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Parasitic Helminths of the Common Loon, *Gavia immer,* on Its Wintering Grounds in Florida

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ABSTRACT: Forty-eight species of helminths (31 trematodes, 5 cestodes, 11 nematodes, and 1 acanthocephalan) were collected from 104 sick or dead common loons collected on Florida beaches between 1971 and 1993. Twenty-three "normal" loons collected in 1984 were infected with 23 species of helminths (13 trematodes, 4 cestodes, 3 nematodes, and 3 acanthocephalans). Two trematodes (*Microphallus forresteri, Amphimerus arcticus*) and 3 cestodes (*Neovalipora parvispinae, Armadoskrjabini rostellata, Tetrabothrius macrocephalus*) were considered common species (>20% prevalence) in both host populations. Of the species shared by the 2 host groups, 1 cestode (*N. parvispinae*) and 1 nematode (*Streptocara crassicauda longispiculatus*) had significantly higher prevalences and 2 trematodes (*Renicola pollaris* and *M. forresteri*) and 2 cestodes (*A. rostellata* and *Microsomacanthus pseudorostellatus*) had significantly higher intensities in the sick loons. The greater species richness in the sick loons and higher numbers of microphallid trematodes are thought to indicate a shift in the loons' diet due to low fish populations.

KEY WORDS: helminths, common loon, parasites, *Gavia immer,* Florida.

Common loons, *Gavia immer* (Brünnich), breed as isolated pairs on freshwater lakes in the northern United States and Canada and overwinter in large numbers in the Gulf and Atlantic coastal waters of northern Florida (Stevenson and Anderson, 1994). Each winter, dead loons are found on both Atlantic and Gulf beaches of Florida, occasionally reaching epizootic levels (Forrester et al., 1997). In one such epizootic episode, which occurred from January to March 1983, more than 13,000 loons were estimated to have died.

The literature on helminths of common loons consists primarily of scattered taxonomic descriptions (e.g., trematodes: Guberlet, 1922; Linton, 1928; Gower, 1939; Dubois and Rausch, 1967; Kinsella and Deblock, 1997; cestodes: Linton, 1927; Joyeux and Baer, 1941, 1950; nematodes: Gibson, 1968; Anderson and Forrester, 1974). Chafel and Pokras (1992) examined a small sample of immature and adult common loons for helminths on their breeding grounds in New England. Forrester et al. (1997) described in general terms the helminth fauna of overwintering common loons in Florida, listing combined intensities and abundances of intestinal trematodes but not identifying helminths to species. Subsequently, Kinsella and Deblock (1997) examined 5 species of microphallid trematodes from this same sample and described 1 species as new, *Microphallus forresteri.*

Herein, we describe the helminth populations of common loons found sick or dead over a 23-yr period in Florida and a smaller sample of "normal" loons collected in the nonepizootic year of 1984.

Materials and Methods

A total of 104 dead or moribund common loons (hereinafter referred to as sick loons) found on Florida beaches were submitted to the Department of Pathobiology, University of Florida, Gainesville, between 1971 and 1993. Diagnostic findings on some of these loons have been presented elsewhere (White et al., 1976; Franson and Cliplef, 1993; Forrester et al., 1997). Carcasses came from the following general areas in Florida: the Atlantic Coast (n = 64), the Gulf Coast (n = 36), inland lakes (Alachua, Broward, and Clay counties) (n = 3), and an unknown locality (n = 1). An additional 23 normal loons were collected by shooting in the vicinity of Dog Island off the coast of Franklin County in 1984 and were used for comparative purposes. Normal loons were defined as healthy birds with ample amounts of body fat and robust pectoral muscles, weighing >2.8 kg.

The 23 normal loons were examined shortly after death; the remainder were frozen and processed later. Techniques for the necropsy of birds and for the collection, fixation, and staining of helminths were similar to those described by Kinsella and Forrester (1972). Microhabitats examined included the trachea, esophagus, proventriculus, Koilon lining of the gizzard, small intestine, cecae, large intestine, cloaca, heart, lungs, liver, gallbladder, pancreas, kidneys, and body cavity.

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Table 1. Helminth parasites of 104 dead or moribund common loons (*Gavia immer*) found on beaches in Florida from 1971 to 1993.

Helminth species (accession no.)	Location*	No. loons infected (%)	Intensity $\bar{x} \pm$ SE	Intensity Range	Abundance ($\bar{x} \pm$ SE)
Trematoda					
Microphallus spp.†	SI	38 (37)	952.8 ± 344.6	1–10,325	348.1 ± 132.7
Apophallus brevis Ransom, 1920 (HWML 38129)	SI	26 (25)	211.9 ± 82.3	1–1,633	53.0 ± 21.8
Plotnikovia fodiens (Linton, 1928) (HWML 38107)	L, P	24 (23)	12.0 ± 3.0	1–53	2.8 ± 0.9
Amphimerus arcticus Kontrimavitschus and Bachmetreva, 1960 (HWML 38108)	L	22 (21)	5.7 ± 1.4	1–29	1.2 ± 0.4
Diplostomum immer Dubois, 1961 (HWML 38111)	SI	19 (18)	20.8 ± 6.2	1–82	3.8 ± 1.4
Renicola pollaris Kontrimavitschus and Bachmetreva, 1960 (HWML 38122)	K	17 (17)	20.2 ± 10.3	1–181	3.3 ± 1.8
Mesostephanus appendiculatoides (Price, 1934) (HWML 38128)	SI	14 (14)	11.4 ± 2.7	1–25	1.5 ± 0.5
Echinochasmus skrjabini Oschmarin, 1946 (HWML 38130)	SI	14 (14)	9.1 ± 2.8	1–28	1.2 ± 0.5
Phagicola longa Ransom, 1920 (HWML 38109)	SI	11 (11)	42.3 ± 20.7	1–230	4.5 ± 2.5
Odhneria odhneri Travassos, 1921 (HWML 38117)	CE	10 (10)	17.6 ± 10.2	1–102	1.7 ± 1.1
Prosthogonimus ovatus (Rudolphi, 1803) (HWML 38120)	CL	10 (10)	9.5 ± 5.3	1–55	0.9 ± 0.6
Mesorchis denticulatus (Rudolphi, 1802) (HWML 38113)	SI	9 (9)	20.1 ± 10.3	1–93	1.7 ± 1.0
Maritrema spp.‡	SI	7 (7)	130.1 ± 113.7	1–810	8.8 ± 7.8
Diplostomum gavium (Guberlet, 1922) (HWML 38110)	SI	7 (7)	4.3 ± 1.4	1–11	0.3 ± 0.1
Austrobilharzia terrigalensis Johnston, 1917 (HWML 38132)	BV	4 (4)	1.3 ± 0.3	1–2	0.1 ± 0.1
Cotylurus platycephalus (Creplin, 1825) (HWML 38124)	SI	2 (2)	1.0	1	<0.1 ± <0.1
Erschoviorchis lintoni (Gower, 1939) (HWML 38125)	P	2 (2)	6.5 ± 3.5	3–10	0.1 ± 0.1
Stictodora lariformicola Sogandares-Bernal and Walton, 1965 (HWML 38582)	SI	1 (1)	12.0	12	0.1 ± 0.1
Parorchis acanthus (Nicoll, 1906) (HWML 38114)	CL	1 (1)	3.0	3	<0.1 ± <0.1
Ribeiroia ondatrae (Price, 1931) (HWML 38121)	PR	2 (2)	5.0 ± 4.0	1–9	0.1 ± 0.1
Cotylurus erraticus (Rudolphi, 1809) (HWML 38112)	SI	1 (1)	2.0	2	<0.1 ± <0.1
Microparyphium facetum Dietz, 1909 (HWML 38123)	CL	1 (1)	1.0	1	<0.1 ± <0.1
Dendritobilharzia pulverulenta (Braun, 1901) (HWML 38131)	BV	1 (1)	1.0	1	<0.1 ± <0.1
Posthodiplostomum minimum (MacCallum, 1921) (HWML 38126)	SI	1 (1)	4.0	4	<0.1 ± <0.1
Posthodiplostomum sp.	SI	1 (1)	20.0	20	0.2 ± 0.2
Himasthla alincia Dietz, 1903 (HWML 38138)	SI	1 (1)	4.0	4	<0.1 ± <0.1
Tanaisia fedtschenkoi Skrjabin, 1924	K	1 (1)	1.0	1	<0.1 ± <0.1
Parvatrema sp. (HWML 38127)	SI	1 (1)	1.0	1	<0.1 ± <0.1
Cestoda					
Armadoskrjabini rostellata§ (Abdilgaard, 1790) (HWML 38133)	SI	67 (64)	107.3 ± 26.9	1–1,164	69.1 ± 17.9
Microsomacanthus pseudorostellatus§ (Joyeux and Baer, 1950) (HWML 38134)	SI	16 (15)			
Neovalipora parvispinae (Linton, 1927) (HWML 38136)	SI	41 (39)	53.6 ± 17.1	1–559	21.1 ± 7.2

Table 1. Continued.

Helminth species (accession no.)	Location*	No. loons infected (%)	Intensity $\bar{x} \pm$ SE	Intensity Range	Abundance ($\bar{x} \pm$ SE)
Tetrabothrius macrocephalus Rudolphi, 1819 (HWML 38135)	SI	29 (28)	6.9 ± 1.8	1–46	1.9 ± 0.6
Cyclustera ibisae Schmidt and Bush, 1972 (HWML 38137)	SI	8 (8)	4.0 ± 1.6	1–12	0.3 ± 0.2
Nematoda					
Cosmocephalus obvelatus (Creplin, 1825) (HWML 38143)	E	31 (30)	2.2 ± 0.5	1–14	0.7 ± 0.2
Paracuaria adunca (Creplin, 1846) (HWML 38142)	E, PR	31 (30)	2.4 ± 0.5	1–13	0.7 ± 0.2
Streptocara crassicauda longispiculatus Gibson, 1968 (HWML 38144)	KL	30 (29)	4.9 ± 1.9	1–57	1.4 ± 0.6
Contracaecum sp. (immature)	E, PR	19 (18)	4.0 ± 1.1	1–18	0.7 ± 0.3
Capillaria mergi Madsen, 1945 (HWML 38146)	SI	12 (12)	4.0 ± 2.5	1–30	0.5 ± 0.3
Streptocara formosus Sugimoto, 1930 (HWML 38145)	KL	3 (3)	1.0	1	<0.1 ± <0.1
Splendidofilaria fallisensis (Anderson, 1954)	SD	3 (3)	4.7 ± 2.4	1–9	0.1 ± 0.1
Eustrongylides tubifex Nitzch in Rudolphi, 1819 (HWML 38150)	PR	2 (2)	6.5 ± 5.5	1–12	0.1 ± 0.1
Cyathostoma phenisci (Baudet, 1937) (HWML 38147)	T	2 (2)	3.0 ± 2.0	1–5	<0.1 ± <0.1
Sciadiocara rugosa Schmidt and Kinsella, 1972 (HWML 38148)	KL	1 (1)	1.0	1	<0.1 ± <0.1
Stegophorus diomedeae (Johnston and Mawson, 1942) (HWML 38149)	KL	1 (1)	1.0	1	<0.1 ± <0.1
Acanthocephala					
Andracantha gravida Schmidt, 1975 (HWML 37465)	SI	4 (4)	1.5 ± 0.5	1–3	<0.1 ± <0.1

* BV = blood vessels; CE = cecae; CL = cloaca; E = esophagus; K = kidneys; KL = under Koilon lining; L = liver; P = pancreas; PR = proventriculus; SD = subdermal; SI = small intestine; T = trachea.

† A complex of 3 species: *Microphallus forresteri* Kinsella and Deblock, 1997 (HWML 38119), *Microphallus nicolli* (Cable and Hunninen, 1938), and *Microphallus* sp.

‡ A complex of 2 species: *Maritrema* sp. Harkema and Miller, 1962 and *Maritrema* sp. near *eroliae* Yamaguti, 1939 (HWML 38115).

§ *Armadoskrjabini rostellata* and *M. pseudorostellatus* were combined because some scolices lacked hooks and could not be differentiated.

Total counts of intestinal trematodes were made by use of an aliquot system.

Ecological terms used in this paper follow the definitions given by Bush et al. (1997). Common species were arbitrarily defined as those species with >20% prevalence; all other species were considered uncommon. Descriptive statistics are presented as a mean ± 1 SE. Prevalences were compared using chi-square analysis of a 2 × 2 contingency table with Yates continuity correction except where there were fewer than 5 observations per cell, in which case Fisher's exact test was used. Intensity data were not normally distributed and were compared by the nonparametric Mann–Whitney rank sum test using a commercial microcomputer program (SigmaStat™ Version 2.00, 1995, Jandel Scientific Software, San Rafael, California). Statistical significance was accepted at $P < 0.05$. Representative specimens of helminths have been deposited in the collection of the Harold W. Manter Laboratory (HWML), University of Nebraska, Lincoln. Accession numbers are listed for each species deposited.

Results

Forty-eight species of helminths (31 trematodes, 5 cestodes, 11 nematodes, and 1 acanthocephalan) were collected from 101 of 104 (97%) sick loons examined from Florida beaches. Infected birds harbored 5.4 ± 0.3 helminth species (range, 1–15). The prevalence, intensity of infection, abundance, and location of each helminth are given in Table 1.

The 23 normal loons collected in 1984 were infected with 23 species of helminths (13 trematodes, 4 cestodes, 3 nematodes, and 3 acantho-

Table 2. Helminth parasites of 23 "normal" common loons from Dog Island, Franklin County, Florida.

Helminth species*	Location*	No. loons infected (%)	Intensity $\bar{x} \pm$ SE	Intensity Range	Abundance ($\bar{x} \pm$ SE)
Trematoda					
Renicola pollaris Kontrimavitschus and Bachmetreva, 1960	K	7 (30)	3.3 ± 1.4	1–10	1.0 ± 0.5
Microphallus spp.†	SI	6 (26)	11.8 ± 6.4	1–32	3.1 ± 1.9
Odhneria odhneri Travassos, 1921	SI	6 (26)	3.0 ± 0.3	2–4	0.8 ± 0.3
Amphimerus arcticus Kontrimavitschus and Bachmetreva, 1960	L	5 (22)	1.8 ± 0.5	1–3	0.4 ± 0.2
Plotnikovia fodiens (Linton, 1928)	L, P	2 (9)	2.5 ± 0.5	2–3	0.2 ± 0.2
Mesorchis denticulatus (Rudolphi, 1802)	SI	2 (9)	1.0	1	<0.1 ± <0.1
Maritrema sp. near *eroliae*	SI	1 (4)	3.0	3	0.1 ± 0.1
Ribeiroia ondatrae (Price, 1931)	PR	1 (4)	4.0	4	<0.1 ± <0.1
Microparyphium facetum Dietz, 1909	C	1 (4)	1.0	1	<0.1 ± <0.1
Dendritobilharzia pulverulenta (Braun, 1901)	H	1 (4)	1.0	1	<0.1 ± <0.1
Austrobilharzia terrigalensis Johnston, 1917	BV	1 (4)	2.0	2	<0.1 ± <0.1
Cestoda					
Neovalipora parvispinae (Linton, 1927)	SI	20 (87)	19.5 ± 5.8	1–116	16.9 ± 5.8
Armadoskrjabini rostellata‡ (Abdilgaard, 1790)	SI	12 (52)	9.8 ± 5.0	1–63	5.1 ± 2.8
Microsomacanthus pseudorostellatus‡ (Joyeux and Baer, 1950)	SI	4 (17)			
Tetrabothrius macrocephalus Rudolphi, 1819	SI	6 (26)	2.0 ± 0.7	1–5	0.5 ± 0.3
Nematoda					
Cyathostoma phenisci (Baudet, 1937)	T	2 (9)	1.0	1	<0.1 ± <0.1
Streptocara crassicauda longispiculatus Gibson, 1968)	KL	1 (4)	1.0	1	<0.1 ± <0.1
Capillaria mergi Madsen, 1945	SI	1 (4)	1.0	1	<0.1 ± <0.1
Acanthocephala					
Andracantha gravida Schmidt, 1975	SI	3 (13)	1.3 ± 0.3	1–2	0.2 ± 0.1
Polymorphus brevis§ (Van Cleave, 1916)	SI	1 (4)	1.0	1	<0.1 ± <0.1
Southwellina hispida§ Van Cleave, 1925	SI	1 (4)	1.0	1	<0.1 ± <0.1

* BV = blood vessels; C = cloaca; H = heart; K = kidneys; KL = under Koilon lining; L = liver; P = pancreas; PR = proventriculus; SI = small intestine; T = trachea.

† A complex of 3 species: *Microphallus forresteri* Kinsella and Deblock, 1997, *Microphallus nicolli* (Cable and Hunninen, 1938), and *Microphallus* sp.

‡ *Armadoskrjabini rostellata* and *M. pseudorostellatus* are combined because some scolices lacked hooks and could not be differentiated.

§ HWML 38139 for *P. brevis* and HWML 38140 for *S. hispida.*

cephalans) (Table 2). Twenty-one of 23 birds (91%) were infected with 4.0 ± 0.4 species (range, 1–8). Only 2 species collected (*Polymorphus brevis* and *Southwellina hispida*) were not found in the first host sample, making a total of 50 species in all.

Immature hymenolepid cestodes of 2 species, *Armadoskrjabini rostellata* and *Microsomacanthus pseudorostellatus,* could be distinguished by the size of their rostellar hooks, 45–47 μm and 56–57 μm, respectively. Because hooks had been lost from many scolices, intensity data for these species were combined; prevalence of each species was based on the presence of at least 1 scolex with hooks. Prevalence and intensities of 3 species of *Microphallus* were combined because many specimens were in poor condition and could not be distinguished. One species, *Microphallus forresteri,* comprised >90% of the 6 species of microphallids collected, including the 2 *Maritrema* species and *Odhneria odhneri.* No adult *Contracaecum* were collected, so the common loon may not be a competent host for this nematode group.

Ten common helminth species (4 trematodes, 3 cestodes, and 3 nematodes) were found in the sick loons and 7 were found in the normal loons (4 trematodes and 3 cestodes). *Apophallus brevis,*

Paracuaria adunca, and *Cosmocephalus obvelatus* were common in the sick loons but absent in the normal loons. Five species (*M. forresteri, Amphimerus arcticus, Neovalipora parvispinae, A. rostellata,* and *Tetrabothrius macrocephalus*) were common in both host populations. Considering both samples combined, infections with 8 species (4 trematodes, 2 nematodes, and 2 acanthocephalans) consisted of a single specimen in 1 or 2 host individuals. Five other trematode species were found in only 1 host individual but had intensities of 2–20.

Of the species shared by the 2 host groups, 1 cestode (*N. parvispinae*) and 1 nematode (*Streptocara crassicauda longispiculatus*) had significantly higher prevalences but not higher intensities in the sick loons. Two trematodes (*Renicola pollaris* and *M. forresteri*) and 2 cestodes (the combined *A. rostellata* and *Microsomacanthus pseudorostellatus*) had significantly higher intensities but not prevalences in the sick loons. No shared species had higher prevalences or intensities in normal loons.

Discussion

Species diversity in the sick loons (48) was double that in the normal loons (23), as might be expected from the larger sample size, much longer time span, and multiple collection localities. However, 8 of the species found only in the sick loons were from a single host individual and could be considered accidental parasites. Twenty-one of 23 species (93%) found in normal loons were also found in sick loons.

According to Mcintyre and Barr (1997), quantitative data on the diet of the common loon are lacking, but fish are the primary component. When fish are scarce or water is murky, crustaceans constitute a major part of the diet. In an analysis of an epizootic involving up to 13,000 common loons in Florida in 1983, Forrester et al. (1997) speculated that large numbers of microphallid trematodes were an indicator of a major shift in the diet of the loons to crustaceans and shrimp because of low fish populations. In that study, a subset of sick loons different than that used here were infected with a mean of 7,665 intestinal trematodes compared with a mean of only 23 in the nonepizootic year of 1984 (the same normal loons used here). This shift was thought to have led to salt loading and increased physiological stress on the loons, contributing to their death. A species of *Microphallus* that comprised about 99% of the total number of microphallids in that study has subsequently been described as *M. forresteri* by Kinsella and Deblock (1997).

The sick loons examined here also had large numbers of *Microphallus* spp. (Table 1), with significantly higher intensities than normal loons, but the diversity of the sample in time and space makes it difficult to draw any conclusions as to their effect on the health of the hosts. Two species of cestodes had higher intensities in sick loons than in normal loons, but many of the infections consisted of scolices only and probably had little effect on the condition of the host. The high species diversity in the sick loons may indicate that they were utilizing a greater variety of prey items than were the normal loons possibly, as speculated by Forrester et al. (1997), because of a shortage of fish populations during epizootic years.

The only parasite survey of *Gavia immer* on its summer range was by Chafel and Pokras (1992), who examined 20 birds from 4 New England states and reported 9 species of helminths (5 trematodes, 2 cestodes, 1 nematode, and 1 acanthocephalan). Direct comparison is difficult because 3 helminths were not identified to species and intensities were only listed as mild, moderate, or severe. Three species of trematodes (*A. brevis, E. lintoni, C. erraticus*) and 1 cestode (*T. macrocephalus*) were shared between summer and winter ranges, and 1 species of cestode (*Hymenolepis* sp.) and nematode (*Eustrongylides* sp.) are likely also to be species found in Florida. In general, the prevalence of helminths was much lower on the summer range, with only 1 species (*A. brevis*) occurring in >10% of the loons, and species richness was considerably reduced (9 vs. 50). The greater variety in the diet on the winter range may explain these differences, although more study of loons on their summer range is needed.

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Parasites of the Great Egret (*Ardea albus*) in Florida and a Review of the Helminths Reported for the Species

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ABSTRACT: Thirty-nine species of helminths (21 trematodes, 12 nematodes, 2 acanthocephalans, and 4 cestodes) were collected from 103 of 106 (97%) great egrets (*Ardea albus*) from Florida, 1987–1997. Infected birds harbored a mean of 6 helminths (range, 1–23). Twenty-eight species are new host records. The most prevalent helminths were trematodes of the genera *Posthodiplostomum* and *Ascocotyle* (represented by at least 4 species each) and the nematode *Contracaecum multipapillatum*. A review of the parasitic helminths reported from great egrets is also presented.

KEY WORDS: great egret, *Ardea albus,* Florida, helminths, trematodes, nematodes, acanthocephalans, cestodes, survey, prevalence, intensity.

Great egrets (*Ardea albus,* Ciconiiformes) range in the Americas from southern Canada to southern Chile and Argentina (American Ornithologists' Union, 1983). In southern Florida, great egrets nest colonially between January and May of each year, foraging on fish and invertebrates (Frederick et al., 1997). Although there is little information on movement and dispersion patterns of great egrets, there is some indication that this species does move considerable distances within the Americas. Lincoln (1939) reported movements of banded great egrets from Florida to South Carolina and from Mississippi to Canada, Colombia, Honduras, and El Salvador.

A list of the helminth species known to occur in great egrets is presented in Table 1. Most of the reports come from Latin America (Mexico, Brazil, Argentina, Colombia, Venezuela, and Cuba), with some information from the United States. None of these studies, however, represent complete parasite surveys. The objective of the present study was to conduct the first systematic survey of helminths in great egrets and to determine the prevalence, intensity, and abundance of infection by each helminth species.

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Methods

One hundred six great egrets were collected from 1987 through 1997 from 9 counties in Florida (Okeechobee = 37 birds; Monroe = 25; Collier = 15; Dade = 11; Pinellas = 7; Broward = 5; Lee = 3; Palm Beach = 2; Hillsborough = 1). Based on body measurements (bill length and body weight) and plumage characteristics, birds were divided into 4 age categories: nestlings, fledglings, juveniles, and adults. The mean ± SD (range) of bill length (cm) and body weight (g) for the 4 age categories were: 4.4 ± 2.1 (1.5–11.2) cm and 219 ± 179 (18.7–820) g for nestlings; 9.0 ± 0.5 (8.3–9.5) cm and 481 ± 17 (465–500) g for fledglings; 11.2 ± 0.7 (9.3–12.1) cm and 825 ± 166 (500–1,110) g for juveniles; and 11.6 ± 0.6 (10.5–12.2) cm and 887 ± 255 (620–1,240) g for adults. Dead nestlings and fledglings were collected during regular visits to breeding colonies (between February and July), and juveniles and adults were collected either as roadkills or from rehabilitation centers (year round). Birds from rehabilitation centers were included in the study only if they died soon after their arrival at the centers and if they did not receive any treatment while in captivity. The sample included a total of 82 nestlings (37 males, 34 females, and 11 of unknown gender), 4 fledglings (1 female and 3 males), 13 juveniles (6 females, 6 males, and 1 of unknown gender), and 7 adult males. In general, both captive and free-ranging birds were examined for the presence of parasites 24–48 hr after they died. Techniques for the necropsy of birds and for the collection, fixation, and staining of helminths were similar to those described by Kinsella and Forrester (1972). The terms prevalence, intensity, and abundance used here follow the definitions given by Bush et al. (1997). Because the tissues examined for parasites differed among birds, the prevalence for each species of helminth was determined by dividing the number of birds infected with a given helminth by the number of birds in which the

Table 1. Parasitic helminths reported from great egrets (*Ardea albus*). Species in bold and marked by • were collected from great egrets in the present study.

Helminth	Geographic location	Source
Trematoda		
• ***Posthodiplostomum minimum*** (MacCallum, 1921)	Mexico	Ponce de León, 1995
Posthodiplostomum nanum Dubois, 1937	Argentina	Boero et al., 1972
Ascocotyle (Phagicola) angrense Travassos, 1916	Louisiana, U.S.A.	Sogandares-Bernal and Lumsden, 1963
	Argentina	Boero et al., 1972
• ***Ascocotyle (Phagicola) diminuta*** Stunkard and Haviland, 1924	Mexico	Scholz et al., 1997a
Ascocotyle chandleri Lumsden, 1963*	Texas, U.S.A.	Lumsden, 1963
Ascocotyle (Phagicola) longa Ransom, 1920	Florida, U.S.A.	Hutton and Sogandares-Bernal, 1960
Ascocotyle megalocephala Price, 1932	Mexico	Scholz et al., 1997a
• ***Ascocotyle (Phagicola) nana*** Ransom, 1920	Mississippi, U.S.A.	Font et al., 1984
	Mexico	Aguirre-Macedo and García-Magaña, 1994
	Mexico	Scholz et al., 1997a
Ascocotyle nunezae Scholz, Vargas-Vásquez, Vidal-Martínez, and Aguirre-Macedo, 1997	Mexico	Scholz et al., 1997b
• ***Ascocotyle tenuicollis*** Price, 1935	Mexico	Aguirre-Macedo and García-Magaña, 1994; Salgado-Maldonado et al., 1997; Scholz et al., 1997a
Ascocotyle sp.	Florida, U.S.A.	Hutton, 1964
Apharyngostrigea cornu (Zeder, 1800)	Mississippi, Georgia, Tennessee, U.S.A.	Byrd and Ward, 1943
Apharyngostrigea brasiliana (Szidat, 1928)	Venezuela	Dubois, 1968
	Argentina	Boero et al., 1972
Strigea pseudibis Odening, 1962†	Germany	Dubois, 1968
• ***Clinostomum complanatum*** (Rudolphi, 1814)	Colombia	Rietschel and Werding, 1978
	Mexico	Ramos-Ramos, 1995
Clinostomum detruncatum Braun, 1899†	Venezuela	Braun, 1899
• ***Ribeiroia ondatrae*** (Price, 1931)	Brazil	Yamaguti, 1971
• ***Ignavia venusta*** Freitas, 1948	Brazil	Freitas, 1948
Philophthalmus lacrymosus Braun, 1902	Brazil	Freitas, 1955
Amphimerus interruptus (Braun, 1901)	Mexico	Ramos-Ramos, 1995
Cladocystis trifolium (Braun, 1901)	Mexico	Ramos-Ramos, 1995
Nematoda		
• ***Contracaecum multipapillatum*** (Drasche, 1882)	Mexico	Vidal-Martínez et al., 1994
Contracaecum microcephalum (Rudolphi, 1809)	Brazil	Vicente et al., 1995
Porrocaecum reticulatum (Linstow, 1899)	Brazil	Vicente et al., 1995
• ***Tetrameres* sp.**	Louisiana, U.S.A.	Mollhagen, 1976
• ***Eustrongylides ignotus*** Jägerskiold, 1909	Delaware, U.S.A.	Wiese et al., 1977
	Ohio, U.S.A.	Cooper et al., 1978
	Florida, U.S.A.	Spalding et al., 1993
	Texas, U.S.A.	Franson and Custer, 1994
Eustrongylides sp.	Louisiana, U.S.A.	Roffe, 1988
Cestoda		
• ***Cyclustera ibisae*** (Schmidt and Bush, 1972)	Cuba	Rysavy and Macko, 1971
Valipora sp.	Cuba	Rysavy and Macko, 1971

* Experimental infection.
† Collected from captive birds.

tissue examined was found to harbor that species of helminth. Representative specimens have been deposited in the U.S. National Parasite Collection, Beltsville, Maryland (USNPC 87691–87727, 82334).

Results and Discussion

The prevalence, mean intensity of infection, abundance, and location of helminths from great egrets are presented in Table 2. At least 1 of 39 species of helminths (21 trematodes, 12 nematodes, 4 cestodes, and 2 acanthocephalans) were collected from 103 of the 106 birds (97%) examined. Infected birds harbored a mean of 6 helminth taxa (range, 1–23). Twenty-eight of these species represent new host records.

Strigeids of the genus *Posthodiplostomum* were the most common trematodes collected in this study, and great egrets were infected with 4 species: *P. opisthosicya, P. boydae, P. macrocotyle,* and *P. minimum.* Unfortunately, because of their similarity, the latter 2 species could not easily be distinguished, so prevalence, mean intensity, and abundance were combined (Table 2). In Florida, *P. minimum* has been reported from white ibises (*Eudocimus albus*) (Bush and Forrester, 1976) and roseate spoonbills (*Ajaia ajaja*) (Sepúlveda et al. 1994), and *P. macrocotyle* has been reported from little blue herons (*Egretta caerulea*) (Sepúlveda et al., 1996). Fish of the family Centrarchidae (*Lepomis* spp.) are known to be intermediate hosts for *P. minimum* (Palmieri, 1975).

Heterophyids of the genus *Ascocotyle* were found commonly in the small and large intestines of great egrets. This genus was represented by 5 species: *A. diminuta, A. mcintoshi, A. tenuicollis, A. nana,* and *A. gemina.* Except for the last species, all are known from great egrets (Table 1). Sepúlveda et al. (1996) reported a similar complex of heterophyid trematodes for little blue herons from southern Florida. There are several reports on the life cycles of heterophyid parasites in Florida. Metacercariae of *A. nana* develop in the centrarchiids *Micropterus salmoides, Lepomis microlophus, L. macrochirus,* and *L. humilis* (Font et al., 1984), and those of *A. diminuta, A. mcintoshi,* and *A. tenuicollis* have been reported from mosquitofish (*Gambusia affinis*) (Leigh, 1956, 1974; Stein, 1978).

Great egrets were infected with 3 species of echinostomes: *Mesorchis denticulatus* (=*Stephanoprora denticulata*), *Echinochasmus dietzevi,* and *Microparyphium facetum.* These trematodes have been reported in Florida from seabirds and long-legged wading birds (Hutton and Sogandares-Bernal, 1960; Kinsella, 1972; Courtney and Forrester, 1974; Bush and Forrester, 1976; Sepúlveda et al., 1994).

Oral flukes, *Clinostomum* spp., are commonly found in different species of fish-eating birds in Florida (Bush and Forrester, 1976; Threfall, 1982; Sepúlveda et al., 1994, 1996) and were collected also from great egrets in the present study. Kidney flukes were represented by *Ignavia venusta* and *Renicola* sp. The former species was originally described from great egrets from Brazil (Freitas, 1948) and represents the first record of the species in North America. Specimens of *Renicola* sp. were collected from only 1 bird and only immature parasites were recovered, suggesting that great egrets are probably not a normal definitive host for this parasite.

The pancreatic fluke, *Diasiella diasi,* was originally described from anhingas (*Anhinga anhinga*) in Brazil by Travassos (1922) and has been reported from the osprey (*Pandion haliaetus*) and bald eagle (*Haliaetus leucocephalus*) in Virginia and the great blue heron (*Ardea herodias*) in Florida (Kinsella et al., 1996). In the present study, the prevalence of this parasite was probably underestimated because the pancreas was examined in only 24 of the 106 egrets.

Contracaecum sp. adults and larvae were the most common nematodes encountered during this study, and because all males found were *C. multipapillatum,* this species was assumed to be the only one present. In Florida, this species of *Contracaecum* has been collected from ciconiiforms and pelecaniforms as definitive hosts (Courtney and Forrester, 1974; Threlfall, 1982; Conti et al., 1986; Sepúlveda et al., 1994, 1996) and from freshwater fishes (families Centrarchidae, Cyprinidae, Poeciilidae, and Cichlidae) as second intermediate hosts (Huizinga, 1967; Vidal-Martínez et al., 1994).

Tetramerid nematodes were also commonly found in this study. Great egrets were infected with a mixture of *Tetrameres microspinosa* and an undescribed species (*Tetrameres* sp.). Mature females were found embedded in the glandular tissue of the stomach, and in extreme cases of parasitism (close to 500 females were collected from 1 bird) the mucosa had a mottled appearance, covered with purple-red cystlike lesions that resembled hematomas. Each of these cysts contained female *Tetrameres* sp. Because of fe-

Table 2. Parasitic helminths of 106 great egrets (*Ardea albus*) from Florida.

Helminth	Location	USNPC no.	Sample size†	Prevalence	Intensity		Mean abundance
					Mean	Range	
Trematoda							
Posthodiplostomum spp.‡§	3	87691, 87692	70	66	556	1–16,000	367
Posthodiplostomum opisthosicya Dubois, 1969	3	87693	70	43	318	1–1,260	137
Posthodiplostomum boydae Dubois, 1969§	3	87694	70	10	79	1–270	8
Ascocotyle tenuicollis Price, 1935	4	87695	68	54	112	1–1,140	60
Ascocotyle (Phagicola) diminuta Stunkard and Haviland, 1924	3	87696	70	33	64	1–3,580	21
Ascocotyle gemina Font, Overstreet, and Heard, 1984§	4	87697	68	26	44	1–260	11
Ascocotyle mcintoshi Price, 1936§	3	87698	70	6	7	1–9	<1
Ascocotyle (Phagicola) nana Ransom, 1920	3	87699	70	40	171	2–1,360	68
Apharyngostrigea pipientis (Faust, 1918)§	3	87700	70	41	26	1–240	11
Echinochasmus dietzevi Issaitschkoff, 1927§	3	87701	70	30	107	1–520	32
Clinostomum complanatum (Rudolphi, 1814)§	1	87702	73	30	4	1–35	1
Clinostomum attenuatum Cort, 1913	1	87703	73	18	6	1–36	1
Microparyphium facetum Dietz, 1909§	5	87704	68	26	7	1–47	2
Diplostomum ardeae Dubois, 1969§	3	87705	70	16	27	1–240	4
Mesorchis denticulatus (=*Stephanoprora denticulata*) (Rudolphi, 1802)§	3	87706	70	13	4	1–10	<1
Ribeiroia ondatrae (Price, 1931)§	2	87707	103	9	7	1–17	<1
Pholeter anterouterus Fischthal and Nasir, 1974§	3	87708	70	9	13	1–40	1
Ignavia venusta Freitas, 1948	6	87709	47	6	3	1–4	<1
Diasiella diasi (Travassos, 1922)§	7	87710	24	4	5		<1
Renicola sp.§	6	87711	47	2	24		<1
Nematoda							
Contracaecum multipapillatum (Drasche, 1882)	1, 2	87712	103	77	37	1–203	28
Tetrameres spp.§‖	2	87713	103	38	70	1–871	27
Eustrongylides ignotus Jägerskiold, 1909	2	82334	103	38	3	1–10	1
Desmidocercella numidica Seurat, 1920§	3, 9	87714	70	21	74	1–660	16
Capillaria herodiae Boyd, 1966§	3	87715	70	21	7	1–21	1
Desportesius trianuchae (Wright, 1879)§	2	87716	103	9	26	1–131	2
Desportesius invaginatus (Linstow, 1901)§	2	87717	103	6	2	1–5	<1
Desportesius larvae	2		103	9	1	1–60	<1
Avioserpens galliardi Chabaud and Campana, 1949§	1, 8	87718	63	4	1	1–2	<1

Table 2. Continued.

Helminth	Location	USNPC no.	Sample size†	Prevalence	Intensity		Mean abundance
					Mean	Range	
Acuaria multispinosa (Perez Vigueras, 1938)§	2	87719	103	2	4	1–6	<1
Chandleronema longigutterata (Chandler, 1942)§	2	87720	103	1	2		<1
Cosmocephalus obvelatus (Creplin, 1825)§	1	87721	73	1	2		<1
Cestoda							
Glossocercus caribaensis (Rysavy and Macko, 1971)§	3	87722	70	7	7	1–26	<1
Dendrouterina ardeae (Rausch, 1955)§	3	87723	70	7	2	1–3	<1
Cyclustera ibisae (Schmidt and Bush, 1972)	3	87724	70	1	1		<1
Plerocercoid§#	10	87725					
Acanthocephala							
Polymorphus brevis (Van Cleave, 1916)§	3	87726	70	39	22	1–180	9
Arhymorhynchus pumilirostris Van Cleave, 1916§	3	87727	70	11	5	1–13	<1

* Location in host: 1 = oral cavity/esophagus; 2 = proventriculus/ventriculus; 3 = small intestine; 4 = large intestine; 5 = cloaca; 6 = kidneys; 7 = pancreas; 8 = lungs; 9 = coelomic cavity; 10 = subcutaneous tissue.

† Number of organs examined differed among birds.

‡ A complex of two species: *P. macrocotyle* Dubois, 1937 (USNPC No. 87692) and *P. minimum* (MacCallum, 1921) (USNPC No. 87691).

§ New host record.

‖ A complex of two species: *T. microspinosa* and *Tetrameres* sp.

Because subcutaneous tissue was not regularly checked for the presence of parasites, the prevalence, mean intensity, and abundance of infection were not calculated for this parasite.

males embedded the number of nematodes present could have been underestimated and could explain why only males were usually recovered.

In the great egret, acuariid nematodes were represented by 5 species: *Desportesius trianuchae, D. invaginatus, Acuaria multispinosa, Chandleronema longigutterata,* and *Cosmocephalus obvelatus.* The latter 3 species were uncommon, suggesting that great egrets are probably not the normal definitive host. Although acuariids of the genus *Desportesius* were recovered at higher prevalences, in 9 birds only larval stages were found, and thus identification to species was not possible.

The nematode *Desmidocercella numidica* has been reported from the air sacs of several ciconiiform birds (Anderson, 1959; Conti et al., 1986). In the present study, this species was found in the gastrointestinal tract (mainly small intestine, but also stomach, large intestine, and cloaca), coelomic cavity, kidneys, lungs, trachea, and liver. The occurrence of this nematode in so many different organs, including the body cavity, might have been a technique artifact; the worms may actually have been in the air sacs and may have contaminated the surfaces of different organs during the process of parasite recovery.

Acanthocephalans and cestodes were represented by 2 and 4 species, respectively. The present study constitutes the first report of acanthocephalans in great egrets. *Cyclustera ibisae* (=*Parvitaenia heardi*) was the most common cestode found. This parasite was originally described from several species of fish-eating birds, including great egrets, from Cuba (Rysavy and Macko, 1971), and in Florida it has been reported from brown pelicans (*Pelecanus occidentalis*) (Courtney and Forrester, 1974) and reddish egrets (*Egretta rufescens*) (Conti et al., 1986). One bird harbored 2 immature cestodes (plerocercoids) in the subcutaneous tissue. Because plerocercoid stages are found in the life cycles of all pseudophyllidean cestodes and consider-

ing that the pseudophyllidean *Spirometra mansoni* is a common parasite of several carnivores in Florida (Forrester, 1992), the immature tapeworm stages found in great egrets may belong to this species. To our knowledge, this is the first report of plerocercoids in an avian host.

