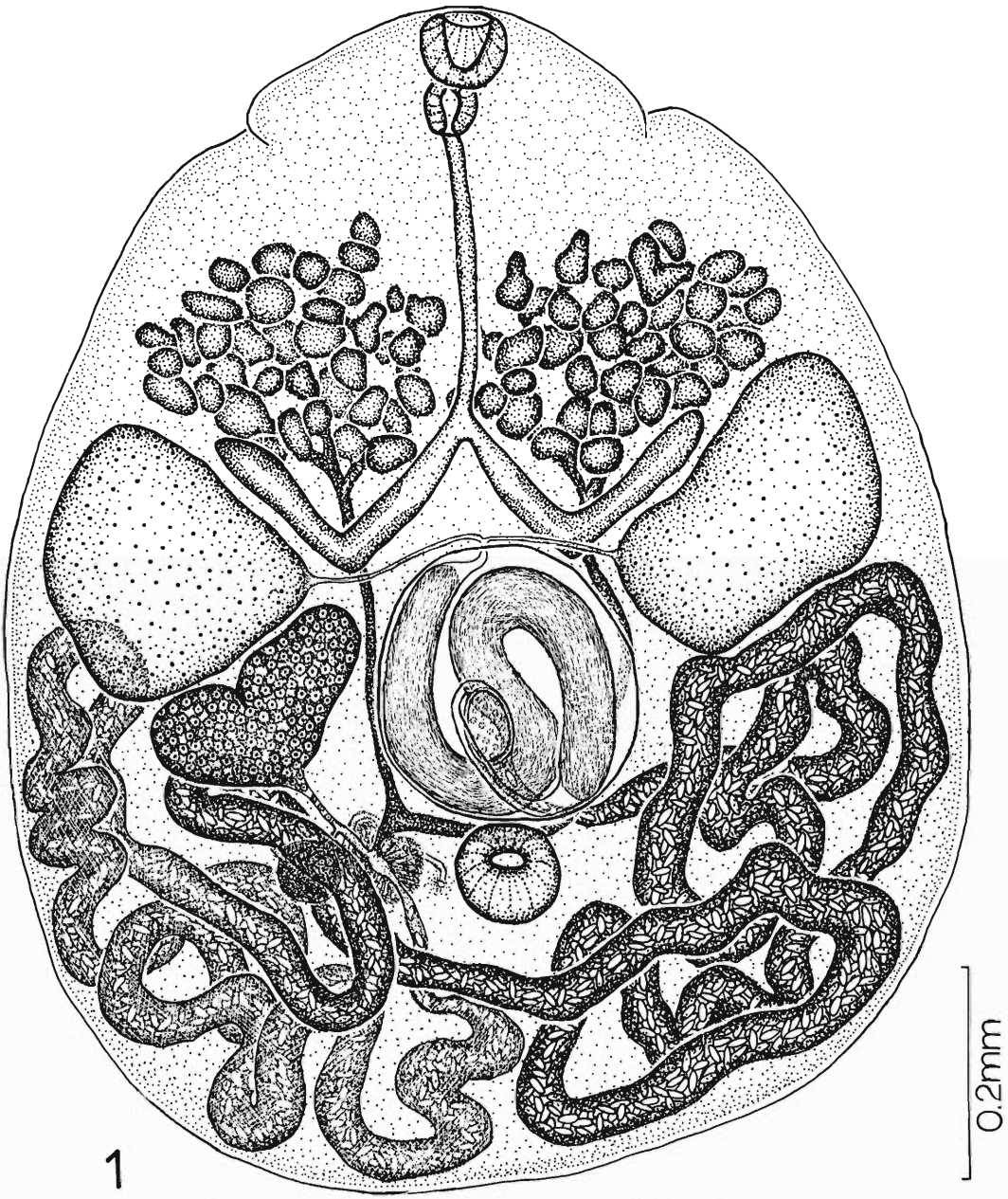

Figure 1. ***Prosthodendrium volaticum,*** **ventral view of holotype.**

left testis 0.26 (0.15–0.27) long and 0.24 (0.16–0.27) wide. Prostate gland complex circular, in middle third of body, bordered anteriorly by intestinal crura, anterolaterally by testes, on right by ovary, and posteriorly by acetabulum. Length of prostate gland complex 0.24 (0.16–0.36); width 0.23 (0.17–0.24), composed of numerous prostate gland cells,

Table 1. Monthly occurrence of *P. volaticum* in *Eptesicus fuscus* and *Lasiurus borealis* in Iowa (1966–68).

	Hosts			
	Eptesicus fuscus		*Lasiurus borealis*	
	No. exam.	No. inf.	No. exam.	No. inf.
January	1	0	0	0
February	0	0	0	0
March	1	0	0	0
April	2	0	0	0
May	1	0	0	0
June	1	1	2	0
July	5	2	1	1
August	11	2	1	0
September	4	0	0	0
October	11	3	0	0
November	7	1	0	0
December	11	2	0	0
Totals	55	11	4	1

coiled seminal vesicle, pars prostatica, ejaculatory duct, and genital atrium. Genital atrium unarmed, 0.07 (0.06–0.08) long and 0.07 (0.05–0.08) wide, situated posteriorly in prostate gland complex. Ovary slightly lobate, dextral, triangular to subtriangular, preacetabular and posttesticular. Apex of ovary wedged between posterior margin of cecum, lateral border of prostate gland complex, and medial margin of right testis. Ovary length 0.20 (0.12–0.26), width 0.19 (0.08–0.32). Oviduct originating from left posterior margin of ovary and passing posteriad, parallel to right margin of prostate gland complex, receiving duct from seminal receptacle to right of acetabulum. Large seminal receptacle in acetabular zone on right side of the body, joining with oviduct anteriorly. Laurer's canal opening dorsally in acetabular region and joining oviduct near junction of seminal receptacle and oviduct. Ootype in acetabular zone on right side of body, surrounded by diffuse Mehlis' gland. Uterine coils limited to posterior third of body, U-shaped. Eggs operculate, 0.021 (0.019–0.023) long and 0.011 (0.010–0.013) wide.

HOSTS: *Eptesicus fuscus* (big brown bat) and *Lasiurus borealis* (red bat).

LOCATION: Small intestine.

LOCALITIES: Boone, Dickinson, Marshall, Muscatine, Plymouth, Polk, and Story counties, Iowa.

HOLOTYPE: USNM Helm. Coll. No. 70517.

Remarks

The genus *Prosthodendrium* was established by Dollfus (1931) for *Prosthodendrium* (*Prosthodendrium*) *dinanatum* (Bhalerao) recovered from the small intestine of an evening bat, *Nycticeius pallidus* Dobson, in Rangoon, Burma. Members of the genus *Prosthodendrium* are distinguished from other genera in the family Lecithodendriidae by possessing pretesticular vitellaria, a preacetabular and median genital pore, a prostatic gland complex, an aspinose genital atrium, and by testes arranged transversely outside the uterine zone. They are parasitic in the intestines of mammals, especially bats.

Prosthodendrium volaticum sp. n. differs from all other members of the genus because of the distinct winglike appearance of its intestinal crura. It also differs from all except *P. posticum* Stafford, 1905, and *P. aranhai* Lent and Freitas, 1945, in possessing an acetabulum larger than the oral sucker. It differs further from *P. aranhai* in being longer than wide, in the characteristic appearance of the intestinal crura, the distribution of the uterus, and the larger relative size and more posttesticular position of the ovary. It is distinguished further from *P. posticum* by the preacetabular position of the testes and ovary and by the smaller size of its eggs.

The highest percentage of bats infected with *P. volaticum* appears to occur in the summer and fall (Table 1). Hibernation of hosts during January–May may be the cause for low infections during these months. However, confirmation of seasonal periodicity for this species will require examination of large numbers of hosts during winter and spring.

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Dactylogyridae (Monogenea) from the Freshwater Fish, *Astyanax fasciatus* (Cuvier), in Costa Rica, with Descriptions of *Jainus hexops* sp. n., *Urocleidoides costaricensis*, and *U. heteroancistrium* combs. n.

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ABSTRACT: Three monogenetic trematodes, *Jainus hexops* sp. n., *Urocleidoides costaricensis* (Price and Bussing, 1967), and *U. heteroancistrium* (Price and Bussing, 1968) combs. n., are described from the gills of *Astyanax fasciatus* (Cuvier) in Costa Rica. With the transfer of the type species of *Palombitrema* Price and Bussing, 1968 (*P. heteroancistrium*) to *Urocleidoides* Mizelle and Price, 1964, the former genus is placed in synonymy.

Five species of Monogenea are known from *Astyanax fasciatus* (Cuvier). These include *Anacanthocotyle anacanthocotyle* Kritsky and Fritts, 1970, *Cleidodiscus costaricensis* Price and Bussing, 1967, *C. strombicirrus* Price and Bussing, 1967, *Gyrodactylus neotropicalis* Kritsky and Fritts, 1970, and *Palombitrema heteroancistrium* Price and Bussing, 1968, all from Costa Rica. In the present study, *Jainus hexops* sp. n. (Dactylogyridae: Ancyrocephalinae) is figured and described. *Cleidodiscus costaricensis* and *P. heteroancistrium* are redescribed and transferred to *Urocleidoides* Mizelle and Price, 1964.

Parasites were removed directly from the gills of the host which had been seined from a marsh near Rincón, Puntarenas Province, Costa Rica. Some were mounted unstained in Gray and Wess' medium for study of sclerotized structures. Other specimens were stained with Mayer's acid carmalum or Heidenhain's hematoxylin for observing internal organs. Measurements were made according to the procedures proposed by Mizelle and Klucka (1953); all are in microns. Illustrations were prepared with the aid of a camera lucida.

Jainus hexops sp. n. (Figs. 1–12)

HOST AND LOCALITY: *Astyanax fasciatus* (Cuvier), Characidae; marsh, approximately 3 km SW of Rincón, Puntarenas Province, Costa Rica.

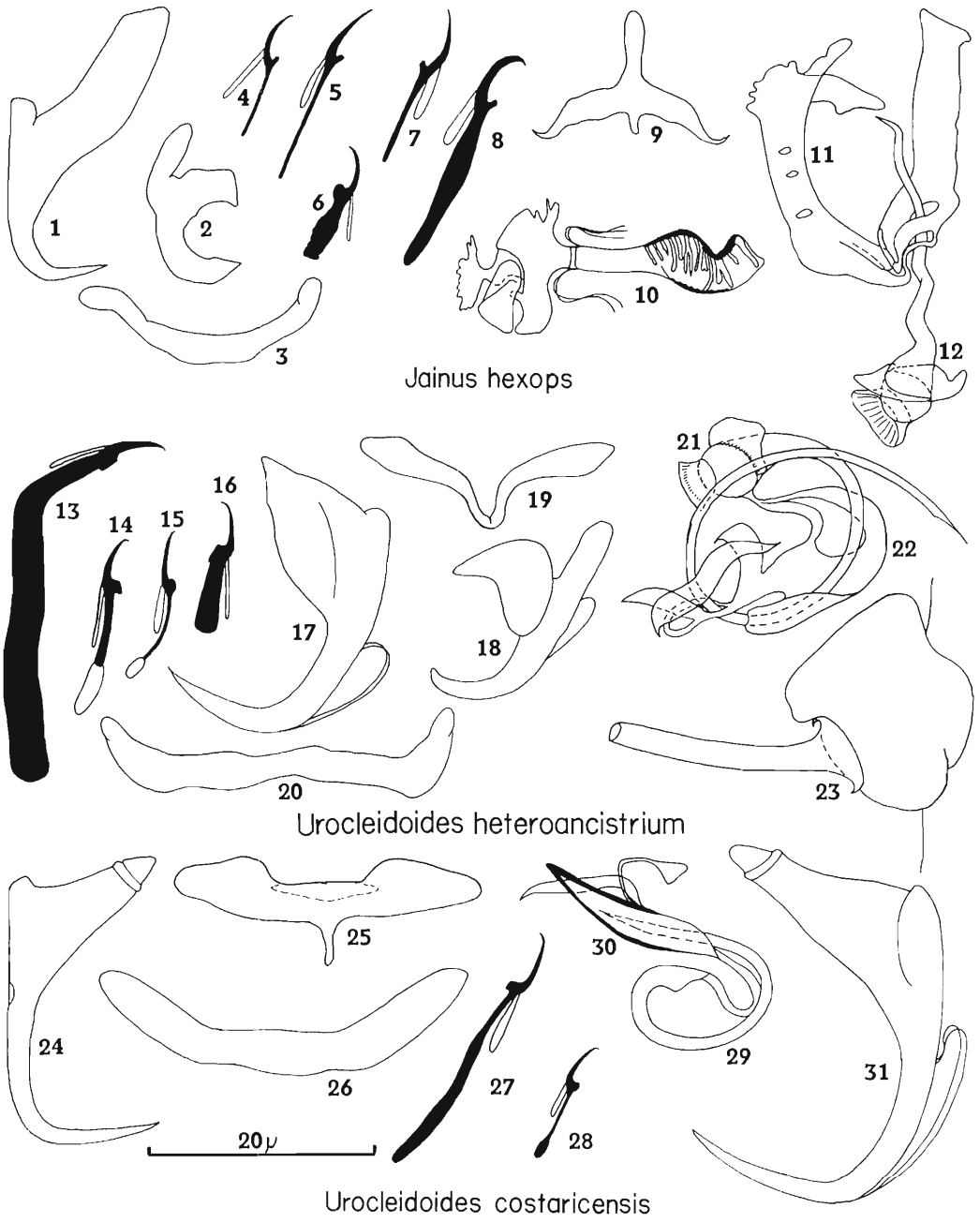
LOCATION: Gills.

SPECIMENS STUDIED: 49.

TYPE SPECIMENS: Holotype, USNM Helm. Coll. No. 71103; 2 paratypes, USNM Helm. Coll. No. 71104; paratypes in authors' collections.

Description

Body pyriform; length 242 (165 to 385), greatest width 143 (99 to 220) in posterior half. Cephalic region with apical and two incipient lateral lobes; head organs poorly developed, restricted to lateral lobes and adjoining cephalic region; cephalic glands large. Three successive pairs of eyes, members of each equidistant; second pair largest. One or both eyes of posterior pair occasionally absent. Component eye granules ovate; accessory granules in trunk and cephalic region. Pharynx spherical, diameter 17 (14 to 19); esophagus reduced; gut confluent, dilated posteriorly. Peduncle short; haptor posteroventral, subovate, 37 (32 to 49) long, 50 (32 to 60) wide. Hook distribution of ancyrocephaline arrangement (Mizelle, 1936). Hooks (except 7) with narrow shank, erect thumb, slightly curved shaft and point; FH loop approximately ½ shank length. Thumb and shank of hook 3 and 4 occasionally dilated (Fig. 6). Shank of hook 7 dilated; FH loop ⅓ shank length. Hook 1—14 (12 to 19); 2, 3, 4, 6—(10 to 11); 5—17 (13 to 19); 7—22 (21 to 25) long. Ventral anchor 16 (14 to 18) long, with knifelike point, short shaft, small elevation on inner surface of base; base (8 to 9)



Figures 1–12. *Jainus hexops* sp. n. 1. Dorsal anchor. 2. Ventral anchor. 3. Dorsal bar. 4. Hook 2. 5. Hook 5. 6. Hook 3. 7. Hook 1. 8. Hook 7. 9. Ventral bar. 10. Vagina. 11. Accessory piece. 12. Cirrus. Figures 13–23. *Urocleidoides heteroancistrium* comb. n. 13. Hook 7. 14. Hook 2. 15. Hook 1. 16. Hook 6. 17. Dorsal anchor. 18. Ventral anchor. 19. Ventral bar. 20. Dorsal bar. 21. Cirrus. 22. Accessory piece. 23. Vagina. Figures 24–31. *Urocleidoides costaricensis* comb. n. 24. Dorsal anchor. 25. Ventral bar. 26. Dorsal bar. 27. Hook 2. 28. Hook 5. 29. Cirrus. 30. Accessory piece. 31. Ventral anchor.

wide. Dorsal anchor 24 (22 to 26) long, with massive superficial root; base 15 (11 to 17) wide. Ventral bar 15 (10 to 17) long, with tapered ends, elongate anterior and short posterior, median processes. Dorsal bar 21 (15 to 26) long, rod-shaped with variable curvature. Testis intercecal, postovarian. Seminal vesicle elongate, coiled, a dilation of vas deferens; prostate pyriform. Cirrus 30 (28 to 32) long; base with two lateral wings, 11 (10 to 12) wide. Accessory piece U-shaped, 21 (19 to 27) long. Ovary intercecal; vagina sinistral; vitellaria coextensive with gut. Egg asymmetrical, filament subterminal.

Remarks

Thus far, only two species, *J. jainus* Mizelle et al., 1968, and *J. robustus* Mizelle et al., 1968, have been described. Based upon the similarity of the anchors, our species appears most closely to resemble *J. robustus*. It differs from this species by possessing three pairs of eyes, hooks of different sizes and shapes, a U-shaped accessory piece, a highly ornamental vagina, and a less pronounced posteromedial process on the ventral bar (Figs. 1–12; Mizelle et al., 1968, figs. 19–28). The specific name is from Greek (*hexa* = six + *ops* = eyes).

Urocleidoides heteronacistrium (Price and Bussing, 1968) comb. n. (Figs. 13–23)

SYNONYM: *Palombitrema heteroancistrium* Price and Bussing, 1968.

HOST AND LOCALITY: *Astyanax fasciatus* (Cuvier); marsh, approximately 3 km SW of Rincón, Puntarenas Province, Costa Rica.

LOCATION: Gills.

SPECIMENS STUDIED: 9.

Redescription

Body robust; length 206 (165 to 253), greatest width 97 (77 to 143) near midlength. Two terminal and two lateral cephalic lobes; head organs and cephalic glands inconspicuous. Four eyes, members of each pair equidistant; posterior pair larger; accessory granules in cephalic region and anterior trunk. Pharynx subspherical, diameter 19 (17 to 20); gut obscure. Peduncle moderately long; haptor variable, 39 (37 to 42) long, 60 (54 to 65) wide. Hook distribution of ancyrocephaline arrangement (Mizelle, 1936). Hooks (except 6, 7) similar; point curved, toe depressed, shank with proximal inflation, FH loop ½ shank length. Hook 6 with depressed toe, robust shank; FH loop ⅘ shank length. Hook 7 flexible, with depressed toe, short FH loop, enlarged shank. Hooks 1, 6—(10 to 11); 2, 3, 4—14 (13 to 15); 5—(12 to 13); 7—30 (27 to 33). Ventral anchor (dorsal anchor in Price and Bussing, 1968) with blunt point, short shaft, long deep root, saddle-shaped superficial root; 19 (17 to 21) long, base 12 (10 to 18) wide. Dorsal anchor with small deep root; 24 (23 to 26) long, base 14 (12 to 15) wide. Ventral bar (dorsal bar in Price and Bussing, 1968) 22 (19 to 23) long, V-shaped, each end capped with hyaline disc. Dorsal bar variable, 30 (26 to 33) long. Testis postovarian; seminal vesicle bulbous, situated posterior to copulatory complex; cirrus with one coil, diameter of coil 17 (16 to 18). Accessory piece 20 (16 to 23) long, complex. Ovary irregular, intercecal; vagina sinistral, heavily sclerotized; seminal receptacle immediately internal to vagina. Vitellaria in two bilateral bands, confluent in posterior trunk and anterior to vagina.

Remarks

Price and Bussing (1968) used the presence of two accessory pieces, hooks of different sizes and shapes, and an irregular and heavily sclerotized vagina for the establishment of *Palombitrema*. Examination of the holotype of *P. heteroancistrium* (USNM Helm. Coll. No. 62987) and comparison of it with our form showed them to be identical. Since all specimens studied are characterized by a single accessory piece rather than two and possess a sinistral vagina and hooks of several sizes, all of which are characteristic of some species of *Urocleidoides*, we propose a recombination. Thus, *P. heteroancistrium* becomes *U. heteroancistrium* comb. n., and the monotypic genus *Palombitrema*, a synonym of *Urocleidoides*.

Urocleidoides costaricensis (Price and Bussing, 1967) comb. n. (Figs. 24–31)

SYNONYM: *Cleidodiscus costaricensis* Price and Bussing, 1967.

HOST AND LOCALITY: *Astyanax fasciatus* (Cuvier); marsh, approximately 3 km SW of Rincón, Puntarenas Province, Costa Rica.

LOCATION: Gills.

SPECIMENS STUDIED: 3.

