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Helminth Parasites of Sea Otters (*Enhydra lutris*) from Prince William Sound, Alaska: Comparisons with Other Populations of Sea Otters and Comments on the Origin of Their Parasites

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ABSTRACT: The helminths found in the gastrointestinal tracts and gallbladders of 68 sea otters (*Enhydra lutris*) from Prince William Sound, Alaska, and their prevalences were: *Corynosoma enhydri* (Acanthocephala), intestine, 51.5%; *Orthosplanchnus fraterculus* (Trematoda), gallbladder, 50%; *Diplogonoporus tetrapterus* (Cestoda), intestine, 12%; and *Pseudoterranova decipiens* (Nematoda), stomach, 1.5%. One pup examined was free of helminth parasites. Throughout its range from the Kuril and Komandorski islands in Russia, across the Aleutian Islands, Alaska, and south to California, the sea otter harbors a total of 17 or 18 species of helminths, of which 5 or 6 are incidental infections with larval (2 species of *Anisakis*) or juvenile worms (3 or 4 species of *Polymorphus*). The adult worms of sea otters (12 species) are derived primarily (9 species) from pinnipeds. One species, *Microphallus pirum* (Trematoda), found widely in sea otters from the Komandorski Islands to California, may be primarily a parasite of various shorebirds. Only one species, *C. enhydri*, is uniquely a parasite of sea otters, occurring throughout its range at prevalences greater than 50%. California populations of sea otters harbor only *M. pirum*, *C. enhydri*, and *Polymorphus* species, lacking any species known to be transmitted by fish; the diet of these sea otters consists almost entirely of invertebrates. Northern sea otter populations from Russia and Alaska have a more varied diet and are hosts for at least 5 fish-transmitted parasites. Among the commonly occurring parasites, the most striking difference between Russian and Alaskan populations of sea otters is the absence of *O. fraterculus* from Russian populations and its frequent occurrence in Alaskan populations.

KEY WORDS: parasites, helminths, *Orthosplanchnus fraterculus*, *Diplogonoporus tetrapterus*, *Pseudoterranova decipiens*, *Corynosoma enhydri*, sea otters, *Enhydra lutris*, Alaska, North Pacific Ocean, zoogeography.

In spring 1989, a major oil spill in Prince William Sound, Alaska, caused by the grounding of the T/V *Exxon Valdez*, resulted in substantial mortalities among the sea otter (*Enhydra lutris*) population. More than 1,000 dead sea otters were recovered during rescue operations in Prince William Sound and neighboring coastal areas (Bayha and Kormendy, 1990). We report on the helminth parasites collected from some of the necropsied animals and compare the findings with previous reports on helminth parasites of sea otters from North American and Asian populations. We conclude with a discussion of the origin of the sea otter parasite fauna.

Materials and Methods

Data on helminth parasites were recorded from 69 sea otters (37 ♀: 27 adults, 7 juveniles, 3 undetermined maturity; 26 ♂: 12 adults, 8 juveniles, 6 undetermined maturity; 1 pup; 6 undetermined sex: 3 adults, 3 undetermined maturity). Fifty-nine of these animals were collected live and necropsied either immediately following death or euthanasia (usually within 1 to 6 days, rarely up to 10 days), or they were refrigerated and examined within several (maximum 6 to 8) hours after death. The remaining 10 otters were dead upon collection, but appeared sufficiently fresh to yield valid parasite prevalence data. Stomach, intestine, and gallbladder were examined macroscopically for all but 1 ♀ and 1 ♂, for which only the gallbladder was examined. Field circumstances did not permit microscopic examination or the use of such techniques as sieving, decanting, or centrifugation of gastrointestinal or gallbladder contents to detect very small helminths. Because the number of worms of each species encountered in each animal was not counted, we report only data on parasite prevalence.

Representative samples of helminths were fixed and preserved in 10% formalin. For microscopic study, nematodes were cleared in lactophenol; trematodes and cestodes were stained in Semichon's acetic carmine,

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Table 1. Prevalence of helminth parasites in adult and juvenile sea otters (*Enhydra lutris*) from Prince William Sound, Alaska.

	Site	No. examined	No. infected	Prevalence (%)
Trematoda				
Orthosplanchnus fraterculus	Gallbladder	68	34	50.0
Cestoda				
Diplogonoporus tetrapterus	Intestine	66	8	12.1
Nematoda				
Pseudoterranova decipiens	Stomach	66	1	1.5
Acanthocephala				
Corynosoma enhydri	Intestine	66	34	51.5

dehydrated in a series of ethanols, cleared in xylene, and mounted in Canada balsam; and acanthocephalans were studied unstained. For cestodes, transverse and longitudinal sections of mature and gravid proglottids were prepared, stained in hematoxylin, and mounted in permount after dehydration in ethanol and clearing in xylene. Representative voucher specimens have been deposited in the U.S. National Parasite Collection (USNPC), Beltsville, Maryland: *Orthosplanchnus fraterculus* (USNPC 86771), *Diplogonoporus tetrapterus* (USNPC 86772), *Pseudoterranova decipiens* (USNPC 86773), and *Corynosoma enhydri* (USNPC 86774). The terms *prevalence* and *intensity* are used in accordance with the definitions provided by Margolis et al. (1982). Parasite prevalences among male, female, adult, and juvenile sea otters were compared statistically using Fisher's exact probability test (Sokal and Rohlf, 1981).

Results

Four species of helminth parasites were found in the sea otters, one each of Cestoda, Trematoda, Nematoda, and Acanthocephala (Table 1). Except for a statistically significant ($P < 0.05$) difference between adult male and female hosts in prevalence of *Diplogonoporus tetrapterus* (von Siebold, 1848) (4 of 12 males and 1 of 27 females infected), no significant differences in parasite prevalence were detected between male and female hosts or between adult and juvenile hosts. We therefore have summarized prevalence data for all sea otters combined (Table 1).

The most frequently encountered parasites were the acanthocephalan *Corynosoma enhydri* Morozov, 1940, in the intestine and the digenean trematode *Orthosplanchnus fraterculus* Odhner, 1905, in the gallbladder. Both were found in half of the animals examined. The cestode *D. tetrapterus* occurred in the intestine of 12% of the otters, and the nematode *Pseudoterranova decipiens* (Krabbe, 1878) (3 specimens) was recovered from the stomach of only 1 adult female otter. The 1 pup examined was free of helminths.

Discussion

The sea otter is an exclusively marine species of the mammalian family Mustelidae. It inhabits coastal areas on the North American and Asian sides of the North Pacific Ocean (Riedman and Estes, 1987) and was the object of intensive human exploitation for its valuable pelt in the 18th and 19th centuries, which resulted in elimination of the species from vast areas of its original range. With complete protection from harvesting, population numbers have been increasing in recent decades, and parts of the former sea otter range have been reoccupied by natural invasion or by deliberate reintroduction of the species. At present, populations exist in a disjunct distribution between about 35°N and 60°N on the North American coast and between about 45°N and 55°N on the Asian coast (Fig. 1).

Within this distributional range, reports on parasites of the sea otter have been published for populations from the Komandorski (Commander) and Kuril islands on the Asian side of the Pacific, and from the Aleutian Islands, Prince William Sound, and California on the North American side (Table 2). Isolated records of parasites of sea otters from islands north and south of the western end of the Alaska Peninsula and from southeast Alaska also have been documented (Van Cleave, 1953; Adams and Rausch, 1989), as well as a record of *C. enhydri* from an unspecified locality in Alaska (Kikuchi and Nakajima, 1993).

Of the 4 parasite species recovered in the present study, *C. enhydri* is the only one specific

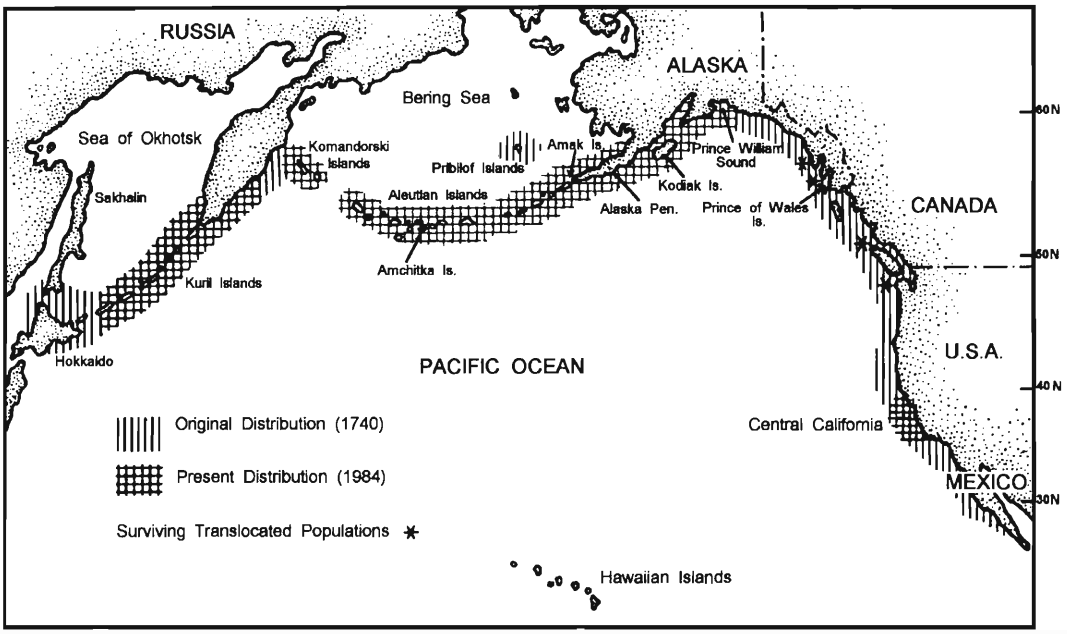

Figure 1. North Pacific region showing original and present sea otter distribution. (Modified from Riedman and Estes [1987].)

to the sea otter. No other definitive hosts are known. Although not reported by Rausch and Locker (1951) or Rausch (1953) from the 31 sea otters they examined from Amchitka Island (Aleutian Islands), it appears to be widely distributed around the North Pacific rim from the Kuril Islands in Asia to California in North America (Table 2). It is probably the most prevalent, although not necessarily the most numerous, parasite of sea otters. In the 3 studies in which more than 60 animals were necropsied (Kuril Islands, Kovalenko, 1975; California, Hennessy and Morejohn, 1977; Hennessy et al., 1979; Prince William Sound, present study), prevalences ranged from 52% (Prince William Sound) to >90% (California) for adult and juvenile (excluding pups) hosts combined.

Orthosplanchnus fraterculus, the second most frequently encountered parasite in our study, also was commonly found by Rausch and Locker (1951) and Rausch (1953) in sea otters from Amchitka Island (prevalence, 90%), but was not found in the Asian populations of sea otters and is probably also absent from the California population. This parasite was found also in southeast Alaska (Adams and Rausch, 1989). It appears, therefore, to be a core parasite of only Alaskan sea otter populations.

The tapeworm *Diplogonoporus tetrapterus* apparently has a low prevalence in northern populations of sea otters from both Asia and North America and is absent from California sea otters. The highest reported prevalence (12%) is for the Prince William Sound population examined in the present study. The difference in *D. tetrapterus* prevalence between adult male and female hosts in our study suggests a more frequent occurrence of fish, the probable second intermediate host of this cestode, in the diet of adult males.

Like *D. tetrapterus*, *P. decipiens* has been found in the northern populations of sea otters in Asia and North America but has not been reported from California sea otters. Prevalences of *P. decipiens* are difficult to interpret from the information provided in most of the Asian and Aleutian Islands studies, but in all cases, they appear to be substantially greater (up to 35–40% or even higher in some small samples) than the 1.5% prevalence reported by us for Prince William Sound sea otters. Intensity of infection also reached much higher levels in Asian and Aleutian Island host samples, with up to 200 worms in some otters (Afanasev, 1941; Kovalenko, 1975).

Among sea otter parasites not reported in our

Table 2. Comparison of helminth parasite occurrence in sea otters (*Enhydra lutris*) from Asian and North American populations.*

	Amchitka, Aleutian Islands	Prince William Sound, Alaska	California	Komandorski Islands	Kuril Islands
Trematoda (Digenea)					
Microphallus pirum (syn. *M. enhydrae*)†	+	+	+	+	–
Nanophyetus sp.	–	–	–	+	–
Orthosplanchnus fraterculus	+	+#	?**	–	–
Phocitrema fusiforme	+	–	–	–	–
Pricetrema zalophi	+	–	–	–	–
Cestoda					
Diplogonoporus tetrapterus	+	+	–	?	+
Diplogonoporus sp.‡	–	–	–	+	–
Pyramicocephalus phocarum§	+	–	–	–	–
Nematoda					
Anisakis sp. larva I	–	–	–	–	+
Anisakis sp. larva II	–	–	–	–	+
Pseudoterranova azarasi	–	–	–	–	+
Pseudoterranova decipiens	+	+	–	+††	+
Acanthocephala					
Corynosoma enhydri syn. *C. macrosomum*	–‖	+	+	+	+
Corynosoma strumosum	+	+	–	–	–
Corynosoma villosum syn. *C.* sp. of Rausch and Locker, 1951 and of Rausch, 1953	+	+	–	–	+
Polymorphus altmani	–	–	+	–	–
Polymorphus kenti	–	–	+	–	–
Polymorphus major	–	–	+	–	–

* Data compiled from Rausch and Locker (1951), Rausch (1953, 1964), Van Cleave (1953), and Kenyon (1969) for the Aleutian Islands; from Golvan (1959), Neiland (1962), Rausch (1964), Kenyon (1969), and the present paper for Prince William Sound; from Hennessy and Morejohn (1977) and Hennessy et al. (1979) for California; from Barabash-Nikiforov (1935, 1947), Morozov (1940, 1957), Afanasev (1941), and Kontrimavichus (1969) for the Komandorski Islands; and from Kovalenko (1975) for the Kuril Islands. All, except *O. fraterculus* (a parasite of the gallbladder), are parasites of the gastrointestinal tract.

† Deblock and Pearson (1969) and Deblock (1971) regarded *M. enhydrae* and *M. pirum* as distinct species, but we treat them here as a single species. Lauckner (1985) believed that the sea otter "is host for 2 species of the genus *Microphallus,*" but accepted the use of the name *M. pirum* for Rausch's (1953) material from Amchitka Island.

‡ Probably *D. tetrapterus* (see Rausch, 1964), but reported as *Diplogonoporus grandis* by Barabash-Nikiforov (1947) and Barabash-Nikiforov et al. (1968).

§ Unidentified cestodes reported from a Komandorski Islands sea otter by Barabash-Nikiforov (1935) were considered by Lauckner (1985) to be "possibly attributable to *Pyramicocephalus phocarum.*" As the parasites were not described, there is no evidence to support this suggestion.

‖ Although *C. enhydri* was not reported from Amchitka Island by Rausch and Locker (1951) or Rausch (1953), it has been found in sea otters from islands to the north and south of the western end of the Alaska Peninsula, adjacent to the eastern Aleutian Islands (Van Cleave, 1953, as *Corynosoma* sp.; Margolis, unpubl., based on specimens collected by Dr. Karl Kenyon at Amak Island, north side of the Alaska Peninsula). Kenyon (1969) reported from 1 to 98 *Corynosoma* sp. (total, 271 specimens) from 8 Amchitka Island sea otters. It is possible that this collection contained some *C. enhydri.*

Also reported from Prince of Wales Island, southeast Alaska, by Adams and Rausch (1989).

** The gall bladder, the site of *O. fraterculus* infection, was not examined in the California sample of sea otters. However, it appears to be a holarctic pinniped parasite not found in California waters.

†† Without providing any justification for their decision, Barabash-Nikiforov et al. (1968) referred to nematodes previously identified (Afanasev, 1941; Barabash-Nikiforov, 1935, 1947) from Komandorski Islands sea otters as *P. decipiens* to *P. azarasi.*

study, the trematode *Microphallus pirum* (Afanasev, 1941) and the 3 acanthocephalan species of the genus *Polymorphus* deserve special mention. *Microphallus pirum* was originally described from the Komandorski Islands (Afanasev, 1941), and was commonly found in the intestine of Amchitka Island sea otters by Rausch and Locker (1951) and Rausch (1953) and in California sea otters by Hennessy et al. (1979). It also was reported previously from a Prince

William Sound sea otter (Kenyon, 1969). Thus, it is widely distributed in sea otters. In our study, this species may have been overlooked because of its small size (<1 mm in length). The three species of *Polymorphus* uniquely reported from California sea otters, with individual species prevalences up to 5% (Hennessy and Morejohn, 1977), are primarily parasites of aquatic birds. Hennessy et al. (1979) referred to 4 (unnamed) species of *Polymorphus*, with combined prevalence of 10%, among California sea otters. The parasites did not reach sexual maturity in sea otters (Hennessy, 1972; Hennessy et al., 1979).

Differences between the parasite fauna of the southern (California) and northern populations of sea otters are largely the consequence of differences in their diets. California sea otters feed almost entirely on a variety of macroinvertebrates, whereas Alaskan and Russian populations of sea otters include fish as well as invertebrates as important elements in their diet (Riedman and Estes, 1990). The fish-transmitted parasites include *D. tetrapterus*, *P. decipiens*, *P. azarasi* (Yamaguti and Arima, 1942), *C. strumosum* (Rudolphi, 1802), and *C. villosum* (Van Cleave, 1953) (see Schiller [1954] and Shults and Frost [1988]), all of which were absent from California sea otters. In contrast to *C. strumosum* and *C. villosum*, *C. enhydri*, as already noted, is found commonly in both the California and northern populations of sea otters and is therefore probably transmitted by 1 or more invertebrates. Afanasev (1941) claimed to have found juvenile *C. enhydri* in the cottid fish *Myoxocephalus stelleri* from the Komandorski Islands. However, the few morphometric data he provided (length 4.6 mm; swollen proboscis with 24 longitudinal rows of hooks) suggest that he may actually have been dealing with *C. villosum*, a species not known at the time. Only 1 other parasite, *M. pirum*, has been found in both northern and California sea otters. Transmission to sea otters is via shore crabs, in which the metacercariae develop. Schiller (1954, 1959) found metacercariae in *Pagurus hirsutiusculus* and *Telmessus* sp. in Alaska, Tsimbalyuk et al. (1968) reported metacercariae in *P. hirsutiusculus* and *Pagurus middendorffii* in the littoral zone of the Komandorski Islands, and Kulikov et al. (1970) discovered metacercariae in *P. middendorffii* and *Pagurus pubescens* in the northern Kuril Islands area. Although the metacercariae of *M. pirum* have not been reported from California, it can be assumed that they occur in crabs, a frequent item in the diet of California sea otters (Riedman and Estes, 1990).

A total of 17 (or possibly 18) parasitic helminth species have been reported from sea otters throughout their distributional range. Five (or 6) species are represented by juvenile forms that occur infrequently and have been found in 1 locality only. In addition to the species of *Polymorphus* from California already mentioned, individual encounters of 2 species of *Anisakis* larvae from Kuril Islands sea otters have been documented by Kovalenko (1975). Species of these genera apparently do not mature in sea otters, which are dead ends in their life cycles. The normal definitive hosts are primarily anseriform birds for the *Polymorphus* species and cetaceans for the *Anisakis* species.

Among the 12 species that use sea otters as definitive hosts, 3 (*C. enhydri*, *M. pirum*, and *O. fraterculus*) may be considered core species, at least in some sea otter populations, because of their high prevalence and intensity of occurrence. Of these 3 species, 2 use the sea otter as the only (*C. enhydri*) or a frequent (*M. pirum*) definitive host. *Orthosplanchnus fraterculus* is a common parasite of some pinnipeds, as are 8 of the remaining 9 species of helminths found in sea otters (Rausch, 1953; Delyamure, 1955; Dailey and Brownell, 1972; Margolis and Dailey, 1972; Shults, 1986; Shults and Frost, 1988; Margolis and Arai, 1989). The only exception is *Nanophyetus* sp., presumably *N. salmincola* (Chapin, 1926), a parasite of various piscivorous birds and mammals, whose metacercarial stage occurs primarily in freshwater and anadromous salmonids (Millemann and Knapp, 1970). Infection has been reported from only 1 Komandorski Islands sea otter (Afanasev, 1941), which must be considered an accidental or occasional host of this parasite acquired by ingestion of an anadromous salmonid.

The helminth fauna of sea otters is thus made up principally of species acquired indirectly from pinnipeds through intermediate hosts in the food chain, plus 2 core species, also acquired through the food chain, that have not been reported from pinnipeds. None of the parasites of sea otters reflect the terrestrial ancestry of this mammal or its relationship with its extant terrestrial–freshwater feeding relatives (Kontrimavichus, 1969). With respect to this dominance of pinniped parasites among the parasites found in

the sea otter, we note that the sea otter evolved in the North Pacific Ocean some 1 to 3 million years ago (Riedman and Estes, 1990) when otariid pinnipeds, and presumably their parasites, were already well established there. These parasites were thus available for colonizing a new mammalian host when the sea otter arrived on the scene. Phocid pinnipeds invaded the North Pacific basin about 2.5 to 3 million years ago (see Hoberg and Adams [1992]) and thus their parasites also became available for colonizing the sea otter early during the latter's appearance in the North Pacific.

The origins of the nonpinniped parasites *C. enhydri* and *M. pirum* remain speculative, although evidence has been accumulating to suggest that the latter species may be primarily a parasite of shorebirds. *Corynosoma* and *Microphallus* each comprise more than 40 species (Deblock, 1971; Amin, 1985). The definitive hosts of members of the genus *Corynosoma* are marine mammals and aquatic birds, with the largest number of species occurring in pinnipeds, which are the likely original hosts for species of this genus. *Corynosoma enhydri*, therefore, presumably arose from an ancestral species parasitic in pinnipeds. Because there are no *Corynosoma* species specific for terrestrial mammals one can rule out the possibility that *C. enhydri* parasitized the sea otter's ancestors before they inhabited the oceans.

Microphallus pirum has been found in large numbers in the arctic fox (*Alopex lagopus*), as well as in the sea otter, on the Komandorski Islands (Afanasev, 1941). Schiller (1959) demonstrated that the glaucous-winged gull (*Larus glaucescens*) could be readily infected experimentally. The worms reared in gulls were larger than those reared in hamsters or recovered from natural infections in sea otters (Schiller, 1959) or arctic foxes (Afanasev, 1941). Although sea otters did not inhabit the Kodiak Island area at the time of Schiller's studies, and the other known mammalian definitive host, the arctic fox, also is absent from Kodiak Island, *M. pirum* metacercariae were nevertheless commonly found there in hermit crabs (*Pagurus hirsutiusculus*). Clearly, some other definitive host was responsible for maintaining infections at Kodiak Island. It is well known that microphallid trematodes lack host specificity in the adult stage (Stunkard, 1953).

The above facts led Schiller (1959) to speculate that lariform birds may prove to be important natural definitive hosts of *M. pirum*. This would not be surprising, because the majority of the 40+ species of *Microphallus* use aquatic birds as definitive hosts (Deblock, 1971). However, Schiller (1954) did not find *M. pirum* in any of 59 shorebirds of 18 species, including 2 specimens of glaucous-winged gulls, examined from Amchitka Island, where sea otters were commonly found by Rausch (1953) to be infected with this trematode. Contrary to Schiller's (1954) findings, Ching (1965) reported *M. pirum* in the white-winged scoter *Melanitta deglandi* from an unspecified locality on the Pacific coast of North America, Tsimbalyuk and Tsimbalyuk (1967) reported 3 species of sandpipers (*Calidris alpina*, *Calidris maritima*, and *Tringa incana*) and the glaucos-winged gull as definitive hosts on the Komandorski Islands, Hoberg (1979) reported *M. pirum* from the glaucos-winged gull at Ugaiushuk Island (located on the south side of the Alaska Peninsula) and Kodiak Island, and Alekseev and Smetanina (1970) and Smetanina (1981) found the parasite common in *Larus crassirostris* from Peter the Great Bay (the Japan Sea coast of Russia), thus reinforcing the likelihood of seabirds being important and perhaps the original definitive hosts of *M. pirum*. In this context, it is significant that Peter the Great Bay lies outside the historical range of the sea otter.

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A Transmission Study of Two Sympatric Digeneans: Spatial Constraints and Solutions

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ABSTRACT: The distributions of infected molluscan hosts of the digeneans *Maritrema misenensis*, a parasite of charadriid birds, and *Lepocreadium pegorchis*, a parasite of sparid fishes, were examined along a transect spanning the mediolittoral and upper infralittoral zones at the edge of a protected small bay in southeastern France, western Mediterranean. In both parasites, the first intermediate host occurs in an area separated spatially from the definitive host; in each case, only a small fraction of the potential first intermediate hosts, those nearest the source of eggs, are infected. In both cases, second intermediate hosts overlap in distribution only slightly (or not at all) with the first intermediate hosts (and, in the case of *L. pegorchis*, with the definitive hosts). We analyze the strategies evolved to overcome these spatial constraints on transmission.

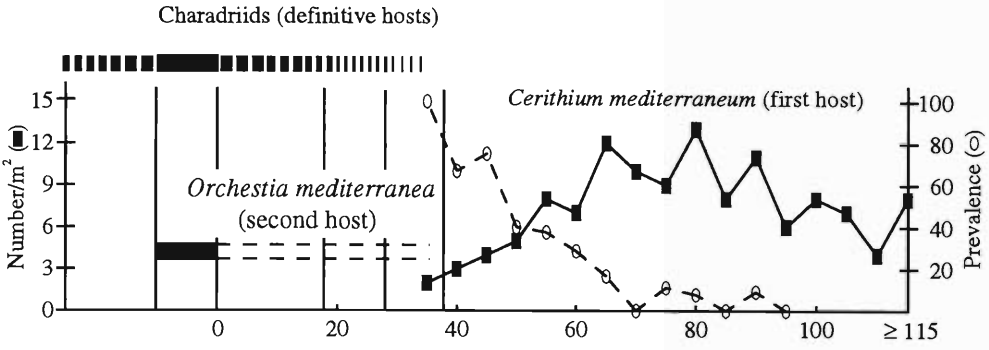
KEY WORDS: *Maritrema misenensis*, *Lepocreadium pegorchis*, Digenea, Mediterranean, transmission constraints, adaptations.

A successful life cycle necessitates that the parasite be adapted not only to each required host, but also to the potential ecological problems of transmission between those hosts. The extent of these problems can be markedly affected by the structure of the habitat (Sousa and Grosholz, 1991) and is minimized if all hosts overlap. As a result, high levels of infection in 1 host species often show a strong relationship with proximity to high numbers of the other required hosts (e.g., Robson and Williams [1970]; Matthews et al. [1985]; Carrol et al. [1990]; Goater [1993]). At relatively large scales, the pattern of overlap can also determine the distribution of the parasite. Bartoli (1981) has shown that 2 closely related gymnophallid digeneans of birds are transmitted in different parts of the Camargue because of differences in the distributions of the first and second intermediate hosts. On a regional scale, Køie (1983) has provided excellent examples of distributions of parasites of flounder (*Limanda limanda*) that are limited by the distributions of their required molluscan hosts.

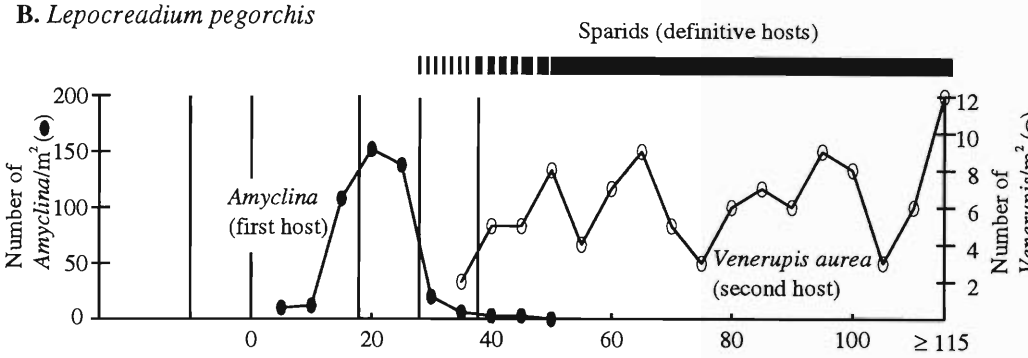
On smaller scales, hosts of parasites do not have to coexist sympatrically if the life cycles include free-living stages (or a mobile intermediate host) that can actively migrate between locations. For example, Shiff (1974) has shown that, under summer conditions in Zimbabwe, the snail hosts of *Schistosoma haematobium* are found in deep, shaded waters but migrate to warmer surface waters when temperatures drop below about 15°C. Shiff also showed that the miracidia switch from being negatively phototropic at high temperatures to positively phototropic at lower temperatures; this switch occurred at the same temperature as for the snails. In addition, Goater et al. (1995) found that metacercariae of *Psilostomum brevicolle* in cockles (*Cerastoderma edule*) were more widely dispersed in the Exe estuary than were cysticercoids of *Microsomacanthus rectacantha*. They suggested that the actively motile cercariae can be more easily distributed by tidal currents than the passively transported eggs of the cestode, which appeared to be dependent on local transmission. Indeed, Bartoli (1989) and Bartoli and Combes (1986) have shown that a variety of specific behavioral patterns of cercariae can bring them from the habitat of the first host to very different habitats occupied by the second intermediate hosts.

Protected shallow waters in the Mediterranean provide particularly good systems to study the potential constraints parasites face when their hosts do not occupy the same habitats, and to investigate the mechanisms that have evolved to overcome those constraints. The virtual absence of tides or currents and the very gentle slopes of some bays and lagoons magnify any constraints generated by occupation of different habitats by successive hosts and may result in situations in which only a small part of the po-

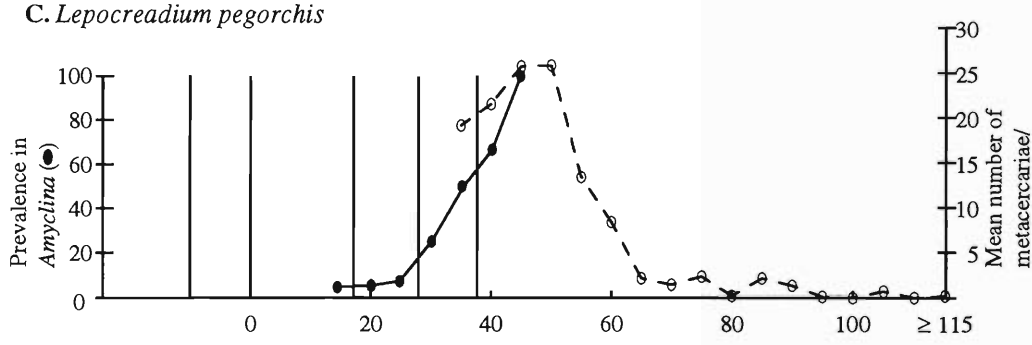
A. *Maritrema misenensis*



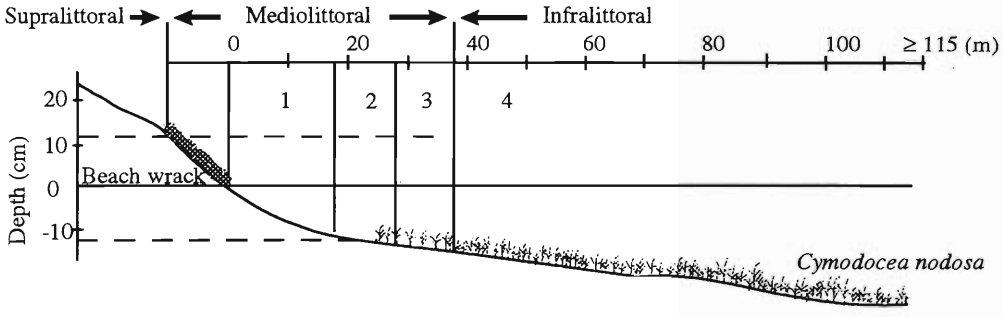
B. *Lepocreadium pegorchis*



C. *Lepocreadium pegorchis*



D. Littoral zonation



tential host population, those occupying a marginal habitat, may actually be exposed to infection. This small proportion of the host population may therefore be critical to survival of the local parasite population.

In this study, we examine the distributions of 2 species of digeneans in such a bay. One is a parasite of birds, the other of fish. The life cycles of both of these digeneans are well known, and both require molluscan hosts that are distributed primarily in the very shallow waters not regularly used by either of these definitive hosts.

Maritrema misenensis (Palombi, 1940) adults are found in a variety of charadriiform birds, especially *Charadrius alexandrinus* and *C. hiaticula*. These birds feed along the water's edge, never venturing into the infralittoral, but may defecate while flying over that region, dispersing eggs. The first intermediate host in the bay is the prosobranch *Cerithium mediterraneum* Deslayes 1843, which occupies the infralittoral, never entering the mediolittoral. The second intermediate host is the talitrid amphipod *Orchestia mediterranea*, which inhabits the beach wrack. This life cycle was described by Prévot et al. (1976), and an ecological study, from the same bay and the surrounding region, was reported by Bartoli and Prévot (1978).

Lepocreadium pegorchis (Stossich, 1900) adults are found in several sparid and other fishes (Saad-Fares, 1985) that feed throughout the bay, except in the shallowest waters. The first host in the bay is the nassid prosobranch *Amyclina corniculum* (Olivi, 1792), which occurs mainly in the mediolittoral, and disappears in the infralittoral, where the seagrass becomes dense. The second intermediate hosts are the venerid lamellibranchs *Venerupis aurea* (Gmelin, 1790) and *Venus verrucosa* L. and the cardiid *Cerastoderma glaucum* (Bruguiere, 1798), all of which occupy only the infralittoral. In this study, we focussed only on *V. aurea*, the most common of the second intermediate hosts; the others are rare in this location. This life cycle, and its ecological aspects, has been reported by Bartoli (1967, 1983).

In this paper, we present quantitative data on the spatial distributions of these parasites in their molluscan intermediate hosts and identify the major transmission constraints faced by each of the parasites. We then discuss adaptations of the 2 parasites to overcome spatial constraints on their transmission.

Materials and Methods

The study was conducted at the southern edge of the Baie du Brusc, near the Isle de Embiez, just west of Toulon, France (in the western Mediterranean). The bay is protected on 3 sides by 2 islands and the mainland, and on the fourth by an extensive bed of living *Posidonia oceanica* reaching the surface, so is virtually waveless. The bay is small (surface area about 50 hectares), shallow (maximum depth 1.2 m), and opens to the north, facing the dominant winds, the mistral (Molinier, 1961). Like the rest of the Mediterranean Sea, there is a very small tidal flux (±10 cm); there are, however, barometric tides (maximum 30 cm), primarily due to atmospheric conditions associated with the dominant mistral winds (Hopkins, 1984). The site is near a private research station (Fondation Scientifique Ricard) and has been studied extensively as an example of Mediterranean calm-water areas (e.g., Vicente [1974]).

The survey was conducted between 8 and 10 July 1991, along a single 150-m transect perpendicular to the shore. The transect started at the lower edge of the beach wrack. The first 15 m (the upper mud zone, "1" in Fig. 1D) is frequently exposed, and the next 10 m (the lower mud zone, "2") is occasionally exposed; the substrate of both is soft and unvegetated. The next 10 m (the sparse seagrass zone, "3") is rarely exposed; the substrate is soft, with scattered seagrass (*Cymodocea nodosa*). These 3 zones, plus that occupied by the beach wrack, constitute the mediolittoral. The remaining part (the infralittoral, "4") is never exposed and has a dense cover of *C. nodosa*. At every 5 m along the transect, the upper 20 cm of substrate within a 1-m^2 iron quadrat were removed and sieved, and all individuals of the 3 major species of molluscs involved in the life cycles (see below) were collected. Snails were crushed and examined for sporocysts or rediae; tissues of the lamellibranchs were removed and pressed between 2 glass plates, and all metacercariae of *Lepocreadium pegorchis* were counted.

Voucher specimens of *Lepocraedium pegorchis*

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Figure 1. Transect through the edge of Baie du Brusc, southern France, western Mediterranean. (A) Distribution of *Maritrema misenensis*; distribution of definitive and second intermediate hosts after Bartoli and Prévot (1978). The dashed distribution of the second intermediate host of *M. misenensis* indicates migration to the water's edge to replenish moisture supplies. (B) Distribution of potential hosts of *Lepocreadium pegorchis*; distribution of definitive hosts after Bartoli (1983). (C) Distribution of molluscs infected with *L. pegorchis*. (D) Profile of the studied zone. Note the vertical exaggeration. Region 1 is the upper mud zone; 2, the lower mud zone; 3, the sparse seagrass zone; and 4, the infralittoral.

have been deposited in the British Museum (Natural History) (BM(NH)1997.2.17.1–23). Voucher specimens of *Maritrema misenensis* are in the collection of the senior author.

Results

Cerithium mediterraneum, the first intermediate host of *M. misenensis*, is restricted to the infralittoral zone, with density being highest in the lower reaches. The trematode, however, attains its highest prevalences in the few snails in the upper infralittoral (Fig. 1A). Only 24% of the snails, but 80% of the infected snails, were found in the shallowest 30 m of the dense *C. nodosa* bed; only 3% of the snails in the rest of the transect were infected.

Amyclina corniculum, the first intermediate host of *L. pegorchis*, was found in large numbers in the lower mud zone and declined rapidly both above and below that zone (Fig. 1B). However, the prevalence of the trematode increased rapidly with depth, reaching its highest levels in the relatively few snails in the upper infralittoral (Fig. 1C).

Venerupis aurea, the common second intermediate host of *L. pegorchis*, was widespread, and in fairly similar numbers, throughout the infralittoral (Fig. 1B). Because the clams were found in similar numbers throughout the infralittoral, we have used the mean number of metacercariae per clam (a measure of relative density) as an index of the true density of metacercariae along the transect. Most of the metacercariae (93%) were found in the 21% of the clams collected from the first 30 m of the upper infralittoral, close to the zones occupied by the infected first hosts (Fig. 1C).

Discussion

Data from this transect provide a snapshot of the distributions of the 2 species of digeneans. The distributions differ, but the patterns are very similar. For one of the species, *M. misenensis*, the pattern is repeatable: Bartoli and Prévot (1978) demonstrated similar distributions of infected snails at each end of a transect between one of the islands and the mainland.

In many life cycles, the areas occupied by the definitive first and second intermediate hosts overlap broadly so that their spatial arrangements do not constrain transmission. However, in these 2 digeneans, spatial arrangements do constrain transmission. For both species, the first constraint is the minimal (at best) overlap between the areas occupied by the definitive hosts and the snail first intermediate hosts. For *M. misenensis*, infections in *C. mediterraneum* are concentrated in a small part of the snail population, those closest to the source of infection. Note, however, that because of the very shallow slope and sandy substrate of the shore, most of the eggs shed high on the shore are probably lost to rainwater percolating into the sand; relatively few are likely to be available to snails. Some eggs are undoubtedly shed by birds defecating as they fly over the water further from shore; these eggs are probably the source of the small proportion of infected snails found further offshore. For *L. pegorchis*, infections in *A. corniculum* are also concentrated in a small part of the snail population, this time those closest to deeper water, again the primary source of infection.

There are 3 possible explanations for these distributions of infected snails: (1) Larger, older individuals could preferentially move to the "zone of infection" (e.g., Blower and Roughgarden [1988]). Such older individuals would have been exposed for a longer period and would therefore be more likely to be infected. No such size-related pattern of distribution was obvious, but we do not have the detailed size or age data, for either species, that would allow us to rule out this possibility. (2) Individuals could have been infected in a wider area but exhibit altered behavior, so that they preferentially migrate into the "zone of infection" (e.g., Curtis [1987, 1990]). The flat topography and relatively long distances make this unlikely, but again, we cannot rule out this possibility. If infected snails do migrate into the zones observed, the altered behavior could constitute an adaptation for transmission. (3) Prevalences of infection could be determined by proximity to the source of infection, i.e., the area most frequented by the definitive hosts (and therefore the highest concentrations of eggs). This is the distribution predicted by diffusion processes. It is clearly the most parsimonious interpretation; if correct, only those snails that occupy the "zone of infection" are likely to serve as first intermediate hosts of these digeneans.

Different solutions to this constraint have evolved in the 2 species of digeneans. In *M. misenensis*, both prevalence and intensity of infection are very high in several species of charad-

riids (Bartoli, unpubl.). The life span of each adult worm appears to be short (no more than 5 days), but birds are apparently infected repeatedly throughout the several months they occupy the region. Each adult worm produces only a relatively small number of eggs (no more than about 200); these eggs are released only when the worm dies, is egested with the feces, and disintegrates (Bartoli, unpubl.). The net result, however, is a large number of eggs deposited each day over a large part of the year. The mechanisms evolved to overcome the first constraint are therefore low definitive host specificity and a large number of eggs because of high transmission rates to the definitive hosts and a rapid turnover in the population of adults over a relatively large proportion of the year.

Lepocreadium pegorchis also exhibits broad host specificity (numerous species of sparid and other fishes—Saad-Fares [1985]). However, this parasite has never been recorded at the high prevalences or intensities of *M. misenensis*. The adults are more long-lived (probably more than 1 mo) and release eggs (at the rate of about 10 eggs per day) throughout most of this period (Bartoli, unpubl.). This protracted, low rate of egg production provides more opportunities for some eggs to be lain in proximity to the few potential first intermediate hosts at the edge of the bay.

Both species are also constrained by the restricted overlap between the areas occupied by the first and second intermediate hosts. In *M. misenensis*, this constraint is due to the fact that the first host is limited to the infralittoral, whereas the second intermediate host lives in the beach wrack, above the water. However, these amphipods periodically move to the water's edge (represented by the dashed extension of the range of the amphipods in Fig. 1A) to replenish their moisture content (Bartoli, 1986). Females, which need to keep the eggs or young in their brood pouches moist, enter the water more frequently than males or juveniles and are more frequently infected. Even when they enter the water, however, they are usually far from the source of cercariae. The primary mechanism selected to overcome this constraint is the behavior of the cercaria. Immediately after emergence, cercariae swim actively to the sea surface, attach to the surface film, and capture an air bubble. Wind and wavelets push some of the cercariae towards the edge of the water, where they may encounter the amphipods. Thus, contact between the cercariae and the amphipods is a consequence of the behavior of each, which brings them to the same location (Bartoli, 1986). As a result, over 70% of the larger amphipods are infected (Bartoli and Prévot, 1978).