Although the main purpose of this study was not to evaluate the pathological effects of helminths on their hosts, some conclusions can be made in this respect. With the exception of infections with some species of trematodes (*Posthodiplostomum* spp., *Ascocotyle* spp., and E. *dietzevi*) and nematodes (*C. multipapillatum, Tetrameres* spp., and *Eustrongylides ignotus*), great egrets had relatively low intensities of parasites and their presence was not associated with significant lesions. Infections with the nematode *E. ignotus* have been implicated as an important cause of mortality in great egret nestlings from Ohio (Cooper et al., 1978), Delaware (Wiese et al., 1977), Florida (Spalding et al., 1993), and Texas (Franson and Custer, 1994).

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Metazoan Parasites of the Atlantic Spadefish *Chaetodipterus faber* (Teleostei: Ephippidae) from the Coastal Zone of the State of Rio de Janeiro, Brazil

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ABSTRACT: One hundred ten Atlantic spadefish *Chaetodipterus faber* (Broussonet, 1782) (Teleostei: Ephippidae) collected from the coastal zone of the State of Rio de Janeiro, Brazil (21–23°S, 41–45°W) between February 1995 and March 1996 were necropsied to study their metazoan parasites. The majority of the fish (82.7%) were parasitized by 1 or more metazoan species. Ten species of parasites were collected: 4 digeneans, 2 monogeneans, and 4 copepods. The copepods were the majority (53.1%) of the total number of parasite specimens collected. The caligid *Anuretes anurus* was the most dominant species with highest prevalence and abundance. *Prosogonotrema labiatum* and *A. anurus* showed a positive correlation between the host's total length and parasite abundance, while *Parancylodiscoides* sp. showed a negative correlation between the host's total length and parasite prevalence and abundance. The sex of hosts did not influence prevalence and abundance of any parasite species. The mean diversity in the infracommunities of *C. faber* was $H = 0.659 \pm 0.280$, with no correlation with the host's total length and with no significant difference between male and female fish. *Chaetodipterus faber* had 4 pairs of parasite species with significant positive association, 3 pairs of endoparasites, and 1 pair of ectoparasites. Negative associations were not found. The low diversity and parasite richness observed might be linked to the low dietary variation of *C. faber*.

KEY WORDS: parasite ecology, community structure, marine fish, Ephippidae, *Chaetodipterus faber*, Brazil.

Chaetodipterus faber (Broussonet, 1782) is a benthic fish distributed from New England, U.S.A., to southern Brazil (Ditty et al., 1994). This species is very common in the southern Brazilian coastal zone (Couto and Vasconcelos, 1980; Menezes and Figueiredo, 1985). The literature on parasites of *C. faber* from Brazil is taxonomic in scope. Kohn (1966), Fernandes et al. (1985), and Wallet and Kohn (1987) recorded digenean parasites of *C. faber* from the state of Rio de Janeiro and Amato (1983a, b) from Florianópolis, state of Santa Catarina. Recently, Cezar and Luque (1998) redescribed *Anuretes anurus* (Bere, 1936), a copepod parasitic on the gills of *C. faber* from the coastal zone of Rio de Janeiro.

In this report, we analyzed the metazoan parasite community of *C. faber* at the component and infracommunity levels and compared our results with those on parasite communities of other marine fishes from the Neotropical region.

Materials and Methods

From February 1995 to March 1996, 110 *C. faber* were examined. Local fishermen collected fish from the coastal zone of the state of Rio de Janeiro (21–23°S, 41–45°W). The fish measured 14.0–46.0 cm (mean = 27.7 ± 7.1 cm) in total length and weighed 150–2,430 g (817.5 ± 462.8 g). Fish were identified according to Menezes and Figueiredo (1985). The ecological approximation of the metazoan parasite community was made to component and infracommunity levels (Esch et al., 1990). The dominance frequency and the relative dominance (number of specimens of 1 species/total number of specimens of all species in the infracommunity) of each parasite species were calculated according to Rohde et al. (1995). Spearman's rank correlation coefficient r_s was calculated to determine possible correlations between the total length of hosts and the abundance of parasites. Pearson's correlation coefficient r was used as an indication of the relationship between the host's total length and the prevalence of parasites, with previous arcsine transformation of the prevalence data (Zar, 1996) and partitioning of host samples into four 10-cm (total length) intervals. The effect of host sex on abundance and prevalence of parasites was tested using the Z normal approximation to the Mann–Whitney test and the chi-square test, respectively. Parasite species diversity was calculated using the Brillouin index (H), because each fish analyzed corresponded to a fully censused community (Zar, 1996). The probable variation of diversity in relation to host sex (Mann–Whitney test) and to host total length (Spearman's rank correlation coefficient) were tested. For each infracommunity, the Pielou evenness index (J') was calculated (Ludwig and Reynolds, 1988). The possible interspecific association between concurrent species was determined using the chi-

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Table 1. Prevalence, intensity, mean intensity, and mean abundance of infection of the metazoan parasites of *Chaetodipterus faber* from the coastal zone of the state of Rio de Janeiro, Brazil.

Parasites	% Prevalence	Intensity	Mean intensity	Mean abundance
Digenea				
Prosogonotrema bilabiatum				
CHIOC No. 33962a, b	27.3	1–10	2.3	0.6
Lecithocladium chaetodipteri				
CHIOC No. 33965	20.9	1–39	8.1	1.7
Multitestis (Multitestis) inconstans				
CHIOC No. 33963a, b	27.3	1–45	7.9	2.1
M. (Multitestoides) brasiliensis				
CHIOC No. 33964a, b	11.8	1–11	4.0	0.5
Monogenea				
Parancylodiscoides sp.				
CHIOC No. 33960	21.8	1–47	6.9	1.5
Sprostoniella sp.				
CHIOC No. 33961	8.2	1–3	1.2	0.1
Copepoda				
Caligus haemulonis				
MNRJ No. 7237–7238	4.5	1–5	2.4	0.1
Caligus mutabilis				
MNRJ No. 7289	5.4	1–2	1.3	0.1
Anuretes anurus				
MNRJ No. 7284–7285	65.4	1–68	10.1	6.6
Lernanthropus pupa				
MNRJ No. 12874	30.0	1–7	2.2	0.7

square test, with the Yates correction. Possible covariation among the abundance of concurrent species was analyzed using the Spearman rank correlation coefficient. Ecological terminology follows Bush et al. (1997). The analysis included only parasite species with prevalence greater than 10% (Bush et al., 1990). Statistical significance level was evaluated at $P \leq 0.05$. Voucher specimens of collected helminths were deposited in the Coleção Helmintológica do Instituto Oswaldo Cruz (CHIOC), Rio de Janeiro, Brazil; copepods were deposited in the Coleção Carcinológica do Museu Nacional (MNRJ), Quinta da Boa Vista, Rio de Janeiro, Brazil.

Results

Component community

Ten species of metazoan parasites were collected (Table 1). Copepods were the most abundant, with 4 species, and they accounted for 53.1% of the total parasites collected. Copepods parasitized 72 (65.4%) of the hosts, with mean abundance of 6.6. *Anuretes anurus* was the dominant species, with 726 specimens collected (52.0% of all parasites), and had the highest values of mean relative dominance and frequency of dominance (Table 2). Digeneans and monogeneans represented 35.3% and 11.5%, respectively, of all parasites collected.

The average total lengths of male (26.45 ± 6.55, $n = 55$) and female (29.0 ± 7.710, $n = 55$) fish in the study sample were not significantly different ($t = -1.892$, $P = 0.06$). Abundances of *Prosogonotrema bilabiatum* and *A. anurus* were each positively correlated with host total length, while the abundance of *Parancylodiscoides* sp. was negatively correlated with host total length (Table 3). The sex of the hosts did not influence parasite prevalence and abundance of any species (Table 4).

Infracommunities

Ninety-one (82.7%) spadefish were parasitized by at least 1 parasite species. A total of 1,545 individual parasites were collected, with a mean abundance of 14.0 ± 21.178 (1–169). No relationship between total parasite abundance and total body length ($r_s = 0.133$, $P = 0.166$) and sex ($Z = -0.260$, $P = 0.794$) of fish was observed. The mean parasite species richness 2.29 ± 1.683 (1.0–6.0) was not correlated with total body length ($r_s = 0.091$, $P = 0.342$) and sex ($Z = -0.115$, $P = 0.908$) of fish. Twenty-one hosts (19.1%) showed infection with 1 parasite species, and 25 (22.7%), 18 (16.4%), 20

Table 2. Frequency of dominance and mean relative dominance of the components of the community of metazoan parasites of *C. faber* from the coastal zone of the state of Rio de Janeiro, Brazil.

Parasites	Frequency of dominance	Frequency of dominance shared with one or more species	Mean relative dominance
Prosogonotrema bilabiatum	2	0	6.330 ± 14.303
Lecithocladium chaetodipteri	7	2	7.984 ± 17.185
Multitestis (Multitestis) inconstans	10	2	11.218 ± 19.723
M. (Multitestoides) brasiliensis	1	2	3.610 ± 12.082
Parancylodiscoides sp.	9	2	10.764 ± 25.934
Anuretes anurus	46	7	48.816 ± 35.397
Lernanthropus pupa	3	2	8.325 ± 17.696

(18.2%), 2 (1.8%), and 5 (4.5%) had multiple infections with 2, 3, 4, 5, and 6 parasite species, respectively. Mean parasite species diversity (H) was 0.659 ± 0.280; the maximum diversity was 1.307. The Pielou evenness index (J') had a mean of 0.824 ± 0.536. Parasite diversity was not correlated to host total length (r_s = 0.194, P = 0.107), and no significant differences ($Z <$ 0.01, $P > 0.50$) in parasite diversity were observed between male (H = 0.650 ± 0.258) and female spadefish (H = 0.670 ± 0.306).

Parasite infracommunities were separated into two groups, ectoparasites (monogeneans and copepods) and endoparasites (digeneans), to determine interspecific associations. Among the ectoparasites, only 1 copepod species pair, *Lernanthropus pupa* and *A. anurus,* shared significant positive association and covariation (Table 5). The infracommunities of endoparasites had 3 pairs of digeneans that exhibited significant positive associations and covariations: *Multitestis (Multitestis) inconstans* and *P. bilabiatum, M. (M.) inconstans* and *Lecithocladium chaetodipteri,* and *M. (Multitestoides) brasiliensis* and *P. bilabiatum* (Table 6).

Discussion

The present study detected some patterns in the structure of the metazoan parasites of *C. faber:* (1) ectoparasite dominance, (2) low parasite richness and diversity, and (3) absence of correlation of parasite abundance, at the infracommunity level, with the size or sex of the host. These patterns were somewhat different from those recorded for other benthic marine fishes from the coastal zone of the state of Rio de Janeiro (Luque et al., 1996a, b; Knoff et al., 1997; Chaves and Luque, 1998). The parasite community of *C. faber* was dominated by ectoparasites, and this was in disagreement with results on other Brazilian marine fishes where digeneans were the dominant parasites. This difference might be explained by the diet of *C. faber.* According to Couto and Vasconcelos (1980) and Hayse (1990), the diet of *C. faber* showed few ontogenetic changes and was restricted to some species of isopods, hydroids, and polychaetes, potential intermediate hosts for digeneans. Bittencourt (1990) gave evidence of the herbivorous habits of *C. faber.* The monoxenic life cy-

Table 3. Spearman's rank correlation coefficient (r_s) and Pearson's correlation coefficient (r) values used to evaluate possible relationships between the total length of *C. faber* and abundance and prevalence of the components of its parasite community from the coastal zone of the state of Rio de Janeiro, Brazil. (P = significance level).

Parasites	r_s	P	r	P
Prosogonotrema bilabiatum	0.221	0.023	−0.312	0.602
Lecithocladium chaetodipteri	0.023	0.832	−0.633	0.254
Multitestis (Multitestis) inconstans	0.182	0.495	0.712	0.172
M. (Multitestoides) brasiliensis	0.042	0.653	0.141	0.821
Parancylodiscoides sp.	−0.293	0.002	−0.891	0.043
Anuretes anurus	0.244	0.015	0.482	0.412
Lernanthropus pupa	0.065	0.520	−0.763	0.131

Table 4. Normal approximation Z of the Mann–Whitney test and chi-square (χ^2) test values used to evaluate possible relationships between the sex of *C. faber* and abundance and prevalence of the components of its parasite community from the coastal zone of the state of Rio de Janeiro, Brazil. (P = significance level).

Parasites	Z	P	χ^2	P
Prosogonotrema bilabiatum	−0.343	0.733	0.182	0.662
Lecithocladium chaetodipteri	−0.202	0.831	0.212	0.645
Multitestis (Multitestis) inconstans	−0.355	0.723	0.421	0.514
M. (Multitestoides) brasiliensis	−0.543	0.592	0.793	0.373
Parancylodiscoides sp.	−0.262	0.792	0.213	0.645
Anuretes anurus	−0.782	0.943	0.162	0.684
Lernanthropus pupa	−0.191	0.842	0.182	0.672

cles of copepods and monogeneans, in addition to possible permanent or temporarily aggregated patterns within *C. faber* populations, might increase the probability of successful parasite transmission by the free-living larval stages of these ectoparasites (Roubal, 1990).

Another difference of the parasite community of *C. faber* from other fishes of the Brazilian coastal zone was the absence of correlation between parasite abundance and diversity and the host size. As pointed out in the classic study by Polyanski (1961), quantitative and qualitative changes in parasitism are expected with fish growth. According to Saad-Fares and Combes (1992), in the case of the digeneans, this correlation might be influenced by changes in the diet of the fish. Regarding ectoparasites, changes in levels of the parasitism with changing host size are expected because the surface area of the infection site increases with growth, and this provides more space to larval monogeneans and copepods (Fernando and Hanek, 1976). However, at the component community level, some digeneans and monogeneans did show correlations between host size and parasite abundance, with some heterogeneity in the population features of the spadefish's parasite community. This situation is clear in the ectoparasites. Abundance and prevalence of the copepod *A. anurus* were each positively correlated with host total length, while the abundance and prevalence of the monogenean *Parancylodiscoides* sp. were negatively correlated with host total length. Better explanation of these patterns will only be possible when the life cycles of the parasites and their relationship with spadefish feeding patterns and population dynamics become known.

Absence of correlation between the sex of the host and the prevalence and abundance of components of the parasite community of marine fishes is common. An exception was seen in *Mugil platanus* from Rio de Janeiro, in which 30% of the components of its parasite community showed differences in their prevalences and abundances relative to host sex (Knoff et al., 1997). In *C. faber,* the lack of such correlation might be attributed to similarity in ecological relationships (behavior, habitat, and diet) of males and females as stated by Luque et al. (1996a) and Takemoto et al. (1996). According to Poulin

Table 5. Concurrent species pairs of ectoparasites on *C. faber* from the coastal zone of the State of Rio de Janeiro, Brazil. Significant values are underlined.

	Parancylodiscoides sp.	*A. anurus*	*L. pupa*
		r_s*	
Parancylodiscoides sp.	—	−0.059	0.104
Anuretes anurus	−0.598	—	<u>0.283</u>
Lernanthropus pupa	0.624	<u>8.566</u>	—
		χ^2†	

* r_s = Spearman rank correlation coefficient.
† χ^2 = chi-square test.

Table 6. Concurrent species pairs of endoparasites in *C. faber* from the coastal zone of the State of Rio de Janeiro, Brazil. Significant values are underlined.

	P. bilabiatum	*L. chaetodipteri*	*M. (M.) inconstans*	*M. (M.) brasiliensis*
			r_s*	
Prosogonotrema bilabiatum	—	0.081	<u>0.337</u>	<u>0.279</u>
Lecithocladium chaetodipteri	0.081	—	<u>0.302</u>	0.003
Multitestis (Multitestis) inconstans	<u>10.742</u>	<u>5.332</u>	—	0.118
M. (Multitestoides) brasiliensis	<u>5.248</u>	0.014	0.930	—
		χ^2†		

* r_s = Spearman rank correlation coefficient.
† χ^2 = chi-square test.

(1996), the influence of host sex on parasite prevalence and abundance is a topic hardly touched upon in discussions of community analysis, and it is necessary to conduct experiments that show the influence of other factors, mainly on physiology and behavior of the fish.

Ecological disturbances are determining factors in the structure of parasite communities (Holmes, 1990). In this study, we collected fewer digeneans than in the studies by Amato (1983a, b) of fishes from Florianópolis, Santa Catarina, Brazil, which is influenced by the subtropical convergence (meeting of the warm Brazilian Current with the cold Falkland Current). According to Luque et al. (1996a), this situation is also seen regarding the digeneans of the haemulid fish *Orthopristis ruber*. This suggests that the subtropical convergence might provide variation in ecological conditions that could affect the population dynamics and diversity of parasites. This situation is mentioned in other papers on the ecology of parasites of marine fishes from the South American Pacific Ocean, a region dominated by an upwelling system and the aperiodic El Niño–Southern Oscillation (ENSO) phenomenon (Oliva et al., 1996; Oliva and Luque, 1998). Additional studies are needed to quantify the impact of ecological disturbances on the structure and composition of parasite communities of marine fishes of the Neotropical region.

Another characteristic of the parasite community of *C. faber* was the absence of larval digeneans, cestodes, and acanthocephalans, which are generally common in marine teleost fishes (George-Nascimento, 1987). This could suggest that the limited diet of *C. faber* does not favor its participation as intermediate or transport host in the life cycle of these parasites. The absence of larval helminths has also been seen regarding the sciaenid fishes from the Peruvian coastal zone, and it will be fully explained only by additional information on the population features of the potential intermediate and definitive hosts.

Four pairs of positively associated species were detected. Associations among parasites suggested that infective stages occurred in the same habitat or at least, in some cases, with the occurrence of cumulative infection of the fish by another species (Rohde et al., 1994). In the congeneric digeneans *Multitestis (M.) inconstans* and *M. (M.) brasiliensis*, the absence of association showed that possibly the intermediate hosts belong to different items of the diet of *C. faber*. This situation may be a function of the diet of *C. faber*. Negative associations were not found. However, according to Rohde et al. (1994), the detection of interspecific associations between parasites must be confirmed by experiments on the biology of the parasite species to provide conclusive evidence for the presence or absence of interspecific competition.

Rohde et al. (1995) stated that the metazoan ectoparasite communities of marine fish live in nonsaturated, little-ordered assemblages. This postulate apparently is also valid for endoparasite communities of marine fish from South America. Data obtained from other neotropical marine fish also showed the low degree of competitive interactions and, in some cases, the dominance of generalist species (George-Nascimento and Iriarte, 1989; Luque, 1996; Luque et al., 1996b; Oliva et al., 1996; Takemoto et al.,

1996; Knoff et al., 1997; Chaves and Luque, 1998; Oliva and Luque, 1998). The parasite community of *C. faber* can be included as yet another example of this.

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A Message from the Editors

In the last issue Sherman Hendrix announced his retirement from 5 years of outstanding editorship and our assumption of the role. We will strive to build on the foundation of excellence that Sherm and all of our predecessors have laid down. The successful production of a journal such as ours depends not only on editors, but on the support of society officers, editorial board members, an outstanding publisher, and most of all the general membership who serve both as authors and peer reviewers. We have been blessed with the unqualified support of all of you in these respects. While the historical "helminthological" element of the Society's name implies a restriction to "worm parasitologists", in reality the term does not truly represent the membership as it is, a diverse group of parasitologists engaged in the study of all aspects of host/parasite relationships. As we move into the next millennium, our discipline will be faced with a whole new array of challenges and one, biodiversity through biological survey, is already emerging as an exciting and rewarding opportunity. We look forward to continuing to provide through the *Journal* a forum for the presentation of your accomplishments in meeting these challenges.

Willis A. Reid, Jr.
Janet W. Reid
Editors

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Diplostomes from the Brown Pelican, *Pelecanus occidentalis* (Pelecanidae), from the Galveston, Texas Area, including Two New Species of *Bursacetabulus* gen. n.

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ABSTRACT: During a study of digeneans of shorebirds from the Galveston, Texas, area of the Gulf of Mexico, brown pelicans, *Pelecanus occidentalis,* were found to be infected with 2 species of a new genus of Diplostomidae, *Bursacetabulus pelecanus* sp. n. and *B. macrobursus* sp. n. *Bursacetabulus* gen. n. can be distinguished from all other genera of Diplostominae by having an inconspicuous, pouchlike tribocytic organ that contains portions of the uterus and vitellaria, a suckerlike copulatory bursa, and ceca terminating some distance anterior to the posterior end of the body. The new genus is most similar to *Tylodelphys* but has a much shorter hind body, the vitellaria do not extend past the testes in the hind body, and it lacks a prepharynx, genital cone, and highly structured tribocytic organ. *Bursacetabulus macrobursus* sp. n. can be distinguished from *B. pelecanus* sp. n. by having a larger body size and a large bell-shaped skirt around the copulatory bursa. One of the brown pelicans also harbored *Bolbophorus confusus,* not previously reported from this host.

KEY WORDS: Diplostomidae, Diplostominae, *Bursacetabulus macrobursus* sp. n., *Bursacetabulus pelecanus* sp. n., *Pelecanus occidentalis,* Gulf of Mexico, Galveston, Texas.

The brown pelican, *Pelecanus occidentalis* Linnaeus, 1766, is a piscivorous species that ranges in the Americas from North Carolina to Brazil in the east and from California to Chile in the west (Rappole and Blacklock, 1994). Courtney and Forrester (1974) examined 130 brown pelicans from Florida and Louisiana and found 11 species of trematodes but did not report any species of diplostomes. Although 2 species of diplostomes have been reported from the American white pelican, *Pelecanus erythrorhynchus* Gmelin, 1789 (*Bolbophorus confusus* (Krause, 1914) Dubois, 1935, by Fox and Olsen [1965] and *Diplostomum spathaceum* (Rudolphi, 1819) Olsson, 1876, by McLaughlin [1974]), none have been reported from the brown pelican. The purpose of this study was to expand our knowledge of the diplostomes from the brown pelican.

Materials and Methods

Three moribund brown pelicans salvaged from the Galveston Bay area of the Gulf of Mexico, died under the care of licensed bird rehabilitators between 1 May 1994 and 3 January 1997 and were examined immediately after death for intestinal parasites under the direction of Dr. Jackie Cole of Galveston, Texas (U.S. Fish & Wildlife Service permit no. PRT 760668; Texas Parks & Wildlife Department permit no. TX SPH 0491253; Texas Veterinary license no. 5982). Live specimens of endohelminths from a fourth brown pelican were provided by the U.S. Fish and Wildlife Service (Dr. Tom Craig, Texas Veterinary Diagnostic Laboratory, College of Veterinary Medicine, Texas A&M University) on 5 January 1998. Trematodes were relaxed in saline, heat-fixed under slight coverslip pressure in AFA, stained in Semichon's carmine, and mounted in Kleermount® or Canada balsam. Drawings were done with the aid of a drawing tube. Measurements are given as the mean, followed by the range in parentheses, unless otherwise stated.

Results

One of 4 brown pelicans harbored 6 specimens of *Bolbophorus confusus* (Bolbophoridae Shoop, 1989), and all 4 harbored 2 undescribed species of Diplostomidae Poirier, 1886 (Diplostominae Monticelli, 1888), representing a new genus.

Bursacetabulus gen. n.

DIAGNOSIS: Diplostomidae, Diplostominae. Body aspinose, bisegmented; forebody longer than hind body, with large, inconspicuous, pouchlike tribocytic organ. Oral sucker and pharynx present; bifurcate ceca, terminating some distance from posterior end; prepharynx absent. Pseudosuckers present, acetabulum absent. Vitellaria distributed primarily in forebody, extending laterally into tribocytic organ and ventrolaterally a short distance into hind body. Re-

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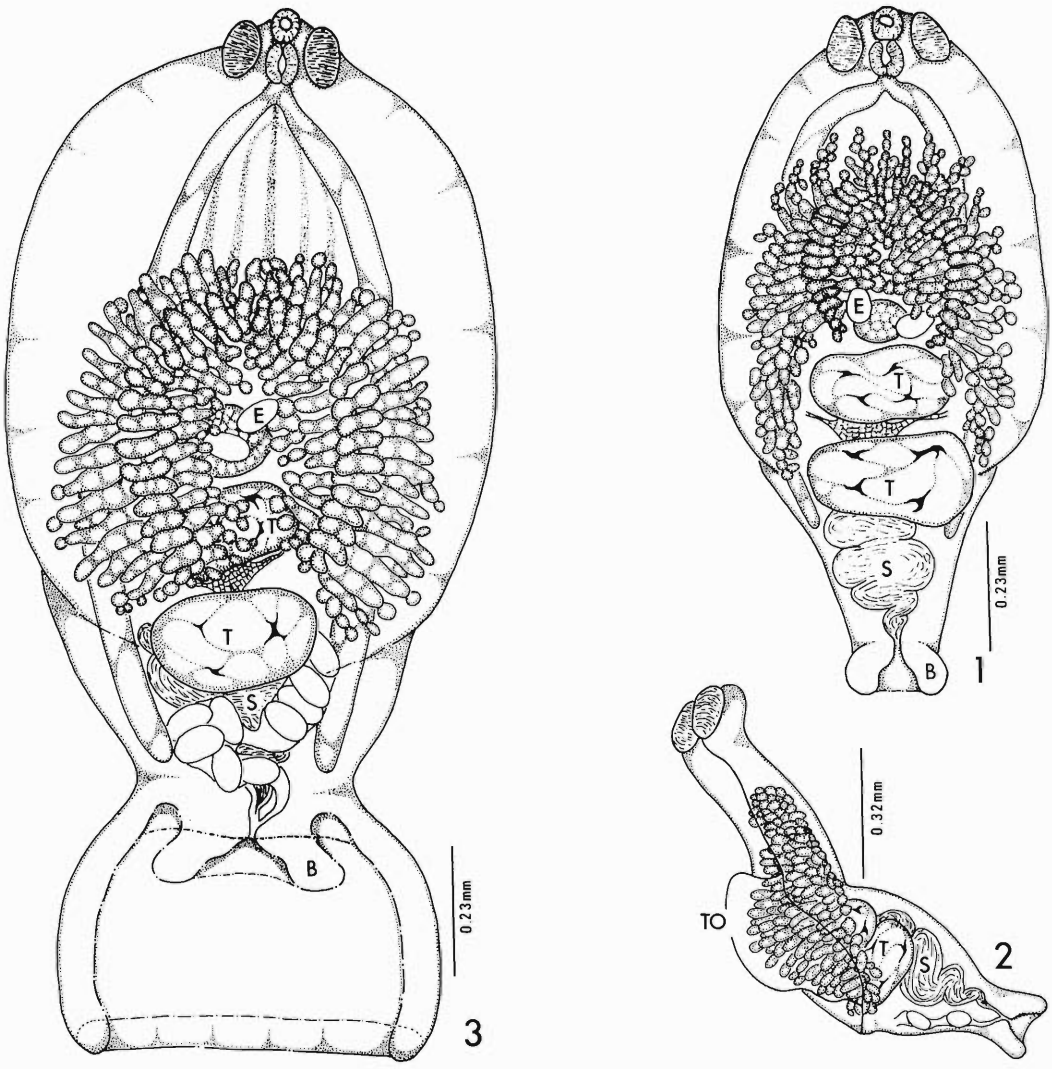

Figures 1–3. ***Bursacetabulus*** **gen. n. 1. Ventral view of** ***B. pelecanus*** **sp. n. showing suckerlike copulatory bursa (B), eggs in uterus (E), seminal vesicle (S), and testes (T). 2. Side view of** ***B. pelecanus*** **sp. n. showing seminal vesicle (S), testes (T), and tribocytic organ (TO). 3. Ventral view of** ***B. macrobursus*** **sp. n. showing copulatory bursa surrounded by bell-shaped skirt (B), eggs in uterus (E), seminal vesicle (S), and testes (T).**

productive organs in hind body; testes smooth to slightly lobed, tandem; cirrus sac absent; ovary median to slightly dextral, immediately pretesticular. Genital pore opening into well developed suckerlike bursa at posterior extremity. Genital cone absent. Eggs large, operculate. Excretory pore opening dorsally on midline of body, just anterior to copulatory bursa.

TYPE SPECIES: *Bursacetabulus pelecanus* sp. n.

ETYMOLOGY: Genus named for the suckerlike appearance of the copulatory bursa.

Bursacetabulus pelecanus sp. n. (Figs. 1, 2)

DESCRIPTION (BASED ON 10 ADULT SPECIMENS): With characteristics of the genus. Body indistinctly bisegmented, 1,210 (1,074–1,400) μm long; forebody slightly spatulate, 886 (790–

1,130) μm long by 535 (470–650) μm wide, hind body 535 (480–600) μm long by 475 (390–550) μm wide. Oral sucker subterminal, 55 (40–70) μm long by 58 (50–65) μm wide. Pseudosuckers well developed, 96 (80–112) μm long by 59 (50–75) μm wide. Acetabulum absent. Tribocytic organ circular to elliptical, 290 (280–300) μm long by 300 (250–375) μm wide. Prepharynx absent, pharynx 46 (36–55) μm long by 49 (40–65) μm wide, esophagus 19 (15–28) μm long, ceca terminating just posterior to middle of hind body. Ratio of pharynx to oral sucker 1:1.2. Testes smooth, tandem; anterior testis 180 (150–220) μm long by 245 (190–300) μm wide, posterior testis 168 (140–210) μm long by 258 (220–330) μm wide. Copulatory bursa well developed, suckerlike, forming posterior end of hind body. Seminal vesicle voluminous, highly coiled, extending posteriorly from level of ovary to near anterior margin of copulatory bursa. Ovary median to slightly dextral, 77 (55–95) μm long by 86 (60–100) μm wide. Ootype located at level of anterior testis, near midline of body. Laurer's canal not observed. Vitelline follicles large, distributed primarily in forebody, extending laterally into tribocytic organ and ventrolaterally into hind body to level of posterior testis. Uterus intercecal, with medial loops extending into tribocytic organ, joining seminal vesicle just above anterior margin of copulatory bursa. Eggs 83 (72–90) μm long by 55 (47–65) μm wide.

TYPE HOST: *Pelecanus occidentalis* Linnaeus.

TYPE LOCALITY: Galveston County, Texas, area of the city of Galveston.

SITE OF INFECTION: Small intestine.

SPECIMENS DEPOSITED: Holotype U.S. National Parasite Collection (USNPC) 88112; paratypes USNPC (2 specimens) 88113 and the University of Nebraska State Museum Harold W. Manter Laboratory (HWML) (3 specimens) 39905.

ETYMOLOGY: Named for the genus of the host from which it was collected.

Bursacetabulus macrobursus sp. n. (Fig. 3)

DESCRIPTION (BASED ON 10 ADULT SPECIMENS): With characteristics of genus. Body indistinctly bisegmented, 1,830 (1,470–2,250) μm long; forebody slightly spatulate, 1,250 (1,070–1,370) μm long by 885 (750–1,000) μm wide, hind body 1,025 (975–1,050) μm long by 740 (670–805) μm wide. Oral sucker subterminal, 62 (57–70) μm long by 70 (60–98) μm wide. Pseudosuckers well developed, 105 (87–133) μm long by 64 (50–75) μm wide. Acetabulum absent. Tribocytic organ circular to elliptical, 385 (375–400) μm long by 340 (330–350) μm wide. Prepharynx absent, pharynx 66 (57–75) μm long by 62 (47–73) μm wide, esophagus 25 (17–30) μm long, ceca terminating just posterior to middle of hind body. Ratio of pharynx to oral sucker 1:1.1. Testes smooth, tandem; anterior testis 190 (145–290) μm long by 240 (150–310) μm wide, posterior testis 187 (145–280) μm long by 260 (130–290) μm wide. Copulatory bursa large, suckerlike, surrounded by bell-shaped skirt, 454 (330–590) μm long by 630 (490–740) μm wide. Seminal vesicle voluminous, highly coiled, extending posteriorly from level of ovary to near anterior margin of copulatory bursa. Ovary median to slightly dextral, 105 (85–120) μm long by 110 (82–138) μm wide. Ootype located at level of anterior testis, near midline of body. Laurer's canal not observed. Vitelline follicles, distributed primarily in forebody, extending laterally into tribocytic organ and ventrolaterally into hind body to level of posterior testis. Uterus intercecal, with medial loops extending into tribocytic organ, joining seminal vesicle just above anterior margin of copulatory bursa. Eggs 89 (80–98) μm long by 57 (47–68) μm wide.

TYPE HOST: *Pelecanus occidentalis* Linnaeus.

TYPE LOCALITY: Galveston County, Texas, area of the city of Galveston.

SITE OF INFECTION: Small intestine.

SPECIMENS DEPOSITED: Holotype USNPC 88114; paratypes USNPC (2 specimens) 88115 and HWML (3 specimens) 39906.

ETYMOLOGY: Named for the large, bell-shaped skirt around the copulatory bursa.

Discussion

Bursacetabulus gen. n. bears some similarities to *Glossodiplostomoides* Bhalerao, 1942, *Hysteromorpha* Lutz, 1931, and *Neolaria* Lal, 1939 but can be distinguished from all genera of Diplostominae by having an inconspicuous pouch-like tribocytic organ that contains portions of both the uterus and vitellaria, a well developed suckerlike copulatory bursa, and shorter ceca that terminate some distance anterior to the posterior end. The new genus is most similar to *Ty-*

lodelphys Diesing, 1850 but differs in having a much shorter hind body and vitellaria that extend into the hind body only to the level of the posterior testis instead of beyond the testes. The new genus also lacks a prepharynx, a genital cone, an acetabulum, and a highly structured tribocytic organ as seen in species of *Tylodelphys*. The new genus is superficially similar to *Austrodiplostomum* Szidat et Nani, 1951, which also has an indistinctly bipartite body, may lack an acetabulum, lacks a genital cone, and has portions of the uterus entering the tribocytic organ. However, unlike *Austrodiplostomum, Bursacetabulus* gen. n. has a well-developed hind body and lacks a well-developed tribocytic organ. *Bursacetabulus macrobursus* sp. n. can be distinguished from *B. pelecanus* sp. n. by its larger body size and its large bell-shaped skirt around the copulatory bursa.

Acknowledgments

We thank the Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service, whose cooperation made this study possible. We also thank Dr. J. R. Lichtenfels for access to specimens of diplostomes from the U.S. National Parasite Collection and Trudy Beltz of Texas City, Dr. Jackie Cole of Galveston, and Dr. Tom Craig of the College of Veterinary Medicine, Texas A&M University, for providing specimens of diplostomes from brown pelicans.

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Obituary Notice

RICHARD M. SAYER
1928–1998

Elected to membership at the
417th Meeting, February 18, 1966

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Lobatocystis euthynni sp. n. (Digenea: Didymozoidae) from Mackerel Tuna (*Euthynnus affinis*) from Sulawesi Island, Indonesia

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ABSTRACT: *Lobatocystis euthynni* sp. n. was found encysted in pairs within the gill sinuses of mackerel tuna (*Euthynnus affinis*) from the island of Sulawesi, Indonesia. It differs from the other 2 species in the genus in having the smallest body size, unequal sizes of the partners, and no lobation on the hindbody. It differs further from both *L. yaito* Yamaguti, 1965, and *L. bengalensis* Hussain, Hanumantha Rao, and Shyamasundari, 1985, in the arrangement of the vitellaria and ovarian tubules and in the relatively large size of the tubular testes. All 3 species parasitize the same fish host with slightly different Indo-Pacific distributions. The new species co-occurs with *L. yaito* in one locality in Sulawesi.

KEY WORDS: *Lobatocystis euthynni,* new species, Didymozoidae, *Euthynnus affinis,* Sulawesi, Indonesia.

Although 67 heminth taxa were compiled for *Euthynnus affinis* by Pozdnyakov (1990), only 3 metazoan parasites have been reported for this fish host in Indonesia (Arthur, 1992). The first author has identified 59 taxa from mackerel tuna collected in 1994 and 1995 from 4 localities in Sulawesi (Celebes), Indonesia. In this report, a new didymozoid digenetic trematode will be described from one of the localities.

Materials and Methods

Fish were purchased from fish sellers and identified by colleagues at Universitas Hasanuddin in Ujungpandang and Universitas Haluoleo in Kendari. The fish were frozen, then thawed with the gills, liver, and digestive and reproductive systems removed and examined by standard parasitological methods. Helminths were preserved unflattened in warm acetic acid-formalin-ethanol, subsequently stained with carmine, and mounted in Permount.® Measurements are given as the ranges in micrometers; the egg size includes the mean and standard deviation in parentheses. Holotype and paratypes were deposited in the U.S. National Parasite Collection (USNPC).

Results

Lobatocystis euthynni sp. n. (Figs. 1–3)

Family Didymozoidae, subfamily Didymozoinae. Description based on 5 specimens. Encysted in pairs, partners unequal in size, with forebodies loosely associated with each other at shallow pockets of hindbodies. Completely hermaphroditic with unequal pairs in different stages of maturity, e.g., smaller of the pair less ovigerous. Forebody scoop shaped, 918–1,142 by 366–510, 49–52 at its narrowest, attached at center of hindbody in shallow pocket (Fig. 1). Oral sucker terminal, with muscular anterior, nonmuscular posterior parts, 164–219 by 90–100; pharynx rudimentary. Esophagus long, slender, dividing into ceca in midforebody; ceca narrow in forebody, not visible in hindbody. Genital pore at base of oral sucker. Hindbody triangular in shape with smooth edges, flattened anteriorly, rounded posteriorly, 1,081–3,142 by 959–1,958 (Fig. 2). Testes divided into 7–8 long, broad tubular, unbranched lobes arranged radially in anterior part of hindbody at its junction with forebody. Vas deferens sinuous, entering forebody and continuing anteriorly to end with metraterm at genital pore. Ovary comprising 7–8 long narrow branches, originating from genital complex at middle of hindbody, taking sinuous course to body periphery; branches confined mostly to posterior half of body. Mehlis gland complex situated at middle of hindbody, from which radiate vitelline, ovarian, and uterine branches (Fig. 3). Juel's organ an oval sac situated near Mehlis gland. Vitellaria largely confined to posterior half of hindbody, consisting of 7 primary branches originating as 2 groups from rounded vitelline reservoir situated adjacent to Mehlis gland. Each primary branch dividing into branches, resulting in numerous subbranches that extend to periphery of hindbody, where they terminate blindly. Uterus originating from Mehlis gland with numerous narrow coils that fill

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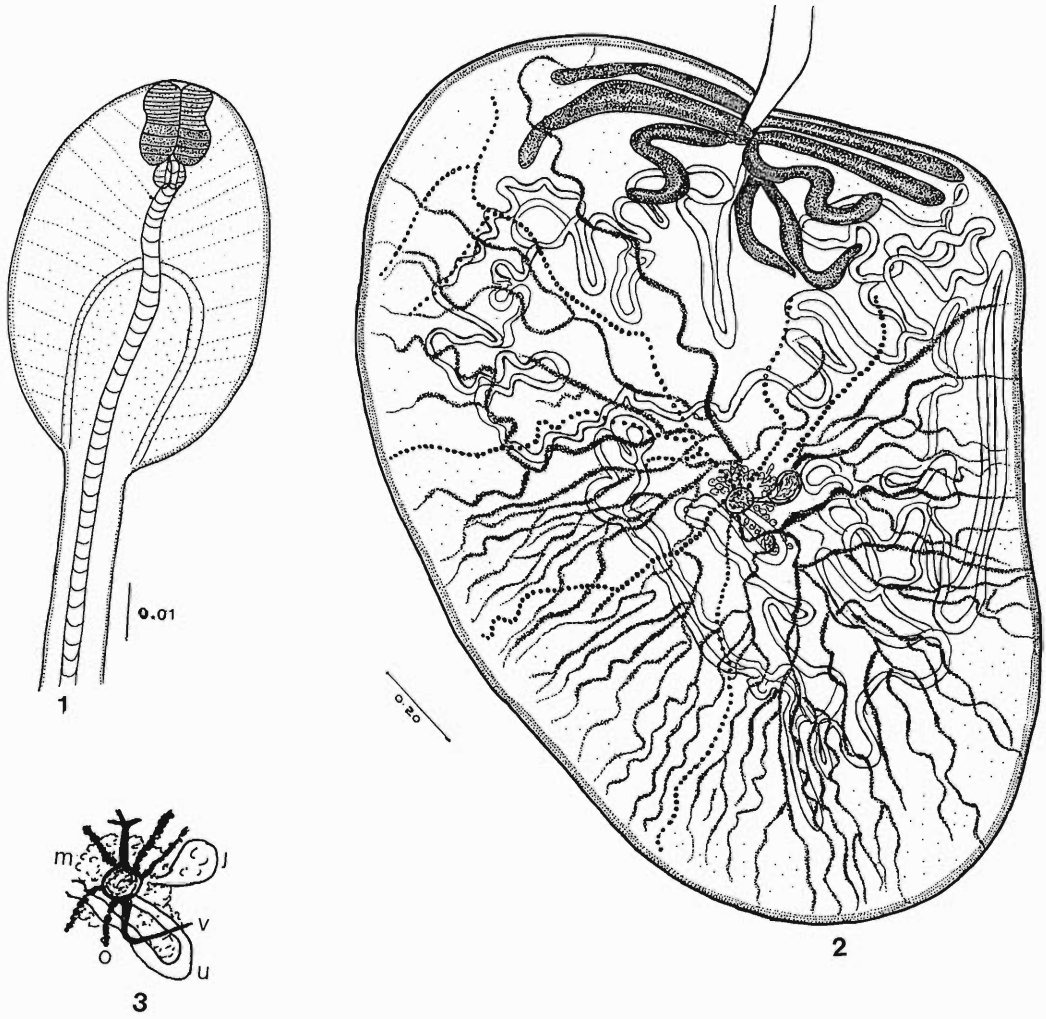

Figures 1–3. Holotype of *Lobatocystis euthynni* sp. n. from the gill sinus of *Euthynnus affinis*. 1. Forebody of *L. euthynni*. 2. Hindbody of *L. euthynni*. Scale of measurements in millimeters. 3. Genital complex of *L. euthynni*. j = Juel's organ, m = Mehlis gland, o = ovary, v = vitellaria, u = uterus.

entire hindbody without forming a uterine reservoir. Metraterm well developed with circular muscles, running straight anteriorly in intercecal space to join vas deferens at genital pore at base of oral sucker. Eggs small, bean shaped (n = 25) 12–20 by 7–10 (14.7 ± 1.79 by 8.36 ± 1.04).