Redescription

Body robust; length 209 (198 to 220), greatest width 99 (66 to 132) near midlength. Two terminal and two lateral cephalic lobes; head organs and cephalic glands inconspicuous. Four eyes subequal; members of posterior pair slightly farther apart; accessory granules infrequent in cephalic region and anterior trunk. Pharynx spherical, diameter 16 (15 to 17); gut obscure. Peduncle reduced; haptor subhexagonal, 50 (44 to 55) long, 69 (66 to 73) wide. Hook distribution of ancyrocephaline arrangement (Mizelle, 1936). Hooks (except 5) similar; shank inflated, thumb depressed, FH loop ⅓ shank length; pair 1—17 (15 to 18), pairs 2, 3, 4, 6, 7—20 (17 to 23) long. Hook 5—10 (9 to 11) long, with small proximal dilation of shank; FH loop ½ shank length. Deep root of ventral anchor externolateral; anchor 33 (30 to 36) long, base 18 (16 to 19) wide; filament inconspicuous. Dorsal anchor (25 to 26) long, with small deep root; base 14 (12 to 17) wide. Ventral bar 24 (22 to 27) long, with short posteromedial process. Dorsal bar 30 long, rod-shaped, bent. Testis postovarian, intercecal. Cirrus with single coil; diameter of coil 15 (13 to 17); accessory piece 20 (17 to 22) long, with three distal processes. Vagina sinistral, slightly sclerotized; vitellaria random in trunk.

Remarks

Price and Bussing (1967) used the presence of a sinistral vagina and an accessory piece articulated with the base of the cirrus as the primary basis for assigning this species to *Cleidodiscus* Mueller, 1934. Comparison of our specimens with the holotype of *C. costaricensis* (USNM Helm. Coll. No. 62989) showed them to be identical except for accessory eye granules in the former. The presence of a coiled cirrus, an externolateral deep root on the ventral anchor, and an arrangement and morphology of the haptoral armament characteristic of *Urocleidoides* clearly places the species in this genus as emended by Mizelle et al. (1968). Furthermore, Price and Bussing (1967) failed to describe the two types of hooks and the posterior process on the ventral bar. Also, the ventral and dorsal positions in the haptor were reversed in their original description. Based on these observations, *C. costaricensis* Price and Bussing, 1967, becomes *Urocleidoides costaricensis* comb. n.

Acknowledgments

The authors wish to extend thanks to Dr. T. H. Fritts for collecting the specimens, Dr. W. A. Bussing for identifying the fish host, and Miss M. Walker for loan of holotypes of *P. heteroancistrium* and *C. costaricensis*.

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Studies on Monogenea of Pakistan. I. *Pseudochauhanea elongatus* sp. n. (Gastrocotylidae: Gastrocotylinae) from the Gills of *Labeo rohita* (Ham.)

D. C. KRITSKY,[1] F. M. BILQEES,[2] AND P. D. LEIBY[1]

ABSTRACT: *Pseudochauhanea elongatus* sp. n. is described from the gills of *Labeo rohita* (Ham.) from Kalri Lake, Sind, Pakistan. It differs from all other members of the genus by possessing a peduncle and in the utilization of a freshwater host. The diagnosis of *Pseudochauhanea* Yamaguti, 1965, is emended.

Yamaguti (1965) proposed the genus *Pseudochauhanea* for his new species, *P. sphyraenae*, from the gills of the marine fish, *Sphyraena barracuda* (Walbaum), in Hawaii. Separation from the closely related genus, *Chauhanea* Ramalingam, 1953, was based on the midventral position of the vagina and the absence of a peduncle. Lamothe-Argumedo (1966) described *P. mexicana* from the gills of *S. ensis* Jordan and Evermann, from Acapulco, Guerrero, Mexico. In the present study, a third species from the freshwater cyprinid, *Labeo rohita* (Ham.), is described from Pakistan. Some characters of this species which were not hitherto reported for the previously described species necessitates emending the generic diagnosis.

The parasites were collected by the second author as a part of a continuing study of the helminths of fishes in Pakistan. Gills of *L. rohita* were removed and placed in a 1:4,000 dilution of formalin and water for relaxation and dislodgment of the parasites. After 1 hr helminths were removed and stored in 5% formalin. Several were mounted unstained in Gray and Wess' medium (Humason, 1967) for observation of haptoral sclerites. The remaining specimens were stained with Delafield's hematoxylin and mounted in Permount for differentiation of internal anatomy. Measurements, in millimeters, were made according to the procedures of Dillon and Hargis (1965).

Pseudochauhanea elongatus sp. n. (Figs. 1–5)

HOST AND LOCALITY: *Labeo rohita* (Ham.); Kalri Lake, Sind, Pakistan.

LOCATION ON HOST: Gills.

SPECIMENS STUDIED: 12 adults, 2 juveniles.

TYPE SPECIMENS: Holotype, USNM Helm. Coll. No. 72013; paratypes in collection of senior author.

Description

Body elongate, lanceolate, with moderate to narrow peduncle; length 11.7 (8.50–15.0), greatest width 0.810 (0.500–1.00) usually at level of ovary. Cuticle thin, smooth. Two small glandular areas near rounded or truncate cephalic tip. Prohaptoral suckers diagonal, subovate, each with median S-shaped septum; sucker length 0.114 (0.098–0.131), width 0.069 (0.053–0.079). Opisthaptor asymmetrical, bearing two bilateral rows of pedunculate clamps; 35 to 50 on right, 29 to 61 on left, left side usually with more clamps; haptor length 2.97 (2.02–4.40), width 0.788 (0.583–0.968). Clamps similar, anteromost members smaller; mature clamp 0.086 (0.072–0.093) long, 0.075 (0.064–0.090) wide. Center clamp sclerite T-shaped; accessory sclerites folded medially.

Mouth subterminal, ventral; pharynx subspherical, immediately posterior to suckers, 0.056 (0.053–0.062) in diameter; esophagus with several lateral diverticulae; crura simple, with lateral and medial diverticulae.

Testes intercecal, approximately 75 in number, 0.124 (0.088–0.154) long; vas deferens coiled proximally; cirrus asymmetrical, muscular, sinistral or dextral, 0.135 (0.121–0.157) long.

Ovary intercecal, 1.12 (0.990–1.32) long. Genitointestinal canal ventral to ovary, unites with right crus. Ootype dorsal to vitelline reservoir, with numerous unicellular glands. Va-

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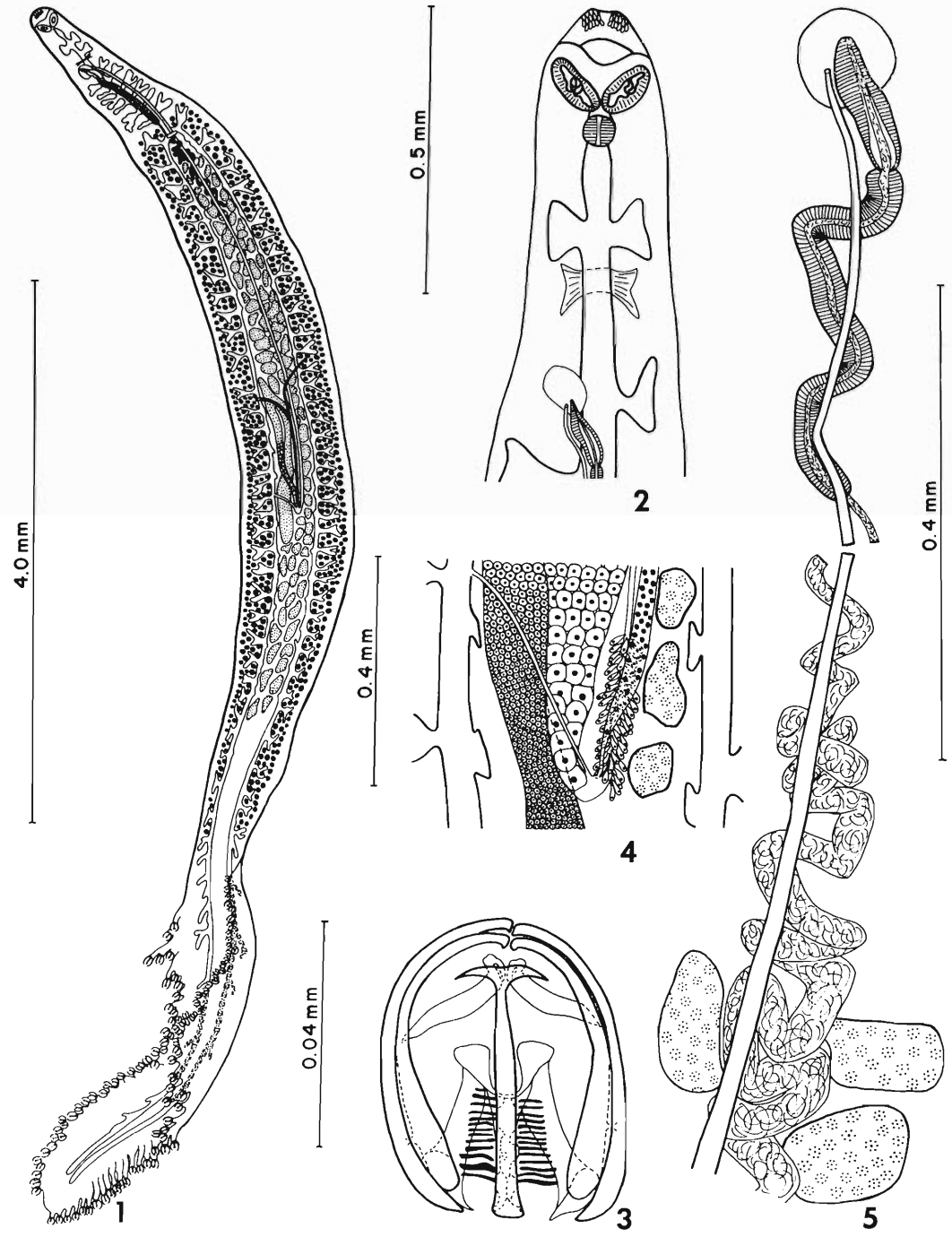

Figures 1–5. 1. *Pseudochauhanea elongatus* sp. n. 2. Cephalic region. 3. Clamp. 4. Reproductive complex of female. 5. Terminal male genitalia and uterus. All figures are ventral views.

gina inconspicuous, immediately posterior to bifurcation of gut; vaginal ducts obscure; seminal receptable not observed. Uterus midventral, opens into genital atrium lateral to cirrus. Vitellaria coextensive with crura except absent in distal peduncle and opisthaptor. Vitelline reservoir Y-shaped, branches unequal. Egg not observed.

Esophageal ganglion dorsal, anterior to genital atrium. Eyes absent.

Remarks

The closest relative of this species appears to be *Pseudochauhanea mexicana* Lamothe-Argumedo, 1966, as indicated by the simple structure of the intestinal crura, the crossed limbs of the ovary, and the variable position of the genital atrium. They differ in the number of testes and clamps and in the morphology of the cirrus and clamps. *Pseudochauhanea elongatus* sp. n. differs from all previously described species of the genus by possessing a narrow peduncle.

Pseudochauhanea elongatus is the first species of the genus reported from a freshwater cyprinid. The remaining two are marine and parasitize members of the genus *Sphyraena* (Sphyraenidae). The specific name is from Latin (*elongatus* = prolonged) and refers to shape of the body.

Pseudochauhanea Yamaguti, 1965

EMENDED GENERIC DIAGNOSIS: Gastrocotylidae, Gastrocotylinae: Body divisible into cephalic region, trunk, peduncle (present or absent), and opisthaptor. Opisthaptor asymmetrical, with large numbers of Gastrocotyle-like clamps; anchors or hooks absent in adult. Paired prohaptoral suckers muscular, usually septate; pharynx small; esophagus elongate with lateral diverticulae; crura blind with lateral and/or medial diverticulae, extend into opisthaptor. Testes pre-, para-, and postovarian, numerous. Distal vas deferens with sheath of circular muscles; cirrus pouch present; cirrus unarmed, protrusible; genital pore submarginal, dextral or sinistral. Ovary near middle of body, dextral, with ascending and descending portions. Vagina unarmed, midventral, posterior to bifurcation of intestine. Eggs elongate with filaments at both ends. Vitellaria coextensive with gut except absent in posteromost regions. Parasites of the gills of marine and freshwater teleosts.

TYPE SPECIES: *P. sphraenae* Yamaguti, 1965, from *Sphyraena barracuda* (Walbaum), Hawaii.

Remarks

This emendation was made in order to accommodate *Pseudochauhanea elongatus* sp. n. The presence of a distally muscularized vas deferens; an ovary with ascending and descending limbs; pre-, para-, and postovarian testes; septate prohaptoral suckers; and an asymmetrical haptor lacking anchors clearly relates it to *Pseudochauhanea*. The presence of a peduncle and occurrence on a freshwater host are not deemed adequate differences to warrant establishment of a new genus.

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Addendum

After this manuscript went to press, we learned that *Chauhanea mediterranea* Euzet and Trilles, 1960, was placed in *Pseudochauhanea* by Dr. B. I. Lebedev (1969, Parazitol. Sb., Zool. Inst. Akad. Nauk SSSR 24: 156–165), increasing the number of recognized species in this genus to four. Our species differs from *P. mediterranea* mainly by possessing a peduncle and two to three times more opisthaptoral clamps.

A Redescription of *Acanthostomum marajoarum* (Teixeira de Freitas and Lent, 1938) with Notes on the Subfamily Acanthostomatinae (Nicoll, 1914) Hughes, Higginbotham, and Clary, 1942 (Trematoda: Acanthostomatidae)

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ABSTRACT: *Acanthostomum marajoarum* adult morphology is redescribed, from both juvenile and adult specimens obtained from *Caiman sclerops*, Colombia, South America. Comparison with the most closely similar neotropical species is made. Anal pores were found in type specimens of *A. spiniceps*, *A. absconditum*, and *A. praeteritum*, but were not reported in their original descriptions. The taxonomic value of anal pores is discussed for the subfamily Acanthostomatinae.

Apparently immature acanthostomatid trematodes were described by Teixeira de Freitas and Lent (1938) from the small intestine of *Caiman sclerops* Gray from Pará, Brazil, and named *Caimanicola marajoara*, the new genus *Caimanicola* being erected for this species. The genus *Caimanicola* was placed into synonymy with *Acanthostomum* by Hughes, Higginbotham, and Clary (1942), who also transferred *C. marajoara* to the genus *Acanthostomum*. The reader is referred to Khalil (1963) for the most recent comprehensive review of the family Acanthostomatidae.

The present report provides a more detailed and improved description of *A. marajoarum*, based on mature and immature adult specimens, reviews the subfamily Acanthostomatinae (Nicoll, 1914) Hughes, Higginbotham, and Clary, 1942, and reconsiders the taxonomic value of anal pores in this group.

Materials and Methods

Sixteen adult and juvenile specimens, identified as *Acanthostomum marajoarum* (Teixeira de Freitas and Lent, 1938), were collected from seven *Caiman sclerops* Gray from Colombia, S. A., and 18 additional specimens were collected from a second group of nine caiman. All specimens were found in the small intestine and fixed in AFA or 10% cold buffered formalin (Lillie's), under light pressure.

Sixteen specimens were stained in Semichon's acetocarmine with $FeCl_3$; eight were stained with Delafield's hematoxylin; the remaining 10 were subjected to Koelle and Friedenwald's (1949) indoxyl acetate reaction for nonspecific esterase activity, five of which were counterstained with Semichon's. All were then dehydrated, cleared, and mounted routinely in gum damar.

The following specimens were obtained from the USNM Helminthological Collection for comparative study: No. 4967, *Acanthostomum imbutiformis* (Molin) and No. 49968, *A. praeteritum* (Looss, 1901) ex *Labrax lupus* in Trieste, No. 49966, *A. absconditus* (Looss, 1901) Poche, 1926 and No. 49969, *A. spiniceps* (Looss, 1896) ex *Bagrus bayad* from the Nile River, Egypt (all four collected and described by Arthur Looss); No. 2982, *A. coronarium* (Cobbold, 1861) Looss, 1899 ex *Crocodilus americanus* collected by A. Hassall in 1897 in Utilla, Honduras, and No. 51352, *A. coronarium* ex *Alligator mississippiensis* from Mandeville, Louisiana, collected by Percy Viosca, Jr. The first four of these were unstained, unmounted specimens in glycerine and alcohol; the second two were slide mounts, stained with Delafield's hematoxylin.

Drawings were made with the aid of a camera lucida, with some details added freehand. All measurements are given in millimeters.

Redescription

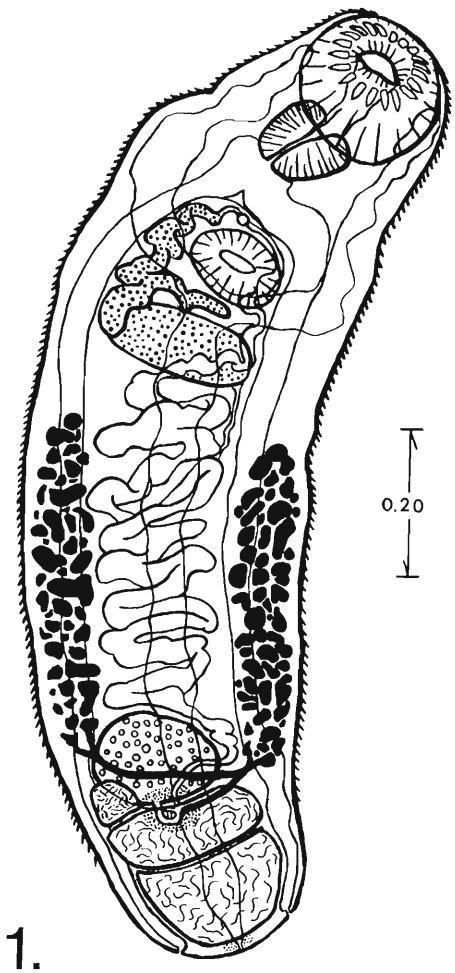
Family—Acanthostomatidae Poche, 1926

Subfamily—Acanthostomatinae (Nicoll, 1914) Hughes, Higginbotham, and Clary, 1942

Acanthostomum marajoarum (Teixeira de Freitas and Lent, 1938)
(Figs. 1–4)
(Syn. *Caimanicola marajoara*)

Body elongate, with slightly truncated posterior end, 1.08–2.05 long by 0.19–0.38 wide (Figs. 1, 3). Tegument finely spined to level of posterior testis. Oral sucker terminal, funnel-shaped, 0.14–0.22 long by 0.14–0.22 wide, usually with a crown of 20 cephalic spines in a single row (two specimens had 18 spines; one had 19; and one had 21), 0.03–0.05 long by 0.006–0.010 in diameter. Prepharynx short, 0.01–0.09 long. Pharynx situated midway between the two suckers, 0.06–0.13 long by 0.05–0.12 wide. Ventral sucker, 0.06–0.13 in diameter. Esophagus short, bifurcating just anterior to ventral sucker. Ceca well developed, opening at the posterior end via anal pores (Fig. 4). Testes tandem, slightly irregular (sometimes oval, sometimes roughly triangular), situated posteriorly and intercecally, 0.04–0.20 wide by 0.06–0.19 long. Seminal vesicle prominent, coiled, leading into the elongated ejaculatory duct. Prostatic cells small, scattered along terminal part of ejaculatory duct. Cirrus and cirrus sac absent. Ovary immediately pretesticular, subspherical, 0.06–0.16 in diameter. Seminal receptacle irregular, elongated, sinistral, partly overlying the ovary, 0.05–0.20 wide by 0.06–0.18 long. Uterus coiled, passing anteriorly in intercecal field from level of ovary to acetabulum; vitellaria extracecal, extending from level of acetabulum to the ovary. Excretory vesicle prominent, Y-shaped, dilated, bifurcating at acetabular level, the arms extending anteriorly to level of oral sucker, opening posteriorly midway between anal pores (Fig. 1). Flame cells paired, but excretory tubules incompletely worked out. Eggs small, operculate, 0.02–0.03 long by 0.01–0.02 wide.

HOST: *Caiman sclerops* Gray.
LOCATION: Small intestine.



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Figures 1–2. *Acanthostomum marajoarum*. 1. Adult, dorsal view, showing major structural features and genital ducts in ootype region. 2. Juvenile, showing gonads and anal pores.

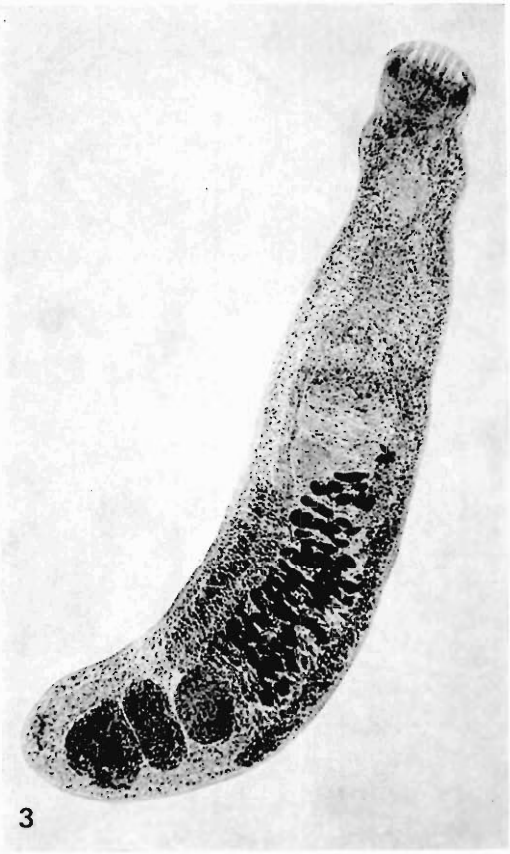

Figure 3. Adult *A. marajoarum*.