The second constraint in *L. pegorchis* is due to the slight overlap in distribution of the first and second intermediate hosts. Two responses have evolved: a long period of shedding cercariae (Bartoli, unpubl.) and the behavior of the cercariae. After release from the snail, the cercariae swim upwards for a short time, then slowly descend into the water layer just above the bottom, where they can be sucked into the incurrent siphon of the clams. If not taken in by a clam, the cercariae may repeat this swimming pattern (Bartoli, 1989). Although the cercariae are weak swimmers and spend most of their time close to the bottom (Bartoli and Combes, 1986), this behavior, along with minor water movement, does allow the parasite to extend the distribution of its metacercariae somewhat further offshore.

Lepocreadium pegorchis, but not *M. misenensis*, is also constrained by the restricted overlap between the areas occupied by the infected second intermediate hosts and the definitive hosts. In the case of *M. misenensis*, the extensive overlap between the distribution of the infected amphipods and the feeding areas of the charadriid birds make most of the latter potentially available as definitive hosts for *M. misenensis*. However, for *L. pegorchis*, only those fish that come closest to shore to feed in the waters inhabited by the infected clams are likely to be definitive hosts. Note that metacercariae in the clams further offshore should be more available to fish than the more abundant metacercariae in the clams nearest the shore and may play a more significant role in the population dynamics of *L. pegorchis*. An alternative view, that the distribution of the metacercariae in the clams reflects the intensity of predation on infected individuals by fish, is unlikely. The weak swimming ability of the cercariae (Bartoli and Combes, 1986) makes extensive infections far from the infected snails unlikely. In addition, the metacercariae, in the labial palps, do not appear to affect the behavior of the clam (Bartoli, unpubl.), as is so obvious, for example, in clams infected with various species of *Meiogymnophallus* (Bowers et al., 1996).

Thus, both species have evolved mechanisms to overcome these spatial constraints on their transmission in the bay ecosystem. These adaptations are apparently more effective for *M. misenensis* than for *L. pegorchis*. However, both species also exist in other nearby systems. In rocky areas adjacent to the bay, and very possibly in other areas, *M. misenensis* is capable of infecting a different (but related) suite of hosts. In those rocky areas, the first host is *Cerithium rupestre* and the second is *Orchestia montagui*. Once again, *C. rupestre* is limited to the infralittoral, but *O. montagui* is limited to banks of dead leaves of *P. oceanica* that accumulate in the supralittoral, and never enters the water. In this case, the more extensive wave action carries the cercariae (with their bubbles) with sea spray to the surface of the banks of *Posidonia* (Bartoli, 1986). These banks of *P. oceanica* retain more moisture than does the beach wrack, so that the amphipods do not need to move to the water. Thus, in this case, the cercariae are carried to the normal habitat of the amphipods directly. Bartoli and Prévot point out that far fewer shorebirds feed in the *Posidonia* beds than along the shallow lagoon margins. Therefore, this alternative system is probably of less importance to the maintenance of the life cycle of *M. misenensis* in this region. Note that the selection pressures should be similar.

However, *L. pegorchis* appears to be better adapted to another ecosystem—that of the high energy sandy shore, where other first (*Sphaeronassa mutabilis*) and second intermediate host species (*Donax semistriatus* and *D. trunculus*) are used (Bartoli, 1983). In these high-energy sandy ecosystems, with their greater slope, there is greater overlap between the distributions of the definitive first and second intermediate hosts, so that the 3 constraints seen in the bay are less apparent and the selection pressures for adaptations weaker.

This bay system, with its very gradual slope and virtual absence of tides or currents, allows us to see clearly the small-scale spatial constraints to transmission of these 2 parasites. The patterns and constraints are familiar at larger scales, as indicated in the introduction. Shifting our focus to this small scale has 2 advantages; First, at this scale, selection pressures on the parasites are obvious, prompting a search for countering adaptations of the parasites. In our view, those adaptations constitute some of the most interesting aspects of parasite life histories. Second, similarities in the selection pressures and adaptations would contribute to the correlated spatial heterogeneity regarded by Lafferty et al. (1994) as a significant contributor to community processes.

We expect that spatial constraints and restricted local distributions may be common in lagoons, other protected marine systems (e.g., Lafferty et al. [1994]), and particularly in lentic freshwater systems (e.g., Williams and Esch [1991]), characterized by shallow slopes and weak water movements. In systems with steeper slopes, where the successive hosts are not as widely separated, these distributional constraints should be less important, as seen in the sandy ecosystem patterns with *L. pegorchis*. Such problems should also be less important in lotic or marine systems with more extensive tides, currents, or wave action, which can transport infective stages of the parasites over longer distances (e.g., James et al. [1976]).

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Helminth Community Structure and Pattern in Sympatric Populations of Double-Crested and Neotropic Cormorants

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ABSTRACT: Helminth communities of double-crested (*Phalacrocorax auritus*) and neotropic (*Phalacrocorax brasilianus*) cormorants from the midcoast of Texas were examined. Twenty-one helminth species were found; 17 species occurred in each host species, and 13 species co-occurred in both host species. The mean number of helminth species was similar, averaging 5.9 ± 0.4 (SE) and 5.8 ± 0.7 species in double-crested and neotropic cormorants, respectively. Helminth infracommunities were depauperate, particularly in commonly utilized microhabitats. Eleven common species were found, in which 9 and 10 species occurred in double-crested and neotropic cormorants, respectively. Of these, the prevalence of *Ascocotyle* sp. 2 was higher in double-crested cormorants, whereas the prevalence of *Capillaria contorta* was higher in neotropic cormorants. Eight species (*Ascocotyle* sp. 2, *Austrodiplostomum mordax*, *Paradilepis caballeroi*, *Capillaria spiculata*, *Contracaecum spiculigerum*, *Syncuaria squamata*, *Tetrameres microspinosa*, and *Andracantha gravida*) were common species in both host populations. The abundance of helminths was similar between double-crested and neotropic cormorants, averaging 134.0 ± 20.2 and 166.9 ± 23.2 helminth individuals, respectively. Of the 11 common species, rank abundances varied between host infrapopulations for 2 species; *C. contorta* was higher in neotropic cormorants, whereas *Desmidocercella skrjabini* was higher in double-crested cormorants. For the 11 common species collectively, rank abundance was higher in neotropic cormorants. Our results suggest that helminth component communities in double-crested and neotropic cormorants occurring in coastal Texas largely share similar characteristics in structure and pattern.

KEY WORDS: community ecology, component communities, cormorants, helminths, *Phalacrocorax auritus*, *Phalacrocorax brasilianus*.

Helminth component communities in migratory avifauna frequently are species rich and diverse (Wallace and Pence, 1986; Fedynich and Pence, 1994), which presumably results from host vagility. Fedynich et al. (1996) demonstrated also that helminth communities in a nonmigratory host are likely influenced by temporally sympatric congeneric hosts.

The double-crested cormorant (*Phalacrocorax auritus*) (Lesson) [120.] is a common species in North America that overwinters on the Texas coast. The neotropic cormorant (*Phalacrocorax brasilianus*) (Gmelin) [121.] is a permanent resident of coastal Texas, which represents the northernmost extension of its geographic range in North America (del Hoyo et al., 1992).

The present study was initiated to compare the helminth communities of 2 related species of cormorants that regularly cooccur. Specifically, our objectives were to (1) determine the helminth fauna of double-crested and neotropic cormorants from coastal Texas, (2) examine the structure and pattern of helminth communities found in both host infrapopulations, and (3) relate these findings to host–parasite interactions.

Materials and Methods

Cormorants were collected in coastal areas of Matagorda County, Texas (28°24′N, 96°09′W). Twelve each of double-crested and neotropic cormorants were collected by shooting, primarily during fall and winter (double-crested cormorants: January 1995, $n = 7$; February 1996, $n = 6$; neotropical cormorants: August 1994 to January 1995, $n = 5$; May 1995, $n = 1$; February 1996, $n = 5$) when both species co-occurred on the study area. Neotropic cormorants are year-round residents on the study area, whereas double-crested cormorants are only winter residents. All cormorants collected were subadults or adults. Cormorants were frozen and stored at −10°C until necropsy. Cormorants were collected in accordance with established guidelines and protocols of U.S. Fish and Wildlife Service scientific collection permit PRT-693859 and Texas Parks and Wildlife Department scientific permit SPR-0490-065.

Helminths were collected, counted, preserved, and examined according to methods described in Wallace and

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Pence (1986). Microhabitats examined for helminths included the trachea, esophagus, proventriculus, gizzard lining, heart, lung, kidney, liver, gallbladder, pancreas, spleen, small intestine, large intestine, ceca, cloaca, mesenteric veins, reproductive tract, and body cavity.

Helminths were identified following the taxonomic keys of Skrjabin et al. (1957), Sonin (1966, 1968), Yamaguti (1958, 1959, 1961, 1971), McDonald (1974), Chabaud (1975), and Anderson and Bain (1976). The identification of *Paradilepis caballeroi* and *Andracantha gravida* was based on the descriptions of Rysavy and Macko (1971) and Schmidt (1975), respectively. Our specimens of *Drepanocephalus spathans* most closely resemble those described by Dietz (1909) and redescribed by Rietschel and Werding (1978), the description of 2 closely related new species of the genus *Drepanocephalus* from *P. brasilianus* (=their *Phalacrocorax olivaceous*) by Nasir and Marval (1968) and Rietschel and Werding (1978), respectively, notwithstanding. Representative specimens of helminths are deposited in the United States National Parasite Collection, Beltsville, Maryland 20705 (USNPC Nos. 86718–86741). Host taxonomy, including the World List Numbers in brackets following the scientific names, is according to Sibley and Monroe (1990).

The terms *prevalence*, *intensity*, and *abundance* follow the definitions of Margolis et al. (1982). Habitat is defined by Whittaker et al. (1973); in relation to helminths, habitat refers to the host individual. Microhabitat refers to anatomical localities within the host. Common helminth species were arbitrarily defined as those species with ≥25% prevalence; all other species were considered uncommon. Helminth infracommunity refers to all infrapopulations of helminth species occurring within an individual host (Holmes and Price, 1986). The component community is defined as all infrapopulations of helminth species occurring in all host individuals sampled from a particular host infrapopulation (Gray et al., 1989).

We compared the influence of host species on helminth community structure and pattern. Frequency data were analyzed with log–linear models (CATMOD; SAS Institute Inc., 1985a) to determine if the prevalence of the common helminth species varied between host infrapopulations. The Jaccard's coefficient of similarity (Jaccard, 1912) was used to measure the similarity of shared helminth species between host infrapopulations. The numerical dominance index (DI) of Leong and Holmes (1981) was used to rank helminth species by the number of individuals that each species contributed to the total number of individuals within each host infrapopulation.

The Brillouin's index (BI), appropriate for fully censused communities, was used to quantify diversity (Pielou, 1975) for each helminth infracommunity. Since BI measures diversity for a fully censused collection at the infracommunity level, and each numerically different BI value is significantly different from all other BI values, there is no significance test to compare multiple collections (Magurran, 1988). An evenness index (EI), based on the ratio of BI/BI_{max} (where BI_{max} = maximum diversity possible given the number of species and the number of individuals in a particular collection), was computed to better interpret BI values (Pielou, 1975). Summary data of BI and EI are presented as range, median, and the 25 to 75% quantiles (Pence, 1990).

The frequency distribution pattern of abundance for the collective common species and for each of the common species was tested for normality (PROC UNIVARIATE NORMAL; SAS Institute Inc., 1985a). Because a non-normal distribution pattern (overdispersion) occurred for most of the common species, abundance values were rank transformed (PROC RANK; SAS Institute Inc., 1985b) prior to further statistical analyses. Rank-transformed abundance values were examined for the main effect of host species, with 1-way analysis of variance (ANOVA; SAS Institute Inc., 1985b) for each common helminth species and with multivariate analysis of variance (MANOVA; SAS Institute Inc., 1985b) for the collective common species. Descriptive statistics are presented as a mean ± 1 SE.

Results

Twenty-one helminth species (11 trematodes, 1 cestode, 8 nematodes, and 1 acanthocephalan) were found in 7 microhabitats from 24 cormorants (Table 1). Seventeen helminth species were found in both the double-crested and neotropic cormorant infrapopulations, respectively (Table 1). Jaccard's index was 0.62, indicating a lack of helminth species co-occurrence between host infrapopulations. Only 13 species co-occurred in both host infrapopulations (Table 1). Helminth infracommunities in double-crested and neotropic cormorants averaged 5.9 ± 0.4 and 5.8 ± 0.7 species, respectively, and were similar ($P = 0.86$).

In both hosts, the proventriculus, esophagus, stomach, small intestine, and large intestine were the most common microhabitats utilized by helminths. However, there was a disparity of helminth species across available microhabitats. At the infracommunity level, 1 to 5 (median = 2) nematode species co-occurred in the combined microhabitats of the proventriculus, esophagus, and stomach in each of the 24 hosts examined, and 3 neotropic cormorants also had a trematode species (*Pseudopsilostoma varium*). In double-crested cormorants, there were 1, 4, 5, and 2 infracommunities occurring in the combined microhabitats of the small and large intestine, with 4, 3, 2, and 1 representatives of each of the 4 major helminth groups (1 to 5 trematodes, 1 cestode, 1 nematode, and 1 acanthocephalan species). For helminth infracommunities occurring in these microhabitats in neotropic cormorants, there were 3, 3, 3, and 3 infracommunities, with 4, 3, 2, and 1 representatives, respectively (1 to 2 trematodes, 1 cestode, 1 nematode, and 1 acanthocephalan species).

Eleven common helminth species were found, in which 9 and 10 species occurred in double-crested and neotropic cormorants, respectively. The prevalence of *Ascocotyle* sp. 2 was higher (*P*

Table 1. Helminths from double-crested and neotropic cormorants collected in Matagorda County, Texas.

Helminth species*	Double-crested cormorant (n = 12)					Neotropic cormorant (n = 12)				
	Prevalence	Intensity		Abundance		Prevalence	Intensity		Abundance	
	No. infected (%)	$\bar{x}$ ± SE	Range	$\bar{x}$ ± SE	Total	No. infected (%)	$\bar{x}$ ± SE	Range	$\bar{x}$ ± SE	Total
DIGENEA										
Amphimerus sp. (L)	2 (17)	1.0	1	0.2 ± 0.1	2	0				
Ascocotyle sp. 1† (SI, LI)	2 (17)	6.0	6	1.0 ± 0.7	12	1 (8)	1.0	1	0.1 ± 0.1	1
Ascocotyle sp. 2‡ (SI, LI)	8 (67)	21.0 ± 9.7	2–83	14.0 ± 7.0	168	3 (25)	47.7 ± 39.2	5–126	11.9 ± 10.4	143
Ascocotyle sp. 3 (LI)	2 (17)	2.5 ± 1.5	1–4	0.4 ± 0.3	5	0				
Austrodiplostomum mordax Szidant and Nani, 1951 (USNPC 86718, 86724)§ (SI, LI)	4 (33)	4.2 ± 1.6	1–8	1.4 ± 0.8	17	4 (33)	1.0	1	0.3 ± 0.1	4
Drepanocephalus spathans Dietz, 1909 (USNPC 86719, 86725) (SI)	1 (8)	1.0	1	0.1 ± 0.1	1	1 (8)	14.0	14	1.2 ± 1.2	14
Hysteromorpha triloba (Rudolphi, 1819) Lutz, 1931 (USNPC 86726) (SI)	0					1 (8)	5.0	5	0.4 ± 0.4	5
Maritrema sp.‖ (SI, LI)	1 (8)	1.0	1	0.1 ± 0.1	1	1 (8)	15.0	15	1.2 ± 1.2	15
Mesoophorodiplostomum pricei (Krull, 1934) Dubois, 1936 (USNPC 86720) (SI)	1 (8)	7.0	7	0.6 ± 0.6	7	0				
Phocitremoides butionis Martin, 1950 (USNPC 86721, 86727) (SI, LI)	1 (8)	51.0	51	4.2 ± 4.2	51	1 (8)	1.0	1	0.1 ± 0.1	1
Pseudopsilostoma varium (Linton, 1928) Yamaguti, 1958 (USNPC 86728) (E, P, S)	0					3 (25)	27.7 ± 25.2	1–78	6.9 ± 6.5	83
CESTODA										
Paradilepis caballeroi Rysavy and Macko, 1971 (USNPC 86722, 86729) (SI)	3 (25)	2.3 ± 1.3	1–5	0.6 ± 0.4	7	6 (50)	13.5 ± 8.2	1–53	6.7 ± 4.4	8
NEMATODA										
Capillaria contorta (Creplin, 1839) Yamaguti, 1935 (USNPC 86731, 86737) (E)	2 (17)	1.5 ± 0.5	1–2	0.2 ± 0.2	3	10 (83)	3.8 ± 0.6	1–6	3.2 ± 0.7	38
Capillaria spiculata Freitas, 1933 (USNPC 86732, 86738) (LI)	8 (67)	3.9 ± 1.3	1–9	2.6 ± 1.0	31	8 (67)	3.9 ± 1.5	1–14	2.6 ± 1.1	31

Table 1. Continued.

Helminth species*	Double-crested cormorant (n = 12)					Neotropic cormorant (n = 12)				
	Prevalence					Prevalence				
	No. infected (%)	Intensity		Abundance		No. infected (%)	Intensity		Abundance	
		$\bar{x}$ ± SE	Range	$\bar{x}$ ± SE	Total		$\bar{x}$ ± SE	Range	$\bar{x}$ ± SE	Total
Contracaecum spiculigerum (Ruddphi, 1809) Ralliet and Henry, 1912 (USNPC 86733, 86739) (E, P, S)	12 (100)	83.9 ± 14.2	11–177	83.9 ± 14.2	1,007	12 (100)	101.0 ± 17.7	16–230	101.0 ± 17.7	1,212
Desmidocercella skrjabini Guschanskaja, 1949 (USNPC 86734) (LU, S)	4 (33)	16.0 ± 8.7	1–32	5.3 ± 3.5	64	0				
Syncuaria squamata (Linstow, 1883) Wong et al., 1986 (USNPC 86735, 86740) (E, P, S)	4 (33)	2.2 ± 0.9	1–5	0.7 ± 0.4	9	3 (25)	2.7 ± 1.7	1–6	0.7 ± 0.5	8
Syngamus sp. (DW)	0					1 (8)	1.0	1	0.1 ± 0.1	1
Synhimanthus sp. (E)	0					1 (8)	2.0	2	0.2 ± 0.2	2
Tetrameres microspinosa Vigneras, 1935 (USNPC 86736, 86741) (P)	8 (67)	25.9 ± 8.1	1–71	17.2 ± 6.4	207	7 (58)	47.4 ± 18.9	4–132	27.7 ± 12.8	332
ACANTHOCEPHALA										
Andracantha gravida (Alegret, 1941) Schmidt, 1975 (USNPC 86723, 86730) (SI, LI)	8 (67)	2.0 ± 0.3	1–3	1.3 ± 0.3	16	7 (58)	4.6 ± 1.7	1–14	2.7 ± 1.2	32

* DW, decantation wash; E, esophagus; L, liver; LI, large intestine; LU, lung; P, proventriculus; S, stomach; SI, small intestine.
† *Ascocotyle (Ascocotyle)* sp.
‡ *Ascocotyle (Leigha)* sp.
§ U.S. National Parasite Collection specimen accession numbers, double-crested and neotropic cormorants, respectively.
‖ Immature individuals only.

Table 2. Dominance index values generated for helminth species from 12 double-crested and 12 neotropic cormorants collected in Matagorda County, Texas.

Double-crested cormorant		Neotropic cormorant	
Helminth species	DI	Helminth species	DI
Contracaecum spiculigerum	62.6	*Contracaecum spiculigerum*	60.5
Tetrameres microspinosa	12.9	*Tetrameres microspinosa*	16.6
Ascocotyle sp. 2	10.4	*Ascocotyle* sp. 2	7.1
Desmidocercella skrjabini	4.0	*Pseudopsilostoma varium*	4.1
Phocitremoides butionis	3.2	*Capillaria contorta*	1.9
Capillaria spiculata	1.9	*Andracantha gravida*	1.6
Austrodiplostomum mordax	1.1	*Capillaria spiculata*	1.5
Andracantha gravida	1.0	*Maritrema* sp.	0.1
Ascocotyle sp. 1	<0.1	*Drepanocephalus spathans*	0.1
Syncuaria squamata	<0.1	*Paradilepis caballeroi*	<0.1
Paradilepis caballeroi	<0.1	*Syncuaria squamata*	<0.1
Mesoophorodiplostomum pricei	<0.1	*Hysteromorpha triloba*	<0.1
Ascocotyle sp. 3	<0.1	*Austrodiplostomum mordax*	<0.1
Capillaria contorta	<0.1	*Synhimanthus* sp.	<0.1
Amphimerus sp.	<0.1	*Ascocotyle* sp. 1	<0.1
Drepanocephalus spathans	<0.1	*Phocitremoides butionis*	<0.1
Maritrema sp.	<0.1	*Syngamus* sp.	<0.1

< 0.05) in double-crested cormorants than in neotropic cormorants, whereas prevalence of *Capillaria contorta* was higher ($P < 0.003$) in neotropic cormorants. Eight species (*Ascocotyle* sp. 2, *Austrodiplostomum mordax*, *P. caballeroi*, *Capillaria spiculata*, *Contracaecum spiculigerum*, *Syncuaria squamata*, *Tetrameres microspinosa*, and *A. gravida*) were common species in both host infrapopulations.

We found 3,611 helminth individuals, of which 1,608 and 2,003 occurred in double-crested and neotropic cormorants, respectively (Table 1). The abundance of helminths was similar ($P = 0.31$) between double-crested and neotropic cormorant infrapopulations, averaging 134.0 ± 20.2 and 166.9 ± 23.2 helminth individuals, respectively. Of the 11 common species, rank abundance varied between host infrapopulations in only 2 species: *C. contorta* was higher ($P < 0.0001$) in neotropic cormorants, whereas *Desmidocercella skrjabini* was higher ($P < 0.03$) in double-crested cormorants. For the 11 common species collectively (MANOVA), rank abundance was higher ($P < 0.02$) in neotropic cormorants.

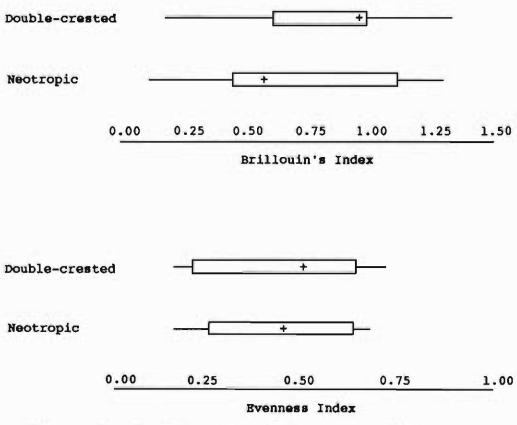

Figure 1. Brillouin's and evenness index values generated from helminth infracommunities, presented as box plots representing median (+), range (———), and the 25 to 75% quantiles (□), for cormorants collected in Matagorda County, Texas.

The 9 and 10 commonly occurring species in double-crested and neotropic cormorants, respectively, accounted for 95 and 94% of all helminth individuals found in each respective host species. *Contracaecum spiculigerum* dominated the helminth component community in both hosts, accounting for 63 and 60% of all helminth individuals found in double-crested and neotropic cormorants, respectively (Table 2). *Tetrameres microspinosa* and *Ascocotyle* sp. 2 also were important (≥10 DI value) species in double-crested cormorants, whereas *T. microspinosa* was numerically important in the helminth component community of neotropic cormorants (Table 2).

Median BI values of double-crested and neotropic cormorants were 0.99 and 0.57, respectively (Fig. 1). Helminth infracommunities in both host species demonstrated a substantial lack of diver-

Table 3. The *F* statistics and *P* values for the main effect of host species from 1-way ANOVA and MANOVA for the ranked abundance of 11 common helminth species from 24 cormorants (12 double-crested and 12 neotropic) collected in Matagorda County, Texas.

Helminth species	*F*	*P*
ANOVA		
Ascocotyle sp. 2	3.03	0.0958
Austrodiplostomum mordax	0.17	0.6874
Pseudopsilostoma varium	3.64	0.0694
Paradilepis caballeroi	2.27	0.1463
Capillaria contorta	22.41	0.0001
Capillaria spiculata	0.01	0.9088
Contracaecum spiculigerum	0.85	0.3670
Desmidocercella skrjabini	5.44	0.0293
Syncuaria squamata	0.18	0.6750
Tetrameres microspinosa	<0.01	0.9543
Andracantha gravida	0.12	0.7279
MANOVA	3.40	0.0229

sity, with median EI values of 0.52 and 0.48 for double-crested and neotropic cormorants, respectively (Fig. 1).

Table 3 lists the *F* statistics and *P* values for the main effect of host species from 1-way ANOVA and MANOVA for the ranked abundance of 11 common helminth species from 24 cormorants collected in Matagorda County, Texas.

Discussion

We found helminth communities in double-crested and neotropic cormorants shared similar characteristics in community structure and pattern. These similarities were reflected in species richness, diversity, prevalence, numerical dominance, abundance, and number of shared common helminth species. Differences in helminth communities between host infrapopulations largely resulted from the lack of co-occurrence of 2 common and 6 uncommon helminth species.

One factor often considered to contribute to diverse helminth communities is host vagility, in which hosts that temporally occupy different habitats are exposed to a greater number of potentially infective parasites (Kennedy et al., 1986). This was a likely factor contributing to the large, species-rich, and diverse communities found in several migratory waterfowl species (Wallace and Pence, 1986; Fedynich and Pence, 1994). In our study, in which the double-crested cormorant is migratory and the neotropic cormorant is a permanent resident, migratory status did not appear to significantly alter helminth community structure and pattern between host infrapopulations. This may be the result of both hosts utilizing the same food resources in coastal Texas. Also, helminth species found in cormorants may have parasitic larval stages that are intermediate host generalists, which infect a range of the respective prey items preferred by each cormorant species.

Kennedy et al. (1986) suggested hosts that have generalist diets tend to have diverse helminth communities, whereas hosts that feed selectively tend to have helminth communities that are dominated by large infrapopulations of a few parasite species. Stock and Holmes (1987) found broad diets in 3 of 4 grebes (Podicipedidae) led to diverse helminth communities. We found relatively low BI and EI values, which is reflective of the lack of diversity and equitability among helminth species within infracommunities in both host species examined in this study. This also was apparent when examining DI values for the helminth component communities in which only a few helminth species dominated (i.e., *C. spiculigerum* and *T. microspinosa*) in both host species. While there are few or no detailed studies on food habits of these 2 sympatric cormorant species in coastal areas of Texas (Morrison et al., 1977; King, 1989), both host species are considered to prey almost exclusively upon small fish (del Hoyo et al., 1992). Thus, our results appear to support the hypothesis of Kennedy et al. (1986) that helminth communities found in avian hosts that are food specialists are more likely to be species-poor and lack diversity than those hosts that are food generalists.

Acknowledgments

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Oschmarinella macrorchis sp. n. (Digenea: Campulidae) from the Liver Sinuses of a Beaked Whale, *Mesoplodon stejnegeri* (Cetacea: Ziphiidae)

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ABSTRACT: *Oschmarinella macrorchis* sp. n. is described from the liver of a beaked whale, *Mesoplodon stejnegeri*. This new species, like other members of the genus *Oschmarinella*, has eggs that are triangular in cross section, intestinal caecae without posterior lateral diverticula, a prepharyngeal pouch, and a uroproct. It is smaller than *O. sobolevi* and larger than *O. laevicaecum* and *O. mascomai* in almost all measurements. Laurer's canal was not observed.

KEY WORDS: Digenea, Campulidae, *Oschmarinella macrorchis* sp. n., beaked whale.

In the course of a study of marine mammal strandings for the Washington State Department of Game, we encountered a number of animals infected with helminth parasites. The present report describes a new species of fluke from the liver sinuses of a beaked whale, *Mesoplodon stejnegeri* True.

Materials and Methods

The host specimen was a live, gravid, near-term beaked whale (*M. stejnegeri*) found stranded 15 October 1981, on the beach of Twin Harbors State Park, 0.8 km. south of Gray's Harbor county line, Washington. The approximate geographical position was 46°48′ by 124°6′W. The whale measured 488.9 cm from snout to fluke notch and was estimated to weigh 1,500 kg. The cause of stranding/death was attributed to complications from pregnancy. Immediately at the time of death, fresh tissue samples were taken and transported in a cold ice chest (1 hr) to a laboratory for examination. The fresh, cold liver was dissected, and helminths were found lining the hepatic sinuses but did not appear to have caused any gross damage or necrosis. The liver was not processed for histology. The helminths were recovered from the liver and immediately placed in neutral buffered formalin and stored for further processing.

Worms were dehydrated to 70% ethanol then stained in either Celestine Blue B or Semichon's Acetic–Carmine, dehydrated to 100% ethanol, cleared in clove oil, rinsed in toluene, and mounted in Permount®. Selected worms were embedded in Paraplast®, serial sectioned at 5 μm, and stained with hematoxylin and eosin. Six additional worms were longitudinally or cross sectioned by hand using razor blades. Drawings were made with the aid of a drawing tube. Measurements are in micrometers, with the mean followed by the range in parentheses; body length and width are in millimeters. Measurements of other species are from the initially published descriptions of those species.

Results

Oschmarinella macrorchis sp. n. (Figs. 1–3)

DESCRIPTION (based on measurements of 20 whole mounts and 53 tissue sections; measurements on 20): Tegument probably spined. Body slender, applanate dorsoventrally, tapering subacutely anteriorly, rounded posteriorly; 18.85 (16–22) mm long by 2.42 (2.2–2.8) mm in maximum width. Oral sucker subterminal, 590 (540–650) in diameter. Acetabulum, 3,020 (2,700–3,700) from anterior end, 530 (480–580) in diameter. Prepharyngeal pouch present, pharynx pear- to flask-shaped, 490 (420–540) long by 300 (250–330) in greatest width. Caeca, with 2 anterior diverticula 600 (450–780) long; posterior limbs joining excetory bladder to form uroproct. Testes 2, lobed, tandem, in midbody third; anterior testis 3,300 (2,200–4,000) long by 1,420 (1,000–1,800) in greatest width; posterior testis 4,190 (3,200–5,000) long by 1,370 (800–2,000) in greatest width. Cirrus pouch curved claviform, extending midway between acetabulum and ovary; cirrus with cuticular papillae at the tip and minute spines (2–4) in length, visible only in sections; prostatic complex present, well developed, internal seminal vesicle large, convoluted, occupying posterior two-thirds of cirrus pouch; external seminal vesicle relatively small, lateral to posterior end of cirrus pouch. Ovary ovoid to lobed, pretesticular, 590 (494–728) in greatest width; ootype and Mehlis' gland pre-

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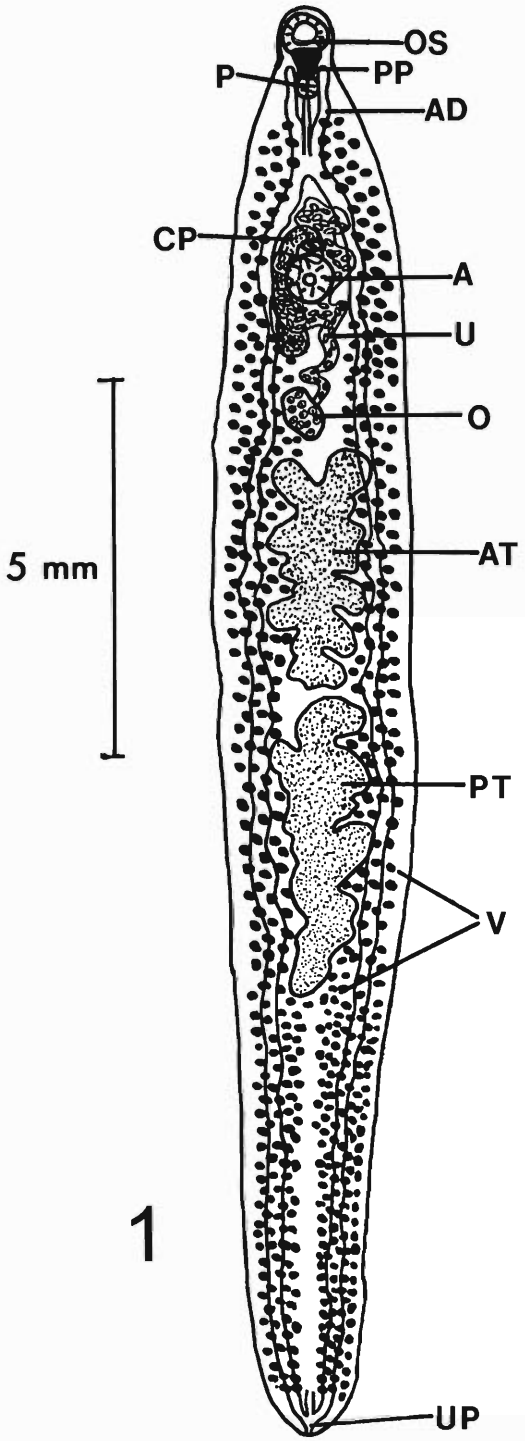


Figure 1. ***Oschmarinella macrorchis*** **sp. n. whole mount, ventral view. A = acetabulum, AD = anterior diverticulum, AT = anterior testis, CP = cirrus pouch, O = ovary, OS = oral sucker, P = pharynx, PP = prepharyngeal pouch, PT = posterior testis, U = uterus, UP = uroproct, V = vitellaria.**

ovarian; Laurer's canal absent; seminal receptacle absent; uterus preovarian, extending dorsal to acetabulum; metraterm muscular, terminal portion armed with spines 4 to 5 in length, opening into genital pore; genital pore immediately preacetabular. Vitellaria follicular, extending dorsally, ventrally, and laterally, from midlevel of anterior caecal diverticula to posterior extremity; vitelline reservoir conspicuous, subtriangular, dorsal to posterior part of ovary; common vitelline duct joining oviduct immediately posterior to ovary. Eggs triangular in cross section, 89.7 (80.0–97.5) long by 48.7 (42.5–55.0) in greatest width; excretory vesicle tubular, joining caeca to form uroproct; pore terminal.

TYPE HOST: *Mesoplodon stejnegeri*, the beaked whale.

TYPE LOCALITY: Pacific Ocean, off the Washington Coast.

SITE OF INFECTION: Liver sinuses.

COLLECTION DATE: 15 October 1981.

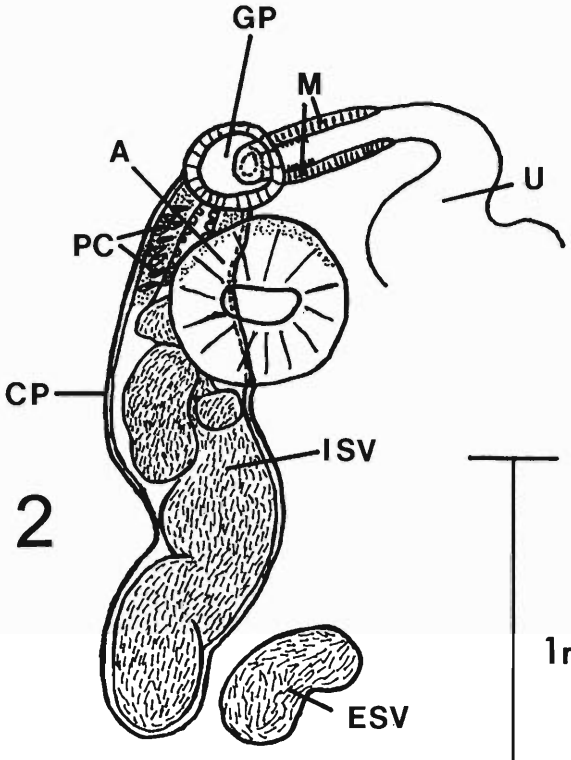
HOLOTYPE: USNPC No. 83305.

PARATYPES: USNPC No. 83306, Beltsville, Maryland; California Academy of Sciences Collection, San Francisco, California CASIZ No. 092497; and corresponding author's collection, C.S.U. Chico.

ETYMOLOGY: The specific epithet *macrorchis* indicates large (*macro*) testes (*orchis*).

Discussion

Salvador et al. (1996) reviewed the taxonomy of Campulidae and compared morphology of 217 specimens from all 7 genera. They concluded that 4 subfamilies are valid (Orthosplanchninae, Campulinae, Lecithodesminae, and Hunterotrematinae). The subfamily Orthosplanchninae was created by Yamaguti (1958) to include campulids with caecae not laterally diverticulate posteriorly but with profuse vitellaria extending the entire length of the caecae (*Orthosplanchnus* and *Oschmarinella*). The new species has profuse vitellaria and no lateral posterior intestinal diverticula. The genus *Orthosplanchnus* was erected by Odhner (1905) and the genus *Oschmarinella* in 1947 by Skrjabin; the latter differs from the former by being elongate and having a prepharyngeal pouch and a uroproct. *Oschmar-*



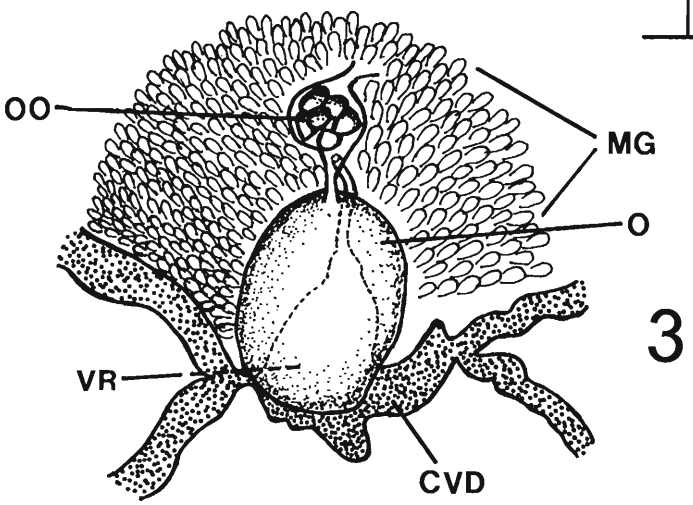


Figure 2. Terminal genitalia, ventral view. A = acetabulum, CP = cirrus pouch, ESV = external seminal vesicle, GP = genital pore, ISV = internal seminal vesicle, M = metraterm, PC = prostatic complex, U = uterus.

Figure 3. Ovarian complex, ventral view. CVD = common vitelline duct, MG = Mehlis' gland, O = ovary, OO = ootype, VR = vitelline reservoir.

Table 1. Comparative measurements of *Oschmarinella* species.

	O. macrorchis present study	*O. sobolevi* Skrjabin, 1947	*O. laevicaecum* Yamaguti, 1942	*O. mascomai* Raga, 1986
No. of specimens	20	6	5	5
Body				
Length (mm)	16–22 (18.9)*	32–34.5	7.5–10.0	8.58–10.6 (9.39)
Width (mm)	2.2–2.8 (2.4)	4.2–4.8	0.75–1.3	1.02–1.60 (1.33)
Oral sucker, maximum diameter	540–650 (590)	800 × 1200(W)	380–450	437.2–556.5 (484.9)
Pharynx				
Length	420–540 (490)	750	250–280	277.9–278.2 (283.3)
Width	250–330 (300)	—	110–200	222.6–301.7 (258.1)
Acetabulum, maximum diameter	480–580 (530)	1,000	350–380	492.9–472.4 (513.5)
Ovary, maximum diameter	494–728 (590)	1,200	210–330 × 220–350	286.2–397.5 (346.6) × 294.1–596.2 (446.7)
Anterior testis				
Length	2,200–4,000 (3,300)	5,400	—	1,040–1,160 (1,112)
Width	1,000–1,800 (1,420)	3,000	—	540–900 (667.1)
Posterior testis				
Length	3,200–5,000 (4,190)	4,700	—	1,120–1,440 (1,308)
Width	800–2,000 (1,370)	3,000	—	420–860 (720)
Eggs				
Length	80–98 (90)	110–120	63–81	80–84 (81.33)
Width	43–55 (49)	62–66	42–48	40–42 (40.66)

* Means are given in parentheses. All values are in micrometers unless otherwise noted.

inella macrorchis sp. n. clearly belongs in the family Campulidae, subfamily Orthosplanchninae, genus *Oschmarinella*. It has a prepharyngeal pouch, eggs triangular in cross section, a uroproct, and caecae without posterior lateral diverticula, and it was found in the liver of a marine mammal.

Oschmarinella macrorchis sp. n. differs from the 3 established species of *Oschmarinella* (Table 1). It is significantly smaller than *O. sobolevi* (Skrjabin, 1947) in every measurement except posterior testis; it is larger than *O. laevicaecum* (Yamaguti, 1942) in every measurement; and it is larger than *O. mascomai* (Raga, 1986) in body length, body width, pharynx length, ovary diameter, and anterior and posterior testes length. The posterior testis of *O. macrorchis* sp. n. is significantly (three times) larger than that of *O. mascomai*. The 2 smaller species of *Oschmarinella* are found in dolphins, while *O. macrorchis* sp. n. and *O. sobolevi* are found in whales of the family Ziphiidae.

We examined 11 specimens of *C. oblonga* borrowed from the Harold W. Manter Laboratory, University of Nebraska State Museum, and another 32 processed by us. The Nebraska specimens were densely spinose, while some processed by us were uniformly spinose and others had patchy spine distribution or no visible spines. Adams and Rausch (1989), in their review of 3 genera of campulids, commented that tegumental spines are often lost when fixation is delayed. Thus, we surmise that the lack of spines in this new species may be a preparation artifact.

In contrast, we did observe Laurer's canal in whole specimens of *C. oblonga* but did not observe it in our new species, either in whole worms or sectioned specimens.