Taxonomic summary

TYPE HOST: *Euthynnus affinis* (Cantor).

SITE IN HOST: Gill sinus.

DATE OF COLLECTION: July 1994.

PREVALENCE AND INTENSITY: 2/25, 1–2 pairs.

TYPE LOCALITY: Ujungpandang, Sulawesi Island, Indonesia.

HOLOTYPE: USNPC. 88295

PARATYPE: USNPC. 88296

ETYMOLOGY: The specific name is derived from the generic name of the host, *Euthynnus*.

Discussion

On the basis of the scoop-shaped forebody, triangular-shaped hindbody, radially arranged testes, and intertwining branches of the ovary and vitellaria, the didymozoid digenean was assigned to the genus *Lobatocystis* Yamaguti, 1965. The new species differs from the other 2, *L. yaito* Yamaguti, 1965, and *L. bengalensis* Hussain, Hanumantha Rao, and Shyamasundari,

1985, in the smooth hindbody, smaller body size, distribution of the ovarian and vitelline branches, and unequal size of the partners. The shape of the hindbody of *L. euthynni* is winglike, without the asymmetric lobation of *L. yaito* or the bilateral lobation of *L. bengalensis.* The hindbody is considerably smaller in size, with the holotype of *L. euthynni* measuring 3 mm in maximum length compared to more than 7–10 mm for the other 2 species. The site of *L. euthynni* is within the gill sinus in contrast to *L. yaito,* which is found on the gill arch, and *L. bengalensis,* which is reported on the "gills." The first author has observed and collected *L. yaito* (prevalence given later) and has observed the larger size, yellow coloration, and distinct asymmetric lobation of the paired cysts loosely attached to the tissue of the gill arches.

All 3 species are reported from the same host with slightly different Indo-Pacific distributions. Yamaguti (1965, 1970) described *L. yaito* from mackerel tuna in Hawaii. The first author has found *L. yaito* in 2 of 4 localities in Sulawesi, in 2/25 fish in Ujungpandang and 4/27 fish in Kendari. These locality records are new for *L. yaito.* None of the hosts infected with *L. yaito* in Ujungpandang was infected with *L. euthynni.* Madhavi (1982) reported *L. yaito* from the Bay of Bengal, so the type species appears to have the widest distribution. Hussain et al. (1985) also described *L. bengalensis* from the Bay of Bengal. All 3 helminths have low prevalence and intensity in their scombrid hosts.

Acknowledgments

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Nematodes of the Indian Star Tortoise, *Geochelone elegans* (Testudinidae) with Description of a New Species *Alaeuris geochelone* sp. n. (Oxyurida: Pharyngodonidae)

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ABSTRACT: Five species of pharyngodonid nematodes were recovered from the large intestines of captive Indian star tortoises, *Geochelone elegans* (Schoepff, 1794). These were identified as *Alaeuris geochelone* sp. n., *Mehdiella microstoma, Tachygonetria conica nicollei, T. dentata quentini,* and *T. macrolaimus dessetae.* The characteristics of *A. geochelone* sp. n. are a very long esophagus, about half of the body, the hemicircular broad caudal alae that reach to the postanal caudal papillae, gubernaculum with rounded knob at distal end, and two claw-shaped lateral lips of the cloaca. All the nematodes found represent new host records.

KEY WORDS: pharyngodonid nematoda, Indian star tortoise, *Geochelone elegans, Alaeuris geochelone* sp. n., *Mehdiella microstoma, Tachygonetria conica nicollei, T. dentata quentini, T. macrolaimus dessetae.*

The Indian star tortoise, *Geochelone elegans* (Schoepff, 1794), Testudinidae, is an herbivorous reptile that is distributed in India, Pakistan, and Sri Lanka (Iverson, 1992). This is one of the tortoises listed under the Convention on the International Trade in Endangered Species of Wild Fauna and Flora (CITES). The tortoises studied in this work were provided to us from Maruyama Zoo, Sapporo City, Hokkaido, and Tennoji Zoo, Osaka City, Osaka, in Japan. They were seized by Customs at Nagoya, Japan, in November 1995 and were placed in zoos. Their origin is unknown.

The parasite fauna of *G. elegans* has not been previously studied, but 6 genera and about 54 species of Pharyngodonidae have been described from tortoises (Adamson, 1994). In the present study, we describe a new species of *Alaeuris* Thapar, 1925, and report 4 other species of Pharyngodonidae from the Indian star tortoise.

Materials and Methods

Thirteen Indian star tortoises died in the Maruyama and Tennoji zoos between May and December 1996. Whole animals or viscera were fixed in 10% formalin. No specific cause of death was identified at necropsy, but nematodes were recovered from the large intestines of 7 tortoises. The nematodes were washed with water and cleared in lactophenol for identification. Drawings were made with an Olympus microscope drawing attachment. Measurements were done using an Olympus video micrometer (Model VM-30). Specimens for scanning electron microscopy (SEM) were fixed in 2% buffer glutaraldehyde (pH 7.3). After being treated in 2% tannic acid, the specimens were washed in distilled water, postfixed in 1% osmium tetroxide, dehydrated in an ethanol series, and critical point dried. Specimens were coated with gold-palladium and examined with a Hitachi field emission scanning electron microscope (Model S-4100) at 15 kV. Measurements are in micrometers unless otherwise noted, with range followed by number measured and mean ± standard deviation in parentheses.

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Results

Five species of nematodes were recovered, including a new species, *Alaeuris geochelone* sp. n. The other four species recovered are as follows: *Mehdiella microstoma* (Drasche, 1884) Seurat, 1918; *Tachygonetria conica nicollei* (Seurat, 1918) Petter, 1966; *Tachygonetria dentata quentini* Petter, 1966; and *Tachygonetria macrolaimus dessetae* Petter, 1966. Prevalence, mean intensity, and mean abundance of these species are presented in Table 1. All the nematodes found represent new host records. Specimens of each nematode species were deposited in the Laboratory of Parasitology, Department of Disease Control, Graduate School of Veterinary Medicine, Hokkaido University, Japan: *A. geochelone* sp. n. (Helm. Coll. No. 2973–2975), *M. microstoma* (Helm. Coll. No. 2976), *T. conica nicollei* (Helm. Coll. No. 2977), *T. dentata quentini* (Helm. Coll. No. 2978), and *T. macrolaimus dessetae* (Helm. Coll. No. 2979). The description of the new species follows.

Table 1. Nematodes from large intestines of 13 captive Indian star tortoises.

Species	Prevalence	Mean intensity ± SD (range)	Mean abundance
Alaeuris geochelone sp. n.	54% (7/13)	154.6 ± 217.35 (1–602)	83.2
Mehdiella microstoma	46% (6/13)	36.5 ± 40.19 (3–101)	16.9
Tachygonetria conica nicollei	23% (3/13)	139.7 ± 146.37 (50–257)	32.2
T. dentata quentini	8% (1/13)	18.0 (18)	1.4
T. macrolaimus dessetae	38% (5/13)	97.0 ± 142.80 (2–349)	37.3

Alaeuris geochelone sp. n. (Figs. 1 and 2)

GENERAL: Pharyngodonidae Travassos, 1919, *Alaeuris* Thapar, 1925. Body small and whitish with thick cuticle. Oral opening triangular to circular surrounded by circum oral ridge. Two small amphids present. Four inner papillae observed in surface view in lactophenol-treated specimens. Six cuticular flaps projecting into buccal cavity. Esophagus elongate, about half of body length. Bulb well developed. Nerve ring at anterior part of esophagus, excretory pore at side of bulb.

MALE (holotype and 14 paratypes): Total length 2.11–2.71 (n = 15, 2.35 ± 0.31) mm. Maximum width 195–289 (234 ± 42) near middle of body. Six cuticular flaps projecting into buccal cavity (Fig. 2A). Nerve ring 151–185 (169 ± 13) and excretory pore 863–1,077 (943 ± 72) from cephalic extremity. Esophagus 1.01–1.27 (1.15 ± 0.13) mm in length including bulb. Bulb 101–122 (110 ± 11) long and 140–153 (146 ± 6) wide. Vas deferens broad and packed with sperm. Tail short 71–90 (78 ± 7) with hemicircular broad caudal alae. Caudal alae width 63–69 (66 ± 3). Three pairs of genital papillae present, preanal, adanal, and postanal. The caudal alae hemicircular, narrows ahead of posterior papillae. Cloaca surrounded by 2 claw-shaped lips. Spicule sharp and straight, 89–110 (100 ± 9) long. Gubernaculum Y-shaped, 31–45 (38 ± 6) long, terminating in knob bearing 2 small round projections (Fig. 2B).

FEMALE (allotype and 14 paratypes): Total length 2.70–3.65 (n = 15, 3.31 ± 0.42) mm. Maximum width 257–456 (345 ± 92) near middle of body. Three cuticular flaps projecting into buccal cavity. Nerve ring 180–245 (202 ± 18) and excretory pore 1.14–1.49 (1.29 ± 0.13) mm from cephalic extremity. Esophagus 1.50–2.05 (1.70 ± 0.28) mm in length including bulb. Bulb 125–141 (131 ± 6) long and 153–178 (162 ± 10) wide. Vulva 1.92–2.35 (2.22 ± 0.26) mm from cephalic extremity. Tail conical, 113–167 (138 ± 21) long. Eggs unembryonated 109–134 (121 ± 10) long by 51–72 (60 ± 8) wide.

Taxonomic summary

TYPE HOST: Indian star tortoise, *Geochelone elegans* (Schoepff, 1794) (Testudines: Testudinidae).

SITE OF INFECTION: Large intestine.

TYPE LOCALITY: India, Pakistan, or Sri Lanka.

TYPE SPECIMENS: Holotype (Helm. Coll. No. 2973), allotype (Helm. Coll. No. 2974), and paratypes (Helm. Coll. No. 2975) deposited in Laboratory of Parasitology, Department of Disease Control, Graduate School of Veterinary Medicine, Hokkaido University, Japan.

ETYMOLOGY: The species was named after the host tortoise.

Remarks

Nematodes of the genus *Alaeuris* are parasites of herbivorous tortoises (Testudinidae) and lizards (Iguanidae) and rarely of carnivorous reptiles (Petter and Quentin, 1976). This genus was proposed by Thapar (1925) with type species *A. numidica numidica* (Seurat, 1918) Petter, 1966 (syn. *A. alaeuris* Thapar, 1925), from the large intestine of *Testudo gracea ibera* Pallas, 1814 (syn. *T. ibera*), and now includes 33 species (Baker, 1987). We placed the new nematode in the genus *Alaeuris,* because it possesses the robust caudal alae and the ventral papillae of the caudal appendage that are characteristic of *Alaeuris* (Petter and Quentin, 1976). We have found only 1 report on the occurrence of *Alaeuris* from *Geochelone radiata* (Shaw, 1802) (syn. *Testudo radiata*) in Madagascar (Petter, 1966). This species is *A. numidica madagascariensis,* but a number of species have been found from tortoises of the genus *Testudo.* The latter genus is closely related to *Geochelone.* The *Alaeuris* spp. recovered from *Testudo* are as follows: *A.*

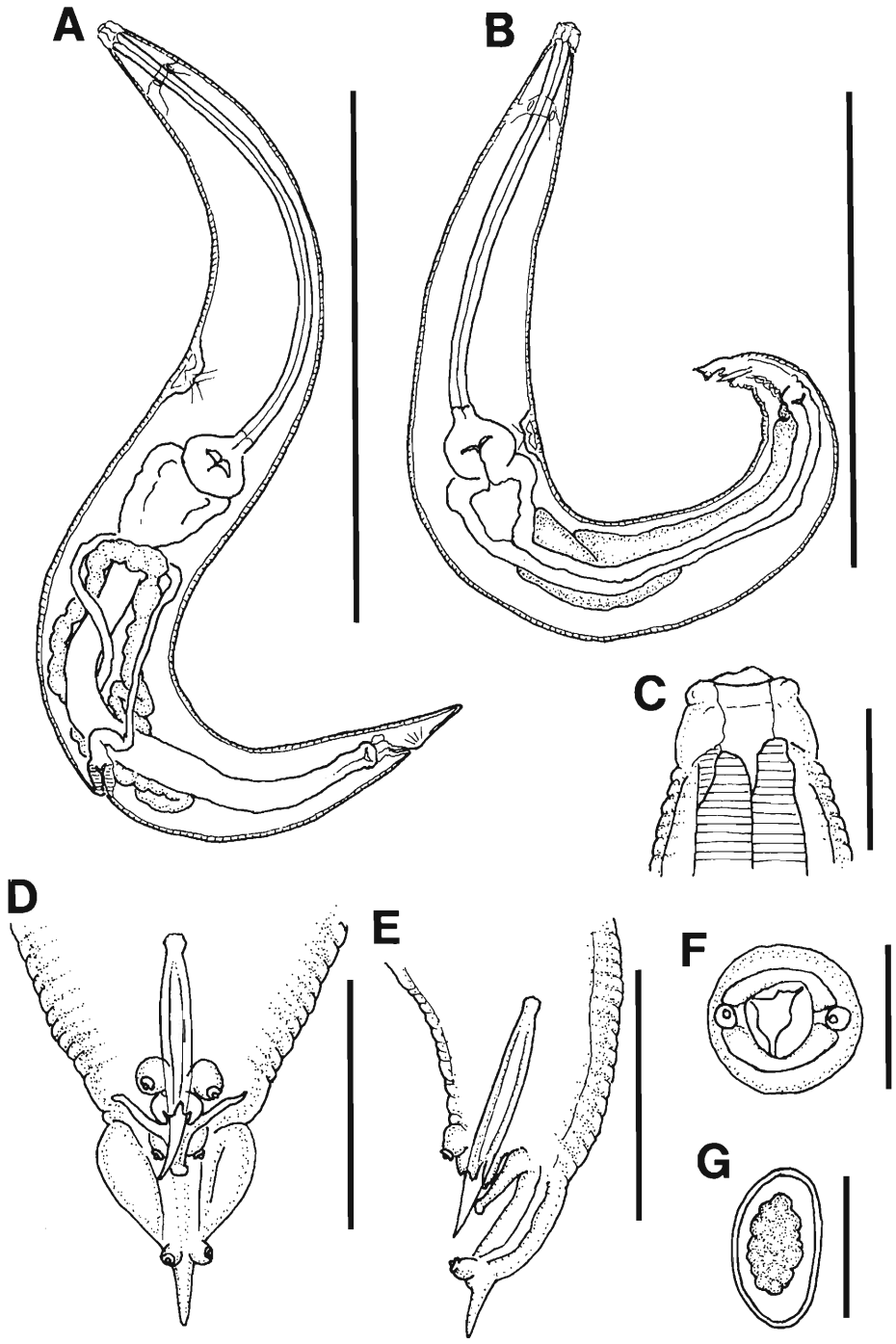

Figure 1. *Alaeuris geochelone* **sp. n. A. Female. B. Male. C. Cephalic end of female, lateral view. D. Caudal end of male, ventral view. E. Caudal end of male, lateral view. F. Cephalic end of female, apical views. G. Egg. Scale bar: A, B = 1 mm; C = 50 μm; D, E = 100 μm; F = 50 μm; G = 100 μm.**

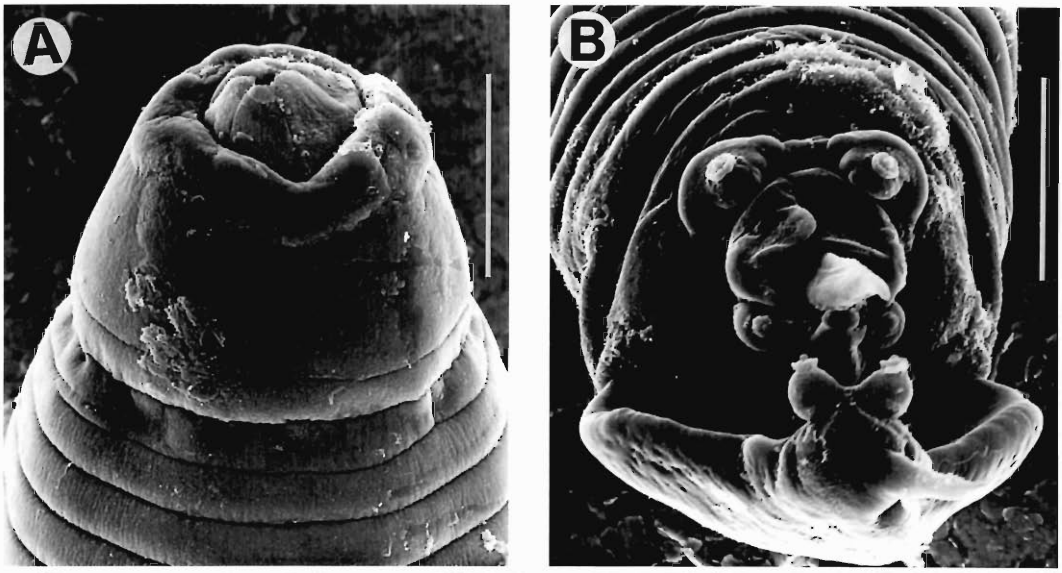

Figure 2. ***Alaeuris geochelone*** **sp. n., SEM micrographs. A. Cephalic end of male, lateral view. B. Caudal end of male. Bar = 20 μm.**

auricularis (Walton, 1942) Petter, 1966, *A. dupuisi* Petter, 1966, *A. macroptera* (Walton, 1942) Petter, 1966, *A. numidica numidica* (Seurat, 1918) Petter, 1966, *A. pharyngodentata* (Walton, 1942) Petter, 1966, *A. quadrilabiata quadrilabiata* Ortlepp, 1933, and *A. quadrilabiata insularis* Petter, 1966. Morphologically, the new nematode is most similar to *A. n. numidica* and *A. n. madagascariensis,* but it can be easily distinguished by characters such as a very long esophagus about half of the body length, the hemicircular broad caudal alae that reach the postanal caudal papillae, gubernaculum with rounded knob at the distal end, and 2 claw-shaped lateral lips of the cloaca. Body size of *A. geochelone* sp. n. is smaller than *A. n. numidica* and *A. n. madagascariensis.* Measurements of these nematodes are presented in Table 2. Petter and Brygoo (1972) reported body size variation of nematodes by host species; however, our new species has other distinct characteristics. The spicule (100 μm) is shorter than *A. n. numidica* (180 μm) but is not as short as *A. n. madagascariensis* (80 μm). Petter (1966) described the cuticule of *A. n. madagascariensis* as detached from the body in the posterior part, but this char-

Table 2. Comparison of ***Alaeuris numidica*** **and** ***A. geochelone*** **sp. n.**

	Petter, 1966 *Alaeuris numidica numidica*		Petter, 1966 *A. n. madagascariensis*		Our specimens *A. geochelone* sp. n.	
	Female	Male	Female	Male	Female (n = 15)	Male (n = 15)
Total length (mm)	5.7	3.4–4.7	5.2	3.8	3.31 ± 0.42	2.35 ± 0.31
Maximum width	400	260–300	500	300	345 ± 92	234 ± 42
Nerve ring	300	200	250	200	202 ± 18	169 ± 13
Excretory pore (mm)	2.2	1–1.8	1.18	1.4	1.29 ± 0.13	943 ± 72
Vulva from cephalic extremity (mm)	3.9		3.5		2.22 ± 0.26	
Esophagus (mm)	2.25	1.55–1.65	1.65	1.35	1.70 ± 0.28	1.15 ± 0.13
Tail	150	80–90	150	60	138 ± 21	78 ± 7
Eggs	120 × 70		140 × 60		121 ± 10 × 60 ± 8	
Spicule		180		80		100 ± 9

acter was not observed in our specimens. This is the first report of *Alaeuris* from *G. elegans*.

Discussion

Indian star tortoises in this study were classified in the genus *Geochelone* according to the taxonomy of Ernst and Barbour (1989). Unfortunately, their origin is unknown; however, they may have originated from India, Pakistan, and Sri Lanka, where they normally occur (Iverson, 1992).

Members of family Testudinidae are terrestrial tortoises and are found primarily in tropical portions of Africa, Madagascar, India, Southeast Asia, South America, Aldabra Atoll, and the Galapagos Archipelago (Ernst and Barbour, 1989). However, the fossil record shows tortoises were much more widespread in northern Europe and England, central Asia, the West Indies, and North America to southern Canada. The family is presently composed of 12 genera and 50 species (Ernst and Barbour, 1989).

The first reptile appeared in the Triassic. Parasitic nematodes of vertebrates are presumed to be derived from soil nematodes (Bain and Chabaud, 1979), and parasitism probably began with the appearance of terrestrial vertebrates (Anderson, 1984). According to Baker (1984), most nematode groups that evolved in amphibians and reptiles have been shown to be at least Mesozoic in age. Older amphibian and reptilian groups have proportionally more nematode species than the more recently evolved groups (Baker, 1984).

Two or more species of Oxyurida frequently occur in the same host individual (Petter, 1966). We observed concurrent infections of 5 species in 1 host in this study. *Alaeuris geochelone* sp. n. had the highest intensity and prevalence among the nematodes collected (Table 1). All nematodes are the first record from *G. elegans* from South Asia. The same nematodes have been reported from Europe, Africa, and Russia (Baker, 1987). It would appear, therefore, that these parasitic nematodes evolved in tortoises before their hosts dispersed.

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Inglechina virginiae sp. n. (Nematoda: Seuratidae) from *Sminthopsis virginiae* (Marsupialia: Dasyuridae) from Northern Australia

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ABSTRACT: *Inglechina virginiae* sp. n. (Nematoda: Seuratidae: Echinonematinae) is described from specimens collected from the small intestine of the red cheeked dunnart *Sminthopsis virginiae* (Marsupialia: Dasyuridae) from the Kimberley region and the Northern Territory, Australia. This parasite was found also in the northern brown bandicoot *Isoodon macrourus* (Marsupialia: Peramelidae) from the Northern Territory. *Inglechina virginiae* is allocated to *Inglechina* because it has 3 rows of cephalic hooks but no body hooks on the esophageal region of the cuticle. It is distinguished from its congener, *I. australis,* in having the second row of cephalic hooks longer than the first, denticles surrounding the mouth opening, a more extensive region of cuticular bosses on the male tail, shorter spicules, and 4 pairs of caudal papillae on the tail tip. The fourth stage larva of *I. virginiae* can be distinguished from fourth stage larvae of *Linstowinema,* the other genus in the Echinonematinae in which the adults have 3 rows of cephalic hooks, in having 2 rather than 3 rows of cephalic hooks.

KEY WORDS: Nematoda, Seuratidae, Echinonematinae, *Inglechina,* marsupial, dasyurid, Australia.

The Echinonematinae, a subfamily endemic to Australia, has been allocated to the Seuratidae (Spirurida) because of affinities with *Seuratum* species (Quentin, 1971; Chabaud et al., 1980). Derived from ancestors close to parasites of bats, the 3 known echinonematine genera have evolved characteristic arrays of body hooks and spines (Chabaud et al., 1980). The type genus *Linstowinema,* containing 8 species (Smales, 1997), has 3 rows of cephalic hooks and up to 18 rows of anterior body hooks; the remainder of the body surface is covered with numerous rows of spines. The monotypic genus *Seurechina* has no cephalic or body hooks but is covered in spines.

As presently constituted, the third genus, *Inglechina,* erected by Chabaud et al. (1980) for forms with cephalic hooks and body spines but no anterior body hooks, is monospecific. *Inglechina australis* (Inglis and Mawson, 1967) was described as *Echinonema australis* from the dasyurid marsupial, the fat-tailed dunnart, *Sminthopsis crassicaudata* (Gould, 1844).

The echinonematine genera occur only in peramelid and dasyurid marsupial hosts. The dasyurids are small carnivores exhibiting an array of primitive morphological characteristics (Morton et al., 1989), and the peramelids (bandicoots) are opportunistic omnivores with a mix of primitive and specialized features (Gordon and Hulbert, 1989). These 2 families are thought to be closely related, and members of both groups readily include arthopods in their diets (Gordon and Hulbert, 1989; Morton et al., 1989).

Examination of material dissected from the red cheeked dunnart *Sminthopsis virginiae* (Tarragon, 1847) revealed a new species of *Inglechina* that is described herein. Fourth stage larvae were also found in 1 host, enabling some comment on the differentiation of larvae of *Inglechina* and *Linstowinema,* the other genus within the subfamily Echinonematinae that has cephalic hooks.

Materials and Methods

Specimens were dissected from *Sminthopsis virginiae,* fixed in hot 10% formalin, stored at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Wildlife and Ecology collection, Canberra, in 70% ethanol, and examined after clearing in lactophenol. Measurements are given as range (mean) and were made with the aid of an ocular micrometer or drawing tube and map measurer. Drawings were made with the aid of a drawing tube.

Description

Inglechina virginiae sp. n. (Figs. 1–8)

GENERAL: Small worms, anterior end with cephalic bulb bearing 3 rows of hooks, each row containing 14 (male) or 16 (female) large hooks, second row longest, third row shortest (Fig. 1). Mouth opening triangular in outline, with den-

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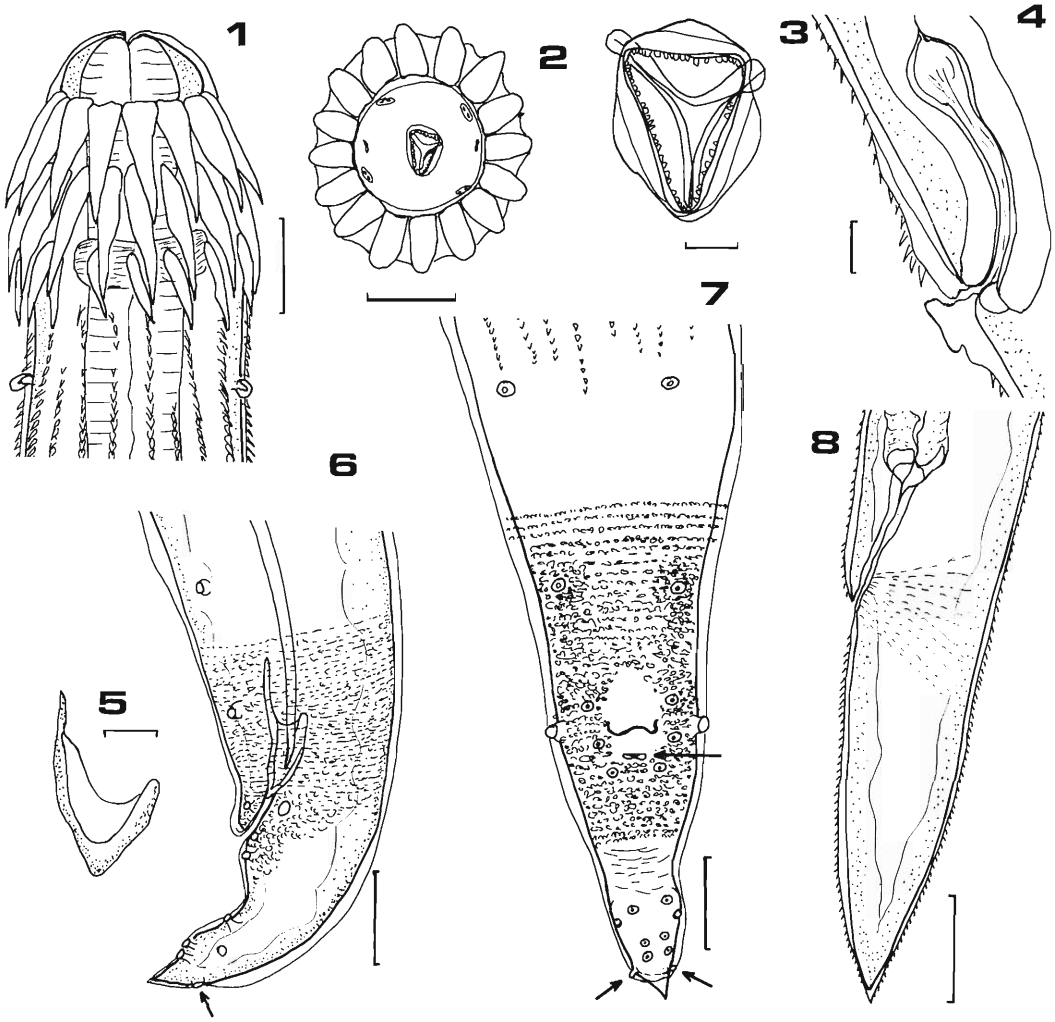

Figures 1–8. ***Inglechina virginiae*** **sp. n. from** ***Sminthopsis virginiae*** **from northern Australia. 1. Anterior end, dorsal view. Bar = 160 μm. 2. Anterior end, en face view. Bar = 160 μm. 3. Mouth, en face view showing denticles. Bar = 10 μm. 4. Vagina, lateral view. Bar = 25 μm. 5. Gubernaculum, ventral view. Bar = 50 μm. 6. Male posterior end, left lateral view. Bar = 160 μm. 7. Male posterior end, ventral view. Bar = 160 μm. 8. Female posterior end, lateral view. Bars = 100 μm. Arrows indicate cuticular projections posterior to cloacal opening and position of phasmids.**

ticles, without lips or liplike structures. Four double submedian cephalic papillae, 1 pair amphids (Figs. 2, 3). Remainder of body with numerous rows of spines extending posteriorly; number of rows of spines increasing progressively to 29 (male) or 34 (female) at midbody, decreasing posteriorly, extending over 70% of body surface dorsally, almost reaching anterior pair of caudal papillae ventrally (male) or extending over entire body (female). Esophagus simple, club shaped, 7–10% body length. Nerve ring surrounding esophagus within cephalic bulb; excretory pore anterior to deirids, both posterior to cephalic bulb.

MALE (measurements of 10 specimens): Length 3.1–5.3 (4.6) mm, width 145–240 (170) mm. Cephalic bulb 110–150 (135) μm long by 100–155 (125) μm wide; cephalic hooks of first row 61–83 (75) μm, second row 77–100 (86) μm, third row 50–60 (56) μm long. Esophagus 500–750 (640) μm long. Deirids 145–195 (156) μm, nerve ring 119 μm (n = 2), excretory pore

165 μm (n = 2) from anterior end. Spicules equal, similar, without alae, 370–470 (410) μm long, about 10% body length. Gubernaculum subtriangular in ventral view, right edge extended anteriorly (Fig. 5), 60–80 (67) μm (n = 6). Ten pairs caudal papillae; 3 pairs ventral and immediately pre-, ad-, and postcloacal, respectively; 1 pair lateral adcloacal, 2 pairs lateral precloacal, all same size; 4 pairs papillae, 1 pair phasmids well posterior to cloaca near tail tip. Cloacal region with small cuticular bosses extending anteriorly beyond level of second pair lateral papillae. Doubled cuticular projection posterior to cloacal opening (Figs. 6, 7). Tail 80–125 (110) μm.

FEMALE (measurements of 9 specimens): Length 7–10 (9) mm, width 100–390 (265) μm. Cephalic bulb 127–182 (161) μm long by 132–168 (157) μm wide; cephalic hooks of first row 68–94 (81) μm, second row 77–109 (97) μm, third row 60–76 (68) μm long. Esophagus 660–1,055 (870) μm long. Deirids 155–235 (203) μm, excretory pore 197–245 μm (n = 3); nerve ring 145 μm (n = 1) from anterior end. Vulva 2.7–3.9 (3.3) mm from anterior end. Vagina 150 (n = 2) μm long, directed anteriorly (Fig. 4). Monodelphic. Tail 495–700 (595) μm long (Fig. 8). Eggs almost spherical 40–50 (45) μm by 36–43 (41) μm.

FOURTH STAGE LARVA (measurements of 10 specimens): Length 1,350–1,800 (1,525) μm, width 74 μm. Cephalic bulb with 2 rows of cephalic hooks, remainder of body with rows of spines extending to tail tip.

TYPE HOST: *Sminthopsis virginiae* (Tarragon, 1847).

TYPE LOCALITY: Mitchell Plateau, Kimberley Region (15°08′S, 125°46′E), Western Australia.

SITE OF INFECTION: Small intestine.

DATE OF COLLECTION: 1982.

ETYMOLOGY: The species name is taken from the species name of the host.

SPECIMENS DEPOSITED: WAM 80-98 (holotype), WAM 81-98 (allotype), WAM 82-98, WAM 53-98, WAM 54-98, WAM 58-98 (14 male, 7 female, 6 fragments of female paratypes) in the West Australian Museum, Perth. AHC 31275, AHC 31276, AHC 31277 (4 male, 2 female, 1 fragment of female paratypes) in the South Australian Museum, Adelaide. N3308, from *S. virginiae* collected from McIlwraith Range, Cape York, Northern Queensland, 13 August 1990 (2 males, 8 females, 10 larvae) and from *S. virginiae* collected from Coomalie Creek, Northern Territory, 2 August 1992 (1 male, anterior end); N4412 from *Isoodon macrourus* collected from Coomalie Creek, Northern Territory, 1 August 1992 (1 male), in the Wildlife and Ecology collection, CSIRO, Canberra.

REMARKS: *Inglechina virginiae* can be distinguished from *I. australis,* the type and only other species in the genus, in having the second row of cephalic hooks longer than the first rather than the first longer than the second. Although the lengths of the cephalic hooks in each row differ among individuals, the relative length of the 3 rows remains consistent for each worm. The denticles surrounding the mouth opening of *I. virginiae* are not present in *I. australis.* This species can be further distinguished from *I. australis* in having shorter spicules, 370–470 μm compared with 460–520 μm for *I. australis,* 4 pairs of caudal papillae on the tail tip, not 3 as in *I. australis,* the cloacal region not inflated but with more extensive cuticular embossing (Fig. 7; Inglis and Mawson, 1967, p. 174, fig. 4). Both species have a doubled cuticular projection just posterior to the cloacal opening, but only *I. australis* has a single median papillalike structure on the anterior lip of the cloaca.

Discussion

The type species, *I. australis,* occurring in the dasyurid host *Sminthopsis crassicaudata,* has only been reported from Oodnadatta in northern South Australia. *Inglechina virginiae,* occurring in the dasyurid *S. virginiae* and the bandicoot *Isoodon macrourus* (Gould, 1842) by contrast, is reported for the first time from the Northern Territory and northern Western Australia.

The finding of a single male specimen of *Inglechina virginiae* in *Isoodon macrourus* is the only instance of the genus occurring in bandicoots. Given that *I. virginiae* was collected from *S. virginiae* in the same locality, this infection may be accidental. However, *I. virginiae* may normally occur in bandicoots. The Echinonematinae have arthropods as intermediate hosts (Chabaud et al., 1980) and both dasyurids and peramelids (bandicoots) are insectivorous. This feeding behavior could explain the occurrence of *I. virginiae* in both groups. More animals are needed from the region to determine whether bandicoots are accidental or regular hosts for *I. virginiae.*

Two genera in the Echinonematinae, *Inglechina* and *Linstowinema,* have 3 rows of cephalic hooks. The fourth stage larvae of *Linstowinema* also have 3 rows of cephalic hooks (Smales, pers. obs.), but those of *Inglechina* have only 2. In both genera, the larvae have similar body spination, i.e., rows of spinules extending posteriorly from the cephalic bulb to the tail tip. Therefore the number of rows of cephalic hooks can be used to distinguish between the larvae of these 2 species.

Acknowledgments

We thank Professor A. Chaubaud, Dr. D. Spratt, and Dr. P. Presidente for giving us access to specimens.

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Pharyngodon oceanicus sp. n. (Nematoda: Pharyngodonidae) from the Oceanic Gecko, *Gehyra oceanica* (Sauria: Gekkonidae) of the Pacific Islands

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ABSTRACT: One hundred twenty-six *Pharyngodon oceanicus* sp. n. were found in the large intestines of 14 of 37 adult *Gehyra oceanica* collected from the Cook and Society islands. *Pharyngodon oceanicus* sp. n. represents the thirty-first species of the genus and the second species to be described from islands of the Pacific Ocean. It can be distinguished from all other species of *Pharyngodon* by the shape of the egg and by the presence of a cluster of spines at the base of the tail of the female.

KEY WORDS: *Pharyngodon oceanicus* sp. n., Pharyngodonidae, *Gehyra oceanica*, Gekkonidae, Pacific Islands.

The oceanic gecko *Gehyra oceanica* (Lesson, 1830) was originally described from Tahiti but occurs in Australia, New Zealand, Indonesia, and throughout Oceania (Welch et al., 1990). It is a common arboreal species that frequents human habitations (McCoy, 1980). In a recent helminthological survey, 5 of 7 *G. oceanica* collected from the Cook Islands were found to harbor 23 male and 33 female nematodes of a previously undescribed species of *Pharyngodon* Diesing, 1861. Subsequently, 7 of 30 *G. oceanica* from the Society Islands were found to be infected with 20 males and 50 females of the same unidentified species of *Pharyngodon*.

The genus *Pharyngodon* was established by Diesing (1861) with *P. spinicauda* (Dujardin, 1845) from a lizard, *Lacerta muralis*, collected at St. Malo, France, as the type species. Skrjabin et al. (1960) revised the genus to retain only those species in which males have well-developed caudal alae forming a genital bursa enveloping the 3 pairs of caudal pedunculate papillae and females have the vulva in the anterior half of the body. There are currently 30 species (an additional 4 species, *P. boulengerula* Ubelaker, 1965, *P. elongata* Markov and Bogdanov, 1961, *P. sphaerodactyli* Barus and Coy Otero, 1974, and *P. polypedatis* Yamaguti, 1941, are known only from female specimens and are designated as *species inquirendae*). Species of *Pharyngodon* occur primarily in lizards of the families Gekkonidae, Phrynosomatidae, Scincidae, and Teiidae; however, 2 species, *Pharyngodon bursatus* Rao, 1980, in *Euphlyctis cyanophlyctis* (=*Rana cyanophlyctis*), and *P. schistopapillatus* Rao, 1980, from *Bufo viridis*, are known from amphibians. Of the species infecting lizards, 9 are found in the Palaearctic Zoogeographical Realm, 5 each in the Nearctic and Australian realms, 4 in the Neotropical Realm, 3 in the Oriental Realm, 1 in the Ethiopian Realm, and 1 in Oceania.

Materials and Methods

Of the 37 *G. oceanica* examined in this study, 7 were collected on Rarotonga, Cook Islands (21°30′S, 160°00′W) in 1991; 10 on Tahiti, Society Islands, French Polynesia (17°42′S, 149°30′W) in 1991; and 20 on Moorea, Society Islands (17°28′S, 149°50′W) in 1992. All were captured by hand and fixed in neutral buffered 10% formalin, then preserved in 70% alcohol. Specimens from Moorea were deposited in the herpetology collection of the Natural History Museum of Los Angeles County as LACM No. 141009–141028. The body cavity was opened by a longitudinal incision from vent to throat, and the gastrointestinal tract was removed and opened longitudinally. Nematodes were placed in undiluted glycerol, allowed to clear, and examined under a light microscope. Measurements are in micrometers unless indicated otherwise.