LOCALITY: Colombia, South America.

PLESIOTYPE SPECIMENS: USNM Helm. Coll. No. 72009.

Discussion

Juvenile worms found in the present study (Fig. 2) were identical to the lageniform specimens described as adults by Teixeira de Freitas and Lent (1938), except for absence of eggs. The ovary was much smaller than the adult ovary. Teixeira de Freitas' and Lent's (1938) figure shows the small ovary, and seminal receptacle primordium exactly as seen in our juvenile specimens. They did not describe the seminal receptacle, and reported the absence of a seminal vesicle. Present juvenile worms had an inconspicuous seminal receptacle which became extremely prominent in adults (Fig. 1), as were the seminal vesicle and ejaculatory duct. Teixeirade Freitas and Lent also failed to find anal pores in *A. marajoarum*, whereas anal pores were very obvious in both juvenile and adult worms in the present study (Fig. 4). Though their description was based on only two immature worms, present material agrees closely in size and form, particularly oral spine number, and justifies identification of our worms as *Acanthostomum marajoarum*.

Other species most similar to *A. marajoarum* are: *Acanthostomum gnerii* Szidat, 1954; *Acanthostomum caballeroi* Peláez and Cruz, 1953; *Acanthostomum megacetabulum* Thatcher, 1963; and *Acanthostomum americanum* Pérez Vigueras, 1956.

The body size of *A. gnerii* is larger than *A. marajoarum*, their body lengths overlapping slightly (1.64–2.00 for *A. gnerii* vs. 1.08–2.05 for *A. marajoarum*). The most distinct difference is the cephalic spine number of 21 to 23 in *A. gnerii*, compared to 20 in *A. marajoarum*. The vitellaria in *A. gnerii* extend more posteriorly, terminating at the level of the anterior testis; and the vitelline follicles also appear more compact than those of *A. marajoarum*. Further, *A. gnerii* is found in a different host, *Rhamdia quelen*, from Argentina.

A. marajoarum differs from *A. caballeroi*, being smaller, lacking a gonotyl, and in larger egg size.

The body size of *A. marajoarum* is also slightly smaller than that of *A. megacetabulum* (1.8–3.9), and the acetabulum of *A. marajoarum* is much smaller (0.06–0.13, as compared to 0.19–0.20). Their eggs are approximately the same size, and the tegumentary spines extend only slightly less posteriorly than in *A. megacetabulum*. Oral spine number ranges from 19 to 21 in *A. megacetabulum*, compared to usually 20 in *A. marajoarum*. The vitellaria extend slightly more posteriorly in *A. megacetabulum*; the coiling intercecal uterus, filled with eggs, and the enormous seminal vesicle resemble those of *A. marajoarum*. *A. megacetabulum* was described from a different host, the Mexican indigo snake, *Drymarchon corais melanurus*; thus, the minor differences in morphology suggest probable synonymy with *A. marajoarum*.

A. marajoarum is markedly smaller in all measurements than *A. americanum*. Herber (1961) found the posterior testis of *A. americanum* was notably larger than the anterior one, a difference Pérez Vigueras (1956) failed to note. We find the same disparity in testis size in *A. marajoarum*. The presence of 20 cephalic spines, as in *A. marajoarum*, and vitellaria of similar extent and follicle size, further suggest great similarity of these two species. Since the host of *A. americanum* (*Crocodylus acutus acutus*) differs from that of *A. marajoarum*, they too may be conspecific; only experimental demonstrations of their life history stages can resolve this question. Therefore, no move to place them into synonymy can be made at present.

Anal pores

Stunkard (1931) stated that classification schemes are arbitrary and presence or absence of posterior connections between the alimentary canal and the exterior are not of major taxonomic importance. Subsequently, however, Stunkard (1938) reversed his position, and stated that anal pores were of taxonomic value in the genus *Acanthostomum*. Khalil's (1963) conclusion was that anal pores were of taxonomic value as a distinguishing character of species, but not genera, of the acanthostome group.

Anal pores, found to be present in both juvenile and adult specimens of *A. marajoarum*, were not described by Teixeira de Freitas and Lent (1938). Anal pores in acanthostome species often have been found by later observers, after being overlooked earlier. Anal pores are described for *A. diploporum* (Stunkard, 1931), *A. crocodili* (Yamaguti, 1954), *A. gnerii* (Szidat, 1954), *A. pakistanensis* (Coil and Kuntz, 1960), *A. americanum* (Herber, 1961), *A. scyphocephalum* and *A. brauni* (Mañé-Garzón and Gil, 1961), *A. spiniceps* and *A. absconditum* (Fischthal and Kuntz, 1963), *A. burminis* (Agrawal, 1966), and *A.* (*Atrophocaecum*) *alii* (Karyakarte, 1967). The writers confirm the presence of anal pores in specimens of *A. spiniceps*, *A. absconditum*, and *A. praeteritum* collected by A. Looss. Tubangui and Masiluñgan (1936) stated only that the intestinal ceca reached near the posterior end of the body in both *A. elongatum* and *A. atae*, two species from *Crocodilus porosus*, but Yamaguti (1954) stated that there is no doubt that they open to the exterior posteriorly in these species, as they do in *A. crocodili*. In light of anal pores being reported in many recently described and redescribed species in both genera of the subfamily Acanthostomatinae, it is apparent this feature is diagnostic for the subfamily.

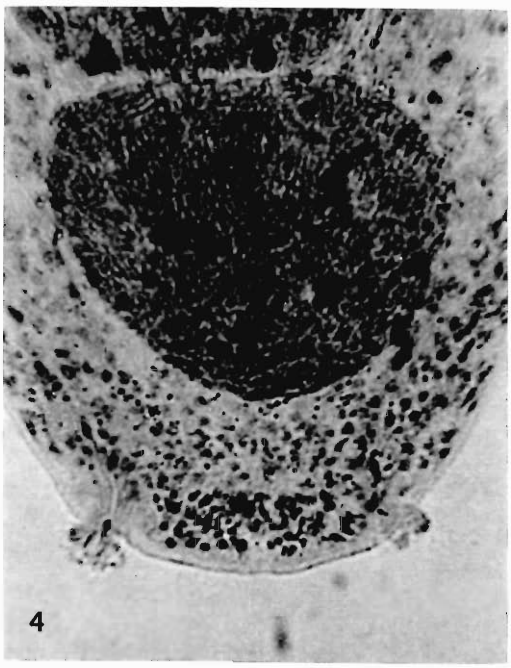

Figure 4. Anal pores of *A. marajoarum*.

Subfamily Acanthostomatinae

The three most comprehensive reviews of acanthostomatid trematodes are Morosov's (1955) review of the family Acanthostomatidae Poche, 1925, Szidat's (1954) review of subfamily Acanthostomatinae (Nicoll, 1914) Hughes, Higginbotham, and Clary, 1942, and Yamaguti's (1958) work on these flukes. Morosov (1955) listed two genera in the subfamily Acanthostomatinae, *Acanthostomum* Looss, 1899, and *Atrophocaecum* Bhalerao, 1940, while Szidat (1954) included only the genus *Acanthostomum* with the genus *Caimani-*

cola as a synonym. Yamaguti (1958) used the subfamily name Acanthostominae Nicoll, 1914, and listed the single genus *Acanthostomum* Looss, 1899, in it (with *Acanthochasmus* Looss, 1900, and *Atrophocaecum* Bhalerao, 1940, as synonyms); for the genera from reptiles in the subfamily, he listed both *Acanthostomum* Looss, 1899, and *Caimanicola* T. de F. and Lent, 1938.

Two recent important papers dealing with the subfamily Acanthostomatinae are Khalil (1963) and Fischthal and Kuntz (1965). Khalil discussed the genera *Acanthostomum* Looss, 1899, *Atrophocaecum* Bhalerao, 1940, *Gymnatotrema* Morosov, 1955, and *Haplocaecum* Simha, 1958. He pointed out the close similarity of these four genera, and synonymized them, leaving one valid genus (*Acanthostomum*) with four subgenera (*Gymnatotrema* Yamaguti, 1958; *Acanthostomum* Khalil, 1963; *Atrophocaecum* Khalil, 1963; and *Haplocaecum* Khalil, 1963). Fischthal and Kuntz (1965) erected the genus, *Paracanthostomum*, based on complete absence of circumoral spines, and the presence of short bladder arms. Since the specimens they described had many characteristics of subfamily Acanthostomatinae, except for the oral spines and excretory bladder form, it was placed in this subfamily. They mentioned that Khalil (1963) had overlooked the genus *Proctocaecum* Baugh, 1957 (whose establishment was based solely on presence of anal pores) and declared it, too, a synonym of *Acanthostomum*.

Accordingly the subfamily Acanthostomatinae is presently constituted of the two genera, *Acanthostomum* [with the four subgenera *Gymnatotrema*, *Acanthostomum* (syns. *Caimanicola*, *Proctocaecum*), *Atrophocaecum*, and *Haplocaecum*] and *Paracanthostomum*. The host range of this subfamily includes fish and reptiles, with the majority of species described from the latter. There are 9 species described from fish, 12 from Crocodilia, 2 from turtles, and 8 from snakes. Among these 31 species, many are probably synonyms [see Fischthal and Kuntz (1963) and Agrawal (1966) for examples of synonymy in Old World species]. The New World species have not had as much comparative work done on them, but their morphological similarities are evident.

Cable and Hunninen (1942) reviewed the affinities of the families Cryptogonimidae, Heterophyidae, and Acanthostomatidae, the status of which has not changed since then. They questioned the separation of these families as proposed by Price (1940), since most of the characters on which the separation is based are of doubtful validity.

Cable (Pers. comm.) stated (in support of his and Hunninen's 1942 paper) that after much more experience with acanthostomatid worms, he is even more convinced that the families Acanthostomatidae and Cryptogonimidae are synonymous and not closely related to the Acanthocolpidae. He further stated that far too much significance has been attached to oral spines and terminal genitalia to the exclusion of the more significant features of egg size, flame-cell pattern, excretory vesicle form and size, and the presence of a true seminal receptacle.

The primary obstacle in determination of phylogenetic relationships of acanthostomatid flukes is, undoubtedly, the dearth of information on their life histories.

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Cercaria criollisima sp. n. from a Marine Snail, *Melongena Melongena* L., in Venezuela

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ABSTRACT: This is the first record of a marine cercaria in Venezuela. The cercaria is an echinostome characterized chiefly by 49 to 53 collar spines, an invaginable caudal tip, rhabditiform contents of cystogenous glands, and 27 flame cells on each side of body. The caudal finfold and eyespots are absent. Also presented is a note on the classification of cercariae.

Cercaria maritima (Lutz, 1933) Lutz, 1935 (syn. *Dicranocercaria maritima* Lutz, 1933), a lophocercous furcocercaria similar to *Cercaria cristata* La Valette, 1852, and *C. utriculata* (Lutz, 1933) Lutz, 1935 (syn. *Dicranocercaria utriculata* Lutz, 1933) of the Vivax group, are the first reports of marine cercariae from South America, but from Brazilian waters. Cable (1956, 1963) contributed substantially to the marine cercariae of Puerto Rico, Curaçao, and Jamaica. Szidat (1963) described two species of bucephalid cercariae from a marine bivalve, *Brachyodontes rodriguezi* (D'Orb.), from the rocks of the Atlantic coast, near Puerto Qucquén, Argentina, which were considered, without experimental evidence, to be the larval forms of *Bucephalus urophyci* Szidat, 1961, and *Prosorhynchus australis* Szidat, 1961. Another marine bucephalid cercaria, *C. chilensis* Szidat, 1963, was found to infect 100% of the population of bivalves in Mehuin, near Valdivia, Chile.

Since the parasitic fauna of marine mollusks

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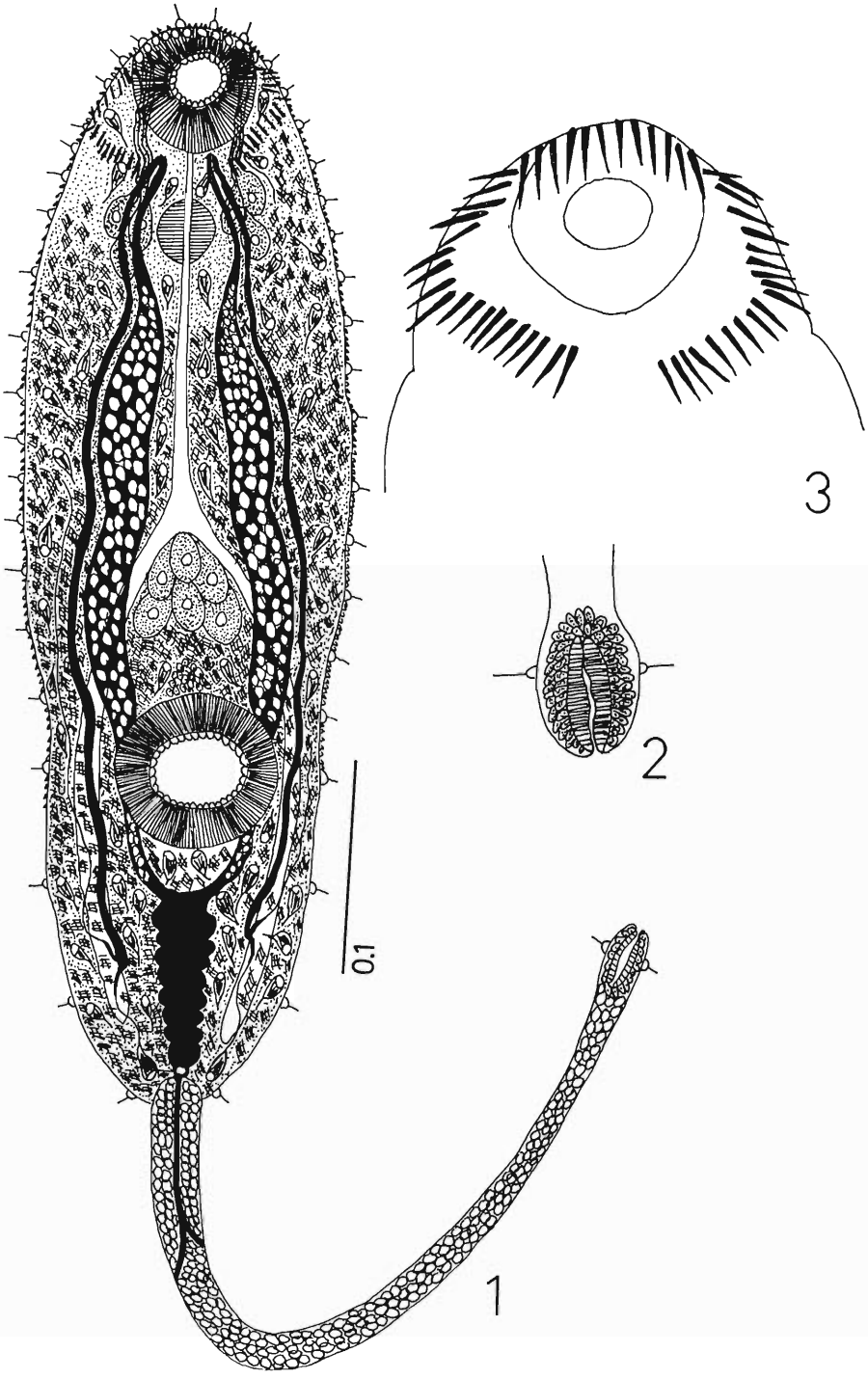

of Venezuela has been neglected, it was decided to study them. Over a period of 2 years 3,000 specimens of a most abundant snail, *Melongena melongena* L., were examined but only two were infected. The emerged cercariae were of the same echinostome type.

The snails were collected by hand, and maintained in continuously aerated aquaria in the laboratory. The cercariae were studied alive in seawater mounts, with or without the aid of intravitam stains. The measurements (in mm) were taken on naturally emerged living material.

Cercaria criollisima sp. n. (Figs. 1–3)

HOST: *Melongena melongena* L.

LOCALITY: Inland side of the Gulf of Cariaco, Sucre State, Cumaná, Venezuela.

Description

Echinostome with body longer than tail, without eyespots, bearing 17 to 21 rows of setate papillae. Tegumental spines not extending beyond ventral sucker. Tail aspinose, subterminally attached ventrally, filled with polyhedral glandular cells. Caudal tip invaginable, furnished with a sucker surrounded by glands with coarsely granular contents. A setate papilla on each side of invaginable part of tail tip. Collar spines extremely delicate, 49 to 53, arranged in single dorsally uninterrupted series, including row of nine angle spines on each side of pharynx. Oral sucker smaller than ventral, orifice bordered with ring of papillae. Ventral sucker in posterior half of body, also with ring of papillae around aperture. Prepharynx present. Pharynx spherical. Esophagus not extending to ventral sucker. Intestinal ceca extending to posterior region of body. Cystogenous glands brownish-yellow, with rhabditiform contents. Penetration glands in two sets: one set of six, three on each side, at level of pharynx, and another set, unpaired, composed of six glands in region of esophageal bifurcation. Twelve openings of penetration ducts along anterior margin of body. Excretory vesicle tubular, with lateral diverticula. Main excretory tubes enclosing refractile excretory granules throughout. Secondary excretory tubes, after reflexing back in region of oral sucker, dividing postacetabularly. Flame cell formula $2[(3+3+3+3+3+3)+(3+3+3)]=54$. Caudal excretory duct dividing in proximal region of tail. Rediae in hepatopancreas, with pharynx, undivided collar, and saccate gut, and without lateral processes. Measurements of 12 randomly selected cercariae: body 0.366 to 0.488 by 0.131 to 0.150; tail 0.206 to 0.400 by 0.018 to 0.028; oral sucker 0.057 to 0.072 in diam; ventral sucker 0.072 to 0.102 in diam; prepharynx 0.018 to 0.024 long; pharynx 0.030 to 0.033 in diam.

Discussion

There are a number of marine echinostome cercariae possessing collar spines. They are: *Acanthoparyphium* sp. Yamaguti, 1934, *Cercaria* l Maxon and Pequegnat, 1949, *C. caribbea* II Cable, 1956, *C. caribbea* III Cable, 1956, *C. fuscata* Holliman, 1961, *C. granifera* Ogata, 1943, *Cercaria* G Hutton, 1952, *Cercaria* L Hutton, 1952, *C. littorinae obtusatae* Lebour, 1911, *C. proxima* Lespes, 1857, *C. ophthalmoechinata* Ito, 1957, *C. yamagutii* Ito, 1957, *Himasthla compacta* Stunkard, 1960, *H. continua* Loos-Frank, 1967, *H. interrupta* Loos-Frank, 1967, *H. littorinae* Stunkard, 1966, *H. leptosoma* (Creplin, 1829) after Lebour, 1911, *H. militaris* (Rudolphi, 1802) Dietz, 1909, after Rebecq, 1964, *H. quissetensis* (Miller and Northup, 1926) Stunkard, 1934 (syn. *Cercaria quissetensis* Miller and Northup, 1926) after Stunkard, 1938, *H. rhigedana* Dietz, 1909, after Adams and Martin, 1963, and *H. secunda* (Nicoll, 1906) Dietz, 1909 (syn. *Echinostomum secunda* Nicoll, 1906) after Lebour, 1911. Of all these species, only *Cercaria fuscata* from *Cerithidea scalariformis* Say from Salt Marsh, St. Marks Height, and Shell Point, Wakulla County, Florida, USA, has a

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Figures 1–3. ***Cercaria criollisima*** **sp. n. 1. Camera lucida diagram, ventral view, details added freehand. 2. Freehand illustration of tail tip. 3. Freehand illustration of anterior end showing collar spines.**

total of 49 collar spines and thus is closest to *C. criollisima*. However, *C. fuscata* possesses two pigmented eyespots, and this character alone is diagnostic enough for the separation of *C. criollisima* which is nonocellate.

In the conservative system of classification initiated by Lühe (1909) and followed by subsequent workers, cercariae have been categorized purely on a morphological basis, with special emphasis on the structure of tail, into larval groups almost entirely independent of adult taxonomy. Cable (1956) remarked "present knowledge makes it possible to assign larvae to adult groups," and suggested abandonment of this conservative system; he introduced several groups like Echinostome Cercariae, Echinostomelike gymnocephalous Cercariae, Micorphalid Cercariae, Hemiuroid Cercariae, and Plagiorchiid Cercariae. Holliman (1961) allocated the known marine cercariae of the world to the adult families, superfamilies, suborders, and superorders. The family Echinostomidae Looss, 1902, was shown to include not only cercariae with collar spines, characteristic of this family, but also *Cercaria* F Hutton, 1952, *C. caribbea* IV Cable, 1956, and *C. caribbea* VI Cable, 1956 which lacked collar spines.

It seems to be rather dangerous practice to classify cercariae into adult taxa without a thorough knowledge of life history stages. *Cercaria udoi* Nasir, Díaz, and Hamana, 1969, and *C. paraudoi* Nasir, Díaz, and Hamana, 1969, could have been easily mistaken for non-echinostome cercariae, but the collar spines appear in their metacercarial stages and therefore are true echinostomes. Similarly, cercariae of *Echinochasmus donaldsoni* Beaver, 1941, *E. zubedakhaname* Nasir and Díaz, 1968, and *Stephanoprora paradenticulata* Nasir and Rodriguez, 1969, lack collar spines, but they are present in metacercariae and adults.