Acknowledgments

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Obituary Notice

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1909–1997

Elected to Membership, June 3, 1950

30th Recording Secretary, 1955

Member of Executive Committee, 1957–1958

14th Representative to the Washington Academy of Science, 1959–1960

27th Vice President, 1961

45th President, 1962

Anniversary Award, 1971

Life Membership, 1975

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Parasites of the Dolphinfish (*Coryphaena hippurus*) in Puerto Rico

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ABSTRACT: Thirteen dolphinfish (*Coryphaena hippurus*) collected during 1993–1994 from La Parguera, Puerto Rico, were examined for parasites. Nine species of helminths were identified including 6 trematodes (*Dinurus barbatus*, *D. breviductus*, *D. tornatus*, *Hirudinella ventricosa*, *Stephanostomum coryphaenae*, and *Tetrochetus coryphaenae*), 1 cestode (*Tentacularia coryphaenae*), 1 nematode (*Hysterothylacium pelagicum*), and 1 acanthocephalan (*Rhadinorhynchus pristis*). Each dolphinfish was infected with at least 2 species of helminths ($\bar{x}$ = 4.7; range = 2 to 7 species). The most common helminths found were *D. barbatus*, *H. pelagicum*, and *Tetrochetus coryphaenae*, with prevalences of 100, 92, and 62%, respectively. Each of the 13 hosts had a different composition of helminths. Crustacean parasites included *Caligus balistae*, *C. coryphaena*, *C. productus*, *Dysgamus* sp., *Euryphorus nordmanni*, and *Pennella varians*.

KEY WORDS: helminths, crustacean parasites, *Coryphaena hippurus*, Puerto Rico.

Coryphaena hippurus (Linnaeus, 1758) is a large pelagic species that has a worldwide distribution in tropical and subtropical waters. It is commonly referred to as either the dolphin or the dolphinfish. We suggest usage of the latter to avoid confusion with the cetacean mammal also known as the dolphin. Occurring singly and in schools, they are swift predators that feed on a variety of fish, squid, and other invertebrates. Fifty-five species of fish, belonging to 34 families, have been recorded from the stomachs of *C. hippurus* from the southeastern and Gulf of Mexico coasts of the United States (Manooch et al., 1984).

Few surveys on the helminths of dolphinfish have been recorded. The majority of reports are restricted either to descriptions of new species or the listing of parasites as a minor study objective in conjunction with a food content survey. The absence of statistical data on the prevalences, intensities, and ranges of occurrence for the various helminths detected is appalling. Herein, we report on the helminths and crustacean parasites collected from a sample of dolphinfish in Puerto Rico.

Materials and Methods

Thirteen dolphinfish (7 females, 4 males, and 2 unknown) with a fork length between 90 and 115 cm were taken in La Parguera, Puerto Rico, during 1993–1994. All helminths were recovered in situ at necropsy from the dolphinfish shortly after death. Trematodes, cestodes, and acanthocephalans were fixed in hot alcohol–formalin–acetic acid (AFA), stained in Harris's hematoxylin, dehydrated, cleared in beechwood creosote, and mounted in Canada balsam. Nematodes were fixed in glacial acetic acid or formalin, stored in a solution of 5 parts glycerin and 95 parts 70% ethanol, cleared in glycerin, and studied as temporary mounts.

For comparative purposes, specimens were borrowed from the U.S. National Parasite Collection: *Dinurus breviductus* (USNPC 39404), *D. barbatus* (USNPC 39405), *D. tornatus* (USNPC 39406), *Hirudinella ventricosa* (USNPC 39408), *Tetrochetus aluterae* (USNPC 39387), *Stephanostomum coryphaenae* (USNPC 39339), *Rhadinorhynchus pristis* (USNPC 60341), *Ascaris increscens* (USNPC 6366), and *Hysterothylacium pelagicum* (USNPC 76617).

The ecological terms *prevalence* and *intensity* used in this report are those recommended by an ad hoc committee of the American Society of Parasitologists (Margolis et al., 1982).

Results and Discussion

Helminths

Nine species of helminths were collected from the 13 dolphinfish, none of which were free of helminths. These included 6 species of digeneans, 1 cestode, 1 nematode, and 1 acanthocephalan. The prevalence and intensity of each of the species are given in Table 1. The most common helminths were *D. barbatus*, *H. pelagicum*, and *Tetrochetus coryphaenae*. Each dolphinfish was infected with at least 2 species of helminths ($\bar{x}$ = 4.7; range = 2 to 7 species). In the 13 dolphinfish sample, multiple infections were as follows: 1 dolphinfish had 2 species of helminths, 1 had 3, 4 had 4, 4 had 5, 1 had 6,

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Table 1. Parasitic helminths of 13 dolphinfish from Puerto Rico, 1993–1994.

Species of helminth	USNPC accession no.	Site*	No. of fish		Total no. worms	Intensity of infection	
			Infected	%		Mean	Range
Trematoda							
Dinurus barbatus	84882	S&I	13	100	8,575	659.6	5–2,779
Dinurus breviductus	84883	S&I	2	15	6	3.0	1–5
Dinurus tornatus	84884	S	5	39	30	6.0	2–12
Hirudinella ventricosa	84887	S	5	39	12	2.4	2–3
Stephanostomum coryphaenae	84886	I	4	31	20	5.0	2–13
Tetrochetus coryphaenae	84885	S&I	8	62	210	26.3	1–41
Cestoda							
Tentacularia coryphaenae		I	7	54	43	6.1	1–14
Nematoda							
Hysterothylacium pelagicum	84881	I	12	92	162	13.5	2–55
Acanthocephala							
Rhadinorhynchus pristis	84888	I	5	39	24	4.8	1–18

* I = intestine, S = stomach.

and 2 had 7. The diversity of the helminth community was unique for each dolphinfish with a total of 9,082 helminths collected. Comparison of prevalences found in the present study with those reported in the literature (Table 2) reveals that trematodes are more prevalent than cestodes and that nematodes are roughly equivalent to acanthocephalans in prevalence.

Trematoda:

Helmiuridae
Dinurus Loose, 1907

Dinurus barbatus (Cohn, 1903) Looss, 1907, had the highest prevalence and intensity of infestation of any helminth detected (Table 1). Of the 3 species of *Dinurus* found, *D. barbatus* occurred as the only member in 8 hosts. *Dinurus tornatus* (Rudolphi, 1819) Looss, 1907, infested 3, and *D. tornatus* and *D. breviductus* Looss, 1907, 2.

Manter (1947) reported all 3 species from dolphinfish taken at Dry Tortugas, Florida. He also reported *D. longisinus* Looss, 1907, in 2 of 6 hosts examined. This species has previously been distinguished from *D. coryphaenae* by Yamaguti (1934) on the basis of egg size. Manter (1947) found that egg measurements of specimens of *D. coryphaenae* were almost identical to those given by Looss (1907b) for *D. longisinus* and considered *D. coryphaenae* a synonym of *D. longisinus*. Later, Yamaguti (1971) concurred with Manter in this synonymy. All 3 species found in the present study have been previously reported in *C. hippurus* on Mona Island, Puerto Rico, by Siddiqi and Cable (1960). Fischthal and Thomas (1971) reported *D. barbatus*, *D. tornatus*, and *D. breviductus* from a single *C. hippurus* from Tema, Ghana. These workers indicate that all 3 species have a wide geographic distribution.

Hirudinellidae
Hirundinella ventricosa (Pallas, 1774) Baird, 1853

Our specimens are tentatively assigned to *Hirudinella ventricosa*, as they appear similar to that species as described by Manter (1947). Hemiurids reported from the stomach of *C. hippurus* taken at Mayaguez, Puerto Rico, were also tentatively identified by Siddiqi and Cable (1960). As indicated by Manter (1947), this genus is complex, and the actual number of species is very uncertain.

Acanthocolpidae
Stephanostomum coryphaenae Manter, 1947

With the exception of *D. breviductus*, *S. coryphaenae* had the lowest rate of prevalence of the 6 species of digeneans detected. *Stephanostomum* is a large genus with a wide distribution among marine fishes. *Stephanostomum coryphaenae* was described from the intestines of 4 specimens of *C. hippuris* off Dry Tortugas, Florida. It has previously been reported in *C. hip-*

Table 2. Helminths reported from *Coryphaena hippurus*.

Species	Geographic locality	Reference
Trematoda		
Bathycotyle banchialis Darr, 1902	Straits of Florida	Burnett-Herkes, 1974
Bathycotyle coryphaena Yamaguti, 1938	Pacific Coast of Japan	Yamaguti, 1938
	Grand Isle, Louisiana	Sparks, 1957
Dinurus barbatus (Cohn, 1903) Looss, 1907	Beaufort, North Carolina	Looss, 1907c
	Secas Island, Panama	Manter, 1934
	Atlantic and Pacific	Manter, 1940b
	Florida	Manter, 1947
	Gulf of Mexico	Manter, 1954
	Puerto Rico	Siddiqi and Cable, 1960
	Curaçao	Nahhas and Cable, 1964
	Ghana	Fischthal and Thomas, 1971
	Ghana	Fischthal, 1972
	Puerto Rico	Present study
Dinurus breviductus Looss, 1907	Atlantic	Looss, 1907c
	Florida	Manter, 1947
	Gulf of Mexico	Manter, 1954
	Puerto Rico	Siddiqi and Cable, 1960
	Curaçao	Nahhas and Cable, 1964
	Ghana	Fischthal and Thomas, 1971
	Senegal	Fischthal and Thomas, 1972b
	Ghana	Fischthal, 1972
	Puerto Rico	Present study
Dinurus hippuri Nadahal, Kappikarayil, and Jacob, 1990	India	Nadahal et al., 1990
Dinurus longisinus Looss, 1907	Red Sea	Looss, 1907a
	Secas Island, Panama	Manter, 1940a
	Atlantic	Manter, 1940b
	Pacific	Manter, 1940b
	Red Sea	Manter, 1940b
	Florida	Manter, 1947
	Gulf of Mexico	Manter, 1954
	Bimini, British West Indies	Sogandares-Bernal and Hutton, 1959
Dinurus tornatus (Rudolphi, 1819) Looss, 1907	North Carolina	Looss, 1907c
	Northwest of Azores	Guiart, 1938
	Florida	Manter, 1947
	Gulf of Mexico	Manter, 1954
	Florida	Ward, 1954
	Bimini, British West Indies	Sogandares-Bernal and Hutton, 1959
	Puerto Rico	Siddiqi and Cable, 1960
	Curaçao	Nahhas and Cable, 1964
	Bahia de Guanabara, Brazil	Fernandes, 1971
	Ghana	Fischthal and Thomas, 1971
	Ghana	Fischthal, 1972
	Florida	Raptopoulou and Lambertsen, 1987
	Puerto Rico	Present study
Helicometrina nimia Linton, 1910	Baja, California	Arai, 1963
	Mexico	Arai, 1963
Hirudinella clavata (Menzies, 1791) Blainville, 1828	Atlantic	Manter, 1940b
Hirudinella marina Garcin, 1730	Florida	Ward, 1954
Hirudinella phalloidea Guiart, 1938	Azores	Guiart, 1938
Hirudinella ventricosa (Pallas, 1774) Baird, 1953	Florida	Manter, 1947
	Puerto Rico	Siddiqi and Cable, 1960
	Puerto Rico	Present study
Hirudinella sp.	Curaçao	Nahhas and Cable, 1964

Table 2. Continued.

Species	Geographic locality	Reference
Stephanostomum coryphaenae Manter, 1947	Florida	Manter, 1947
	Gulf of Mexico	Manter, 1954
	Bimini, British West Indies	Sogandares-Bernal and Hutton, 1959
	Puerto Rico	Siddiqi and Cable, 1960
	Curaçao	Nahhas and Cable, 1964
	Ghana	Fischthal and Thomas, 1972a
	Puerto Rico	Present study
Tetrochetus aluterae (Hanson, 1955) Yamaguti, 1958a	Puerto Rico	Siddiqi and Cable, 1960
Tetrochetus coryphaenae Yamaguti, 1931	Toyama Bay	Yamaguti, 1934
	Pacific Coast of Japan	Yamaguti, 1934
	Florida	Manter, 1947
	Gulf of Mexico	Manter, 1954
	Bimini, British West Indies	Sogandares-Bernal and Hutton, 1959
	San Jose Island, Panama Pacific	Sogandares-Bernal and Hutton, 1959
	Curaçao	Nahhas and Cable, 1964
	Pacific	Korotaeva, 1976
	Puerto Rico	Present study
Cestoda		
Bothriocephalus janickii Markowski, 1971	Southern Sea	Markowski, 1971
	Bay of Bengal	Devi, 1975
Dibothriocephalus attenuatus Guiant, 1935	Azores	Guiart, 1935
Pterobothrium acanthotruncatum Escalante and Carvajal, 1984	Peru	Escalante and Carvajal, 1984
Tentacularia coryphaenae Bosc, 1797	Peru	Escalante and Carvajal, 1984
Nematoda		
Anisakis sp.	Nagasaki	Sakaguchi and Katamine, 1971
Hysterothylacium marinum (Linnaeus, 1767)	Australia	Johnston and Mawson, 1943
Hysterothylacium pelagicum Deardorff and Overstreet, 1982	Hawaii	Deardorff and Overstreet, 1982
	Gulf of Panama	Deardorff and Overstreet, 1982
	New Guinea	Deardorff and Overstreet, 1982
	Alabama	Deardorff and Overstreet, 1982
	South Carolina	Deardorff and Overstreet, 1982
	Southeastern United States	Manooch et al., 1984
	Gulf of Mexico	Manooch et al,. 1984
Acanthocephala		
Nipporhynchus katsuwonis (Harada, 1928) Chandler, 1934	Izu, Kanagawa Prefecture	Kamegai, 1963
Rhadinorhynchus pristis (Rudolphi, 1802)	Curaçao	Cable and Linderoth, 1963

purus from Mona Passage, Puerto Rico, by Siddiqi and Cable (1960) and has since been reported in the host from Curaçao by Nahhas and Cable (1964).

Accocoeliidae

Tetrochetus coryphaenae Yamaguti (1934)

Our material exhibits features that concur with the description of *T. coryphaenae* as given by Yamaguti (1934) for an unspecified number of specimens taken from the small intestine of *C. hippurus* in Toyama Bay and the Pacific. Hanson (1955) established the genus *Paratetrochetus*, with *P. aluterae* as type based on a single specimen found in the small intestine of *Aluterus scriptus* (Osbeck 1765) of Hawaii. Later, Yamaguti (1958) reduced *Paratetrochetus* to synonymy with *Tetrochetus* since the 2 species differ only as to whether the conelike elevation at the base of the oral sucker is pharyngeal or prepharyngeal. Siddiqi and Cable (1960) identified specimens from the stomach and intestine of *C. hippurus* and a wahoo, *Acanthocybium solanderi* (Cuvier 1832), from Puerto Real, Mona

Island, Puerto Rico, as *T. aluterae*. Type and paratypes for *T. coryphaenae* were not available for examination, but according to published descriptions, *T. coryphaenae* and *T. aluterae* are very similar except for a slight difference in egg size. However, the range for the egg size of *T. aluterae* overlaps with that given for *T. coryphaenae* suggesting, as pointed out by Siddiqi and Cable (1960), that the 2 species may be identical. Nahhas and Cable (1964) reported *T. coryphaenae* from *C. hippurus* at Curaçao and in a new host, the porcupinefish, *Diodon hystrix* L. from Jamaica.

Cestoda:

Tentaculariidae
***Tentacularia coryphaenae* Bosc, 1797**

Larvae of *T. coryphaenae* were found on the viscera of 7 of 13 dolphinfish. According to Dollfus (1942), larvae have been reported from teleosts worldwide. Adult parasites have been reported from sharks from the Atlantic, Indian, and North Pacific oceans (Dollfus, 1942, 1960; Heinz and Dailey, 1974).

Nematoda:

Anisakidae
Hysterothylacium pelagicum
Deardorff and Overstreet, 1982

A total of 162 (134 females and 19 males) nematodes were collected from 12 of 13 dolphinfish. All of the specimens concurred with the description of *H. pelagicum* as given by Deardorff and Overstreet (1982), based on specimens from the lumen of the stomach, pyloric ceca, and intestine of *C. hippurus* taken offshore at Hawaii, in the Gulf of Panama, in the Gulf of Mexico off Alabama, and off South Carolina. According to these researchers, *H. pelagicum* most closely resembles *H. cornutum* (Stossich, 1904) but differs conspicuously by lacking modified ventral annules (ventral crests) on the males and by having a vulva in the anterior 30 to 40% for the female rather than the anterior 18 to 25% (Deardorff and Overstreet, 1982). They reported a prevalence of 57.6% (19 of 33 fish) from Hawaii, with an intensity ranging from 1 to 35 worms ($\bar{x}$ = 10). Manooch et al. (1984) sampled the stomach contents of 2,630 *C. hippurus* off the southeastern United States and Gulf of Mexico. Since the primary purpose of their investigation was concerned with food content rather than a survey of parasites, and since only the stomach was examined, *H. pelagicum* was the only helminth detected. They reported a prevalence of 4.5 to 5.0%. The number of parasites ranged from 1 to 100 ($\bar{x}$ = 11).

Our sample size was too small to confirm the conclusion of Manooch et al. (1984) that the prevalence and intensity of this nematode increases with the fish size. These authors also indicated that infestation of *H. pelagicum* was less when data were analyzed by season and area of collection; they also emphasized that such factors as small sample sizes from certain areas along with the compounding effect of fish size would make comparisons difficult.

Acanthocephala:

Rhadinorhynchidae
***Rhadinorhynchus pristis* (Rudolphi, 1802)**

This was the only acanthocephalan found. Our material exhibits characters that concur with the redescription of *R. pristis* as given by Cable and Linderoth (1963) based on a single male and 2 females without eggs from *C. hippurus* taken near Curaçao. To our knowledge, the finding of this acanthocephalan in *C. hippurus* from Puerto Rico constitutes a new geographic locality.

There was a positive correlation at the 0.005 level of confidence between the number of *D. barbatus* and *Hysterothylacium pelagicum*; at the 0.01 level between *D. barbatus* and *Hirudinella ventricosa*; and at the 0.05 level between *D. tonatus* and *R. pristis*, *H. pelagicum* and *R. pristis*, *H. ventricosa* and *R. pristis*, and *H. pelagicum* and *H. ventricosa*. This could indicate similar or associated intermediate hosts for their larval stages or lack of competition in the final host. No negative correlations between parasite species occurred. No correlations between parasites and the sex of the host, between parasites and the size of the host, or between the helminth community and host size and sex were found.

There is a need for information on the host–parasite relationships of gastrointestinal parasites similar to those provided by Burnett-Herkes (1974) for parasites of the gills and buccal cavity of *C. hippurus* from the Straits of Florida.

Crustaceans:

The number and species of crustacean parasites were probably reduced by rough commercial handling of the hosts and therefore have not been included along with the helminths in Table

1. One female *Caligus balistae* Steenstrup and Lutken 1861 was found on the skin of 1 host. This copepod occurs largely on balistids (filefish and triggerfish) (Cressey 1991; Williams et al. 1994), but 1 female has been noted on the dolphinfish. From 9 to 35 *Caligus coryphaena* Steenstrup and Lutken occurred on the skin of each host, and from 6 to 21 *Caligus productus* Dana also occurred on the gills of each dolphinfish. These species have also been reported on dolphinfish from the Straits of Florida (Burnett-Herkes, 1974). Cressey (1991) suggests that these copepods are found primarily on scombroids, but we have found them on most dolphinfish. Four *Dysgamus* sp. were found on the skin of 1 host, while a single female *Euryphorus nordmanni* Edwards occurred on the skin of another host. From 5 to 20 *Pennella* sp. were found on the skin of 13 out of 17 dolphinfish. Members of this genus are rarely reported from *Coryphaena* spp. (Hogans, 1988). None are listed in the summaries of Palko et al. (1982) or Hogans (1988).

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A Checklist of Metazoan Parasites of Cichlid Fish from Mexico

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ABSTRACT: Based on previously published records and original data, a checklist of the metazoan parasite fauna reported in 26 species of native cichlids from Mexico is presented. The checklist contains 90 metazoan parasite species, including 5 species of monogeneans, 19 adult trematodes, 27 metacercariae, 1 adult cestode, 3 larval cestodes, 5 adult acanthocephalans, 2 cystacanths, 10 adult nematodes, 13 larval nematodes, 2 leeches, 2 pentastomids, and 1 molluscan larva. It includes 140 new host parasite records for Mexico and records 13 species for the first time.

KEY WORDS: *Cichlasoma* spp., *Petenia splendida*, helminths, pentastomids, leeches, molluscs.

At present, there is no checklist of metazoan parasites (Platyhelminthes, Acanthocephala, Nematoda, Annelida, Hirudinea, Mollusca, Bivalvia, Arthropoda, and Pentastomida) of Mexican fish. Literature on the parasite fauna of cichlids is mainly scattered in taxonomic papers (Caballero-Rodríguez, 1982; Lamothe-Argumedo and Jaimez-Cruz, 1982a, b; Meave-Gallegos, 1982; Salgado-Maldonado, 1982). A few regional surveys, e.g., that of Pineda-López et al. (1985), include compiled lists of macroparasites from hydrological systems for a limited number of host species. Notwithstanding, some studies (Pineda-López, 1985a, Osorio-Sarabia et al., 1987) paid particular attention to Cichlidae, since this is one of the most speciose, common, and widely distributed families among the Mexican ichthyofauna. According to Miller (1966), Miller and Smith (1986), and Conkel (1993), this family includes approximately 67 species in Mexico, but only 26 of these have been investigated for parasites. Recently, as a consequence of increasing interest in the native cichlids for aquaculture (Martínez-Palacios et al., 1993; Martínez-Palacios and Ross, 1994), there has been a growing interest in their parasitic fauna (Salgado-Maldonado, 1993; Pineda-López, 1994; Vidal-Martínez, 1995).

The objective of this paper is to compile the extant information on the macroparasites of native cichlid fishes from Mexico, published in regional or local scientific journals with a limited distribution, and to include original data derived from our own research. It is expected that this checklist will facilitate future research on ecology, zoogeography, and biodiversity, but it is also directed to researchers working in aquaculture projects.

The checklist is organized in a parasite–host list, including host/locality records, arranged following a phylogenetic order: Trematoda, Monogenea, Cestoda, Acanthocephala, Nematoda, Annelida, Mollusca, and Arthropoda. Within each phylum or class, families are listed in the order followed by these authorities: Yamaguti (1971) for trematodes; Boeger and Kritsky (1993) for monogeneans; Khalil et al. (1994) for cestodes; Amin (1985) for acanthocephalans; and Anderson et al. (1974–1983), Anderson (1992), and Moravec (1994) for nematodes. Genera and species are listed in alphabetical order. This list also shows for each parasite species: the current scientific name followed by the author(s) and date(s), the site(s) of infection, and the host(s)/locality(ies) in which the parasite species was recovered. A list of the features and codes for each locality is shown in Table 1. Published records are presented first; unpublished data from our own records are indicated by an asterisk (*) and new localities by a double asterisk (**). No attempt was made to evaluate taxonomic validity of previously published rec-

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Table 1. Codes and features of the localities sampled or reported in the literature from which cichlids were collected.

CODE	Name of the locality	Type*	State
ANG	Angostura	D-f	Chiapas
ATA	Atasta	E-b	Campeche
BAL	Balancán	R-f	Tabasco
BOX	Box-Toro	C-f	Yucatán
CAB	Cabañas	C-f	Quintana Roo
CAM	Santiago	E-b	Campeche
CAT	Catemaco	L-f	Veracruz
CAY	Cayo	L-b	Campeche
CEA	Cenote Azul (Bacalar)	C-f	Quintana Roo
CEL	Celestún	E-b	Yucatán
CEN	Cenote Azul (Puerto Aventuras)	C-f	Quintana Roo
COR	El Corozal	R-f	Tabasco
CUA	Los Cuates	C-f	Yucatán
CUC	Cuatro Ciénegas	Lf-f	Coahuila
CHA	Champotón	E-b	Campeche
CHE	Chen-há	C-f	Yucatán
CHI	Chiribital	L-f	Tabasco
CHK	Chek-há	C-f	Yucatán
CHL	Chelem	E-b	Yucatán
CHN	Chicoasén	D-f	Chiapas
CHO	Camellones Chontales	R-f	Tabasco
DZA	Dzaptún	C-f	Yucatán
DZI	Dzibilchaltún	C-f	Yucatán
DZO	Dzonot Cervera	C-f	Yucatán
EMZ	Emiliano Zapata	L-f	Tabasco
ESP	El Espino	R-f	Tabasco
FRA	Framboyán	C-f	Yucatán
GRA	Gran Cenote	C-f	Yucatán
GER	Santa Gertrudis	L-b	Campeche
GUA	El Guanal	L-f	Tabasco
GUE	Laguna Guerrero	L-f	Quintana Roo
HOD	Hodz-Ob	C-f	Yucatán
HON	Río Hondo	R-f	Quintana Roo
HOR	Laguna El Horizonte	L-f	Tabasco
HUN	Hunucmá	C-f	Yucatán
ILU	Laguna Ilusiones	L-f	Tabasco
INF	Presa El Infiernillo	D-f	Michoacán
JON	Jonuta	R-f	Tabasco
LAG	Río Lagartos	C-f	Yucatán
LPA	Puerta	R-f	Chiapas
MAL	Presa de Malpaso	D-f	Chiapas
MIT	Mitza	C-f	Yucatán
NOB	Noh Bek	L-f	Quintana Roo
NOC	Noc-Choncunchey	C-f	Yucatán
PAL	Palizada	L-b	Campeche
PAR	Estero Pargos	E-b	Campeche
PRG	Presa Rodrigo Gómez	D-f	Nuevo León
PUE	Puerto Morelos (spring near to)	R-f	Quintana Roo
RIO	Río de los Pescados	R-f	Veracruz
ROS	El Rosario	L-f	Tabasco
SAE	Santa Elena	C-f	Yucatán
SAN	Santa Anita	L-f	Tabasco
SIL	Silvituc	L-f	Campeche
SPE	Río San Pedro	R-f	Tabasco
TEA	Teapa	P-f	Tabasco
TEM	Presa Temazcal	D-f	Oaxaca
TEN	Tenosique	R-f	Tabasco
TLA	Tlacotalpan	L-f	Veracruz
TUC	Tucta	P-f	Tabasco
USU	Río Usumacinta	R-f	Tabasco
VAP	Laguna El Vapor	L-f	Campeche
VIG	Vicente Guerrero	R-f	Tabasco
XOL	Xtoloc	C-f	Yucatán
XPO	Xpoc	C-f	Yucatán
YUC	Unspecified	—	Yucatán
ZAC	Zaci	C-f	Yucatán

* C, other bodies of water ("sinkholes" = cenotes; gravel pits); D, dam; E, estuary; L, coastal lagoons; Lf, inner lake; P, ponds for aquaculture; R, river; b, brackish water; f, freshwater.

ords. However, new name combinations and known misidentifications of the metazoan parasites are noted when necessary. The scientific names of the fish are those recommended by Miller (1966, 1986) and Miller and Smith (1986).

Comments

This checklist includes a total of 90 species, some of which were determined only to family or genus level because of the poor condition of the preserved specimens or the developmental stage of the specimens (larvae). This checklist includes 433 new locality and 140 new host records. There are 47 species of native cichlid fish in southern México (Grijalva—Usumacinta basin and the Yucatan Peninsula provinces of Miller, 1966), and most of the records of their parasites come from this area. The helminth record in Mexican cichlids presented herein concerns only 26 of these cichlid species. The list therefore is still incomplete. Cichlid species are widely distributed in Central America and even reach the Caribbean Islands; however, data on their helminths are scarce.

Parasite–Host List

Monogenea

Family Dactylogyridae Bychowsky, 1933

1. *Sciadicleithrum bravohollisae* Kritsky, Vidal-Martínez, and Rodríguez-Canul, 1994. Gills of *Cichlasoma pearsei* (VAP), *C. synspilum* (ATA, VAP), *Petenia splendida* (VAP) (Kritsky et al., 1994); *C. synspilum* (SIL**).

2. *Sciadicleithrum mexicanum* Kritsky, Vidal-Martínez, and Rodríguez-Canul, 1994. Gills of *C. urophthalmus* (ATA, CHA, CHL, LAG, SIL) (Kritsky et al., 1994); *C. urophthalmus* (MIT) (Mendoza-Franco et al., 1995); *C. urophthalmus* (SAE**, VAP**).

3. *Sciadicleithrum splendidae* Kritsky, Vidal-Martínez, and Rodríguez-Canul, 1994. Gills of

P. splendida (VAP) (Kritsky et al., 1994); *C. synspilum**, *P. splendida* (SIL**).

4. *Sciadicleithrum* sp. Gills of *C. geddesi* (SAN), *C. pearsei* (EMZ), *C. synspilum* (JON, SAN) (Pineda-López et al., 1985); *C. synspilum* (JON, TUC**), *C. urophthalmus** (TUC**). Remarks: Reported as "Dactylogyridae" by Pineda-López et al. (1985).

5. Dactylogyridae gen. sp. Gills of *Cichlasoma* spp. (CUC) (Guajardo-Martínez, 1984).

Adult Trematoda

Family Haploporidae Nicoll, 1914

6. *Saccocoelioides beauforti* (Hunter and Thomas, 1961). Intestine of *C. managuense** (GUA**), *C. synspilum** (ILU**, SAN**), *C. urophthalmus** (GUA**, HOR**), *P. splendida** (TUC**).

7. *Saccocoelioides* sp. Intestine of *Cichlasoma* spp. (CUC) (Guajardo-Martínez 1984); *C. synspilum* (CEA) (Scholz et al., 1995b).

Family Angiodictydae Looss, 1902

8. *Cichlasotrema ujati* Pineda-López and Andrade-Salas, 1989. Intestine, mainly rectum of *C. fenestratum* (ROS), *C. helleri* (ROS), *C. pearsei* (EMZ), *C. rectangulare* (EMZ), *C. synspilum* (JON) (Pineda-López et al., 1985); *C. synspilum* (ROS) (Fucugauchi et al., 1988); *C. synspilum* (SAN) (Pineda-López and Andrade-Salas, 1989); *C. synspilum* (CEA) (Scholz et al., 1995b); *C. geddesi** (VAP**), *C. helleri* (ILU**, VAP**), *C pearsei* (VAP**), *C. synspilum* (ILU**, VAP**), *P. splendida** (SAN**). Remarks: Previously reported as *Octangioides* sp. (Pineda-López et al., 1985).

Family Gorgoderidae (Looss, 1899)

9. *Phyllodistomum lacustris* (Loewen, 1929). Urinary bladder and intestine of *C. geddesi** (VAP**), *C. synspilum** (SAN**, VAP**), *C. urophthalmus** (VAP**, HOR**).

Family Zoogonidae Odhner, 1911

10. *Diphtherostomum brusinae* (Stossich, 1888). Intestine of *C. urophthalmus** (CAY**).

Family Callodistomidae Poche, 1926

11. *Prosthenhystera obesa* (Diesing, 1850). Gallbladder of *C. helleri* (ROS), *P. splendida* (ROS) (Fucugauchi et al., 1988); *P. splendida* (TUC**).

Family Acanthocolpidae Lühe, 1909

12. *Stephanostomum* sp. Intestine of *C. urophthalmus** (CAY**).

Family Homalometridae (Cable and Hunninen, 1942)

13. *Crassicutis bravoae* Jiménez and Caballero y Caballero, 1974. Intestine of *C. cyanoguttatus* (PRG) (Jiménez and Caballero y Caballero, 1974); *Cichlasoma* spp. (CUC) (Guajardo-Martínez, 1984).

14. *Crassicutis cichlasomae* Manter, 1936. Intestine of *C. mayorum* (XOL) (Manter, 1936; Pearse, 1936); *C. bifasciatum* (SPE), *C. managuense* (JON), *C. pearsei* (EMZ), *C. synspilum* (JON, SAN, SPE), *C. urophthalmus* (JON, SAN), *Cichlasoma* sp. (SPE), *P. splendida* (SPE) (Pineda-López et al., 1985); *C. hartwegi* (MAL), *P. splendida* (ANG) (Pineda-López, 1985a); *C. urophthalmus* (HOR) (Osorio-Sarabia et al., 1987); *C. gadovii* (CAT) (Ponciano-Rodríguez, 1986); *C. fenestratum* (ROS), *C. geddesi* (ROS), *C. helleri* (ROS) (Fucugauchi et al., 1988); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. meeki*, *C. urophthalmus* (MIT) (plus "several cenotes around Mérida, Yucatán Peninsula") (Scholz, et al., 1995a); *C. meeki* (CHK, NOC), *C. octofasciatum* (DZO), *C. pearsei* (NOC), *C. synspilum* (CEA), *C. urophthalmus* (CHE, DZA, DZI, DZO, GRA, NOC, ZAC), (Scholz et al., 1995b); *Cichlasoma* sp. (PUE), (Lamothe-Argumedo et al., 1991, *C. friedrichstahli** (TUC**), *C. geddesi** (TUC**, VAP**), *C. helleri* (HOR**, ILU**, TUC**, VAP**), *C. managuense* (GUA**, VAP**), *C. pasionis** (ILU**, TUC**), *C. pearsei* (VAP**), *C. robertsoni** (CAM**), *C. synspilum* (ILU**, ROS, TUC**, VAP**,), *C. urophthalmus* (ATA**, CAM**, CEL**, CHA**, CHL**, GER**, GUA**, GUE**, HOR**, LAG**, NOB**, PAL**, SAE**, VAP**), *P. splendida* (VAP**).

15. *Crassicutis opisthoseminis* Bravo-Hollis and Arroyo, 1962. Intestine of *C. motaguense* (JON) (Pineda-López et al., 1985).

16. *Homalometron pallidum* Stafford, 1905. Intestine of *C. rectangulare* (EMZ), (Pineda-López et al., 1985); *C. geddesi** (VAP**), *C. helleri** (HOR**, VAP**), *C. pearsei** (VAP**), *C. synspilum** (SAN**, VAP**), *C. urophthalmus** (GER**, HOR**, MIT**, VAP**), *P. splendida** (TUC**, VAP**). Re-

marks: *Crassicutis* sp. 2 of Pineda-López et al. (1985) is *H. pallidum*.

Family Opecoelidae Ozaki, 1925

17. *Helicometrina nimia* Linton, 1910. Intestine of *C. urophthalmus** (CAY**).

Family Cryptogonimidae Ward, 1917

18. *Palaeocryptogonimus* sp. Intestine of *C. helleri** (ROS**). Remarks: Cryptogonimidae A of Fucugauchi et al. (1988) is *Paleocryptogonimus* sp.

19. *Oligogonotylus manteri* Watson, 1976. Intestine, rectum of *C. urophthalmus* (JON, SAN) (Pineda-López et al., 1985); *C. urophthalmus* (MAL) (Pineda-López, 1985a); *C. urophthalmus* (HOR) (Osorio-Sarabia et al., 1987); *C. synspilum* (ROS) (Fucugauchi et al., 1988); *Cichlasoma* sp. (PUE) (Lamothe-Argumedo et al., 1991); *C. urophthalmus* (CEL, CHA, GUE, LAG, MIT, NOB, PAR, VAP) (Scholz et al., 1994); *C. friedrichstahli* (CEN), *C. meeki* (CAB, CEA), *C. synspilum* (CAB, CEA), *C. urophthalmus* (CAB, DZO, GRA) (Scholz et al. 1995b); *C. geddesi** (VAP**), *C. helleri** (ILU**), *C. managuense** (VAP**, GUA**), *C. synspilum* (ATA**, SAN, ILU**), *C. urophthalmus* (ATA**, CAM**, CEL, CHA, CHL**, GER**, GUA**, GUE, HOR, LAG, MIT, NOB, PAL**, PAR, TUC**, VAP).

20. *Tabascotrema verai* Lamothe-Argumedo and Pineda-López, 1989. Intestine of *P. splendida* (ROS) (Fucugauchi et al., 1988); *P. splendida* (SPE, SAN, JON, VAP, TUC) (Lamothe-Argumedo and Pineda-López, 1989).

21. *Pseudocaecincola batallae* Lamothe-Argumedo, Salgado-Maldonado, and Pineda-López, 1991. Intestine of *P. splendida* (VAP) (Lamothe-Argumedo et al., 1991).

22. *Campechetrema herrerai* Lamothe-Argumedo, Salgado-Maldonado, and Pineda-López (1997). Intestine of *P. splendida* (VAP), Lamothe-Argumedo et al., 1997.

Family Derogenidae Lühe, 1910

23. *Genarchella isabellae* (Lamothe-Argumedo, 1977). Stomach, sometimes intestine of *C. cyanoguttatum*, *Cichlasoma* spp. (CUC) (Jiménez et al., 1981); *C. synspilum* (ROS), *C. urophthalmus* (ROS) (Fucugauchi et al., 1988); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. urophthalmus* (CHA, USU) (Scholz and Salgado-Maldonado, 1994); *C. friedrichstahli* (CEA), *C. meeki* (CAB, CEA), *C. octofasciatum* (CAB), *C. pearsei* (NOC), *C. synspilum* (CAB), *C. urophthalmus* (CAB, DZO) (Scholz et al., 1995b); *C. friedrichstahli* (TUC**), *C. geddesi** (VAP**), *C. helleri** (HOR**, ILU**, VAP**), *C. managuense** (GUA**, VAP**), *C. pearsei** (VAP**), *C. synspilum* (VAP**), *C. urophthalmus* (GUA**, HOR**, MIT**, TUC**, VAP), *P. splendida** (SAN**). Remarks: *Quadripaludis luistoddi* of Jiménez et al. (1981) and of Guajardo-Martínez (1984) is *G. isabellae* (Scholz and Salgado-Maldonado, 1994).

Family Hemiuridae Lühe, 1901

24. *Lecithochirium floridense* (Manter, 1934). Intestine of *C. urophthalmus** (CAY**, CEL**, PAR**).

Larval Trematoda, Metacercariae

Family Microphallidae (Ward, 1901)

25. *Maritreminoides* sp. From *Cichlasoma* spp. (CUC) (Guajardo-Martínez, 1984).

Family Acanthostomidae Poche, 1926

26. *Pelaezia loossi* (Perez-Vigueras, 1957). Scales of lateral line, muscles, fins, and eyes of *C. urophthalmus* (CEL, CHA, LAG, NOB, VAP) (Salgado-Maldonado and Aguirre-Macedo, 1991; Aguirre-Macedo and García-Magaña, 1994); *C. meeki* (NOC, CHK), *C. octofasciatum* (BOX) (Scholz et al., 1995c).

27. *Atrophecaecum* (?) *astorquii* (Watson, 1976). Fins (mainly pelvic), occasionally gills, scales, eyes, and swimbladder of *C. meeki* (CHE, HUN, NOC), *C. octofasciatum* (BOX), *C. pearsei* (NOC), *C. synspilum* (CAB), *C. urophthalmus* (CAB, CHE, DZA, DZO, GRA, NOC), *P. splendida* (NOC) (Scholz et al., 1995c).

28. Acanthostomidae gen. sp. Fins and muscles of *C. geddesi** (VAP**), *C. helleri** (VAP**), *C. pearsei** (VAP**), *C. urophthalmus** CEL**, CHA**, LAG**, NOB**, VAP**); *P splendida** (VAP**).

Family Opisthorchiidae Braun, 1901

29. *Cladocystis trifolium* (Braun, 1901). Gills and operculum of *C. synspilum* (JON), *Cichlasoma* sp. (SPE) (Pineda-López, 1985b); *C. fenestratum* (ROS), *C. helleri* (ROS), *C. synspilum* (ROS) (Fucugauchi et al., 1988); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. meeki* (NOC) (Scholz et al., 1995c); *C. synspilum*

(CHO, HOR, TEN, VAP); *C. urophthalmus* (VAP) (Aguirre-Macedo and García-Magaña, 1994); *C. geddesi** (VAP**), *C. pearsei** (VAP**), *C. synspilum* (CHA**, TUC**), *P. splendida** (VAP**). Remarks: Acanthostomidae metacercariae of Pineda-López (1985b) were determined as *Cladocystis trifolium* in Pineda-López et al. (1985).

30. *Perezitrema bychowskyi* (Caballero y Caballero, 1974). Gills, fins, mesenteries, liver, spleen, heart, swimbladder, and intestinal wall of *C. bifasciatum* (SPE), *C. managuense* (JON), *C. synspilum* (JON) (Pineda-López (1985b); *C. geddesi* (TEN), *C. helleri* (TEA, VAP), *C. synspilum* (CHO, ESP), *C. urophthalmus* (CHO, ESP), *Cichlasoma* sp. (TEN) (Aguirre-Macedo and García-Magaña, 1994); *C. geddesi* (VAP**), *C. managuense* (SIL**, VAP**), *C. pearsei** (VAP**), *C. synspilum* (VAP**), *C. urophthalmus* (GER**, VAP**), *P. splendida** (VAP**).

Family Bucephalidae Poche, 1907

31. *Bucephalus* sp. Pectoral fins of *C. synspilum** (ATA**).

Family Cryptogonimidae Ward, 1917

32. *Oligogonotylus manteri* Watson, 1976. Intestinal wall, mesenteries, gills, pectoral, and pelvic fins of *C. urophthalmus* (CEL, CHA, GUE, LAG, MIT, NOB, VAP) (Scholz et al., 1994); *C. friedrichstahli* (CEA, CEN), *C. meeki* (CAB, CEA, CUA), *C. octofasciatum* (BOX, CAB), *C. synspilum* (CAB, CEA, FRA), *C. urophthalmus* (CAB, DZA, DZO, HOD) (Scholz et al., 1995c); *C. urophthalmus* CHL**, GER**, PAL**, PAR**.

33. Cryptogonimidae gen. sp. From *C. fenestratum** (ROS), *C. helleri** (VAP**), *P. splendida** (SAN**) (Fucugauchi et al., 1988).

Family Echinostomatidae Poche, 1926

34. *Drepanocephalus* sp. Scales of lateral line of *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. geddesi** (VAP**); *C. helleri* (VAP**); *C. pearsei** (VAP**), *C. synspilum** (VAP**), *C. urophthalmus** (VAP**).