Results

Five of the 7 (71%) *G. oceanica* collected from Rarotonga, 4 of 10 (40%) from Tahiti, and 3 of 20 (15%) from Moorea were infected. A description of the new species follows.

Pharyngodon oceanicus sp. n. (Figs. 1–8)

Description

Males with caudal alae that envelop posterior postcloacal pair of pedunculate papillae; females

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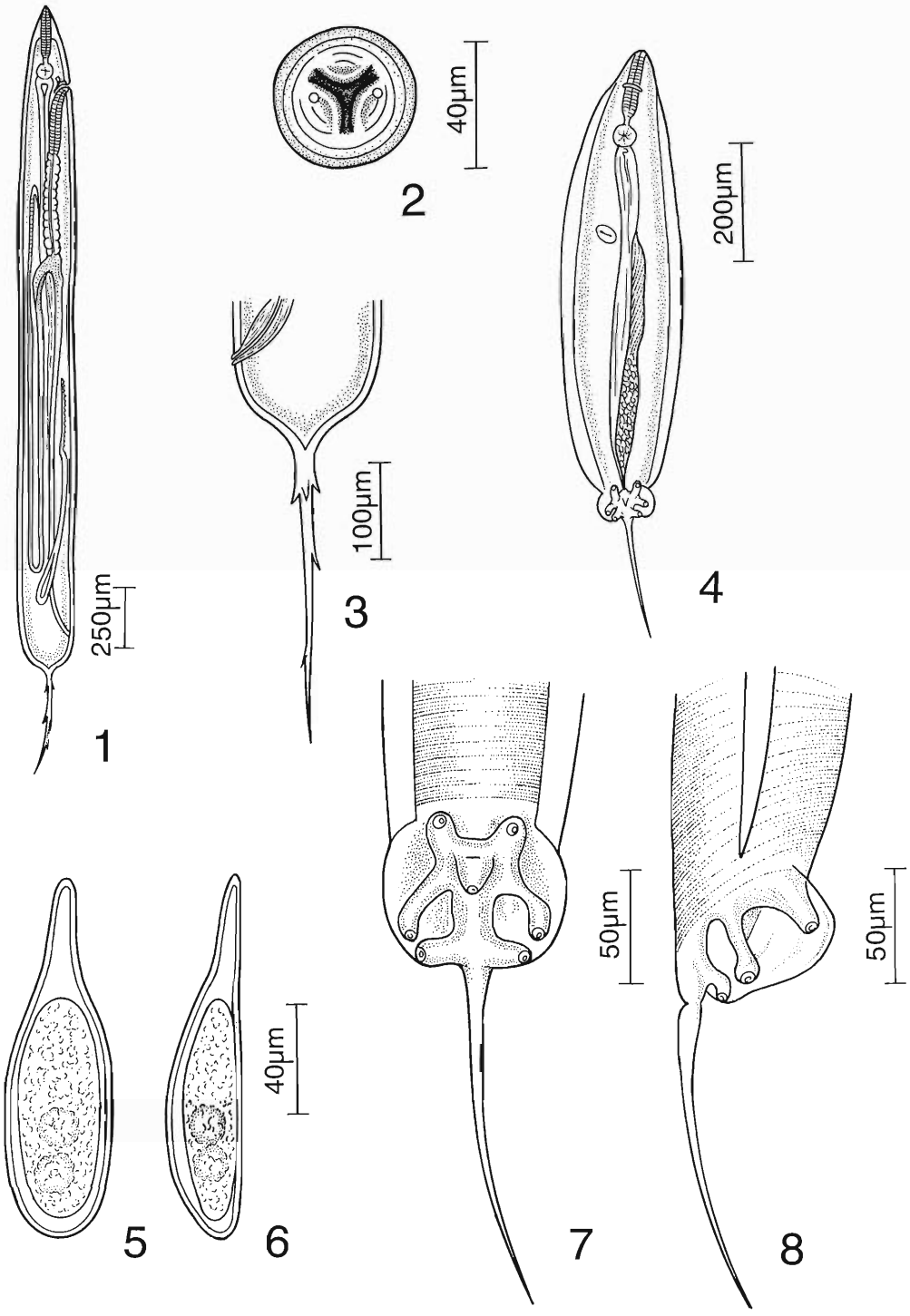

Figures 1–8. ***Pharyngodon oceanicus*** **sp. n. 1. Female, entire, lateral view. 2. Female, *en face* view. 3. Posterior end of female, lateral view. 4. Male, entire. 5. Egg, dorsal view. 6. Egg, lateral view. 7. Posterior end of male, ventral view. 8. Posterior end of male, lateral view. Scale bar values are given in micrometers.**

with vulva in anterior half of body. Nematodes of small size with cylindrical body tapering anteriorly and posteriorly. Cuticle with distinct transverse striations extending from behind lips to level of anus. Lateral alae present in males only. Mouth bounded by 3 lips. Esophagus ending in valvulate, spherical bulb separated from esophageal body by small constriction. Filamentous tail in both sexes.

MALE (based upon 10 specimens; mean measurement and range in micrometers): Small, white, fusiform nematodes tapering both anteriorly and posteriorly; length 1,413 (1,111–1,820); width at level of excretory pore 152 (100–190). Lateral alae 12 (10–13) wide, extending from level of nerve ring to middle of genital bursa. Cuticle with fine cross-striations at 1-μm intervals, extending entire length of body. Mouth opening surrounded by 3 lips, V-shaped notch between each. One small, pedunculate amphid on each ventrolateral lip. Esophagus (excluding bulb) 134 (97–160); bulb length 50 (46–54), bulb width 48 (46–54). Nerve ring 111 (103–120), excretory pore 497 (360–590) from anterior end, respectively. Well-developed caudal alae present. Three pairs of caudal papillae; precloacal pair situated on slightly inflated anterior portion of caudal end, adcloacal pair posteriolaterally directed, and postcloacal pair enclosed by caudal alae, behind adcloacal pair. Filiform tail extending 152 (137–177) beyond postcloacal papillae. Spicule absent; prominent genital cone with the posterior lip supported by sclerotized V-shaped structure. Single vas deferens and testis terminating at level of excretory pore.

FEMALE (based on 10 gravid specimens): Slender, white, cylindrical nematodes tapering anteriorly and posteriorly; posterior supporting filamentous tail. Length 6,150 (4,500–7,500); maximum width 276 (228–325). Lateral alae absent. Cuticle with fine cross-striations at 3–4-μm intervals. Esophagus (excluding bulb) 223 (204–242), bulb length 84 (77–91), bulb width 80 (68–88). Nerve ring 107 (91–125); excretory pore 353 (255–434), vulva 409 (293–510) from anterior end, respectively. Vagina directed posteriorly, thick, muscular anterior portion 430 (322–510) and glandular posterior portion 647 (536–765). Ovaries with flattened oocytes arranged in single file. Anterior fifth of body usually devoid of ovarian and uterine coils. Filamentous portion of tail 415 (357–484) with cluster of 2–3 heavy spines 45 (34–57) from junction with body, 3–4 small spines along remaining length. Thick-shelled nonoperculated eggs 137 (131–143) by 34 (31–37) flattened on one side, one end drawn out, poles unadorned. Pronucleus stage of development at deposition.

TYPE SPECIMENS: Holotype male, U.S. National Parasite Collection, Beltsville, Maryland USNPC No. 87745. Allotype female, USNPC No. 87746. Paratypes, USNPC No. 87747.

TYPE HOST: *Gehyra oceanica.*

TYPE LOCALITY: Rarotonga, Cook Islands.

OTHER LOCALITIES: Moorea, Tahiti, Society Islands.

ETYMOLOGY: The specific epithet is derived from the general name of the nematode's geographic location.

Discussion

The general morphology of *P. oceanicus* sp. n. allows its assignment to the Oxyuroidea Railliet, 1916, Pharyngodonidae Travassos, 1919. Within the family, there are 3 genera characteristic of reptiles, which exhibit a vulvar opening in the anterior part of the body just behind the postbulbar excretory pore: *Pharyngodon, Spauligodon* Skrjabin, Schikhobalova, and Lagodovskaja, 1960, and *Skrjabinodon* Inglis, 1969. These genera are distinguished by the relationship of the caudal alae to the genital papillae; males of *Pharyngodon* have well-developed caudal alae that form a genital bursa enveloping all genital papillae; males of *Spauligodon* have the posterior pair of papillae excluded from the genital bursa; and males of *Skrjabinodon* lack caudal alae. Inclusion of the described specimens in the genus *Pharyngodon* is based on the position of the vulva and the configuration of the caudal alae.

Species of *Pharyngodon* are separated on the presence or absence of a spicule, the morphology of the caudal alae, the shape of the egg, the presence or absence of spines on the tail filament of adults, and their distribution (see Table 1 in Bursey and Goldberg [1996]). One other species has been reported from islands of the Pacific Ocean, namely *P. lepidodactylus* from Hawaii. *Pharyngodon oceanicus* is easily distinguished from *P. lepidodactylus* by the tail filament of the female; in *P. lepidodactylus,* a subulate tail filament without spines is in contrast to the filamentous tail filament with cuticular spines of *P.*

oceanicus. Both *P. lepidodactylus* and *P. oceanicus* have "bottle-shaped" eggs, i.e., one end is drawn out into a narrow projection, which contrast with the truncated, fusiform, or oval eggs of the other species. In *P. lepidodactylus,* the eggs have cuticular knobs at the poles; the egg poles of *P. oceanicus* are unadorned.

Acknowledgments

Specimens of *G. oceanica* from Moorea were collected under permit 4186/BCO issued to the second author by the Haut-Commissariat de la République en Polynésie Française. Kathryn A. Hanley provided nematodes from *G. oceanica* collected on Rarotonga and Tahiti. Peggy Firth prepared the illustrations constituting Figures 1–8.

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Diagnostic Parasitology Course

The "Diagnostic Parasitology Course" is being offered 2–13 August, 1999 at the Uniformed Services University of the Health Sciences, Bethesda, Maryland 20814-4799. This course will consist of a series of lectures and hands-on laboratory sessions covering the diagnosis of parasitic infections of humans. In addition to the examination of specimens, participants will be able to practice various methods used in the diagnosis of intestinal, blood, and tissue parasitic diseases. Parasitic diseases encountered throughout the world will be included. Slide presentations and videotapes will be available for study. The course will be held at the University's campus, utilizing up-to-date lecture rooms and laboratory facilities. Microscopes will be available on a loan basis and laboratory supplies will be provided. Certain reference specimens will also be available for personal use.

The registration fee for the 2-week course is US$1,000.00. U.S. Government employees, including military personnel, may take the course at a reduced rate. Enrollment is limited, so those interested should register as soon as possible. Previous laboratory experience is recommended.

For further information contact Dr. John H. Cross, (301) 295-3139 or Ms. Ellen Goldman, (301) 295-1971.

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Adult *Gnathostoma* cf. *binucleatum* Obtained from Dogs Experimentally Infected with Larvae as an Etiological Agent in Mexican Gnathostomiasis: External Morphology

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ABSTRACT: We examined the muscles of 3 pelicans and obtained as many as 570 gnathostome larvae. Each of 2 dogs was experimentally infected with 20 larvae obtained using this method. Eight and 9 mo later, 4 and 9 adults were obtained from the gastric nodules in each dog, respectively. The morphology of the worms and eggs was examined, primarily using scanning electron microscopy (SEM) to identify the species. The adults demonstrated tridentate cuticular spines in their anterior forefront regions. The shape of the cuticular spines changed to di- and monodentate forms in the anterior one-third of the body. Very minute monodentate spines covered the posterior two-thirds of the body. The ventral surface of the tail of the male had 4 pairs of caudal papillae and 3 pairs of small papillae. The spines in this area were short. The morphological characteristics of the adults examined for this study were very similar to those of *Gnathostoma spinigerum*. One noticeable difference between *G. spinigerum* and the present specimens was the egg surface morphology. We found no pits on the eggshell surface of our specimens. In contrast, *G. spinigerum* has clear pits on its eggshell. The 3 previously reported gnathostomes indigenous to Latin America, *G. turgidum, G. procyonis,* and *G. americanum,* also have many pits on their eggshells. The adult worms of these 3 species have multidigitated spines on their anterior regions, and except for *G. turgidum,* obvious spines cover their entire body surfaces. However, the eggs of *G. turgidum* have bipolar plugs. In these latter features, the present species was more similar to *G. binucleatum*.

KEY WORDS: adult *Gnathostoma binucleatum,* gnathostomiasis, Mexico, morphology, eggshell surface, *Pelicanus erythrorhynchos,* SEM.

The first human cases of gnathostomiasis in Mexico were reported by Peláez and Pérez-Reyes (1970). Since 1990, the number of such patients has dramatically increased, especially in the Oaxaca-Veracruz and Sinaloa-Culiacán areas (Ogata et al., 1998). The normal source of infection for humans is considered to be the consumption of either raw or insufficiently cooked freshwater fish, mainly tilapia (Almeyda-Artigas, 1991). There have also been sporadic case reports regarding ocular and cutaneous gnathostomiasis (Hernández-Ortiz et al., 1982; Martínez-Cruz et al., 1989). Lamothe-Argumedo et al. (1989) found *Gnathostoma* sp. larvae in tilapia from the Presidente Miguel Alemán Reservoir in Temazcal, Oaxaca-Veracruz. Almeyda-Artigas (1991) also found *Gnathostoma* larvae (the advanced third-stage larvae) in the muscles of fish obtained from this reservoir and named this Mexican gnathostome *G. binucleatum* (Almeyda-Artigas, 1991). Three domestic cats were experimentally infected with these larvae, and 3 female worms were later obtained from the stomach of one of them. In addition, Almeyda-Artigas (1991) also found adult worms of this species in the stomachs of a wild ocelot (*Felis pardalis pardalis*) and a stray cat.

We examined pelicans (*Pelicanus erythrorhynchos*) (a paratenic host) from the same reservoir and obtained many advanced third-stage larvae from their muscles. After experimentally infecting dogs, adult worms were also obtained from these hosts. We report the first scanning electron microscopy (SEM) profile of adult *G. binucleatum*.

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Materials and Methods

Harvesting gnathostome larvae

We collected 3 pelicans from the Presidente Miguel Alemán Reservoir in Temazcal and examined their muscles to collect gnathostome larvae. The muscles were removed, chopped into small pieces, and the pieces cut into thin slices. The slices were then placed between 2 glass plates (10 by 10 cm), pressed by hand, and examined under a dissecting microscope. The inspected muscle remnants were next digested in artificial gastric juice (0.2 g pepsin in 0.7 ml HCl/100 ml distilled water) for 3 hr at 37°C to harvest any larvae that had been overlooked. We eventually found a total of 570 larvae. We examined pelicans instead of the intermediate fish host to collect the larvae in a short period, as it was much easier to collect a large number of larvae from pelicans than from fish. Because pelicans consume a large number of many different types of fish, gnathostome larvae accumulate in their muscles, and the nematodes are more easily collected.

Adult worm investigation

We supposed that *G. binucleatum* would have a broad range of natural mammalian hosts. Acevedo-Hernández et al. (1988) earlier reported that *Gnathostoma* eggs found in the feces of dogs and pigs in Temazcal were morphologically similar to those of *G. hispidum* (Fedtschenko, 1872) and not to those of *G. binucleatum*. However, we examined *G. hispidum* eggs from China using both ordinary optical and scanning electron microscopy and found them to be similar to those of *G. spinigerum* (Koga, 1996). We then searched for adult worms in hosts from the same district. Four opossums (1 *Philander opossum* and 3 *Didelphis marsupialis*) and 2 raccoons (*Procyon lotor*) were collected. The stomachs of these animals, however, were negative for *Gnathostoma*. In addition, 10 fecal samples from 2 pigs and 8 dogs were also examined for *Gnathostoma* eggs, but none were found. Thus, the range of natural final hosts is not as broad as we expected.

Experimental infection

Two dogs were each infected experimentally with 20 larvae obtained from pelicans, and thereafter, they were maintained at an animal center. To assess egg shedding, fecal examinations were performed once a month starting at 5 mo postinfection. Gnathostome eggs were first observed in the feces 8 and 9 mo after infection. The dogs were then anesthetized by sodium barbital and killed by bleeding from the cervical arteries. The peritonea were then gently opened, and the stomachs were removed and opened by cutting along the lesser curvature. A single hard nodule was evident in the mucous membrane in each stomach. In the nodules from each dog, 4 (1 ♂, 3 ♀) and 9 (6 ♂, 3 ♀) adult worms were found. After optical observation, the adult worms were processed for SEM. The eggs were removed from the uteri of the gravid female worms for further examination. One pair of adult worms consisting of 1 male and 1 female worm from each dog was deposited at the Meguro Parasitological Museum in Tokyo as representative voucher specimens (Accession No. 19726).

SEM sample preparation

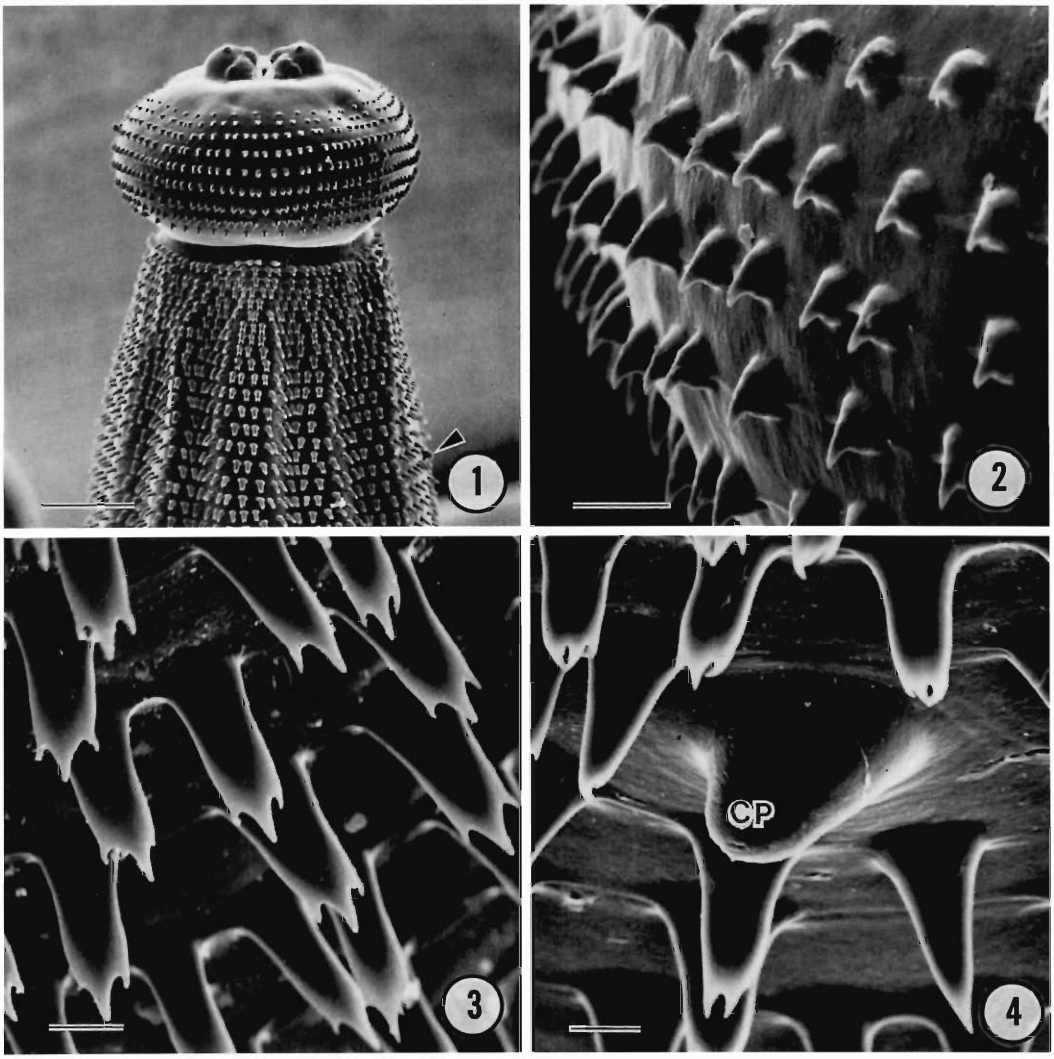
Viable adult male and female worms were washed in several changes of tap water and soaked in physiological saline solution. The worms were fixed in 10% formalin for at least 1 wk, washed in running tap water overnight to remove the fixative, then transferred to distilled water. The specimens were rinsed twice in Millonig's phosphate buffer and postfixed for 3 hr in 1% OsO_4 in the same buffer. During postfixation, the worms were cut transversely into 7 pieces to facilitate observations by SEM. These pieces were dehydrated in an ascending ethanol series, transferred into amyl acetate, and critical-point dried with a Hitachi HCP-2 critical-point dryer. The specimens were sputter coated with gold and examined with a JEOL JSM-U3 SEM operated at 15 kV.

Results

The adult male and female specimens of our *Gnathostoma* sp. had a hemispherical head bulb armed with 8–9 transverse rows of cephalic hooks (Fig. 1). The hooks had tapering points composed of hard keratin (about 7–8 μm in length) that emerged from a conical chitinous base (Fig. 2). The body spines immediately behind the cephalic bulb were tridentate (Fig. 3) and not multidigitated. One pair of cervical papillae was located laterally near the twentieth transverse striation (Fig. 1, arrow) and had a mammiform shape. The shapes of the spines around these papillae were mixed, with 2–3 denticles, and only rare unidentate spines (Fig. 4). A domelike excretory pore was situated ventrally a little behind the cervical papillae and was covered only by single denticle spines (Fig. 5). These unidentate spines gradually decreased in size posteriorly along the body (Fig. 6), and most posterior spines were minute (Fig. 7).

On the ventral side of the tail of the male, single-toothed unidentate spines were densely distributed over the entire extremity. Four pairs of caudal papillae (a, b, c, and d) and a few small papillae, which bore no spines (arrows), were also seen on this side (Fig. 8).

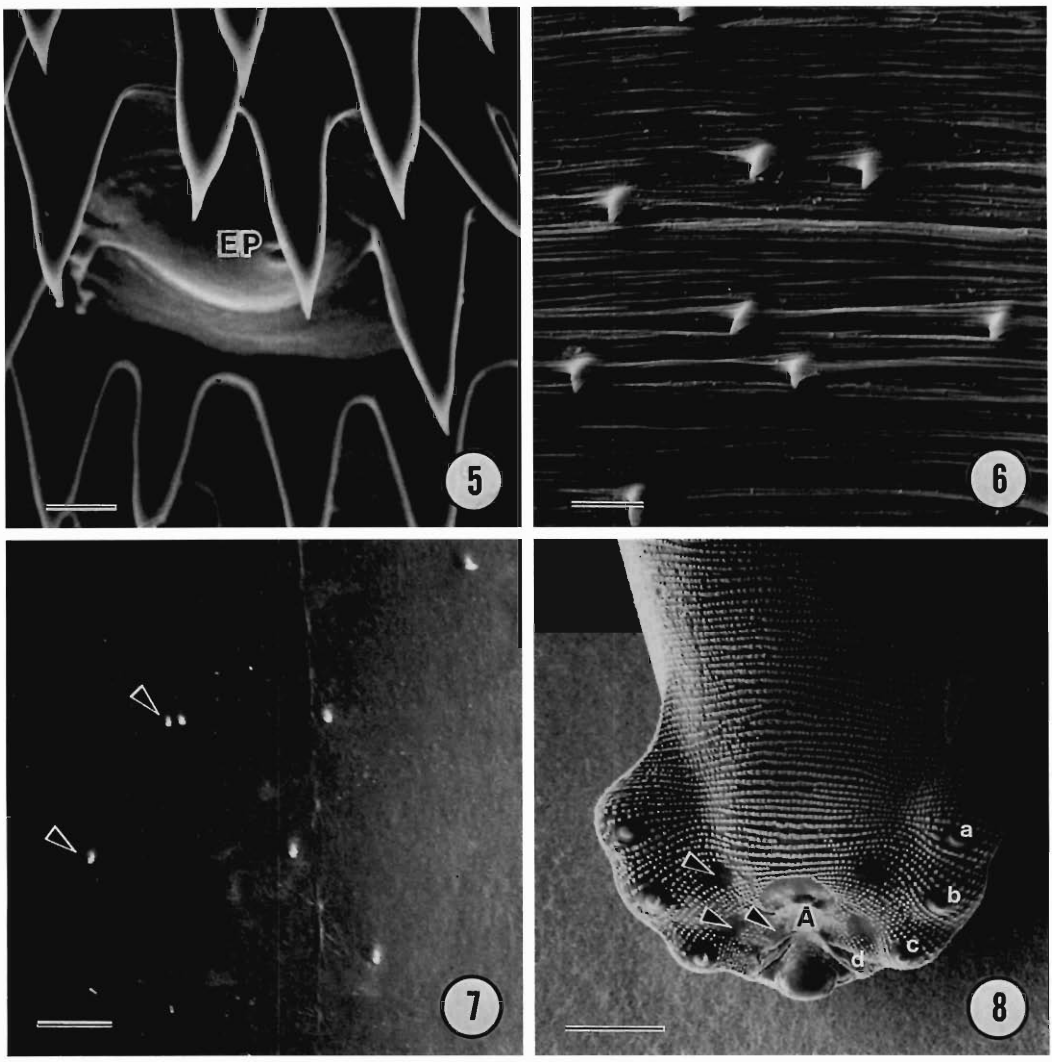
The fertilized uterine eggs of this *Gnathostoma* sp. were oval (66 ± 2.92 by 40 ± 3.1 μm) and had an operculum (Fig. 9, OP) on one end. The eggshell surface was plain and without pits (Fig. 10). This plain, nonpitted appearance is characteristic of this species and is the major feature differentiating *G. spinigerum* from other gnathostome species.



Figures 1–4. 1. Lateral view of the head bulb of *Gnathostoma* sp. The arrow indicates cervical papilla. Bar = 100 μm. 2. A higher magnification of the hooks on the head bulb, which have conical bases and acute tips. Bar = 10 μm. 3. Short, stumpy tridentate spines lying immediately behind the head bulb. Bar = 10 μm. 4. Mammiform cervical papilla (CP) located between the eighteenth and twentieth transverse striations, with spines on the body surface. Bar = 10 μm.

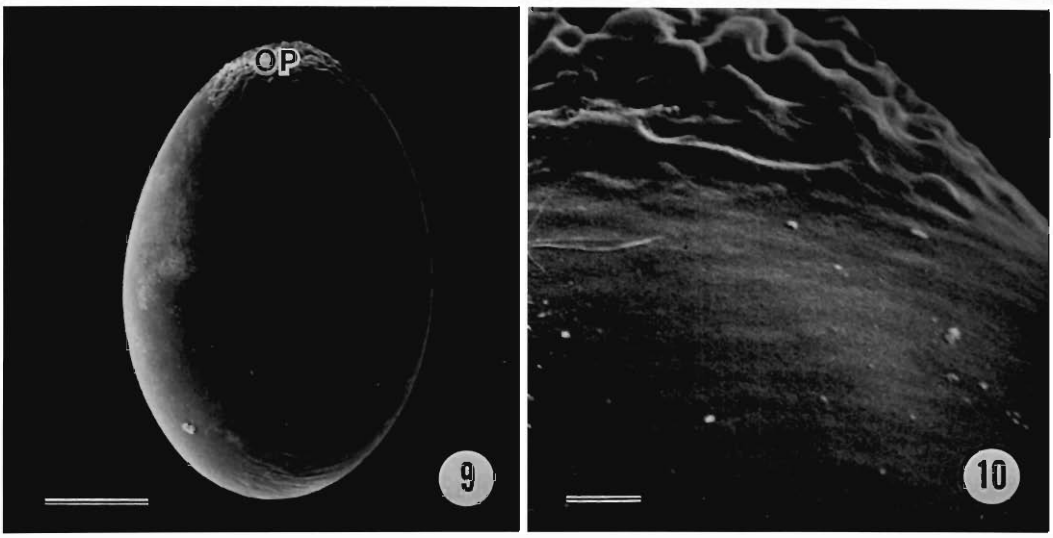
Discussion

Almeyda-Artigas (1991) experimentally obtained female worms from a cat stomach that could not produce fertilized eggs in the host feces. Therefore, his description of the eggs was limited to eggs from naturally infected mammals. The eggs were 64 by 38 μm in size, with a plug at one end. The size of the eggs was similar to that of our specimens. Almeyda-Artigas (1991) considered these worms to be a new species and named them *G. binucleatum* in reference to the presence of 2 nuclei in the intestinal cells of the advanced third-stage larvae. Based on this general description of the morphology of the surface spines of adult worms and of the ventral side of the tail of the male by light microscopy, our belief is that the worms described by Almeyda-Artigas (1991) were very similar to *G. spinigerum*. However, the morphological details were not described precisely enough for us to be certain of this similarity. Akahane et al. (1994) reported that most of the



Figures 5–8. 5. Dome-shaped excretory pore (EP). Around this pore, all spines are unidentate with acute tips. Bar = 10 μm. 6. Smaller unidentate spines located on posterior one-third of body. Bar = 10 μm. 7. Very minute spines (arrows) are sparsely distributed around the terminal area of the body. Bar = 10 μm. 8. Ventral surface of the tail of the male. Four pairs of dome-shaped caudal papillae (a, b, c, and d) and several small flat papillae without spines (arrows) are evident. Dense minute cuticular spines oriented anteriorly are also evident. A = anal pore. Bar = 20 μm.

larvae from Temazcal that they examined had 4 nuclei in the intestinal cells. Moreover, the other features of those advanced third-stage larvae were very similar to those of *G. spinigerum,* except for the number of hooklets in each row of the head bulb. Koga et al. (1991) reported the surface ultrastructure of both adults and eggs of *G. spinigerum* from Thailand using SEM. By comparison, in the adult *G. spinigerum* from Thailand, the spines immediately behind the cephalic bulb were broad, blunt, and multidigitate in *G. spinigerum,* while the corresponding spines of the Mexican specimens were more slender and only tridentate. The spines around the excretory pore are tridentate in *G. spinigerum,* but the corresponding spines of the Mexican specimens are unidentate. All specimens in this study had minute cuticular spines, even on the



Figures 9, 10. Egg from the uterus of a gravid female of *Gnathostoma* sp. from Mexico having an operculum on one end, showing smooth surface. OP = operculum. Bars = 20 and 1 μm, respectively.

posterior half of the body. However, *G. spinigerum* is usually reported to have a naked posterior half (Miyazaki, 1960). The ventral appearance of the tail of the male was almost the same in our specimens as that of *G. spinigerum.* The most noticeable difference between *G. spinigerum* and the Mexican species is therefore the surface of the eggshell. The eggshells of *G. spinigerum* and other gnathostome species have many pits on the surface, and the shape of these pits is species-specific (Koga, 1996), while the eggshells of the Mexican species are not pitted.

In Central and South America, 3 species of gnathostomes have been recorded: *G. procyonis* (Chandler, 1942) from a raccoon in Texas, *G. turgidum* (Stossich, 1902, quoted *in* Travassos, 1925) from an opossum, and *G. americanum* (Travassos, 1925) from *Felis tigrina,* the latter two in Brazil. The adults of these 3 species have multidigitate (4–5 teeth) spines on their anterior regions and dense spines on the posterior half of their body surfaces, except for *G. turgidum.* In contrast, our specimens had very minute spines sparsely distributed over the posterior half of their bodies, and these spines were recognizable only by SEM examination. In *G. procyonis,* the eggs have a plug on either pole and also have many pits on the eggshell surface. The eggs of *G. turgidum* and *G. americanum* have bipolar plugs on both sides and thus can be easily distinguished from those of *G. spinigerum.* Our Mexican specimens had 1 operculum at one end and no pits on the surface. Both the adults and larvae of the present species were very similar to those described as *G. binucleatum* by Almeyda-Artigas (1991).

We therefore tentatively consider our specimens to be *G. binucleatum,* but note that the taxonomic status remains inconclusive. We consider it premature at this point to propose a new species, pending further studies. The description by Almeyda-Artigas (1991) does not provide sufficient information for a definitive determination of the status of our specimens; thus, we must tentatively assign them to *G. binucleatum.* Further study of both species is needed to determine the specific status of each and to evaluate *G. binucleatum* in relation to the characters described in this study.

In Latin America, human gnathostomiasis has previously been reported in Ecuador (Ollague-Loaiza et al., 1981). It is highly possible that migratory waterfowl may have spread the same species of nematode to various Latin American countries. It is possible that the Ecuadorian parasite might be the same species as in the present study, because in Ecuador adult worms were also recovered from domestic cats and dogs infected both naturally and experimentally (Ollague-Loaiza et al., 1985, 1987; Ollague-Tor-

res and Buchelli de Cevallos, 1985). The morphology of those worms was also quite similar to that of our Mexican specimens. The Ecuadorian specimen was identified as *G. spinigerum,* but this designation is uncertain, and specimens from that area should be reexamined.

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Acanthocephala of Cichlids (Pisces) in Lake Malawi, Africa, with a Description of *Acanthogyrus* (*Acanthosentis*) *malawiensis* sp. n. (Quadrigyridae) from *Labeo cylindricus* Peters, 1852 (Cyprinidae)

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ABSTRACT: Two species of acanthocephalans are reported from fishes collected during the summer of 1996 in the southeast arm of Lake Malawi (Lake Nyasa), East Africa. The common *Acanthogyrus* (*Acanthosentis*) *tilapiae* (Baylis, 1948) had infected 18 cichlid and 1 bagrid host species (all new host records) netted by divers wearing scuba gear around Harbor Island or caught by hook and line in deep water. The specimens of this parasite were some of the smallest ever reported for that species. Two males of a new species, *Acanthogyrus* (*Acanthosentis*) *malawiensis*, are described from 2 male *Labeo cylindricus* (Cyprinidae). This is the fifth species of this genus and subgenus described in Africa. It is distinguished from the other 4 African and 33 mostly Asian species in that the proboscis hooks of the middle circle are longer than those of the anterior circle. The new species further differs from the other African species in proboscis and hook size, posterior hook root, trunk spination, and lemniscal form. Observations on host and geographical distribution, prevalence, and developmental stages of *A.* (*A.*) *tilapiae* are also reported.

KEY WORDS: Acanthocephala, *Acanthogyrus* (*Acanthosentis*) *malawiensis* sp. n., *Acanthogyrus* (*Acanthosentis*) *tilapiae*, cichlids, *Labeo cylindricus*, Lake Malawi, Lake Nyasa.

The acanthocephalan family Quadrigyridae Van Cleave, 1920 (Order Gyracanthocephala Van Cleave, 1936) includes 2 subfamilies, Quadrigyrinae Van Cleave, 1920, with 2 genera, and Pallisentinae Van Cleave, 1928, with 6 genera, including the genus *Acanthogyrus* Thapar, 1927 (= *Acanthosentis* Varma and Datta, 1929; *Hemigyrus* Achmerov and Dombrowskaja-Achmerova, 1941). In synonymizing *Acanthosentis* with *Acanthogyrus*, the former taxon was reduced to a subgenus of the latter (Golvan, 1959). The 2 subgenera were distinguished based on the number of hooks on the proboscis, being 18 in *Acanthosentis* (3 circles of 6 hooks each) and 24 in *Acanthogyrus* (3 circles of 8 hooks each). This arrangement was accepted by systematists, including Amin (1985), but Golvan (1994) decided to elevate *Acanthosentis* back to generic status, without justification. The latter decision is not accepted and the subgeneric classification is herein retained.

Only 5 of the 38 known species of the subgenus *Acanthosentis* (including the new species) are found in Africa. Thirty-one of the remaining 33 species are Asian, found mostly in the Indian subcontinent and China. Of the African species, *Acanthogyrus* (*Acanthosentis*) *tilapiae* (Baylis, 1948) is an endemic and widely distributed species of Oriental affinities (Khalil, 1971b). The other African species appear to be of more restricted distributions and include *Acanthogyrus* (*Acanthosentis*) *maroccanus* (Dollfus, 1951) from Morocco, *Acanthogyrus* (*Acanthosentis*) *nigeriensis* Dollfus and Golvan, 1956, from the Niger River, *Acanthogyrus* (*Acanthosentis*) *papilo* Troncy and Vassiliades, 1974, from West Africa, and the new species, *Acanthogyrus* (*Acanthosentis*) *malawiensis*, from Lake Malawi.

In this paper, the new species is described and distinguished from other species of the subgenus, and some host–parasite relationships of *A.* (*A.*) *tilapiae* are reported.

Materials and Methods

Cichlid and cyprinid fishes were collected, usually late in the afternoon, by netting by divers wearing scuba gear in the southeast arm of Lake Malawi, mostly at or near Harbor Island during July and August 1996. Bagrid and clariid fishes were caught by hook and line in the deeper water offshore in the southeast arm of the lake. Fish were held alive overnight in buckets and examined the following day. All acanthocephalans were alive when removed from the fish small intestine and placed in Lake Malawi water to evert the proboscis. Worms were then fixed in alcohol-formalin-acetic acid fixative and eventually transferred to 70% ethanol.

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Not all fishes examined had acanthocephalans. Preserved fishes were deposited as voucher specimens in the Pennsylvania State University Fish Museum (PSUFM).

Worms were stained in Mayer's acid carmine, dehydrated in ascending concentrations of ethanol, cleared in graded terpineol–100% ethanol, and mounted in Canada balsam. Measurements are in micrometers unless otherwise stated. Width measurements refer to maximum width. Body (=trunk) length does not include neck, proboscis, or male bursa. Specimens are deposited in the U.S. National Parasite Collection (USNPC), Beltsville, Maryland.

Results

Sixty-four fishes (primarily cichlids) of 28 species were examined for parasites. Twenty-eight fishes of 19 species were infected with 95 (44 males, 51 females) *A.* (*A.*) *tilapiae*. A single *Bagrus meridionalis* (Bagridae) contained 1 male *A.* (*A.*) *tilapiae*. Most worms were sexually mature adults that were quite small in size (Table 1). Two male *Labeo cylindricus* Peters, 1852, were infected with a new species of *Acanthogyrus* (*Acanthosentis*), which is described below. Fish species (and numbers) that were examined for acanthocephalan infections, along with prevalence and measurement data, are included in Table 1.

Acanthogyrus (*Acanthosentis*) *malawiensis* sp. n. (Figs. 1–9)

The description of this species is based on the only 2 male specimens available; females are unknown.

Description

Quadrigyridae, Pallisentinae, with characters of the genus *Acanthogyrus* and the subgenus *Acanthosentis*. Males small, spindle-shaped, with gradual, almost equal tapering toward both ends, with some ventral curvature (Fig. 1). Trunk 4.545–6.363 mm long by 1.273–1.333 mm wide at middle. Transverse anastomoses connect main dorsal and ventral lacunar canals. Giant subcuticular nuclei very few; 1 ventral and 1 or 2 dorsal, and complex vessel-shaped in profile or amoeboid-star-shaped in face view. Many spheroid, rib, or double-walled sensory papillae, 12–23 in diameter, randomly distributed mostly in the middle region of the trunk (about 40) and bursa (about 5) (Fig. 7). Rose-thorn-shaped cuticular spines with a shaft and robust, complex fan-shaped rayed or ribbed subcuticular plate anteriorly (Figs. 3–6). Spines in 32–38 circles; anteriorly 23–26 complete circles. Anterior circles with 30–46 spines that increase to 40–55, then decrease in number posteriorly as they become less closely spaced. Next, circles of spines become progressively more incomplete laterally where only dorsal and ventral spines remain in posteriormost circles near posterior end of trunk. Anterior spines somewhat larger, 20–25 long, with root, than posterior spines. Dorsal and ventral spines symmetrical, with no numerical differentiation anteriorly, but more ventral than dorsal spines retained as spine circles become incomplete posteriorly (Figs. 1, 2). Proboscis small, cylindrical, straight-sided, about as long as wide, 98–112 long by 98–112 wide, with a remarkable apical organ, abruptly widening posteriorly into a broadening neck (Fig. 8). Proboscis hooks slender; hooks in middle circle longer (42–45 long) than those of anterior circle (31–36), with posteriormost hooks only slightly shorter (28–36) than anterior hooks. Hook roots simple, directed posteriorly, and markedly shorter than blades. Roots of posteriormost hooks with short anterior manubria (Fig. 8). Proboscis receptacle 381–419 long by 114–140 wide, with cerebral ganglion at its base (Fig. 2). Lemnisci subequal, about twice as long as proboscis receptacle, with successive constrictions, and gradually tapering posteriorly (Fig. 2). Longer lemniscus 660–775 long by 102–140 wide; shorter lemniscus 546–648 long by 102–140 wide. Reproductive system in posterior half of trunk (Fig. 1). Testes broad, pear-shaped, greatly overlapping. Anterior testis 533–762 long by 571–787 wide; posterior testis 406–889 long by 470–737 wide. Cement gland 444–999 long by 343–533 wide, with at least 4 giant nuclei. Sperm sac 190–316 long by 190–305 wide. Saefftigen's pouch 432–698 long by 165 wide. Bursa 851 long by 508 wide.