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New Geographic Distribution Records of *Trichuris skrjabini* Baskakov, 1924, in Sheep in the United States and Measurements of Various Morphological Characters

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ABSTRACT: Recovery of *Trichuris skrjabini* from sheep in Montana, Wisconsin, Maryland, Mississippi, Nebraska, and New Mexico indicates that this nematode is distributed throughout the United States. Measurements of various morphological characters of the worms generally agree with those of specimens from Dagestan, USSR, where the species has been studied extensively. Ranges of body measurements of *T. skrjabini* in the United States are presented.

Specimens of *Trichuris skrjabini* were initially identified in the United States from Nebraska sheep at the Meat Animal Research Center, Clay Center, in 1967 (Knight, 1971). Since 1967, collections of sheep whipworms from different parts of the United States have been examined to determine the geographic distribution of *T. skrjabini* in this country.

Table 1. Averages and ranges of selected body measurements of male and female *Trichuris skrjabini* from sheep in the United States with comparisons of measurements of worms from Dagestan, USSR.[1]

Character	Dagestan (Magomedbekov, 1957)	United States	
		Average	Range
Males			
Length of spicule	0.84–1.50	1.12	0.83–1.57
Length of vas deferens	3.00–4.75	4.59	2.10–7.27
Length of ejaculatory duct	5.50–7.50	7.90	4.80–10.92
Ratio of ejaculatory duct to vas deferens	1.16–2.50:1	1.81:1	1.10–3.43:1
Females			
Distance vulva to sphincter of uterus	—	2.68	1.70–3.94
Length of straight portion of ovary	—	0.30	0.10–0.75
Distance from loop of oviduct to posterior end of body	—	1.17	0.13–2.31
Width of everted vagina	—	0.04	0.03–0.06

[1] All measurements in millimeters.

Materials and Methods

Collections of whipworms from sheep which became available to me for examination were made by (1) Dr. David E. Worley at Bozeman, Montana, in 1963; (2) Dr. Rex W. Allen from Albuquerque, Las Cruces, and Roswell, New Mexico, in 1951–59; (3) Dr. Kendall G. Powers in 1961 in Wisconsin. In addition, collections of whipworms were made by me at (1) State College, Mississippi, in 1962 and 1964 from native sheep; (2) the Meat Animal Research Center in Nebraska in 1969 and 1970; and (3) the Agricultural Research Center, Beltsville, Maryland, in 1967, 1969, and 1970. Moreover, three older collections made by Mr. Merle L. Colglazier at Beltsville from one lamb in each year—1959, 1960, and 1963—were examined.

All worms were stored in 70% alcohol, or an alcohol–glycerin–formalin preservative, and were in good condition. The worms were cleared in lactophenol for study. Ten mature males and 10 mature females were randomly chosen for study from each geographic location, and selected morphological characters were measured with an ocular micrometer. In a few instances, 10 specimens of each sex were not available. Identification was based on the redescriptions of Magomedbekov (1957) and Knight (1971).

Trichuris skrjabini collected by me from the three geographic areas have been deposited in the following collections: Mississippi, USNM Helm. Coll. No. 72004; Maryland, USDA Pars. Coll. Nos. 66303 and 66304, and USNM Helm. Coll. No. 72005; Nebraska, USDA Par. Coll. No. 66302, and USNM Helm. Coll. No. 72006.

Results and Discussion

T. skrjabini was commonly recovered from sheep in Montana, New Mexico, Wisconsin, Mississippi, Maryland, and Nebraska. A maximum of 54 worms was recovered from one sheep, but generally less than 10 were present. Recovery of *T. skrjabini* from such widely separated areas indicates that it is distributed throughout the United States wherever sheep are found. In all probability, it has been present in this country for a long time, but overlooked. *Trichuris skrjabini* was described by Baskakov (1924) in Turkestan, USSR, while its biology was studied by Magomedbekov (1956a, b) in Dagestan, USSR. Because their work was not translated into English, few workers in the United States may have been aware of it; consequently, various records of *T. discolor* (normally a parasite of cattle) from sheep in the United States may be in error, and the worms could prove to be *T. skrjabini* if reexamined.

Average measurements of various morphological characters are fairly uniform in specimens from different areas of the United States (Table 1), and agree with the ranges given by Magomedbekov (1957), with the exception of lengths of ejaculatory duct and vas deferens.

Analysis of variance of measurements shows significant size differences ($P < 0.01$) of ejaculatory duct, vas deferens, and distance from vulva to sphincter of uterus between *T. skrjabini* collected in Nebraska in 1967 and 1969. The male characters were larger in 1969 except for the length and width of the spicule and length of cloaca. Total length,

length and width of anterior and posterior portions, distance of the vulva to the sphincter of uterus, and length and width of the eggs were significantly larger in the females of 1969. Two explanations for the size difference can be suggested. (1) Possibly whipworms continue to grow after patency has been reached. In 1967, three immature females without eggs were present which might suggest that the infection was a recent one, with the worms not having reached full size. While studying the biology of *T. muris* in white mice, Shikhobalova (1941) found that the average measurements for worm body length and diameter increased for approximately 20 days after patency was reached. (2) The smaller size of the 1967 worms may have been the result of host response. The 1967 lambs were placed in dry lot from pasture in October 1966, and were killed in early January, whereas the 1969 lambs were killed in July and August. The longer interval of exposure on pasture in 1966 may have resulted in the development of host resistance which was expressed against the growth of succeeding worms.

Characters for separation of *T. skrjabini* from *T. ovis* and *T. discolor* remain essentially the same as I presented in 1971. Greater variation in the length of ejaculatory duct was encountered herein than in 1971, but a distinct separation exists between the range of measurements for this character in *T. discolor* and *T. skrjabini*. The length of the vas deferens appears to be a less reliable character for identification because of the overlapping of ranges of measurement, especially in the case of *T. skrjabini* and *T. discolor*; however, separation can be made on the basis of spicule length and length of ejaculatory duct.

Acknowledgments

I wish to thank Dr. David E. Worley, Dr. Rex W. Allen, Dr. Kendall G. Powers, and Mr. Merle L. Colglazier for the opportunity to examine and study collections of whipworms made by them.

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Some Acanthocephalans from Panama and Colombia[1]

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ABSTRACT: Eighteen species of Acanthocephala (in 11 genera) are listed from neotropical Panama and Colombia. Of these species, 10 are new locality records. Additionally, the findings of: *Centrorhynchus giganteum* in *Buteogallus urubitinga* and *Leucopternis semiplumbea*; *Oncicola oncicola* in *Felis wiedii*; and *Quadrigyrus torquatus* in *Hoplias microlepis* represent new host records.

Little is known of the acanthocephalans of Panama and Colombia. Only a few reports of these parasites in the area have been published (e.g., Dunn, 1934; Calero et al., 1950; Takos and Thomas, 1958; Thatcher and Porter, 1968; Nickol and Thatcher, 1971).

The present paper is a list of the acanthocephalans which we have encountered in vertebrate hosts during the past 9 years in the two countries.

Materials and Methods

Acanthocephalans were removed from the intestinal tracts of the hosts by inserting dissecting needles near the proboscides. They were then left in tap water until turgid with the proboscides extruded. They were fixed in a heated solution of alcohol–formalin–acetic acid (AFA), stained in Mayer's carmalum stain, cleared in methyl salicylate, and mounted in Canada balsam.

Results and Discussion

Acanthocephala Rudolphi, 1808

Family Centrorhynchidae Van Cleave, 1916

Centrorhynchus albidus Meyer, 1932

HOST: *Micrastur semitorquatus* (Vieillot) (collared forest-falcon).

SITE: Lower intestinal tract.

LOCALITY: Chilibre, Provincia de Panama, Panama. R. P.

Ninety-eight specimens of this species were recovered from a single collared forest-falcon obtained near Panama City.

Centrorhynchus tumidulus (Rud., 1819)

HOST: *Heterospizias meridionalis* (Latham) (savanna hawk).

SITE: Lower intestinal tract.

LOCALITIES: Province of Panama, R. P.; Department of Meta, Colombia.

This species was found in one savanna hawk in Panama, and in a hawk of the same species in eastern Colombia. Four specimens of *C. tumidulus* were recovered from each of these two birds. This parasite has been reported previously from Brazil, Cuba, Uruguay, Venezuela, and India. We report the species in Panama and Colombia for the first time.

Centrorhynchus giganteus Travassos, 1921

HOSTS: *Heterospizias meridionalis* (Latham) (savanna hawk); *Buteogallus urubitinga* (Gmelin) (great black hawk); *Leucopternis semiplumbea* Lawrence (semiplumbeous hawk).

SITE: Lower intestinal tract.

LOCALITIES: Provinces of Panama and Colon, R. P.

From four to 42 specimens of this parasite were recovered from one each of the host hawks listed above. In the savanna hawk, *C. giganteus* was found in a mixed infection with *C. tumidulus*, and in the great black hawk, it was accompanied by *Oligacanthorhynchus iheringi*. The findings of *C. giganteus* in the great black hawk and the semiplumbeous hawk represent new host records, and this acanthocephalan has not been reported previously from the Republic of Panama.

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Centrorhynchus sp.

HOST: *Leucopternis princeps* (Schlater) (barred hawk).

SITE: Lower intestinal tract.

LOCALITY: Anchicaya, Valle, Colombia.

Two specimens of the rare barred hawk were examined, and they contained 2 and 182 specimens of an unidentified species of *Centrorhynchus*, respectively. Because of poor fixation of the parasites, it has not been possible to fully identify them, but they appear to represent an undescribed species.

Family Oligacanthorhynchidae Southwell and Macfie, 1925

Oligacanthorhynchus iheringi Travassos, 1917

HOST: *Buteogallus urubitinga* (Gmelin) (great black hawk).

SITE: Lower intestinal tract.

LOCALITY: Pacora, Province of Panama, R. P.

Nine specimens of this species were encountered in a single great black hawk killed near Panama City. These specimens were found in a mixed infection with 42 specimens of *C. giganteus*. This is a new locality record for the species.

Hamanniella microcephalus (Rud., 1819)

HOST: *Didelphis marsupialis* L. (common opossum); *Metachirus nudicaudatus* L. (brown-masked opossum).

SITE: Lower intestinal tract.

LOCALITIES: Province of Panama and Colon, Panama; Departments of Valle, Cauca, Chocó, and Meta, Colombia.

This conspicuous and widespread species is common in the opossums of Panama and Colombia. In Panama the species has been collected from both the Pacific and Caribbean coasts, and in Colombia we have seen specimens from the Pacific coastal lowlands, the Andean valleys, and the eastern plains area. This species has been taken in Colombia from sea level to about 6,000 feet in elevation. It is probable that *H. microcephala* occurs throughout both of these countries wherever the common opossum is able to survive. The infection rate for the species is about 10 to about 50% and the intensity of infection ranges from one to about eight worms per host.

Prosthenorchis elegans (Diesing, 1851)

HOST: *Saguinus geoffroyi* Pucheran (marmoset).

SITE: Lower intestinal tract.

LOCALITY: Province of Panama, R. P.

This species was reported in the marmosets of Panama by Thatcher and Porter (1968). They reported seven of 161 marmosets infected with one to 12 worms per host. This parasite apparently infects jungle populations of marmosets at a very low level, but it can become a serious problem in animals that are kept in captivity for any length of time. There can be no doubt that *P. elegans* does cause deaths in marmoset and monkey colonies as has been pointed out by Takos and Thomas (1958).

Prosthenorchis lenti Machado, 1950

HOST: *Saguinus geoffroyi* (marmoset).

SITE: Lower intestinal tract.

LOCALITY: Province of Panama, R. P.

Three specimens of this species were reported from two marmosets in Panama by Thatcher and Porter (1968). *P. lenti* is smaller than *P. elegans* and it lacks the cephalic collar.

Prosthenorchis luehei Travassos, 1917

HOST: *Nasua narica* L. (coatimundi).

SITE: Lower intestinal tract.

LOCALITIES: Provinces of Panama and Colon, R. P.

This species was found in two of two coatis from Central Panama with infections of 23 and 47 worms per host. Chandler (1953) reported a natural infection of *Prosthenorchis* in a coati from Mexico. He called his specimens *P. spirula* accepting the opinion of Dollfus (1938) that *P. luehei* is synonymous with *P. spirula*. Discovery that *P. luehei* parasitizes Panamanian coatis helps bridge the discontinuity in distribution of this species. The fact that *P. spirula* was not present in Panamanian primates, including 251 specimens representing five species of Cebidae examined by Thatcher and Porter (1968), adds evidence that *P. luehei* is a distinct species.

Prosthenorchis procyonis Machado, 1950

HOST: *Procyon cancrivorus* Cuvier (crab-eating raccoon).

SITE: Lower intestinal tract.

LOCALITY: Province of Colon, R. P.

Eight specimens of this species were obtained from a single crab-eating raccon in Panama. Two juvenile hosts of the same species were negative for the parasite. This paper represents the first report of *P. procyonis* in Panama.

Oncicola oncicola (Ihering, 1892)

HOST: *Felis onca* L. (jaguar); *F. wiedii* Gray (margay cat); *F. pardalis* L. (ocelot).

SITE: Lower intestinal tract.

LOCALITIES: Province of Colon, R. P.; Departments of Choco and Meta, Colombia.

This species was found in three of three jaguars in Panama, one of two ocelots in Colombia, and one of one margay cats in Colombia. The number of worms per host ranged from six to more than 100. The present paper represents a range extension for the species, and the margay cat is a new host record.

Macracanthorhynchus hirudinaceus (Pallas, 1781)

HOST: *Sus scrofa* L. (domestic pig).

SITE: Lower intestinal tract.

LOCALITY: Department of Valle, Colombia.

This species is a common parasite of pigs in Valle, Colombia. Many specimens of the species have been seen, but no special study has been made to determine the infection rate or intensity.

Family Gigantorhynchidae Hamann, 1892

Gigantorhynchus echinodiscus (Diesing, 1851)

HOST: *Tamandua tetradactyla* L. (anteater).

SITE: Intestinal tract.

LOCALITY: Province of Panama, R. P.

Dunn (1934) reported this species from a captive anteater at the Gorgas Memorial Laboratory in Panama City. Although eight anteaters of the same species were examined in Panama, and two were autopsied in Colombia, this species was not seen in the present study.

Gigantorhynchus ortizi Sarmiento, 1954

HOST: *Metachirus nudicaudatus* L. (brown-masked opossum).

SITE: Lower intestinal tract.

LOCALITIES: Darien Province, R. P.; Departments of Choco, Meta, and Nariño, Colombia.

This species was originally described from the brown-masked opossum from Peru. It has not been reported from any other country. *G. ortizi* appears to be host specific for *M. nudicaudatus*, and in this host the infection rate approaches 100%. Numerous worms per host (20 to 60) are the rule, and in several of the hosts examined, the intestinal tract appeared to be nearly occluded by these parasites.

Family Neoechinorhynchidae Van Cleave, 1919

Neoechinorhynchus prochilodorum Nickol and Thatcher, 1971

HOST: *Prochilodus reticulatus* Steindachner ("bocachico," small-mouthed fish).

SITE: Intestinal diverticula.

LOCALITIES: Sonso Lake and Cauca River (at Cali), Valle, Colombia.

The type locality of this species is the Sonso Lake, Valle, Colombia. Since the original description, we have found this species in the same fish host from the Cauca River.

Gorytocephalus plecostomorum Nickol and Thatcher, 1971

HOST: *Plecostomus plecostomus* L. (armored catfish).

SITE: Intestinal tract.

LOCALITY: Cárdenas River, Province of Panama, R. P.

This species has been found only in the type host and in the type locality. Three other genera of armored catfish (*Pseudancistrus*, *Chaetostomus*, and *Sturisoma*) were examined in Colombia and were found to be negative for acanthocephalans. *G. plecostomorum* may well be of limited distribution.

Family Quadrigyridae Van Cleave, 1920

Quadrigyrus torquatus Van Cleave, 1920

HOST: *Hoplias microlepis* (Günther) (dogfish).

SITE: Intestinal tract.

LOCALITY: Juan Mina, Chagres River, Panama Canal Zone.

Four specimens of this species were obtained from a single dogfish from the Chagres River in Central Panama. *Q. torquatus* was described from Venezuela, and has been reported from Surinam (Ortlepp, 1924). The present paper presents new host and locality records for the species.

Family Moniliformidae Van Cleave, 1924

Moniliformis moniliformis (Bremser in Rud., 1819)

HOST: *Rattus rattus* L. (common rat); accidentally in *Aotus trivirgatus* Humboldt (night monkey).

SITE: Lower intestinal tract.

LOCALITY: Province of Panama, R. P.

This species was seen commonly in the rats of Panama City, and Calero et al. (1950) reported an infection rate of 16%. A single immature specimen of *M. moniliformis* was also recovered from the intestinal tract of a night monkey in Panama. This specimen has been reported by Thatcher and Porter (1968), who regarded it as an accidental infection. Vives and Zeledón (1957) reported an infection rate of 18.4% for this species in the rats of Costa Rica.

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Marine Fish Trematodes of W. Pakistan. XII. A New Genus, *Paradiplobulbus*, Including Two Species, *P. isorchis* and *P. hetrorchis*[1]

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ABSTRACT: A new genus, *Paradiplobulbus*, including two new species, *P. isorchis* and *P. hetrorchis*, is described from the fish, *Tetrodon lunaris* (Bl. Schn.), of Karachi coast. The genus is characterized by possessing long ceca extending to the posterior extremity, acetabulum in anterior half of body with its aperture bounded by one or two distinct muscular, transversely extended pads, smooth or irregular; equal or unequal testis, clavate or slender cirrus sac far anterior to the acetabulum containing bilobed seminal vesicle; tubular pars prostatica; well-differentiated prostate gland cells and muscular cirrus, median or submedian genital opening at the intestinal bifurcation, trilobed ovary, receptaculum seminis uterinum and shell gland (present or absent) and almost fused vitelline follicles in the lateral fields of hindbody; uterus long reaching to the posterior end.

A new genus, *Paradiplobulbus*, is proposed to accommodate two new trematodes which are usually present with *Diplobulbus vitellosus* (Bilqees, 1972) in the fish, *Tetrodon lunaris* (Bl. Schn.), of Karachi coast. The species are named *Paradiplobulbus isorchis* and *P. hetrorchis* according to the shape of testis.

Eighty-seven fish, *Tetrodon lunaris*, were collected from the Korangi Creek and West Wharf, Karachi coast, during March–September 1971 and were examined for trematodes. One or more trematodes of the genus described here were recovered from the intestine of nine fish. After gross examination the specimens were fixed under cover glass pressure in FAA (50% alcohol, formalin, and acetic acid mixture in the ratio of 100: 6: 2.6) for 24 hr, then removed to 70% alcohol for another 24 hr, stained with Mayer's carmalum, and mounted permanently for detailed study. Drawings were made with the aid of a camera lucida. Measurements are given in millimeters.

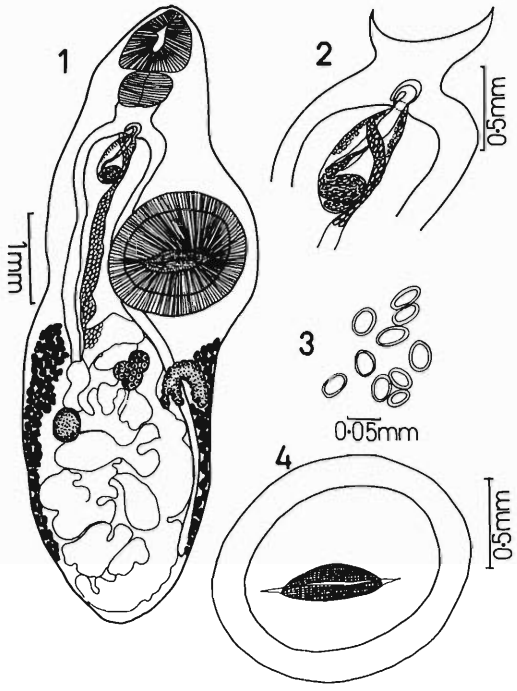
Paradiplobulbus gen. n.

GENERIC DIAGNOSIS: Allocreadiidae, Allocreadiinae. Body medium to large, fusiform to elliptical, unarmed. Oral sucker subterminal. Pharynx moderately large. Esophagus short. Ceca long, extending to posterior end of body. Acetabulum in anterior half of body with its aperture bounded by one or two distinct muscular, transversely elongated pads. Testes smooth or irregular, equal or unequal in the middle or posterior half of body, slightly oblique or at the same level. Cirrus pouch clavate or slender far anterior to acetabulum containing bilobed seminal vesicle, tubular pars prostatica, well-developed prostate gland cells, and muscular cirrus. Genital pore at the intestinal bifurcation, median or submedian. Ovary trilobed, median or submedian, ahead of anterior testis. Receptaculum seminis uterinum present. Shell gland (present or absent) diffused anterior to ovary. Vitelline follicles almost fused together and extending in lateral fields from the level of ovary to near about posterior one-half or three-fourth of body. Uterus long, coiled, occupying most of the hindbody, reaching to posterior extremity. Eggs numerous, nonfilamented. Excretory vesicle not observed.