35. *Echinochasmus leopoldinae* Scholz, Ditrich, and Vargas-Vázquez, 1996. Gills of *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. urophthalmus* (CHE, DZO, HOD), *P. splendida* (NOC) (Scholz et al., 1995c); *C. synspilum* (HON), *C. urophthalmus* (CHE, DZO, HOD, MIT), *P. splendida* (NOC) (Scholz et al., 1996); *C. geddesi** (VAP**), *C. helleri** (VAP**), *C. managuense** (VAP**), *C. pearsei** (VAP**), *C. robertsoni** (CAM**), *C. synspilum* (ATA**, VAP**), *C. urophthalmus* (ATA**, CEL**, SAE**, VAP**), *P. splendida* (VAP**). Remarks: These metacercariae were previously misidentified as *E. zubedakhaname* Nasir and Diaz, 1968 (Lamothe-Argumedo and Aguirre-Macedo, 1991a, b; Salgado-Maldonado, 1993; Jiménez-García, 1993) and reported as *Echinochasmus* sp. 1 (Scholz *et al.*, 1995c). However, Scholz (pers. comm.) suggested *E. zubedakhaname* does not occur in Yucatán, Mexico.

Family Cathaemasiidae Fuhrmann, 1928

36. *Ribeiroia ondatrae* (Price, 1931). Scales of lateral line of *C. urophthalmus* (BAL, COR, GUA, JON, SPE, VAP), *C. geddesi* (VAP), *C. pearsei* (VAP), *C. synspilum* (VAP) (Aguirre-Macedo and García-Magaña, 1994); *C. synspilum* (SIL**), *C. urophthalmus* (LAG**, SIL**, VAP), *P. splendida** (SIL**).

Family Heterophyidae Odhner, 1914

37. *Ascocotyle* (*Phagicola*) *nana* Ramson, 1920. Fins, gills, eyes, muscles, mesenteries, swimbladder, spleen, heart, kidney, liver, intestinal wall, brain, and gonads of *C. urophthalmus* (CEL, LAG, USU) (Salgado-Maldonado and Aguirre-Macedo, 1991); *C. friedrichstahli* (CEA), *C. meeki* (CAB, CUA, NOC), *C. octofasciatum* (BOX, CAB), *C. synspilum* (CAB, CEA, FRA), *C. urophthalmus* (CAB, CHE, DZI, DZO, GRA, HOD, NOC) (Scholz *et al.*, 1995c); *C. rectangulare** (TEN**); *C. helleri** (VAP**), *C. geddesi** (VAP**), *C. managuense** (VAP**), *C. pearsei** (VAP**), *C. robertsoni** (CAM**), *C. synspilum* (ATA**, HOR**, TUC**, VAP**), *C. urophthalmus* (ATA**, BAL**, CAM**, CAY**, GUA**, HOR**, MIT**, SAE**, SPE**, TEA**, TUC**), *P. splendida** (VAP**). Remarks: This species was previously identified as *Phagicola angrense* (Salgado-Maldonado and Aguirre-Macedo, 1991, but see Scholz *et al.*, 1995c, who reported on this species as *A.* (*Phagicola*) sp. 2); present identification is due to Scholz (pers. comm.).

38. *Ascocotyle* (*Ascocotyle*) sp. Gills of *C. meeki* (CAB, CHK, CUA, NOC), *C. octofasciatum* (BOX), *C. urophthalmus* (NOC) (Scholz *et al.*, 1995c). Remarks: Previously reported as *Ascocotyle* (*Phagicola*) sp. 3 (Scholz *et al.*, 1995c),

this species will be described elsewhere, Scholz (pers. comm.).

39. *Ascocotyle leighi* Burton, 1956. Gills, mesenteries, heart, and kidney of *C. helleri* (ROS) (Fucugauchi *et al.*, 1988); *C. geddesi** (VAP**), *C. helleri* (ILU**), *C. managuense** (VAP**), *C. pearsei** (VAP**), *C. synspilum** (ILU**), *P. splendida** (VAP**).

40. *Ascocotyle* (*Ascocotyle*) *tenuicollis* Price, 1935. Heart of *C. friedrichsthali* (TUC), *C. geddesi* (VAP) (Aguirre-Macedo and García-Magaña, 1994); *C. octofasciatum* (CAB), *C. synspilum* (CEA, CAB) (Scholz *et al.*, 1995c); *C. pearsei** (VAP**).

41. Heterophyidae gen. sp. Muscles of *C. meeki* (CHK) (Scholz *et al.*, 1995c).

Family Clinostomidae Lühe, 1901

42. *Clinostomum intermedialis* Lamont, 1920. Muscles of *C. urophthalmus* (SAN) (Pineda-López *et al.*, 1985).

43. *Clinostomum complanatum* (Rudolphi, 1814). Fins, operculum, gills, muscles, mesenteries, heart, liver, and gonads of *C. mojarra* (TUX) (Bravo-Hollis and Caballero Deloya, 1973); *C. istlanum* (INF) (Osorio-Sarabia, 1982b); *C. pearsei* (SAN), *C. synspilum* (JON, SAN), *C. urophthalmus* (SAN), *P. splendida* (JON, SAN, SPE) (Pineda-López, 1985b); *C. synspilum* (SAN, JON, SPE), *Cichlasoma* sp. (JON), *P. splendida* (SAN, JON, SPE) (Pineda-López, *et al.*, 1985); *C. urophthalmus* (ROS), *P. splendida* (ROS) (Fucugauchi *et al.*, 1988); *C. pasionis* (CHI), *P. splendida* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. urophthalmus* (CHE) (Scholz *et al.*, 1995c); *C. synspilum* (TUC), *Cichlasoma* sp. (TEN), *C. urophthalmus* (CEL, CHA, CHL, GER, JON, LAG, NOB, PAL, PAR, TEN, VAP) (Aguirre-Macedo and García-Magaña, 1994); *C. geddesi** (VAP**), *C. helleri* (ILU**, VAP**), *C. pasionis* (ILU**), *C. pearsei* (VAP**), *C. robertsoni** (SIL**), *C. synspilum* (VAP**), *C. urophthalmus* (CAM**, HOR** MIT**, PAL**, TUC**), *P. splendida* (SIL**, VAP**).

Family Diplostomidae Poirier, 1886

44. *Diplostomum (Austrodiplostomum) compactum* (Lutz, 1928). Eye (humor body) and brain of *C. aureum* (TLA) (Caballero and Winter, 1954); *C. motaguense* (EMZ), *C. synspilum* (JON), *Cichlasoma* sp. (SPE), *P. splendida* (JON, SPE) (Pineda-López, 1985b); *C. motaguense* (EMZ), *C. synspilum* (JON), *Cichlasoma* sp. (SPE), *P. splendida* ((JON, SPE) (Pineda-López *et al.*, 1985); *C. grammodes* (LPA), *C. hartwegi* (LPA), *P. splendida* (LPA) (Pineda-López, 1985a); *C. meeki* (CHI, HOR), *C. urophthalmus* (CHI, HOR), *P. splendida* (CHI, HOR) (Osorio-Sarabia *et al.*, 1987); *C. meeki* (CUA, CEA, NOC), *C. synspilum* (CEA), *C. urophthalmus* (CHE, HOD) (Scholz *et al.*, 1995c); *C. geddesi** (TEN**, VAP**), *C. helleri* (HOR**, ILU**, TEA**, VAP**), *C. managuense* (VAP**), *C. pasionis** (ILU**), *C. pearsei** (VAP**), *C. synspilum* (SIL**, TUC**, VAP**), *C. urophthalmus* (CHL, GER**, GUA**, HOR**, JON**, MIT**, NOB**, SAN**, SIL**, SPE**, TUC**, VAP**), *P. splendida* (MAL**, SAN**, SIL**, VAP**). Remarks: *D. spathaceum* of Caballero and Winter (1954) is *D. (A.) compactum* (Osorio-Sarabia *et al.*, 1987).

45. *Diplostomum spathaceum* (Rudolphi, 1819). Eye of *C. istlanum* (INF) (Osorio-Sarabia, 1982b).

46. *Diplostomum* sp. Muscles, mesenteries of *C. helleri* (ROS) (Fucugauchi *et al.*, 1988); *C. geddesi** (VAP**), *C. helleri* (ROS, VAP**), *C. pearsei** (VAP**), *C. synspilum** (VAP**), *C. urophthalmus* (CEL**, VAP**), *P. splendida** (SIL**, VAP**).

47. *Posthodiplostomum minimum* (MacCallum, 1921). Fins, gills, muscles, and mesenteries of *C. friedrichstahli* (CEA), *C. meeki* (CHK), *C. octofasciatum* (BOX), *C. pearsei* (NOC), *C. urophthalmus* (CHE, DZO, GRA, HOD, ZAC) (Scholz *et al.*, 1995c); *C. urophthalmus* (CHA, CHL, GUA, MIT, NOB, PAR, VAP) (Aguirre-Macedo and García-Magaña, 1994); *C. urophthalmus* (CAY**, CHA, GER**, LAG**, NOB, PAL**, PAR, VAP).

48. *Posthodiplostomum* sp. Muscles, mesenteries, spleen, liver, brain, and kidney of *C. pearsei* (SAN), *C. synspilum* (JON, SAN, SPE), *C. urophthalmus* (SAN), *P. splendida* (JON, SAN, SPE) (Pineda-López, 1985b); *C. hartwegi* (LPA) (Pineda-López, 1985a); *C. pasionis* (HOR) (Osorio-Sarabia *et al.*, 1987); *C. helleri* (ROS) (Fucugauchi *et al.*, 1988); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. octofasciatum* (BOX), *C. pearsei* (NOC), *C. urophthalmus* (DZO, HOD) (Scholz *et al.*, 1995c); *C. helleri* (VAP), *Cichlasoma* sp. (TEN) (Aguirre-Macedo and García-Magaña, 1994); *C. friedrichstahli**

(TUC**), *C. geddesi** (ROS**, TUC**, VAP**), *C. helleri** (ILU**, TUC**), *C. managuense** (SIL**, VAP**), *C. pasionis* (ILU**), *C. pearsei* (VAP**), *C. robertsoni** (SIL**), *C. synspilum* (ATA**, ILU**, SIL**, TUC**, VAP**), *C. urophthalmus** (CAY**, GER**, MIT**, SIL**, TUC**, VAP**), *P. splendida* (JON, ROS, SAN, SIL**, SPE, TUC**, VAP**).

Family Proterodiplostomidae Dubois, 1936

49. Proterodiplostomidae gen. sp. Gills, swimbladder, and gonads of *C. synspilum* (ROS) (Fucugauchi *et al.*, 1988); *C. octofasciatum* (BOX) (Scholz *et al.*, 1995c); *C. synspilum* (ROS).

Family Strigeidae Railliet, 1919

50. Strigeidae gen. sp. Mesenteries of *C. synspilum** (VAP**), *P. splendida** (VAP**).

51. Tetracotyle. Opercula, gills, mesenteries, liver, and intestine of *C. mayorum* (XOL) (Manter, 1936); *C. meeki* (CHI), *P. splendida* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. helleri* (TEA); *C. synspilum* (TUC), *C. urophthalmus* (CHO, ESP) (Aguirre-Macedo and Garcia-Magaña, 1994); *C. geddesi** (VAP**), *C. helleri* (TUC**), *C. pearsei** (VAP**), *C. synspilum* (VAP**). Remarks: Probably, this is a species of *Apharyngostrigea* (see Scholz *et al.*, 1995c).

Adult Cestoda

Family Bothriocephalidae Blanchard, 1849

52. *Bothriocephalus acheilognathi* Yamaguti, 1934. Intestine of *C. istlanum* (INF) (Osorio-Sarabia, 1982b); *C. urophthalmus** (JON**, CEL**).

Larval Cestoda

Order Trypanorhyncha Diesing, 1863

53. Trypanorhyncha gen. sp. Lumen of intestine of *C. managuense** (VAP**), *C. urophthalmus** (CEL**).

Order Tetraphyllidea Carus, 1863

54. Tetraphyllidea gen. sp. Lumen of intestine of *C. urophthalmus** (CAY**, CEL**, CHA**, CHL**, GER**, PAL**, PAR**, VAP**).

Order Proteocephalidea Mola, 1928

55. Proteocephalidea gen. sp. Mesenteries and intestine of *C. synspilum* (ROS), *P. splendida* (ROS) (Fucugauchi *et al.*, 1988); *C. geddesi* (SAN), *C. managuense* (JON), *C. rectangulare* (JON, EMZ, SAN), *C. synspilum* (SAN), *C. urophthalmus* (EMZ), *P. splendida* (EMZ, SPE) (Pineda-López *et al.*, 1985); *C. managuense* (VAP**), *C. pasionis** (TUC**), *C. robertsoni** (SIL**), *C. synspilum* (SIL**, TUC**, VAP**), *C. urophthalmus* (CEL**, CHL**, MIT**, TUC**, VAP**), *P. splendida* (SIL**, VAP**).

Adult Acanthocephala

Family Echinorhynchidae Cobbold, 1876

56. *Acanthocephalus dirus* (Van Cleave, 1931). Intestine of *C. urophthalmus* (CHA**).

Family Illiosentidae Golvan, 1960

57. *Dollfusentis chandleri* Golvan, 1969. Intestine of *C. urophthalmus** (CHA**).

Family Neoechinorhynchidae Ward, 1917

58. *Floridosentis mugilis* (Machado, 1951). Intestine of *C. istlanum* (INF) (Osorio-Sarabia, 1982b).

59. *Neoechinorhynchus golvani* Salgado-Maldonado, 1978. Intestine of *C. aureum* (CAT) (Salgado-Maldonado, 1978); *C. geddesi* (SAN), *C. managuense* (EMZ), *C. pearsei* (SAN), *C. rectangulare* (SAN), *C. synspilum* (SAN), *C. urophthalmus* (EMZ, SAN), *P. splendida* (EMZ) (Pineda-López *et al.*, 1985); *C. fenestratum* (CHI, VIG, SPE, ESP), *C. meeki* (CHI, VIG, SPE, ESP), *C. pasionis* (CHI, VIG, SPE, ESP), *C. pearsei* (CHI, VIG, SPE, ESP), *C. rectangulare* (CHI, VIG, SPE, ESP), *C. urophthalmus* (CHI, VIG, SPE, ESP), *P. splendida* (CHI, VIG, SPE, ESP) (Salgado-Maldonado, 1985); *C. meeki* (CHI, HOR), *C. pasionis* (CHI), *C. urophthalmus* (CHI, HOR), *Cichlasoma* sp. (CHI, HOR), *P. splendida* (CHI, HOR) (Osorio-Sarabia *et al.*, 1987); *C. helleri* (ROS), *C. synspilum* (ROS) (Fucugauchi *et al.*, 1988); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. urophthalmus* (CHE) (Scholz *et al.*, 1996); *C. friedrichstahli** (TUC**), *C. geddesi* (TUC**, VAP**), *C. helleri* (ILU**), *C. managuense* (GUA**, SIL**, VAP**), *C. pasionis* (ILU**, TUC**), *C. pearsei* (VAP**), *C. rectangulare* (SIL**), *C. robertsoni** (SIL**), *C. synspilum* (ATA**, ILU**, TUC**, VAP**), *C. urophthalmus* (ATA**, CAY**, CEL**, CHA**, GUA**, GER**, PAL**, SAE**, SIL**, TUC**, VAP**), *P. splendida* (SAN**, SIL**, VAP**).

60. *Octospiniferoides chandleri* Bullock, 1957.

Intestine of *C. friedrichstahli* (CEN) (Scholz *et al.*, 1996).

Larval Acanthocephala, Cystacanths

Family Polymorphidae Meyer, 1931

61. *Polymorphus brevis* (Van Cleave, 1916). Intestinal wall of *C. synspilum* (CUA) (Scholz *et al.*, 1996).

62. *P. mutabilis* (Rudolphi, 1819). Mesenteries and kidney of *C. urophthalmus* (CHI), *P. splendida* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. friedrichstahli** (TUC**), *C. geddesi** (VAP**), *C. managuense** (VAP**); *C. pasionis** (TUC**), *C. pearsei** (VAP**), *C. synspilum** (ATA**, VAP**), *C. urophthalmus* (ATA**, CAY**, CEL**, CHL**, HOR, LAG**, MIT**, NOB**, PAL**), *P. splendida* (SAN**, TUC**). Remarks: Polymorphid cystacanths of Osorio-Sarabia *et al.* (1987) are *P. mutabilis*.

Adult Nematoda

Family Capillariidae Railliet, 1915

63. *Capillaria* (*Hepatocapillaria*) *cichlasomae* Moravec, Scholz, and Mendoza-Franco, 1995. Intestine of *C. urophthalmus* (XPO) (Moravec *et al.*, 1995b).

Family Pharyngodonidae Travassos, 1919

64. *Laurotravassoxyuris bravoae* Osorio-Sarabia, 1984. Intestine of *C. istlanum* (INF) (Osorio-Sarabia, 1984).

Family Cosmocercidae (Railliet, 1916)

65. *Raillietnema kritscheri* Moravec, Salgado-Maldonado, and Pineda-López, 1993. Posterior intestine of *C. pearsei* (CHN, EMZ, SPE, VAP), *C. synspilum* (VAP), *C. urophthalmus* (LAG, VAP) (Moravec *et al.*, 1993). Remarks: Cited in Pineda-López *et al.* (1985) as Oxyuroidea.

Family Cucullanidae Cobbold, 1864

66. *Cucullanus* sp. Intestine of *C. synspilum** (SAN**).

Family Anisakidae Railliet and Henry, 1912

67. *Goezia nonipapillata* Osorio-Sarabia, 1982. Intestine of *C. istlanum* (INF), (Osorio-Sarabia, 1982a).

68. *Goezia* sp. Intestine of *C. hartwegi* (ANG) (Pineda-López *et al.*, 1985); *C. geddesi** (VAP**), *C. pearsei** (VAP**), *C. synspilum** (VAP**), *C. urophthalmus** (VAP**, HOR**), *P. splendida** (VAP**).

Family Camallanidae Railliet and Henry, 1915

69. *Procamallanus* (*Spirocamallanus*) *rebecae* Andrade-Salas, Pineda-López, and García-Magaña, 1994. Intestine of *C. rectangulare* (EMZ), *C. synspilum* (SAN), *Cichlasoma* sp. (SPE), *P. splendida* (JON) (Pineda-López *et al.*, 1985); *C. meeki* (CHI), *C. pasionis* (CHI), *P. splendida* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. geddesi* (ROS), *C. helleri* (ROS), *C. synspilum* (ROS), *C. urophthalmus* (ROS), *Cichlasoma* sp. (ROS), *P. splendida* (ROS) (Fucugauchi *et al.*, 1988); *C. synspilum* (ILU) (Andrade-Salas *et al.*, 1994); *C. meeki* (CEA, CAB), *C. synspilum* (CEA), *C. urophthalmus* (CHE, CAB) (Moravec *et al.*, 1995a, c); *C. geddesi* (TUC**, VAP**), *C. helleri* (HOR**, ILU**, TUC**, VAP**), *C. managuense** (GUA**, SIL**, VAP**), *C. pasionis* (ILU**, TUC**), *C. rectangulare** (SIL**), *C. robertsoni** (SIL**); *C. synspilum* (SIL**, TUC**, VAP**), *C. urophthalmus* (HOR**, GER**, GUA**, GUE**, MIT**, NOB**, SIL**, TUC**, VAP**), *P. splendida* (SAN**, SIL**, VAP**). Remarks: *S. pereirai* of Pineda-López *et al.* (1985b) and of Osorio-Sarabia *et al.* (1987) is *P.* (*S*). *rebecae*.

Family Daniconematidae Moravec and Køie, 1987

70. *Mexiconema cichlasomae* Moravec, Vidal, and Salgado-Maldonado, 1992. Skin beneath scales, abdominal cavity, mesenteries, swimbladder, liver, spleen, kidney, intestinal lumen, and serous membrane covering intestine of *C. helleri* (HOR, VAP), *C. managuense* (VAP), *C. pearsei* (VAP), *C. urophthalmus* (CAY, CEL, CHA, CHL, GER, LAG, NOB, PAL, PAR, VAP) (Moravec *et al.*, 1992).

Family Rhabdochonidae Travassos, Artigas, and Pereira, 1928

71. *Rhabdochona kidderi* Pearse, 1936. Intestine of *C. managuense* (EMZ, JON), *C. urophthalmus* (JON, SAN), *Cichlasoma* sp. (SPE) (Pineda-López *et al.*, 1985); *C. helleri* (ROS) (Fucugauchi *et al.*, 1988); *C. fenestratum* (CAT) (Jiménez-García, 1993); *C. helleri* (ILU**), *C. synspilum** (VAP**).

Family Cystidicolidae Skrjabin, 1946

72. *Spinitectus* sp. Intestine of *C. fenestratum* (ROS), *P. splendida* (ROS) (Fucugauchi *et al.*, 1988).

Larval Nematodes

Family Kathlaniidae Lane, 1914

73. *Falcaustra* sp. Abdominal cavity (mainly surface of intestine), liver, gallbladder, mesenteries, and brain (free or encysted) of *C. meeki* (NOC), *C. octofasciatum* (BOX), *C. urophthalmus* (CHE, DZO, HOD), *P. splendida* (NOC) (Moravec *et al.*, 1995d).

Family Anisakidae Railliet and Henry, 1912

74. *Raphidascaris* sp. Intestine of *C. managuense* (EMZ) (Pineda-López *et al.*, 1985).

75. *Thynnascaris habena* Lutton, 1900. Intestine of *C. istlanum* (INF) (Osorio-Sarabia, 1982b). Remarks: the genus *Thynnascaris* is a partial synonym of *Hysterothylacium*.

76. *Contracaecum multipapillatum* (Von Drasche, 1882). Mesenteries of *C. istlanum* (INF) (Osorio-Sarabia, 1982b); *C. synspilum** (ATA**, SIL**), *C. urophthalmus** (CAM**, CEL**, LAG**, MIT**). Remarks: Osorio-Sarabia (1982b) described *C. robustum* from cichlids of Infiernillo, Michoacan; however, Deardorff and Overstreet (1980) pointed out that *C. robustum* is a junior synonym of *C. multipapillatum*.

77. *Contracaecum* sp. Mesenteries, liver, gonads, and intestinal wall of *C. mayorum* (XOL) (Pearse, 1936); *C. baeni* (INF) (Osorio-Sarabia, 1982b); *C. managuense* (EMZ, JON), *C. rectangulare* (EMZ); *C. urophthalmus* (EMZ, JON, SAN), *P. splendida* (EMZ, JON, SPE) (Pineda-López *et al.*, 1985); *C. hartwegi* (ANG), *C. pasionis* (CHI), *C. urophthalmus* (CHI), *P. splendida* (CHI) (Osorio-Sarabia *et al.*, 1987); *P. splendida* (ROS) (Fucugauchi *et al.*, 1988); *C. synspilum* (CAB), *C. urophthalmus* (CAB, CHE, DZO, HOD, NOC) (Moravec *et al.*, 1995d); *C. geddesi** (VAP**), *C. helleri** (ILU**, VAP**), *C. managuense* (SIL**, VAP**), *C. pearsei** (VAP**), *C. synspilum* (CEA**, SAN**, SIL**), *C. urophthalmus* (CEL**, CHA**, CHL, GER**, LAG**, NOB**, PAL**, PAR**, SAE**, SIL**, VAP**), *P. splendida* (VAP**). Remarks: Moravec *et al.* (1995b) differentiate 2 *Contracaecum* type larvae; adults of Type 2 larvae may belong to the group of species of *C. microcephallum* (Rud., 1819), *C. multipapillaum* (von Drasche, 1882), *C. micropapillatum* (Stossich, 1890), *C. caballeroi* (Bravo Hollis, 1939), *C. plagiaticum* (Lent and Freitas, 1948) among others, parasitizing mainly fish-eating birds. Adult *Contracaecum* of 2 species, *C. multipapillatum* and *C. spinigerum*, have been already identified in the same single bird in some localities in southern México (Amaya-Huerta, 1991; Vidal-Martínez *et al.*, 1994).

Family Gnathostomatidae Railliet, 1895

78. *Gnathostoma binucleatum* Almeyda-Artigas, 1991. Muscle of *C. fenestratum* (TEM), *C. urophthalmus* (TEM), *P. splendida* (TEM), Almeyda-Artigas (1991).

79. *Gnathostoma* sp. Muscles of *C. gadovii* (TEM), *C. urophthalmus* (TEM), *P. splendida* (TEM) (Lamothe-Argumedo *et al.*, 1989).

80. *Spiroxys* sp. Mesenteries of *C. managuense* (JON), *C. urophthalmus* (SAN) (Pineda-López *et al.*, 1985); *C. meeki* (CHI), *C. pasionis* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. meeki* (NOC), *C. urophthalmus* (CHE) (Moravec *et al.*, 1995d); *C. managuense* (SIL**), *C. pearsei** (VAP**), *C. synspilum* (SIL**, VAP**), *C. urophthalmus* (GER**, LAG**, MIT**, NOB**, SIL**, VAP**).

81. Ascaridae gen. sp. Muscles of *C. managuense* (EMZ) (Pineda-López *et al.*, 1985).

Family Camallanidae Railliet and Henry, 1915

82. *Camallanus* sp. Intestine of *C. meeki* (CHI, HOR), *Cichlasoma* sp. (CHI, HOR), *P. splendida* (CHI, HOR) (Osorio-Sarabia *et al.*, 1987); *C. urophthalmus** (HOR**). Remarks: Larvae of *C. lacustris* of Osorio-Sarabia *et al.* (1987) are a misidentification.

83. *Procamallanus* (*Spirocamallanus*) *rebecae* Andrade-Salas, Pineda-López, and García-Magaña, 1994. Intestine of *C. meeki* (CHI), *C. pasionis* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. gadovii** (RIO**), *C. synspilum* (VAP**), *C. urophthalmus** (HOR**, VAP**), *P. splendida** (SAN**). Remarks: Moravec *et al.* (1995a) identified larvae previously reported as *Procamallanus* sp. by Osorio-Sarabia *et al.* (1987) as the third-stage larvae of *P.* (*S.*) *rebecae*.

84. Camallanidae gen. sp. Intestine of *C. geddesi* (VAP**), *C. helleri* (VAP**), *C. motguense* (VAP**), *C. synspilum* (VAP**), *C. urophthalmus* (VAP**).

Family Acuariidae Railliet, Henry and Sisoff, 1912

85. Acuariidae gen. sp. Mesentery of *C. urophthalmus* (CHE) (Moravec *et al.*, 1995d).

Hirudinea

Family Piscicolidae Johnson, 1865

86. *Myzobdella patzcuarensis* (Caballero, 1941). Site of infection:? *Petenia splendida* (YUC), (Moore, 1936, *in* Ringuelet, 1982).
87. *Myzobdella* sp. Body surface, fins, opercula, and mouth of *C. geddesi* (SAN), *C. pearsei* (SAN), *C. rectangulare* (SAN), *C. synspilum* (JON, SAN), *P. splendida* (JON, SPE) (Pineda-López *et al.*, 1985); *P. splendida* (CHI) (Osorio-Sarabia *et al.*, 1987); *C. helleri* (ROS), *P. splendida* (ROS) (Fucugauchi *et al.*, 1988); *C. geddesi* (VAP**), *C. helleri** (VAP**), *C. motaguense** (VAP**), *C. pearsei* (VAP**), *C. synspilum* (TUC, VAP**), *C. urophthalmus** (HOR**, VAP**), *P. splendida* (SAN**, VAP**).

Mollusca, Larvae

88. *Proptera alata* (Say, 1817). Body surface, fins, and gills of *C. friedrichstahli** (TUC**), *C. geddesi** (TUC**), *C. helleri** (ROS**, TUC**), *C. pasionis** (TUC**), *C. synspilum** (TUC**), *C. urophthalmus** (TUC**), *P. splendida** (TUC**).

Arthropoda, Pentastomida, Larvae

89. *Subtriquetra subtriquetra* Sambon, 1922. Mesenteries of *C. synspilum** (VAP**), *C. urophthalmus** (VAP**).
90. *Sebekia* sp. Mesenteries of *C. motaguense* (SPE) (Pineda-López and García-Magaña, 1991).

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1997–1998 Meeting Schedule

22 October 1997	Naval Medical Research Institute (NMRI), Bethesda, MD (Contact person: Kevin Baird, 301-295-1650)
19 November 1997	Anniversary Dinner–Meeting, Location TBA
21 January 1998	Johns Hopkins University, Montgomery County Center (Contact person: Thomas Simpson, 410-366-8814 or 757-787-7689)
8 March 1998	Nematology Laboratory, BARC-West, Beltsville, MD (Contact person: David Chitwood, 301-504-8634)
9 May 1998	University of Pennsylvania, New Bolton Center, Kennett Square, PA (Contact person: Phillip Scott, 215-898-1602)

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Neotropical Monogenoidea. 30. Ancyrocephalinae (Dactylogyridae) of Piranha and Their Relatives (Teleostei, Serrasalmidae) from Brazil: Species of *Calpidothecium* gen. n., *Calpidothecioides* gen. n., *Odothecium* gen. n., and *Notothecioides* gen. n.

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ABSTRACT: Two species of *Calpidothecium*, 2 species (1 new) of *Calpidothecioides*, 1 new species of *Odothecium*, and 1 new species of *Notothecioides* (Dactylogyridae, Ancyrocephalinae) are described and/or reported from the gills of 4 species of Serrasalmidae from the Brazilian Amazon: *Calpidothecium crescentis* (Mizelle and Price, 1965) comb. n. (syn. *Urocleidus crescentis* Mizelle and Price, 1965), *C. serrasalmus* (Mizelle and Price, 1965) comb. n. (syn. *Cleidodiscus serrasalmus* Mizelle and Price, 1965), and *Calpidothecioides pygopristi* sp. n. from *Pygopristis denticulata*; *Odothecium raphidiophallum* sp. n. from *Catoprion mento*; and *Notothecioides llewellyni* sp. n. from *Myleus torquatus* and *M. rubripinnis*. Four new genera are proposed: *Calpidothecium* is characterized by dactylogyrids with a single vagina opening sinistrolaterally, 1 pair of eyes, overlapping gonads, a seminal vesicle representing a dextral loop of the vas deferens, and a distal rod of the accessory piece with terminal branches; *Calpidothecioides* is characterized by species with a double vagina (left branch opening sinistrolaterally, right branch looping right cecum and opening on the dorsomedial body surface), 1 pair of eyes, overlapping gonads, a seminal vesicle comprising a dextral loop of the vas deferens, and a simple termination of the distal rod of the accessory piece; *Odothecium* is characterized by helminths with a single vagina looping the left cecum and opening on the middorsal body surface, 2 pairs of eyes, overlapping gonads, a seminal vesicle representing a dextral loop of the vas deferens, and a hook-shaped termination of the distal rod of the accessory piece; *Notothecioides* is characterized by species with the vagina looping the left cecum and opening on the middorsal body surface, 2 pairs of eyes, overlapping gonads, a sigmoid seminal vesicle, and a simple or hook-shaped termination of the distal rod of the accessory piece. *Urocleidus orthus* Mizelle and Price, 1965, is transferred to *Calpidothecioides*.

KEY WORDS: Monogenoidea, Dactylogyridae, Ancyrocephalinae, *Calpidothecioides* gen. n., *Calpidothecium* gen. n., *Notothecioides* gen. n., *Odothecium* gen. n., *Calpidothecioides orthus* comb. n., *Calpidothecioides pygopristi* sp. n., *Calpidothecium serrasalmus* comb. n., *Calpidothecium crescentis* comb. n., *Notothecioides llewellyni* sp. n., *Odothecium raphidiophallum* sp. n., Serrasalmidae, *Catoprion mento*, *Pygopristis denticulata*, *Myleus rubripinnis*, *Myleus torquatus*, Amazon Basin, Brazil.

The present paper is the third of 4 contributions dealing with the Ancyrocephalinae from the gills of Serrasalmidae from the Brazilian Amazon (see Kritsky et al. [1996, 1997, 199X]) and includes the proposal of 4 new genera. Three new species are described; and *Urocleidus crescentis* Mizelle and Price, 1965, *U. orthus* Mizelle and Price, 1965, and *Cleidodiscus serrasalmus* Mizelle and Price, 1965, are reassigned to neotropical genera.

Methods of host [*Catoprion mento* (Cuvier), *Myleus torquatus* (Kner), *M. rubripinnis* (Müller and Troschel), and *Pygopristis denticulata* (Cuvier)] and parasite collection, preparation of helminths for study, measurement, and illustration are those of Kritsky et al. (1986, 1996). Measurements, all in μm, represent straight-line distances between extreme points and are expressed as a mean followed by the range and number of specimens measured in parentheses; body length includes that of the haptor; length of the accessory piece is that of the distal rod. Measurements of internal organs (gonads and pharynx), the body, and haptoral bars were obtained from stained unflattened specimens; those of the anchors, hooks, and copulatory complex were from unstained specimens mounted in Gray and

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Wess' medium. Numbering (distribution) of hook pairs follows that recommended by Mizelle (1936; see Mizelle and Price [1963]). Type and voucher specimens are deposited in the helminth collections of Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil (INPA); the United States National Parasite Collection, Beltsville, Maryland (USNPC); and the University of Nebraska State Museum (HWML), as indicated in the respective descriptions or accounts. For comparative purposes, the following specimens also were examined: holotype (USNPC 60465), *Urocleidus crescentis* Mizelle and Price, 1965; holotype (USNPC 60466), *U. orthus* Mizelle and Price, 1965; and holotype (USNPC 60464), *Cleidodiscus serrasalmus* Mizelle and Price, 1965.

Taxonomic Account

Class Monogenoidea Bychowsky, 1937
Order Dactylogyridea Bychowsky, 1937
Dactylogyridae Bychowsky, 1933
Ancyrocephalinae Bychowsky, 1937
Calpidothecium gen. n.

DIAGNOSIS: Body fusiform, comprising cephalic region, trunk, peduncle, haptor. Tegument thin, smooth, or with scaled annulations. Two terminal, 2 bilateral cephalic lobes; head organs, unicellular cephalic glands present. Anterior eyes absent, infrequently represented by single cluster of granules; granules elongate ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; intestinal ceca 2, confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens looping left intestinal cecum; seminal vesicle comprising a dextral loop of vas deferens, with circular muscles in wall. Two saccate prostatic reservoirs; prostates comprising rosette of glandular areas lying in dorsal field of anterior trunk. Genital pore midventral near level of cecal bifurcation. Copulatory complex comprising articulated copulatory organ, accessory piece; copulatory organ tubular, single ramus opening terminally or subterminally; distal rod of accessory piece with terminal digitations, proximal articulation process present. Vagina nonsclerotized; vaginal aperture sinistrolateral; vaginal duct opening proximally to anterior wall of seminal receptacle; seminal receptacle lying on midline anterior to germarium. Haptor subhexagonal; with pairs of dorsal and ventral anchor/bar complexes, 7 pairs of similar hooks with ancyrocephaline distribution. Hooks similar; each with delicate point, truncate protruding thumb, expanded shank comprising 2 subunits; proximal subunit variable in length between hook pairs. FH loop extending to union of shank subunits. Ventral bar lacking anteromedial projection. Parasites of gills of serrasalmid fishes.

TYPE SPECIES: *Calpidothecium crescentis* (Mizelle and Price, 1965) comb. n. from *Pygocentrus nattereri* (type host) and *Pygopristis denticulata*.

OTHER SPECIES: *Calpidothecium serrasalmus* (Mizelle and Price, 1965) comb. n. from *Pygocentrus nattereri* (type host) and *Pygopristis denticulata*.

REMARKS: *Calpidothecium* is characterized by dactylogyrids, with a single vagina opening sinistrolaterally, 1 pair of eyes, overlapping gonads, a seminal vesicle representing a dextral loop of vas deferens, and a distal rod of the accessory piece with terminal branches. It is apparently sister group of *Calpidothecioides* gen. n. based on 2 synapomorphies: lost or tendency to loose the anterior pair of eyes, and presence of a seminal vesicle with circular muscles in its wall. It differs from *Calpidothecioides* by lacking a dextral branch of the vagina. The generic name is from Greek (*kalpidos* = an urn + *theke* = a small case).

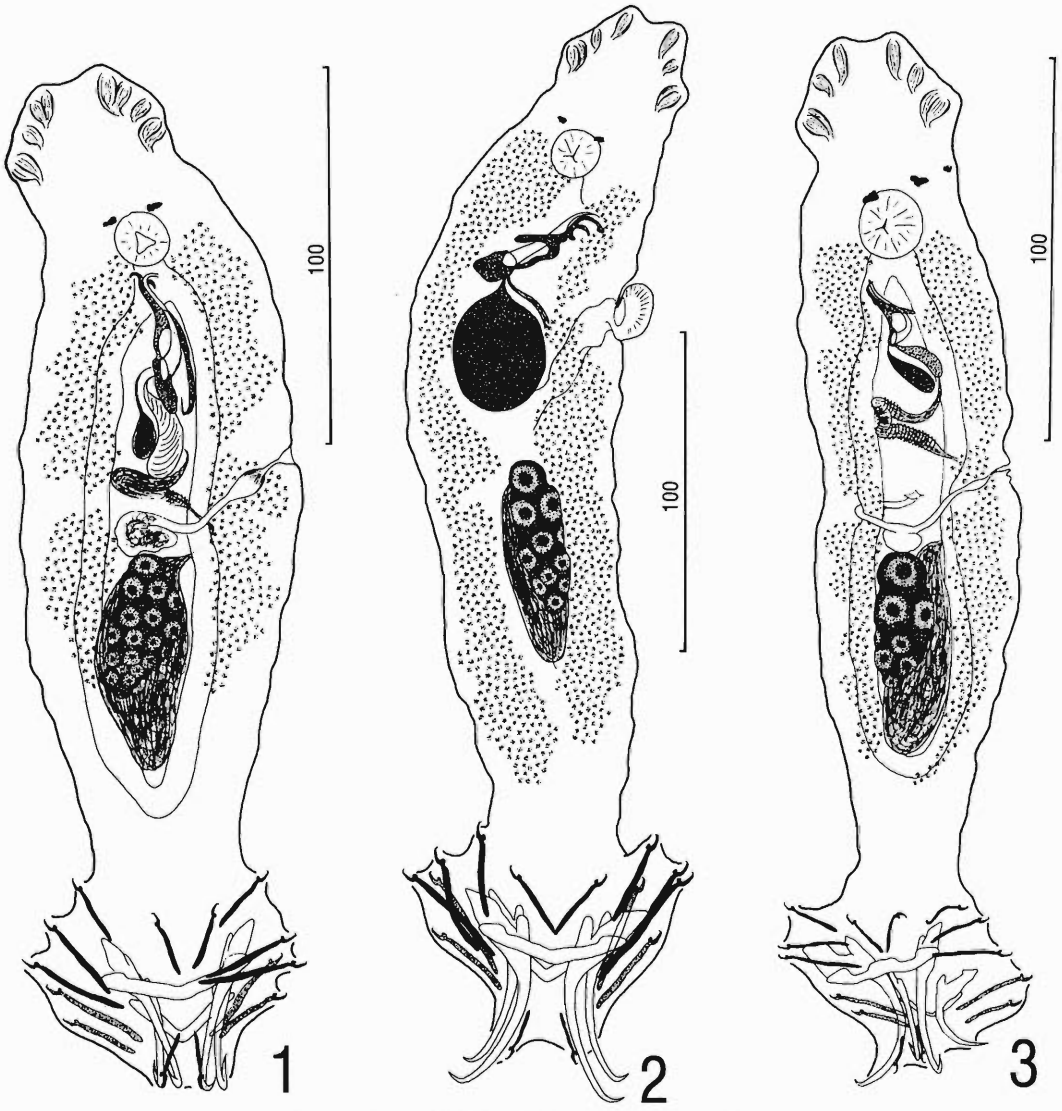
Calpidothecium crescentis (Mizelle and Price, 1965) comb. n. (Figs. 1, 4–11)

SYNONYM: *Urocleidus crescentis* Mizelle and Price, 1965.

RECORDS: *Pygopristis denticulata*: Rio Uatumã, Lago Tapaná, near Santana, Amazonas (58°00′W 02°38′S) (3 November 1989); Rio Xingu, Parana Maxipana, Pará (52°02′ 12″W 02°17′ 41″S) (17, 18 October 1992); Rio Araguari, Lago Comprido, Amapá (50°08′ 12″W 01°22′21″N) (15 August 1992).

PREVIOUS RECORD: *Pygocentrus nattereri* (type host). Amazon River (type locality). The original host was obtained from Steinhart Aquarium, San Francisco, California (Mizelle and Price, 1965).

SPECIMENS STUDIED: Holotype from *Pygocentrus nattereri*, USNPC 60465; 47 vouchers from *Pygopristis denticulata*, USNPC 85891, 85892, 85893.



Figs. 1–3. Whole mount illustrations of *Calpidothecium* spp. and *Calpidothecioides pygopristi* sp. n. (composite, ventral views). Fig. 1. *Calpidothecium crescentis* (Mizelle and Price, 1965) comb. n. (from *Pygopristis denticulata*). Fig. 2. *Calpidothecium serrasalmus* (Mizelle and Price, 1965) comb. n. (from *Pygopristis denticulata*). Fig. 3. *Calpidothecioides pygopristi* sp. n. All drawings are to respective 100-μm scales.