Taxonomic Summary

TYPE HOST: *Labeo cylindricus* Peters, 1852 (Cyprinidae).

SITE OF INFECTION: Small intestine.

TYPE LOCALITY: Southeast arm of Lake Malawi at Harbor Island, Nankumba Peninsula, Mangochi District, Malawi, Africa (14°04′07.21″S, 34°55′49.94″E).

DATE COLLECTED: 31 July 1996.

SPECIMENS DEPOSITED: USNPC No. 88013 (holotype male); No. 88014 (paratype male).

HOST SPECIMENS DEPOSITED: PSUFM No. 3243.

ETYMOLOGY: The new species is named for the country of the type locality.

Remarks

Of the 38 species of the subgenus *Acanthosentis* known from freshwater fishes, 5 are found in Africa (including *A.* (*A.*) *malawiensis* sp. n.) and 31 in Asia (India and China). The new species is distinguished from all other species of the subgenus by having the proboscis hooks of the middle circle longer than those in the anterior circle, instead of the opposite. In addition, the large number of sensory papillae found on the trunk and bursa of *A.* (*A.*) *malawiensis* sp. n. has not been reported in any of the other species. It is unlikely that they may have been overlooked in other species.

The new species is further distinguished from the other African species based on host and geographical distribution and distinct anatomical differences. *Acanthogyrus* (*Acanthosentis*) *maroccanus* was described from *Barbus setivimensis* in Morocco by Dollfus (1951). It has a considerably longer proboscis, 184 long by 107 wide, that does not broaden posteriorly and lacks an apparent apical organ. Its proboscis hooks are larger, 62, 62, 48 from the anterior, and all have simple roots, none of which have anterior manubria. The trunk has 10–12 giant nuclei and only 12–18 circles of spines spread over the interior quarter of the trunk, with the posterior circles having 2–4 spines each. The lemnisci have no constrictions and the testes appear to be oblong. All measurements are calculated from Dollfus' (1951) figure 60. *Acanthogyrus* (*Acanthosentis*) *nigeriensis* was described from *Labeo coubie* in the Niger River, Mali, by Dollfus and Golvan (1956). It is a larger species than ours. Males are 12–15 mm long by 2.0–2.4 mm wide; the proboscis is 150 long by 200 wide, and the proboscis receptacle is 700 long by 200 wide. The proboscis hooks are situated in successive circles and measure 70 (2 hooks), 55–65 (4 hooks), 40 (6 hooks), and 40 (6 hooks) from the anterior. Each possesses an apical granular structure set in a heavy muscular wall. Cuticular spines are 30 long, covering the whole length of the trunk in 70 circles. *Acanthogyrus* (*Acanthosentis*) *papilo* was described from *Periopthalmus papilo* in Senegal by Troncy and Vassiliades (1974). Specimens of that species are very small (less than 2 mm). The anterior proboscis hooks are 35–40 long and are widely separated from the smaller hooks of the middle and posterior circles, which are 8–11 long. The lemnisci have no constrictions. The trunk is totally covered with 1–2 long spines in up to approximately 30 unequally spaced circles. *Acanthogyrus* (*Acanthosentis*) *tilapiae* is an endemic species that was originally described from *Oreochromis* (*Tilapia*) *lidole* from an unknown locality in Lake Malawi (Lake Nyasa), Tanzania, by Baylis (1948) and has since been reported from a large number of fish species, mostly of the genus *Tilapia,* in many African countries, including Malawi (Khalil, 1971a; Amin, 1978). The reports by Baylis (1948) and Amin (1978) described smaller males (1.2–3.5 mm long by 0.4–1.1 mm wide), with a smaller proboscis (90 long by 64 wide), larger anterior probscis hooks (45–48), and considerably smaller hooks in the middle circle (12–22 long) and posterior circle (10–13 long) compared to the new species. The lemnisci are without constrictions. The trunk possesses 28–38 circles of small (10 long) cuticular spines distributed throughout and 2–4 dorsal and 4–6 ventral giant nuclei. The middle trunk of about half of the 79 *A.* (*A.*) *tilapiae* specimens examined by Amin (1978) had shallow sensory pits with an eversible knoblike center (Amin, 1978, figs. 15, 17). There was usually 1 such pit observed in each of these specimens. Similar pits were observed in a few specimens of our *A.* (*A.*) *tilapiae* from Lake Malawi.

The shape of the giant subcuticular nuclei of *A.* (*A.*) *malawiensis* was similar to that observed in mature *A.* (*A.*) *tilapiae* (Amin, 1978) and is considered indicative of an active reproductive state of the worms, as has been demonstrated in other sexually mature acanthocephalans (Amin and Vignieri, 1986a, b; Amin and Gunset, 1992).

Acanthogyrus (*Acanthosentis*) *tilapiae* (Baylis, 1948)

This acanthocephalan is endemic in Africa and has been reported in at least 10 species of the cichlid genus *Tilapia* in Tanzania (Baylis, 1948), Congo (Prudhoe, 1951; Golvan, 1957), Madagascar (Golvan, 1965), Uganda (Khalil and Thurston, 1973), Chad (Troncy, 1974), Nigeria (Shotter, 1974), Egypt (Amin, 1978), and unidentified locations (Marchand and Mattei, 1976; Marchand, 1984). These host species are *T. aurea, T. galilaea, T. heudelotti, T. lidole, T. leu-*

Table 1. Fishes examined for prevalence and size of *Acanthogyrus* (*Acanthosentis*) *tilapiae* collected in the southeast arm of Lake Malawi during July and August 1996.

Host species (USNPC No.)	Locality*	Prevalence (%)†	No. worms		Male length × width (*n*)		Female length × width (*n*)		
			MM	FF	Immature	With sperm	With ovarian balls only	With ovarian balls & eggs	With mostly eggs
Cichlidae									
Aristochromis christyi Trewavas, 1935	H	1/2 (50)	1	3	—	2,121 × 576 (1)	3,030 × 818 (1)	2,121 × 636 (1)	2,424 × 848 (1)
Copidochromis cf. *thinos* (Regan, 1922) (USNPC 88016)	H	1/1 (100)	1	4	—	1,515 × 454 (1)	2,424–2,545 × 606 (3)	—	2,545 × 727 (1)
Ctenopharynx (*Otopharynx*) *pictus* (Trewavas, 1935)	K	1/1 (100)	2	1	—	1,363–1,424 × 515–545 (2)	— —	— —	1,818 × 727 (1) —
Dimidiochromis kiwinge (Ahl, 1926)	H	0/1 (0)	—	—	—	—	—	—	—
Genychromis mento Trewavas, 1935 (USNPC 88017)	H	1/2 (50)		1	—	—	—	—	1,909 × 606 (1)
Labeotropheus fullerborni Ahl, 1926 (USNPC 88018)	H	3/3 (100)	1	6	—	1,121 × 364 (1)	788–1,606 × 303–606 (6)	—	—
Labidochromis vellicans Trewavas, 1935	H	0/3 (0)	—	—		—	—	—	—
Lichnochromis acuticeps Trewavas, 1935 (USNPC 88019)	H	1/1 (100)	1	—	—	970 × 364 (1)	—	—	—
Melanochromis auratus (Boulenger, 1897)	H	1/3 (33)	2	1	—	1,363–2,030 × 424–818 (2)	—	—	2,303 × 970 (1)
Melanochromis cf. *melanopterus* Trewavas, 1935	H	0/1 (0)	—	—	—	—	—	—	—
Melanochromis heterochromis Trewavas, 1935 (USNPC 88020)	H	4/5 (80)	13	8	—	727–1,969 × 242 × 606 (13)	788–2,424 × 333–697 (5)	—	1,212–2,272 × 515–727 (3)
Metriaclima zebra BB (Boulenger, 1899) (USNPC 88027)	H	2/5 (40)	5	4	818–909 × 212–242 (3)	848–909 × 333–394 (2)	1,303–1,386 × 424–576 (3)	—	2,424 × 970 (1)
Metriaclima zebra "redtop"	K	0/1 (0)	—	—	—	—	—	—	—
Oreochromis sp. (USNPC 88021)	H	1/1 (100)	1	—	—	1,666 × 666 (1)	—	—	—
Petrotilapia genalutea Marsh, 1983 (USNPC 88022)	H	1/1 (100)	10	7	697–879 × 303–364 (2)	909–1,666 × 364–666 (8)	909–1,273 × 394–576 (3)	3,030 × 757 (1)	1,666–3,030× 818–1,151 (3)

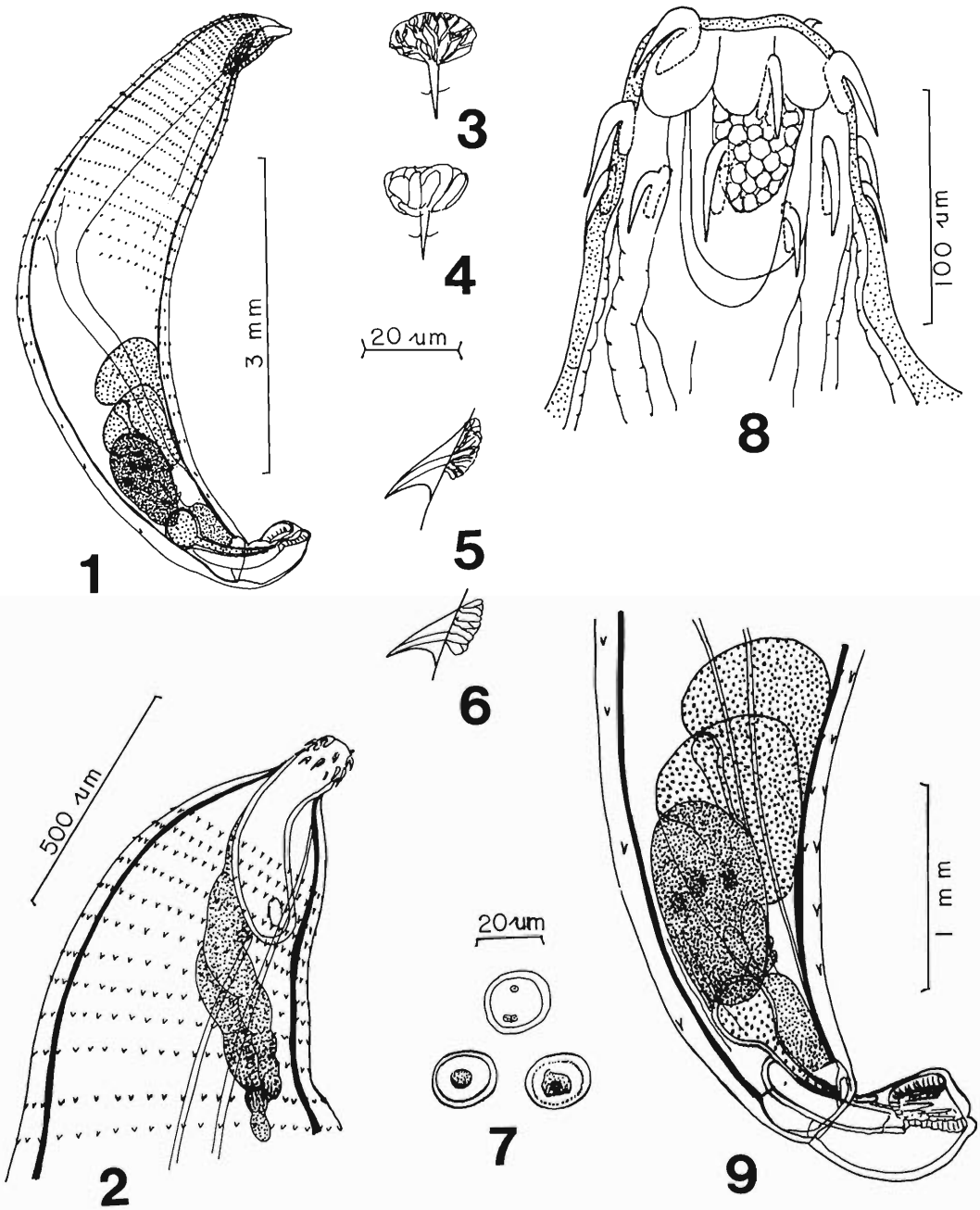
Table 1. Continued.

Host species (USNPC No.)	Locality*	Prevalence (%)†	No. worms MM	No. worms FF	Male length × width (*n*) Immature	Male length × width (*n*) With sperm	Female length × width (*n*) With ovarian balls only	Female length × width (*n*) With ovarian balls & eggs	Female length × width (*n*) With mostly eggs
Placidochromis johnstoni "gold"‡ (Gunther, 1894) (USNPC 88023)	K	1/1 (100)	1	—	—	1,363 × 545 (1)	—	—	—
Placidochromis johnstoni	S	0/1 (0)	—	—	—	—	—	—	—
Protomelas annectens (Regan, 1922) (USNPC 88024)	S	1/3 (33)	1	—	—	1,151 × 364 (1)	—	—	—
Protomelas cf. *taeniolatus* (Trewavas, 1935)	K	0/1 (0)	—	—	—	—	—	—	—
Pseudotropheus elongatus "aggressive" Fryer, 1956 (USNPC 88025)	H	1/1 (100)	2	4	—	970–1,030 × 394 (2)	1,060–1,454 × 454–606 (4)	—	—
Pseudotropheus tropheops "broadmouth" (Regan, 1922)	H	0/1 (0)	—	—	—	—	—	—	—
Pseudotropheus tropheops "orange chest" (USNPC 88026)	H	2/2 (100)	—	4	—	—	1,069–2,272 × 606–848 (3)	—	1,606 × 576 (1)
Stigmatochromis woodi (Regan, 1922) (USNPC 88028)	H	3/3 (100)	1	1	—	1,969 × 666 (1)	Not observed	—	—
Taeniolethrinops praeorbitalis (Regan, 1922)	S	0/2 (0)	—	—	—	—	—	—	—
Trematocranus placodon (Regan, 1922) (USNPC 88029)	S	1/2 (50)	1	6	—	1,363 × 454 (1)	—	1,151–1,515 × 424–515 (2)	1,242–1,727 × 636–879 (4)
Tyrannochromis macrostoma (Regan, 1922) (USNPC 88030)	H	1/2 (50)	—	1	—	—	2,363 × 1,030 (1)	—	—
Tyrannochromis macrostoma	K	0/1 (0)	—	—	—	—	—	—	—
Tryannochromis nigriventer Eccles, 1989	H	0/1 (0)	—	—	—	—	—	—	—
Bagridae									
Bagrus meridionalis Gunther, 1893 (USNPC 88015)	D	1/1 (100)	1	—	—	1,666 × 606 (1)	—	—	—

Table 1. Continued.

Host species (USNPC No.)	Locality*	Prevalence (%)†	No. worms MM	No. worms FF	Male length × width (*n*) Immature	Male length × width (*n*) With sperm	Female length × width (*n*) With ovarian balls only	Female length × width (*n*) With ovarian balls & eggs	Female length × width (*n*) With mostly eggs
Clariidae									
Bathyclarias nyasensis (Worthington, 1933)	D	0/1 (0)	—	—	—	—	—	—	—
Clarias mossambicus Peters, 1852	D	0/1 (0)	—	—	—	—	—	—	—
Cyprinidae									
Labeo cylindricus Peters, 1852	H	0/4 (0)	—	—	—	—	—	—	—
Labeo cylindricus	K	0/1 (0)	—	—	—	—	—	—	—
Mastacembelidae									
Mastacembelus shiranus Gunther, 1896	M	0/4 (0)	—	—	—	—	—	—	—
Totals and size range		28/64	44	51	697–909 × 212–364 (5)	727–2,121 × 242–818 (39)	788–3,030 × 303–1,030 (30)	1,151–3,030 × 424–757 (4)	1,212–3,030 × 515–1,151 (17)

* H = Harbor Island; D = deep water of southeast arm; K = Kanchedzda Island; M = Marsh near Massasa Village; S = Songwe Hill site.
† No. infected/No. examined (%).
‡ Names in quotes are aquarium trade color morphs.



Figures 1–9. ***Acanthogyrus*** **(*Acanthosentis*)** ***malawiensis*** **sp. n., holotype male. 1. Whole specimen. 2. Anterior end. 3–6. Face and lateral views of trunk spines. 7. Sensory papillae. 8. Proboscis. 9. The reproductive system. Sensory papillae and lacunar vessels are not shown in Figs. 1, 2, and 9.**

costicta, T. melanopleura, T. multiradiata, T. nilotica, T. tanganicae, and *T. zilli.* Fish hosts of *A.* (*A.*) *tilapiae* belonging to other genera are few and include *Potamogale velox* (possibly an accidental host) and *Tetraodon fohaka* in Chad (Troncy 1970, 1974) and 2 cichlids, *Haplochromis squamipinnus* and *Haplochromis* sp. in Uganda (Khalil and Thurston, 1973). The re-

ported records of *A* (*A.*) *tilapiae* from the 18 cichlid and 1 bagrid species collected in southeastern Lake Malawi (Table 1) represent new host records. Khalil and Thurston (1973) also reported *A* (*A.*) *tilapiae* from unidentified cichlids in Lake Malawi, Lake Tanganyika, and various lakes in The Congo..

Morphologically, our specimens from Lake Malawi were similar to those collected from *T. nilotica* and *T. zilli* in Egypt during June 1975 (Amin, 1978), except our specimens were markedly smaller, even though the 2 populations were comparable in their developmental and reproductive states (Table 1). Specimens from Egypt were 1.20–3.40 mm (mean, 1.99) long (males) and 1.20–5.00 mm (mean, 3.22) long (females) and 50% of females (n = 52) had only ovarian balls in their body cavity, thus indicating a young summer population. Most males from Lake Malawi (39 of 44) were mature with sperm, and most females (30 of 51) were also in the ovarian ball stage (Table 1). A few Lake Malawi specimens had 1 sensory papilla each, and the trunk spines of some younger worms were so underdeveloped as to be barely visible.

Shotter (1974) reported *A* (*A.*) *tilapiae* from *T. zilli* in a northern Nigeria stream and lake throughout the year with peak densities and greatest declines during winter (November–February, dry season) and summer (June and July), respectively. If this pattern is similar to that in Lake Malawi, the prevalence and abundance and perhaps the degree of sexual maturity of the Malawi worms (Table 1) would be expected to be higher during the winter.

SPECIMENS DEPOSITED: USNPC No. 88015-88030.

HOST SPECIMENS DEPOSITED: PSUFM Nos. 3243–3253.

Acknowledgments

We would like to thank Matthew Arnegard for netting the fishes, Dr. Jay R. Stauffer, Pennsylvania State University, for permission to work at his research camp at Lake Malawi, and the Government of Malawi for enabling us to collect the fishes under Dr. Stauffer's permit through the University of Malawi.

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New Books Available

An Atlas of Protozoan Parasites in Animal Tissues (Second Edition). By C. H. Gardiner, R. Fayer, and J. P. Dubey. 1998. Armed Forces Institute of Pathology, 84 pp. ISBN 1-881041-48-4. 8¼″ × 10¾″ softcover. Available from the American Registry of Pathology, Room G-134, Armed Forces Institute of Pathology, Washington DC 20306-6000. Cost is US$35.00 per copy plus shipping and handling cost of US$4.00 within the continental United States or US$8.75 outside of the continental United States. "**Abstract**: This atlas illustrates protozoan parasites in animal tissues. To facilitate identification, it provides a brief description of parasites, hosts, transmission, and pathogenesis of the most important protozoans and simplified life-cycle drawings. Also included are 257 color photographs of protozoans and associated lesions, recorded using optimal conditions, and 36 color photomicrographs of fungi that are commonly confused with protozoans."

Atlas of Ultrastructure of the Infective Juveniles of the Soybean Cyst Nematode, *Heterodera glycines*. By Burton Y. Endo. 1998. U.S. Department of Agriculture, Agriculture Handbook No. 711, 224 pp. 8½″ × 11″ softcover. While supplies last, single copies of this publication may be obtained at no cost from the Nematology Laboratory, USDA-Agricultural Research Service, 10300 Baltimore Avenue, Building 011A, Room 165B, Beltsville, MD 20705-2350. Copies may then be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, phone (703) 605-6000. ISBN and prices not available at this printing. "**Abstract**: This atlas . . . shows the transition from preparasitic to parasitic juveniles and their relation to host tissues . . . . The electron micrographs are grouped into subunits to emphasize various features of the nematode and host–parasite interactions. Illustrations also include changes in nematode anatomy related to . . . nematode development and early host responses. This handbook is a comprehensive compilation of previously published electron micrographs, combined with new data. [It] is an educational tool for those interested in nematode morphology and a reference for researchers interested in applying physiological studies to functional units of the nematode."

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Differentiation of *Coronocyclus sagittatus* and *Coronocyclus coronatus* (Nematoda: Cyathostominea) of Horses

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ABSTRACT: An increased interest worldwide in small strongyles of horses has prompted a revision of the systematics in order to support research on improving antiparasitic chemotherapy, biocontrol, and other management practices. A 1997 international workshop developed a revised list of recommended names for 51 recognized species of Cyathostominea and indicated problems in the differentation of some species, including *Coronocyclus coronatus* (Looss, 1900) and *C. sagittatus* (Kotlan, 1920). These morphologically similar species are members of *Coronocyclus* Hartwich, 1986, a genus with prominent and sclerotized external leaf crown supports that are separated from the buccal capsule. The two species can be distinguished from one another by differences in the shape of the buccal capsule, in the shape of the buccal capsule wall in optical section, in the point of insertion of elements of the internal leaf crown, and in the dorsal ray of the male. Drawings and photomicrographs are presented that illustrate the characteristics useful for differentiating *C. coronatus* and *C. sagittatus*.

KEY WORDS: *Coronocyclus sagittatus, Coronocyclus coronatus,* Nematoda, Cyathostominea, horses.

The Cyathostominea, or small strongyles of horses, can cause considerable morbidity and mortality in horses (Herd, 1990). Research activity on these nematodes is currently high for a number of reasons: 1) there is increasing recognition of larval cyathostominosis, a syndrome in which large numbers of larvae emerge from the walls of the large intestine, colon, and cecum, causing severe colitis that may result in death (Mair, 1994; van Loon et al., 1995); 2) resistance to anthelmintics in the Cyathostominea has been widely reported (Herd and Coles, 1995; Ihler, 1995); and 3) biological control prospects using nematode-trapping fungi appear promising (Bird and Herd, 1995; Larsen et al., 1996). This increased research interest required an update of the taxonomy and systematics of the Cyathostominea; the update was based on 3 differing classifications of genera and species (Lichtenfels, 1975; Hartwich, 1986; Dvojnos and Kharchenko, 1994). Differences among these classifications were resolved at an international workshop in Sun City, South Africa (Lichtenfels et al., 1998). The workshop developed a revised list of recommended names for 51 recognized species of Cyathostominea and indicated problems in the differentiation of some species, including difficulties in separating 2 similar species of the genus *Coronocyclus* Hartwich, 1986, *C. coronatus* (Looss, 1900) and *C. sagittatus* (Kotlan, 1920). The objective of this report is to describe morphological characteristics that can be used to differentiate these 2 species.

The genus *Coronocyclus* was defined (Hartwich, 1986) by distinguishing from the genus *Cyathostomum* (sensu Lichtenfels, 1975) the 4 species that have the sclerotized support of the external leaf crown (ELC) separated anteriorly from the wall of the buccal capsule. A fifth species was added to the genus by Dvojnos et al. (1994). *Coronocyclus* was recognized by the Sun City workshop as having the following 5 species: (1) *C. coronatus* (Looss, 1900) Hartwich, 1986, type species, =*Trichonema subcoronatum* Yamaguti, 1943; (2) *C. labiatus* (Looss, 1902) Hartwich, 1986, =*Cylicostomum labiatum digitatum* Ihler, 1921; (3) *C. labratus* (Looss, 1900) Hartwich, 1986; (4) *C. sagittatus* (Kotlan, 1920) Hartwich, 1986; and (5) *C. ulambajari* Dvojnos, Kharchenko, and Lichtenfels, 1994. Of these 5 species, only *C. sagittatus* and *C. coron-*

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Table 1. Geographic locality, host, number, sex, and type of specimens of *Coronocyclus sagittatus* and *C. coronatus* studied.

Geographic locality	Host	USNPC No.	No. studied		Type	Collector
			Males	Females		
Coronocyclus sagittatus						
Japan	*Equus caballus*	79081	2	2	Voucher	M. Ito
Mongolia	*Equus caballus*	83402		4	Voucher	G. M. Dvojnos
Moscow, Russia	*Equus caballus*	83403	2	1	Voucher	G. M. Dvojnos
Coronocyclus coronatus						
Cairo, Egypt	*Equus caballus*	9598	2	2	Syntypes	A. Looss
Panama	*Equus caballus*	58476	2	2	Voucher	A. O. Foster
Frederiksberg, Denmark	*Equus caballus*	85073	2	2	Voucher	J. Monrad

atus are difficult to distinguish from each other. In fact, Skladnik (1935) considered *C. sagittatus* to be a synonym of *C. coronatus*. However, Ershov (1933) and most, if not all, modern researchers recognize both species (McIntosh, 1951; Popova, 1958; Baruš, 1962; Lichtenfels, 1975; Hartwich, 1986; Dvojnos and Kharchenko, 1994). *Coronocyclus sagittatus* has been reported only rarely from Eastern Europe and Asia and once from the Caribbean islands (Hartwich, 1994). Because it has not been collected from North America, it was described only briefly in the most widely available identification manual (Lichtenfels, 1975). With the international movement of horses, *C. sagittatus* can be expected to have a wider distribution than has been indicated in the literature. Hartwich (1994) suggested that the distribution of *C. sagittatus* is probably more extensive than has been reported because of the difficulty in distinguishing it from the similar species *C. coronatus*. The information in this article will enable *C. sagittatus* to be identified and separated from the commonly reported species *C. coronatus*.

Materials and Methods

Type specimens of *C. coronatus* were obtained from the U.S. National Parasite Collection (USNPC) maintained by the Agricultural Research Service at Beltsville, Maryland. Other specimens studied are listed in Table 1. Scientific naming follows the recommendations of the 1997 Workshop on the systematics of the Cyathostominea reported in an annotated checklist by Lichtenfels et al. (1998). Nematodes were studied in temporary wet mounts in the clearing agent phenol-alcohol (80 parts melted phenol crystals in 20 parts absolute ethanol) with the aid of a light microscope equipped with interference contrast optics.

Drawings were made with the aid of a camera lucida attached to the microscope; these drawings have been published previously (Dvojnos and Kharchenko, 1994). Photomicrographs were obtained with a 35-mm camera mounted on an Olympus Vanox research microscope at magnifications ranging from ×100–400 using Kodak T-Max black-and-white negative film.

Measurements are in micrometers unless otherwise indicated (Tables 2, 3). Measurements employed standard methods. Buccal capsule depth was measured from the anterior edge of the buccal capsule wall to the anterior edge of the esophagus. Buccal capsule width was measured from the outside edges at its widest point. Measurements of previous authors are included in Tables 2 and 3 for comparison.

The term "anterior deirid" is used for the bilateral cervical papillae, even though the posterior deirid described in other nematodes (Lichtenfels et al. 1995) of the class Secernentea has not been described in the Cyathostominea.

Results

The 2 similar species *Coronocyclus coronatus* and *C. sagittatus* can be distinguished from one another by differences in the shape of the buccal capsule wall, in the point of insertion of elements of the internal leaf crown (ILC), and in the configuration and spacing of the branches of the dorsal bursal ray of the male copulatory bursa.

SHAPE OF BUCCAL CAPSULE: The buccal capsule of both species is nearly cylindrical, and it is somewhat wider than deep. The capsule of *C. sagittatus* is proportionally wider than that of *C. coronatus* (Figs. 1, 2, 11, 12, 19–22; Tables 2, 3).

SHAPE OF BUCCAL CAPSULE WALL IN OPTICAL SECTION: The shape of the buccal capsule wall in the optical section is thumblike, thicker at the bottom and middle than at the top. In *C. sagittatus,* the anterior portion of the wall is thinner, especially in a lateral view, than it is in *C. co-*

Table 2. Morphometric comparison (in micrometers unless otherwise indicated, range and mean) of *Coronocyclus sagitttatus* with data reported by Kotlan (1920),* Dvojnos and Kharchenko (1994), and Hartwich (1994).

Characters	Present study	Kotlan (1920)	Dvojnos and Kharchenko (1994)	Hartwich (1994)
Males				
Body length (mm)	8.14–11.3 (9.93)	10.0–11.0	9.50–11.0	9.70–11.0
Body width	375–492 (448)	400	—	400–520
Buccal capsule width	116–135 (124)	100–120	146–160	72–113
Buccal capsule depth	41–49 (45)	40	32–36	32–50
Elements of ELC	—	18–20	16–20	16–20 (18)
Elements of ILC	—	70–80	60–80	66–74
Nerve ring†	307–319 (311)	—	—	—
Cervical papillae†	431–476 (447)	—	422–524	post. to ep
Excretory pore†	394–420 (409)	—	384–486	300–480
Esophagus length†	675–712 (689)	600–700	541–620	540–620
Esophageal bulb width	176–274 (220)	180	—	130–260
Spicule length (mm)	1.24–1.46 (1.36)‡	—	1.00–1.42	1.00–1.42
Gubernaculum length	200–217 (207)	—	180–239	180–240
Dorsal ray length	469–994 (751)	—	420	740–860
Females				
Body length (mm)	9.15–12.4 (11.1)	12.0–12.5	10.5–12.8	9.10–12.8
Body width	441–566 (519)	500	—	480–670
Buccal capsule width	112–157 (130)	—	96–128	72–113
Buccal capsule depth	45–56 (49)	40	33–40	32–50
Elements of ELC	—	18–20	16–20	16–20
Elements of ILC	—	70–80	60–80	66–74
Nerve ring†	285–349 (317)	—	—	—
Cervical papillae†	439–547 (481)§	—	422–524	post. to ep
Excretory pore†	382–495 (476)	—	384–486	300–480
Esophagus length†	675–776 (733)	600–700	620–730	620–730
Esophageal bulb width	154–225 (220)	180	—	130–260
Vagina length	210–712 (356)§	—	—	—
Sphincter length	154–330 (228)	—	—	—
Infundibulum length	187–289 (228)	—	—	—
Vulva-to-anus length	79–180 (155)§	160	—	140–220
Female tail length	180–262 (214)§	140	140–193	140–240
Eggs (length × width)	67–92 (78) × 41–49 (46)	—	86–94 × 44–50	86–94 × 44–50

* Kotlan's measurements as reported by Theiler (1923).
† Measurement from anterior end.
‡ N = 3 of 4 males measured.
§ N = 6 of 7 females measured.

ronatus, which has a more uniform thickness overall (Figs. 19–22).

INSERTION OF ILC: The bases of the elements of the internal leaf crown rest, or are inserted, on the inner surface of the anterior part of the buccal capsule. In *C. sagittatus,* the ILC insertion is at a point about ⅓ of the depth of the buccal capsule (Figs. 19, 21); in *C. coronatus,* the ILC insertion is at $\frac{1}{5}$ to ¼ of the buccal capsule depth (Figs. 20, 22).

RELATIVE WIDTH OF ELEMENTS OF ILC: A comparison of the width or thickness of the palisade-like elements of the ILC of the 2 species revealed that they are wider in *C. sagittatus* (Fig. 23) than they are in *C. coronatus* (Fig. 24).

ESOPHAGUS, NERVE RING, ANTERIOR DEIRIDS, EXCRETORY PORE: These characteristics are illustrated (Figs. 25, 26), and measurements pertaining to them are included in Tables 2 and 3, but differences between species were regarded as being related to differences in size of the nematodes. On average, *C. sagittatus* is 16–22% longer than *C. coronatus* (Tables 2, 3).

DORSAL RAY OF COPULATORY BURSA: Almost

Table 3. Morphometric comparison (in micrometers unless otherwise indicated, range and mean) of *Coronocyclus coronatus* with data reported by Theiler (1923), Dvojnos and Kharchenko (1994), and Hartwich (1994).

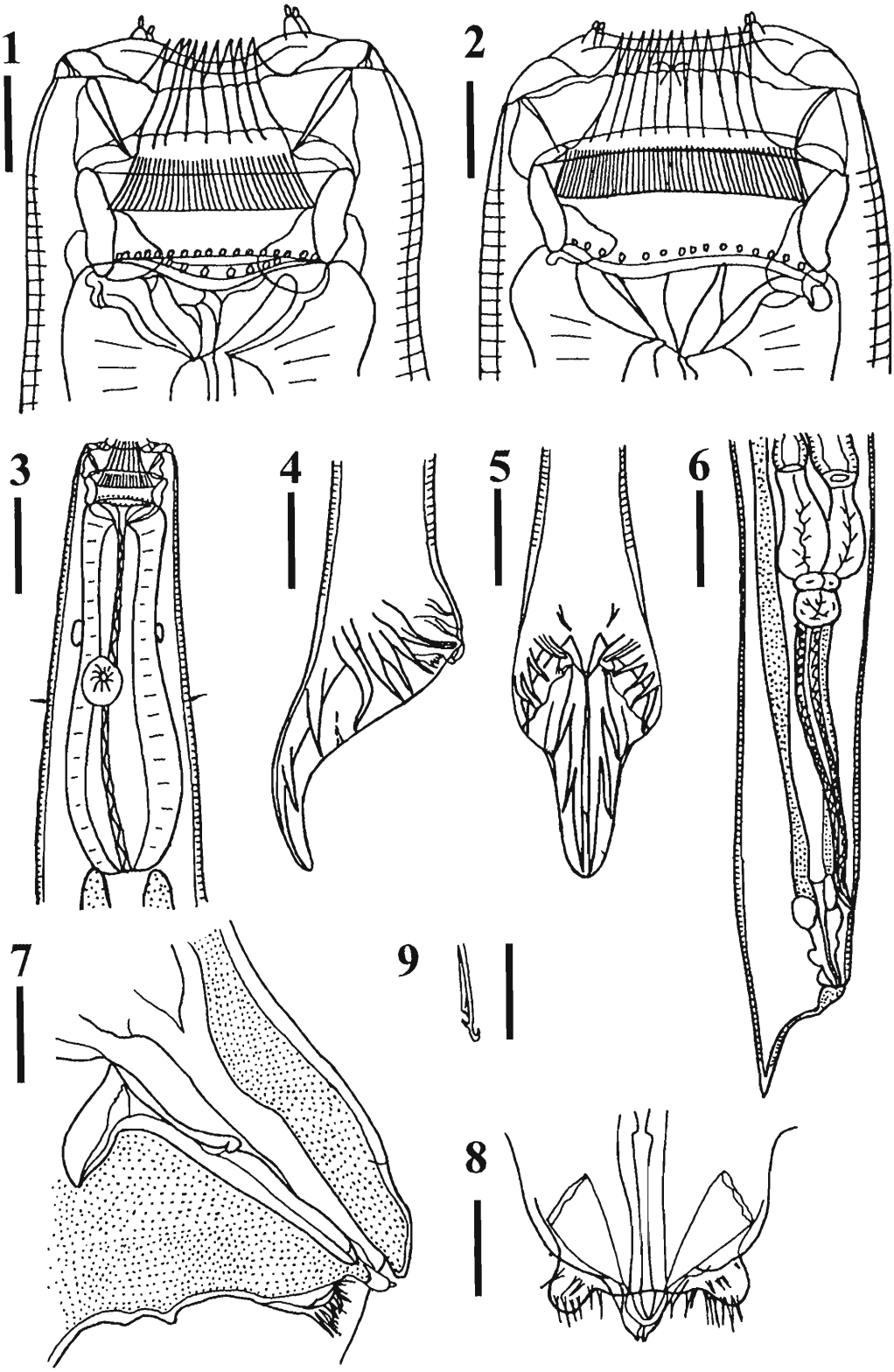
Characters	Present study	Theiler (1923)	Dvojnos and Kharchenko (1994)	Hartwich (1994)
Males				
Body length (mm)	8.42–9.32 (8.56)	8.75–9.00	6.84–10.28	6.40–10.3
Body width	300–370 (335)	340–360	—	210–410
Buccal capsule width	67–75 (69)	24–28	62–92	39–100
Buccal capsule depth	37–49 (43)	44–50	32–40	28–51
Elements of ELC	—	22	20–22	20–24
Elments of ILC	—	—	72–80	70–80
Nerve ring*	228–255 (244)	—	—	—
Cervical papillae*	317–379 (362)	280–300	320–376	250–440
Excretory pore*	284–356 (329)	280–300	—	250–440
Esophagus length	442–499 (454)	380–400	360–520	360–680
Esophageal bulb width	97–262 (133)	100	—	90–100
Spicule length (mm)	0.72–1.06 (0.94)	—	0.72–1.35	0.67–1.40
Gubernaculum length	146–169 (164)	—	156–210	110–200
Dorsal ray length	600–675 (648)	600	502–717	460–720
Females				
Body length (mm)	8.14–10.4 (9.06)	9.50–10.0	7.50–10.47	5.90–10.5
Body width	300–416 (374)	400–440	—	240–460
Buccal capsule width	65–75 (72)	24–28	68–126	39–100
Buccal capsule depth	39–45 (43)	44–50	38–44	28–51
Elements of ELC	—	22	20–22	20–24
Elements of ILC	—	—	72–80	70–80
Nerve ring*	244–281 (259)	—	—	—
Cervical papillae*	311–394 (362)	280–300	352–450	250–440
Excretory pore*	300–378 (329)	280–300	—	250–440
Esophagus length	469–510 (491)	380–400	400–683	360–680
Esophageal bulb width	105–146 (133)	100	—	180
Vagina length	247–435 (336)	280–360	280–360	—
Sphincter length	240–307 (260)	—	—	—
Infundibulum length	206–318 (251)	—	—	—
Vulva-to-anus length	112–120 (115)	120–140	74–89†	75–150
Female tail length	146–180 (164)	160–200	150–223	120–220
Eggs (length × width)	79–93 (84) × 37–55 (44)	80–90 × 36–44	92–103 × 44–55	75–103 × 36–55

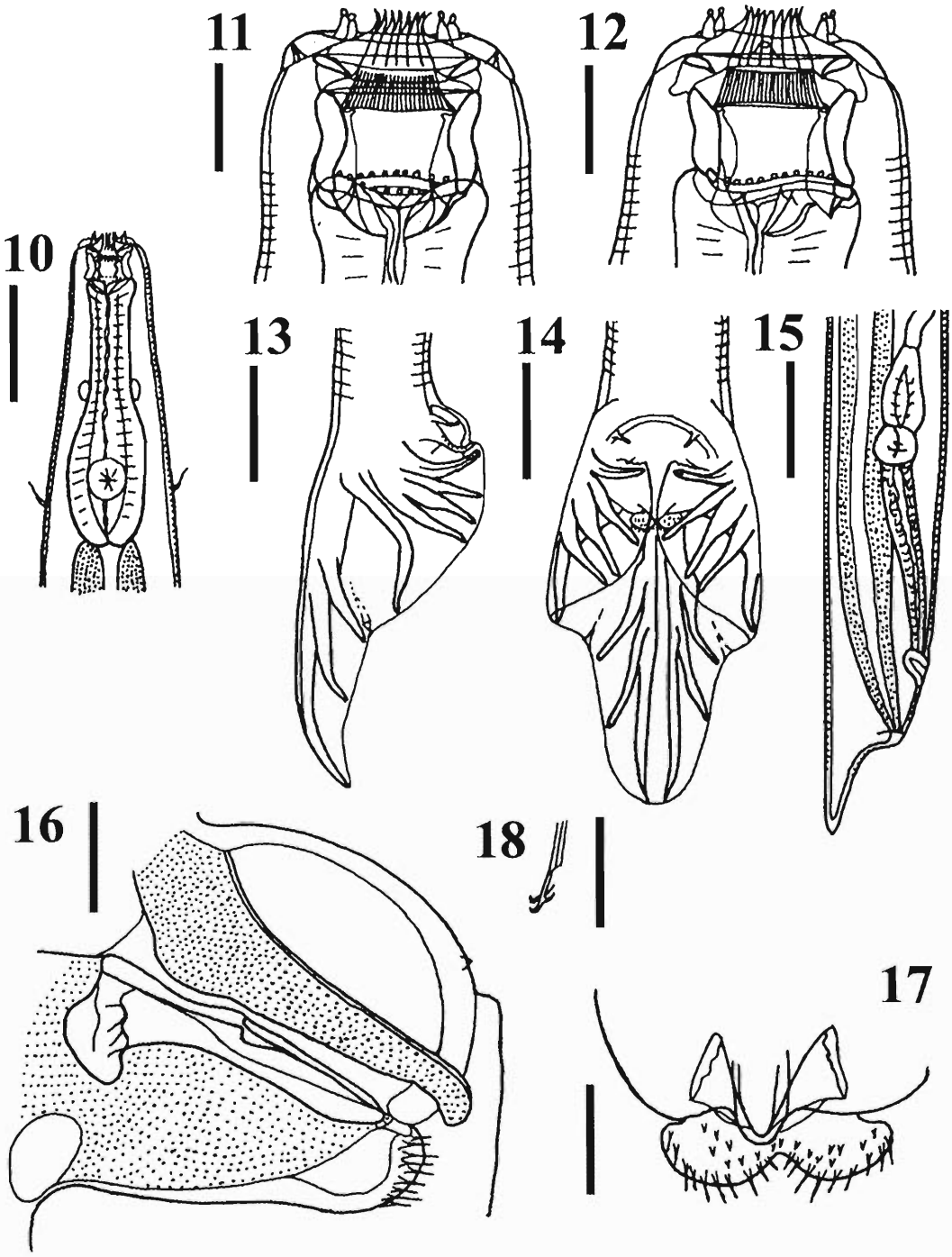
* Measured from the anterior end.