Remarks

Among the recognized genera of fish trematodes *Paradiplobulbus* indicates its relationship with *Diplobulbus* (Yamaguti, 1934), *Labrifer* (Yamaguti, 1936), and *Brevicreadium* (Manter, 1954), in having a transverse slitlike acetabular aperture bounded by distinct muscular lips. In *Diplobulbus*, vitellaria extend into the forebody, ceca terminate posterior to acetabulum, a muscular metraterm is absent, and acetabular lips

[1] Financial support from the University of Karachi is gratefully acknowledged.



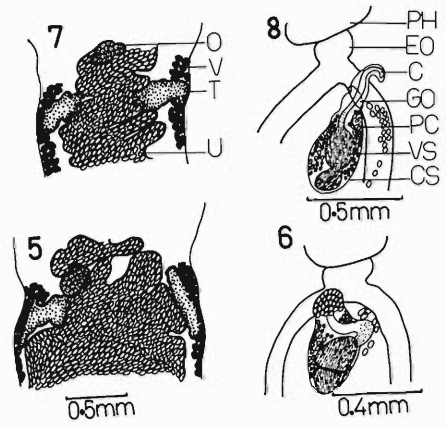
Abbreviations: C, cirrus; CS, cirrus sac; EO, esophagus; GO, genital opening; O, ovary; PC, prostate gland cells; PH, pharynx; RS, receptaculum seminis; SH, shell gland; T, testis; U, uterus; V, vitellaria; VS, vesicula seminalis.

Figure 1. *Paradiplobulbus hetrorchis* gen. et sp. n., holotype, ventral view.

Figure 2. Terminal genital ducts.

Figure 3. Eggs.

Figure 4. Acetabulum at a higher magnification showing the liplike structures in the acetabular opening.



Figures 5, 7. Postacetabular region of two paratypes showing variations in testis.

Figures 6, 8. Terminal genital ducts of the same two paratypes.

apparently have longitudinal muscles. The genus *Labrifer* has vitellaria circumcecal in hindbody which may intrude into the forebody, uterus anterior to ovary and dorsal to acetabulum, ceca long terminating near posterior extremity, external seminal vesicle with prostate cells massed together on either side, and acetabular lips with transverse muscles. The genus *Brevicreadium* is characterized by possessing fewer postacetabular vitelline follicles not extending posterior to testis, uterus extending to posterior end of testis, short ceca not reaching middle of acetabulum, almost horizontal cirrus sac, and acetabular lips with transverse muscles (as in *Labrifer*).

Paradiplobulbus is separated from these three genera by possessing postacetabular, lateral, almost fused vitelline follicles which extend from the level of ovary to one-half or one-third of hindbody; long coiled uterus with numerous eggs reaching to posterior extremity of the body; ceca extending to near posterior extremity; testes smooth or irregular, equal or unequal; trilobed ovary, conspicuous receptaculum seminis uterinum; and acetabular opening with one or two muscular lips with both the circular and longitudinal muscles running at right angles to each other. Acetabulum in *Paradiplobulbus* is also peculiar in being composed of two distinct muscular tiers.

The name *Paradiplobulbus* indicates its relationship and simultaneous occurrence with *Diplobulbus vitellosus* in the fish, *Tetrodon lunaris*, of Karachi coast (Bilqees, 1972).

Paradiplobulbus hetrorchis sp. n. (Figs. 1–8)

HOST: *Tetrodon lunaris* (Bl. Schn.), Tetrodontidae.

LOCATION: Intestine.

LOCALITY: Korangi Creek and West Wharf, Karachi coast.

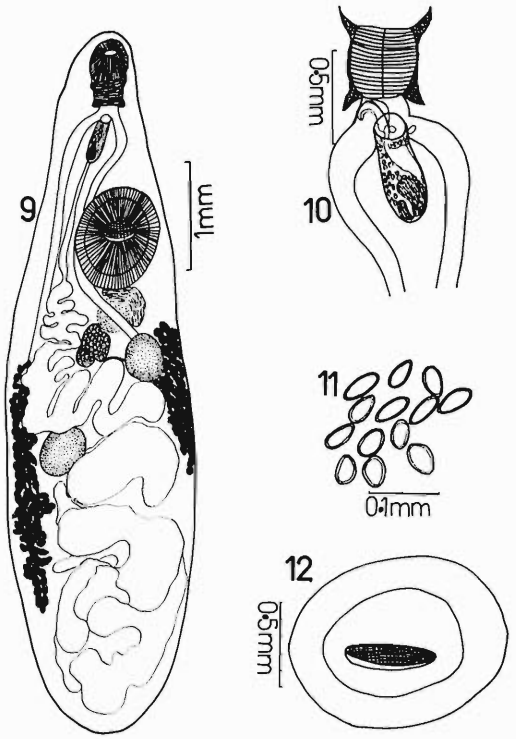


Figure 9. ***Paradiplobulbus isorchis*** **gen. et sp. n., holotype, ventral view.**

Figure 10. Terminal genital ducts.

Figure 11. Eggs.

Figure 12. Acetabulum at a higher magnification showing a well-developed acetabular lip.

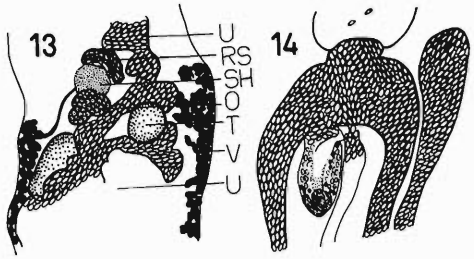


Figure 13. Postacetabular region of an atypical paratype of ***P. isorchis.***

Figure 14. Terminal genital ducts of the same paratype.

NUMBER: Seven from six of 87 hosts examined.

HOLOTYPE: USNM No. 72220.

PARATYPE: USNM No. 72221.

Description

Body smooth, plump, forebody tapering; hindbody flattened; posterior extremity broadly pointed. Length 5.2–7.6, greatest width at the acetabular region, 1.5–2.4, oral sucker usually triangular, subterminal, 0.43–0.68 wide. Pharynx 0.22–0.38 by 0.35–0.55. Esophagus 0.15–0.17 in length. Ceca long, reaching to near posterior extremity of body. Acetabulum somewhat nearer anterior than posterior end, consisting of two muscular tiers, slightly wider than long, 0.99–1.44 wide. Sucker ratio 1:2.1 to 2.3. Acetabular aperture a transverse slit bounded by two distinct lips with transverse and longitudinal muscles running at right angles to each other. Genital pore median or submedian, at the intestinal bifurcation. Either one or both the testes irregular, mostly extracecal, symmetrical or subsymmetrical, in anterior portion of the hindbody. Cirrus sac clavate 0.53–0.88 by 0.15–0.34, containing bilobed seminal vesicle, tubular pars prostatica, well-differentiated prostate gland cells, and stout muscular protrusible cirrus 0.34–0.59 long, situated 0.3–0.8 anterior to acetabulum. Posterior smaller lobe of seminal vesicle 0.05–0.08 by 0.08–0.1, and the anterior lobe 0.12–0.25 by 0.12–0.15. Ovary submedian, distinctly trilobed, at the level or anterior to left testis. Receptaculum seminis uterinum present. Shell gland indistinct. Vitelline follicles close together extending laterally from the level of ovary or slightly anterior to near posterior end of body, may be interrupted at the level of testes. Number of vitelline follicles decrease from anterior to posterior end. Extension of vitelline follicles equal on both sides. Uterus long, coiled, reaching to posterior extremity occupying intercecal field of hindbody. Eggs numerous, nonoperculate, thick-shelled, brownish, oval, 0.03–0.035 by 0.028–0.03. Excretory vesicle not observed due to enormous development of uterus.

Paradiplobulbus isorchis sp. n. (Figs. 9–14)

HOST: *Tetrodon lunaris* (Bl. Schn.), Tetrodontidae.

LOCATION: Intestine.

LOCALITY: Korangi Creek and West Wharf, Karachi coast.

NUMBER: Four from three of 87 hosts examined.

HOLOTYPE: USNM No. 72218.

ATYPICAL PARATYPE: USNM No. 72219.

Description

Body smooth, fusiform; forebody tapering, hindbody flattened; posterior end rounded. Length 4.95–7.29, greatest width at the testicular region, 1.7–2.6, oral sucker subterminal 0.47–0.62 wide. Pharynx 0.27–0.35 by 0.40–0.41, provided with four dark staining areas, two anteriorly and two posteriorly connected with each other by fine ducts; this represents the nervous complex in this region. Esophagus 0.1–0.15 long. Ceca long reaching to near posterior end of body. Acetabulum near anterior end 1.1–1.39 wide, consisting of two distinct muscular tiers. Acetabular aperture provided with a single well-developed liplike structure. Sucker ratio 1:2.2 to 2.3. Genital pore median or submedian, at the intestinal bifurcation, genital atrium prominent. Testes slightly oblique, mostly intercecal, in anterior portion of hindbody, ovoid, equal or unequal, anterior testis 0.38–0.39 by 0.25–0.59, posterior 0.28–0.55 by 0.42–0.59. Cirrus sac slender 0.62–0.66 long containing relatively small twisted, bilobed seminal vesicle, short pars prostatica, prostate gland cells, and cirrus 0.2–0.3 long. Smaller posterior lobe of seminal vesicle 0.08–0.1 by 0.05–0.07, larger lobe 0.13–0.17 by 0.07–0.10. Ovary distinctly trilobed, median or submedian, equatorial. Receptaculum seminis immediately posterior to acetabulum. Shell gland well differentiated between ovary and receptaculum seminis. Vitelline follicles almost fused together extending in the extracecal fields of hindbody from the level of shell gland or ovary to one-half or one-third of hindbody. The extension of vitelline follicles on both the sides always unequal. Uterus long, coiled, occupying whole of intercecal field of hindbody up to the posterior end. Eggs numerous, nonoperculate thick-shelled, dark brown, elongated 0.05 by 0.03. Excretory vesicle not obvious due to uterus.

Among the four specimens of *Paradiplobulbus isorchis* one atypical paratype was also present with anterior testis smooth and posterior larger testis smooth dorsally and indented ventrally (Fig. 13). This specimen was also peculiar in having an extracecal uterine coil in the preacetabular region in contrast to other specimens (Fig. 14).

Remarks

Paradiplobulbus isorchis is close to *P. hetrorchis* as far as trilobed ovary, bilobed seminal vesicle, sucker ratio, and position of genital opening is concerned but the symmetrical or subsymmetrical irregular testis, indistinct shell gland, equal extent of vitelline follicles on both the sides of body which may be interrupted at the level of testis, differences in the position of testis and acetabulum, relatively larger cirrus sac and seminal vesicle, and two acetabular lips instead of one serve to distinguish *P. hetrorchis* from *P. isorchis*.

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The *Stomachicola rubea: Tubulovesicula pinguis* Enigma

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ABSTRACT: *Stomachicola rubea* (Linton, 1910) Manter, 1947, is reported from 28 species of marine fishes collected near Sapelo Island, Georgia, between 1 October 1969 and the fall of 1971. Lack of clearly definable descriptive differences between S. *rubea* and S. *magna* (Manter, 1931) Manter, 1947, indicates synonymy of these species. *Stomachicola rubea* and S. *magna* were transferred to *Pseudostomachicola* by Skrjabin and Guschanskaja (1954) but retained as *Stomachicola* by Yamaguti (1958). An additional synonymy with S. *rubea* is the designation *Distomum tornatum* (in part) of Linton (1901, 1905, 1940), later referred to as *Dinurus pinguis* by Linton (1940) and Dawes (1946) and as *Tubulovesicula pinguis* by Manter (1947, 1954), Skrjabin and Guschanskaja (1954), Yamaguti (1958), Sogandares (1959), and Overstreet (1968). *Stomachicola rubea* uses a large number of small fishes as "transfer hosts" in which it is found encysted or wandering freely in the body cavity or in tissues of various organ systems and often reaches full maturity while in these hosts. Response by these hosts eventually kills the worm which is then "mummified" in melanated cysts. "Transfer hosts" become infected in late spring or early summer and growth of worms in these hosts is then continuous. Larger piscivorous fishes apparently become infected by feeding on "transfer hosts." Variability of sizes and proportions of worms in definitive hosts often reflects stage of development attained by the postmetacercarial organism in a "transfer host" before it is contracted by a definitive host. Maturation time in definitive hosts apparently is shorter than in transfer hosts.

The hemiurid trematode genus *Stomachicola* Yamaguti, 1934, is reportedly represented by two species in marine fishes of North American and Caribbean waters: S. *rubea* (Linton, 1910) Manter, 1947, and S. *magna* (Manter, 1931) Manter, 1947. Separate listings of these two species plus unassigned *Stomachicola* sp. have been made by Melugin (1940), Hanson (1950), Sparks (1958), Corkum (1959), Nahhas and Cable (1964), Nahhas and Short (1965), Corkum (1966), and Overstreet (1968). S. *rubea* and S. *magna* were transferred to a new genus, *Pseudostomachicola*, by Skrjabin and Guschanskaja (1954) but, on examination of type specimens, they were retained as *Stomachicola* by Yamaguti (1958).

Resolution of Synonymic Conflict

Stomachicola magna and S. *rubea* are distinguished according to Manter (1931) solely by difference in extent of the pars prostatica. While seemingly worded as such by Linton (1910), his figures and type material contradict this distinction. As well, this structure is variable in extent and size and strongly influenced by method of specimen preparation: hot fixation resulting in extension and fixation at room temperature resulting in contraction in specimens obtained from the same host. The exact method of preparation was not given in either description. A preoral lobe was noted by Linton (1910) in the description of *D. rubeus*. Such a structure was not shown in figures of S. *magna* (Manter, 1931) nor mention made by Manter (1931, 1947) but was by Corkum (1959). We find that room temperature fixation of these worms clearly demonstrates this feature, while hot fixation often obliterates it and relaxation in Chloretone, fresh water, etc., always does due to swelling. A more serious and presumably unalterable discrepancy exists between the description of S. *magna* and S. *rubea*. Manter (1931) gave a length range of uterine eggs of 9–11 μ for S. *magna* while Linton (1910) reported 17–18 μ for S. *rubea*. Though most were collapsed, we found measurable eggs of the type specimen (USNM Helm. Coll. No. 8437) of S. *magna* to be 15–18 μ. With no clear distinction between the two species, we consider S. *magna* to be a synonym of S. *rubea*.

Further synonymy with *Stomachicola rubea* exists in the literature. Linton (1901, 1905,

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1940) recorded *Distomum tornatum* Rudolphi, 1819, for several host species from a number of different geographical locations. Linton (1940) erected *Dinurus pinguis* to encompass most forms listed as *Distomum tornatum* in his earlier publications. The type description of *D. pinguis* was based only on a single small worm from the silverside, *Menidia notata* (Mitchill), although additional data from other hosts followed. Linton, who only once listed *D. rubeus* (= *Stomachicola rubea*), has never indicated any relation between that organism and *D. pinguis* or *D. tornatum*. After examination of type material of *Dinurus pinguis* (USNM Helm. Coll. Nos. 8367–8371), we believe that these worms are merely less mature forms of *Stomachicola rubea*. Linton's collections were made during summer months at which time, due to seasonal regimentation, *S. rubea* in most hosts is much smaller than its maximal size. Our collections of *S. rubea* from its many hosts yield matching specimens and a range of data encompassing data provided by Linton (1910, 1940) in his descriptions of *D. rubeus* and *D. pinguis*. Also, many of the host species listed for *D. tornatum* (= *D. pinguis*) (Linton, 1901, 1905, 1940) have been found to harbor *Stomachicola rubea* during the present study (Table 1). Linton's (1940) notation of an encysted form of *D. pinguis* recovered from *Cynoscion* sp. matches descriptively a number of similar forms found by us encysted in the stomach walls of *Cynoscion spp.* and *Symphurus plagiusa*. Extreme difference in size and availability of only a few specimens would seem to account for the lack of connection between *D. rubeus* and *D. pinguis* described by Linton.

Manter (1947) placed *D. pinguis* in the genus *Tubulovesicula* Yamaguti, 1934, as *T. pinguis*, seemingly ignoring that he had previously (Manter, 1931) used a number of Linton's designations [*Distomum tornatum* (Linton, 1905) = *Dinurus pinguis* (Linton, 1940)] in his description of *Stomachicola magna*. Sogandares (1959), who revised Manter's (1954) key to species of *Tubulovesicula*, synonymized a number of the species, but retained *T. pinguis*. Other listings have been made by Skrjabin and Guschanskaja (1954) and Yamaguti (1958). Overstreet (1968) also listed this worm in his compilation of parasites of *Synodus foetens* but no one has reportedly observed it except Linton. Regarding the synonymic conflict and the referral of *S. rubea* to two separate genera, priority goes to *Stomachicola* as it precedes pagewise the erection of the genus *Tubulovesicula* in the same publication by Yamaguti (1934).

The distinction between *Tubulovesicula* and *Stomachicola* based on relative length of ecsoma (either shorter or longer than body proper), stemming from the work of Manter (1947) (Skrjabin and Guschanskaja, 1954; Schell, 1970), should be rescrutinized since length and relative proportion is merely a matter of age or preparation of specimens. Manter's (1931) description of *D. magnus* (= *S. magna*), with no further reports of the species by its describer, was based on two specimens (one twice the size of the other) from a single host (*Synodus foetens*) which fails to account for variability witnessed by more extensive study of this organism. The type specimen deposited by Manter (USNM Helm. Coll. No. 8437) is excessively flattened. *S. rubea* (= *S. magna*) on fixation, if not subjected to stretching and excessive pressure, displays a length of about one-half of its extensibility while living, and especially affected is the length of the ecsoma. This is most pronounced in larger examples of this species. Variability of treatment of specimens by different helminth taxonomists would be extremely misleading in regard to this particular parasite if reliance on size and relative proportions of specimens is stressed for identification. Specimens of *S. rubea* from the stomach of one lizardfish (*Synodus foetens*) taken in October, mixed, randomly isolated to separate groupings, and treated in three different ways yielded the following results:

Hot water (near boiling) then immediate AFA fixation: (16 worms) total length, 3.0–9.7 mm; ecsomal length, 1.0–7.7 mm; relative length of ecsoma, 33–79 (avg 64)%.

Chloretone for relaxation then AFA fixation: (15 worms) total length, 4.1–9.6 mm; ecsomal length, 2.0–6.1 mm; relative length of ecsoma, 49–71 (avg 63)%.

Room temperature fixation with AFA: (19 worms) total length, 2.7–5.7 mm; ecsomal length, 0.5–3.7 mm; relative length of ecsoma, 19–65 (avg 47)%.

Coupling innate variability and variability of treatment with time of year of recovery of specimens of *S. rubea* would in many cases cause the assignment of the same organism not only to different species but different genera if the hard and fast rule of relative size of ecsoma (more or less than 50% of total length) is adhered to in separating *Stomachicola* from *Tubulovesicula*.

The basic color of *S. rubea* varies from a pale pink transparency while small to an opaque brick red in very mature specimens. This is seen in both transfer and definitive hosts but larger immature cystic forms maintain the pink coloration no matter the size attained.

Ecological Considerations

Ecological aspects of *Stomachicola rubea* (= *S. magna* and *T. pinguis*) have been scanty, the only known indication being by Corkum (1966). He reported the recovery of a single mature and several immature *S. magna* from the stomach and intestine of one of 108 *Paralichthys lethostigma* and commented on the unlikelihood of this being the proper definitive host. Our finding of one-third of examined specimens of this host species infected with *S. rubea* with up to 48 worms per host would seem to indicate a higher incidence of *S. rubea* on the Atlantic than on the Gulf Coast (Table 1). This regional difference is made more notable by the many surveys of fish parasites of the Gulf Coast that have failed to yield reports of either *Stomachicola* or *Tubulovesicula pinguis*. Corkum's (1966) report of metacercariae of *S. magna* encysted in *Symphurus plagiusa* should not be interpreted literally, as it is doubtful that the organisms viewed by him were metacercariae. We have viewed such encysted forms in this and other host species and it appears that encystment in muscular tissue is just one of the variable sites selected for residence by younger stages of the postmetacercarial organism of this species. Corkum's (1966) account only concerned encysted worms observed during summer, thus

Table 1. Incidence of *Stomachicola rubea* (Linton, 1910) Manter, 1947, in fishes† off Sapelo Island, Georgia.