REDESCRIPTION: Body 275 (206–341; n = 13) long; greatest width 75 (56–94; n = 13) near midlength or in anterior trunk. Tegument infrequently with scaled annulations in posterior trunk, peduncle. Cephalic lobes moderately developed. Accessory eye granules usually present in cephalic, anterior trunk regions. Pharynx spherical, 15 (12–18; n = 13) in diameter. Peduncle broad; haptor 74 (64–89; n = 13) long, 83 (62–98; n = 13) wide. Anchors similar; each with depressed superficial root, prominent deep root, moderate to long shaft, short point; ventral anchor 46 (41–50; n = 23) long, base 17 (14–18; n = 19) wide; dorsal anchor 38 (35–40; n = 23) long, base 12 (11–14; n = 18) wide. Ventral bar 38 (36–40; n = 12) long, bent at midlength, with subterminal, terminal enlargements; dorsal bar 32 (30–33; n = 11) long, broadly U- or V-shaped, with slightly enlarged ends directed laterally. Hook pair 1—20 (18–22; n = 12),

pair 2—22 (21–25; n = 15), pair 3—27 (25–29; n = 18), pair 4—29 (27–31; n = 12), pair 5—14–15 (n = 15), pair 6—21 (19–23; n = 14), pair 7—28 (26–30; n = 16) long. Copulatory organ 28 (25–32; n = 23) long, tapered, usually recurved distally; base with sclerotized margin, prominent proximal flap. Accessory piece 33 (29–36; n = 25) long; proximal articulation process elongate, flattened; distal rod with free proximal end, bifurcate distally. Testis pyriform, 54 (42–64; n = 6) long, 27 (19–31; n = 6) wide; germarium subovate, 53 (38–67; n = 6) long, 18 (16–19; n = 6) wide. Dextral loop of vas deferens (seminal vesicle) conspicuous; sinistral prostatic reservoir with spiralling muscular wall. Oviduct, ootype, uterus not observed; vaginal pore a simple indentation of tegument, vagina having subterminal dilation with inverted funnel-shaped series of sclerotized ridges; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: This species, originally placed in *Urocleidus* by Mizelle and Price (1965), is the type species of *Calpidothecium* gen. n. It differs from *C. serrasalmus* by possessing a bifurcate end of the distal rod of the accessory piece and by lacking a fleshy pad immediately posterior to the vaginal pore.

Calpidothecium serrasalmus (Mizelle and Price, 1965) comb. n. (Figs. 2, 12–20)

SYNONYM: *Cleidodiscus serrasalmus* Mizelle and Price, 1965.

RECORD: *Pygopristis denticulata*: Rio Uatumã, Lago Tapaná, near Santana, Amazonas (58°00′W 02°38′S) (3 November 1989).

PREVIOUS RECORD: *Pygocentrus nattereri* (type host). Amazon River (type locality). The original host was obtained from Steinhart Aquarium, San Francisco, California (Mizelle and Price, 1965).

SPECIMENS STUDIED: Holotype from *Pygocentrus nattereri*, USNPC 60464; 2 vouchers from *Pygopristis denticulata*, USNPC 85894.

REDESCRIPTION: Body 340 (334–345; n = 2) long; greatest width 87 (75–99; n = 2) in anterior trunk. Tegument smooth. Cephalic lobes moderately developed. Eyes 2, anterior cluster of eye granules infrequent; granules small; accessory granules absent (1 granule found in position of missing anterior eye in 1 specimen). Pharynx spherical, 15 (n = 1) in diameter. Peduncle broad; haptor 88 (87–90; n = 2) long, 103 (85–121; n = 2) wide. Anchors similar; each with depressed superficial root, prominent deep root, elongate shaft, short point; ventral anchor 62 (61–64; n = 2) long, base 21–22 (n = 2) wide; dorsal anchor 55 (n = 2) long, base 16 (14–17; n = 2) wide. Ventral bar 45 (n = 1) long, slightly bent near midlength, with enlarged terminations; dorsal bar 41 (n = 1) long, V-shaped, with enlarged ends. Hook pairs 1, 6—25–26 (n = 4), pair 2—27–28 (n = 2), pair 3—31 (29–32; n = 2), pairs 4, 7—34 (32–35; n = 4), pair 5—17 (n = 2) long. Copulatory organ 40 (32–48; n = 2) long, a broad straight tube with arcuate diagonal aperture; base with sclerotized margin, short proximal flap. Accessory piece 32 (28–35; n = 2) long; distal rod with 3 distal branches. Gonads subovate; testis 46 (n = 1) long, 21 (n = 1) wide; germarium 47 (n = 1) long, 18 (n = 1) wide. Seminal vesicle not observed; 1 prostatic reservoir observed, large, saccate. Oviduct, ootype, uterus, seminal receptacle not observed; vagina with light to minimal sclerotization at aperture, opening in anterior trunk, dilated, protruding pad posterior to aperture; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: Although some features of the internal anatomy could not be determined from the holotype and 2 voucher specimens, this species is assigned to *Calpidothecium* based on presence of terminal branches of the distal rod of the accessory piece, comparative morphology of the anchors and bars, and the position of the vaginal aperture. *Calpidothecium serrasalmus* differs from *C. crescentis* by possessing larger haptoral sclerites and in the comparative morphology of the copulatory organs.

Calpidothecioides gen. n.

DIAGNOSIS: Body fusiform, comprising cephalic region, trunk, peduncle, haptor, Tegument thin, smooth, or with scaled annulations. Two terminal, 2 bilateral cephalic lobes; head organs, unicellular cephalic glands present. Eyes 2; granules elongate ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; intestinal ceca 2, confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens looping left intestinal cecum; seminal vesicle comprising a dextral loop of vas defer-

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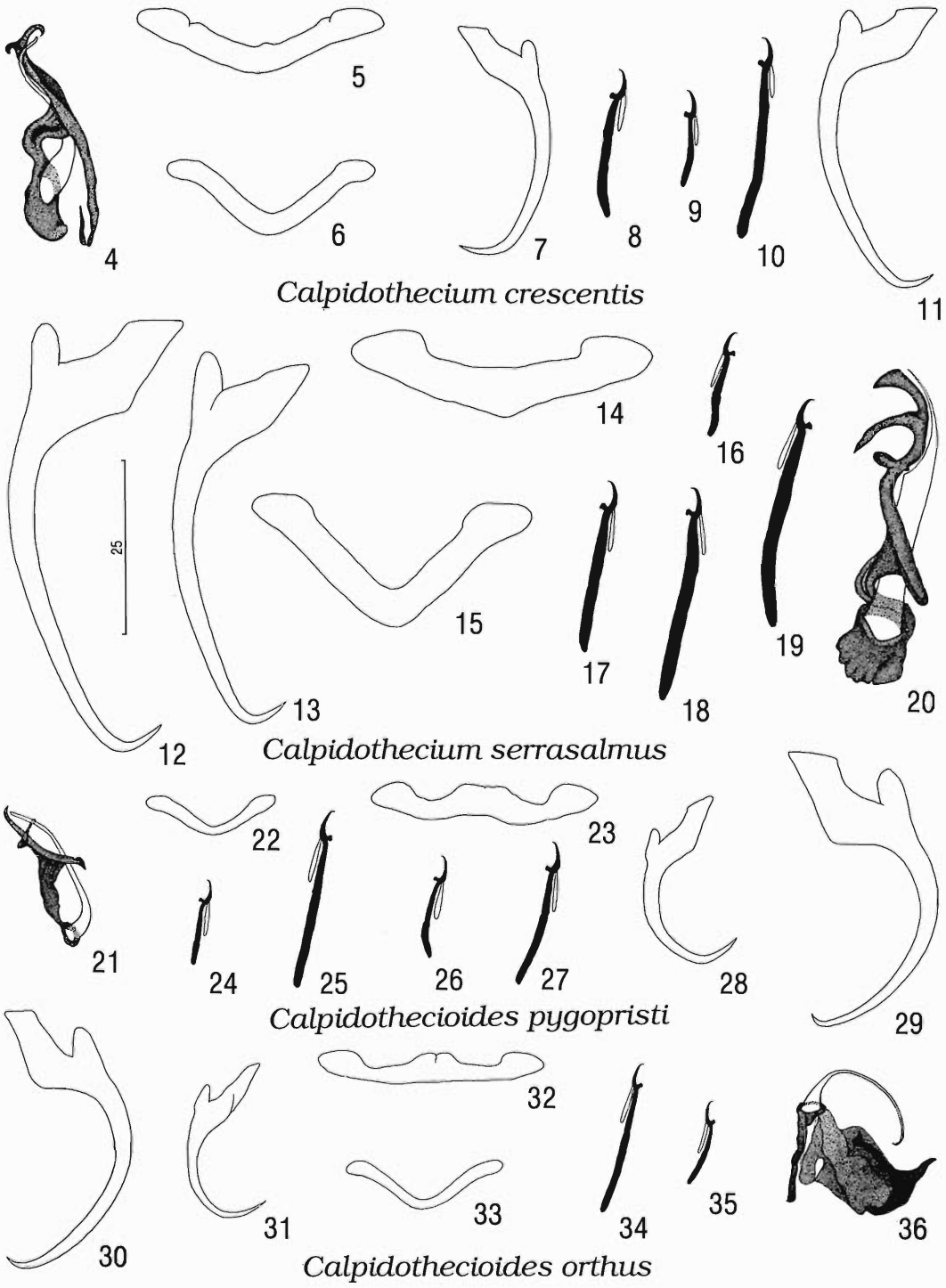


Figs. 4–36. Sclerotized structures of *Calpidothecium* spp. and *Calpidothecioides* spp. Figs. 4–11. *Calpidothecium crescentis* (Mizelle and Price, 1965) comb. n. (from *Pygopristis denticulata*). Fig. 4. Copulatory complex (ventral view). Fig. 5. Ventral bar. Fig. 6. Dorsal bar. Fig. 7. Dorsal anchor. Fig. 8. Hook pair 1. Fig. 9. Hook pair 5. Fig. 10. Hook pair 7. Fig. 11. Ventral anchor. Figs. 12–20. *Calpidothecium serrasalmus*

ens, with circular muscles in wall. Two saccate prostatic reservoirs; prostates comprising glandular areas in dorsal field of anterior trunk. Genital pore midventral near level of cecal bifurcation. Copulatory complex comprising articulated copulatory organ, accessory piece; copulatory organ tubular, single ramus opening terminally; distal rod of accessory piece sigmoid, proximal articulation process present. Vagina double, nonsclerotized; sinistral branch opening sinistrolaterally; dextral branch looping right cecum, opening on middorsal surface of trunk; vaginal ducts leading to anterior wall of seminal receptacle; seminal receptacle lying on midline anterior to germarium. Haptor subhexagonal; with pairs of dorsal and ventral anchor/bar complexes, 7 pairs of hooks with ancyrocephaline distribution. Hooks similar; each with delicate point, truncate protruding thumb, expanded shank comprising 2 subunits; proximal subunit variable in length between hook pairs. FH loop extending to union of shank subunits. Ventral bar lacking anteromedial projection. Parasites of gills of serrasalmid fishes.

TYPE SPECIES: *Calpidothecioides pygopristi* sp. n. from *Pygopristis denticulata*.

OTHER SPECIES: *Calpidothecioides orthus* (Mizelle and Price, 1965) comb. n. from *Pygocentrus nattereri*.

REMARKS: *Calpidothecioides* is characterized by species with a double vagina (left branch opening sinistrolaterally, right branch looping the right cecum and opening on the dorsomedial body surface), 1 pair of eyes, overlapping gonads, a seminal vesicle comprising a dextral loop of the vas deferens, and a simple termination of the distal rod of the accessory piece. The feature differentiating this genus from its apparent sister taxon, *Calpidothecium*, is presence of a double vagina (single sinistral branch in *Calpidothecium*). The generic name indicates similarity of this genus to *Calpidothecium*.

Calpidothecioides pygopristi sp. n. (Figs. 3, 21–29)

TYPE HOST AND LOCALITY: *Pygopristis denticulata*: Rio Uatumã, Lago Tapaná, near Santana, Amazonas (58°00′W 02°38′S) (3 November 1989).

OTHER RECORDS: *Pygopristis denticulata*: Rio Xingu, Parana Maxipana, Pará (52°02′ 12″W 02°17′ 41″S) (17, 18 October 1992); Rio Araguari, Lago Comprido, Amapá (50°08′ 12″W 01°22′ 21″N) (15 August 1992).

SPECIMENS STUDIED: Holotype, INPA PLH 332; 17 paratypes, INPA PLH 333, PLH 334, PLH 335, USNPC 85895, 85896, 85897, HWML 38618.

DESCRIPTION: Body 275 (273–277; $n = 2$) long; greatest width 60 (56–64; $n = 2$) at various levels in trunk. Tegument infrequently with scaled annulations on posterior trunk, peduncle. Cephalic lobes moderately developed. Accessory eye granules usually absent, occasionally in cephalic, anterior trunk regions. Pharynx spherical, 18 ($n = 2$) in diameter. Peduncle broad; haptor 58 (57–59; $n = 2$) long, 69 (66–71; $n = 2$) wide. Ventral anchor 40 (38–42; $n = 15$) long, with large depressed superficial root, prominent deep root, evenly curved shaft and point, tip of point recurved; base 15 (13–17; $n = 12$) wide. Dorsal anchor 25 (23–27; $n = 10$) long, with elongate depressed superficial root, short deep root, curved shaft, elongate point; base 11 (10–12; $n = 9$) wide. Ventral bar 32 (31–33; $n = 2$) long, thickened medially, with enlarged terminations; dorsal bar 21 ($n = 2$) long, delicate, broadly V-shaped, with slightly enlarged ends. Hook pairs 1, 5—15 (14–16; $n = 13$), pairs 2, 6—17 (16–19; $n = 12$), pair 3—21 (19–23; $n = 5$), pair 4—23 (22–24; $n = 5$), pair 7—27 (25–28; $n = 6$) long. Copulatory organ 21 (18–23; $n = 13$) long, delicate, tapered; base with sclerotized margin, lacking proximal

←

(Mizelle and Price, 1965) comb. n. (from *Pygopristis denticulata*). Fig. 12. Ventral anchor. Fig. 13. Dorsal anchor. Fig. 14. Ventral bar. Fig. 15. Dorsal bar. Fig. 16. Hook pair 5. Fig. 17. Hook pair 1. Fig. 18. Hook pair 3. Fig. 19. Hook pair 7. Fig. 20. Copulatory complex (ventral view). Figs. 21–29. *Calpidothecioides pygopristi* sp. n. Fig. 21. Copulatory complex (ventral view). Fig. 22. Dorsal bar. Fig. 23. Ventral bar. Fig. 24. Hook pair 5. Fig. 25. Hook pair 7. Fig. 26. Hook pair 1. Fig. 27. Hook pair 3. Fig. 28. Dorsal anchor. Fig. 29. Ventral anchor. Figs. 30–36. *Calpidothecioides orthus* (Mizelle and Price, 1965) comb. n. Fig. 30. Ventral anchor. Fig. 31. Dorsal anchor. Fig. 32. Ventral bar. Fig. 33. Dorsal bar. Fig. 34. Hook pair 7. Fig. 35. Hook pair 1. Fig. 36. Copulatory complex. All drawings are to the 25-μm scale.

flap. Distal rod of accessory piece 15 (14–17; n = 15) long, terminally acute; articulation process with free terminal projection. Gonads subovate; testis 49 (n = 1) long, 24 (n = 1) wide; germarium 37 (n = 1) long, 20 (n = 1) wide. Seminal vesicle comprising a slight dilation of dextral loop of vas deferens, encircled by muscular fibers. Oviduct, ootype, uterus not observed; vaginal pores lightly sclerotized; seminal receptacle small; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: *Calpidothecioides pygopristi* resembles *C. orthus* in morphology of the haptoral armament. It differs from this species by lacking an elongate proximal flap on the base of the copulatory organ and by possessing a free termination of the articulation process of the accessory piece. The specific name is derived from the generic epithet of its host.

Calpidothecioides orthus (Mizelle and Price, 1965) comb. n. (Figs. 30–36)

SYNONYM: *Urocleidus orthus* Mizelle and Price, 1965.

PREVIOUS RECORD: *Pygocentrus nattereri*: Amazon River (type locality). The original host was obtained from Steinhart Aquarium, San Francisco, California (Mizelle and Price, 1965).

SPECIMEN STUDIED: Holotype, USNPC 60466.

REMARKS: The holotype (the only known specimen of this species) is mounted unstained in glycerine jelly and is twisted, with the anterior end in lateral view and the posterior end in a dorsoventral orientation. Haptoral structures closely resemble those of *Calpidothecioides pygopristi*. Details of the copulatory complex are problematical in the holotype in that the complex apparently was damaged during slide preparation (Fig. 36). The elongate proximal flap of the base of the copulatory organ appears to be composed of a different substance from that of the remaining portion of the base, and it may be an artifact. The distal rod of the accessory piece is apparently displaced, and the articulation process may have been broken away from the base of the copulatory organ; the lightly stippled portion of Figure 36 may be an artifact resulting from this damage.

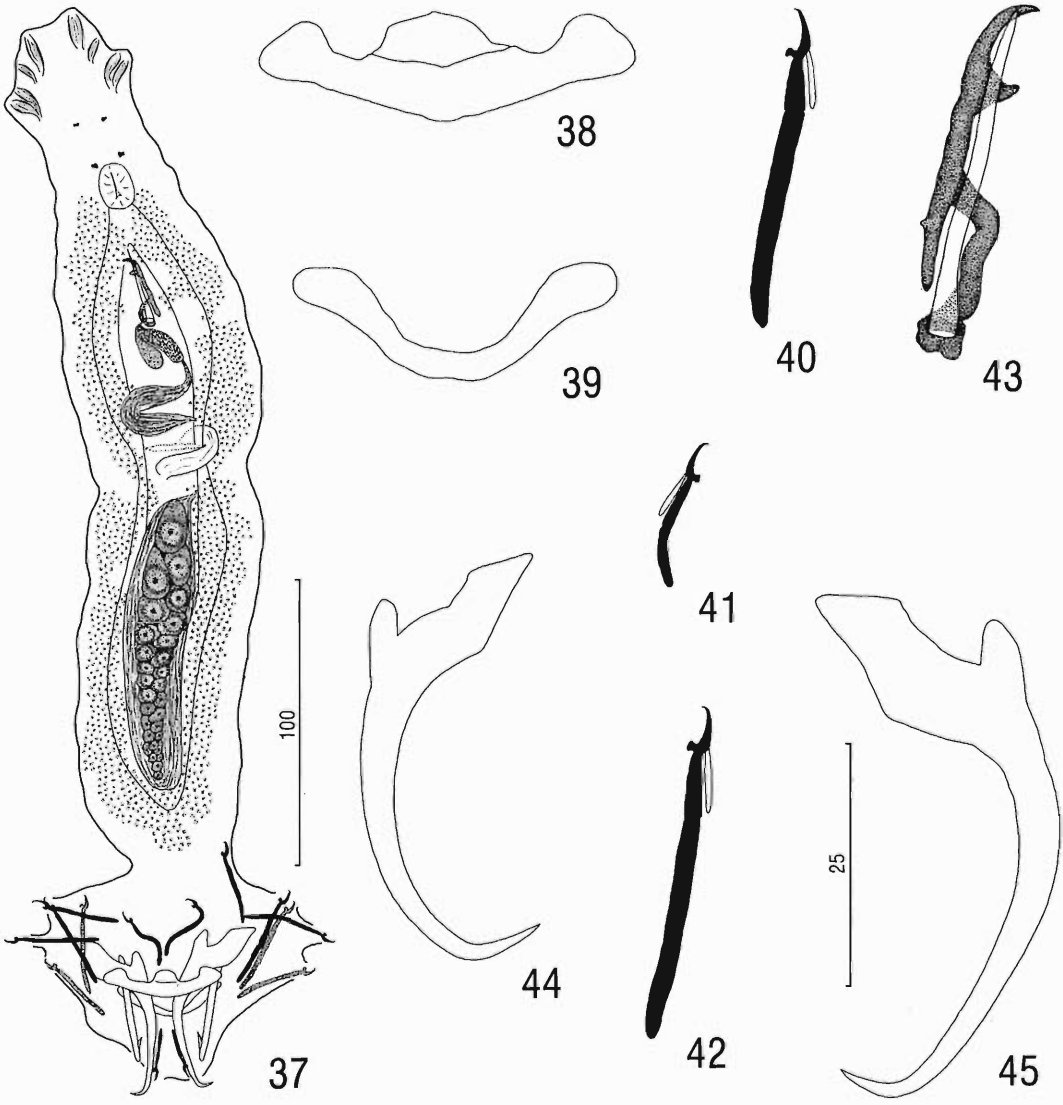
The assignment of this specimen to *Calpidothecioides* is based on the comparative morphology of the haptoral armament and copulatory complex and presence of a single pair of eyes. Details of the internal anatomy could not be determined from the unstained holotype.

Odothecium gen. n.

DIAGNOSIS: Body fusiform, comprising cephalic region, trunk, peduncle, haptor. Tegument thin, smooth. Two terminal, 2 bilateral cephalic lobes; head organs present; cephalic glands unicellular, lateral or posterolateral to pharynx. Eyes 4; granules elongate ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; intestinal ceca 2, confluent posterior to gonads, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens apparently looping left intestinal cecum; seminal vesicle a C-shaped dilated loop of vas deferens extending into right half of trunk; 2 saccate prostatic reservoirs. Copulatory complex comprising articulated copulatory organ, accessory piece; copulatory organ with single ramus; accessory piece comprising distal rod, proximal articulation process. Seminal receptacle absent; vagina looping left intestinal cecum, dilated, nonsclerotized, opening on middorsal surface near body midlength. Genital pore midventral near level of intestinal bifurcation. Vitellaria coextensive with intestine. Haptor subhexagonal, with dorsal and ventral anchor/bar complexes, 7 pairs of hooks with ancyrocephaline distribution. Hooks similar; each with delicate point, truncate protruding thumb, expanded shank comprising 2 subunits; proximal subunit variable in length between hook pairs. FH loop extending to union of shank subunits. Ventral bar with shield-like anteromedial process. Parasites of gills of serrasalmid fishes.

TYPE SPECIES: *Odothecium raphidiophallum* sp. n. from *Catoprion mento*.

REMARKS: *Odothecium* is monotypic and is characterized by helminths with a single vagina looping the left cecum and opening on the middorsal body surface, 2 pairs of eyes, overlapping gonads, a seminal vesicle representing a dextral loop of the vas deferens, and a hook-shaped termination of the distal rod of the accessory piece. It is apparently related to *Notothecioides*, from which it differs by including species with a dextral loop of the vas deferens, a shield-like anteromedial process on the ventral bar, a dilated vagina, and a fusiform body. The generic name



Figs. 37–45. ***Odothecium raphidiophallum*** **sp. n. Fig. 37. Whole mount (composite, ventral view). Fig. 38. Ventral bar. Fig. 39. Dorsal bar. Fig. 40. Hook pair 1. Fig. 41. Hook pair 5. Fig. 42. Hook pair 7. Fig. 43. Copulatory complex (dorsal view). Fig. 44. Dorsal anchor. Fig. 45. Ventral anchor. All figures are drawn to the 25-μm scale, except Fig. 37. (100-μm scale).**

is from Greek (*hodos* = a way + *theke* = a small case).

Odothecium raphidiophallum sp. n. (Figs. 37–45)

TYPE HOST AND LOCALITY: *Catoprion mento*: Balbina, Rio Uatumã, Amazonas (59°28′22″W 01°53′15″S) (20 September 1985).

OTHER RECORDS: *Catoprion mento*: Rio Uatumã, Lago Tapaná, near Santana, Amazonas (58°00′W 02°38′S) (3 November 1989); Furo do Catalão, Manaus, Amazonas (59°55′W 03°09′S) (5 January 1989).

SPECIMENS STUDIED: Holotype, INPA PLH 336; 17 paratypes, INPA PLH 337, PLH 338, USNPC 85898, 85899, 85900, HWML 38619.

DESCRIPTION: Body with constriction near midlength, 387 (324–442; n = 7) long; greatest

width 87 (72–107; n = 10) in anterior trunk. Cephalic lobes moderately developed. Eyes equidistant; posterior eyes larger than anterior eyes; accessory granules absent. Pharynx ovate, 17 (15–19; n = 11) wide. Peduncle broad; haptor 83 (78–89; n = 11) long, 104 (87–116; n = 11) wide. Anchors similar; each with elongate depressed superficial root, prominent deep root, elongate shaft, short to moderately long point. Ventral anchor 57 (54–59; n = 6) long, base 23 (22–24; n = 6) wide; dorsal anchor 45–46 (n = 4) long, base 17 (14–18; n = 4) wide. Ventral bar 40 (38–41; n = 9) long, bent at midlength, with enlarged ends, anteromedial shield-like process short; dorsal bar 32 (30–34; n = 8) long, broadly U-shaped, with slightly enlarged ends directed laterally. Hook pairs 1, 3—38 (37–39; n = 5), pair 2—33 (32–34; n = 3), pair 4—42 (41–43; n = 3), pair 5—18–19 (n = 4), pair 6—28 (25–30; n = 5), pair 7—40 (38–42; n = 3) long. Copulatory organ 38 (34–42; n = 6) long, a straight slightly tapered tube; base with sclerotized margin, lacking flap. Distal rod of accessory piece 31 (27–33; n = 6) long, with large terminal hook, subterminal triangular thumb. Testis bacilliform, 97 (77–108; n = 8) long, 25 (22–28; n = 8) wide; germarium elongate pyriform, 97 (72–112; n = 9) long, 22 (18–30; n = 9) wide. Seminal vesicle delicate. Oviduct, ootype, uterus not observed.

REMARKS: By monotypy, *Odothecium raphidiophallum* is the type for the genus. Its name is derived from Greek (*rhaphidos* = a needle + *phallos* = penis) and refers to the shape of the copulatory organ.

Notothecioides gen. n.

DIAGNOSIS: Body fusiform, comprising cephalic region, trunk, peduncle, haptor. Tegument thin, smooth. Two terminal, 2 bilateral cephalic lobes; head organs, unicellular cephalic glands present. Eyes 4; granules elongate ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; intestinal ceca 2, confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens apparently looping left intestinal cecum; seminal vesicle comprising a sigmoid dilation of vas deferens. Two saccate prostatic reservoirs; prostates comprising bilateral glandular areas lying dorsal to anterior portions of ceca. Genital pore midventral near level of cecal bifurcation. Copulatory complex comprising articulated copulatory organ, accessory piece; accessory piece with distal rod, proximal articulation process. Vagina looping left intestinal cecum, opening on middorsal surface of trunk, with sclerotized plate at aperture; seminal receptacle present, a proximal dilation of vaginal duct. Haptor subhexagonal, with dorsal and ventral anchor/bar complexes, 7 pairs of similar hooks with ancyrocephaline distribution. Hooks similar; each with delicate point, truncate protruding thumb, expanded shank comprising 2 subunits; proximal subunit variable in length between hook pairs; FH loop extending to union of shank subunits. Ventral bar lacking anteromedial process. Parasites of gills of serrasalmid fishes.

TYPE SPECIES: *Notothecioides llewellyni* sp. n. from *Myleus torquatus* (type host) and *M. rubripinnis*.

REMARKS: *Notothecioides* is monotypic and is characterized by species with the vagina looping the left cecum and opening on the middorsal body surface, 2 pairs of eyes, overlapping gonads, a sigmoid seminal vesicle, and a simple or hook-shaped termination of the distal rod of the accessory piece. It differs from related genera, *Odothecium*, *Notothecium*, and *Enallothecium*, by lacking a dextral C-shaped loop of the vas deferens forming the seminal vesicle. In *Notothecioides* species, the seminal vesicle is a sigmoid dilation of the vas deferens lying in the left side of the trunk. The generic name indicates similarity of this genus to *Notothecium*.

Notothecioides llewellyni sp. n. (Figs. 46–55)

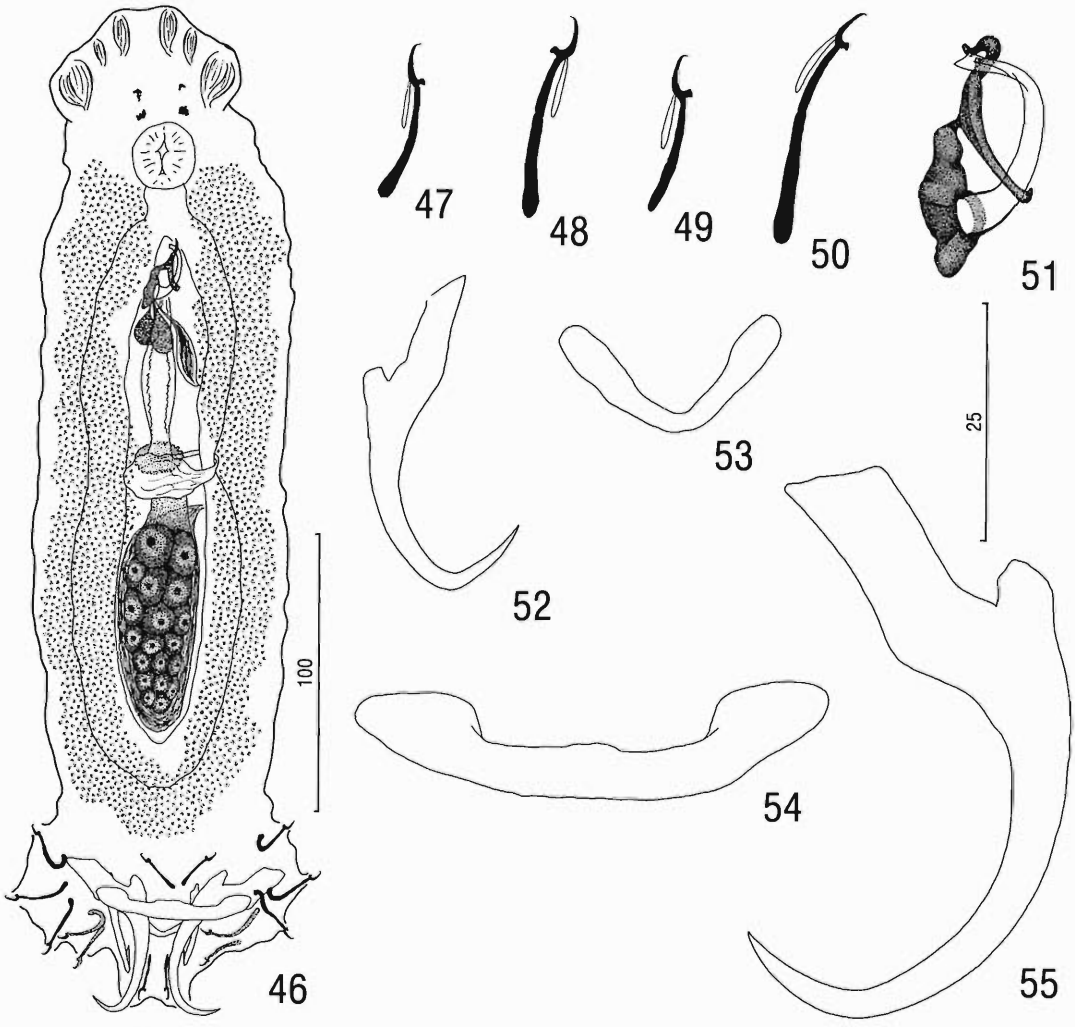
TYPE HOST AND LOCALITY: *Myleus torquatus*: Kaikuta, Rio Xingu, Pará (51°47′28″W 03°33′45″S) (12, 13 October 1992).

OTHER RECORD: *Myleus rubripinnis*: Nazaré, Rio Uatumã, Amazonas (59°57′20″W 01°30′S) (10 September 1985).

SPECIMENS STUDIED: Holotype, INPA PLH 339; 27 paratypes, INPA PLH 340, USNPC 85901, HWML 38620. 10 vouchers from *M. rubripinnis*, USNPC 85902.

COMPARATIVE MEASUREMENTS: Measurements of specimens from *M. rubripinnis* follow those of the type series in brackets.

DESCRIPTION: Body fusiform, 321 (266–371; n = 11) long; greatest width 96 (66–120; n = 14) near midlength. Cephalic lobes moderately



Figs. 46–55. ***Notothecioides llewellyni*** **sp. n. Fig. 46. Whole mount (composite, ventral view). Fig. 47. Hook pair 1. Fig. 48. Hook pair 2. Fig. 49. Hook pair 5. Fig. 50. Hook pair 7. Fig. 51. Copulatory complex (ventral view). Fig. 52. Dorsal anchor. Fig. 53. Dorsal bar. Fig. 54. Ventral bar. Fig. 55. Ventral anchor. All figures are drawn to the 25-μm scale, except Fig. 46 (100-μm scale).**

developed. Anterior eyes smaller than posterior eyes; accessory granules absent or present in cephalic, anterior trunk regions. Pharynx spherical, 20 (18–23; n = 14) in diameter. Peduncle broad to nonexistent; haptor 81 (77–86; n = 10) long, 95 (85–110; n = 11) wide. Ventral anchor 58 (55–60; n = 12) [50 (47–54; n = 9)] long, with large depressed superficial root, prominent deep root, evenly curved shaft, long point; base 26 (22–28; n = 11) [19 (17–21; n = 9)] wide. Dorsal anchor 34 (31–36; n = 12) [28 (27–32; n = 8)] long, with slender elongate superficial root, short deep root, curved shaft, long point; base 13 (12–14; n = 9) [9–10 (n = 6)] wide. Ventral bar 47 (46–49; n = 11) long, straight, with enlarged terminations; dorsal bar 24 (22–25; n = 9) long, V-shaped, with spatulate ends. Hook pair 1—18 (17–19; n = 8) [16–17 (n = 4)], pair 2—23 (22–24; n = 6) [18 (17–19; n = 7)], pair 3—24–25 (n = 5) [19–20 (n = 6)], pair 4—25–26 (n = 5) [21 (20–22; n = 6)], pair 5—17–18 (n = 11) [15–16 (n = 5)], pair 6—22 (21–23; n = 5) [19 (18–20; n = 5)], pair 7—28 (27–29; n = 3) [26 (23–29; n = 3)] long. Copulatory organ 28 (25–33; n = 13) [29 (25–32; n = 8)] long, arcuate, with flared opening; base with large

sclerotized margin. Distal rod of accessory piece 21 (18–26; n = 12) [25 (21–28; n = 8)] long, curved, variably bent distally, with indistinct thumb; proximal articulation process short. Gonads subovate; testis 56 (48–69; n = 5) long, 32 (25–45; n = 5) wide; germarium 52 (45–70; n = 9) long, 24 (19–32; n = 9) wide. Oviduct, ootype not observed; uterus with heavy wall; seminal receptacle midventral; vitellaria in trunk, except absent in regions of reproductive organs.

REMARKS: *Notothecioides llewellyni* is the type species for the genus. It is named for Dr. Jack Llewellyn, School of Biological Sciences, University of Birmingham, U.K., in recognition of his contributions to the biology and evolution of the Monogenoidea.

Acknowledgments

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Distribution and Prevalence of the Asian Fish Tapeworm, *Bothriocephalus acheilognathi*, in the Colorado River and Tributaries, Grand Canyon, Arizona, Including Two New Host Records

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ABSTRACT: The Asian fish tapeworm, *Bothriocephalus acheilognathi*, has invaded the lower Little Colorado River (LCR), a tributary of the Colorado River, where it infects humpback chub (*Gila cypha*), speckled dace (*Rhinichthys osculus*), and fathead minnow (*Pimephales promelas*). This study examined the distribution of *B. acheilognathi* in the Colorado River and tributaries in Grand Canyon. In 1994, 22.5% of humpback chub, 10.3% of plains killifish (*Fundulus zebrinus*), 3.8% of speckled dace, and 2.2% of fathead minnow were infected. In 1995, 2.4% of fathead minnow and 1.4% of speckled dace were infected. Humpback chub, an endangered species, and plains killifish are new host records for this parasite. Nearly all (66.7 to 100%) infected fish were captured in areas near the LCR and were probably the result of infected fish emigrating from that tributary. However, 4 infected fish (1 plains killifish, 1 speckled dace, and 2 fathead minnows) were caught 92.8 to 202.1 km downstream from the LCR. Another speckled dace was caught in the lower section of Kanab Creek, a warm tributary, indicating a potential expansion of the parasite's range. Infection of humpback chub by *B. acheilognathi* is of concern due to the endangered status of this fish. Because *B. acheilognathi* requires high water temperature for completion of its life cycle, this species is largely confined to the LCR by the cold water of the mainstem Colorado River. The potential effects of plans to seasonally warm the Colorado River on *B. acheilognathi* are discussed.

KEY WORDS: *Bothriocephalus acheilognathi*, Colorado River, humpback chub, speckled dace, fathead minnow, plains killifish, distribution, prevalence.

The closure of Glen Canyon Dam in 1963 turned the Colorado River in Grand Canyon from a seasonally warm and muddy river into a typically clear and constantly cold one due to hypolimnetic discharge from Lake Powell. The drastic changes in the riverine environment, particularly water temperature and turbidity, caused by the closure of Glen Canyon Dam, have had a severe negative impact on the native fishes in Grand Canyon (Minckley, 1991). Of the original 8 endemic fishes in Grand Canyon, reproducing populations of only 4 remain, one of which is endangered. Lost to this reach of the Colorado River are the Colorado squawfish (*Ptychocheilus lucius*), bonytail chub (*Gila elegans*), and roundtail chub (*G. robusta*), and the razorback sucker (*Xyrauchen texanus*) is extremely rare and probably not reproducing. Remaining are humpback chub (*G. cypha*; federally endangered), flannelmouth sucker (*Catostomus latipinnis*; category II), bluehead sucker (*Catostomus discobolus*), and speckled dace (*Rhinichthys osculus*). Reproduction of these fish is now largely restricted to a few perennial tributaries (AGFD, 1996); however, backwaters of the mainstem Colorado River are important rearing areas for larval and juvenile native and exotic fish (Holden, 1978; Valdez and Clemmer, 1982; Carter et al., 1985; AGFD, 1996).

Recently, a management proposal (Bureau of Reclamation, 1995) suggested the installation of a multilevel intake structure (MLIS) in Glen Canyon Dam to increase downstream water temperatures seasonally and improve conditions for native fish. Changing from hypolimnetic releases to epilimnetic releases in the spring may provide sufficient temperature elevation for increased mainstem reproduction and survival and growth of native young-of-the-year (YOY) fish. However, an important consideration of warming the river is the potential for an increase in the incidence of fish parasites and diseases.

The Asian fish tapeworm, *Bothriocephalus acheilognathi*, a pseudophyllidean cestode, was originally described from *Acheilognathus rhombea* in Japan (Yamaguti, 1934). It has spread to Europe, Russia, and North America with introductions of grass carp (*Ctenopharyngodon idella*) in the early 1970's (Hoffman and Shubert, 1984). *Bothriocephalus acheilognathi* is now well established in golden shiner (*Notemigonus crysoleucas*), red shiner (*Cyprinella lutrensis*),

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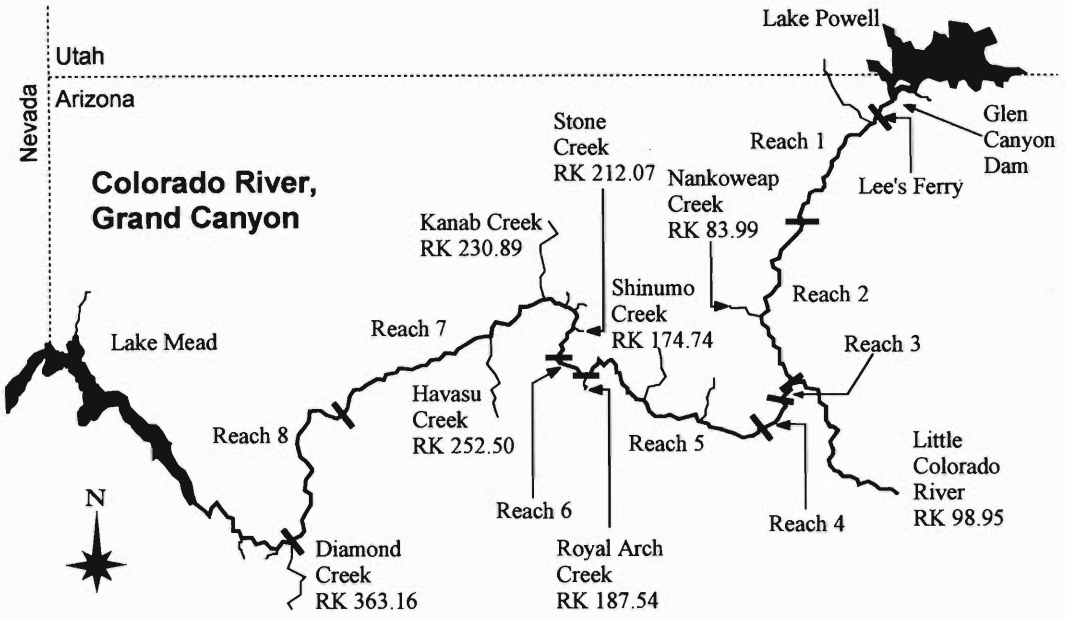

Figure 1. Boundaries (bars) of 8 designated fish sampling reaches and location of sampled tributaries of the Colorado River, Grand Canyon, Arizona. River kilometer (RK) is distance downstream from Lee's Ferry. Colorado River reach boundaries are as follows: Reach 1—Lee's Ferry (RK 0) to Shinumo Wash (RK 47.17); Reach 2—Shinumo Wash to Little Colorado River (RK 99.0); Reach 3—LCR to Lava Chuar Rapid (RK 105.44); Reach 4—Lava Chuar Rapid to Hance Rapid (RK 123.47); Reach 5—Hance Rapid to Elve's Chasm (Royal Arch Creek, RK 187.54); Reach 6—Elve's Chasm to Forster Rapid (RK 197.68); Reach 7—Forster Rapid to Hell's Hollow (RK 293.78); Reach 8—Hell's Hollow to Diamond Creek (RK 363.16).

fathead minnow (*Pimephales promelas*), grass carp, and mosquitofish (*Gambusia affinis*) in the mid-south and southeastern United States (Hoffman and Schubert, 1984; Riggs and Esch, 1987). Heckmann et al. (1987) found *B. acheilognathi* in speckled dace (*Rhinichthys osculus*), red shiner, the endangered woundfin (*Plagopterus argentissimus*), Virgin River chub (*G. robusta seminuda*), and Virgin spinedace (*Lepidomeda mollispinis*) from the Virgin River, Utah, Nevada, and Arizona. Heckmann et al. (1993) found *B. acheilognathi* elsewhere in Nevada: in red shiner in the Muddy River, roundtail chub from the Moapa Power Plant cooling pond, and golden shiner from bait shops around Las Vegas. Font and Tate (1994) have also reported *B. acheilognathi* from native Hawaiian freshwater fish.