† Calculated measurement from Dvojnos and Kharchenko (1994).

→

Figures 1–9. Camera lucida drawings of *Coronocyclus sagittatus*. Scale bars = 50 μm (Figs. 1, 2, 7–9) and 200 μm (Figs. 3–6). 1. Anterior end, dorsoventral view, showing optical section of cylindrical buccal capsule; a shallow, thick-walled esophageal funnel; elements of ILC; elements of ELC; spindle-shaped optical sections of ringlike sclerotized support (supports) for elements of ELC; mouth collar; lateral papillae (amphids); and 4 submedian cephalic papillae. 2. Anterior end, lateral view, showing same structures as in previous figure from different view. 3. Anterior end, ventral view, showing esophagus, nerve ring, anterior deirids, and excretory pore. 4. Male tail, lateral view. 5. Male tail, ventral view. 6. Female tail, lateral view, showing anus, vulva, and some portions of the ovejectors. 7. Genital cone of male, lateral view, showing gubernaculum and projections on ventral part of cone. 8. Genital cone, ventral view, showing distal tip of gubernaculum, internal plates, and projections of ventral part of cone. 9. Fused spicule tips.





Figures 10–18. Camera lucida drawings of *Coronocyclus coronatus*. Scale bars = 50 μm (Figs. 11, 12, 16–18) and 200 μm (Figs. 10, 13–15). 10. Anterior end, ventral view, showing esophagus, nerve ring, anterior deirids, and excretory pore. 11. Anterior end, dorsoventral view, showing optical section of cylindrical buccal capsule; a shallow, thick-walled esophageal funnel; elements of ILC; elements of ELC; spindle-shaped optical sections of ringlike sclerotized support (supports) for elements of ELC; mouth collar; lateral papillae (amphids); and 4 submedian cephalic papillae. 12. Anterior end, lateral view,

all dorsal rays of the Cyathostominea have 6 branches, 3 on each side of a medial fissure that usually extends to a point between the level of the origins of the proximal branches of the dorsal ray and the externodorsal rays. The 3 branches on each side of the dorsal ray are the proximal branch, the middle branch, and the longest or main branch (Figs. 4, 5, 13, 14, 27, 28). In *C. sagittatus,* the distance between the origin of the proximal branch and the origin of the medial branch is equal to or less than the length of the proximal branch. The proximal branch does not overlap the origin of the middle branch (Figs. 5, 27). In *C. coronatus,* the distance between the origins of the proximal and middle branches is less than the length of the proximal branch, and the proximal branch overlaps the origin of the middle branch (Figs. 14, 28). In *C. sagittatus,* the dorsal ray is divided by the medial fissure only to the level of the proximal branch, but in *C. coronatus* the medial fissure divides the dorsal ray to its base.

RELATIVE LENGTH OF FEMALE TAIL TO DISTANCE BETWEEN VULVA AND ANUS: Based on previously published measurements of *C. sagittatus* and *C. coronatus,* the length of the female tail compared to the distance between the vulva and the anus appeared to provide a useful character in females for distinguishing these 2 species. In *C. sagittatus,* these measurements were reported to be about equal, but in *C. coronatus,* the tail was reported to be longer than the distance from vulva to anus (Tables 2, 3). However, our measurements of just 6 females of *C. sagittatus* found the vulva-to-anus distance to be somewhat shorter than the tail length, as in *C. coronatus* (Table 2).

Discussion

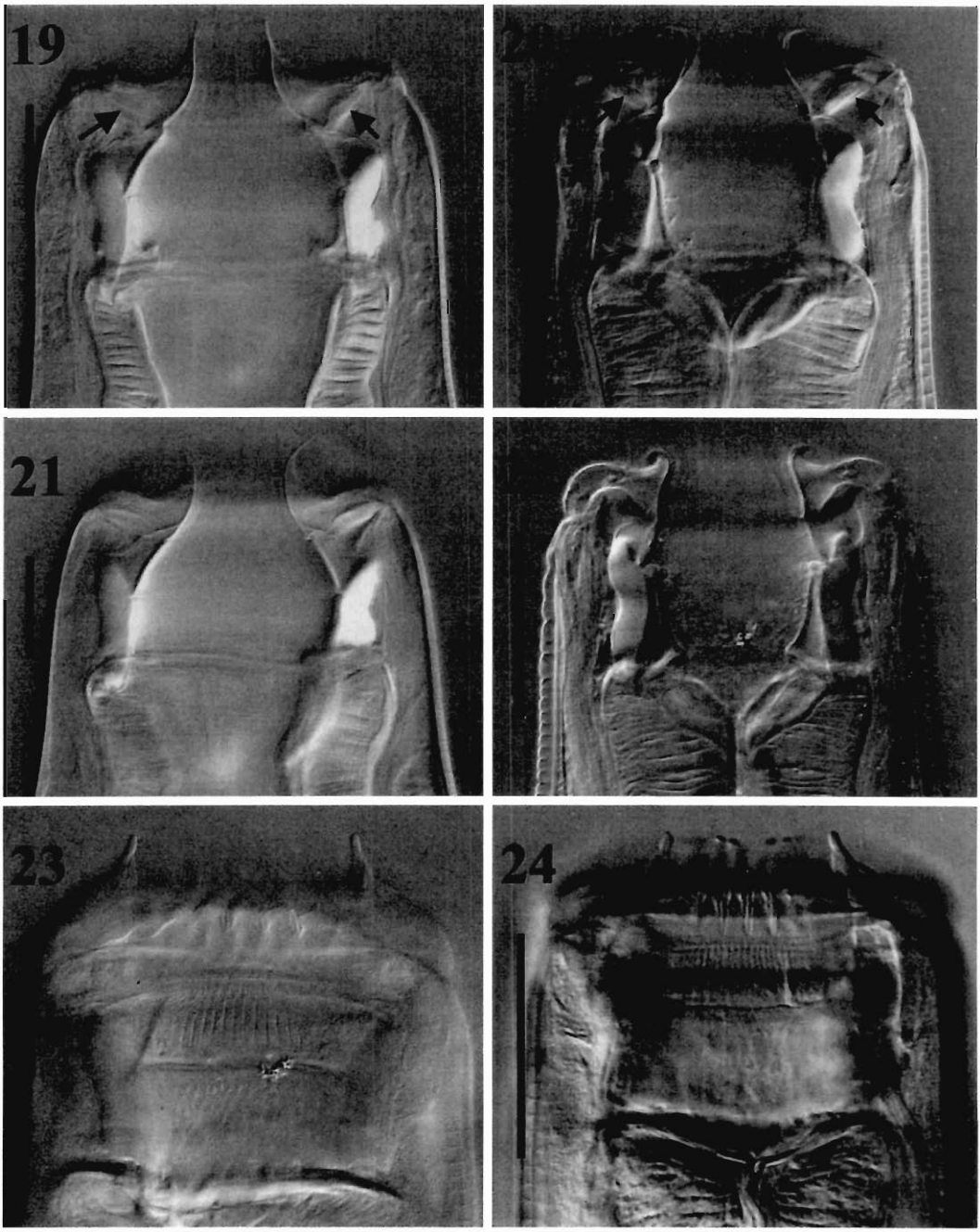
The characters described in the Results section and illustrated in the photomicrographs and line drawings can be used to distinguish adult, fifth-stage specimens of the 2 similar species *Coronocyclus coronatus* and *C. sagittatus.* Three key cephalic characters that are applicable to both sexes (the shape of the buccal capsule, the shape of the buccal capsule wall in optical section, and the point of insertion of elements of the ILC on the inside of the buccal capsule wall) are provided, and an additional key character is provided for males (the configuration of the branches of the dorsal ray of the copulatory bursa of the male).

Our data indicated that characteristics of the female tail could not be used to separate these species. Previously published measurements indicated that differences between the distance from vulva to anus and the length of the tails and differences between vagina lengths might exist between *C. sagittatus* and *C. coronatus* (Tables 2, 3), but our measurements did not support the use of these characters. Our method of sampling variation within species involved measuring a few specimens from as many different isolates as was practical. We included specimens from 3 different isolates of each species in our measurements. This may explain the greater range of variation in our measurements compared to those described in earlier reports (Tables 2, 3).

Although the greater width of the ILC elements of *C. sagittatus* can be used as a supplementary character to distinguish the species from *C. coronatus,* the numbers of elements in the leaf crowns cannot. Because of overlap and considerable variation in the number of elements in the ELC and in the ILC, the number of elements is not a useful character for separating these species. Kosupko and Nechinenny (1982) studied en face preparations of both species and reported on *C. sagittatus* as having 20 ELC elements and 68–74 ILC elements. They reported that *C. coronatus* had 20–22 ELC elements and 72–80 ILC elements. Braide and Georgi (1974) studied en face preparations of *C. coronatus* and reported 22 ELC elements. Looss (1900, 1902) reported "about 22" ELC elements in *C. coronatus.* In his survey of the literature, Hartwich (1994) reported a wide range of numbers of leaf crown elements.

←

showing same structures as in previous figure from different view. 13. Male tail, lateral view. 14. Male tail, ventral view. 15. Female tail, lateral view, showing anus, vulva, and some portions of the ovejectors. 16. Genital cone of male, lateral view, showing gubernaculum and projections on ventral part of cone. 17. Genital cone, ventral view, showing distal tip of gubernaculum, internal plates, and projections of ventral part of cone. 18. Fused spicule tips.



Figures 19–24. ***Coronocyclus sagittatus*** **and** ***C. coronatus,*** **photomicrographs of key differentiating characters. Scale bars = 50 μm. Figures 19, 20. Anterior ends, dorsoventral views, showing optical sections of cylindrical buccal capsules, elements of ILC and ELC, spindle-shaped optical sections of ringlike sclerotized supports of the ELC (supports) (arrows), and lateral papillae (amphids). 19.** ***C. sagittatus.*** **20.** ***C. coronatus.*** **Figures 21, 22. Anterior ends, lateral views, showing optical sections of cylindrical buccal capsules, elements of ILC and ELC, spindle-shaped supports, and the mouth collar. 21.** ***C. sagittatus.*** **22.** ***C. coronatus.*** **Figures 23, 24. Anterior ends, dorsoventral views, focused on submedian cephalic papillae and elements of the ILC. 23.** ***C. sagittatus.*** **24.** ***C. coronatus.***

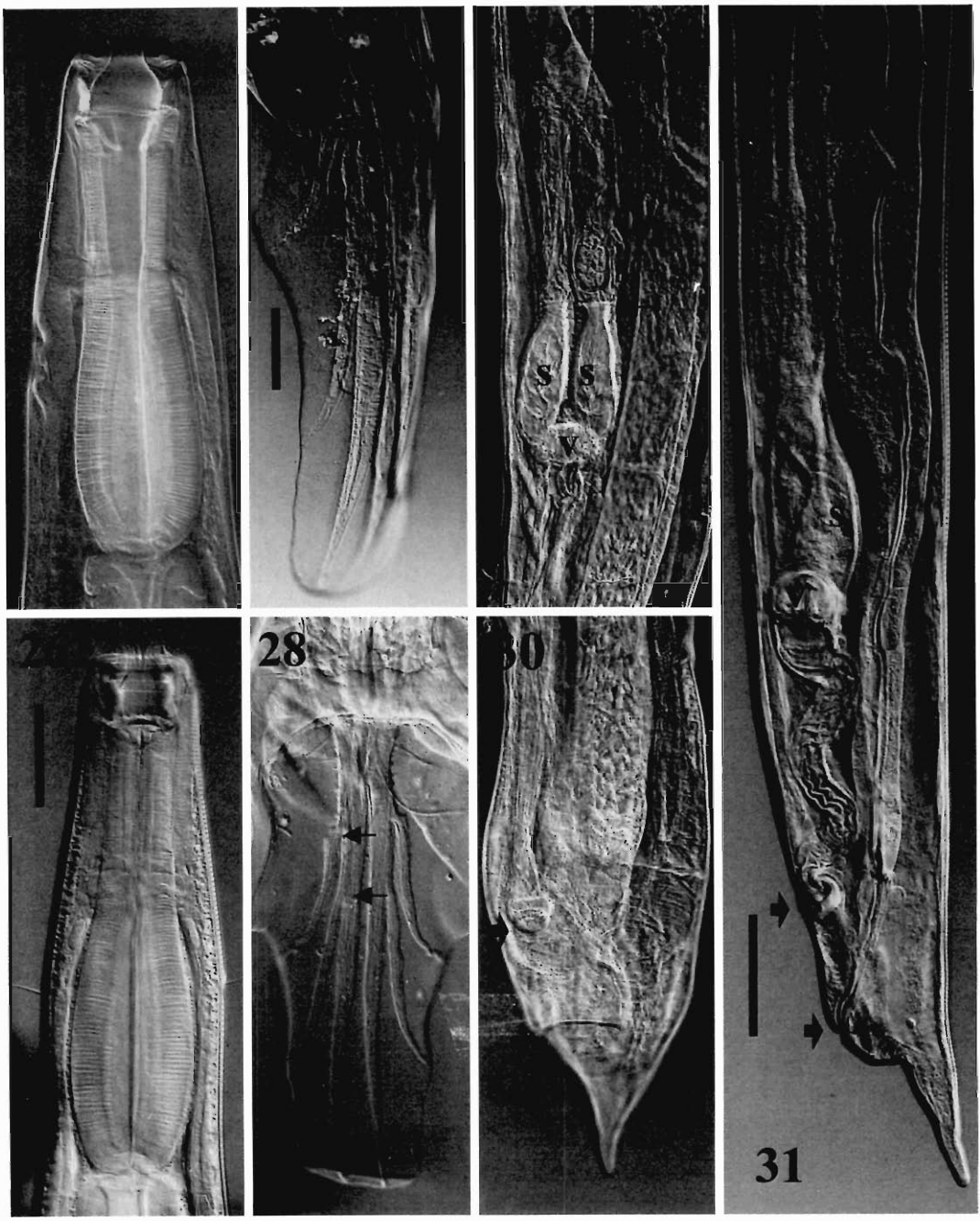


Figure 25–31. *C. sagittatus* and *C. coronatus*, photomicrographs of the esophagus and key differentiating characters of the male and the female. Scale bars = 100 μm. 25. *C. sagittatus*, lateral view (arrow at excretory pore). 26. *C. coronatus*, dorsoventral view, showing positions of nerve ring and cervical papillae (anterior deirids). Figures 27, 28. Male tails, dorsolateral and dorsal views respectively, showing proximal (upper arrow), middle (lower arrow), and main branches of the dorsal rays. 27. *C. sagittatus*. 28. *C. coronatus*. Figures 29–31. Female tails, showing positions of anus, vulva (large arrows), and constituent parts of the ovejectors including vestibule (v), sphincters (s), and infundibula (between small arrows). 29, 30. *C. sagittatus*. 31. *C. coronatus*.

Distinguishing *C. sagittatus* from *C. coronatus* requires a careful comparison of the characteristics of the buccal capsules and of the ILC elements. To assist in these identifications, we have provided photomicrographs of these characteristics side by side (Figs. 19–24). This improved identification aid should provide the research tools needed to determine whether the apparently low distribution of the rarely reported *C. sagittatus* has resulted from an inability to distinguish it from the more commonly reported *C. coronatus,* as suspected by Hartwich (1994).

Coronocyclus coronatus is distributed throughout the range of the hosts, *Equus caballus, E. przhewalskii, E. asinus, E. hemionus,* and hybrids of horses. Its most common habitat is the caecum. *Coronocyclus sagittatus* is a rare species, not found in *E. asinus* or *E. hemionus.* Its preferred habitat is not known.

Larvae of the fourth stage have only been identified in *C. coronatus.* The larva's buccal capsule is large; the width is less than or equal to the length; and the walls are thick, with a sharply pointed anterior edge. A thick, triangular, ringlike anterior part of the lining of the esophageal funnel supports the buccal capsule. The esophageal funnel is well developed, with a pointed dorsal tooth that has a wide base. The tooth does not project into the buccal cavity (Dvojnos and Kharchenko, 1987).

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Research Note

Parasites and Commensals of the West Indian Manatee from Puerto Rico

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ABSTRACT: Metazoan parasites and commensals were collected from dead manatees salvaged in Puerto Rico. Thirty-five manatees were examined between 1980 and 1998. Parasites and commensals were identified in 20 (57%) manatees and included 3 species of helminths, 1 nematode (*Heterocheilus tunicatus*) and 2 digeneans (*Chiorchis fabaceus* and *Cochleotrema cochleotrema*). Two species of commensals were also associated with manatees: a barnacle (*Chelonibia manati*) and a fish (whitefin remora, *Echeneis neucratoides*). The 3 species of helminths found in manatees constitute the first records of these parasite–host relationships for the study area. The record of *C. manati* is the first for the Caribbean, and thus the species is not endemic to the Gulf of Mexico as previously described. The speculation that West Indian manatees closer to the center of their geographic distribution would have a greater diversity of parasites was found not true for these insular specimens but perhaps could be true for continental South American specimens.

KEY WORDS: Sirenia, *Trichechus manatus*, helminths, nematodes, digeneans, barnacles, remoras, Caribbean.

After reporting on the prevalence of parasites in West Indian manatees (*Trichechus manatus* Linnaeus 1758) from Florida, Beck and Forrester (1988) proposed that an examination of manatees recovered near the center of the species distribution may yield a greater diversity of parasite fauna than had been reported previously. Several references to the helminths of manatees in the Caribbean and South America exist (see Beck and Forrester, 1988; Coy-Otero, 1989), but the parasite and commensal fauna of manatees inhabiting the waters of Puerto Rico has not been described.

To assess the parasite and commensal fauna of manatees in Puerto Rico, helminths and symbionts were collected from dead manatees salvaged by the U.S. Fish and Wildlife Service (USFWS) between 1980 and 1988 and by the Caribbean Stranding Network (CSN) between 1989 and 1998 (Mignucci-Giannoni, 1996). When the condition of the animals allowed, carcasses salvaged or necropsied were examined for metazoan endoparasites by searching the entire gastrointestinal tract, major organs, blubber, and nares. The skin was searched for external parasites and commensal associates. Specimens of each parasite or commensal collected were initially fixed with 10% buffered formalin and then stored in glass vials in 70% ethanol. Representative helminth specimens were deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland.

Thirty-five manatees were examined. Parasites and commensals were collected from 20 (57%) of these animals. Three species of parasites were identified: 1 nematode (*Heterocheilus tunicatus* Diesing, 1839) and 2 digeneans (*Chiorchis fabaceus* (Diesing, 1838) and *Cochleotrema cochleotrema* (Travassos and Vogelsang, 1931)) (Table 1). Two species of commensals were associated with manatees: 1 cirriped barnacle (*Chelonibia manati* Pilsbry, 1916) and 1 fish (whitefin remora, *Echeneis neucratoides* Zuieuw, 1789) (Table 1). No cestodes, acanthocephalans, or cyamids were observed.

Heterocheilus tunicatus was collected from 10 manatees (29%), mostly in the stomach and rarely extending to the intestine. The paramphistome fluke *C. fabaceus* was found in 14 animals (40%) in the duodenal diverticula, ileum, cecum, large intestine, and colon. *Cochleotrema coch-*

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Table 1. Parasite and commensal fauna collected from manatees (*Trichechus manatus*) in Puerto Rico.

Date of collection	Host			Parasite	Location in host	USNPC
	Sex	Length (cm)	Locality			
19 Sep 1980	M	313	Vega Baja	*C. fabaceus*	Cecum	
1 Nov 1982	M	295	Cabo Rojo	*C. fabaceus*	Intestine	
2 Oct 1982	M	210	Salinas	*H. tunicatus*	Stomach	
13 Aug 1984	F	151	Peñuelas	*C. manati*	Skin	
7 Jun 1989	F	208	Salinas	*C. fabaceus*	Cecum, colon	
14 Jan 1990	F	329	Ceiba	*H. tunicatus*	Stomach	87830.00
4 Oct 1990	F	206	Luquillo	*C. fabaceus*	Ileum	
				C. cochleotrema	Nares	
				H. tunicatus	Stomach, jejunum	87821.00
11 Apr 1991	F	210	Toa Baja	*C. fabaceus*	Cecum	87811.00
31 May 1991	F	300	Cabo Rojo	*C. fabaceus*	Ileum	87812.01
				C. cochleotrema	Nares, trachea	87812.02
				H. tunicatus	Stomach	87812.03
				C. manati	Skin	
18 Apr 1992	M	294	Ceiba	*C. fabaceus*	Cecum	87813.01
				C. cochleotrema	Nares	
				H. tunicatus	Stomach	87813.02
				E. neucratoides	Skin	
26 Aug 1992	M	258	Ponce	*C. fabaceus*	Colon	78643
				C. cochleotrema	Nares	78642
				H. tunicatus	Stomach	78641
24 Mar 1993	M	296	Fajardo	*C. fabaceus*	Intestine, colon	87814.01
				C. cochleotrema	Nares	
				H. tunicatus	Stomach	87814.02
28 Aug 1993	M	273	Guayanilla	*C. fabaceus*	Intestine, colon	87815.01
				C. cochleotrema	Nares	87815.02
				H. tunicatus	Stomach, ileum	87815.03
14 Sep 1993	F	331	Rincón	*C. fabaceus*	Small intestine	87816.00
15 Jul 1994	M	307	Ceiba	*H. tunicatus*	Stomach	87822.00
9 Jun 1995	M	229	Aguada	*C. cochleotrema*	Nares	87823.00
10 Apr 1996	F	207	Juana Díaz	*C. fabaceus*	Colon	87818.00
10 Feb 1997	M		Humacao	*C. fabaceus*	Colon	87819.01
				C. cochleotrema	Nares	87819.02
				H. tunicatus	Stomach	87819.03
21 Jan 1998	F	148	Juana Díaz	*C. manati*	Skin	
18 Mar 1998	M	277	Toa Baja	*C. fabaceus*	Colon	87820.01
				C. cochleotrema	Nares	87820.02

leotrema was found in 9 manatees (26%), in the nares of the host, although on 1 occasion this trematode was also found in the trachea and larynx. *Chelonibia manati* was only found in 3 manatees. In 1 manatee, the commensal *E. neucratoides* was reported. Remoras have been observed regularly on free-roaming manatees in the study area.

Only 1 of the manatees was parasitized simultaneously by 4 of the species of parasites and commensals identified, 6 (17%) were infected by 3 species of parasites, 1 was infected by only 2 species of parasites, and 12 (34%) were infected by only 1 species of parasite. In some manatees some parasites were not observed, probably because of the state of decomposition of the animal and not the lack of antemortem presence of the parasite. All manatees that had parasites were either freshly dead or moderately decomposed when necropsied. Of the manatees examined in which parasites were not found, 6 were in an advanced state of decomposition and 4 were moderately decomposed.

Parasitized animals ranged in age from <1 to >28 years (ages determined following the technique of Marmontel et al., 1996) and were 148–335 cm in length. The youngest animals found as a host (<1 year of age, 148 and 151 cm in length) had only the commensal *C. manati*. The 2–3-yr-old animals with endoparasites were

feeding on seagrass. Neonates <130 cm were not parasitized by helminths. A captive-reared manatee (Mignucci-Giannoni, 1998) that died at approximately 1.9 yr of age (210 cm in length, 190 kg) was not parasitized by any helminth.

All 3 species of helminths noted here are known to parasitize manatees in Florida, Mexico, Brazil, and Guyana (see Beck and Forrester, 1988). A new species of paramphistomid trematode from the intestines of a manatee from Ciénaga de Zapata in Cuba was described by Coy-Otero (1989) as *Chiorchis groschafti* Coy-Otero, 1989, but this specimen appears not to differ from *C. fabaceus.* The trematodes *Nudacotyle undicola* Dailey, Vogelbein and Forrester, 1988 and *Moniligerum blairi* Dailey, Vogelbein and Forrester, 1988 and coccidian oocysts *Eimeria manatus* Upton, Odell, Bossart, and Walsh, 1989 and *Eimeria nodulosa* Upton, Odell, Bossart, and Walsh, 1989 have also been reported to parasitize Florida manatees (Beck and Forrester, 1988; Dailey et al., 1988; Upton et al., 1989) but were not collected in the gastrointestinal tracts of manatees examined from Puerto Rico.

The 3 species of helminths found in these manatees constitute the first records of these parasite–host relationships for the study area. The commensal *C. manati* is the first record in the Caribbean. It was initially described from western Florida on a manatee and loggerhead turtles (*Caretta caretta* (Linnaeus, 1758)), and 1 record exists from Texas from an unknown host (Gittings et al., 1986). The Texas finding convinced Gittings et al. (1986) that the species was endemic to the Gulf of Mexico, which our present findings contradict.

Although Puerto Rico is closer to the center of the West Indian manatee's geographic distribution than is Florida, the parasite diversity was not greater than that found in the northern part of the species' range. Puerto Rico is located in the middle of an island chain and thus has fewer shallow-water faunal species than do areas closer to the continental shelves. Thus, intermediate hosts of other described manatee helminths may be lacking. Continental specimens from the shores of Central America or South America may be a better test for Beck and Forrester's (1988) hypothesis.

Salvage and specimen collections were conducted under USFWS permits PRT 2-8430 and PRT-684532 and under a cooperative agreement with Puerto Rico's Department of Natural and Environmental Resources. Support for the study was provided in part by a grant to the CSN from the USFWS Caribbean Field Office. M. Marmontel (Projeto Mamirauá, Brazil) and D. J. Banowetz (Florida Department of Environmental Protection) determined the ages of the animals used in the study. We are grateful for the assistance of CSN participants in the study. The research and preparation of this contribution was conducted as part of a postdoctoral fellowship for A.A.M.G. with the U.S. Geological Survey Biological Resources Division Sirenia Project in Gainesville, Florida.

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Research Note

Helminths of the Round Goby, *Neogobius melanostomus* (Perciformes: Gobiidae), from Southern Lake Michigan, Indiana

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ABSTRACT: Round gobies (*Neogobius melanostomus*) were collected from Hammond Marina and Calumet Harbor, southern Lake Michigan, Indiana, and examined for helminths. Sixty-four gobies were collected at Hammond Marina and 245 gobies and 4 sculpins were collected from Calumet Harbor. Larval helminths recovered from gobies included *Diplostomum* sp. and *Eustrongylides* sp. *Acanthocephalus dirus* (Van Cleave, 1931) was the only other parasite found. *Diplostomum* sp. was only found in gobies from Calumet Harbor, but *A. dirus* and *Eustrongylides* sp. were found in gobies from both collection sites. Parasite species richness, prevalence, mean intensity, and mean abundance were low in gobies. Parasite species found in gobies have been found previously in native fish species in the Great Lakes.

KEY WORDS: round goby, *Neogobius melanostomus,* introduced species, helminths, southwest Lake Michigan, Indiana, *Acanthocephalus dirus, Diplostomum* sp., *Eustrongylides* sp.

The round goby, *Neogobius melanostomus,* was introduced into the Great Lakes between 1986 and 1988 (Jude et al., 1992) probably from the Black Sea to the St. Clair River or Lake St. Clair in the ballast water of transoceanic freighters. The round goby is merely one of numerous animal species that have been introduced into the Laurentian Great Lakes (Mills et al., 1993). Jude et al. (1992) discussed the impact of round gobies on native fish species and suspected that native sculpins may be significantly impacted because they share similar resource requirements with the more aggressive gobies. The round goby appears to have established dense populations (Jude et al., 1992), leading to a decline in local native species (Crossman et al., 1992).

Muzzall et al. (1995) reported that all species of parasites of the round goby and tubenose goby, *Proterorhinus marmoratus,* from the St. Clair River and Lake St. Clair, Michigan, had been previously reported from other fish species in the Great Lakes and suggested that no parasites from the Black Sea had become established when the gobies were introduced to the Great Lakes. However, the following fish pathogens and parasites have been introduced into the Great Lakes: the myxosporean *Myxosoma cerebralis,* which causes whirling disease in salmonids, the microsporidian *Glugea hertwigi,* which infects rainbow smelt, and the bacterium *Aeromonas salmonicida,* which causes furunculosis (Mills et al., 1993).

The purpose of this study was to determine which parasite species were being recruited as the round gobies spread into southern Lake Michigan. We wanted to determine if the gobies were recruiting parasites found in native fish species, as found by Muzzall et al. (1995), and if parasites from Eurasia had become established in the gobies.

Divers utilizing SCUBA netted gobies in southern Lake Michigan from 2 sites. From June through October 1995, gobies were collected from Hammond Marina (41°69′N, 87°51′W). From May through October 1996 and June through October 1997, they were collected from Calumet Harbor (41°72′N, 87°52′W). The Hammond Marina site was used only during 1995 because the site was destroyed by human development in 1996. The 2 sites were approximately 4 km apart along the southwestern shore of Lake Michigan. Fish were collected near shore in water depths ranging from 2 to 8 m. Gobies were transported alive to the laboratory, where they were euthanized with MS-222. At necropsy, they were weighed and measured (total length), and sex was determined. The location of collection, number of fish examined, and weight and

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Table 1. Prevalence (PR), mean (±SD) intensity (I) and (A), and number of helminths found in *Neogobius melanostomus* from southern Lake Michigan, 1995, 1996, and 1997.

Parasite	Calumet Harbor (n = 245) PR	I	A	No. worms recovered (range)	Hammond Marina (n = 64) PR	I	A	No. worms recovered (range)	Site
Digenea									
Diplostomum sp.	6.1	4.5 ± 5.3	0.3 ± 0.5	67 (1–21)					lens
Acanthocephala									
Acanthocephalus dirus	2.4	1.0	0.2 ± 0.5	6	4.7	1.3 ± 0.6	0.06 ± 0.01	4 (1–2)	intestine
Nematoda									
Eustrongylides sp.	0.5	1.0	0.004 ± 0.06	1	1.6	1.0	0.02 ± 0.1	1	encysted in mesenteries

total length ranges (followed by mean ± SD) are as follows: round gobies: Hammond Marina (Hammond, Indiana), n = 64, 0.7–78.0 (10.7 ± 14.4) g, 2.0–19.5 (8.1 ± 3.0) cm; Calumet Harbor (Illinois–Indiana state line), n = 245, 0.3–33.1 (5.3 ± 5.2) g, 3.3–13.3 (7.1 +1.8) cm; sculpins: Calumet Harbor (Illinois–Indiana state line), n = 4, 4.1–14.2 (7.8 ± 4.6) g, 7.2–9.8 (8.3 ± 1.1) cm.

The skin, gills, eyes, orbits, peritoneal cavity, mesenteries, and peritoneal viscera were examined for parasites. Fish were examined within 24 hr of capture. Routine procedures were used to collect and process parasites. Terminology follows the definitions given by Bush et al. (1997). Voucher specimens of *Acanthocephalus dirus* and *Diplostomum* sp. were deposited in the U.S. National Parasite Collection (USNPC), Beltsville, Maryland (USNPC 87778 and 87779, respectively).

The current study is the first to report parasites from naturalized gobies in southern Lake Michigan. *Acanthocephalus dirus, Diplostomum* sp., and *Eustrongylides* sp. were found in gobies from 1 or both sites (Table 1). *Diplostomum* sp. was found only in gobies from Calumet Harbor. All 4 sculpins were infected with *A. dirus* at the same mean intensity and mean abundance, 4.0 ± 2.4. The mean intensity, mean abundance, and prevalence of helminth species were too low to make any meaningful comparisons for sampling site, sex, or length of the gobies.

We found only 3 species of helminths compared with the 7 species found in round gobies by Muzzall et al. (1995). Additionally, we observed very low intensities of infection (Table 1). Muzzall et al. (1995) suggested that low intensities for most helminth species may result from the limited time the gobies have been present in the system. This explanation also applies to our results. Gobies were first reported from Hammond Marina and Calumet Harbor in 1994 (Charlebois et al., 1997). Our collections of gobies in Hammond Marina began 1 yr after they were first reported.

A second factor is the presence or absence of intermediate hosts that can serve to complete a parasite life cycle. Intermediate hosts may serve as food items for the gobies or may merely release larval stages that can infect the gobies. For example, snails of the genus *Lymnaea* serve as the first intermediate host for *Diplostomum* sp., and these snails may have been less common in Hammond Marina than in Calumet Harbor. *Acanthocephalus dirus* utilizes aquatic isopods (*Caecidotea* spp.) as intermediate hosts, and these isopods were not well represented in the gut contents of the gobies we examined. However, zebra mussels were a common food item in the gut of round gobies, as was found by Muzzall et al. (1995) and Pronin et al. (1997). Toews et al. (1993) reported very low prevalence and intensity of infection of zebra mussels with parasites from Lake St. Clair. We also examined 500 zebra mussels from southern Lake Michigan and found no parasites in them. Zebra mussels do not appear to be a significant source of infective stages of parasites.

In a similar study, Radomski et al. (1991) suggested that armadillos, *Dasypus novemcinctus,*

near the periphery of their geographic range have fewer species and lower numbers of helminths, whereas more established populations tend to have greater numbers and species richness. The round gobies in southern Lake Michigan are near the periphery of their distribution and exhibit lower mean intensities and species richness when compared with the gobies from the St. Clair River and Lake St. Clair.

The founding population in southern Lake Michigan was most likely small and would have carried few if any parasites (Marcogliese, 1992; Pronin et al., 1997). This latter phenomenon has been termed the geographic barrier hypothesis (Radomski et al., 1991).

Muzzall et al. (1995, p. 228) suggested that native species such as sculpins might also "have low intensities in similar niches and should be examined for comparative purposes." We collected 4 sculpins that were all infected with *A. dirus,* but the sample size was too small to make any meaningful comparisons with the present goby infection data. Although the sample size of sculpins was small, 1 female *A. dirus* found in a sculpin was gravid, suggesting that native sculpins can serve as a suitable host for *A. dirus.* However, the female *A. dirus* found in gobies were not gravid, so it is not known if gobies can serve as a suitable host.

Parasite species in the round gobies apparently did not arrive with the original goby colonizers of Lake Michigan but were acquired after their introduction to the lake. *Diplostomum* sp., *Eustrongylides* sp., and *A. dirus* have been previously reported from native fishes in the Great Lakes (Amin, 1977, 1985; Dechtiar et al., 1988). The larval *Diplostomum* sp. and *Eustrongylides* sp. infecting the gobies can mature in vertebrates found in the Great Lakes region (Muzzall et al., 1995). Although *Diplostomum* sp. has a widespread distribution (including the Black Sea watershed), it was most likely recruited locally as opposed to being introduced from the Black Sea.

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Research Note

Helminths Infecting Froglets of the Northern Leopard Frog (*Rana pipiens*) from Foggy Bottom Marsh, Michigan

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ABSTRACT: Twelve helminth taxa (6 Nematoda, 5 Trematoda, and 1 Cestoda) were found in 43 froglets of the northern leopard frog, *Rana pipiens* Schreber, from Foggy Bottom Marsh in southern Michigan during July–October 1997. The cestode, *Mesocestoides* sp., had the highest mean intensity. Four taxa of larval trematodes occurred in the froglets, with the strigeid metacercariae having the highest prevalence and mean abundance and the unidentified metacercariae having the highest mean intensity. *Clinostomum* sp. and *Fibricola* sp. were also found. Of the nematodes, *Oswaldocruzia priceae* had the highest prevalence, and *Rhabdias ranae* had the highest mean intensity and mean abundance. Larval digeneans were the first members of the helminth community to become established in the froglets, along with *O. priceae* and *Cosmocercoides dukae*. Taxonomically, 536 (40%) cestodes, 484 (36%) trematodes, and 309 (23%) nematodes were found in the froglets. Although there are reports of parasites causing amphibian deformities, abnormalities were not observed in froglets that were commonly infected with larval helminths. One adult leopard frog was infected with *Mesocestoides* sp., *O. priceae*, *R. ranae*, and *Gorgodera amplicava*.

KEY WORDS: *Rana pipiens*, northern leopard frog, froglet, helminths, Nematoda, Trematoda, Cestoda, deformities, Michigan.

Parasites of the northern leopard frog in North America have been investigated by several authors: Faust (1918), Hegner (1922), Walton (1929), Reiber et al. (1940), Chandler (1942), Ulmer (1970), Baker (1976, 1978, 1985), Levine and Nye (1977), Williams and Taft (1980), Martin and Conn (1990), McAllister and Conn (1990), and McAlpine (1997). Jewell (1916), Cort (1917), Fortner (1923), Cort and Brooks (1928), Hughes (1928), Krull (1930, 1931), Talbot (1933), Cort and Brackett (1938), Olivier and Odlaug (1938), Herber (1939), Lawler (1939), Thomas (1939), Olivier (1940, 1942), Najarian (1952, 1953a, b, 1954, 1955), Ridgeway (1964), and Werner and Walewski (1976) all reported on the parasites of Michigan leopard frogs. As far as we know, McAlpine's (1997) is the only publication on parasites of young and juveniles of this species in North America. Populations of anurans, including leopard frogs, with limb abnormalities occur throughout North America. Sessions and Ruth (1990) found metacercariae in close association with hindlimb deformities of the Pacific tree frog, *Hyla regilla*, and the long-toed salamander, *Ambystoma macrodactylum*. They suggested that metacercariae cause a mechanical disruption in limb growth, thus explaining the presence of limb deformities. The objectives of our study were to survey the helminths of froglets in a natural population of northern leopard frogs and to report if metacercariae were associated with limb abnormalities.

A total of 44 frogs (43 froglets and 1 adult) were collected by hand or dip net during the day in July–October 1997 from Foggy Bottom Marsh, Mason County, southern Michigan. It has an area of approximately 40 acres and ranges in depth from 0.5 to 1 m. Cattails (*Typha* spp.) and various sedges border the marsh's edge, and oaks (*Quercus* spp.) and maples (*Acer* spp.) surround the northern and eastern shores. We consider a froglet to be a young of the year individual with both forelimbs and hindlimbs and not of breeding size. Froglets less than 5 mo old were collected on 5 dates, 2 wk apart, mostly in the transition area between land and water and in water approximately 20 cm in depth. Frogs were pithed, and most were examined within 48 hr; a few were fixed in 20% formalin and preserved in 70% EtOH. The mean snout–vent length (mm ± 1 SD) of the 43 froglets was 43.3 ± 6.8, range = 30–57 mm. The lungs, liver, gall bladder, stomach, small intestine, rectum, urinary bladder, abdominal cavity, mesentery, and musculature were examined. The helminths that were collected were processed using conven-

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Table 1. Prevalence, mean intensity, mean abundance, and total number of helminths occurring in 43 froglets of the northern leopard frog from Foggy Bottom Marsh, Michigan, during July–October 1997.