Host	No. infected/ No. examined	No. of worms
**Anchoa mitchilli* (Valenciennes) (bay anchovy)	13/1,236	1–2
Anguilla rostrata (LeSueur) (American eel)	1/3	1
**Bairdiella chrysura* (Lacépède) (silver perch)	15/346	1–2
**Centropristes striatus* (Linnaeus) (black sea bass)	1/2	1
**Chaetodipterus faber* (Broussonet) (Atlantic spadefish)	2/102	2–2
Cynoscion nebulosus (Cuvier) (spotted seatrout)	12/21	1–6
**C. nothus* (Holbrook) (silver seatrout)	10/135	1–5
C. regalis (Bloch and Schneider) (weakfish)	414/695	1–7
**Fundulus majalis* (Walbaum) (striped killifish)	11/19	1–11
**Arius felis* (Linnaeus) (sea catfish)	11/123	3–5
**Leiostomus xanthurus* Lacépède (spot)	20/287	1–3
**Megalops atlantica* Valenciennes (tarpon)	1/7	2
**Menidia menidia* (Linnaeus) (Atlantic silverside)	4/15	1–2
**Menticirrhus americanus* (Linnaeus) (southern kingfish)	50/97	1–20
**Micropogon undulatus* (Linnaeus) (Atlantic croaker)	11/393	1–2
Opsanus tau (Linnaeus) (oyster toadfish)	1/16	1
Paralichthys dentatus (Linnaeus) (summer flounder)	5/5	1–22
P. lethostigma Jordan and Gilbert (southern flounder)	10/30	1–48
**Peprilus alepidotus* (Linnaeus) (southern harvestfish)	2/10	4–4
**Prionotus evolans* (Linnaeus) (striped searobin)	9/51	1–8
**P. scitulus* Jordan and Gilbert (leopard searobin)	1/1	2
**Sciaenops ocellata* (Linnaeus) (red drum)	1/6	1
**Selene vomer* (Linnaeus) (lookdown)	1/18	1
**Stellifer lanceolatus* (Holbrook) (star drum)	514/3,384	1–13
Strongylura marina (Walbaum) (Atlantic needlefish)	1/3	9
Symphurus plagiusa (Linnaeus) (blackcheek tonguefish)	12/1,364	1–2
Synodus foetens (Linnaeus) (inshore lizardfish)	15/15	13–84
**Trinectes maculatus* (Bloch and Schneider) (hogchoker)	1/11	1

† Names according to American Fisheries Society Sp. Publ. 6. 1970.
* New host records.

nearly eliminating any chance of observing mature specimens in similar situations.

In all but four of the host species examined by us, *Stomachicola rubea* was found encysted or wandering freely through the coelomic cavity or body tissues, often invading liver, spleen, heart, kidney, swim bladder, or body musculature. Nahhas and Short (1965) reported *Stomachicola* sp. on the ovary of *Diplectrum formosum* (Linnaeus) and *Tubulovesicula* sp. beneath the ovarian membrane and in body wall muscles of *Cynoscion arenarius* Ginsburg and *C. nebulosus* (Cuvier). Such worms are able to mature fully, often leaving trails of eggs in tissues during passage. The worms in time become trapped in tissues, are walled off in melanated cysts, and then become "mumified"; morphological features still are apparent after the worms are dead, shrunken, and hardened. "Mummification" is most common in late winter or early spring. The apparent lack of "mummified" specimens during most of the year would seem to indicate absorption by the host after a time. Often, cystic areas are observed that are hollow or contain indistinguishable masses of tissue or saclike structures that could well be remnants of mummified worms. These cystlike structures are morphologically comparable to those surrounding some live worms. In *Symphurus plagiusa*, *Stomachicola rubea* is more commonly encysted than not, often within noticeable swellings on the stomach wall.

An indication of past or present infections in the bulk of transfer hosts is often immediately noticeable on opening the coelomic cavity of these fishes, especially in cases of high infection. Opposed to the clean condition of uninfected hosts, coelomic cavities of infected fish are murky with melanated particulate matter. Among this tissue can be found living worms in all stages of maturation and/or the above reported cystic forms. We strongly suspect that Linton's many records of *D. pinguis* from the intestinal tract of fishes are in error as many of the species reported by him are only transfer hosts and do not carry the organism in the digestive tract. The worms were probably transferred to preserving or viewing containers while clinging to the exterior of the intestine.

The only "true" definitive hosts of *Stomachicola rubea* found by us were the American eel (*Anguilla rostrata*), tarpon (*Megalops atlantica*), inshore lizardfish (*Synodus foetens*), and mature southern kingfish (*Menticirrhus americanus*). From the nature and habits of these and other reported hosts, it appears that *S. rubea* uses a considerable number of small fishes as transfer hosts in which the postmetacercarial organism reaches various stages of maturity. Larger piscivorous fishes apparently acquire the worm from these hosts and retain it in the stomach, the common site of adult hemiurid trematodes. This hypothesis is supported by the presence of live active worms in coelomic cavities of known prey which were in the stomachs of lizardfish. Two of the prey hosts were identified as a *Cynoscion* sp. and *Prionotus scitulus*. Linked to the above is a statement by Overstreet (1968), "A low incidence of *Stomachicola* in small fish [*Synodus foetens*, lizardfish], accompanied by a higher incidence in the larger *Synodus* collected at the same time, suggests that the parasite is acquired from an intermediate host not normally fed on by small individuals of *S. foetens*." As well, the southern kingfish, which, when small, is one of the more common transfer hosts, carries *S. rubea* in the stomach when it reaches a larger size (above 30 cm). This dual site for infection in the same host species depending on size of the host would suggest that residence in a transfer host is a necessary part of the life cycle of *S. rubea*, as it is unlikely that the piscivorous definitive hosts acquire it from the metacercarial host (most likely a small crustacean).

Infection of transfer hosts with *Stomachicola rubea* appears to be initiated in late spring and early summer, with maturation and continued growth of worms occurring until they are killed off by host defense reactions or are contracted by a definitive host, the organisms ultimately ending in definitive hosts reflecting this seasonality of initiation of infection. In June, 32 *S. rubea* from lizardfish had a total length ranging from 0.96–4.96 (avg 2.52) mm with the ecsoma contributing 0–62 (avg 42)% of this length. By early September, 128 worms ranged in size from 1.28–9.55 (avg 5.99) mm with the ecsoma contributing 0–77 (avg 61)%.

By early October, 16 specimens had the following lengths: 3.0–9.7 (avg 8.24) mm; ecsoma, 33–79 (avg 64)%. All worms were taken from the same geographic location and were similarly "relaxed" with near boiling water before fixation so are believed to be comparable. This same pattern is portrayed in coelomic inhabitants of transfer hosts, with only quite large and mature worms being found during late fall and winter months. The larger species of transfer host appear to provide a more favorable milieu; in kingfish and *Cynoscion* spp. the worms attain a length of 9.44–14.40 (avg 11.48) mm by midwinter. From the pattern observed it would appear that the very largest worms (22–25 mm) of this species could well be more than one year of age.

The growth pattern of *Stomachicola rubea* in transfer hosts is quite diverse and dependent on microhabitat. Worms encysted in the stomach wall of hosts enlarge considerably in bodily dimensions with little growth of ecsoma and no apparent genital organ differentiation. Those free in the coelom or in body tissues elongate with comparable growth of soma and ecsoma and eventually become ovigerous. Thus the diversity of forms in definitive hosts seemingly reflects developmental stage attained in the many transfer hosts before they are ingested by a definitive host.

Maturation of coelomic forms in transfer hosts occurs at a larger size than stomach inhabitants of definitive hosts. Egg production is initiated in coelomic forms at a somal length of 3.0–3.5 mm, while in stomach inhabitants this occurs at a length of 2.0–2.4 mm. Total lengths at this stage are not suitably comparable. Relative length of ecsoma of worms in definitive hosts would seem to be influenced by stage of acquisition, as ecsomal growth is apparently retarded in coelomic and definitely is in cystic forms. The more robust worms in definitive hosts are probably acquired at a larger body size and this proportion maintained while in a definitive host.

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Survival, Wound Healing, and Development in Laboratory-Injured Trematode Metacercariae of *Leucochloridiomorpha constantiae*[1]

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ABSTRACT: To determine survival, wound healing, and development of the experimentally injured trematode *Leucochloridiomorpha constantiae*, metacercariae were transected posterior to the pharynx (anterior-transected metacercariae) or posterior to the acetabulum (posterior-transected metacercariae) and transplanted to the chick cloaca or chorioallantois. Although normal postmetacercarial development did not occur, some anterior- and posterior-transected flukes invaded the bursa of Fabricius and survived for 2 days. Some anterior- and posterior-transected chorioallantoic flukes developed vitellaria within 4 days and survived for 5 days postimplantation, suggesting that biological conditions on the membrane were more favorable for survival of injured worms as compared with the bursa of Fabricius. Wound healing of the body surface occurred in transected worms and was effected by contraction of the body wall and formation of a parenchymal wound plug. This healing occurred in the absence of lost parts.

Studies on wound healing in naturally (Manter, 1930; Sinitsin, 1932), accidentally (Senft and Weller, 1956; Fried and Penner, 1964), or experimentally (Beaver, 1937; Cheng, 1963; Smithers and Terry, 1967; Fried et al., 1971) damaged trematodes are limited to adults. This work reports use of a metacercaria for the first time in studies of wound healing. Its purpose is to study survival, wound healing, and development of laboratory-injured metacercariae of *Leucochloridiomorpha constantiae* (Mueller, 1935) in the domestic chick bursa of Fabricius and chorioallantois.

Materials and Methods

Metacercariae of *L. constantiae* obtained from *Campeloma decisum* snails (Mueller, 1935; Allison, 1943; Fried and Harris, 1971) were transected with a microscalpel either immediately posterior to the pharynx, i.e., anterior-transected metacercariae, or posterior to the acetabulum, i.e., posterior-transected metacercariae. In chick studies 120 transected metacercariae, i.e., 60 anteriors and 60 posteriors and 20 whole metacercariae (controls) were implanted, 10 per host, using the "cloacal drop" procedure of Allison (1943), into 12 1- to 7-day-old chicks anesthetized with Equi-Thesin (Fried and Berry, 1961). Chicks were necropsied 1 hr to 3 days postimplantation and the bursa was examined for live transected or control worms (Table 1). In chorioallantois studies 420 transected metacercariae, i.e., 210 anteriors and 210 posteriors, and 40 controls rinsed in sterile Ringer's containing antibiotics (Fried et al., 1968) were implanted, 5 per egg, on chorioallantoic membranes of 7- to 10-day-old chick embryos (Zwilling, 1959). Eggs maintained at 37.5 C were examined

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Table 1. Survival of transected and control *L. constantiae* metacercariae in the bursa of Fabricius of chicks.[1]

Exp.[2]	No. of chicks used	No. of worms used	No. and (%) of live recoveries in hr or days postimplantation				
			1 hr	12 hr	1 day	2 days	3 days
A	6	60	3/10 (30)	1/10 (10)	0/10 (0)	0/10 (0)	0/20 (0)
B	6	60	3/10 (30)	2/10 (20)	1/10 (10)	1/10 (10)	0/20 (0)
C	2	20	—	—	—	—	13/20 (65)

[1] In Tables 1 and 2 numerator = number of live worms recovered, and denominator = number of worms implanted.
[2] In Tables 1 and 2 A = anterior-transected metacercariae, B = posterior-transected metacercariae, and C = control metacercariae.

1 to 7 days postimplantation (Table 2). To determine survival and possible development in a nonnutrient medium a total of 15 metacercariae, anterior- and posterior-transected, and controls were maintained, 5 per tube, in 2 ml of sterile Locke's solution (Paul, 1960).

Live worms from all sites were fixed in AFA and either examined as Gower's (1939) whole mounts or as paraffin sections stained with Harris' hematoxylin and eosin.

Results

The results of cloacal implantation studies are summarized in Table 1. Live anterior- or posterior-transected metacercariae were not recovered after 12 hr or 2 days postimplantation, respectively, whereas 13 (65%) of 20 whole metacercariae were recovered as ovigerous adults from the bursa 3 days postimplantation. Transected metacercariae were loosely attached in the bursa whereas control flukes were tenaciously attached to the bursal surface with oral and ventral suckers. Observations on transected metacercariae recovered from the bursa showed that contraction of the body wall effected partial closure of wound margins in worms recovered 1 hr to 2 days postimplantation. Postmetacercarial development of transected worms was not observed.

The results of chorioallantois studies are summarized in Table 2. Control and posterior-transected worms were attached with oral and ventral suckers to the membrane, whereas anteriors were loosely attached or not attached. Transected and control worms were recovered on the chorioallantois singly or in clusters. Recovery of live anterior-transected worms (Fig. 1) declined from 28% at 2 days postimplantation to 0% by 6 days. Sections indicated that wound closure was effected by partial closure of the body wall and completed by a parenchymal wound plug (Fig. 2). Erythrocytes from the chorioallantois present in the ceca of control worms were not seen in anterior-transected flukes. Although minimal vitellinogenesis occurred within 4 days postimplantation (Fig. 1), oviposition or progressive repair of missing parts did not occur.

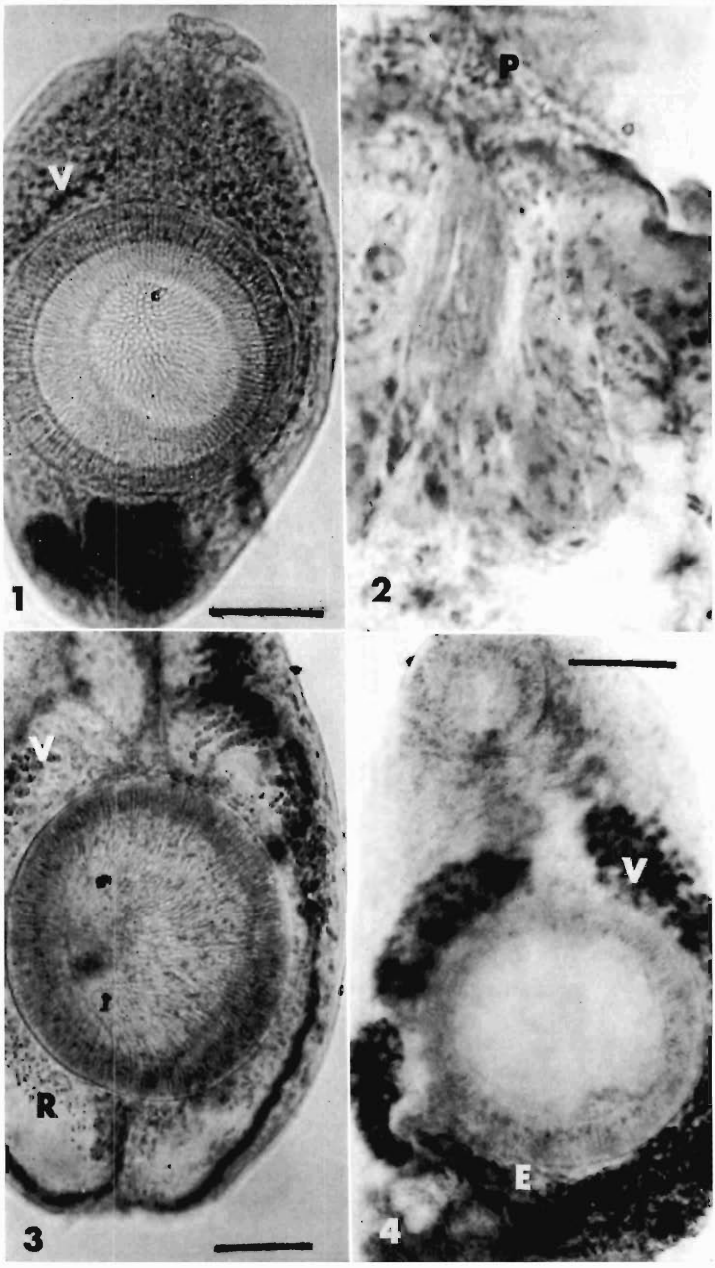
Recovery of posterior-transected chorioallantoic worms declined from 36% at 1 day postimplantation to 0% at 6 days. Sections showed closure of wound margins as observed in anterior-transected flukes but failed to show reopening of excretory tubules, oviposition, or progressive repair of lost parts. Four-day-old posterior-transected flukes were vitelline-positive and showed blood feeding (Fig. 3).

Control metacercariae maintained on the chorioallantois were vitelline positive by 2 days and ovigerous by 4 days (Fig. 4) and 33 (82.5%) of 40 controls were recovered 2 to 6 days postimplantation (Table 2, C).

Transected metacercariae survived a maximum of 2 days in Locke's at 37.5 C whereas

Table 2. Survival of transected and control *L. constantiae* metacercariae on the chick chorioallantois.

Exp.	No. of eggs used	No. of worms used	No. and (%) of live recoveries in days postimplantation					
			1	2	3	4	5	6
A	42	210	6/25 (24)	7/25 (28)	4/25 (16)	3/45 (6.7)	1/45 (2.2)	0/45 (0)
B	42	210	9/25 (36)	7/25 (28)	9/25 (36)	4/45 (8.9)	2/45 (4.4)	0/45 (0)
C	6	40	—	8/10 (80)	—	7/10 (70)	10/10 (100)	8/10 (80)



Figures 1–4. Photomicrographs of transceted and control chorioallantoic flukes. Scale bars 0.1 mm. 1. This 4-day-old anterior-transected chorioallantoic fluke measured 0.54 by 0.33 mm. Note (V) vitellaria. 2. Section showing wound plug (P) in 4-day-old anterior-transected fluke. 3. This 4-day-old posterior-transected chorioallantoic fluke measured 0.94 by 0.44 mm. Note (R) erythrocytes in crura and (V) vitellaria. 4. This 5-day-old chorioallantoic control measured 1.05 by 0.38 mm. Note (V) vitellaria and (E) eggs.

whole metacercariae survived up to 5 days. All metacercariae maintained in Locke's were vitelline-negative and nonovigerous.

Discussion

Previous studies on injured *Echinostoma revolutum* adults implanted into avian cloacas (Beaver, 1937; Fried et al., 1971) have reported the absence of live recoveries for trematodes with damaged or missing oral suckers. The survival of anterior-transected metacercariae on the chorioallantois up to 5 days is in accord with observations of Senft and Weller (1956) on the survival of anterior-injured *Schistosoma mansoni* for several days in vitro and on the survival of posterior-half schistosomes for 24 hr and possibly 3 days in the mesenteric veins of monkeys (Smithers and Terry, 1967). Some anterior- and posterior-transected chorioallantoic flukes produced vitellaria suggesting that nutritional or physical factors on the membrane initiated post-metacercarial development of injured flukes.

Recently, Smithers and Terry (1967) reported survival up to 10 weeks and wound healing of anterior-half adults of *S. mansoni* implanted into the mesenteric veins of monkeys. In our study the reduced survival of transected metacercariae compared with whole worms and the absence of progressive repair of lost parts suggest that the metacercaria of *Leucochloridiomorpha constantiae* is capable of only limited wound healing and can survive only a short time following wounding as has generally been reported for adult intestinal trematodes.

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Research Note

Effects of Penicillin and Streptomycin on In Vitro Survival of the Metacercaria of *Leucochloridiomorpha constantiae* (Mueller, 1935) (Trematoda) and on its Development on the Chick Chorioallantois

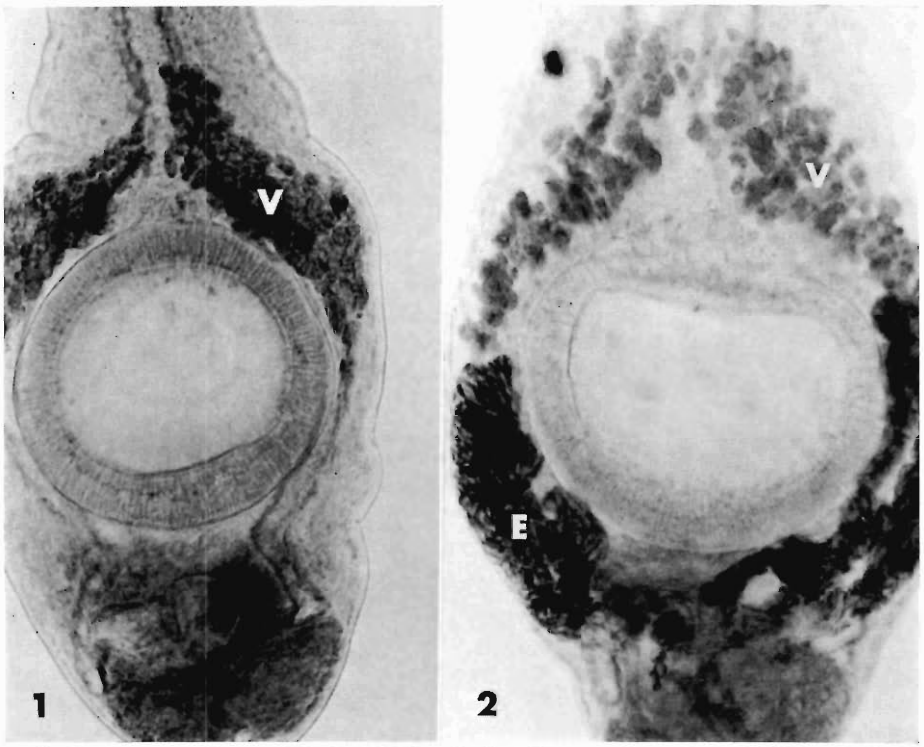
Antibiotics included in cultivation media for parasitic flatworms may inhibit growth and development (Clegg, 1965, Exp. Parasit. 16: 133–147; Berntzen, 1962, J. Parasit. 48: 785–797). However, Taylor (1961, Exp. Parasit. 11: 176–187) reported penicillin and streptomycin included in cultivation media were not toxic for *Hymenolepis diminuta* and *H. nana*, and Schiller (1965, J. Parasit. 51: 516–518) successfully cultivated *H. diminuta* in the presence of antibiotics. Since little is known of the effects of antibiotics on the development of digenetic trematodes, we attempted to determine the effects of penicillin and streptomycin on in vitro survival of the metacercaria of *Leucochloridiomorpha constantiae* (Mueller, 1935) and on its development on the chick chorioallantois.