Cyclopoid copepods are the intermediate hosts of *B. acheilognathi* (Marcogliese and Esch, 1989a), and the definitive hosts are a broad range of fish, particularly cyprinids (Hoffman and Schubert, 1984). Temperatures in excess of 20°C are required for maturation of this cestode (Granath and Esch, 1983a). Currently, *B. acheilognathi* appears to be confined to the Little Colorado River (LCR), probably by cold mainstem water temperatures that do not reach 20°C (Stanford and Ward, 1991). Temperatures in many of the other tributaries throughout Grand Canyon are similar to those in the LCR (AGFD, 1996) and thus should be capable of colonization by *B. acheilognathi*. This study examined the present distribution and prevalence of *B. acheilognathi* in native and exotic fish of the Colorado River, Grand Canyon, and its tributaries.

Materials and Methods

Native and exotic fish were collected in 1994 and 1995. In 1994, as part of a diet study of small (<150 mm) fish, we attempted to collect 5 fish from each of 2 size classes, ≤30 mm and >30 mm total length, from each of the 8 mainstem Colorado River reaches (Figure 1) during each of 3 river trips. These species included: humpback chub, speckled dace, flannelmouth sucker, bluehead sucker, rainbow trout (*Oncorhynchus mykiss*), fathead minnow, and plains killifish (*Fundulus*

Table 1. Prevalence of *Bothriocephalus acheilognathi* in humpback chub and plains killifish collected from the Colorado River and tributaries, Grand Canyon, Arizona, 1994. Dashes indicate that no collections were attempted at that location.

Reach/Tributary	Humpback chub			Plains killifish		
	N	Number infected	Percent infected	*N*	Number infected	Percent infected
1	0	0	0.0	0	0	0.0
2	4	1	25.0	1	0	0.0
Nankoweap Creek	—	—	—	—	—	—
Little Colorado River	—	—	—	—	—	—
3	39	16	41.0	9	1	11.1
4	58	10	17.2	12	1	8.3
5	0	0	0.0	1	0	0.0
Shinumo Creek	—	—	—	—	—	—
Royal Arch Creek	—	—	—	—	—	—
6	9	0	0.0	5	1	20.0
7	7	0	0.0	1	0	0.0
Stone Creek	—	—	—	—	—	—
Kanab Creek	—	—	—	—	—	—
Havasu Creek	—	—	—	—	—	—
8	3	0	0.0	0	0	0.0
Total	120	27	22.5	29	3	10.3

zebrinus). In 1995, we further examined the distribution of this parasite by attempting to collect 5 speckled dace and 5 fathead minnows from each of the 8 reaches and 7 tributaries on each of 3 river trips. We were not permitted to collect humpback chub in 1995 due to its endangered status. Fish were collected using seines, hoop nets, dip nets, minnow traps, and electrofishing. Total length (TL; mm) and weight (g) of fish and date and location of capture (tributary or river kilometer (RK) downstream from Lee's Ferry) were recorded. Fish were then preserved in either 70% ethanol or 10% formalin, as field examination was not practical. In the laboratory, fish were examined to determine the presence or absence of Asian fish tapeworms in each fish. A representative specimen of *B. acheilognathi* has been deposited in the U.S. National Parasite Collection, Beltsville, Maryland (USPNC Coll. No. 86818).

Results

A total of 1,902 fish representing 7 species in 4 families was examined for *B. acheilognathi* in this study. These fish included all 4 remaining native species and 3 common exotic species. Species sampled included: humpback chub, speckled dace, and fathead minnow (Cyprinidae); plains killifish (Cyprinodontidae); bluehead and flannelmouth suckers (Catostomidae); and rainbow trout (Salmonidae).

In 1994, 1,669 fish were sampled from the mainstem Colorado River. Twenty-seven of 120 (22.5%) humpback chub (12 to 110 mm TL; $\bar{x}$ = 36.2 mm), 7 of 185 (3.8%) speckled dace (12 to 132 mm TL; $\bar{x}$ = 35.7 mm), 5 of 234 (2.2%) fathead minnows (12 to 78 mm TL; $\bar{x}$ = 35.1 mm), and 3 of 29 (10.3%) plains killifish (21 to 57 mm TL; $\bar{x}$ = 35.1 mm) were infected with *B. acheilognathi* (Tables 1, 2, and 3). None of 329 flannelmouth suckers (15 to 98 mm TL; $\bar{x}$ = 34.2 mm), 562 bluehead suckers (12 to 106 mm TL; $\bar{x}$ = 29.0), or 210 rainbow trout (22 to 416 mm TL; $\bar{x}$ = 267.4 mm) were infected.

In 1995, 148 speckled dace and 85 fathead minnows were examined from the Colorado River and 7 tributaries in Grand Canyon. Two of 85 (2.4%) fathead minnows and 2 of 148 (1.4%) speckled dace were infected with *B. acheilognathi*.

In both 1994 and 1995, the majority of the fish infected with *B. acheilognathi* were captured in the reach directly above (Reach 2) and 2 reaches directly below (Reaches 3 and 4) the confluence of the Little Colorado and Colorado rivers. Of the infected fish, all of the 27 humpback chub, 7 of 9 (77.8%) speckled dace, 5 of 7 (71.4%) fathead minnow, and 2 of 3 (66.7%) plains killifish were captured in this area. Of greater interest are the fish captured outside of this area. One infected fathead minnow was captured at RK 265.2 and another at RK 301.1. One infected plains killifish was captured at RK 191.8. An infected speckled dace was captured in Kanab Creek (RK 230.9) and another in a backwater at RK 266.6. No infected fish were

Table 2. Prevalence of *Bothriocephalus acheilognathi* in speckled dace collected from the Colorado River and tributaries, Grand Canyon, Arizona, 1994 and 1995. Dashes indicate that no collections were attempted at that location.

	1994			1995		
Reach/Tributary	*N*	Number infected	Percent infected	*N*	Number infected	Percent infected
1	7	0	0.0	0	0	0.0
2	18	0	0.0	3	0	0.0
Nankoweap Creek	—	—	—	6	0	0.0
Little Colorado River	—	—	—	11	1	9.1
3	16	2	12.5	13	0	0.0
4	17	4	23.5	15	0	0.0
5	0	0	0.0	1	0	0.0
Shinumo Creek	—	—	—	25	0	0.0
Royal Arch Creek	—	—	—	7	0	0.0
6	17	0	0.0	5	0	0.0
7	32	1	3.1	14	0	0.0
Stone Creek	—	—	—	3	0	0.0
Kanab Creek	—	—	—	4	1	25.0
Havasu Creek	—	—	—	24	0	0.0
8	78	0	0.0	17	0	0.0
Total	185	7	3.8	148	2	1.4

captured in Nankoweap, Shinumo, Royal Arch, Stone, or Havasu creeks.

Discussion

Bothriocephalus acheilognathi was found in 4 of 7 species of fish examined from the Colorado River, Grand Canyon: 3 cyprinids (humpback chub, speckled dace, and fathead minnow) and 1 cyprinodontid (plains killifish). The Colorado and lower Little Colorado rivers are new localities for this parasite, which likely invaded via infected nonnative fish species or copepods from the upper LCR. Although *B. acheilognathi* has not been documented in the upper LCR, common carp, fathead minnow, and plains killifish are all potential hosts of this parasite and are

Table 3. Prevalence of *Bothriocephalus acheilognathi* in fathead minnow collected from the Colorado River and tributaries, Grand Canyon, Arizona, 1994 and 1995. Dashes indicate that no collections were attempted at that location.

	1994			1995		
Reach/Tributary	*N*	Number infected	Percent infected	*N*	Number infected	Percent infected
1	0	0	0.0	0	0	0.0
2	17	0	0.0	3	1	33.3
Nankoweap Creek	—	—	—	0	0	0.0
Little Colorado River	—	—	—	8	0	0.0
3	78	0	0.0	16	0	0.0
4	36	3	8.3	18	1	6.3
5	0	0	0.0	0	0	0.0
Shinumo Creek	—	—	—	0	0	0.0
Royal Arch Creek	—	—	—	0	0	0.0
6	29	0	0.0	13	0	0.0
7	42	1	2.4	15	0	0.0
Stone Creek	—	—	—	0	0	0.0
Kanab Creek	—	—	—	7	0	0.0
Havasu Creek	—	—	—	0	0	0.0
8	32	1	3.1	5	0	0.0
Total	234	5	2.2	85	2	2.4

common upstream, in the perennial headwaters of the LCR in the White Mountains area of eastern Arizona. Although the middle portion of the LCR is ephemeral (from Lyman Lake to 21 km above the confluence with the Colorado River), infected fish or copepods may easily have been flushed downstream into the lower LCR during floods. Although Heckmann et al. (1987) found *B. acheilognathi* in speckled dace at Beaver Dam Wash, Virgin River, Arizona, it is highly unlikely that any of these fish moved down to Lake Mead, then upstream over 400 km and through many large rapids to the LCR. The paucity of infected fish in the lower part of the canyon and the absence of infected fish from the upper canyon, above the LCR, casts doubt on invasion of this area via migration up or down the Colorado River.

This is the first report in the refereed literature of *B. acheilognathi* in the endangered humpback chub. *Bothriocephalus acheilognathi* has been reported in humpback chub and speckled dace in the LCR in 1990 in an Arizona Game and Fish Department agency report (Clarkson and Robinson, 1993). This cestode was first discovered in the Grand Canyon in May 1990 in humpback chub from the LCR (C.O. Minckley, U.S. Fish and Wildlife Service, pers. comm.). Kaeding and Zimmermann (1983) examined 26 humpback chub for pathogens from the LCR and Colorado River from 1979 to 1981. They reported 13 bacteria, 6 protozoans, 1 fungus, and the parasitic copepod *Lernaea cyprinacea*, but not *B. acheilognathi*. Heckmann et al. (1987) and Heckmann et al. (1993) reported *B. acheilognathi* in the closely related roundtail chub. Infection of humpback chub by *B. acheilognathi* is expected since copepods were found in 7.2% of the humpback chub stomachs collected in 1994 (AGFD, 1996).

The occurrence of *B. acheilognathi* in 10.3% of the plains killifish examined is also the first report of this species as a host for this parasite. However, mosquitofish, another cyprinodontid, is also susceptible to this parasite (Granath and Esch, 1983b; Riggs and Esch, 1987; Marcogliese and Esch, 1989b). None of the 29 plains killifish examined from 1994 contained copepods in their stomachs (AGFD, 1996). Plains killifish is a surface feeder and is omnivorous, with insects and aquatic invertebrates being dominant food items (Shute and Allen, 1980), but they may also consume benthic material (Simon, 1946). Although copepods do not appear to be a dominant food item for plains killifish, infection with *B. acheilognathi* indicates that copepods are occasionally ingested.

Neither flannelmouth sucker, bluehead sucker, nor rainbow trout contained *B. acheilognathi*. Copepods were ingested by both species of suckers, more so by flannelmouth suckers (AGFD, 1996). Presumably, all species that ingested copepods were exposed to this parasite, since they were collected from the same sites as infected species. Therefore, since both sucker species contained copepods in their stomachs, it appears that they are not susceptible to infection by the Asian fish tapeworm. This result supports Heckmann et al. (1987), who found no *B. acheilognathi* in the 3 flannelmouth suckers they examined. No copepods were found in rainbow trout stomachs. Although most of the trout were caught upstream from the LCR, to our knowledge, *B. acheilognathi* has never been reported in salmonids.

Bothriocephalus acheilognathi was found in fish collected throughout the entire mainstream Colorado River and 2 tributaries from RK 97.9 to RK 301.1. However, the majority of the fish that were infected by *B. acheilognathi* were captured in reaches directly above and below the confluence of the Little Colorado and Colorado rivers (Reaches 2, 3, and 4) and were probably the result of fish emigrating from the LCR. The fish caught upstream from the LCR were captured in a backwater only 1.1 km from the mouth of the LCR and did not need to negotiate any rapids to get there. Therefore, it appears that *B. acheilognathi* is currently only able to complete its life cycle within the LCR.

Five infected fish were captured outside of the LCR and nearby reaches, at least 92.8 km and as far as 202.1 km downstream from the LCR. Of particular concern is the speckled dace captured in Kanab Creek. Water temperatures of Kanab Creek are warm enough to allow for reproduction by *B. acheilognathi*, with mean temperatures exceeding 20°C from May through August and reaching as high as 34°C (Otis, 1994; AGFD, 1996). Whether this occurrence of an infected speckled dace is indicative of a separate, reproducing population of *B. acheilognathi* or simply an infected fish that had emigrated downstream from the LCR is not clear. This fish was caught in the lower section (<500 m from the mouth) of Kanab Creek, so either alternative

is possible. In any event, since speckled dace and fathead minnow are resident and humpback chub are occasionally found in Kanab Creek (AGFD, 1996), the potential certainly exists for this parasite to become established in this tributary. Therefore, although the cold water temperature of the mainstem Colorado River seems to be limiting the distribution of this parasite, there is an indication that it may have colonized Kanab Creek. Further examination of the potential colonization of Kanab Creek by *B. acheilognathi* is warranted and planned.

Three of the 4 components for successful invasion by *B. acheilognathi* are present in the mainstem of the Colorado River, Grand Canyon. First, definitive hosts (native and exotic cyprinid fishes) are present throughout the river. Secondly, the intermediate host, cyclopoid copepods, are abundant in the mainstem of the Colorado River and are ingested by native and exotic fishes (AGFD, 1996). Thirdly, *B. acheilognathi* is present in the lower reaches of the LCR (Clarkson and Robinson, 1993). The fourth and apparently limiting factor is water temperature. Although the temperature in the mainstem of the Colorado River is currently too cold for the parasite to disperse throughout the entire Grand Canyon, the proposed MLIS could increase the water temperature in the mainstem by 3 to 10°C (Bureau of Reclamation, 1995). This could cause water in the mainstem to reach the minimum temperature required for *B. acheilognathi* to complete its life cycle. Even if main channel temperatures do not reach 20°C, backwater temperatures will certainly exceed 20°C and may permit *B. acheilognathi* to complete its life cycle in these habitats or improve the chances of its colonizing other tributaries.

The major factor affecting egg maturation, coracidium motility, growth, development of adult worms, and ultimately the size and composition of *B. acheilognathi* populations is water temperature. Granath and Esch (1983a) found that growth and development of this parasite was stimulated by temperatures above 25°C and that temperatures of 25 to 30°C maximized egg maturation, hatching, and coracidium motility. At temperatures outside that range, these activities were depressed. Temperatures exceeding 35°C caused a decrease in recruitment of this parasite in mosquitofish (Granath and Esch, 1983b). Water temperature in the LCR is suitable for *B. acheilognathi*, exceeding 20°C from May through September in 1993 and reaching as high as 26.1°C (Gorman, 1994). Conversely, temperatures in the main channel Colorado River are unsuitable for this parasite, reaching only 18.4°C from 1991 to 1994 (AGFD, 1996). Maximum backwater temperatures reached 28.0°C in shallow areas, suitable for *B. acheilognathi* to complete its life cycle. However, the water level in the Colorado River, Grand Canyon, fluctuates daily with the demand for electric power. This dynamic nature causes inundation and desiccation of backwaters, prevents these temperatures from being stable, and flushes zooplankton from the backwaters. Mean backwater temperatures never exceeded 20°C during 4 yr of study (AGFD, 1996). However, construction of an MLIS or implementation of steady flows, another suggested mitigation measure (U.S. Fish and Wildlife Service, 1994), will likely cause mean backwater temperatures to increase above 20°C and may regularly approach 25°C, aiding the completion of the life cycle of *B. acheilognathi*. Copepods inhabit backwaters, which are important rearing areas for larval and juvenile native and exotic fishes (AGFD, 1996). These fish are planktivorous and regularly ingest copepods (AGFD, 1996). Therefore, warming of the river may permit *B. acheilognathi* to expand its range beyond the LCR.

The infection rates for speckled dace (1.4 to 3.8%) and fathead minnow (2.2 to 2.4%) in this study were relatively low. Only 1.4% of the speckled dace and none of the fathead minnows sampled from 1994 contained copepods in their stomachs (AGFD, 1996). The fact that fathead minnows were infected with *B. acheilognathi* indicates that copepods are ingested. Clarkson and Robinson (1993) also found low prevalence (0.4%) in speckled dace from the LCR captured in 1991 but higher prevalence (17.0%) in 1992. Heckmann et al. (1987) found 17% of 107 speckled dace were infected from Beaver Dam Wash, Virgin River, Arizona. Riggs and Esch (1987) found prevalence of *B. acheilognathi* in fathead minnows in Belews Lake, North Carolina, to range from approximately 15 to 95%, depending on season and site. The low prevalence of *B. acheilognathi* in speckled dace and fathead minnow in our study may be due to the dynamic nature of the LCR. The base discharge of the LCR, approximately 5.6 m^3/s, comes from a series of springs approximately 21 km from the mouth (Minckley, 1991). However, flooding

is common in spring (rain and snow melt) and in late summer (monsoonal rains) and can exceed 850 m^3/s. Differences in the frequency and severity of these floods may have dramatic effects on copepod populations, which would then affect *B. acheilognathi* populations, as noted by Marcogliese and Esch (1989b). These low prevalences of *B. acheilognathi* in speckled dace and fathead minnow also reflect our inclusion of samples from areas where the parasite was not found.

The infection of humpback chub by *B. acheilognathi* (rates as high as 41% in Reach 3 and an overall infection rate of 22.5% in 1994) is of concern, considering the endangered status of this fish. Clarkson and Robinson (1993) reported infection rates in juvenile humpback chub in the LCR as high as 78.9% in 1990 and 77.8% in 1992 and as low as 12.4% in 1991 and 0% in 1989 (1989 may have been preinvasion). Valdez and Ryel (1995) reported finding *B. acheilognathi* in 3.6% of 168 adult (>250 mm) humpback chub. However, the prevalence of *B. acheilognathi* in these fish may have actually been higher since their data were from stomach contents obtained by flushing the gastrointestinal (GI) tract and may not have dislodged parasites from all infected fish. High intensity infections can lead to mortality by blockage of the GI tract, intestinal perforation, and/or destruction of the intestinal mucosa, killing the fish (Hoffman, 1980; Schäperclaus, 1986). The humpback chub in and around the Little Colorado River comprise the largest remaining population of this species (Maddux et al., 1993). Douglas and Marsh (1996) used various models to estimate population size of humpback chub (>150 mm TL) in Grand Canyon, which ranged from 4,508 to 10,444 fish. This small population size, high infection rates, and potential for mortality do not bode well for this endangered fish.

The proposed MLIS may increase water temperatures of the mainstem Colorado River 3 to 10°C (Bureau of Reclamation, 1995). This increase in mainstem water temperature may be high enough to allow *B. acheilognathi* to become established in other tributaries and possibly the mainstem of the Colorado River in Grand Canyon. This is a more likely scenario in streams further downstream from Glen Canyon Dam where the water is warmer. Increasing mainstem water temperature may initially increase growth and survival of YOY native fish. However, it may also prove to be detrimental to these fish in the long run, due to an increase in the prevalence of *B. acheilognathi* and/or other parasites and diseases.

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Redescription and Range Extension of *Spirocamallanus istiblenni* Noble, 1966 (Nematoda: Camallanidae) from Coral Reef Fishes in the Pacific

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ABSTRACT: The coral reef fish parasite *Spirocamallanus istiblenni* Noble, 1966 (Nematoda: Camallanidae) is redescribed from the type host (*Istiblennius zebra* [Blennidae]) and locality (O'ahu, Hawai'i). This nematode is also reported here from *Entomacrodus marmoratus* (Blennidae) and *Eleotris sandwicensis* (Eleotridae) from Hawai'i; *Bothus pantherinus* (Bothidae) from Fiji; and *Zebrasoma scopas* (Acanthuridae), *Bothus mancus*, *B. pantherinus* (Bothidae), *Lutjanus kasmira* (Lutjanidae), and *Mulloides flavolineatus* (Mullidae) from Moorea in French Polynesia. *Spirocamallanus istiblenni* is here reported for the first time from Fiji and French Polynesia. *Spirocamallanus philippinensis* Velasquez, 1980, is regarded as a species *inquirenda*.

KEY WORDS: Nematoda, Camallanidae, *Spirocamallanus istiblenni*, coral reef fishes, Fiji, French Polynesia, Hawai'i.

The intestinal parasite *Spirocamallanus istiblenni* Noble, 1966 (Nematoda: Camallanidae) was found in helminth surveys of coral reef associated fishes in Fiji (Suva Bay), Moorea (in the Society Islands of French Polynesia), and the islands of Hawai'i and O'ahu. Previously, this nematode has been reported from a blenny in O'ahu (Noble, 1966) and a wide variety of coral reef associated fishes in Okinawa, Japan (Hasegawa et al., 1991). While this parasite appears to have both a wide geographic distribution and host species range, and should therefore be well known to parasitologists studying fishes in the south Pacific, the available description of the species is not entirely diagnostic nor could diagnostic features be easily discerned from the syntypes deposited in the United States National Parasite Collection (USNPC). Thus, we redescribe *S. istiblenni* recovered from the type host in the type locality (the zebra blenny, *Istiblennius zebra* [Blennidae], in O'ahu, Hawai'i) and present measurements from conspecific worms from other host coral reef fishes in other localities in the south Pacific.

Materials and Methods

Nematodes from Moorea were killed in hot 70% EtOH and stored in 70% EtOH and 5% glycerin; those from Hawai'i were killed in Berland's fluid (9 parts glacial acetic acid: 1 part 100% formalin) and stored in 70% EtOH and 5% glycerin; and those from Fiji were killed in hot Bouin's fluid and stored in 70% EtOH. All nematodes were examined as temporary whole mounts in glycerin after clearing in alcohol–glycerin–phenol. Line drawings were made using a drawing tube, scanned into digital format, and final illustrations were prepared with Adobe Illustrator™. Measurements given are means and standard deviations followed by ranges in parentheses. All measurements are in micrometers.

Syntypes of *Spirocamallanus istiblenni* Noble, 1966 (1 male and 1 female, United States National Parasite Collection [USNPC] accession numbers 72590 and 72591, respectively) from *I. zebra* in Hawai'i were examined for the distribution of the male caudal papillae. Voucher specimens of *S. istiblenni* Noble, 1966, from Okinawa, Japan (USNPC 81816, 4 males and 4 females from *Bothus pantherinus*; USNPC 81817, 1 male from *Parapercis cylindrica*; USNPC 81818, 1 male from *Parapercis polythalma*; and USNPC 81819, 4 males from *Plectorhynchus picus*), and the type specimens of *S. monotaxis* Olsen, 1952 (1 male and 1 female, USNPC 37251) from *Monotaxis grandoculis* in Hawai'i were also examined for comparative purposes.

Results

Spirocamallanus istiblenni Noble, 1966 (Fig. 1)

REDESCRIPTION: Nematoda, Spirurida, Camallanoidea, Camallanidae, Procamallaninae, *Spirocamallanus*. Translucent red in life. Long slender worms. Anterior portion of buccal capsule thin and transparent in *en face* view with

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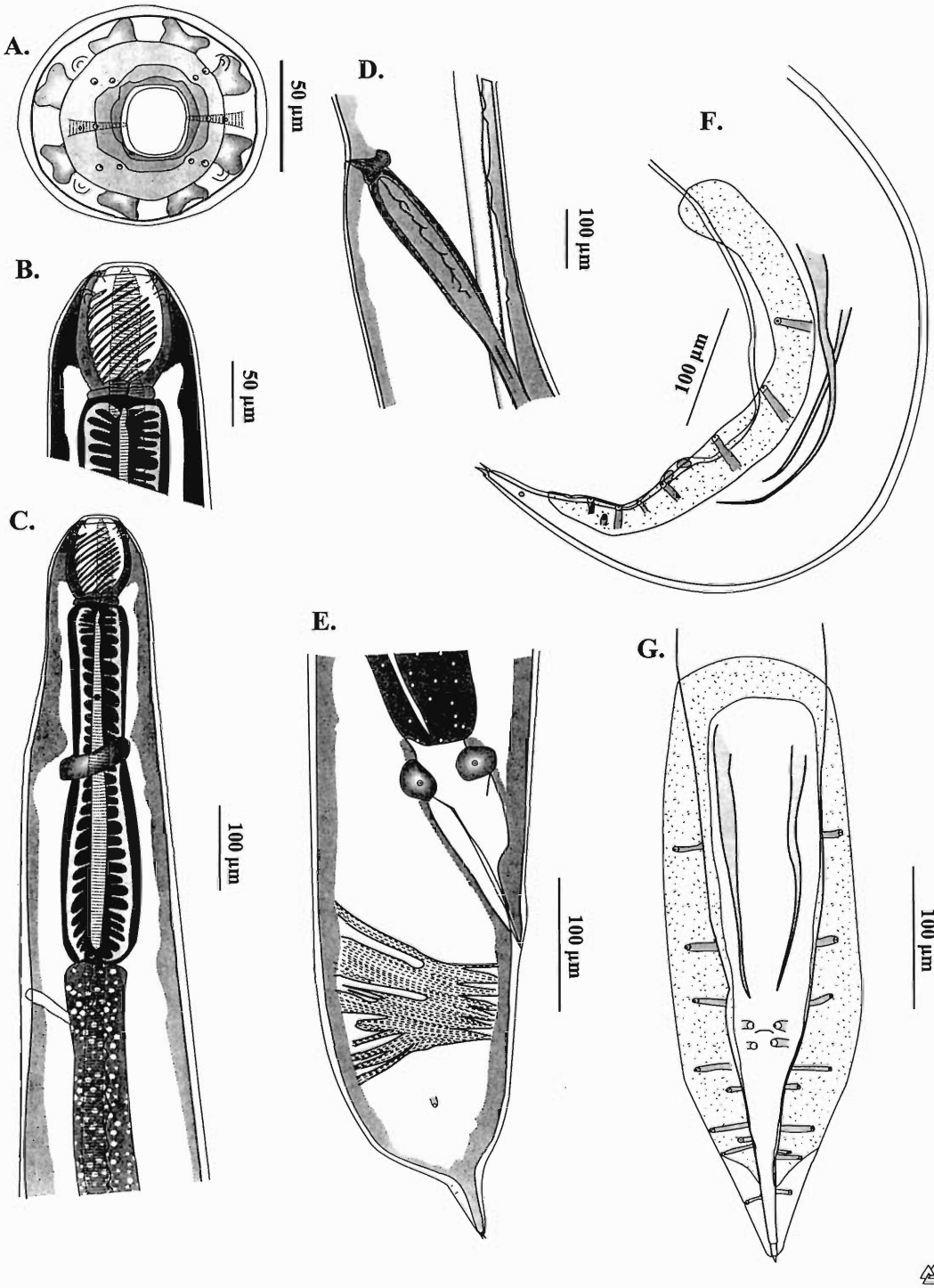

Figure 1. *Spirocamallanus istiblenni* **Noble, 1966. A. Apical view of female buccal region. B. Lateral view female buccal region. C. Lateral view of female anterior end. D. Lateral view of vulva from a nongravid female. E. Lateral view of female posterior end. F. Lateral view of male posterior end. G. Ventral view of male posterior end.**

lateral cords running to anterior margin of capsule. Oral opening oval to rectangular. Cephalic papillae arranged in 3 concentric rings with 6 papillae in the inner ring and 4 in each of the next 2 rings. Amphids lateral, at level of middle ring of cephalic papillae. Amphidial pouches conspicuous. Median teeth (see Petter and Thatcher [1988]) not seen. Lateral hypodermal cords prominent, running length of worm, rugose. Buccal capsule supported by 8 cuticular reinforcements to which cephalic muscles attach. Buccal capsule elongate, generally longer than wide, greatest width at two-thirds length from anterior margin, lined with spiral ridges (some discontinuous), with basal ring. Two cervical papillae (anterior deirids) present, lateral, usually two-thirds of distance from posterior margin of buccal capsule to nerve ring. Esophagus long and slender; divided into anterior claviform muscular portion and posterior glandular portion. Glandular esophagus projecting slightly into intestine in valve-like formation. Excretory pore near level of junction between muscular and glandular esophagus. Phasmids present. Tail of both sexes terminating with 2 spine-like projections (mucrons), 1 dorsal and 1 ventral, occasionally abraded.

MALE (4 specimens): Length 15,683 ± 1,335 (14,275–17,491), maximum width near midbody 258 ± 17 (233–271). Buccal capsule 89 ± 5 (83–94) long, including ring at base 7 ± 2 (5–9) long, 71 ± 1 (70–72) at widest point, length/width ratio 1.25 ± 0.05 (1.18–1.31). Buccal capsule with 13 ± 2 (12–15) spirals when counted diagonally, upper fifth smooth. Muscular esophagus 372 ± 16 (349–384) long, glandular esophagus 593 ± 51 (549–658) long, ratio 1.59 ± 0.1 (1.48–1.73). Cervical papillae 190 ± 22 (173–222) from apex. Nerve ring 244 ± 10 (230–252) from apex. Excretory pore 518 ± 35 (477–564) from apex. Anterior flexure of testis 2,324 ± 664 (1,460–3,072) from apex. Alae well developed, extend 476 ± 13 (463–491) from posterior extremity, posterior end of alae united ventrally 61 ± 3 (57–64) from posterior extremity. Caudal papillae 10; 3 preanal pedunculate papillae, 2 adanal pedunculate papillae not attached to alae, 5 postanal pedunculate papillae. Second preanal papilla 65% ± 4 (60–70) of distance from first to third papillae. First 2 postanal papillae grouped, separated from next 3. Fourth postanal papilla closer to fifth than third postanal papilla, distances between postanal papillae variable. Phasmids lateral, slightly posterior to union of alae, 47 ± 3 (43–50) from posterior extremity. Positions of caudal features measured on one side, expressed as percent of the distance from anterior union of alae to posterior extremity, as follows: first preanal papilla 31 ± 4 (27–35), second preanal papilla 50 ± 3 (47–52), third preanal papilla 60 ± 1 (59–61), anus 63 ± 1 (63–64), first postanal papilla 72 ± 2 (69–73), second postanal papilla 76 ± 1 (75–77), third postanal papilla 79 ± 2 (77–81), fourth postanal papilla 83 ± 2 (81–84), fifth postanal papilla 86 ± 3 (84–89), phasmid 91 ± 1 (90–92). Spicules 2, unequal, similar in shape, taper to fine point; left spicule (3 specimens) 198 ± 22 (185–223), right spicule (3 specimens) 281 ± 20 (263–302), ratio 1.42 ± 0.07 (1.35–1.50). Gubernaculum absent. Anus 171 ± 10 (158–181) from posterior extremity. Tail flexed ventrally, with prominent lateral muscle bands, gradually tapers to a point. Terminal spines 3 ± 0 (3–4) long.

FEMALE (1 specimen): Length 17,110, maximum width near midbody 311. Buccal capsule 101 long, including ring at base 5 long, 76 at widest point, length/width ratio 1.32. Buccal capsule with 15 spirals when counted diagonally, upper fifth smooth. Muscular esophagus 421 long, glandular esophagus 687 long, ratio 1.63. Cervical papillae 193 from apex. Nerve ring 275 from apex. Excretory pore 554 from apex. Anterior flexure of ovary 2,205 from apex. Vulva 7,435 or 43% of body length from apex. Vagina directed posteriorly from vulva, fusiform, muscular, vagina vera tapers gradually into vagina uterina, vagina vera 356 long, 81 at greatest width, vagina uterina 1,595 long, 25 wide. Uterus amphidelphic, posterior ovary reduced. Larvae present within voluminous uterus, occupying most of body cavity and obscuring ovary. Anus 167 from base of terminal digit, anal muscles prominent. Phasmids lateral, approximately halfway between anus and base of terminal digit, 59 from base of terminal digit. Tail rounded, with digit-like projection 48 long. Terminal spines 4 long.

HOST: *Istiblennius zebra* (Vaillant and Sauvage, 1875) (Perciformes, Blennidae).

SITE IN HOST: Intestines.

LOCALITY: Tide pools on Kaupo Beach near Waimanalo, O'ahu, Hawai'i.

DATE OF COLLECTION: January 1996.

OTHER LOCALITIES AND HOSTS: (1) Hawai'i

Table 1. Comparison of measurements of *Spirocamallanus istiblenni*. Measurements are in micrometers and given as ranges.

		Noble, 1966	Present study			
Locality		Oahu	Oahu	Hawaii	Hawaii	Fiji
Host(s)		*Istiblennius zebra*	*Istiblennius zebra*	*Eleotris sandwicensis*	*Entomacrodus marmoratus*	*Bothus pantherinus*
No. infected/examined		25/30	2/12	9/10	9/10	3/5
Mean intensity		5	2.0	4.6	3.5	1.7
Specimens examined	m	5	4	2	6	1
	f	9	1	5	6	4
Total length	m	14,900	14,274–17,491	8,334–9,802	8,118–12,255	14,494
	f	21,500	17,110	10,635–18,834	13,196–19,011	17,475–20,087
Buccal capsule	m	75 × 72	83–94 × 70–72	60–61 × 49–53	81–99 × 62–71	76 × 54
	f	77 × 77	101 × 76	67–74 × 58–60	85–101 × 73–79	74–90 × 58–64
Buccal spirals	m	13–14	12–15	13–15	13–16	11
	f	13–14	15	11–14	12–16	9–11
Muscular esophagusG	m	325	349–384	371–380	323–374	324
	f	397	421	383–496	387–463	363–419
landular esophagus	m	485	549–658	470–479	401–601	535
	f	588	687	519–723	599–683	451–669
Ratio G/M esophagi	m	1.49	1.48–1.73	1.24–1.29	1.13–1.78	1.65
	f	1.48	1.63	1.28–1.55	1.4–1.75	1.24–1.72
Deirid	m		173–222	159	174–252	177
	f		193	156–200	163–208	141–218
Nerve ring	m	208	230–252	214	243–305	214
	f	220	275	205–255	235–252	231–263
Excretory pore	m	400	477–564	356–452	408–501	
	f	400	554	404–543	497–550	457–506
Alae		400*	463–491	391–393	407–474	384
Spicule	l	184	185–223	159–170	171–203	171
	r	274	263–302	260–266	273–297	225
Spicule ratio		1.49	1.35–1.5	1.53–1.67	1.4–1.62	1.32
2nd preanal papilla relative to 1st and 3rd		74%*	61–70%	64–69%	64–74%	60%
Vulva %		38%	43%	46–51%	41–44%	36–48%

* : Indicates our measurements.

from *Entomacrodus marmoratus* (Perciformes, Blennidae) and *Eleotris sandwicensis* (Eleotridae); (2) Fiji from *Bothus pantherinus* (Pleuronectiformes, Bothidae); and (3) Moorea in French Polynesia from *Zebrasoma scopas* (Perciformes, Acanthuridae), *Lutjanus kasmira* (Lutjanidae), *Mulloides flavolineatus* (Mullidae), *Bothus mancus*, and *B. pantherinus* (Pleuronectiformes, Bothidae).

SPECIMENS DEPOSITED: (1) Hawai'i, 1 male and 1 female each from *Istiblennius zebra* (USNPC 86742), *Entomacrodus marmoratus* (Muséum National D'Histoire Naturelle [MNHN] 505 HF, USNPC 86743), *Eleotris sandwicensis* (MNHN 506 HF, USNPC 86744); (2) Fiji, 1 male and 1 female from *Bothus pantherinus* (USNPC 86747); and (3) Moorea in French Polynesia, 1 male and 1 female each from *Lutjanus kasmira* (MNHN 509 HF, USNPC 86748), *Mulloides flavolineatus* (MNHN 507 HF, USNPC 86745), and *B. pantherinus* (MNHN 508 HF, USNPC 86746).

PREVIOUSLY REPORTED: (1) Hawai'i from *Istiblennius zebra* (Perciformes, Blennidae) (see Noble [1966]) and (2) Okinawa, Japan, from *Valencienna strigata* (Perciformes, Gobiidae), *Plectorhynchus picus*, *Scolopsis bilineatus* (Haemulidae), *Parapercis cylindrica*, *P. polyphthalma* (Pinguipedidae), *Amphiprion clarkii* (Pomacentridae), *Variola albimarginata*, *V. louti* (Serranidae), *Bothus pantherinus* (Pleuronectiformes, Bothidae), and *Soleichthys heterorhinos* (Soleidae) (see Hasegawa et al. [1991]). (Some of this material may represent another species, and these records should be reevaluated.)

REMARKS: Worms similar to those found in

Table 1. Continued.

		Noble, 1966	Present study			
Locality		Moorea	Moorea	Moorea	Moorea	Moorea
Host(s)		*Zebrasoma scopas*	*Bothus mancus*	*B. pantherinus*	*Lutjanus kasmira*	*Mulloides flavolineatus*
No. infected/examined		1/18	1/1	4/4	2/2	3/5
Mean intensity		2	5	7.5	2	4.7
Specimens examined	m	1	1	6	2	6
	f	1		10	2	3
Total length	m	19,724	23,288	9,202–17,523	17,629–17,632	10,386–17,239
	f	27,033		14,639–27,902	22,105–24,745	16,975–35,387
Buccal capsule	m	67 × 63	77 × 72	68–86 × 51–78	83–86 × 66–67	64–70 × 60–67
	f	70 × 73		75–91 × 97–96	87–95 × 81–84	74–81 × 79–84
Buccal spirals	m	15	17	13–20	16–18	12–16
	f	12		8–18	11–12	12
Muscular esophagus	m	418	442	345–466	378–386	236–402
	f	456		365–568	469–503	418–505
Glandular esophagus	m	560	709	421–724	588–654	367–562
	f	664		487–772	764–779	442–775
Ratio G/M esophagi	m	1.34	1.6	1.14–1.57	1.55–1.69	1.18–1.56
	f	1.46		1.19–1.46	1.52–1.66	1.06–1.53
Deirid	m	171	211	128–205	160–204	124–175
	f	170		157–226	190–199	168–209
Nerve ring	m	248	262	206–277	243–253	194–236
	f	273		233–318	278–289	254–269
Excretory pore	m	536	634	377–556	461–507	452–491
	f	645		387–721	598–607	410–556
Alae		496	575	375–524	544–562	378–536
Spicule	l	168	167	151–185	172–177	153–185
	r	264	230	246–287	240–263	244–302
Spicule ratio		1.57	1.38	1.36–1.81	1.39–1.49	1.54–1.78
2nd preanal papilla relative to 1st and 3rd		75%	81%	67–70%	63–69%	61–71%
Vulva %		43%		38–44%	45%	39–40%

I. zebra were also found in tide pool specimens of *E. marmoratus*, brackish pond and stream mouth specimens of *E. sandwicensis* (but not in freshwater specimens sampled from the same island) from Hawai'i, and in the coral reef associated fishes listed above from Fiji and Moorea. These worms agreed with our specimens from *I. zebra* in number and relative position of caudal papillae; shape of buccal capsule; relative number of buccal capsule spirals; relative positions of the deirid, nerve ring, excretory pore, and vulva; ratio between the 2 portions of the esophagus; shape of the female tail; presence of a terminal digit in the female; 2 tail spines in both sexes; and spicule ratio (Table 1). Despite differing fixation methods among island localities, measurements of the specimens overlapped strongly (Table 1), and the suite of characters used above to identify *S. istiblenni* applied to all specimens examined. Although fixation may have influenced the size of structures, variation due to differences in fixation was apparently inconsequential in comparison with the variation within specimens treated in the same way. Therefore, fixation method did not significantly affect morphology. Based on these similarities, we believe these worms to be conspecific with those recovered from *I. zebra*, and we regard the differences among the worms as individual or host-induced variation.

Discussion

Twenty-five species of *Spirocamallanus* have been reported from the Indo-Pacific, 4 species of which have been reported from the Pacific with 2 unequal spicules (Andrade-Salas et al., 1994): *Spirocamallanus guttatusi* Andrade-Salas, Peneda-López, and García-Magnanã, 1994, *S. istiblenni, S. monotaxis*, and *S. philippinensis* Velasquez, 1980. The present worms agree with

Noble's (1966) measurements of *S. istiblenni* (Table 1), including our measurements of the relative distances among the preanal papillae in Noble's syntypes. Although Noble reported 6 postanal papillae in *S. istiblenni*, 5 postanal papillae and a phasmid (as in our material) were figured and observed in the syntypes. Also, while the third through fifth postanal papillae were figured as being close together by Noble (1966), examination of the syntypes revealed that they were generally further apart and agreed more closely with our specimens. Additionally, from the present material, one of the males examined agreed with the others for all characters examined except that it lacked spicules. Measurements from this individual have been included with the others, as it merely appears to be a mutant lacking spicules. Therefore, we assign our material to *S. istiblenni*.

Our material may be distinguished from *S. guttatusi* by the shorter alae (anterior margin of alae to terminal extremity of worm) (463–491 vs. 610–720), spicules (left spicule: 185–223 vs. 200–260; right spicule: 263–302 vs. 300–350), and the longer vagina vera (356 vs. 100–150) for worms of approximately the same size. The inner rings of cephalic papillae of *S. guttatusi* do not appear to have been figured; however, those cephalic papillae that are figured are in agreement with our material. Our material may also be distinguished from *S. monotaxis* by the arrangement of the preanal caudal papillae (the second preanal papilla, in our material, was 60 to 70% of the distance from the first to the third preanal papilla vs. 35 to 48% in *S. monotaxis* [Rigby and Adamson, in press]). Our material, and other similar worms (e.g., *S. guttatusi* and *S. monotaxis*), cannot be reliably differentiated from the description of *S. philippinensis* except by the anteriorly directed vagina in *S. philippinensis*, which appears to be an artifact of fixation. Since type specimens were not deposited in the USNPC, as stated in the description (Lichtenfels, pers. comm.), *S. philippinensis* should be regarded as *inquirenda*.

Hasegawa et al. (1991) reported *S. istiblenni* from several species of coral reef associated fishes in Okinawa, Japan. In our examination of some of that material (see above), the females examined lacked spinelike projections (mucrons) on the terminal digit, and the distribution of the preanal caudal papillae was not consistent with our concept of this species. In the material from Okinawa that we examined, the second preanal papilla was 44 to 60% of the distance from the first to the third preanal papillae, whereas in all other material of *S. istiblenni* examined, the second preanal papilla was 60 to 70% of the distance from the first to the third preanal papillae and in all other material of *S. monotaxis* examined, the second preanal papilla was 35 to 48% of the distance from the first to the third preanal papillae (Rigby and Adamson, in press). Additionally, the displacement of the postanal papillae varied more than in *S. istiblenni*. These differences suggest that more than 1 species may be included in their material, possibly including *S. istiblenni*. Therefore, the material from Okinawa should be reexamined. We have not included their published measurements in this paper.