	Prevalence	Mean intensity ±1 SD (max.)	Mean abundance ±1 SD	No. of helminths found (% of community)	Location in host†
Digenea					
Clinostomum sp.*	19	2.5 ± 2.3 (7)	0.46 ± 1.4	20 (1.5)	US, LM
Fibricola sp.*	5	5.0 ± 2.8 (7)	0.23 ± 1.2	10 (0.75)	LF
Immature plagiorchid	2	1.0	0.02 ± 0.15	1 (0.08)	R
Strigeid metacercariae*	49	22.3 ± 43.4 (160)‡	9.71 ± 30.3‡	378 (28.4)‡	LM, EH, US, ESI, ME, LV, BC
Unidentified metacercariae*	7	25.0 ± 23.0 (50)	1.7 ± 8.2	75 (5.6)	K
Cestoda					
Mesocestoides sp.*	9	134.0 ± 153.1 (283)	12.3 ± 56.8	536 (40.3)	ME, ESI, EST, LV, LF, US, BC
Nematoda					
Cosmocercoides dukae	19	2.1 ± 1.8 (6)	0.4 ± 0.1	17 (1.2)	SI, R
Oswaldocruzia priceae	33	8.8 ± 12.6 (50)	2.9 ± 8.1	123 (9.2)	SI
Raillientnema sp.	7	7.6 ± 9.8 (19)	0.5 ± 2.9	23 (1.7)	SI, R
Rhabdias ranae	26	13.0 ± 15.8 (40)	3.3 ± 9.6	143 (10.7)	L
Spiroxys sp.*	5	1.0	0.05 ± 0.21	2 (0.15)	EST, ESI
Immature larva*	2	1.0	0.02 ± 0.15	1 (0.08)	LM

* Larval stage.

† Location in host: US = under skin, LM = encysted in leg muscle, LF = free in leg muscle, R = rectum, EH = external surface of heart, ESI = external surface of small intestine, ME = mesentery, K = kidneys, BC = body cavity, LV = liver, EST = external surface of stomach, SI = small intestine, L = lungs.

‡ Values based on 17 infected froglets.

tional techniques. Prevalence is the percentage of froglets infected, mean intensity is the mean number of parasites per infected froglet, and mean abundance is the mean number of parasites per examined froglet. Strigeid metacercariae were not counted in 4 froglets; therefore, these strigeid numbers were not included in the calculations for mean intensity, mean abundance, and total mean helminth abundance. Values are expressed as a mean ± 1 SD. Voucher specimens have been deposited in the United States National Parasite Collection, Beltsville, Maryland: *Gorgodera amplicava* (No. 88222), *Cosmocercoides dukae* (No. 88247), *Oswaldocruzia priceae* (No. 88223), and *Rhabdias ranae* (No. 88224).

Twelve helminth taxa infected froglets of the northern leopard frog, including 4 larval trematode taxa (Table 1). The *Clinostomum* sp. was easily seen in a large cyst. The diplostomulum type metacercariae of *Fibricola* sp. was found free or enveloped by host tissue and was identified by having oral and ventral suckers, the absence of lateral pseudosuckers, a holdfast organ with a slitlike opening posterior to the ventral sucker, intestinal ceca enlarged, tegument with spines, and a small conical hindbody. Strigeid metacercariae were small and were identified by having oral and ventral suckers, a holdfast organ posterior to the ventral sucker, intestinal ceca not enlarged, and faintly seen spines. Over 150 strigeid metacercariae were counted in the hindlimb of 1 froglet. The unidentified metacercariae had oral and ventral suckers, lacked a collar of spines around the oral sucker, and were found only in the kidneys.

Larval cestode tetrathyridia had the highest mean intensity and mean abundance. These were identified by possessing a deeply invaginated and inverted unarmed scolex with 4 suckers, and the high tetrathyridia intensity in the present study is suggestive of *Mesocestoides* sp. More than 160 tetrathyridia were reported by McAllister and Conn (1990) from 1 leopard frog in New York. Four nematode genera, including immature *R. ranae,* occurred in the digestive tract. Of the helminths identified to genus, *O. priceae* had the highest prevalence. Our specimens of *O. priceae* were identified using the key in Ben Slimane and Durette-Desset (1997). The single adult leopard frog (snout–vent length = 76 mm) collected in September harbored 221 *Mesoces-*

Table 2. Summary of the parasites of *Rana pipiens* and their prevalences from Michigan.

Parasite	% Prevalence	Reference
Protozoa		
Nyctotherus cordiformis	2 (1917), 22 (1919)†	Fortner (1923)
Octomitus intestinalis	30 (1917), 48 (1919)	Fortner (1923)
Opalinia obtrigonoidea	61 (1917), 80 (1919)	Fortner (1923)
Trypanasoma pipientis	8	Werner and Walewski (1976)
Trypanasoma ranarum	17	Werner and Walewski (1976)
Trypanasoma rotatorium	71	Werner and Walewski (1976)
Digenea		
*Alaria mustelae**	‡	Olivier and Odlaug (1938)
*Alaria marcianae**	‡	Cort (1917)
	‡	Cort and Brooks (1928)
*Apharyngostrigea pipientis**	‡	Hughes (1928)
Cephalogonimus americanus	20	Najarian (1955)
*Cercaria elodes**	‡	Olivier (1942)
*Clinostomum attenuatum**	2 (1917)	Fortner (1923)
Clinostomum sp.*	19§	This paper
*Diplostomum micradenum**	‡	Olivier (1940)
	‡	Cort and Brackett (1938)
*Echinoparyphium flexum**	42	Najarian (1952)
	42	Najarian (1953a)
	‡	Najarian (1953b)
	50	Najarian (1954)
Fibricola sp.*	5§	This paper
Gorgodera amplicava	100‖	This paper
Gorgodera attenuata	51 (1917), 38 (1919)	Fortner (1923)
Haematoloechus medioplexus	‡	Krull (1930)
	‡	Krull (1931)
	5 (1917), 30 (1919)	Fortner (1923)
Haematoloechus similiplexus	1 (1917), 0.9 (1919)	Fortner (1923)
Halipegus occidualis	<1	Thomas (1939)
*Lechriorchis primus**	‡	Talbot (1933)
Megalodiscus temperatus	30 (1917), 1 (1919)	Fortner (1923)
	63	Herber (1939)
Immature plagiorchid	2§	This paper
Renifer sp.*	20	Najarian (1955)
Strigeid metacercariae*	49§	This paper
Unidentified metacercariae*	7§	This paper
Cestoda		
Cylindrotaenia americana	‡	Jewell (1916)
	‡	Lawler (1939)
Mesocestoides sp.*	9§	This paper
Proteocephalidae	1 (1919)	Fortner (1923)
Nematoda		
Cosmocercoides dukae	19§	This paper
Oswaldocruzia priceae	33§	This paper
Oswaldocruzia sp.	‡	Ridgeway (1964)
Raillientnema sp.	7§	This paper
Rhabdias ranae	26§	This paper
Spiroxys sp.*	5§	This paper
Immature larva*	2§	This paper

* Larval stage.
† Prevalence (year of study).
‡ Present but prevalence not indicated.
§ Prevalence calculated from 43 froglets.
‖ Found in 1 adult.

toides sp. (encysted in the liver, external surface of the stomach and small intestine, and free in the body cavity), 8 *O. priceae* (small intestine), 4 *R. ranae* (lungs), and 3 *G. amplicava* (urinary bladder).

Of the 38 (88%) froglets infected with ≥1 helminths, 18 harbored 1 taxon, 7 harbored 2 taxa, 7 harbored 3 taxa, 5 harbored 4 taxa, and 1 harbored 6 taxa. The mean helminth species richness for all froglets was 1.8 ± 1.4 (range = 0–6). A significant correlation existed between the number of helminth species and froglet length (Spearman's correlation, $r_s = 0.69$, $P < 0.01$). Although not significant, helminth richness values increased with each subsequent collection; they were (range, number of froglets examined): for July 24, 0.6 ± 0.51 (0–1, 10); August 6, 1.5 ± 1.1 (0–4, 11); August 23, 1.7 ± 0.8 (0–3, 11); September 17, 3.2 ± 1.6 (0–6, 9); and October 8, 3.5 ± 0.7 (0–4, 2). The total mean helminth abundances ± SE for the 34 infected froglets and for the 34 infected and 5 uninfected froglets were 39.1 ± 11.9 and 34.0 ± 10.6, respectively. These values are higher than the total mean helminth abundances in young (15.3 ± 3.9) and juvenile (12.7 ± 2.5) leopard frogs reported by McAlpine (1997).

By major parasite group, 536 (40%) cestodes, 483 (36%) trematodes, and 309 (23%) nematodes were recovered from the froglets. In our samples, larval digeneans were the first members of the helminth community to become established in froglets, along with *O. priceae* and *Cosmocercoides dukae*. Likewise, McAlpine (1997) reported larval *Echinostoma trivolvis* and *Apharyngostrigea pipientis* to first infect young leopard frogs. *Mesocestoides* sp. was the last helminth species to be recruited by froglets in the present study.

Twenty-three studies including the present one have investigated some aspect of the parasites of Michigan leopard frogs. However, the only study on parasites from the Upper Peninsula is that of Werner and Walewski (1976), who investigated blood parasites. Ridgeway (1964) provided the most recent report on a helminth of Michigan leopard frogs. A total of 37 parasite taxa (6 Protozoa, 21 Trematoda, 3 Cestoda, and 7 Nematoda) have been found in leopard frogs from Michigan (Table 2). Thirteen larval trematode taxa have been reported from Michigan leopard frogs. The literature reports concerning larval trematode taxonomy, systematics, specific sites found within this anuran species, measurements of larvae, and observable morphological variation are often confusing. Of the taxa identified in the present study, *Clinostomum* sp. and *Oswaldocruzia* sp. are the only parasites to have been previously reported in this frog species in Michigan. The other 10 helminth taxa represent new host records in Michigan.

Sessions and Ruth (1990) reported that metacercariae found in close proximity to deformed limbs caused the abnormalities seen in *H. regilla* and *A. macrodactylum*. They did not specify, however, the number of metacercariae present in the leg musculature of deformed amphibians. Sessions and Ruth (1990) concluded that the timing of infection was important for the development of abnormalities, which could explain why some infected amphibians lacked deformities. These authors implanted inert resin beads in the developing hindlimb buds of laboratory-bred frogs and salamanders and produced the abnormalities seen in wild-caught amphibians. If the presence of metacercariae could cause a mechanical disruption in limb development as suggested by Sessions and Ruth (1990), might it be possible, if their hypothesis is correct, that other larval helminths found within the musculature of the hindlimbs could cause deformities? However, although larval helminths commonly occurred within the muscles of the hindlimbs of the northern leopard frog in the present study, no limb abnormalities were seen in froglets.

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Research Note

Helminths of the Day Geckos, *Rhoptropus afer* and *Rhoptropus barnardi* (Sauria: Gekkonidae), from Namibia, Southwestern Africa

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ABSTRACT: Twenty specimens each of the day geckos *Rhoptropus afer* and *R. barnardi* from Namibia, southwestern Africa, were examined for helminths. *Rhoptropus afer* harbored 4 species of nematodes, *Maxvachonia dimorpha, Parapharyngodon rotundus, Spauligodon petersi,* and *Physocephalus* sp. *Rhoptropus barnardi* harbored 1 species of cestode, *Oochoristica truncata,* and 6 species of nematodes, *Maxvachonia dimorpha, Parapharyngodon rotundatus, Spauligodon petersi, Physalopteroides impar, Thubunaea fitzsimonsi,* and *Physocephalus* sp. *Rhoptropus afer* and *R. barnardi* represent new host records for these helminths.

KEY WORDS: *Rhoptropus afer, Rhoptropus barnardi,* Gekkonidae, Nematoda, *Maxvachonia dimorpha, Spauligodon petersi, Parapharyngodon rotundatus, Physalopteroides impar, Thubunaea fitzsimonsi, Physocephalus* sp., Cestoda, *Oochoristica truncata.*

The genus *Rhoptropus* is composed of 6 species of diurnal geckos endemic to arid and semiarid zones of Namibia and southern Angola, Africa (Bauer and Good, 1996). There are no reports on helminths from any species of *Rhoptropus.* The purpose of this note is to report helminths from *Rhoptropus afer* Peters, 1869 and *R. barnardi* Hewitt, 1926 from Namibia, Africa. *Rhoptropus afer* occurs in rocky desert from the Kuiseb River to southern Angola; *R. barnardi* inhabits semidesert environments and occurs inland in the western half of Namibia from Damaraland north to southern Angola (Branch, 1988). *Rhoptropus afer* occupies granite outcrops surrounded by sandy substrates; reptile diversity is low in these areas, with almost no amphibians present. *Rhoptropus barnardi* was taken from boulders in areas ranging from semiarid savanna to arid basalt plains.

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Twenty each of *R. afer* and *R. barnardi* from Namibia were borrowed from the California Academy of Sciences (CAS) for helminthological examinations. *Rhoptropus afer* specimens were collected by one of us (A.M.B.) in 1987 (CAS 167677–167679, 167683, 167685, 13 km S of Cape Cross), 1989 (CAS 175396–175398, 175400, 175401, 56 km N of Cape Cross), and 1993 (CAS 193867–193876, 30 km N of Swakopmund); mean (±SD) snout–vent length (SVL) = 44.3 ± 2.6 mm (range, 37–48 mm). *Rhoptropus barnardi* specimens were collected in 1987 (CAS 167666, 167667, 63 km E of Kamanjab), 1989 (CAS 175334–175337, 9 km S of Kamanjab, CAS 175345, 175355, 175358, 175375, 6 km W of Kamanjab, CAS 175385, 175386, 175388, 175390, 175391, 21°50′S, 15°10′E) or 1993 (CAS 193775, 193779, 193781–193783, Epupa Falls); SVL = 41.3 ± 1.9 mm (range, 37–45 mm).

The abdominal cavity was opened, and the esophagus, stomach, and small and large intestines were removed, slit longitudinally, and examined under a dissecting microscope. The lungs, liver, and body cavity were also visually inspected for helminths. Each helminth, formalin-fixed in situ, was removed to a vial of 70% ethanol for a minumum of 48 hr and then cleared on a glass slide in undiluted gylcerol. Selected cestodes were washed in distilled water, stained with hematoxylin, and mounted on glass slides in balsam. Identifications were made from these preparations (glycerol or balsam) utilizing a compound microscope. Prevalence, mean intensity, mean abundance, and locations are given in Table 1. Terminology is in accordance with Bush et al. (1997).

Rhoptropus afer harbored 4 species of nema-

Table 1. Helminths from *Rhoptropus afer* (n = 20) and *R. barnardi* (n = 20) from Namibia, southwestern Africa.

Host Helminth	Prevalence (%)	Intensity $\bar{x}$ ± SD	Intensity Range	Abundance ($\bar{x}$ ± SD)	Location
Rhoptropus afer					
Maxvachonia dimorpha	10	1.0		0.10 ± 0.31	small intestine
Parapharyngodon rotundatus	15	2.0 ± 1.7	1–4	0.30 ± 0.92	large intestine
Spauligodon petersi	25	7.4 ± 5.0	2–12	1.85 ± 4.00	large intestine
Physocephalus sp. (encysted larvae)	20	13.5 ± 17.4	1–39	2.70 ± 8.86	peritoneal surfaces
Rhoptropus barnardi					
Oochoristica truncata	5	1.0		0.05 ± 0.22	small intestine
Maxvachonia dimorpha	5	1.0		0.05 ± 0.22	small intestine
Parapharyngodon rotundatus	15	3.3 ± 4.0	1–8	0.50 ± 1.79	large intestine
Spauligodon petersi	30	4.0 ± 2.4	1–8	1.20 ± 2.26	large intestine
Physalopteroides impar	15	1.0		0.15 ± 0.37	stomach
Thubunaea fitzsimonsi	10	2.0 ± 1.4	1–3	0.20 ± 0.70	stomach
Physocephalus sp. (encysted larvae)	10	4.5 ± 5.0	1–8	0.45 ± 1.79	peritoneal surfaces

todes: *Maxvachonia dimorpha* Chabaud and Brygoo, 1960, *Parapharyngodon rotundatus* (Malan, 1939), *Spauligodon petersi* Bursey, McAllister and Freed, 1997, and *Physocephalus* sp. (larvae in cysts); *R. barnardi* harbored 1 species of cestode, *Oochoristica truncata* Zschokke, 1905, and 6 species of nematodes, *M. dimorpha, P. rotundatus, S. petersi, Physalopteroides impar* (Malan, 1939), *Thubunaea fitzsimonsi* (Ortlepp, 1931), and *Physocephalus* sp. (larvae in cysts). Selected helminths were placed in vials of 70% ethanol and deposited in the U.S. National Parasite Collection (USNPC), Beltsville, Maryland: *R. afer*: *M. dimorpha* (USNPC 87604), *P. rotundatus* (USNPC 87605), *S. petersi* (USNPC 87606), and *Physocephalus* sp. (larvae) (USNPC 87607); *R. barnardi*: *O. truncata* (USNPC 87608), *M. dimorpha* (USNPC 87609), *P. rotundatus* (USNPC 87610), *S. petersi* (USNPC 87611), *P. impar* (USNPC 87612), *T. fitzsimonsi* (USNPC 87613), and *Physocephalus* sp. (larvae) (USNPC 87614).

Oochoristica truncata (Linstowiidae) is probably the most common tapeworm of reptiles in Africa. It has been recorded from sub-Saharan reptiles such as the lizards *Agama aculeata, A. hispida,* and *A. planiceps* (Agamidae), *Chamaeleo namaquensis* (Chamaeleonidae), *Meroles knoxii* (Lacertidae) (Malan, 1939; Prudhoe and Harris, 1971; Heideman, 1991) and the snake *Psammophis sibilans* (Colubridae) (Fantham and Porter (1950). *Rhoptropus* is a new host genus for *O. truncata.*

Maxvachonia dimorpha (Cosmocercoidea) was described from the chameleon *Furcifer pardalis* from Madagascar (Chabaud and Brygoo, 1960) and has been reported from other Madagascan lizards, namely *F. oustaleti, Zonosaurus maximus,* and *Mabuya gravenhorstii* (Chabaud et al., 1964; Caballero, 1968). Here, we report the first 2 host records for this nematode from the African continent.

Parapharyngodon rotundatus (Oxyuroidea) was originally described as *Thelandros rotundus* based upon a large number of female and 15 male specimens from *A. atra* and *Pseudocordylus microlepidotus* collected in South Africa (Malan, 1939). Freitas (1957), in a revision of the genus *Thelandros,* moved the species to the genus *Parapharyngodon. Rhoptropus afer* and *R. barnardi* are the third and fourth lizard species reported to harbor *P. rotundatus.*

Spauligodon petersi (Oxyuroidea) was recently described from 45 female and 10 male specimens taken from 2 *Mabuya sulcata* collected in Springbok, Northern Cape Province, South Africa (Bursey et al., 1997). *Rhoptropus afer* and *R. barnardi* are the second and third species reported to harbor *S. petersi.*

Physalopteroides impar (Physalopteroidea) was originally described as *Thubunaea impar* on the basis of 24 female and 11 male specimens obtained from the stomach of 1 *Cordylus cordylus* collected at Wellington, South Africa; 2 immature individuals were found in the stomach of 1 *A. atra* (Malan, 1939). Chabaud and Brygoo (1960) revised the genus *Thubunaea,* moving *T. impar* to the genus *Physalopteroides.* Ca-

ballero (1968) subsequently described a subspecies of *P. impar, P. i. minor,* taken from 1 *Lygodactylus verticillatus,* 1 *M. comorensis,* and 3 *Cryptoblepharus boutonii* collected on Europa Island, Madagascar. *Rhoptropus barnardi* is the sixth species of lizard reported to harbor *P. impar.*

Thubunaea fitzsimonsi (Physalopteroidea) was originally described from 15 female and 2 male specimens obtained from the stomach of 1 *Ichnotropis squamulosa* collected in the Damara Pan, Botswana (Ortlepp, 1931). *Rhoptropus barnardi* is the second species of lizard reported to harbor *T. fitzsimonsi.*

Encapsulated infective larvae of *Physocephalus* sp. commonly occur in the tissues of amphibians, reptiles, birds, and mammals (Anderson, 1992). The extent of infection of South African species is apparently unknown; however, Malan (1939) reported encysted unidentified larvae from the stomach wall of *A. atra.*

Currently, the life cycles of these helminths are unknown, although some assumptions can be made: *M. dimorpha, P. rotundatus,* and *S. petersi* infect a host directly, and *O. truncata, P. impar, T. fitzsimonsi,* and *Physocephalus* sp. require an insect intermediate host. *Maxvachonia dimorpha* and *P. impar* have been reported from Madagascar and the African continent, but the other helminths found in this study are only known from continental Africa. The lizards previously noted as hosts were mostly arid zone reptiles, but whereas some of the lizards were restricted to particular arid regions (Namib for *Rhoptropus,* Kalahari for *Ichnotropis squamulosa,* Karoo for many "Cape" lizards), the helminths show no such barriers. The presence of some of the same helminth species in phylogenetically, ecologically, and geographically diverse lizards may suggest they are ubiquitous, or nearly so, in insectivorous lizards of the African subcontinent. However, more work will be required to understand which reptiles are capable of harboring these helminths.

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Research Note

A Synonym of *Metacamopiella euzeti* Kohn, Santos, and Lebedev, 1996 (Monogenea: Allodiscocotylidae) Parasitic on Fishes (Teleostei: Carangidae) from the Coastal Zone of the State of Rio de Janeiro, Brazil

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ABSTRACT: Based on the study of the type material and additional specimens collected by the authors from the type host, the carangid fish *Oligoplites palometa* (Cuvier, 1833), collected from the type locality, the coastal zone of the State of Rio de Janeiro, Brazil, the allodiscocotylid *Metacamopia oligoplites* Takemoto, Amato, and Luque, 1996, is considered a junior synonym of *Metacamopiella euzeti* Kohn, Santos, and Lebedev, 1996.

KEY WORDS: Monogenea, Allodiscocotylidae, *Metacamopiella euzeti, Metacamopia oligoplites, Oligoplites palometa, Trachinotus carolinus,* Carangidae, Brazil.

Takemoto et al. (1996) described *Metacamopia oligoplites* using specimens collected from *Oligoplites palometa, O. saliens,* and *O. saurus* from the coastal zone of the State of Rio de Janeiro, Brazil, and emended the original diagnosis of *Metacamopia* Lebedev, 1972. During a parasitological survey of carangid fishes conducted between March and October 1997, 38 specimens of *O. palometa* (Cuvier, 1833) were examined from the coastal zone of the State of Rio de Janeiro, Brazil (21–23°S, 41–45°W). The fish were identified according to Menezes and Figueiredo (1980). Numerous monogeneans were collected, including some that were similar to those described by Takemoto et al. (1996). The monogeneans were fixed and preserved in 5% formalin, stained with Gomori's trichromic, and mounted in Canada balsam. Measurements are in micrometers unless otherwise indicated; the ranges are followed by the mean in parentheses. Voucher specimens were deposited in the Coleção Helmintológica do Instituto Oswaldo Cruz (6 voucher specimens, CHIOC No. 33958a–f), Rio de Janeiro, Brazil, and in the United States National Parasite Collection (5 voucher specimens, USNPC No. 88110), Beltsville, Maryland, U.S.A. In addition, the following material was examined: *M. oligoplites* Takemoto, Amato, and Luque, 1996 (holotype, CHIOC No. 33623a, 9 paratypes, CHIOC No. 33623b, c, 33624, and 33625; USNPC No. 85411–85414); *Metacamopiella euzeti* Kohn, Santos, and Lebedev, 1996 (holotype, CHIOC No. 33059, paratypes, CHIOC No. 30060a, 30062a).

Measurements based on 17 whole-mounted specimens: total length 3.26–6.52 (4.64) mm; maximum width 0.72–1.45 (0.93) mm; anterior region 1.45–3.26 (2.05) mm long; middle region 0.54–1.08 (0.78) mm long; posterior region 0.72–2.77 (1.72) mm long; haptor 0.32–1.90 (0.79) mm long. Buccal organs 43–70 (53) long, 32–65 (44) wide. Pharynx 49–59 (53) long, 38–65 (49) wide. Esophagus 162–432 (291, n = 15) long. Testes 26–46 (37, n = 8) in number, 16–27 (23, n = 8) in diameter. Copulatory organ 356–702 (451, n = 15) long. Germarium 243–486 (293, n = 10) long, 65–135 (81, n = 10) wide. Vaginal ducts 243–529 (283, n = 12) long. Seminal receptacles 162–432 (242, n = 14) long. Eggs 270–540 (459, n = 6) long, 48–59 (55, n = 6) wide.

Kohn et al. (1996) placed *Metacamopiella* in Allodiscocotylidae because of the presence of ventrolateral vaginal pores, vaginal ducts lacking sclerotized structures, and by the presence or absence of a row of internal papillalike thickenings in the vaginal ducts. The type species *M. euzeti* Kohn, Santos, and Lebedev, 1996, is parasitic on the carangid *Trachinotus carolinus* from Rio de Janeiro, Brazil. Type material of *M. oligoplites* examined agreed in all major respects

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with the characteristics of *Metacamopiella* above; therefore, a new synonym of *M. euzeti* Kohn, Santos, and Lebedev, 1996, is proposed. The examination of type material of *M. oligoplites* allowed comparisons with the original description and illustrations by Takemoto et al. (1996) to be made: (1) the papillalike structures in the vaginal ducts were not described, and (2) the description and illustration of the midsclerite of the clamp were incomplete. Observation of the paratype illustrated by Takemoto et al. (1996) showed that the midsclerite bifurcates at their extremities and is not bifurcated only in the anterior extremity as illustrated by these authors.

Metacamopia Lebedev, 1972 is characterized by the presence of sclerotized structures in the vaginal ducts. Because the specimens described by Takemoto et al. (1996) did not show this character, the authors emended the diagnosis of *Metacamopia* to accommodate their specimens, including in this genus the species with or without sclerotized structures in the vaginal ducts. This emended diagnosis is not valid, because it was based on insufficiently studied material. As mentioned above, the specimens described in Takemoto et al. (1996) do not have sclerotized structures in the vaginal duct but have papillalike thickened structures, as in *Metacamopiella*. Also, the position of the vagina (ventral, as in *Metacamopiella*) annotated by Takemoto et al. (1996) does not correspond to the original diagnosis (dorsolateral) of *Metacamopia* made by Lebedev (1972).

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Research Note

Histochemistry and Ultrastructure of the Metacercarial Cyst of *Cryptogonimus chyli* (Trematoda: Cryptogonimidae)

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ABSTRACT: Histochemical and ultrastructural studies were conducted on metacercarial cysts of the cryptogonimid trematode *Cryptogonimus chyli* from the skeletal muscles of the fantail darter *Etheostoma flabellare*. Metacercarial cysts were composed of an outer host capsule and an inner parasite cyst. The host capsule contained an outer region of fibrocytes, collagen, and lymphocytes and a thin inner layer. The parasite cyst was a uniformly thin and homogeneous layer. The host capsule stained strongly for connective tissues and protein and moderately for lipids, nucleic acids, nonspecific esterase activity, and acid and alkaline phosphatase activities. The parasite cyst stained intensely for acid mucopolysaccharides and moderately for neutral

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mucopolysaccharides and proteins. Although the metacercarial cysts of the related cryptogonimid, *Bolbogonotylus corkumi,* are also located in the muscle tissue of fantail darters, differences are apparent in the host and parasite response.

KEY WORDS: *Bolbogonotylus corkumi,* electron microscopy, glycocalyx, mitochondria, fantail darter, fibrocyte.

Adults of *Cryptogonimus chyli* Osborn, 1903 are intestinal parasites of several North American fish species (Hoffman, 1967; Margolis and Arthur, 1979; Font, 1987). Small fish serve as second intermediate hosts, and several species of darters (Font, 1987) harbored the parasite at our collection site in O'Neil Creek near Eagleton, Chippewa County, Wisconsin (91°45′00″N, 44°95′00″W). In this study, metacercariae were obtained from fantail darters, *Etheostoma flabellare* Rafinesque.

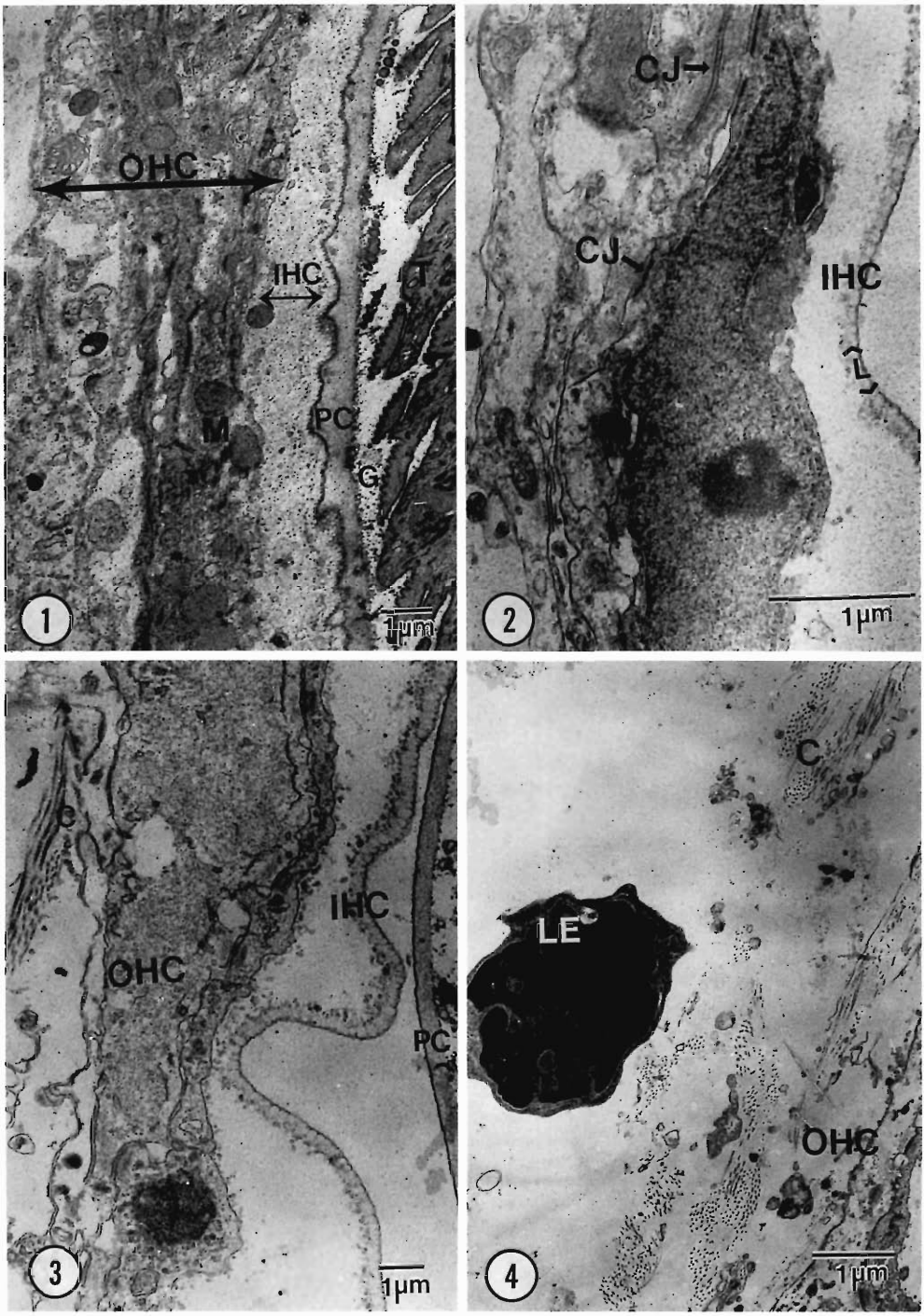
There have been a number of ultrastructural studies on the metacercarial cysts of digenetic trematodes from fishes (Sogandares-Bernal and Lumsden, 1964; Stein and Lumsden, 1971; Mitchell, 1974; Higgins et al., 1977; Halton and Johnston, 1982; So and Wittrock, 1982; Wittrock et al., 1991). Walker and Wittrock (1992) were the first to describe the metacercarial cyst of a member of the Cryptogonimidae in their study of *Bolbogonotylus corkumi* Font, 1987. The host used as the source of metacercariae for *B. corkumi* was also the fantail darter. Here, we describe the composition of the metacercarial cyst of *C. chyli* and compare our findings with what was previously described for the metacercarial cyst of *B. corkumi.*

The collection and processing of parasites and host tissues for histochemistry and transmission electron microscopy were as described by Walker and Wittrock (1992). Many of the fantail darters were infected with hundreds of *C. chyli* metacercariae. Whereas the metacercariae of *B. corkumi* were encysted only in skeletal muscle tissue, *C. chyli* metacercariae were distributed throughout a number of organs, including adipose and connective tissue, kidney, liver, and skeletal muscle. However, the majority of cysts were located within the muscle tissue. For subsequent comparisons of *C. chyli* with *B. corkumi,* the results of this study pertain only to those metacercariae encysted within skeletal muscle. Voucher specimens of *B. corkumi* (HWML 39821) and *C. chyli* (HWML 39820) were deposited in the Harold W. Manter Laboratory of Parasitology at the University of Nebraska State Museum.

Fifteen metacercarial cysts averaged 113 by 123 μm in diameter. The cyst wall varied in thickness from 2.0 to 9.2 μm ($\bar{x}$ = 3.2 μm). The cyst wall consisted of an outer host capsule and an inner cyst of parasite origin (Fig. 1). The host capsule stained intensely with Gömöri trichrome and Pollak rapid trichrome, indicating the presence of collagenous connective tissue. This layer was also strongly reactive with mercuric bromphenol blue and Sudan black B and moderately reactive with oil red O and azure B, suggesting the presence of a lipoprotein component. The parasite cyst stained moderately with the periodic acid–Schiff test (PAS) and intensely with alcian blue (pH 2.5), indicating the presence of both neutral and acid mucopolysaccharides. This layer also stained moderately with bromphenol blue, suggesting the presence of proteinaceous material.

The outer host capsule contained fibrocytes, unidentified cells, and scattered patches of collagen, which demonstrated its typical periodicity (Figs. 2, 3). Large numbers of fibrocytes but only an occasional lymphocyte were observed in the outer host capsule (Fig. 4). Numerous mitochondria, presumably from degenerating cells, were distributed throughout the entire host capsule (Fig. 1). The inner host capsule was often separated from both the outer host capsule and the parasite cyst (Fig. 3). This portion of the host capsule contained a row of oblong, lightly stained spheres that rested upon a thin electron-dense layer (Fig. 2). The parasite cyst was very uniform in size and structure with a thickness of <1 μm (Fig. 3). Similar to the inner host capsule, the outer parasite cyst consisted of a thin electron-dense layer that was more dense than that of the inner host capsule (Fig. 3). The major portion of the parasite cyst was composed of a homogeneous, light-staining material (Figs. 1, 3). Sloughed debris and glycocalyx were present between the parasite cyst and tegument (Figs. 1, 3).

Metacercarial cysts of *C. chyli* and *B. corkumi* were compared from fantail darter skeletal muscle. Although the cyst composition in these 2 species was similar, there were a number of differences. The host capsule was much thinner in *C. chyli,* particularly the zone of compacted, degenerative cells within the inner host capsule.



Figures 1–4. Transmission electron micrographs of the metacercarial cyst wall of *Cryptogonimus chyli*. **1.** Tegument (T) enclosed by thin, lightly stained parasite cyst (PC). Note glycocalyx (G) between the tegument and parasite cyst. Lightly stained material and some cell debris, such as mitochondria (M), form the inner host capsule (IHC). Unidentified and degenerative cells form the outer host capsule (OHC). **2.** An apparent lipid layer (L) occurs at the inner boundary of the inner host capsule. Note the fibrocyte (F) within the outer host capsule. Cell junctions (CJ) occur irregularly throughout the outer host capsule. **3.** Collagen (C) is occasionally scattered throughout the outer zone of the outer host capsule. Note separation of the inner host capsule from both the parasite cyst and outer host capsule. **4.** Lymphocyte (LE) and collagen (C) on external margins of the outer host capsule.

The spheres of the inner host capsule in *B. corkumi* occurred in a multiple rather than a single layer, as observed in *C. chyli* (Walker and Wittrock, 1992). These spheres were tentatively identified as lipid droplets because of their physical appearance and the positive reaction of oil red O and Sudan black B in this region. In *B. corkumi,* the dense layer of cells compacted against the parasite cyst probably prevented the host layers from separating. The lack of a dense inner host capsule in *C. chyli* probably allowed separation of the host layers. This detachment may be occurring, however, only after processing of tissues. Nevertheless, these results suggest a higher degree of structural rigidity or compactness of the *B. corkumi* cyst.

In *B. corkumi,* granulocytes, probably functioning as macrophages, were occasionally observed in the outer host capsule, whereas only an occasional lymphocyte was identified in C. *chyli.* For both species, many cysts were studied from several darters, but relatively few granulocytes were observed at the ultrastructural level. However, metacercarial cysts of both species stained with moderate intensity for acid and alkaline phosphatase activities and for nonspecific esterase activity. Macrophages demonstrate all 3 enzyme activities (Pearsall and Weiser, 1970; Vernon-Roberts, 1972; Ross and Reith, 1985). In teleosts, granulocytes stain positively for both alkaline and acid phosphatases (Hine, 1992). Therefore, the host's immune response probably is directing phagocytic activity against the cysts, but at the ultrastructural level it is difficult to observe macrophages, much less ascertain the intensity of macrophage infiltration. Moreover, the lack of identified granulocytes in our ultrastructural observations of *C. chyli* may result from the host directing phagocytic activity against the much larger cyst of *B. corkumi.* This granulocytic activity in *B. corkumi* could certainly be the result of its larger cyst size and the much greater quantities of fibrocytes and cell debris.

Many more fibrocytes and collagen fibers were observed in the host capsule of *B. corkumi* than in *C. chyli* in all the cysts studied. Additionally, an increased staining reaction for the Gömöri and Pollak stains implies greater deposits of collagenous connective tissue in *B. corkumi.* This finding suggests differential host responses to *B. corkumi* and *C. chyli* even though they are closely related species.

Another apparent difference between the 2 cryptogonimids is the relatively small amount of glycocalyx covering the tegument of *C. chyli* as compared with the thick layer of glycocalyx encompassing *B. corkumi* (Walker and Wittrock, 1992). The glycocalyx, which is an acid mucopolysaccharide and stains with both alcian blue and PAS, is commonly observed surrounding the encysted trematode. Numerous cysts of both species were observed, and relatively little material stained between the tegument and parasite cyst of *C. chyli* as compared with *B. corkumi.* Lumsden (1975) hypothesized that the glycocalyx, in one of its properties, plays a protective role against the host immune response. The question is whether the reduced host activity is in response to the lower levels of glycocalyx secreted by *C. chyli* or whether because of a weak host response, less glycocalyx is needed to protect the parasite from its host. Moreover, could the apparently weaker host response be simply related to the much smaller size of the *C. chyli* cysts, because less damage would occur with these metacercariae? These are difficult questions to answer without more detailed studies of host responses to encysted parasites.

This study demonstrates that, as has been noted by others, one should not generalize too much on the structure and chemical composition of metacercarial cysts (Huffman, 1987; Wittrock et al., 1991). Even between closely related species infecting the same host in identical tissue, there are differences in both the host and the parasite responses.

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Research Note

Distribution and Prevalence of *Alloglossoides caridicola* (Trematoda: Macroderoididae), a Parasite of the Crayfish *Procambarus acutus* Within the State of Louisiana, U.S.A., and into Adjoining States

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ABSTRACT: A survey of 765 crayfish conducted during April and May 1998 indicated that *Alloglossoides caridicola* infected the antennal glands of *Procambarus acutus* from a variety of habitats within Louisiana, north of the coastal marsh region. Infections were absent from crayfish collected in the prairie region of southwestern Louisiana but extended into eastern Texas, southern Arkansas, and southwestern Mississippi. Prevalence of infection was 0% at 22 localities but ranged from 5.6% to 100% at 23 localities.

KEY WORDS: Trematoda, Macroderoididae, *Alloglossoides caridicola,* distribution, prevalence, crayfish, *Procambarus acutus,* Louisiana, Texas, Arkansas, Mississippi.

Alloglossoides caridicola was described by Corkum and Turner (1977) from the antennal glands of crayfish, *Procambarus acutus* (Girard, 1852), collected near Rosedale, Louisiana. Although its life cycle is unknown, *A. caridicola* is unusual in that it attains sexual maturity and reproduces in an invertebrate. No other hosts have been reported for the worm, nor has it been reported from other localities.