L. constantiae metacercariae (Fried and Harris, 1971, J. Parasit. 57: 866–868) were washed in three changes of sterile Ringer's solution then placed, 4 worms/tube, in 2 ml of sterile Locke's solution at 37.5 C in the presence or absence of streptomycin sulfate or potassium penicillin G (E. Lilly Co., Indianapolis, Ind.). Survival was determined by daily examination for activity with a dissecting scope. Fifty percent of controls and of metacercariae in 100,000 to 49 μg/ml of streptomycin or 20,000 to 39 units/ml of penicillin survived 3 to 4 days, and individuals survived up to 6 days. Hoffman's (1958, Exp. Parasit. 7: 23–50) observations of increased survival of *Posthodiplostomum minimum* metacercariae in Ringer's with 500 to 1000 units/ml of streptomycin and penicillin compared with untreated worms may have been due to inhibition of contamination in cultures with antibiotics. His findings that streptomycin and penicillin at dilutions of 2000 units/ml or greater reduced survival differ from our results for *L. constantiae* metacercariae.

To determine the effects of antibiotics on subsequent development of metacercariae and young adults on the chick chorioallantois, metacercariae and 1- and 2-day-old chorioallantoic-grown worms were maintained, 5 worms per culture, for 1 day at 37.5 C in 2 ml of sterile Locke's in the presence or absence (controls) of penicillin or streptomycin. Flukes were removed from cultures, passed through three changes of sterile Ringer's, and implanted, 7 to 10/egg, on the chorioallantois of 9- to 12-day-old chick embryos. Worms were maintained on membranes at 37.5 C and recovered 3 to 5 days postimplantation so that on recovery each worm had been on the chorioallantois a total of 5 days and maintained in antibiotic solutions 1 day. Worms were flattened on slides with light coverslip pressure, fixed in AFA, and prepared as Gower's carmine whole mounts. The results of these experiments (Table 1) show that all untreated (control) metacercariae developed vitellaria 1–2 days and became ovigerous 3–4 days after implantation (Fig. 2). Similar results were obtained with flukes grown 2 days on the membrane before antibiotic treatment. But the highest

Table 1. Oviposition in antibiotic-treated- and control-flukes maintained 5 days on the chick chorioallantois.

Treatment	Number of flukes with eggs/ Number treated		
	Metacercariae	day-old	2-days-old
Penicillin			
20,000 units/ml	5/5	5/6	5/5
200 units/ml	5/5	6/6	5/5
Streptomycin			
100,000 μg/ml	1/5	1/5	5/5
1,000 μg/ml	3/6	3/5	5/5
None	10/10	5/5	8/8



Figures 1, 2. *L. constantiae* on the chorioallantois. 1. Metacercaria maintained 1 day in Locke's containing 100,000 μg/ml of streptomycin and grown 5 days on the chorioallantois. Note presence of vitellaria (V), and absence of eggs. 2. Metacercaria maintained 1 day in Locke's without antibiotics and grown 5 days on the chorioallantois. Note presence of vitellaria (V) and eggs (E).

concentration of penicillin and both concentrations of streptomycin prevented egg production in some metacercariae and some worms grown 1 day on the membrane before antibiotic treatment (Fig. 1).

Reasons for the inhibition of oviposition of some antibiotic-treated flukes are not apparent from observations made in this study. Although the antibiotic may have directly affected the worm, the possibility exists that in some worms treated in antibiotic and then transferred to the chorioallantois, the antibiotic then leaked out of the worm, inhibited chick embryo, and hence worm development.

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Research Note

A Report of *Taenia taeniaeformis* from the Muskrat, *Ondatra zibethicus zibethicus* in Central Maryland

From one to ten strobilocerci of *Taenia taeniaeformis* were encysted in the livers of 19 out of 103 *Ondatra zibethicus zibethicus*, the common muskrat, collected during 1967 and from November 1970 to March 1971 from ponds, streams and rivers in Frederick County, Maryland (Table 1). The incidence of the parasite was essentially the same in muskrats collected in different localities or at different times. By contrast, there was no evidence of *T. taeniaeformis* in the livers of 75 muskrats collected from the brackish marshes of Dames Quarter in Somerset County, on Maryland's Eastern Shore (Table 1).

Table 1. Incidence of *Taenia taeniaeformis* in *Ondatra zibethicus zibethicus* collected in Frederick and Somerset Counties, Maryland.

Host locality	Number of muskrats Examined	Infected
Frederick County		
Cregger Pond	19	2
Humerick Pond	36	7
Humerick Stream	1	1
Lewistown Pond	12	1
Waesche Pond	11	4
Monocacy River	4	1
Bennet Creek	20	3
Somerset County		
Dames Quarter Marshes	75	0
TOTAL	178	19

According to Gallati (1956, Ohio J. Sci. 56: 71–74), the parasite *T. taeniaeformis* in muskrats is widely distributed in the United States, with an incidence of 8% to 96%. The cestode has been reported in Minnesota by Penner (1940, Ph. D. Diss. Univ. of Minn. 275 p.); in Michigan by Ameel (1942, Trans. Am. Microscop. Soc. 61: 267–271); in Ohio by Rausch (1946, J. Wildl. Mgmt. 10: 70), Gallati [(loc. cit.) (1956, Ohio J. Sci. 56: 71–74)], and Beckett and Gallichio (1967, J. Parasit. 53: 1169–1172); in Massachusetts by Rankin (1946, Am. Midl. Nat. 35: 756–768); in Oregon by Rider and Macy (1947, Trans. Am. Microscop. Soc. 66: 176–181); in New York by Edwards (1949, J. Parasit. 35: 547–548); in Maine by Meyer and Reilly (1950, Am. Midl. Nat. 44: 467–477); in Virginia by Byrd (1953, J. Wildl. Mgmt. 17: 384–385); in Illinois by Gilford (1954, J. Parasit. 40: 702–703); and Alaska by Dunagan (1957, Trans. Am. Microscop. Soc. 76: 318–320). On the other hand, studies in Texas by Chandler (1941, J. Parasit. 27: 175–181); in Louisiana by Penn (1942, J. Parasit. 28: 348–349); and in Colorado by Ball (1952, J. Parasit. 38: 83–84), indicated absence of *T. taeniaeformis*.

This study was supported by funds from the College Science Improvement Program (COSIP) of the NSF, through Hampton Institute, Hampton, Virginia. Grateful acknowledgment is extended to Walter McKinney of Thurmont, Maryland for trapping, to Mark Allen and Michael Chew of Hampton Institute, who also assisted in the research.

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Research Note

An Anomalous *Taenia saginata* from a Human Case in Colombia

Abnormalities in cestodes have been seen frequently, and anomalous specimens of *Taenia saginata* (Goeze, 1782) have reported from various parts of the world (Burrows and Klink, 1955, J. Parasit. 41: 56–58; Merdivence, 1964, J. Parasit. 50: 476–477). The present paper is believed to be the first account of an anomalous *T. saginata* from Colombia, and the

worm reported is considerably more unusual than the others mentioned in the literature.

On 6 September 1970, Dr. Juan Vargas Gutierrez, a Cali physician, sent a partial strobila to the author for examination. This portion of a cestode had been spontaneously passed in the stool of one of his patients, an adult caucasian woman. The specimen measured 56 cm. in length and was very abnormal in appearance. It was thought that the material probably represented part of an anomalous *T. saginata* although specific determination was not possible. Arrangements were made with the physician and the patient to recover the complete post-treatment stool. Initial treatment was made with piperazine citrate solution in the belief that the patient was also infected with *Ascaris lumbricoides* L. Although this drug is not generally recommended for treatment of cestode infections, the entire strobila (including scolex) was expelled and recovered some five hours later.

The specimen obtained after therapy measured about 90 cm. long. A few detached proglottids were also recovered. The scolex was unarmed and measured about 1.4 mm. in diameter. The scolex was provided with six suckers which measured about 0.36 mm. in diameter (Fig. 1). A ridge, which began in the neck region about two mm. from the anterior extremity, extended the length of the strobila. This ridge caused the strobila to be T-shaped in the neck region and V-shaped more posteriorly. The strobila in two different places was divided into two lateral branches. These thin branches continued for some 4 to 8 segments and then fused together again.

In the mature and gravid segments, the genital pores were all arranged on the central ridge. That is they were on one of the three edges of the strobila and did not alternate as in a normal specimen. Reproductive organs were seen in the mature proglottids but were difficult to interpret since they were irregularly arranged and extended into the two sides of the V-shaped strobila. The gravid segments had numerous irregular uterine branches which also extended into both sides of the V (Fig. 2). Some of the uterine branches contained eggs, but many of them were empty. It was apparent that far fewer eggs had been produced

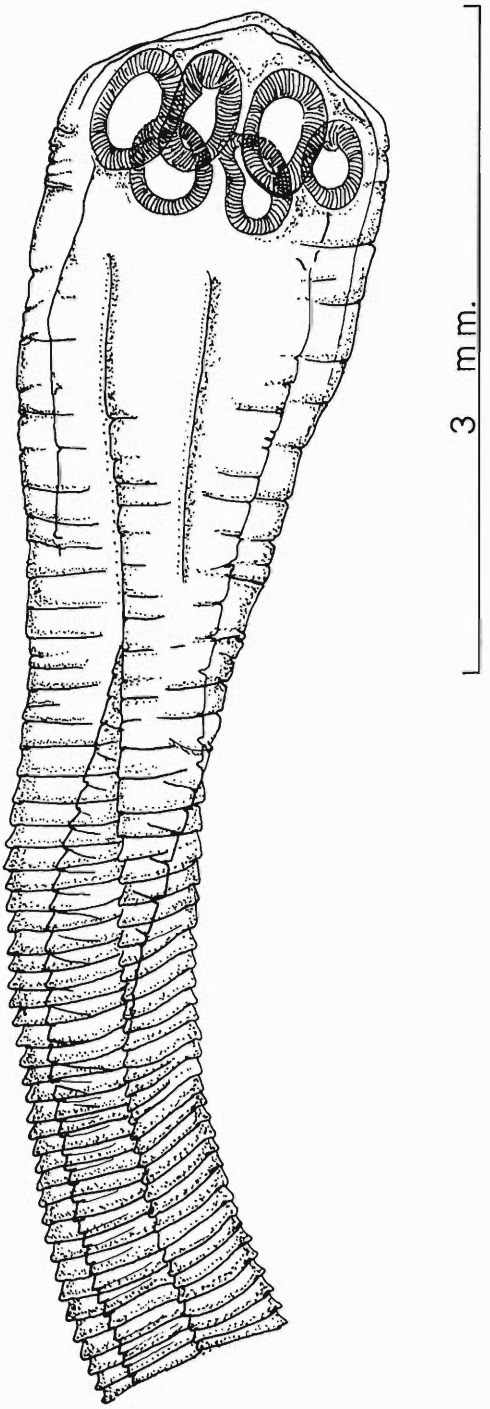

Figure 1.

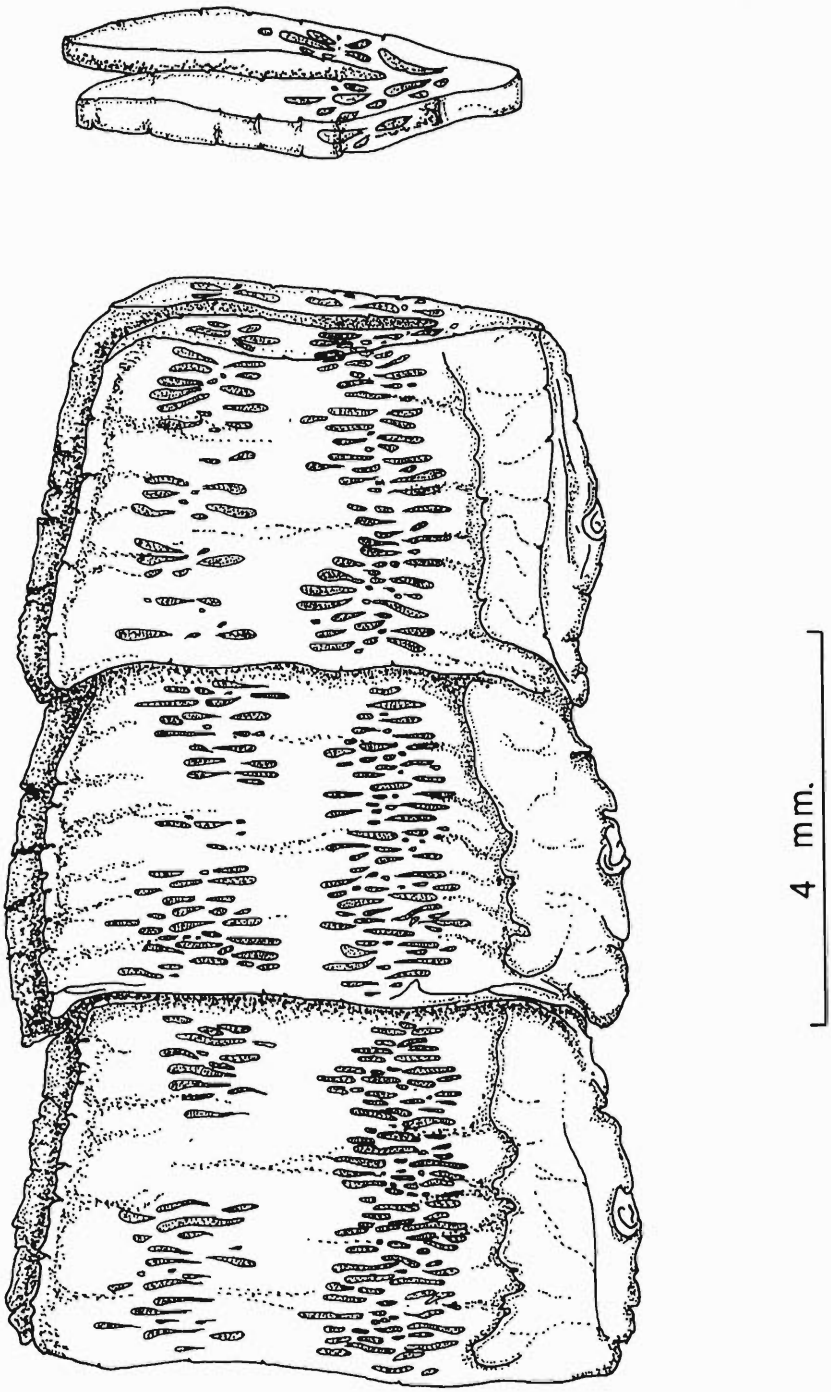

Figure 2.

than would have been the case in a normal specimen. The eggs themselves, however, seemed to be viable in that they contained the usual hexacanth larvae. Whether such an abnormal form could perpetuate itself is unknown, but because of the obviously reduced fertility, this possibility would seem to be highly unlikely.

This specimen has been assigned to *T. saginata* because it was a large taeniid from a human infection and because the scolex had neither rostellum nor hooks. In addition, the patient, a woman of high social standing, admitted to a fondness for rare beef, and insisted that she never consumed improperly cooked pork.

This study was supported, in part, by research grant 2919-25 from the Oficina de Investigaciones of the Universidad del Valle, Cali, Colombia. Thanks are extended to Mrs. Anne Eder and Mr. Daniel Dossman for valuable technical assistance.

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Research Note

Encotyllabe latridis Lebedev, 1967 and *Mediavagina forsteri* Lawler and Hargis, 1968 are identical Monogeneans[1,2]

Lebedev (1967, Akad. Nauk SSSR, Parazitologiia 1: 529–534) described *Encotyllabe latridis* from the gills of *Latridopsis forsteri* (Castelnau) [Paxton and Talbot, personal communication] from the Tasman Sea. Lawler and Hargis (1968, Proc. Biol. Soc. Wash. 81: 367–402) described *Mediavagina forsteri* from the gills of the same host near Hobart, Tasmania. Lebedev (personal communication to ARL) initially indicated that these two species might be identical. Lawler (1971, Ph.D. Diss., College of William and Mary, xxii + 638 p.) noted that the testicular arrangement of *Encotyllabe latridis* Lebedev, 1967 did not agree with the generic diagnosis given by Yamaguti (1963, Systema Helminthum, Vol. IV, Monogenea and Aspidocotylea, John Wiley & Sons, Inc, N.Y.: 131) "Testes two, juxtaposed, pre-equatorial," and suggested that the species be restudied in order to determine its taxonomic position.

The major differences between the original descriptions of Lebedev (1967, loc. cit.) and Lawler and Hargis (1968, loc. cit.) concerned number of anchors and septation, there being two pairs of anchors and no septation initially indicated for *Encotyllabe latridis*.

Subsequent study of a whole mount, and haptoral sections of the only other specimen of *Encotyllabe latridis* by one of the present coauthors (BIL), revealed a third pair of anchors and septation identical (in reconstruction) to that described for *Mediavagina forsteri*, respectively. We are satisfied that the two species are therefore conspecific.

We therefore transfer *Encotyllabe latridis* to the genus *Mediavagina* Lawler and Hargis, 1968, in the subfamily Trochopodinae (Price, 1936) Sproston, 1946, as follows:

Mediavagina: Trochopodinae. Diagnosis as given by Lawler and Hargis (1968, loc. cit.).

TYPE SPECIES: *Mediavagina latridis* (Lebedev, 1967) comb. n.

[1] Contribution No. 415 from the Virginia Institute of Marine Science.
[2] Contribution No. 1286 from the Institute of Biology and Pedology, Far-Eastern Scientific Centre of the USSR Academy of Sciences.

SYNONYMS: *Encotyllabe latridis* Lebedev, 1967

Mediavagina forsteri Lawler and Hargis, 1968

ADDITIONAL SPECIES: *Mediavagina macropteri* Lawler and Hargis, 1968

For the more complete present description of *Mediavagina latridis* (Lebedev, 1967), see Lawler and Hargis (1968, loc. cit.).

Appreciation is expressed to Drs. John R. Paxton and Frank Talbot, the Australian Museum, for verifying the current scientific name of the host.

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Research Note

Infectivity of *Oesophagostomum columbianum* Larvae After Prolonged Storage

Infective larvae of *Oesophagostomum columbianum* are difficult to maintain in a viable condition for long periods of time. At the National Animal Parasite Laboratory (NAPL), viable larvae have been maintained most successfully on moist filter paper in tightly covered bottles at a constant temperature of 24 C.* Even with this procedure the isolates deteriorate in a short time, possibly through growths of molds and bacteria, necessitating nearly continuous serial infection of lambs and culturing of eggs to maintain a pure infection. Infectivity of stored larvae of *O. columbianum* was investigated in a small trial using 10 helminth-free lambs divided into 4 groups of 2, 3, 3, and 2 lambs each. The lambs were 10 months old with the exception of No. 391 which was 22 months of age. Isolates that had been stored at 24 C for 25, 106, 123, and 252 days were used to infect the respective groups of lambs. At the time of inoculation, most of the larvae in the cultures stored more than 25 days were dead; living larvae were reisolated by means of baermanization through lens tissue. Each lamb was infected with 2,500 motile larvae, except for lambs receiving larvae which had been stored 252 days. The 2 lambs in the latter group were given only 1,250 motile larvae each, as no more were available. About 60 days after inoculation, the lambs were necropsied and counts were made of adult worms in the cecum and large intestine; numbers of nodules in the small and large intestines were noted also (Table 1).

These limited data show that some *O.*

Table 1. Numbers of adult *Oesophagostomum columbianum* and nodules in lambs necropsied 60 days after infection.

Lamb No.	Length of Larval storage (days)	No. adult worms	No. nodules	
			Small intestine	Large intestine
567	25	100	6	92
584	"	4	12	solid mass
580	106	132	9	110
583	"	8	5	396
592	"	11	48	solid mass
391	123	9	17	112
575	"	32	14	60
576	"	55	6	158
562	252	10	3	14
568	"	11	2	81

* This procedure was developed at NAPL by Mr. Awdry Jones, technician.

columbianum larvae remained viable and infective when stored for as long as 252 days, although there is an indication that infectivity is reduced after 123 days. Williams and Mayhew (Am. J. Vet. Res. 28: 629–640) reported that, in Louisiana, *O. radiatum*, a parasite of cattle, survived for as long as 4 months on pasture in the spring; no attempt was made to check infectivity. Their observation was on a different species of *Oesophagostomum*, but it agrees rather closely with the apparent reduction in infectivity after 123 days encountered in this test.