Our records significantly increase the geographic range of *S. istiblenni* to include widely spaced islands in the tropical Pacific Ocean. As this species appears to have a very low host specificity (currently recorded from 8 species from 6 families), and fishes of these families are widespread throughout the Indo-Pacific (e.g., see Myers [1992]), suitable hosts may be found on islands throughout the Indo-Pacific, and further investigation of helminth parasites of coral reef fishes in the Indo-Pacific may reveal a much greater geographic range of these worms. This wide geographic distribution may be achieved through copepod intermediate hosts (Stromberg and Crites, 1973), some of which may be pelagic, and pelagic postcyclic fish hosts (e.g., the related parasitic fish nematode *Camallanus marinus* has been reported from epipelagic carangid fishes [Schmidt and Kuntz, 1969]), which may enhance dispersal.

Acknowledgments

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Spauligodon petersi sp. n. and *Spauligodon smithi* sp. n. from Lizards of Cape Province, South Africa

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ABSTRACT: *Spauligodon petersi* sp. n. and *Spauligodon smithi* sp. n. (Nematoda: Pharyngodonidae) discovered in the large intestines of *Mabuya sulcata* and *Pachydactylus bibronii*, respectively, are described and illustrated. *Mabuya sulcata* harbored 45 nematodes, *P. bibronii* 34. *Spauligodon petersi* and *S. smithi* are easily separated from the 2 previously described Ethiopian species. Males and females of *S. petersi* have smooth, filiform tails; eggs have truncated ends. Females of *S. smithi* have spines on a flexible, filiform tails; males have smooth tails; eggs have pointed ends.

KEY WORDS: *Spauligodon petersi* sp. n., *S. smithi* sp. n., nematode, lizard, South Africa.

In a recent helminthological survey of lizards collected in Cape Province, South Africa, 2 western rock skinks, *Mabuya sulcata sulcata* (Peters, 1867), were found to harbor 10 male and 45 female nematodes of an undescribed species of *Spauligodon*, and 1 Bibron's gecko, *Pachydactylus bibronii* (A. Smith, 1845), was found to harbor 10 males and 24 female nematodes of a second undescribed species of *Spauligodon*. *Mabuya s. sulcata* occurs throughout most of western Cape Province, central and western Namibia, and southern Angola. *Pachydactylus bibronii* occurs throughout Cape Province. In South Africa, it is sympatric with about 57 other lizard species.

The genus *Spauligodon* was established when Skrjabin et al. (1960) divided *Pharyngodon* (Diesing, 1861) into 3 genera (*Pharyngodon*, *Parathelandros* [Baylis, 1930], and *Spauligodon* [Skrjabin, Schikhobalova, and Lagodovskaja, 1960]). There are currently 32 recognized species and, with the exception of *Spauligodon goldbergi*, a parasite of the colubrid snake *Sonora semiannulata* from Texas (Bursey and McAllister, 1996), all are from lizards. Of these, 19 species are found in the Palearctic Realm, 6 in the Neotropical, 4 in the Nearctic, 2 in the Ethiopian, and 1 from Oceania. This paper describes the third and fourth species of *Spauligodon* from the Ethiopian Realm.

Materials and Methods

Lizards were collected in Cape Province, South Africa: 1 juvenile *M. sulcata* from Garies, 23 March 1990; 1 adult *M. sulcata* from Springbok, 25 March 1992; 1 adult *Pachydactylus bibronii* from Springbok, 24 March 1990. The lizards were fixed in 10% formalin and preserved in 70% ethanol. In July 1995, the body cavity was opened by a longitudinal incision from vent to throat, and the gastrointestinal tract was removed by cutting across the esophagus and rectum. The esophagus, stomach, small intestine, and large intestine of each lizard were examined separately for helminths. Nematodes were placed in undiluted glycerol, allowed to clear, and examined under a light microscope. Lizards were deposited in the herpetological collection of the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania (*Mabuya sulcata*, CM 130303; *Pachydactylus bibronii*, CM 119285). Measurements (mean and range) are given in millimeters unless otherwise stated.

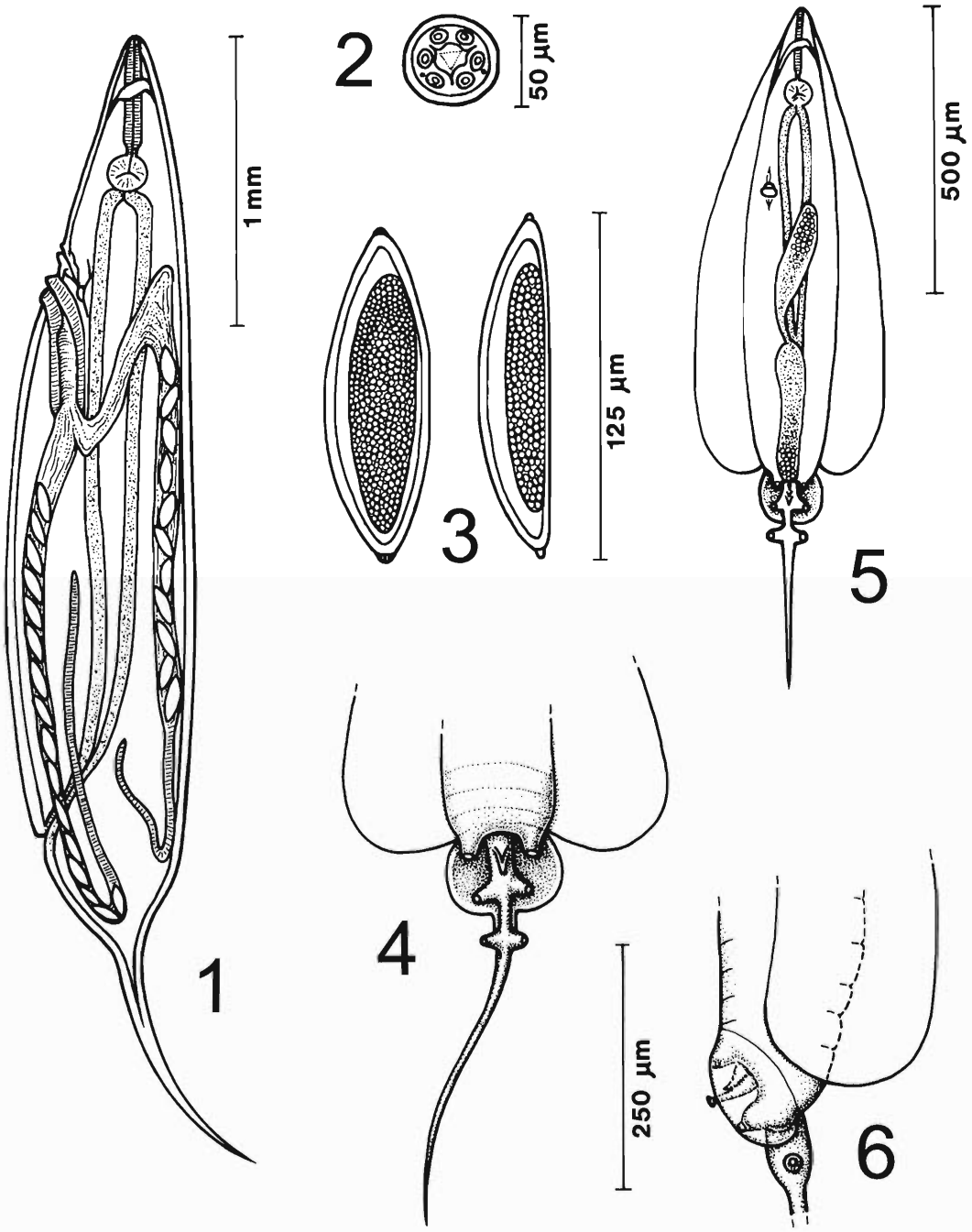
Taxonomic Account

Family Pharyngodonidae Travassos, 1919
Genus *Spauligodon* Skrjabin, Schikhobalova, and Lagodovskaja, 1960
Spauligodon petersi sp. n.
Figs. 1–6

DESCRIPTION: With characters of the genus: specifically; males having caudal alae that do not envelop posterior postcloacal pair of pedunculate papillae; females having vulva in anterior half of body. Nematodes of small size with cylindrical body tapering anteriorly and posteriorly. Lateral alae present in males. Mouth opening triangular, bounded by 3 lips, each with a shallow midline indentation. Esophageal bulb separated from esophageal corpus by small constriction. Excretory pore behind esophageal bulb in both males and females.

MALE (based on 10 specimens): Small,

[4] Corresponding author.



Figures 1–6. ***Spauligodon petersi*** **sp. n. 1. Female, entire, lateral view. 2. Female, en face view. 3. Eggs. 4. Male, posterior end, ventral view. 5. Male, entire, ventral view. 6. Male, posterior end, lateral view.**

white, fusiform nematodes; distinctly truncated posterior end; length 1.23 (0.97–1.50); width at level excretory pore 0.14 (0.09–0.17). Lateral alae 70 μm (65–75) wide at posterior end, narrowing consistently to end at the level of nerve ring. Cuticle smooth but with annulae at 5–8 μm intervals. Mouth opening bounded by 3 bilobed lips. Buccal cavity 10 μm (6–14). Esophagus (including bulb) 0.21 (0.17–0.23); bulb length 0.06 (0.05–0.07); bulb width 0.06 (0.04–0.07). Nerve ring 0.09 (0.07–0.11); excretory pore 0.32 (0.22–0.40), from anterior end. Posterior end truncated, terminating dorsally in elongated filiform tail and laterally in narrow caudal alae. Three pairs of caudal papillae present; precloacal pair sessile and situated at anterior ventral inlet of caudal bursa; adcloacal pair directed posteriolaterally; postcloacal pair not enclosed by caudal alae. Smooth filiform tail 0.24 (0.20–0.26) extends beyond postcloacal papillae. Spicule absent; prominent genital cone in midventral line consisting of small, sharply pointed anterior lip and larger blunt posterior lip.

FEMALE (based on 10 gravid specimens): Small, white, cylindrical nematodes; tapering anteriorly to a blunt point, posterior ending in a long, flexible filiform tail; length 3.08 (2.28–3.77); width at level of vulva 0.30 (0.23–0.36). Cuticle smooth but with annulae at 6–11 μm intervals. Esophagus (including bulb) 0.34 (0.31–0.37); bulb length 0.09 (0.08–0.10); bulb width 0.10 (0.09–0.10). Nerve ring 0.11 (0.09–0.11); excretory pore 0.48 (0.36–0.59); vulva 0.53 (0.38–0.64) from anterior end. Thick-walled ovijector extends posteriorly 0.60 mm, continuing as thinner-walled vagina, 0.12, before joining 2 uteri, 1 directed anteriorly and the other posteriorly. The anteriorly directed uterus reaches the level of the vulva then bends posteriorly. Anterior quarter of gravid female usually free of eggs. Flexible, filiform tail 0.46 (0.36–0.56), without cuticular spines. Eggs fusiform, 130 μm (125–137) × 40 μm (34–43), small knob at each end, flattened on 1 side, with some development at deposition.

Taxonomic summary

TYPE HOST: *Mabuya sulcata sulcata* (Peters, 1867), western rock skink (Sauria: Scincidae).

TYPE LOCALITY: Springbok, Cape Province, South Africa.

SITE OF INFECTION: Large intestine.

TYPE SPECIMENS: Holotype: male, U.S. National Parasite Collection, No. 86749; allotype, 86750; paratypes (9 males, 9 females), 86751.

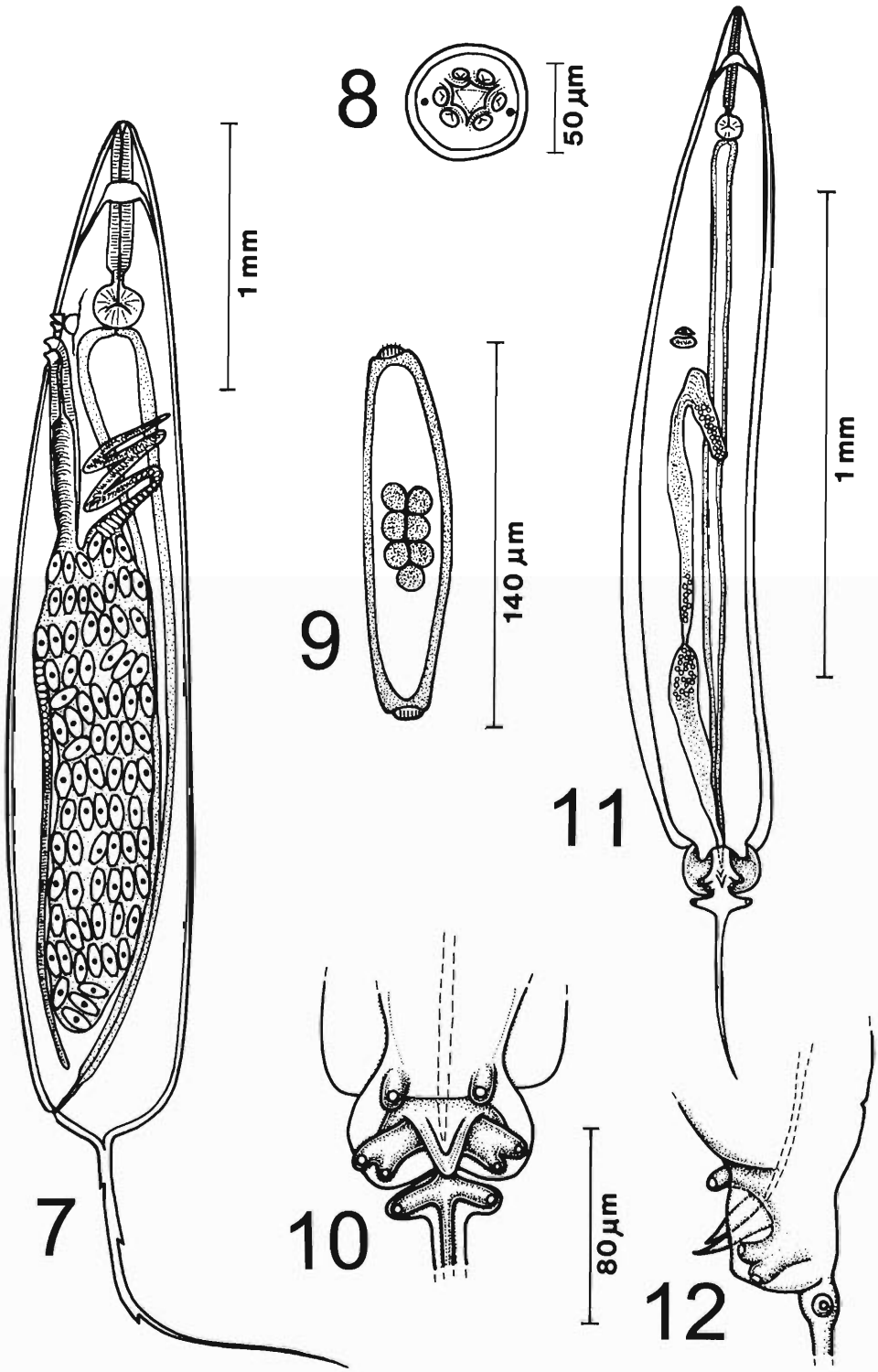
ETYMOLOGY: The specific epithet is given in honor of Wilhelm Peters (1815–1883), German Zoologist, who named *M. sulcata* in 1867.

Family Pharyngodonidae Travassos, 1919
Genus *Spauligodon* Skrjabin, Schikhobalova, and Lagodovskaja, 1960
Spauligodon smithi sp. n.
Figs. 7–12

DESCRIPTION: With characters of the genus, as stated above.

MALE (based on 8 specimens): Small, white, fusiform nematodes; distinctly truncated posterior end; length 1.71 (1.40–2.04); width 0.13 (0.10–0.16) at level excretory pore. Lateral alae 12 μm (9–15) wide, maintaining width from posterior end to level of esophageal bulb, then tapering to end at level of nerve ring. Cuticle smooth with annulations at 12-μm intervals. Mouth opening bounded by 3 bilobed lips; buccal cavity 11 μm (9–14). Esophagus (including bulb) 0.29 (0.27–0.30); bulb length 0.06 (0.05–0.07); bulb width 0.06 (0.05–0.06). Nerve ring 0.11 (0.07–0.14); excretory pore 0.55 (0.46–0.71), from anterior end. Posterior end truncated, terminating dorsally in elongated filiform tail and laterally in narrow caudal alae. Three pairs of caudal papillae present; precloacal pair sessile and situated at anterior ventral inlet of caudal bursa; adcloacal bifurcated laterally and directed posteriorly; postcloacal pair not enclosed by caudal alae. Postcloacal papillae separated from caudal alae by narrow cleft. Smooth filiform tail 0.20 (0.18–0.21), extends beyond postcloacal papillae. Spicule 90 μm (80–97); ventrally directed genital cone in midventral line consisting of small, sharply pointed anterior lip and larger pointed posterior cloacal lip.

FEMALE (based on 6 specimens): Small, white, cylindrical nematodes; tapering anteriorly to a blunt point, posterior ending in a long filiform tail; length 3.05 (2.60–3.77); maximum width 0.38 (0.33–0.41). Cuticle with striations at 1 μm intervals and annulae at 10–15 μm intervals. Esophagus including bulb 0.32 (0.25–0.40); bulb length 0.10 (0.08–0.12); bulb width 0.10 (0.08–0.12). Nerve ring 0.11 (0.10–0.13); excretory pore 0.29 (0.28–0.31); vulva 0.33 (0.31–0.34), from anterior end. Thick-walled ovijector 0.11, leading to thin-walled vagina 0.24, joining 2 uteri, 1 directed anteriorly and the oth-



Figures 7–12. ***Spauligodon smithi*** **sp. n. 7. Female, entire, lateral view. 8. Female, en face view. 9. Egg. 10. Male, posterior end, ventral view. 11. Male, entire, ventral view. 12. Male, posterior end, lateral view.**

Table 1. Mean comparative measurements of various structures in *Spauligodon* spp. from Africa.*

Structure	*S. dimorpha*	*S. morgani*	*S. petersi* sp. n.	*S. smithi* sp. n.
Males				
Length	1.15	1.69	1.23	1.71
Width	0.19	0.14	0.14	0.13
Esophagus	0.35	0.27	0.21	0.29
Bulb (μm)	70 × 75	65 × 65	60 × 60	60 × 60
Nerve ring	0.13	0.08	0.09	0.11
Excretory pore	0.62	0.50	0.32	0.55
Tail length	0.18	0.29	0.24	0.20
Spicule (μm)	Absent	Absent	Absent	90
Females				
Length	4.3	4.4	3.1	3.1
Width	0.35	0.46	0.30	0.38
Esophagus	0.59	0.48	0.34	0.32
Bulb (μm)	130 × 130	110 × 110	90 × 100	100 × 100
Nerve ring	0.14	0.12	0.11	0.11
Excretory pore	0.58	0.69	0.48	0.29
Vulva	0.65	0.76	0.53	0.33
Tail cuticle	Smooth	9–11 spines	Smooth	4–10 spines
Tail appearance	Flexible, filiform	Stiff, spike-like	Flexible, filiform	Flexible, filiform
Eggs (μm)	100 × 41	143 × 35	130 × 40	140 × 48
Reference	Chabaud and Brygoo, 1962	Fitzsimmons, 1961	This paper	This paper

* Measurements are from anterior end and are in millimeters unless otherwise stated.

er posteriorly. The anterior-directed uterus reaches the level of the esophageal bulb then bends posteriorly. Gravid females with eggs reaching to level of esophageal–intestinal junction. Flexible, filiform tail 0.58 (0.54–0.64) with 7 (4–10) cuticular spines. Eggs fusiform 140 μm (137–148) × 48 μm (40–51), truncated ends, slightly flattened on 1 side, development to morula at deposition.

Taxonomic summary

TYPE HOST: *Pachydactylus bibronii* (A. Smith, 1845), Bibron's gecko (Sauria: Gekkonidae).

TYPE LOCALITY: Springbok, Cape Province, South Africa.

SITE OF INFECTION: Large intestine.

TYPE SPECIMENS: Holotype: male, U.S. National Parasite Collection, No. 86752; allotype, 86753; paratypes (9 males, 9 females), 86754.

ETYMOLOGY: The specific epithet is given in honor of Sir Andrew Smith (1797–1872), father of South African Zoology, who named *P. bibronii* in 1845.

Remarks

Species of *Spauligodon* are distinguished on the basis of the shape of the egg, the presence or absence of spines on the tail filament of adults, and geographical distribution (see Table 1 of Bursey and Goldberg [1995]). Both new nematodes should be added to that table. *Spauligodon petersi* sp. n., no spicule; male tail smooth; female tail smooth; egg ends pointed. *Spauligodon smithi* sp. n., spicule 80–97 μm; male tail smooth; female tail 4–10 spines; egg ends truncated. Chabaud and Brygoo (1962) have suggested that geographical distribution is the most important factor in the speciation of reptilian oxyurids. Comparisons of selected measurements of species from the Ethiopian Realm are presented in Table 1. *Spauligodon petersi* sp. n. and *S. smithi* sp. n. are easily separated from the 2 previously described Ethiopian species. Males and females of *S. morgani* have spines on short, nonflexible tail spikes; the eggs have pointed ends. Males and females of *S. dimorpha* have smooth, flexible, filiform tails; the eggs have truncated ends. Males and females of *S. petersi* sp. n. have smooth, filiform tails; the eggs have truncated ends. Females of *S. smithi* sp. n. have spines on a flexible, filiform tail; males have smooth tails; the eggs have pointed ends.

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Report on the Brayton H. Ransom Memorial Trust Fund

The Brayton H. Ransom Memorial Trust Fund was established in 1936 to "Encourage and promote the study and advance of the Science of Parasitology and related sciences." Income from the Trust currently provides token support of the *Journal of the Helminthological Society of Washington* and limited support for publication of meritorious manuscripts by authors lacking institutional or other backing. Donations or memorial contributions may be directed to the Secretary-Treasurer. Information about the Trust may be found in the following articles: *Proceedings of the Helminthological Society of Washington* (1936) 3:84–87; (1983) 50:200–204 and (1993) 60:144–150.

Financial Report for 1996

Balance on hand, January 1, 1996		$16,260.14
Receipts:		$2,494.37
Contributions		
Donations from members of the Helminthological Society of Washington for 1994 and 1995	$349.00	
In memory of A. O. Foster*	$1,150.00	
In memory of M. B. Chitwood*	$50.00	
Interest received in 1996	$945.37	
Disbursements		($380.00)
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Thubunaea ctenosauri sp. n. (Nematoda: Physalopteridae) from the Iguanid Lizard *Ctenosaura pectinata* and Other Lizard Helminths from Mexico

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ABSTRACT: *Thubunaea ctenosauri* sp. n. is described from the large intestine of the iguanid lizard *Ctenosaura pectinata* from Aguamilpa, Mexican State of Nayarit. It is characterized mainly by the position of the vulva, number and distribution of caudal papillae, length of spicules (0.066 mm), and size of eggs (0.054–0.060 × 0.039–0.042 mm). Other recorded species of parasitic nematodes are *Skrjabinodon scelopori* from *Phyllodactylus lanei; Parapharyngodon alvarengai* from *P. lanei, Anolis nebulosus*, and *Sceloporus nelsoni*; and *Atractis scelopori* from *C. pectinata* and *Sceloporus* sp. The findings represent new host records, and *P. alvarengai* is reported from Mexico for the first time.

KEY WORDS: nematodes, *Skrjabinodon, Parapharyngodon, Atractis, Thubunaea, Anolis nebulosus, Ctenosaura pectinata, Phyllodactylus lanei, Sceloporus nebulosus,* Mexico.

During recent studies on helminth parasites of lizards from the Pacific coast of Nayarit State, central Mexico, several nematode species, including a new species, were collected from 4 endemic species of lizards. One of them was also recorded from a lizard originating from the Mexican State of Veracruz. All findings represent new host records. Species of the nematode genera *Alaeuris* Thapar, 1925 and *Ozolaimus Dujardin*, 1845, forming a part of this material, have already been dealt with in the paper by Moravec et al. (1996). The present paper describes the new species and gives an account of the other nematode species recorded, including 1 new to science.

Materials and Methods

Most nematodes were collected from the following 4 species of lizards in Aguamilpa (21°05′32″N, 104°, 46′20″W), Nayarit, Mexico, from August to November 1993: *Phyllodactylus lanei* Smith, 1935 (56 specimens) (Gekkonidae), *Anolis nebulosus* (Wiegmann, 1834) (Polychrotidae) (4), *Ctenosaura pectinata* (Wiegmann, 1834) (Iguanidae) (29), and *Sceloporus nelsoni* Cochran, 1923 (Phrynosomatidae) (10) (all Iguanidae). A specimen of *Sceloporus* sp. originating from Xalapa, Veracruz, accidentally was examined in the same period. The nematodes were washed in physiological saline, fixed and stored in 70% ethanol, and cleared in glycerine. Drawings were made with aid of a Zeiss microscope drawing attachment. One female specimen of *Thubunaea ctenosauri* was transferred to 4% formaldehyde, postfixed in 1% OsO_4, dehydrated through an ethanol series and acetone, and then subjected to critical-point drying. The specimen was coated with gold and examined with a JSM-6300 scanning electron microscope at an accelerating voltage of 15 kV. All measurements are given in millimeters unless otherwise stated. Types of the new species are deposited in the Institute of Biology, National Autonomous University of Mexico (UNAM), Mexico City; voucher specimens of the remaining species are deposited in the same institute (UNAM) and also in the Institute of Parasitology, Academy of Sciences of the Czech Republic (IPASCR), in České Budějovice. Host specimens are deposited in the herpetological collection of the UNAM.

[3] Corresponding author.

Results

Physalopteroidea

Family Physalopteridae Railliet, 1893

Thubunaea ctenosauri sp. n. (Figs. 1A–D, 2)

DESCRIPTION: Medium-sized nematodes with almost smooth cuticle. Cephalic end rounded, with 2 rounded, slightly elevated lateral pseudolabia; each pseudolabium provided with a pair of submedian papillae and small lateral amphid. Pseudolabia slightly asymmetrical, one of them somewhat more pronounced than another one. Each pseudolabium equipped with 3 small teeth. Oral opening dorsoventrally elongate. Deirids small, simple, situated approximately at level of nerve ring. Esophagus composed of short "pharynx," anterior muscular portion and posterior, much longer and wider glandular portion. Nerve

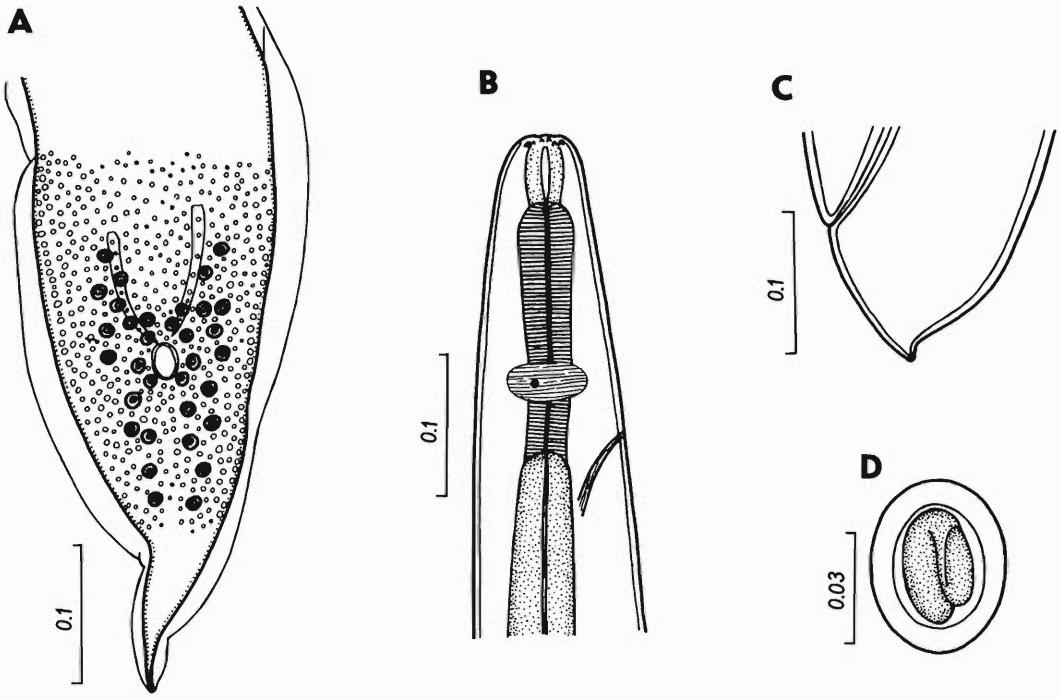

Figure 1. ***Thubunaea ctenosauri*** **sp. n. A. Posterior end of male, ventral view. B. Anterior end of gravid female. C. Female tail. D. Egg.**

ring encircling muscular esophagus at its posterior half. Excretory pore near end of muscular esophagus. Tail conical in both sexes.

MALE (1 specimen, holotype): Length of body 8.09, maximum width 0.272. "Pharynx" 0.036 long, length of muscular and glandular parts of esophagus 0.150 and 0.696, respectively. Nerve ring and excretory pore 0.150 and 0.165, respectively, from anterior extremity. Deirids 0.150 from anterior end of body. Tail conical, pointed, 0.258 long. Caudal alae well developed. Numerous preanal (8 pairs), adanal (2 pairs), and postanal (6 and 7) papillae present; altogether, 16 papillae on right side and 17 papillae on left side. Papillae rather similar in appearance, 4 pairs of more lateralmost preanal papillae and 4 pairs of lateralmost postanal papillae appearing to be somewhat pedunculate. Ventral surface with dense cuticular ornamentation (protuberances) extending anteriorly somewhat anterior to anteriormost pair of preanal papillae and posteriorly slightly posterior to last pair of postanal papillae. Spicules equal, slightly sclerotized, 0.066 long.

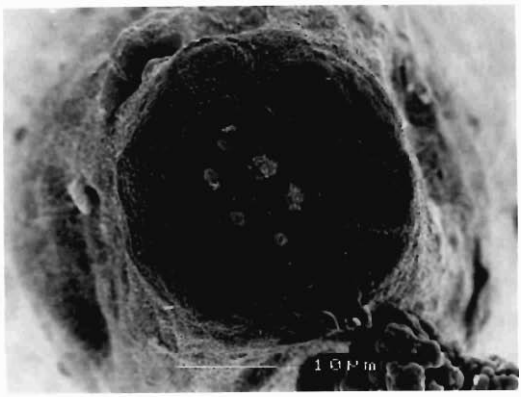

Figure 2. ***Thubunaea ctenosauri*** **sp. n. Scanning electron micrograph of female cephalic end, apical view.**

FEMALE (2 specimens, allotype and paratype; measurements of latter in parentheses): Length of body 27.32 (15.42), maximum width 0.299 (0.299). "Pharynx" 0.039 (0.045) long, length of muscular and glandular parts of esophagus 0.195 (0.198) and 1.11 (1.11), respectively, from anterior extremity; distance of deirids 0.186 (0.222). Tail conical, 0.105 (0.168) long, pointed. Vulva situated 1.84 (1.88) from anterior ex-

tremity, posterior to esophagus end; vulvar lips not elevated. Vagina pointing backward. Two parallel uteri present. Eggs oval, thick-walled, larvated; size of eggs 0.054–0.060 × 0.039–0.042 (only immature eggs in paratype), egg wall 0.009 (—) thick.

TYPE HOST: *Ctenosaura pectinata* (Wiegmann, 1834).

SITE: Large intestine.

TYPE LOCALITY: Aguamilpa, Nayarit, Mexico (24 August 1993).

PREVALENCE AND INTENSITY: 3% and 8 nematodes.

DEPOSITION OF TYPES: Holotype (♂) and allotype (♀) in the helminthological collection of the UNAM, Mexico City (Coll. No. 2643).

ETYMOLOGY: The specific name of this nematode is derived from the generic name of its type host.

COMMENTS: In contrast to Skryabin and Sobolev (1964), many species originally listed in the genus *Thubunaea* Seurat, 1914, are now considered as members of the related genus *Physalopteroides* Wu and Liu, 1940, on the basis of their asymmetrical oral opening (e.g., Chabaud, 1975; Baker, 1987; Bursey and Goldberg, 1991). Unfortunately, the species of the present genus *Thubunaea* have not been studied by scanning electron microscopy to confirm the symmetry of cephalic structures. Because the asymmetry of the oral opening and pseudolabia of the new species is only slightly developed and the number of teeth is identical on both sides of the oral opening and their size is very similar, we consider it more reasonable to assign this nematode species to *Thubunaea* than to *Physalopteroides*. In our opinion, it will be necessary to reconsider the delimitation of the 2 preceding genera when more exact data on the morphology of individual species are available.

According to Bursey and Goldberg (1991), there are at present 17 species of *Thubunaea*, including the parasites of reptiles. Unfortunately, the descriptions of many species are inadequate and frequently misleading, preventing any detailed comparison. Only 5 *Thubunaea* species are known from the Western Hemisphere (Baker, 1987; Bursey and Goldberg, 1991): *T. parkeri* Baylis, 1926, from *Tropidurus occipitalis* and *Dicrodon calliscelis* from Peru; *T. leiolopismae* Harwood, 1932, from *Scincella lateralis* from Texas, U.S.A.; *T. iguanae* Telford, 1965, from 10 species of lizards (*Callisaurus, Cnemidophorus, Coleonyx, Gambelia, Sceloporus, Uma, Uta, Xantusia*) from California, U.S.A., and Mexico; *T. cnemidophorus* Babero and Matthias, 1967, from *Cnemidophorus tigris* from Nevada, U.S.A.; and *T. intestinalis* Bursey and Goldberg, 1991, from *Sceloporus jarrovii* from Arizona, U.S.A.

Of the preceding species, *T. ctenosauri* sp. n. differs from *T. parkeri* mainly in the distinctly more anterior position of the vulva (1.84–1.88 vs. 3–3.5 from anterior extremity, although the body of *T. parkeri* is shorter), more numerous caudal papillae in the male, and geographical distribution. In contrast to *T. ctenosauri* sp. n., the vulva of *T. leiolopismae* is situated anterior to the esophagus end, and it possesses fewer caudal papillae in the male, whereas *T. iguanae* has unequal, conspicuously smaller spicules (0.015/0.013 vs. 0.066) and smaller eggs (0.040 × 0.032 vs. 0.054–0.060 × 0.039–0.042). *Thubunaea cnemidophorus* has smaller eggs (0.038 × 0.023) and no spicules in the male, and *T. intestinalis* has conspicuously larger eggs (0.120 × 0.082), a different shape and length of the female tail, and different distribution of caudal papillae in the male, and its vulva is situated slightly posterior to the nerve ring level (posterior to esophagus in *T. ctenosauri*).

When compared to *Thubunaea* species from other continents, *T. ctenosauri* differs in various morphological features, hosts, and geographical distribution.

Related species listed in the genus *Physalopteroides* sensu Chabaud (1975) differ from *T. ctenosauri* mainly in a well-pronounced asymmetry of the cephalic structure and in other morphological features.

Oxyuroidea
Family Pharyngodonidae Travassos, 1919

Skrjabinodon scelopori (Caballero, 1938) (Fig. 3)

DESCRIPTION: Medium-sized nematodes. Cuticle with fine transverse striations. Lateral alae present. Cephalic end rounded, with 3 small lips; oral papillae indistinct in lateral view. Esophagus almost cylindrical, with well-developed bulb. Nerve ring encircling esophagus at its anterior third in females and at its middle in males. Excretory pore somewhat posterior to end of esophagus. Tail conical, elongate, sharply pointed.

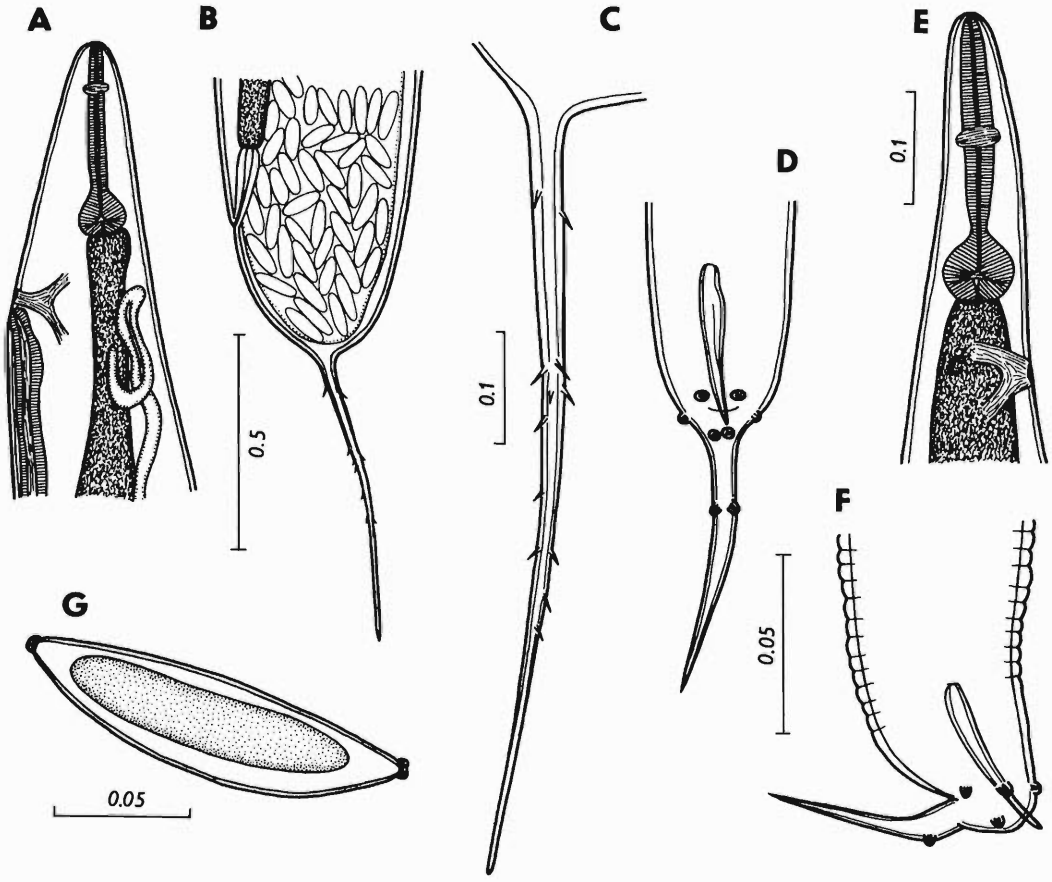

Figure 3. ***Skrjabinodon scelopori*** **(Caballero, 1938). A. Anterior end of gravid female. B. Posterior end of female. C. Caudal appendage of female. D. Caudal end of male, ventral view. E. Anterior end of male. F. Caudal end of male, lateral view.**

MALE (1 specimen): Length of body 1.96, maximum width 0.136. Length of entire esophagus 0.285; bulb 0.072 long and 0.072 wide. Nerve ring and excretory pore 0.132 and 0.449, respectively, from anterior extremity. Tail elongate, slender, 0.081 long, sharply pointed. One pair of preanal papillae and 3 pairs of postanal papillae present; first postanal pair sublateral and second pair subventral, situated at short distance below cloacal opening; third postanal pair situated approximately at border of first and second thirds of tail. Spicule simple, well sclerotized, 0.057 long.

FEMALE (3 specimens): Body of gravid females 3.81–5.73, maximum width 0.381–0.598. Entire esophagus 0.490–0.517 long; bulbus 0.105–0.108 long and 0.120–0.129 wide. Nerve ring and excretory pore 0.109–0.120 and 0.571–0.653, respectively, from anterior extremity. Tail suddenly narrowed at its approximately 2 last thirds, forming needlelike appendage bearing 12–14 cuticular spikes; total length of tail 0.857–1.156, its appendage 0.625–0.775 long. Uterus amphidelphic; anterior ovary not reaching anteriorly to esophagus. Vagina long, muscular, directed posteriorly from vulva; latter situated closely posterior to excretory pore, 0.625–0.721 from anterior end of body. Uterus filled with numerous eggs. Eggs elongate, size 0.162–0.171 × 0.036–0.048, with narrowed ends; each egg pole bearing small, knoblike formation; these polar structures absent from less-developed eggs. Mature eggs nonembryonated.

HOST: *Phyllodactylus lanei* Smith, 1935.

SITE: Large intestine.

LOCALITY: Aguamilpa, Nayarit.

PREVALENCE AND INTENSITY: 30% and 1–48 ($\bar{x}$ = 10) nematodes per lizard.

DEPOSITION OF VOUCHER SPECIMENS: UNAM (Cat. No. 2644) and IPASCR (Cat. No. N-648).

COMMENTS: Inglis (1968) revised the genus *Parathelandros* Diesing, 1861, and restricted it to accommodate only the species parasitic in Australian frogs; other species were transferred by him to a newly established genus *Skrjabinodon* Inglis, 1968. This has been accepted by many authors (e.g., Petter and Quentin, 1976; Baker, 1987; Ainsworth, 1990). On the other hand, since Inglis's (1968) revision, a number of *Parathelandros* species in lizards outside Australia have been described, with questionable status (Baker, 1987). In this paper, we accept the system of Inglis (1968) and, consequently, the specimens of the present material are listed in the genus *Skrjabinodon*.

By its morphology and measurements, the specimens of the present material are very close to *S. scelopori* (Caballero, 1938), differing from it somewhat in the location of caudal papillae and in the shape of the male spicule and in the location of the vulva in relation to the female excretory pore; polar knoblike formations have not been described on eggs in *S. scelopori*. Because only 1 male was studied, it is highly probable that these differences are within the intraspecific variability of this species and, consequently, we assign the present specimens to *S. scelopori*.