In April and May 1998, I undertook a survey of the distribution and prevalence of *A. caridicola* within Louisiana and the contiguous border areas of adjoining states (eastern Texas, southern Arkansas, and southwestern Mississippi, U.S.A.). Crayfish were taken by dip net from 45 localities (Table 1) representing a variety of aquatic habitats and were identified according to descriptions in Hobbs (1972, 1981). Paired antennal glands of 668 *P. acutus* and 97 *P. clarkii* (Girard, 1852) were removed, dissected under a stereomicroscope, and examined for presence of worms. Representative voucher specimens of *A. caridicola* from 23 localities were fixed in hot alcohol-formalin-acetic acid, stained in Semi-

Table 1. Prevalence of *Alloglossoides caridicola* infection in *Procambarus acutus* from localities in Louisiana, Texas, Arkansas, and Mississippi, U.S.A.

Collection site	Collection date	% Prevalence	USNPC No.
Louisiana:			
Roadside ditch 3.2 km N of Crowley	7 Apr	0/18 (0)	—
Roadside ditch 6.9 km ENE of Eunice	7 Apr	0/15 (0)	—
Roadside ditch 3.7 km NE of Ville Platte	7 Apr	0/5 (0)	—
Stream crossing highway I-49 near 44-mi marker	7 Apr	0/16 (0)	—
Roadside ditch 21.7 km NW of Bunkie	7 Apr	0/3 (0)	—
Roadside ditch 10.6 km SW of Jonesville	7 Apr	0/12 (0)	—
Roadside ditch 13.2 km ESE of Jonesville	7 Apr	9/14 (64.3)	88116
Roadside ditch 9.2 km W of Franklin	8 Apr	0/17 (0)	—
Roadside ditch 5.8 km W of Amite	8 Apr	1/12 (8.3)	88117
Roadside ditch 19 km WNW of Montpeller	8 Apr	0/16 (0)	—
Roadside ditch 13.5 km E of Opelousas	8 Apr	1/16 (6.3)	88118
Roadside ditch 5.3 km W of Opelousas	8 Apr	0/10 (0)	—
Roadside ditch 11.9 km SSW of Lawtell	8 Apr	0/7 (0)	—
Crayfish pond 7 km S of Henderson	13 Apr	0/27 (0)	—
Roadside swamp 13.5 km NW of DeQuincy	24 Apr	3/13 (23.1)	88119
Roadside ditch 4.8 km NNE of Bancroft	24 Apr	2/5 (40)	88120
Roadside swamp 3.9 km N of Merryville	24 Apr	4/5 (80)	88121
Roadside stream 13.8 km NNW of Kitsatchie	24 Apr	21/25 (84)	88122
Roadside swamp 3.8 km WSW of Starks	25 Apr	0/25 (0)	—
Roadside swamp 3.9 km NE of New Roads	2 May	15/29 (51.7)	88123
Roadside ditch 5.1 km S of Varnado	2 May	0/9 (0)	—
Roadside swamp 5.8 km S of Converse	18 May	21/29 (72.4)	88124
Roadside ditch 3.5 km SW of Edgefield	18 May	12/15 (80)	88125
Roadside swamp 3.7 km ENE of Summerfield	18 May	0/28 (0)	—
Roadside ditch 0.8 km S of Monroe	19 May	1/1 (100)	88126
Roadside ditch 0.1 km S of Eros	19 May	3/9 (33.3)	88127
Roadside swamp 12.2 km SE of Montgomery	19 May	6/25 (24)	88128
Roadside swamp 9.6 km SSE of Colfax	19 May	4/6 (66.6)	88129
Roadside ditch 2.8 km S of Hineston	19 May	1/2 (50)	88130
Roadside ditch 19.6 km SSW of Oakdale	19 May	0/6 (0)	—
Roadside ditch 3 km ENE Rosedale	27 May	22/34 (64.7)	88131
Texas:			
Roadside swamp 4.8 km W of Milam	25 Apr	18/18 (100)	88132
White Oak Creek 13.7 km SSW of Newton	25 Apr	1/14 (7.1)	88133
Roadside ditch 49 km S Newton	25 Apr	0/8 (0)	—
Arkansas:			
Roadside swamp 12.8 km SW of Calion	18 May	0/26 (0)	—
Roadside ditch 14.6 km NNE of Calion	18 May	1/18 (5.6)	88134
Roadside ditch 3.4 km W of Warren	18 May	18/25 (72)	88135
Roadside ditch 13 km ESE of Hamburg	18 May	5/9 (55.6)	88136
Mississippi:			
Roadside ditch 14.9 km SSW of Lumberton	8 Apr	0/7 (0)	—
Roadside ditch 8.9 km SW of Poplarville	8 Apr	0/21 (0)	—
Stream crossing road 12.5 km W of Woodville	2 May	0/22 (0)	—
Roadside swamp 9.3 km WNW of Liberty	2 May	0/11 (0)	—
East Fork of Amite River 10.8 km SE of Liberty	2 May	4/13 (30.8)	88137
Roadside ditch 12.2 km WSW of Magnolia	2 May	1/12 (8.3)	88138
Roadside ditch 0.8 km SSW of Sandy Hook	2 May	0/10 (0)	—

chon's acetocarmine, and mounted in Permount® for deposit in the United States National Parasite Collection (USNPC), Beltsville, Maryland.

According to Penn (1959), *P. acutus* was ubiquitous in habitat and had the widest distribution of any crayfish species in Louisiana. Only *P. clarkii* rivaled that record, having been reported from slightly fewer parishes. Penn (1959)

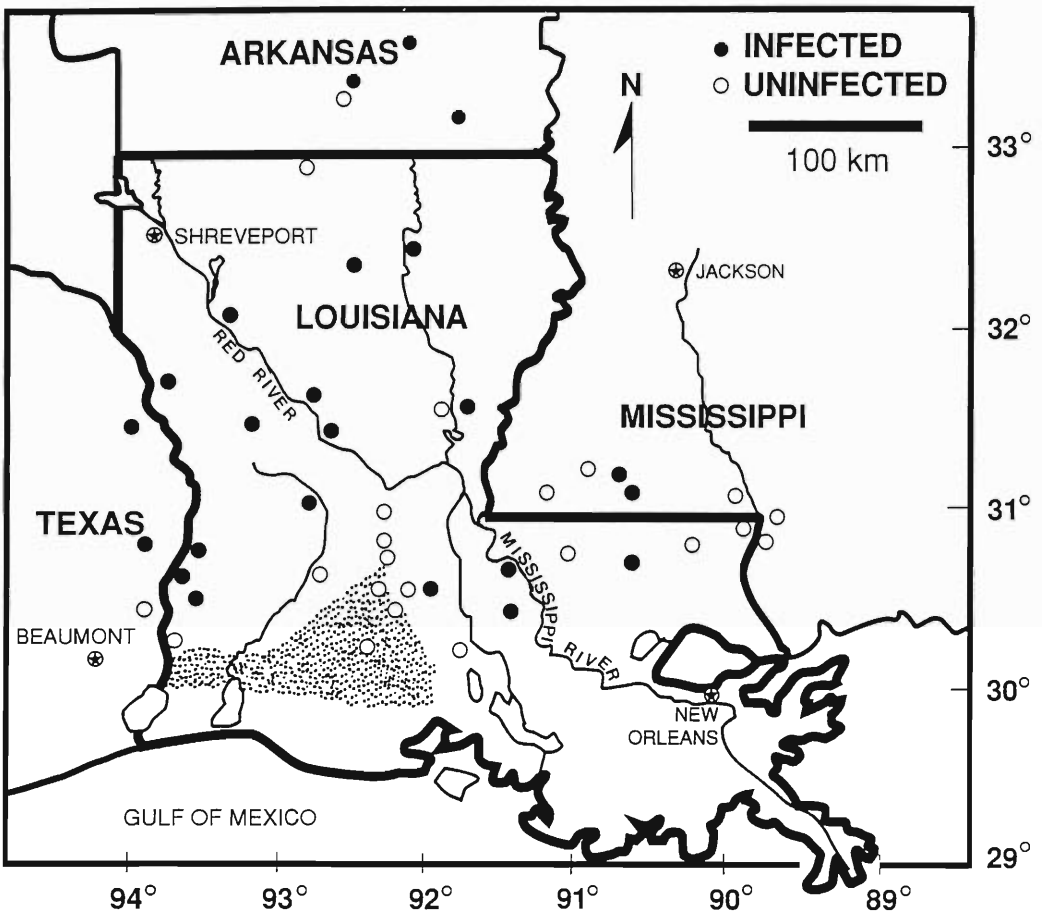

Figure 1. Map of Louisiana, eastern Texas, southern Arkansas, and southwestern Mississippi showing distribution of uninfected *Procambarus acutus* as well as those infected with *Alloglossoides caridicola*. Stippled area indicates the prairie vegetation region of southwestern Louisiana.

noted a few scattered locations (map points) for *P. acutus* in the marsh vegetation region, which lies mostly south of 30°N latitude (Fig. 1). After extensive collecting in that region, I have been unable to obtain *P. acutus*; however, *P. clarkii* was abundant and presumably displaces *P. acutus* in the marsh.

Procambarus acutus was collected from all of Louisiana's other major vegetation regions, as recognized by Brown (1972). Within these regions, infected *P. acutus* occurred in all type habitats sampled (Table 1), except a commercial crayfish pond near Henderson, Louisiana. This pond had been a swamp prior to aquaculture and also supported a population of *P. clarkii*. While both species were sympatric at 13 other Louisiana localities, only *P. acutus* harbored *A. caridicola*.

Distribution of *A. caridicola* was not as widespread as that of its crayfish host. Results of examination of crayfish from the prairie vegetation region (Fig. 1) proved unexpected, in that none of 40 *P. acutus* from 3 localities (Crowley, Eunice, and Lawtell) exhibited infection. Furthermore, no infections were noted in 40 crayfish from 3 localities (Starks, Ville Platte, and west of Opelousas) closely bordering the prairie.

Infection with *A. caridicola* extended beyond Louisiana and into eastern Texas, southern Arkansas, and southwestern Mississippi (Fig. 1). In these adjoining states, as in Louisiana, swamps, ditches, streams, creeks, and rivers evidently

provided suitable habitats for completion of the parasite's life cycle.

Prevalence of infection was 0% at 22 localities, but it ranged from 5.6% to 100% at 23 localities (Table 1). Significant among high prevalence localities was a roadside swamp near Milam, Texas, where all of 18 crayfish were infected. Because worms are long, slender, and fragile, they are difficult to remove intact. Therefore, no attempt was made to determine intensity of infection. However, the Milam crayfish had relatively higher estimated intensities (≥10 worms per antennal gland) than those from lower prevalence localities, where estimated worm burdens usually ranged from 1 to 5 per infected gland.

Hobbs and Hobbs (1990) believed *P. acutus* to be a species complex and that over its range, certain populations, previously identified as *P. acutus,* were in fact new species. One such species was *P. zonangulus,* which was described from specimens collected in Hardin, Jefferson, and Orange counties in southeastern Texas (Hobbs and Hobbs, 1990). Although none of my collecting sites were within those 3 counties, *P. zonangulus* was not collected from sites in Newton County, Texas, nor from Calcasieu Parish, Louisiana, both of which border the region where *P. zonangulus* reportedly occurs.

In light of the apparent host specificity exhibited by *A. caridicola,* further research is warranted to determine whether *P. zonangulus* harbors this infection.

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Research Note

Nematodes of Two Skinks, *Ctenotus leonhardii* and *Ctenotus quattuordecimlineatus* (Sauria: Scincidae), from Western Australia

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ABSTRACT: Thirty-one *Ctenotus leonhardii* and 30 *C. quattuordecimlineatus* from Western Australia were examined for helminths. *Ctenotus leonhardii* harbored the nematodes *Maxvachonia chabaudi* and *Abbreviata* sp. (larvae), and *C. quattuordecimlineatus* harbored the nematodes *M. chabaudi, Parapharyngodon kartana, Physalopteroides filicauda, Wanaristrongylus ctenoti,* and *Abbreviata* sp. (larvae). Highest prevalence (30%) was recorded for *Abbreviata* sp. in *C. quattuordecimlineatus,* and greatest mean intensity (3.5) was recorded for *Abbreviata* sp. in *C. leonhardii. Ctenotus leonhardii* represents a new host record for *M. chabaudi* and *Abbreviata* sp. *Ctenotus quattuordecimlineatus* represents a new host record for *M. chabaudi* and *P. kartana.*

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KEY WORDS: *Ctenotus leonhardii, Ctenotus quattuordecimlineatus,* Scincidae, Western Australia, *Maxvachonia chabaudi, Parapharyngodon kartana, Physalopteroides filicauda, Wanaristrongylus ctenoti, Abbreviata* sp.

Ctenotus leonhardii (Sternfeld, 1919) occurs from the central coast of Western Australia through the southern Northern Territory and northern South Australia to Queensland and New South Wales; *C. quattuordecimlineatus* (Sternfeld, 1919) occurs from central Western Australia through adjacent regions of northwestern South Australia and southwestern Northern Territory (Cogger, 1992). There are no previous reports of nematodes from *C. leonhardii*; there is 1 report (Jones, 1995a) from *C. quattuordecimlineatus*. The purpose of this note is to report intestinal nematodes from *C. leonhardii* and *C. quattuordecimlineatus* from Western Australia.

Thirty-one *C. leonhardii* (17 females, 14 males; mean ± SD snout–vent length [SVL] = 67.8 ± 6.5 mm, range = 56–79 mm) and 30 *C. quattuordecimlineatus* (16 females, 14 males; SVL = 59.3 ± 4.5 mm, range = 52–72 mm) were borrowed from the herpetology collection of the Natural History Museum of Los Angeles County and examined for helminths. The *C. leonhardii* specimens were collected between 1966 and 1967, 29 km S of Atley homestead, (28°27′S, 119°05′E), Western Australia; *C. quattuordecimlineatus* specimens were collected in 1967, 10 from 29 km S of Neale Junction (28°30′S, 125°50′E) and 20 from 38 km E of Laverton (28°28′S, 112°50′E). All lizards were mature. The Natural History Museum of Los Angeles County accession numbers for the hosts that we examined are as follows: *C. leonhardii*: 55862, 55864, 55866, 55869, 55871, 55876, 55878, 55879, 55882, 55884, 55886, 55888, 55890, 55892, 55893, 55895, 55896, 55900, 55902, 55903, 55906, 55908–55912, 55914, 55915, 55918, 55925, 55927; *C. quattuordecimlineatus*: 56087, 56089, 56091–56093, 56097, 56098, 56111, 56112, 56121, 56124, 56126, 56128, 56130–56133, 56135, 56136, 56139, 56140, 56142, 56145–56147, 56150, 56151, 56154, 56156. These specimens had been collected for use in an ecological study (Pianka, 1969) and they were originally fixed in 10% formalin and preserved in ethanol. Because the ecological study included stomach analysis, only small and large intestines remained with the carcasses; however, 4 pyloric stomach regions were present in the *C. leonhardii* sample and 2 were present in the *C. quattuordecimlineatus* sample. The portions of stomach, small intestine, large intestine, and body cavity were examined with a dissecting microscope. Nematodes were removed and identified using the standard glycerol wet mount procedure. Terminology usage is in accordance with Bush et al. (1997).

Ctenotus leonhardii harbored 2 species of nematodes: *Maxvachonia chabaudi* Mawson, 1972 and *Abbreviata* sp. (third stage larvae only). The lizard is a new host record for these nematodes. *Ctenotus quattuordecimlineatus* harbored 5 species of nematodes: *M. chabaudi, Parapharyngodon kartana* (Johnston and Mawson, 1941), *Physalopteroides filicauda* Jones, 1985, *Wanaristrongylus ctenoti* Jones, 1987, and *Abbreviata* sp. (third stage larvae only). This lizard is a new host record for *M. chabaudi* and *P. kartana*. Selected nematodes were deposited in the United States National Parasite Collection (USNPC) with the following accession numbers: *M. chabaudi* from *C. leonhardii,* USNPC 87615; *Abbreviata* sp. from *C. leonhardii,* USNPC 87616; *M. chabaudi* from *C. quattuordecimlineatus,* USNPC 87617; *P. kartana* from *C. quattuordecimlineatus,* USNPC 87618; *Abbreviata* sp. from *C. quattuordecimlineatus,* USNPC 87619; *P. filicauda* from *C. quattuordecimlineatus,* USNPC 87620. Prevalence, mean intensity, mean abundance, and sites of infection are given in Table 1. There was no significant difference for prevalence of infection (percentage of lizards infected) between *C. leonhardii* and *C. quattuordecimlineatus* for *M. chabaudi* or *Abbreviata* sp. (χ^2 = 1.02 and 1.72, respectively, 1 df, $P > 0.05$). Too few individuals of the other helminth species were found to permit statistical analysis.

With the exception of *P. kartana,* the other 4 helminth species found in this study have previously been reported from species of *Ctenotus*. *Maxvachonia chabaudi* was found in *C. australis, C. labillardieri, C. leae,* and *C. regius* (Mawson, 1972; Goldberg and Bursey, 1995); *P. filicauda* was found in *C. calurus, C. dux, C. grandis, C. helenae, C. pantherinus, C. quattuordecimlineatus,* and *C. schomburgkii* (Jones, 1995a); *W. ctenoti* was found in *C. ariadnae, C. calurus, C. dux, C. grandis, C. helenae, C. pantherinus, C. quattuordecimlineatus,* and *C. schomburgkii* (Jones, 1987, 1995a); and *Abbrev-*

Table 1. Nematodes from *Ctenotus leonhardii* (n = 31) and *C. quattuordecimlineatus* (n = 30) from Western Australia.

Host Nematode	Prevalence (%)	Intensity $\bar{x}$ ± SD	Intensity Range	Abundance ($\bar{x}$ ± SD)	Site
Ctenotus leonhardii					
*Maxvachonia chabaudi**	26	3.3 ± 2.0	1–6	0.84 ± 1.73	stomach, intestines
Abbreviata sp. (encysted larvae)*	13	3.5 ± 1.7	2–6	0.45 ± 1.31	gastric peritoneum
Ctenotus quattuordecimlineatus					
*Maxvachonia chabaudi**	13	3.3 ± 2.1	1–6	0.43 ± 1.31	stomach, intestines
*Parapharyngodon kartana**	10	2.7 ± 1.5	1–4	0.27 ± 0.91	intestines
Physalopteroides filicauda	3	1.0		0.03 ± 0.18	stomach
Wanaristrongylus ctenoti	7	1.0		0.07 ± 0.25	stomach, small intestine
Abbreviata sp. (encysted larvae)	30	1.7 ± 1.0	1–4	0.50 ± 0.94	gastric peritoneum

* New host record.

iata sp. larvae was found in *C. regius* and *C. schomburgkii* (Goldberg and Bursey, 1995). In addition, cysts containing larvae of physalopterid nematodes (possibly *Abbreviata* sp.) were found in *C. calurus, C. dux, C. grandis, C. helenae, C. pantherinus, C. quattuordecimlineatus,* and *C. schomburgkii* (Jones, 1995a).

The 5 helminth species reported have also occurred in other reptile genera. *Maxvachonia chabaudi* was found in Australia in the scincids *Egernia, Eulamprus, Hemiergis, Lerista,* and *Morethia,* in a gekkonid, *Phyllurus,* and in an elapid snake, *Pseudonaja* (Baker, 1987). *Parapharyngodon kartana* was originally described from the Australian skink, *Hemiergis peronii,* as *Thelandros kartana* Johnston and Mawson, 1941 but was moved to the genus *Parapharyngodon* by Adamson (1981). It is known in Australia from the agamid *Amphibolurus,* a gekko *Christinus,* and the scincids *Hemiergis, Lerista,* and *Lygosoma* (Baker, 1987) and from Samoa from the scincid *Emoia* (Goldberg and Bursey, 1991). *Physalopteroides filicauda* has been reported in Australia from the agamids *Ctenophorus, Lophognathus,* and *Pogona,* from the scincids *Cryptoblepharus, Egernia,* and *Lerista,* from a varanid *Varanus,* and from the gekkonids *Diplodactylus, Gehyra,* and *Nephrurus* (Jones, 1986, 1987, 1995a). *Wanaristrongylus ctenoti* has been reported in Australia from the scincid *Egernia,* from an agamid *Ctenophorus,* and from the gekkonid *Nephrurus* (Jones, 1995a). Larvae of *Abbreviata* sp. are widespread in Australia; Jones (1995b) reported larvae in gastric tissues from snakes (Elapidae) and 5 lizard families (Agamidae, Gekkonidae, Pygopodidae, Scincidae, and Varanidae).

The genus *Ctenotus* is diverse, with >70 described species (Cogger, 1992). Initial helminthological work with the genus *Ctenotus* indicates that known parasites are shared with hosts representing other families of reptiles. Examination of additional species will be required before helminth diversity and specificity can be evaluated for Australian reptiles.

Eric R. Pianka (University of Texas, Austin) and Robert L. Bezy (Natural History Museum of Los Angeles County) permitted the examination of *Ctenotus leonhardii* and *C. quattuordecimlineatus.* The identification of *Wanaristrongylus ctenoti* was made by Marie-Claude Durette-Desset (Muséum National d'Histoire Naturelle, Paris, France).

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Research Note

Presence of *Eustrongylides* sp. (Jägerskiöld, 1909) (Nematoda: Dioctophymatoidea) in *Galaxias maculatus* (Jenyns, 1842) (Pisces: Galaxiidae) from Patagonia, Argentina

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ABSTRACT: During a study of the parasitofauna of *Galaxias maculatus* from Patagonia, Argentina, specimens with melanosis on the caudal peduncle were found. The melanosis was caused by encapsulation of an *Eustrongylides* sp. larva. By experimentation using chicks, a subadult with a poorly developed posterior end and a cephalic end similar to *E. tubifex* was obtained. This is the first report of *Eustrongylides* in fishes from Argentina and in *G. maculatus* from South America, including a new location and type of reaction.

KEY WORDS: *Eustrongylides* sp., *Galaxias maculatus,* melanosis, Argentina, Patagonia.

Eustrongylides sp. (Jägerskiöld, 1909) is a cosmopolitan genus, and its larva has been reported as parasitizing galaxiids from Australia (Johnston and Mawson, 1940) and *Galaxias maculatus* from New Zealand (Hine, 1978) and Australia (Pollard, 1974). Its life cycle includes an aquatic oligochaete, a fish, and a piscivorous bird. In the fish, the larva migrates from the digestive tract to the cavity or musculature of the body wall (Measures, 1988 a, b, c).

Eustrongylidosis can reach epizootic proportions when the environment has been altered by anthropic action, allowing proliferation of aquatic oligochaetes (Spalding et al., 1993); for example, a high mortality of piscivorous birds due to *E. ignotus* has been reported in North America (Spalding and Forrester, 1993). Also, humans can acquire the parasite by eating raw or poorly cooked fish (Lichtenfels and Stroup, 1985).

During a survey of parasites of *G. maculatus* (Jenyns, 1842) in Patagonia, Argentina, monthly samples were taken at different depths (0 to 50 m) from Lake Gutiérrez (41°12′S, 71°26′W). This oligotrophic, nonpolluted lake is of glacial origin, with 112.2 m of maximum depth and water temperatures ranging from 6° to 16°C. A total of 1,669 *G. maculatus* specimens (33.7–61.3-mm length; $\bar{X}$ = 44.5) were checked between 1994 and 1997.

Macroscopic observation revealed fish with swelling and a strongly melanized capsule at the caudal peduncle (Fig. 1). The capsules are 3.7

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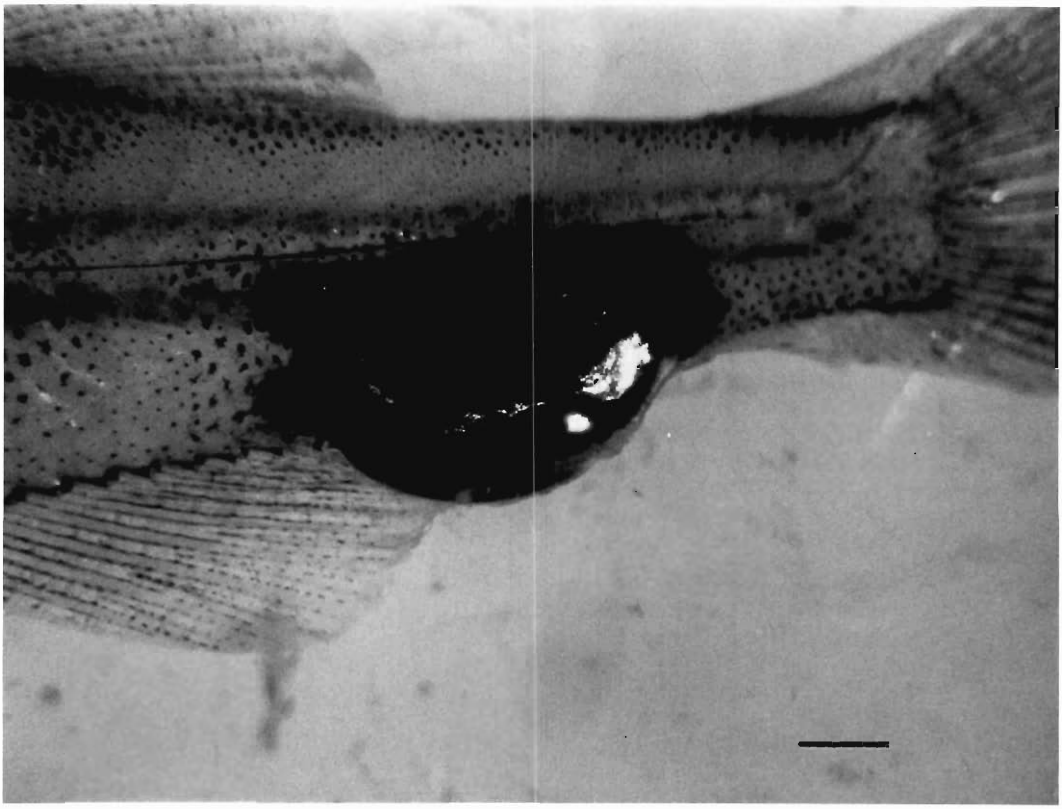

Figure 1. Capsule formed by *Eustrongylides* sp. in *G. maculatus* caudal peduncle. Scale bar = 1 mm.

to 5 mm in length, 1.4 to 3.9 mm in height, nearly oval shaped, black colored, and with smooth and regular surface. Dissection of capsules showed the presence of 1 living nematode larva in each one. The intracapsular liquid is colorless, and the larva is situated between muscle and vertebral column. Third- or fourth-stage larvae obtained were assigned to the genus *Eustrongylides,* as they had a mouth in the form of a dorsoventral slit, 2 rings of 6 labial papillae, terminal genital primordia, and rounded posterior extremity with terminal anus (Lichtenfels and Madden, 1980).

The parasites occurred only during summer months, with temperatures ranging from 10° to 16°C. Infected fish (39–60-mm length) were only captured near the shore. The total prevalence of *Eustrongylides* in *G. maculatus* was 0.78%, with the highest value (8%) recorded in January 1997. Mean intensity was always 1.00.

Of the nematodes obtained, 6 specimens were third-stage larvae and 5 were fourth-stage larvae, according to characterization of Lichtenfels and Pillit (1986) for larvae of *Eustrongylides* sp. Both third-stage larvae (9–19 mm long) and fourth-stage larvae (16–24 mm long) were smaller than larvae of *E. tubifex* described by Measures (1988c). Morphology of genital primordia allowed identification of the sexes of fourth-stage larvae as 3 males and 2 females.

Three fourth-stage larvae were used for experiments using 3 newly hatched chicks to obtain adults for species determination. A fourth-stage larva was obtained at 22 hr postinfection and a subadult at 18 days postinfection. Both were located in the wall of the proventriculus. One chick died at 6 days postinfection, and no worms were found at necropsy.

The subadult worm (40 mm long) was studied following Measures (1988a). It had an inner circle of 6 labial papillae with spinelike apices and an outer circle of 6 larger cephalic papillae with wide bases and nipplelike apices. Due to the stage of conservation and maturity, the poorly developed caudal end was not of diagnostic value. The morphological features described coin-

cide with the redescription of *E. tubifex* by Measures (1988a). The species can only be definitively assigned after further experimentation, which is difficult to carry out because of the low prevalence and intensity of infections in nature.

The fish host is probably an important item in the diet of piscivorous birds, but only 1 such report about *Phalacrocorax atriceps* has been published and *G. maculatus* is indeed included as an element in its diet (Rasmussen et al., 1992). Infection to man is possible, but to our knowledge, this particular fish is routinely used as food only in Chile.

Although nematode parasites are often encapsulated by the host, the aberrant location in the caudal peduncle and this type of reaction have not been previously recorded in any species of *Eustrongylides* described in fishes. This is the first report of *Eustrongylides* sp. from Argentina and the first in *G. maculatus* from South America.

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Research Note

Parasites of *Dicentrarchus labrax, Anguilla anguilla,* and *Mugil cephalus* from a Pond in Corsica, France

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ABSTRACT: Three species of fish of great economic interest, *Dicentrarchus labrax* (Linnaeus) (N = 15), *Anguilla anguilla* (Linnaeus) (N = 20), and *Mugil cephalus* Linnaeus (N = 20), were collected during April and June 1997 from Biguglia Pond in Corsica, France, and examined for metazoan parasites. A total of 25 ectoparasite and endoparasite species were recovered, 13 of which were from *M. cephalus,* 5 from *A. anguilla,* and 7 from *D. labrax.* The copepod *Nipergasilus bora* is reported for the first time from Corsica.

KEY WORDS: Corsica, fish, *Anguilla anguilla, Dicentrarchus labrax, Mugil cephalus,* ectoparasites, endoparasites, *Nipergasilus bora.*

Biguglia Pond, a natural reserve–listed site, is the largest coastal pond in Corsica, France. It is a brackish environment in which fishery is a preponderant activity (Frisoni and Dutrieux, 1992), and the sea bass, *Dicentrarchus labrax* (Linnaeus), the European eel, *Anguilla anguilla* (Linnaeus), and the flathead grey mullet, *Mugil cephalus* Linnaeus, are of great economic interest. Two of these 3 fish, the sea bass and the flathead grey mullet, migrate to the open sea at the beginning of the egg-laying period, whereas the European eel stays many years in the pond and is more sensitive to the quality of the environment (Bruslé, 1989). Consequently, the European eel can be considered a sedentary species.

To our knowledge, nothing has been published about the parasite fauna of these 3 hosts in Mediterranean ponds. The recent study of Sasal et al. (1997) focused on parasites of fish collected from the open sea.

Fifteen adult sea bass (mean standard length [SL], 29.6 cm ± 2.1 SD, range: 24.0–33.0 cm), 20 adult flathead grey mullet (mean SL, 34.7 cm ± 2.7 SD, range: 30.0–39.0 cm) and 20 adult European eels (mean SL, 53.8 cm ± 9.4 SD, range: 40.0–72.0 cm) were collected by netting from Biguglia Pond during April and June 1997. All fish were dissected the day they were captured. The digestive tract extending from the esophagus to the rectum was removed, along with gills, liver, and swimbladder. Each organ was examined separately under a dissecting microscope. Monogeneans and digeneans were fixed in Bouin's solution (Langeron, 1949), and the other metazoan parasites were fixed in 70% alcohol.

The terms "prevalence," "abundance," and "mean intensity" are used as defined by Bush et al. (1997).

Of the 55 fish, only 3 eels and 2 sea bass were free of parasites. Seven species of parasites were recorded from *D. labrax*: 2 copepods (*Lernanthropus kroyeri* Van Beneden, 1851 and *Caligus minimus* Otto, 1828), 2 monogeneans (*Diplectanum aequens* Wagener, 1857 and *Serranicotyle labracis* (Van Beneden and Hesse, 1863)), 2 digeneans (*Labratrema minimus* (Stossich, 1887) and *Timoniella praeteritum* (Looss, 1901)), and 1 unidentified larval nematode found encapsulated in the gut wall (Table 1). The prevalence and the mean intensity of the monogenean *D. aequens,* 80% (12 of 15) and 48.7, respectively, are the highest observed in this study. In the partly closed system, this monogenean may infest all hosts and reach very high intensity levels (Oliver, 1987). Sea bass is a voracious predator, and many species of Digenea have been reported from it. Yet only 2 digeneans were identified in our sample, 1 with a prevalence of 13% (2 of 15) and the other with a prevalence of 27% (4 of 15). The study of Sasal et al. (1997) has shown that sea bass are not infected with digeneans in open water. However, their study and our studies are not quite comparable, since we

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Table 1. Prevalences, abundances, and intensities of sea bass (N = 15), European eel (N = 20) and flathead grey mullet (N = 20) in Corsica, France.

Species		Accession No.	Location in host	Prevalence		Abundance ± SD	Intensity	
				No.	%		Mean ± SD	Range
Dicentrarchus labrax (Linnaeus)								
Copepoda	*Lernanthropus kroyeri* (Van Beneden, 1851)	MNHN-Cp1495	G	3	20	3.3 ± 11.8	16.3 ± 25.7	1–46
	Caligus minimus (Otto, 1828)	MNHN-Cp1494	G	2	13	0.1 ± 0.35	1.0 ± 0	1
Monogenea	*Diplectanum aequens* (Wagener, 1857)	597MF	G	12	80	39.0 ± 57.1	48.7 ± 60.3	5–226
	Serranicotyle labracis (Van Beneden and Hesse, 1863)	600MF	G	1	7	1.1 ± 4.1	16.0 ± 0	16
Digenea	*Labratrema minimus* (Stossich, 1887)	603MF	I	2	13	1.0 ± 2.7	7.5 ± 2.2	6–9
	Timoniella praeteritum (Looss, 1901)	608MF	P	4	27	1.9 ± 5.2	7.2 ± 8.6	2–20
Nematoda	Unidentified nematode larvae	—	GW	2	13	—	90.5 ± 13.4	81–100
Anguilla anguilla (Linnaeus)								
Copepoda	*Ergasilus gibbus* (Nordmann, 1832)	—	G	7	35	6.2 ± 14.7	17.6 ± 21.3	1–48
Monogenea	*Pseudodactylogyrus anguillae* (Yin and Sproston, 1948)		G	3	15	1.6 ± 6.2	10.7 ± 15.0	1–28
Digenea	*Deropristis inflata* (Molin, 1858)	607MF	I	11	55	4.5 ± 5.6	8.2 ± 5.2	1–14
Cestoda	*Bothriocephalus claviceps* (Goeze, 1782)	598MF	I	4	20	0.25 ± 0.5	1.2 ± 0.5	1–2
Nematoda	*Anguillicola crassus* (Kuwahara, Niimi, and Itagaki, 1974)	599MF	SW	11	55	3.35 ± 4.8	6.1 ± 5.0	1–16
Mugil cephalus Linnaeus								
Isopoda	*Nerocila orbignyi* (Guerin-Méneville, 1829–1832)	MNHN-Is5101	S	1	5	0.1 ± 0.2	1.0 ± 0	1
Copepoda	*Pseudocaligus apodus* (Brian, 1928)	MNHN-Cp1491	G	2	10	0.2 ± 0.5	1.5 ± 0.7	1–2
	Ergasilus lizae (Kroyer, 1863)	MNHN-Cp1492	G	12	60	6.0 ± 11.3	9.9 ± 13.4	1–46
	Nipergasilus bora (Yamaguti, 1939)	MNHN-Cp1493	G	9	45	3.0 ± 5.2	6.7 ± 6.0	1–17
Monogenea	*Ligophorus mugilinus* (Hargis, 1955)	606MF	G	5	25	3.8 ± 9.3	15.0 ± 14.1	3–35
	Ligophorus chabaudi (Euzet and Suriano, 1977)	605MF	G	1	5	0.6 ± 2.7	12.0 ± 0	12
	Metamicrocotyla cephalus (Azim, 1939)	601MF	G	6	30	0.7 ± 1.2	2.2 ± 1.2	1–4
	Microcotyle mugilis (Vogt, 1878)	602MF	G	9	45	0.9 ± 1.1	1.8 ± 0.9	1–3
Myxozoa	Unidentified myxosporidia	—	G	1	5	—	—	—
Digenea	*Haplosplanchnus pachysomus* (Eysenharrdt, 1829)	595MF	I	8	40	2.9 ± 4.5	7.2 ± 8.8	1–26
	Haploporus sp.	604MF	I	9	45	26.4 ± 42.8	58.6 ± 47.1	5–150
Nematoda	Cucullanus sp.	596MF	I	1	5	0.1 ± 0.4	2.0 ± 0	2
Acanthocephala	*Neoechinorhynchus agilis* (Rudolphi, 1819)	594 MF	I	16	80	26.9 ± 49.4	33.6 ± 53.4	1–201

* All specimens were deposited at National Museum of Natural History (Paris, France).

† Location in host: G = gill, GW = gut wall, I = intestine, P = pylorus, S = skin, SW = swimbladder.

are dealing with fish from lagoons, which provide a special, partially closed milieu rich in intermediate hosts (Maillard, 1976).

Five parasite species were recorded from the European eel: 1 copepod (*Ergasilus gibbus* Nordmann, 1832), 1 monogenean (*Pseudodactylogyrus anguillae* (Yin and Sproston, 1948)), 1 digenean (*Deropristis inflata* (Molin, 1858)), 1 nematode (*Anguillicola crassus* Kuwahara, Niimi, and Itagaki, 1974), and 1 cestode (*Bothriocephalus claviceps* (Goeze, 1782)) (Table 1). *Pseudodactylogyrus anguillae* and *A. crassus,* with a prevalence of 15% (3 of 20) and 55% (11 of 20), respectively, are both allochthonous species that are only found in a freshwater or oligohaline (very low salt content) milieu (Dupont and Petter, 1988; Køie, 1991). Their initial host is the Japanese eel (Køie, 1991). Similarly, the development of the copepod *E. gibbus* is stimulated by a weak salinity of the environment (Raibaut and Altunel, 1976). The presence of *A. crassus* in Corsica is enigmatic, since no Japanese eel (and no European eel, to our knowledge) has ever been introduced to the island.

Parasite diversity of the flathead grey mullet is much higher than was observed for the 2 previous hosts, especially for the ectoparasites (Table 1). For the flathead grey mullet, 3 copepod species were identified (*Pseudocaligus apodus* Brian, 1928, *Ergasilus lizae* Kroyer, 1863, and *Nipergasilus bora* (Yamaguti, 1939)). For 1 of them, *N. bora,* Corsica is a new locality record for *M. cephalus. Ergasilus lizae,* however, reaches maximum infection rates in the oligohaline milieu (Ben Hassine, 1983). One isopod, *Nerocila orbignyi* (Guerin-Méneville, 1829–1832), was collected from the skin of only 1 individual host. Four monogeneans were recovered from the gills (*Ligophorus mugilinus* (Hargis, 1955), *Ligophorus chabaudi* Euzet and Suriano, 1977, *Metamicrocotyla cephalus* (Azim, 1939), and *Microcotyle mugilis* Vogt, 1878). One species, *L. chabaudi,* has been rarely found in the flathead grey mullet in the Mediterranean Sea (Euzet et al., 1993). Cysts of a myxosporidian parasite were also found on the gills of 1 fish. Among the endoparasites removed from the gut, 2 digeneans and an acanthocephalean, *Neoechinorhynchus agilis* (Rudolphi, 1819) were identified. *Neoechinorhynchus agilis* showed high prevalence and mean intensity.

With the exception of *P. anguillae* (see Køie 1988) and *N. orbignyi,* the latter of which is seldom reported found in *M. cephalus* (see Trilles 1968), the other ectoparasites observed are specialists found only on their preferred host (Euzet and Combes, 1969; Euzet and Suriano, 1977; Raibaut and Ben Hassine, 1977). The same is true for the endoparasites, except for *N. agilis,* which is not specific for *M. cephalus* (Petrochenko, 1971; Maillard, 1976).

Mean intensities observed for our samples may not really reflect the mean intensities found generally in this biotope, which is an enclosed environment favoring parasite circulation. The values of parasite diversity, species richness, and abundance seem to be low compared to similar biotopes around the Mediterranean Sea. For example, Ben Hassine (1983) found higher prevalence of copepods in brackish Tunisian ponds, and Maillard (1976) found higher species richness of digeneans in brackish ponds of Languedoc-Roussillon (France) than those encountered in Corsica. Similarly, although described as a sedentary species, the European eel from Corsica did not harbor many macroparasites compared to the results obtained by Køie (1988) in Denmark.

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