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Research Note

Helminth Parasites of Wilson's Phalarope, *Steganopus tricolor* Vieillot, 1819, in Montana and Colorado

Wilson's phalarope, *Steganopus tricolor*, is a charadriiform bird of the family Phalaropodidae, which also contains the red phalarope, *Phalaropus fulicarius*, and the northern phalarope, *Lobipes lobatus*. A literature survey, including the Index-Catalogue of Medical and Veterinary Zoology at the National Animal Parasite Laboratory, Beltsville, Maryland, reveals that no parasites have been reported from Wilson's phalarope.

The feeding habits of this bird expose it to many organisms which serve as intermediate hosts or vectors of parasitic helminths. Being more adept at swimming than most shore birds, its diet consists more of organisms existing beyond the psammolittoral zone of lakes and ponds (Wetmore, 1925, U. S. Dept. Agr. Bull. 1359). The many different geographical and ecological locales visited during its migration from the breeding grounds in northcentral North America to the wintering grounds in central Chile, Argentina and south to the Falkland Islands adds greatly to this bird's biological exposures. A study was undertaken to compare the parasite burdens of Wilson's phalarope in its summer nesting grounds in Montana, with those of birds returning from their winter migration.

Fifty phalaropes were collected in late summer of 1964 near Missoula, Montana, by Dr.

Table 1. Helminth parasites of Wilson's phalarope in Montana and Colorado.

Parasite	Found in Montana	Found in Colorado
Cestoidea		
Anomotaenia clavigera (Krabbe, 1869) Cohn, 1900	yes	no
Hymenolepis (*Echinocotyle*) *brachycephala* (Creplin, 1829) Deblock, 1964	yes	yes
Hymenolepis (*Hymenolepis*) *calumnacantha* Schmidt, 1963 (immature)	yes	no
Hymenolepis (*Hymenolepis*) *capellae* Baer, 1940	no	yes
Trematoda		
Cyclocoelum (*Cyclocoelum*) *obscurum* (Leidy, 1887) Harrah, 1922	yes	no
Notocotylus sp. (immature)	yes	no
Plagiorchis vitellatus (Linstow, 1875) Braun, 1901	yes	no
Nematoda		
Echinuria skrjabinensis Efimov in Sultanov, Rhizikov et Kozlov, 1960	yes	yes
Stellocaronema skrjabini Gil'bert, 1930	yes	no
Tetrameres dubia Travassos, 1917	yes	yes

E. W. Pfeiffer, University of Montana, and were donated to us for examination. An additional 40 birds were collected by one of us (D. W. F.) in early spring near Greeley, Colorado, while they were en route from their southern wintering grounds. The results of these surveys are summarized in Table 1. All are new host records and all but *Anomotaenia clavigera*, *Hymenolepis capellae*, *H. calumnacantha*, and *Cyclocoelum obscurum* are new records for the United States. No microfilaria or blood protozoans were found. All specimens have been deposited in the USNM Helm. Coll.

The survey of these 90 birds suggests that most of their parasitic worms were obtained in their summer breeding grounds. All of the parasites found are known exclusively from the Northern Hemisphere, except for *Hymenolepis capellae*, known from the Caribbean, and *Tetrameres dubia*, described originally from Brazil. The complete absence of trematodes in the Colorado sample may indicate a loss of existing infections during the winter migration.

We wish to thank Dr. E. W. Pfeiffer for the Montana birds, Dr. S. Deblock for confirmation of the identification of *H. brachycephala*, and Miss J. M. Humphrey for searching the Index-Catalogue for records of parasites from *Steganopus tricolor*.

GERALD D. SCHMIDT AND DONALD W. FRANTZ
Department of Biology
University of Northern Colorado
Greeley, Colorado 80631

THE HELMINTHOLOGICAL SOCIETY OF WASHINGTON CONSTITUTION

ARTICLE 1

Name

The name of the Society shall be the Helminthological Society of Washington.

ARTICLE 2

Object

The object of the Society shall be to provide for the association of persons interested in parasitology and related sciences for the presentation and discussion of items of interest pertaining to those sciences.

ARTICLE 3

Membership

Section 1. There shall be three classes of members, namely, regular, life, and honorary.

Section 2. Any person interested in parasitology or related sciences may be elected to membership in the Society. The privileges and responsibilities of members are set forth in the By-Laws.

Section 3. Any member who has rendered conspicuous and continuous service to the Society for a period of not less than 15 years, and has reached the age of retirement, may be elected to life membership. Life members shall have all the privileges of regular members but shall be exempted from payment of dues. The number of life members shall not exceed 5% of the membership at the time of election.

Section 4. Any person who has attained eminent distinction in parasitology or related sciences may be elected to honorary membership. An honorary member shall have all the privileges of membership except voting, holding office, or having any interest in the real or personal property of the Society. He shall be exempted from the payment of dues. The number of honorary members shall not exceed 10 at any one time and not more than one honorary member shall be elected in any one year.

ARTICLE 4

Officers

Section 1. The officers of the Society shall be a President, a Vice-President, a Recording Secretary, a Corresponding Secretary-Treasurer, and such other officers as the Society may deem necessary. Only members in good standing and whose dues are not in arrears shall be eligible for election to office. Terms of office shall be 1 year.

Section 2. The President shall preside over all meetings, appoint all committees except the Executive Committee, and perform such other duties as may properly devolve upon a presiding officer. The President may appoint an Archivist, a Librarian, a Custodian of Back Issues, and an Assistant Corresponding Secretary-Treasurer as needed.

Section 3. The Vice-President shall preside in the absence of the President, and when so acting shall perform such duties as would otherwise devolve upon the President. The Vice-President shall serve as Program Officer.

Section 4. In the absence of both President and Vice-President, the member, among those present, who last held the office of President shall be the presiding officer. Under other circumstances, members may elect a presiding officer but business actions taken shall be reviewed by the Executive Committee.

Section 5. The Recording Secretary shall record the proceedings of all meetings and shall present at each meeting a written report of the transactions of the preceding meeting, shall keep an accurate and complete record of the business transacted by the Society in its meetings, and shall notify the Corresponding Secretary-Treasurer of the election of new members. He shall prepare for publication in the Proceedings an annual digest of scientific

meetings and business transacted, including elections of officers and new members.

Section 6. The Corresponding Secretary-Treasurer shall be responsible for all funds, collections, payment of bills, and maintenance of financial records. At the beginning of each year, he shall present to the Society an itemized statement of the receipts and expenditures of the previous year; this statement shall be audited by at least two members of the Society.

ARTICLE 5

Executive Committee

Section 1. There shall be an Executive Committee which shall be the administrative body of the Society.

Section 2. The number of members of the Executive Committee, their duties, terms of office, the method of selecting them, and of filling vacancies shall be provided in the By-Laws.

ARTICLE 6

Awards Committee

Section 1. There shall be an Awards Committee to select individuals for special commendation.

Section 2. The number of its members, their duties, and terms of office shall be provided in the By-Laws.

ARTICLE 7

Editorial Board

Section 1. There shall be an Editorial Board for the Society's publications, which shall include The Proceedings of the Helminthological Society of Washington.

Section 2. The number of its members, their duties, terms of office, the method of selecting them and of filling vacancies shall be provided in the By-Laws.

ARTICLE 8

Publication

The publications of the Society shall be issued at such times and in such form as the Society through its Editorial Board may determine.

ARTICLE 9

Meetings

Section 1. Meetings of the Society shall be held monthly during January, February, March, April, May, October, November, and December, the time and place to be determined by the officers of the Society.

Section 2. The October meeting shall be known as the Anniversary Meeting and the Anniversary Award, when made, ordinarily shall be presented at this meeting.

ARTICLE 10

Amendments to the Constitution

Any amendment to the Constitution shall be presented in writing at a regular meeting. It shall not be acted upon until the following meeting. A two-thirds vote of the members in attendance shall be required for the adoption of any proposed amendment.

BY-LAWS

ARTICLE 1

Procedure

The rules contained in Robert's *Rules of Order*, Revised, shall govern the Society in all cases to which they are applicable, and in which they are not inconsistent with the By-Laws or the special rules of order of this Society.

ARTICLE 2

Order of Business

Call to order.
Reading of minutes of previous meeting.
Election of new members.
Reports of committees.
Unfinished business.
New business.
Presentation of notes and papers.

ARTICLE 3

Election of Members

Section 1. Candidates for election to membership may be sponsored and proposed only

by members in good standing. The candidate shall submit a duly executed and signed application to the Recording Secretary, who in turn shall submit the application to the Executive Committee. The Committee shall review the application and submit its findings to the Society. Voting may be either by voice or by ballot. The Corresponding Secretary-Treasurer shall inform the candidate of the action of the Society.

Section 2. Payment of dues shall be considered as evidence of acceptance of membership in the Society. Election to membership shall be void if the person elected does not pay dues within 3 months after the date of notification of election.

Article 4

Nomination and Election of Officers

Section 1. The Executive Committee, acting as the nominating committee of the Society, shall prepare a slate of officers and present this to the Society at the October meeting of each year. Independent nominations may be made in writing by any five members. In order to receive consideration, such nominations must be in the hands of the Recording Secretary at the time of the election at the November meeting.

Section 2. The election of officers shall be held prior to the presentation of notes and papers at the November meeting. Voting may be either by voice or by ballot.

Section 3. The last order of business at the December meeting shall be the installation of officers, and the naming of necessary appointees.

Article 5

Meetings

Notice of the time and place of meetings shall be given by the Recording Secretary at least 10 days before the date of the meeting.

Article 6

Quorum

The members in attendance at any regular meeting shall constitute a quorum.

Article 7

Dues and Debts Owed to the Society

Section 1. Annual dues shall be fixed by the Executive Committee, subject to ratification by the Society. Spouses of members who do not wish independent subscriptions to the Proceedings may be admitted to full membership upon payment of one dollar annual dues.

Section 2. The fiscal year for payment of dues and for all other business purposes shall be the same as the calendar year, that is, from 1 January to 31 December, and dues shall be payable on or before 1 January. The dues of a newly elected member paid prior to 1 July of the year of his election shall be credited to that year; if paid after 1 July, they shall be credited either to the current fiscal year or to the following one, at the option of the new member. The dues shall include subscription to the Society's publication; only those members whose dues are paid shall receive the publication.

Section 3. All other obligations owed to the Society by members or nonmembers shall be due and payable 30 days after bills are rendered; the further extension of credit to those whose obligations are in arrears shall be a matter for decision by the Executive Committee.

Article 8

Suspension and Reinstatement

Any member whose dues are in arrears for 2 years shall be dropped from membership. Members who have been dropped for nonpayment of dues may be reinstated automatically upon payment of the dues in arrears and the dues for the current year, or may be otherwise reinstated by action of the Executive Committee.

Article 9

Editorial Board

Section 1. The Editorial Board shall consist of an Editor and other members in good standing, representing to the fullest practicable degree the varied scientific interests and the employment-group affiliations of the Society's membership.

Section 2. The Editor shall be elected by the Society for a term of 5 years on nomination by the Executive Committee.

Section 3. Other members of the Editorial Board shall be appointed for terms of 3 years.

Section 4. The Editor, after consultation with the Editorial Board, shall appoint new members, formulate publication policies, and make all decisions with respect to format and content of the Society's publications. The Editor shall operate within financial limitations determined by the Executive Committee.

ARTICLE 10

Executive Committee

Section 1. The Executive Committee shall consist of 10 members in good standing as follows: The President, Vice-President, Recording Secretary, Corresponding Secretary-Treasurer, Editor, Immediate Past-President, and four members-at-large. The Committee shall represent to the fullest practicable degree the varied scientific interests of the Society's membership and the local distribution of its members.

Section 2. The President shall serve as chairman of the Executive Committee.

Section 3. Members-at-large shall serve for a term of 2 years. Two members-at-large shall be appointed each year in November by the President-elect for the prescribed term of 2 years.

Section 4. Vacancies occurring on the Executive Committee for any reason shall be filled by appointment by the President, except as otherwise provided, the appointee to serve for the remainder of the unexpired term.

Section 5. The Executive Committee shall carry out the provisions of the Constitution and By-Laws and shall make decisions on all matters of general and financial policy not otherwise set forth in the Constitution and By-Laws and shall report its actions to the Society annually at the last regular meeting.

Section 6. The Executive Committee shall approve the selection of a depository for the current funds, direct the investment of the permanent funds, and act as the administrative body of the Society on all matters involving finance. It shall prepare and present to the Society at the beginning of each calendar year a budget based on the estimated receipts and expenditures of the coming year with such recommendations as may seem desirable.

Section 7. With the presentation of the annual budget the Executive Committee shall present to the Society, if feasible, the estimated cost for publication to be charged to contributors to the Society's publication for that year.

Section 8. Costs of publication, in excess of amounts borne by the Society, shall be borne by authors in accordance with guidelines established by the Executive Committee.

Section 9. The Executive Committee shall pass on the eligibility of all applicants proposed for membership and on the reinstatement of delinquent members, except as otherwise provided, and shall make its recommendations to the Society.

ARTICLE 11

Awards Committee

Section 1. The Awards Committee shall consist of three members.

Section 2. Members shall serve for a term of 3 years with appointments staggered so that one new member is added each year. The senior member of the Committee shall serve as Chairman.

Section 3. The Awards Committee shall be charged with the duty of selecting recipients of the Anniversary Award which may be given annually or less frequently at the discretion of the Committee.

Section 4. The recipient of the Anniversary Award shall be or have been a Society member who is honored for one or more achievements of the following nature: (a) Outstanding contributions to parasitology or related sciences that bring honor and credit to the society, (b) an exceptional paper read at a meeting of the Society or published in its Proceedings, (c) outstanding service to the Society, and (d) other achievement or contribution of distinction that warrants highest and special recognition by the Society.

Section 5. The individual selected shall be subject to approval by the Executive Committee.

ARTICLE 12

Provision for Dissolution of Funds

In the event the Society is disbanded, all monies shall be presented to the Trustees of the Brayton Howard Ransom Memorial Trust Fund for such purposes as that continuing body may deem advisable.

ARTICLE 13

Amendments to the By-Laws

Any amendment to these By-Laws shall be presented in writing at a regular meeting. It shall not be acted upon until the following meeting. A two-thirds vote of the members in attendance shall be required for adoption.

Report of the Brayton H. Ransom Memorial Trust Fund

FUNDS ON HAND, 1 January 1971	$3,024.89
RECEIPTS: Interest rec'd in 1971	154.10
DISBURSEMENTS: Grant to Helminthological Society of Washington	10.00
BALANCE ON HAND, 31 December 1971	$3,168.99

A. O. Foster
Secretary-Treasurer

MINUTES

Four Hundred Sixty-first Through Four Hundred Sixty-eighth Meetings

461st Meeting: University of Maryland, Zoology Department, College Park, Maryland, 22 October, 1971. Dr. G. F. Otto presented a brief tribute in memory of Dr. W. W. Cort, and the members stood for a minute of silence. Slate of officers for 1972 presented: E. Buhrer (President), T. K. Sawyer (Vice President), H. Herlich (Recording Secretary), R. S. Isenstein (Corresponding Secretary-Treasurer). These were approved unanimously. Walking sticks were presented to Dr. A. O. Foster and Dr. G. F. Otto in appreciation of their outstanding contributions to the Second International Congress of Parasitology. Papers presented: "Some aspects of the ecology of a plagioporid trematode of the hog sucker," Sherman Hendrix; "Some recent trends in microsporidia research," Burdette Erickson; "The biology of *Hepatozoon griseisciuri* of the eastern gray squirrel," Bryce Redington; "*In vitro* cultivation of *Hepatozoon griseisciuri*," Larry Hendricks.

462nd Meeting: National Animal Parasite Laboratory, Beltsville, Maryland, 19 November, 1971. Papers presented: "*In vitro* studies on invasion of red cells by the Rickettsia, *Anaplasma marginale*," David Fahrney; "Histochemical distribution of "leucine" aminopeptidase in *Oesophagostomum radiatum* developmental stages grown *in vitro* and in calves," F. W. Douvres and D. E. Thompson; "Morphogenesis of *Stephanurus dentatus* in swine," J. R. Lichtenfels and F. G. Tromba.

463rd Meeting: Patuxent Wildlife Research Center, Laurel, Maryland, 17 December 1971. Dr. L. Jachowski presented the Society's Anniversary Award to Dr. C. M. Herman, tracing the highlands of an active and varied career. It was most appropriate that the Award should be presented at the scene of so much of Dr. Herman's activities. Newly elected officers were installed; however, due to the illness of Miss Edna Buhrer (President-Elect), Dr. E. J. L. Soulsby agreed to continue to preside as President until such time as Miss Buhrer's health allowed her to be installed in that post. Papers presented: "Effect of route of inoculation on immunity to, and development of *Trichomonas gallinae* infections in pigeons," R. M. Kocan; "Cellular basis for pathology of *Entamoeba histolytica*," J. L. Griffin; "Parasites encountered in rare and endangered wildlife species," J. Miller; "Historical aspects of oil pollution and disease and parasitism in marine animals," T. K. Sawyer.

464th Meeting: National Institutes of Health, Bethesda, Maryland, 21 January, 1971. Papers presented: "The interaction of *Trypanosoma cruzi* with bovine embryonic muscle cells in vitro. I. Discussion of individual host cell-parasite interactions at the cellular and subcellular level," James A. Dvorak and Thomas P. Hyde; "The interaction of *Trypanosoma cruzi* with bovine embryonic muscle cells in vitro. II. Quantitative analysis of the penetration phase," Thomas P. Hyde and James A. Dvorak; "Alterations in the plasma membrane of malaria infected red cells," Louis H. Miller; "Immunity to microfilariae of *Dirofilaria immitis*: Immobilization and agglutination," R. F. Knauft and Guillermo Pacheco; "Distribution of microfilaria of *Dirofilaria immitis*, *D. corynoides*, *Dipetalonema viteae* and *Litosomoides carinii* in natural and abnormal hosts," Guillermo Pacheco and Gabriel Schmunis.

465th Meeting: Plant Nematology, Beltsville, Maryland, 18 February, 1972. Papers presented: "Several of the nematodes close to us—a look at some lawn and garden problems," J. Feldmesser and A. M. Golden; "Amoeboid organism predacious on root-knot nematodes," R. M. Sayre; "Taxonomy, life history, and pathology of mermithid parasites of insects," W. R. Nickle.

466th Meeting: Walter Reed Army Institute of Research, Washington, D. C., 17 March, 1972.. Miss Edna Buhrer returned from her convalescence and presided in her capacity as President of the Society. Copies of a revision of the Society's Constitution were distributed

for consideration of the membership. Papers presented: "Mass screening of drugs against schistosomiasis," J. I. Bruce; "Pathogenic free-living amoebae of the genera *Naegleria* and *Acanthamoeba*," J. L. Griffin; "*Plasmodium falciparum* and its ultrastructural relationship to its red cell host," J. E. Bodammer; "The course of malaria in bursectomized chickens," D. R. Stutz; "Immunization against African trypanosomiasis with irradiated parasites," E. H. Sadun.

467th Meeting: Naval Medical Research Institute, Naval Medical Center, Bethesda, Maryland, 21 April, 1972. The revision of the Constitution was approved for adoption and publication in the Proceedings. A. O. Foster was elected to Life Membership in the Society, filling the vacancy created by the death of Dr. W. W. Cort. Papers presented: "Some immunological research in schistosome infections," Darwin Murrell; "Host antigen adsorption by schistosomula of *Schistosoma mansoni*," David Dean; "Chemoprophylaxis against schistosome infection," Fred Austin; "Fine structure of cercariae and schistosomules of *Schistosoma mansoni*," Charles Dorsey.

468th Meeting: Alumni House, New Bolton Center, Kennett Square, Pennsylvania, 13 May, 1972. The Society was greeted by Dean M. W. Allam. Papers presented: "A plaque assay for enumerating antigen-reactive cells in delayed hypersensitivity," Colin Johnstone; "The local lymphoid cell response of the guinea pig to *Ascaris suum*," Philip B. Khoury; "The capacity of homologous larval stages to induce immunity to *Ascaris suum* in guinea pigs," Bert Stromberg; "Immune adhesion phenomenon in larval ascariasis," Ruth Leventhal; "Peripheral blood lymphoid cell response in haemonchosis: further studies," Priscilla Chen.

A most congenial hospitality session and dinner were enjoyed by members and guests.

The following were elected to membership at the meetings indicated: *461st*: L. R. Grimes, T. J. Hayes, W. R. Jolley, B. Langer, W. B. LeFlore, M. S. N. de A. Santos, N. R. Sinclair, C. Speer, M. L. Walker, J. G. Zeltergren. *462nd*: C. G. Dean. *463rd*: J. Chang, J. K. Chlada, J. P. Harley, D. D. Miller, W. M. Samuel, E. E. Stafford. *464th*: D. K. Hass, B. E. Stromberg. *465th*: J. A. Ajayi, C. L. Cooper, R. C. Gant, W. B. Jansma, B. F. Mujib, S. S. Rana, J. E. Thacher. *466th*: None. *467th*: R. C. Bergstrom, D. Fredericksen, J. A. Oaks, P. J. Phillips, S. C. Schell, S. J. Taft. *468th*: A. M. Chute, M. B. Chute.

HARRY HERLICH
Recording Secretary

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