Skrjabinodon scelopori is the only species of this genus known from Mexico. It was originally described by Caballero (1938) from the phrynosomatid lizard *Sceloporus torquatus*; later the same species was reported from Mexico by Prado Vera (1971) from *S. grammicus microlepidotus*. *Phyllodactylus lanei* (Gekkonidae) represents a new host record for this nematode.

By the female morphology and egg structure, *S. scelopori* resembles *Spauligodon oxkutzcabiensis* (Chitwood, 1938) described from *Thecadactylus rapicaudus* (Gekkonidae) from Yucatan, Mexico, but the male of the latter species possesses caudal alae.

Parapharyngodon alvarengai Freitas, 1957 (Fig. 4)

DESCRIPTION (based on specimens from *P. lanei*): Medium-sized nematodes with body tapering to both ends. Cuticle thick, roughly transversely striated. Head end rounded, provided with 3 minute lips; oral papillae indistinct. Esophagus almost cylindrical, with well-developed posterior bulb. Nerve ring encircling esophagus at its anterior part. Excretory pore situated somewhat posterior to esophagus end.

MALE (1 specimen): Length of body 2.83, maximum width 0.340. Annuli on cuticle 0.015–0.030 long. Lateral alae well developed, extending from level of esophagus end posteriorly to some distance anterior to cloacal opening. Length of entire esophagus 0.476; bulb 0.102 long and 0.114 wide. Nerve ring and excretory pore 0.150 and 0.615 from anterior extremity. Spicule weakly sclerotized, 0.096 long, with sharply pointed distal tip. Tail 0.102 long, suddenly narrowed slightly posterior to cloacal opening, forming caudal appendage. Three pairs of cloacal papillae present: 1 pair of subventral preanal papillae, 1 pair of sublateral postanal papillae situated near posterior lip of cloaca, and 1 pair of subventral papillae at midlength of tail; papillae of first postanal pair larger than others.

FEMALE (2 specimens): Length of body 6.91–8.16, maximum width 0.775–0.884. Lateral alae absent. Entire esophagus 1.29–1.40; bulb 0.190–0.218 long and 0.231–0.245 wide. Nerve ring and excretory pore 0.245–0.286 and 1.50–1.56, respectively, from anterior extremity. Vulva somewhat preequatorial, 2.86–3.02 from anterior end of body. Uterus containing numerous nonembryonated eggs of oval shape, size 0.078–0.087 × 0.042–0.045, with subterminal operculum near 1 pole. Genital apparatus didelphic and prodelphic; ovaries long, their anterior ends forming prominent coils around base of esophagus. Tail short, conical, ending in sharp cuticular spike; length of tail 0.517–0.585.

HOSTS: *Phyllodactylus lanei* Smith, 1935, *Anolis nebulosus* (Wiegmann, 1834), and *Sceloporus nelsoni* Cochran, 1923.

SITE: Large intestine.

LOCALITY: Aguamilpa, Nayarit.

PREVALENCE AND INTENSITY: *P. lanei*: 29% and 1–10 ($\bar{x}$ = 3) nematodes; *A. nebulosus*: 2% and 2 (2) nematodes; *S. nelsoni*: 30% and 1–22 (11) nematodes.

DEPOSITION OF VOUCHER SPECIMENS: UNAM and (Cat. No. 2644) and IPASCR (Cat. No. 649).

COMMENTS: Although *Parapharyngodon* Chatterji, 1933, is considered by some authors (e.g., Petter and Quentin, 1976; Vicente et al., 1993) a synonym of *Thelandros* Wedl, 1862, in

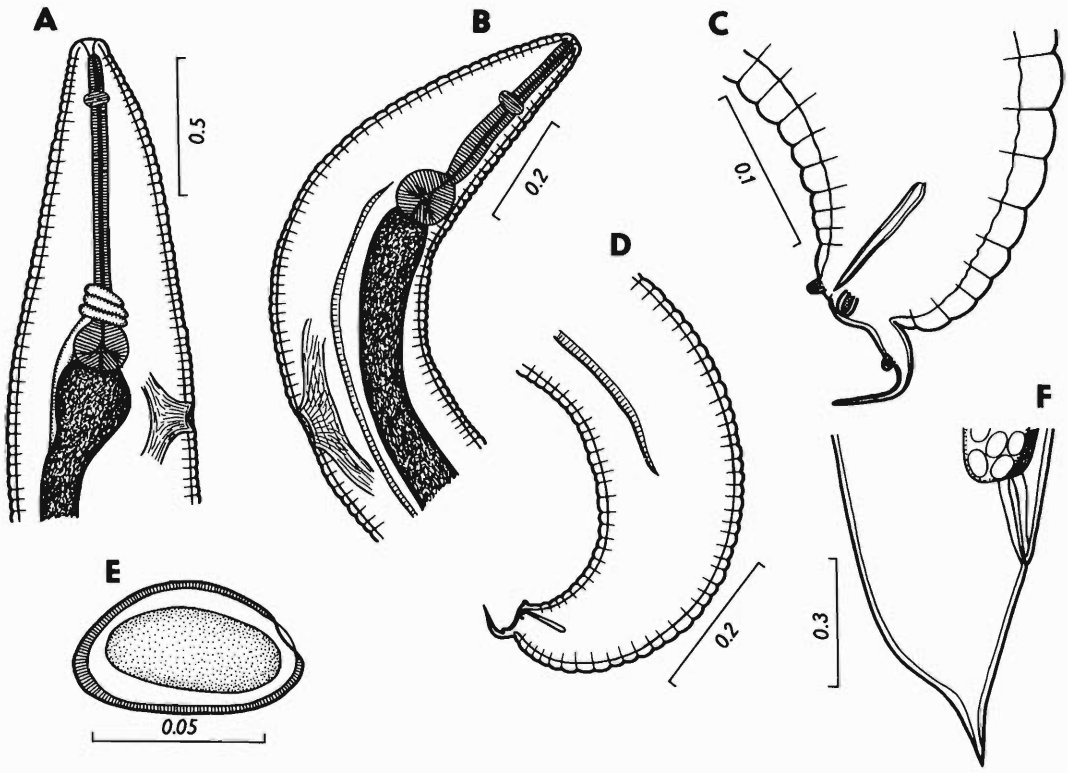

Figure 4. ***Parapharyngodon alvarengai*** **Freitas, 1957. A. Anterior end of gravid female. B. Anterior end of male. C. Caudal end of male. D. Posterior end of male. E. Egg. F. Posterior end of female.**

this paper we follow Adamson (1981) and Baker (1987), taking the former as an independent genus. Accordingly, the present specimens are listed in *Parapharyngodon.*

The genus *Parapharyngodon* comprises many species parasitizing lizards and amphibians (Baker, 1987). By their morphology and measurements, the present specimens appear identical to *P. alvarengai* Freitas, 1957, described originally from *Mabuya maculata* from Brazil and later reported from Brazil also from *Ameiva ameiva* (Freitas, 1957; Vicente et al., 1993). Although a few *Parapharyngodon* species have been reported from North and Central America (Baker, 1987), this is the first record of *P. alvarengai* from Mexico.

Cosmocercoidea
Family Atractidae Railliet, 1917
Atractis scelopori (Gedoelst, 1919) (Fig. 5)

DESCRIPTION (based on specimens from *Sceloporus* sp.): Small, whitish nematodes with smooth cuticle. Cephalic end rounded, with 6 small lips; 4 prominent oral papillae present. Esophagus with well-developed corpus, isthmus and bulb provided with sclerotized apparatus. Nerve ring encircling anterior end of isthmus; excretory pore at level of bulb. Tail conical, with rounded tip.

MALE (2 specimens): Length of body 2.48–2.52, maximum width 0.150–0.163. Length of esophageal corpus 0.246–0.249, maximum width 0.039; isthmus 0.090–0.093 long and 0.027–0.033 wide; bulb 0.081–0.084 long and 0.075–0.078 wide. Nerve ring and excretory pore 0.258–0.264 and 0.321–0.342, respectively, from anterior extremity. Testis not reaching anterior end of esophagus. Spicules unequal; right spicule 0.174–0.192 long, left spicule 0.105–0.108 long. Length of small, slightly sclerotized gubernaculum 0.063–0.066. Three pairs of subventral preanal papillae present. Postanal papillae: 4 pairs, of which first pair lateral, second and fourth subventral and third dorsolateral; last 2 pairs almost at same level. Tail 0.108–0.111 long.

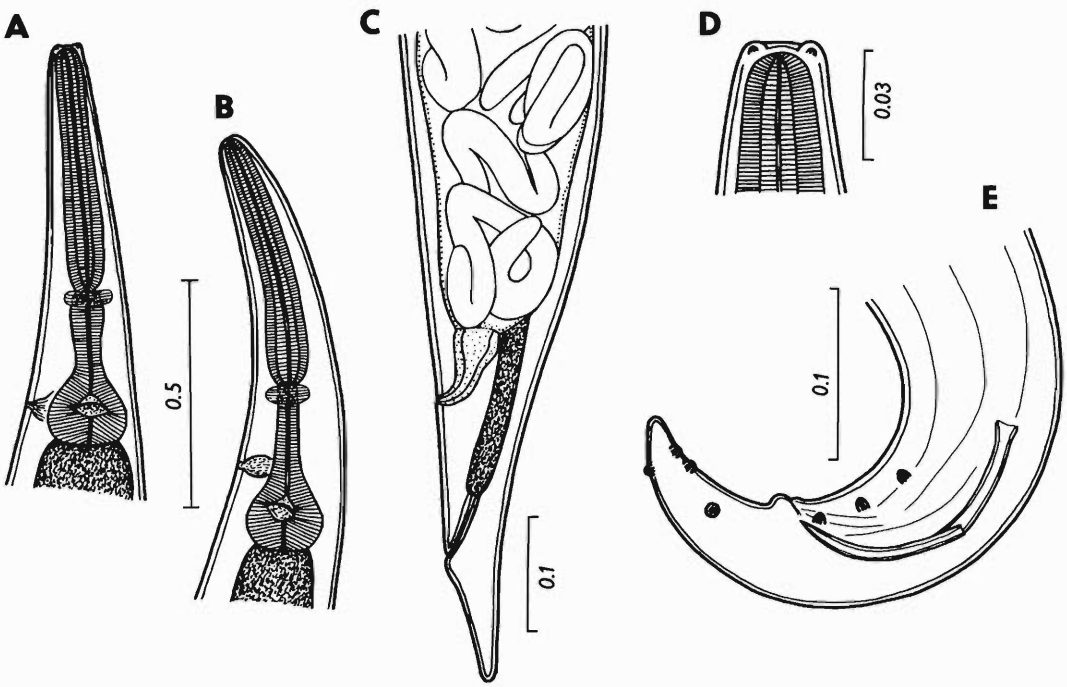

Figure 5. ***Atractis scelopori*** **(Gedoelst, 1919). A. Anterior end of gravid female. B. Anterior end of male. C. Posterior end of female. D. Cephalic end of gravid female, lateral view. E. Posterior end of male.**

FEMALE (4 specimens): Length of gravid specimens 2.16–2.41, maximum width 0.218. Length of esophageal corpus 0.240–0.279, maximum width 0.036; isthmus 0.090–0.105 long and 0.030–0.033 wide; bulb 0.075–0.081 long and 0.078–0.084 wide. Nerve ring and excretory pore 0.252–0.303 and 0.318–0.384, respectively, from anterior extremity. Ovary situated anteriorly; uterus containing developing larvae, its distal part with a few already fully formed larvae. Vagina short. Vulva situated somewhat in front of anal opening (at distance of 0.156–0.165). Tail 0.126–0.150 long.

HOST: *Ctenosaura pectinata* (Wiegmann), *Sceloporus* sp.

SITE: Large intestine.

LOCALITIES: Aguamilpa, Nayarit (*C. pectinata*) and Xalapa, Veracruz (*Sceloporus* sp.).

PREVALENCE AND INTENSITY: *C. pectinata*: 52% and 8–12,721 ($\bar{x}$ = 2,906) nematodes; *Sceloporus* sp.: 6 nematodes in a single host examined.

DEPOSITION OF VOUCHER SPECIMENS: UNAM (Cat. No. 2646) and IPASCR (Cat. No. N-650).

COMMENTS: According to Baker (1987), the genus *Atractis* Dujardin, 1845 (syn. *Cyrtosomum* Gedoelst, 1919; *Pseudatractis* Yamaguti, 1961), includes many species parasitic in turtles and lizards.

Of the 5 species known from North and Central American lizards, the specimens of the present material are closest to *A. scelopori* (Gedoelst, 1919) and, therefore, are considered to belong to this species. In contrast to existing descriptions of *A. scelopori* (e.g., Bravo Hollis, 1942; Coy Otero, 1970), the males of the present material have 4 (instead of 3) pairs of postanal papillae, but there is a considerable variation in the number of caudal papillae in individual *Atractis* species, which renders this character useless for separating species (Gambino and Hynemann, 1960; Bowie and Franz, 1974). *Atractis scelopori* can be distinguished from *A. opeatura* Leidy, 1891, by considerably shorter spicules and from *A. longicaudatum* (Brenes and Bravo Hollis, 1960) and *A. mega* (Bowie and Franz, 1974) by a markedly shorter female tail (Bowie and Franz, 1974); the features (oral papillae) used by Bowie and Franz (1974) to distinguish *A. scelopori* and *A. penneri* (Gambino, 1957) seem to be questionable.

Atractis scelopori has been reported from

many species of iguanid lizards of different genera (the type host is *Sceloporus undulatus*) from North and Central America (U.S.A., Mexico, Panama, Nicaragua, Cuba) (see Baker, 1987). In Mexico, it was previously found in *Ctenosaura acanthura* by Bravo Hollis (1942) and in *C. hemilopha* by Gambino (1957).

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Helminths of 12 Species of *Anolis* Lizards (Polychrotidae) from the Lesser Antilles, West Indies

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ABSTRACT: Twelve species of anoles (*Anolis aeneus*, *A. extremus*, *A. gingivinus*, *A. griseus*, *A. luciae*, *A. marmoratus*, *A. oculatus*, *A. richardi*, *A. roquet*, *A. sabanus*, *A. trinitatis*, and *A. wattsi*) from the Lesser Antilles were examined for helminths. Twelve species of helminths were found: *Mesocoelium monas*, *Oochoristica maccoyi*, *Oswaldocruzia marechali*, *Parapharyngodon cubensis*, *Spauligodon caymanensis*, *Trichospirura teixeirai*, *Abbreviata* sp., *Ascarops* sp., *Physaloptera* sp., *Physocephalus* sp., *Porrocaecum* sp., and *Centrorhynchus* sp. Twenty-nine new host records are reported. The highest prevalence (75%) was *P. cubensis* in *A. sabanus*; greatest mean intensity (56.8) was *S. caymanensis* in *A. marmoratus*. The highest diversity of helminths was found in *Anolis gingivinus*, which harbored 9 species; the lowest diversity occurred in *A. trinitatis*, which harbored 1 species. Islands with the greatest numbers of helminth species are located in the northern Lesser Antilles.

KEY WORDS: *Anolis*, Polychrotidae, Acanthocephala, Cestoda, Nematoda, Trematoda, Lesser Antilles.

The genus *Anolis* Daudin contains some 300 species that inhabit Central America, southern U.S.A. northern South America, and the Caribbean islands (Roughgarden, 1995). About 130 species are known from the West Indies alone (Schwartz and Henderson, 1991). The isolation necessary for such diversity to evolve was provided by the splitting of ancestral stock into some 3,000 separate populations at the end of the last Ice Age (Roughgarden, 1995). The larger islands of the Greater Antilles have more species of *Anolis*; there are over 35 in Cuba, over 35 in Hispaniola, 11 in Puerto Rico, and 7 in Jamaica; small islands, as typified by the Lesser Antilles, have 1 or 2 species (Roughgarden, 1995).

Sixteen species of anoles occur on the islands of the Lesser Antilles, namely, *Anolis aeneus* Gray, 1840, *A. bimaculatus* Sparrman, 1874, *A. extremus* Garman, 1888, *A. ferreus* Cope, 1864, *A. gingivinus* Cope, 1864, *A. griseus* Garman, 1888, *A. lividus* Garman, 1888, *A. luciae* Garman, 1888, *A. marmoratus* Duméril and Bibron, 1837, *A. nubilis* Garman, 1888, *A. oculatus* Cope, 1879, *A. richardi* Duméril and Bibron, 1837, *A. roquet* Lacépède, 1788, *A. sabanus* Garman, 1887, *A. trinitatis* Reinhardt and Lütken, 1863, and *A. wattsi* Boulenger, 1894. Five of these have been introduced to other regions: *A. aeneus* in Trinidad and Guyana; *A. bimaculatus* in Bermuda; *A. extremus* in St. Lucia, Bermuda, and Caracas, Venezuela; *A. roquet* in Bermuda; and *A. trinitatis* in Trinidad (Schwartz and Henderson, 1991). Although anoles of the Lesser Antilles have been studied extensively (see Roughgarden, 1995), there are reports of helminths from only *A. bimaculatus*, *A. ferreus*, *A. gingivinus*, *A. lividus*, *A. marmoratus*, *A. oculatus*, *A. sabanus*, and *A. wattsi* (Dobson et al., 1992; Ben Slimane et al., 1995; Goldberg and Bursey, 1996; Goldberg et al., 1996a). The purpose of this paper is to report helminths from *Anolis aeneus*, *A. extremus*, *A. gingivinus*. *A. griseus*, *A. luciae*, *A. marmoratus*, *A. oculatus*, *A. richardi*, *A. roquet*, *A. sabanus*, *A. trinitatis*, and *A. wattsi* and to compare helminth infections among anoles of the Lesser Antilles.

Materials and Methods

All anoles examined in this study (N = 261) were museum specimens (for museum accession numbers, see Appendix 1). Anole species, collection location, sample size, and mean snout–vent length in millimeters are given in Table 1. The islands of the Lesser Antilles labeled with the species of *Anolis* we examined for helminths are shown in Figure 1. The body cavity was opened by a longitudinal incision from vent to throat, and the digestive tract was removed by cutting across the anterior esophagus and rectum. The esophagus, stomach, and small and large intestines were slit longitudinally and examined under a dissecting microscope. The gallbladder, liver, and body cavity

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Table 1. Samples of *Anolis* lizards examined from the Caribbean.

Species	Locality	*N*	$\bar{x}$ snout–vent length ± SD (mm)	Range (mm)
Anolis aeneus	Grenada	20	62.2 ± 3.7	54–68
Anolis extremus	Barbados	5	64.0 ± 8.0	53–70
	St. Lucia	5	61.4 ± 3.4	57–66
Anolis gingivinus	Anguilla	64	50.6 ± 6.8	39–63
	St. Barthélemy	14	58.4 ± 4.9	43–64
Anolis griseus	St. Vincent	10	91.7 ± 13.1	74–107
Anolis luciae	St. Lucia	34	64.5 ± 12.3	31–82
Anolis marmoratus	Guadeloupe	25	60.8 ± 4.6	48–68
Anolis oculatus	Dominica	11	69.1 ± 9.7	52–80
Anolis richardi	Grenada	20	91.5 ± 11.7	66–110
Anolis roquet	Martinique	4	58.0 ± 7.2	51–68
Anolis sabanus	Saba	12	53.0 ± 4.8	45–60
Anolis trinitatis	St. Vincent	17	52.4 ± 8.8	37–68
Anolis wattsi	Antigua	20	41.3 ± 3.4	36–47

were also searched for helminths. Each helminth was initially placed in a drop of glycerol on a glass slide. Nematodes were identified from these temporary mounts. Cestodes were stained with hematoxylin, mounted in balsam, and identified. Acanthocephalans were cleared in xylene, mounted in balsam, and assigned to a genus.

Results

The helminths found in the 12 anole species examined in this study consisted of 1 species of trematode, *Mesocoelium monas* (Rudolphi, 1819); 1 species of cestode, *Oochoristica maccoyi* Bursey and Goldberg, 1996; 9 species of nematodes, *Oswaldocruzia marechali* Ben Slimane, Durette-Desset, and Chabaud, 1995, *Parapharyngodon cubensis* (Baruš and Coy Otero, 1969), *Spauligodon caymanensis* Bursey and Goldberg, 1995, *Trichospirura teixeirai* (Baruš and Coy Otero, 1968), *Abbreviata* sp., *Ascarops* sp., *Physaloptera* sp., *Physocephalus* sp., and *Porrocaecum* sp., and 1 species of acanthocephalan, *Centrorhynchus* sp. The first 6 species were represented by mature individuals; only immature individuals of the latter 6 species were found. Occurrences of helminths and 29 new host records are listed in Table 2. Helminths were placed in vials of 70% ethanol and deposited in the United States National Parasite Collection [USDA], Beltsville, Maryland (Appendix 2).

Discussion

The known helminth fauna for anoles of the Lesser Antilles is presented in Table 3. Only *Anolis nubilis*, which is restricted to the tiny island of Redonda (ca. 19 km NW of Montserrat), is unlisted and remains to be examined. For these anoles, known helminths consist of 2 species of trematodes, *Alloglyptus crenshawi* Byrd, 1950, and *Mesocoelium monas*; 1 species of cestode, *Oochoristica maccoyi*; 14 species of nematodes, *Abbreviata* sp., *Ascarops* sp., *Physaloptera* sp., *Physocephalus* sp., *Porrocaecum* sp. represented by larvae only, *Oswaldocruzia dorsarmata* Ben Slimane, Durette-Desset, and Chabaud, 1995, *O. jeanbarti* Ben Slimane, Durette-Desset and Chabaud, 1995, *O. marechali*, *O. mauleoni* Ben Slimane, Durette-Desset and Chabaud, 1995, *Parapharyngodon cubensis*, *Rhabdias* sp., *Spauligodon caymanensis*, *Spinicauda spinicauda* (Olfers, 1819), and *Trichospirura teixeirai*; and 1 species of acanthocephalan, *Centrorhynchus* sp., represented by cystacanths only. With the exception of *Oochoristica maccoyi*, *Oswaldocruzia dorsarmata*, *O. jeanbarti*, *O. marechali*, and *O. mauleoni*, all of these helminths have been reported from other amphibian or reptilian host species, some of which are outside the Lesser Antilles (Baker, 1987).

The life cycles of *Alloglyptus crenshawi* and *Mesocoelium monas* have not yet been investigated, but they are the only trematodes so far reported from anoles of the Lesser Antilles and could be expected to exhibit typical life cycles. *Alloglyptus crenshawi* was described by Byrd (1950) from 30 specimens found in the small intestine of 1 *Anolis carolinensis* collected in Georgia. It has been found in 3 *Anolis carolinensis* collected in Putnam County, Florida

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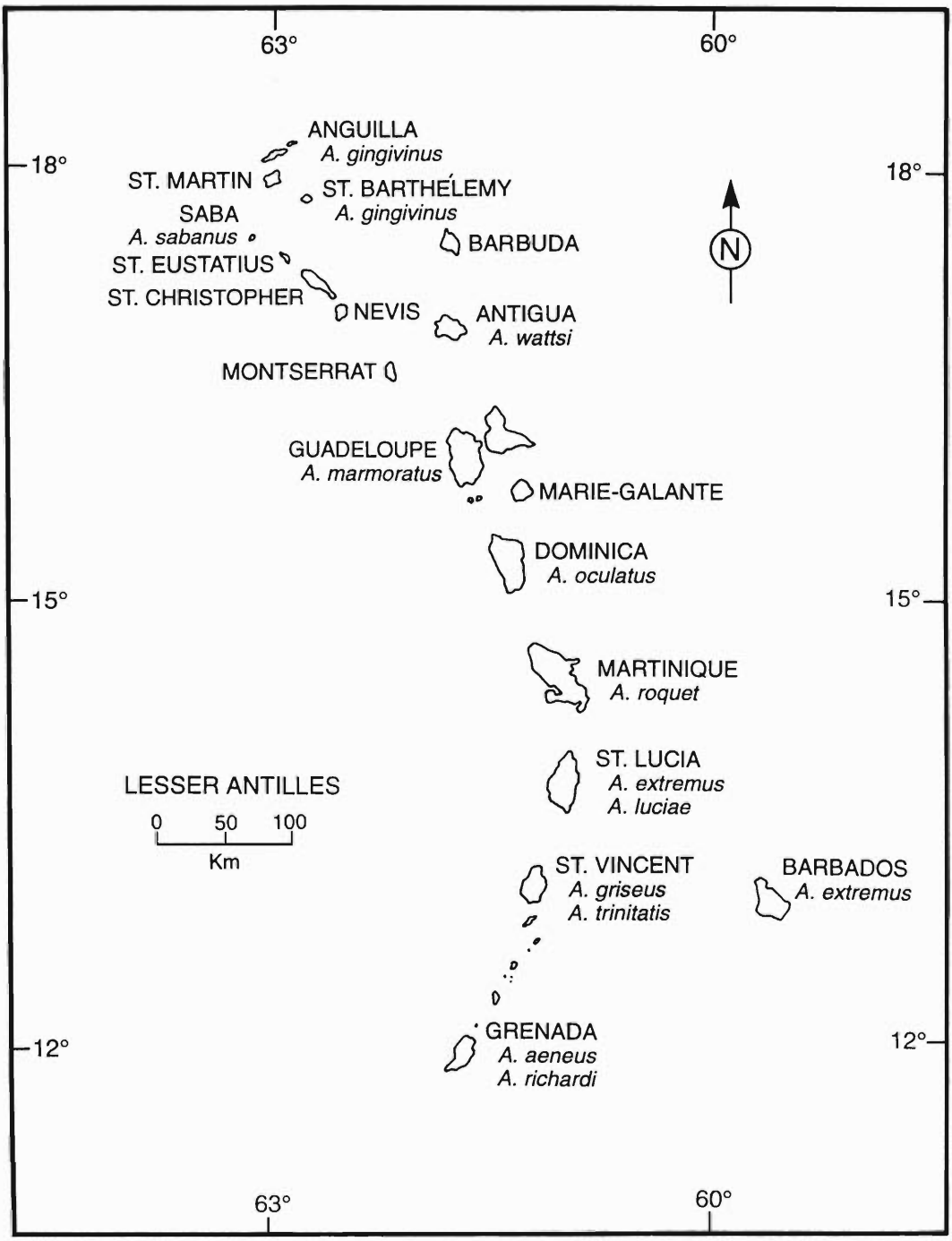

Figure 1. Islands of the Lesser Antilles with species of *Anolis* labeled next to the island from which they were collected. All other named islands are sites with published records of helminths from *Anolis* spp.

Table 2. Prevalence and mean intensity of helminths found in *Anolis* spp. examined in this study.

Species	Helminth	Prevalence	Mean intensity	Range	Site
Anolis aeneus	*Parapharyngodon cubensis**	25% (5/20)	1.2	1–2	Large intestine
	Physocephalus sp. (larvae)*	5% (1/20)	2.0	—	Encysted stomach wall
	Centrorhynchus sp. (cystacanths)*	15% (3/20)	1.0	—	Coelom
Anolis extremus	*Ascarops* sp. (larvae)*	30% (3/10)	6.7	1–12	Encysted stomach wall
	*Parapharyngodon cubensis**	20% (2/10)	4.0	2–6	Large intestine
	*Trichospirura teixeirai**	20% (2/10)	5.5	3–8	Gallbladder
Anolis gingivinus	*Mesocoelium monas*	1% (1/78)	1.0	—	Small intestine
	Oochoristica maccoyi	8% (6/78)	1.5	1–3	Small intestine
	Abbreviata sp. (larvae)*	10% (8/78)	14.5	1–72	Encysted stomach wall
	Ascarops sp. (larvae)*	8% (6/78)	4.3	1–9	Encysted stomach wall
	Parapharyngodon cubensis	32% (25/78)	2.0	1–5	Large intestine
	Physocephalus sp. (larvae)*	3% (2/78)	1.5	1–2	Encysted stomach wall
	Spauligodon caymanensis	23% (18/78)	12.9	1–65	Large intestine
	*Trichospirura teixeirai**	1% (1/78)	1.0	—	Gallbladder
	Centrorhynchus sp. (cystacanths)*	3% (2/78)	2.5	1–4	Coelom
Anolis griseus	*Ascarops* sp. (larvae)*	20% (2/10)	1.5	1–2	Encysted stomach wall
	*Parapharyngodon cubensis**	60% (6/10)	8.0	2–14	Large intestine
	Physaloptera sp. (larvae)*	10% (1/10)	1.0	—	Stomach
Anolis luciae	*Oochoristica maccoyi**	3% (1/34)	1.0	—	Small intestine
	*Parapharyngodon cubensis**	44% (15/34)	2.3	1–7	Large intestine
	Porrocaecum sp. (larvae)*	9% (3/34)	14.3	5–23	Encysted coelom
Anolis marmoratus	*Oswaldocruzia marechali*	4% (1/25)	2.0	—	Small intestine
	*Parapharyngodon cubensis**	40% (10/25)	3.0	1–9	Large intestine
	*Spauligodon caymanensis**	48% (12/25)	56.8	1–417	Large intestine
Anolis oculatus	*Mesocoelium monas*	18% (2/11)	3.0	2–4	Small intestine
	Oswaldocruzia marechali	18% (2/11)	1.0	—	Small intestine
	Parapharyngodon cubensis	27% (3/11)	1.7	1–3	Large intestine
	Physaloptera sp. (larvae)	18% (2/11)	1.5	1–2	Stomach
	Spauligodon caymanensis	27% (3/11)	6.3	2–11	Large intestine
	*Trichospirura teixeirai**	9% (1/11)	9.0	—	Gallbladder
	Centrorhynchus sp. (cystacanths)	18% (2/11)	7.0	2–12	Coelom
Anolis richardi	*Parapharyngodon cubensis**	65% (13/20)	4.2	1–23	Large intestine
	Physocephalus sp. (larvae)*	5% (1/20)	18.0	—	Encysted stomach wall
	*Spauligodon caymanensis**	10% (2/20)	6.0	2–10	Large intestine
	Centrorhynchus sp. (cystacanths)*	10% (2/20)	5.0	1–9	Coelom
Anolis roquet	*Parapharyngodon cubensis**	25% (1/4)	2.0	—	Large intestine
	Physocephalus sp. (larvae)*	25% (1/4)	9.0	—	Encysted stomach wall
Anolis sabanus	*Mesocoelium monas*	8% (1/12)	1.0	—	Small intestine
	Abbreviata sp. (larvae)*	17% (2/12)	1.5	1–2	Encysted stomach wall
	Parapharyngodon cubensis	75% (9/12)	1.8	1–3	Large intestine
Anolis trinitatis	*Physocephalus* sp. (larvae)*	18% (3/17)	25.7	22–33	Encysted stomach wall
Anolis wattsi	*Abbreviata* sp. (larvae)*	15% (3/20)	1.0	—	Encysted stomach wall
	Parapharyngodon cubensis	70% (14/20)	1.9	1–4	Large intestine
	Spauligodon caymanensis	10% (2/20)	2.5	1–4	Large intestine
	Trichospirura teixeirai	10% (2/20)	5.5	3–8	Gallbladder

* New host record.

(Franz and Telford, 1972) and was also reported from the Georgia population by Sellers and Hertz (1982). The only other report of *Alloglyptus crenshawi* is that of Dobson et al. (1992). All of these reports involve only anoles as hosts.

Mesocoelium monas has been reported frequently from the toad, *Bufo marinus*, from widely separated geographical regions such as Brazil, Colombia, Costa Rica, Hawaii, Paraguay, Puerto Rico, and Samoa (Nasir and Díaz, 1971; Goldberg and Bursey, 1992). It is also known from other amphibians and reptiles (Acholonu, 1976;

Table 3. Helminths and *Anolis* hosts of the Lesser Antilles.

Helminth	Host	Island	Reference
Trematoda			
Alloglyptus crenshawi	*A. gingivinus*	St. Martin	Dobson et al., 1992
	A. lividus	Montserrat	Dobson et al., 1992
Mesocoelium monas	*A. bimaculatus*	Antigua	Dobson et al., 1992
	A. gingivinus	Anguilla	This paper
		St. Martin	Dobson et al., 1992
	A. oculatus	Dominica	This paper
		Dominica	Goldberg and Bursey, 1996
	A. sabanus	Saba	This paper
		Saba	Dobson et al., 1992
Cestoda			
Oochoristica maccoyi	*A. bimaculatus*	Antigua	Goldberg et al., 1996a
	A. gingivinus	Anguilla	This paper
		Anguilla	Bussey and Goldberg, 1996
	A. trinitatis	St. Vincent	This paper
Nematoda			
Abbreviata sp.	*A. bimaculatus*	Antigua	Goldberg et al., 1996a
	A. gingivinus	Anguilla	This paper
	A. sabanus	Saba	This paper
	A. wattsi	Antigua	This paper
Ascarops sp.	*A. extremus*	Barbados	This paper
	A. gingivinus	Anguilla	This paper
	A. griseus	St. Vincent	This paper
	A. oculatus	Dominica	Goldberg and Bursey, 1996
Oswaldocruzia dorsarmata	*A. marmoratus*	Guadeloupe	Ben Slimane et al., 1995
Oswaldocruzia jeanbarti	*A. marmoratus*	Guadeloupe	Ben Slimane et al., 1995
Oswaldocruzia marechali	*A. marmoratus*	Guadeloupe	Ben Slimane et al., 1995
	A. marmoratus	Guadeloupe	This paper
	A. oculatus	Dominica	This paper
		Dominica	Goldberg and Bursey, 1996
Oswaldocruzia mauleoni	*A. marmoratus*	Guadeloupe	Ben Slimane et al., 1995
Parapharyngodon cubensis	*A. aeneus*	Grenada	This paper
	A. bimaculatus	Antigua	Goldberg et al., 1996a
		Antigua	Dobson et al., 1992
		Barbuda	Goldberg et al., 1996a
		Nevis	Goldberg et al., 1996a
		St. Christopher	Goldberg et al., 1996a
		St. Eustatius	Goldberg et al., 1996a
		St. Eustatius	Dobson et al., 1992
	A. extremus	Barbados	This paper
	A. ferreus	Marie-Galante	Dobson et al,. 1992
	A. gingivinus	Anguilla	This paper
		Anguilla	Dobson et al,. 1992
		St. Martin	Dobson et al,. 1992
	A. griseus	St. Vincent	This paper
	A. lividus	Montserrat	Dobson et al,. 1992
	A. luciae	St. Lucia	This paper
	A. marmoratus	Guadeloupe	This paper
	A. oculatus	Dominica	This paper
		Dominica	Goldberg and Bursey, 1996
	A. richardi	Grenada	This paper
	A. roquet	Martinique	This paper
	A. sabanus	Saba	This paper
		Saba	Dobson et al., 1992
	A. wattsi	Antigua	This paper
		Antigua	Dobson et al,. 1992
		St. Eustatius	Dobson et al,. 1992
		St. Martin	Dobson et al,. 1992

Table 3. Continued.

Helminth	Host	Island	Reference
Physaloptera sp.	*A. bimaculatus*	Antigua	Dobson et al,. 1992
		Barbuda	Goldberg et al., 1996a
	A. griseus	St. Vincent	This paper
	A. lividus	Montserrat	Dobson et al,. 1992
	A. oculatus	Dominica	This paper
		Dominica	Goldberg and Bursey, 1996
	A. wattsi	Antigua	Dobson et al,. 1992
		St. Eustatius	Dobson et al,. 1992
Physocephalus sp.	*A. aeneus*	Grenada	This paper
	A. gingivinus	Anguilla	This paper
		St. Barthélemy	This paper
	A. richardi	Grenada	This paper
	A. roquet	Martinique	This paper
	A. trinitatis	St. Vincent	This paper
Porrocaecum sp.	*A. luciae*	St. Lucia	This paper
Rhabdias sp.	*A. wattsi*	St. Eustatius	Dobson et al., 1992
Spauligodon caymanensis	*A. bimaculatus*	Antigua	Dobson et al., 1992
		St. Eustatius	Goldberg et al., 1996a
		St. Eustatius	Dobson et al., 1992
	A. ferreus	Marie-Galante	Dobson et al., 1992
	A. gingivinus	Anguilla	This paper
		Anguilla	Dobson et al., 1992
		St. Barthélemy	This paper
	A. lividus	Montserrat	Dobson et al., 1992
	A. marmoratus	Guadeloupe	This paper
	A. oculatus	Dominica	This paper
		Dominica	Goldberg and Bursey, 1996
	A. richardi	Grenada	This paper
	A. sabanus	Saba	Dobson et al., 1992
	A. wattsi	Antigua	This paper
		Antigua	Dobson et al., 1992
		St. Eustatius	Dobson et al., 1992
Spinicauda spinicauda	*A. bimaculatus*	Antigua	Dobson et al., 1992
	A. oculatus	Dominica	Goldberg and Bursey, 1996
Trichospirura teixeirai	*A. bimaculatus*	Antigua	Dobson et al., 1992
	A. extremus	Barbados	This paper
	A. gingivinus	Anguilla	This paper
	A. oculatus	Dominica	This paper
	A. wattsi	Antigua	This paper
Acanthocephala			
Centrorhynchus sp.	*A. aeneus*	Grenada	This paper
	A. bimaculatus	Antigua	Dobson et al., 1992
		St. Eustatius	Dobson et al., 1992
	A. gingivinus	Anguilla	This paper
	A. lividus	Montserrat	Dobson et al., 1992
	A. oculatus	Dominica	This paper
		Dominica	Goldberg and Bursey, 1996
	A. richardi	Grenada	This paper
	A. wattsi	Antigua	Dobson et al., 1992
		St. Eustatius	Dobson et al., 1992

Price and Underwood, 1984; Bundy et al., 1987; Sellers and Graham, 1987; Dobson et al., 1992; Goldberg and Bursey, 1996; Goldberg et al., 1996a).

Oochoristica maccoyi was recently described from *A. gingivinus* from Anguilla (Bursey and Goldberg, 1996). It has been found in *A. bimaculatus* from Antigua (redetermination of the specimen in Goldberg et al., 1996a). *Anolis luciae* is a new host record for *O. maccoyi*.

The nematodes separate into 2 categories. Five are heteroxenous helminths requiring an in-

termediate host: *Abbreviata* sp., *Ascarops* sp., *Physaloptera* sp., *Physocephalus* sp., and *Porrocaecum* sp. These species were represented by encysted larvae in the species of *Anolis* studied here, but they are known to parasitize a wide variety of vertebrates as adults and are found encysted in a number of amphibians and reptiles (Anderson, 1992). Because insects or earthworms are intermediate hosts for species in these genera, it is probably not surprising that larvae are found encysted in anoles. Whether anoles serve as paratenic hosts or accidental hosts only remains to be determined. New host records for these larvae in *Anolis aeneus*, *A. extremus*, *A. gingivinus*, *A. griseus*, *A. luciae*, *A. richardi*, *A. roquet*, *A. sabanus*, *A. trinitatus*, and *A. wattsi* are given in Table 2.

The other 6 nematodes are monoxenous with skin penetration, egg ingestion, or autoinfective routes of infection, and all have wide distribution patterns in the Caribbean. *Oswaldocruzia marechali* was recently described from *Anolis marmoratus* from Guadeloupe by Ben Slimane et al. (1995). It had previously been found in *A. oculatus* from Dominica (redetermination of specimen in Goldberg and Bursey, 1996).

Parapharyngodon cubensis has been reported from lizards, an amphisbaenid, and snakes (Coy Otero and Baruš, 1973, 1979; Bundy et al., 1987; Dobson et al., 1992; Goldberg et al., 1995). Its presence in *Anolis aeneus*, *A. extremus*, *A. griseus*, *A. luciae*, *A. marmoratus*, *A. richardi*, and *A. roquet* represents new host records (Table 2).

Spauligodon caymanensis was described recently from *Anolis conspersus* (Bursey and Goldberg, 1995) and has been reported from *A. oculatus* from Dominica (Bursey and Goldberg, 1996). Dobson et al. (1992) reported a nematode, *Skrjabinodon* sp. (possibly *anolis*), present in 6 species of anoles from the Lesser Antilles. This identification was done before *Spauligodon caymanensis* was described. Females of these 2 species are similar in appearance, with *S. caymanensis* the larger of the 2 species. Males are necessary for proper identification; species of *Skrjabinodon* lack caudal alae, whereas species of *Spauligodon* have caudal alae. We have examined 24 species of anoles and have never found representatives of *Skrjabinodon*. Prior to Dobson et al. (1992), the only reports of *Skrjabinodon anolis* were from Cuba and Puerto Rico (Baruš and Coy Otero, 1974; Acholonu, 1976; Coy Otero and Baruš, 1979). We believe the specimens found by Dobson et al. (1992) to be *Spauligodon caymanensis* and have so listed them in Table 3; likewise, *Skrjabinodon anolis* is not listed as a nematode of anoles of the Lesser Antilles. *Anolis marmoratus* and *A. richardi* are new host records for *S. caymanensis*.

Trichospirura teixeirai has been found in the small intestine of several species of lizards from Cuba and the Dominican Republic (Baruš and Coy Otero, 1968; Powell et al., 1990). New host records are established for *Trichospirura teixeirai* in *Anolis extremus*, *A. gingivinus*, and *A. oculatus* (Table 2).

Two species of nematodes previously reported in Lesser Antillean anoles were not encountered in this study. Dobson et al. (1992) reported *Rhabdias* sp. from *Anolis wattsi* from St. Eustatius; Torres Ortiz (1980) reported *Rhabdias* sp. from *Anolis cristatellus*, *A. evermanni*, and *A. gundlachi* from several Caribbean locations. Species of *Rhabdias* are known from a large number of amphibians and reptiles (see Baker, 1987). The taxonomy of this group is complicated because adult parasites are all hermaphrodites and are difficult to separate to species. *Spinicauda spinicauda* was found previously in *Anolis oculatus* from Dominica (Goldberg and Bursey, 1996) and has been reported from *Ameiva ameiva*, *Anolis armouri*, and *Tupinambis teguixin* from Brazil and Trinidad (Pereira, 1935; Everard, 1975; Oliveira Rodrigues and Feijó, 1976).

Cystacanths of *Centrorhynchus* sp. have been reported from several species of anoles of the Caribbean (Bundy et al., 1987; Dobson et al., 1992; Goldberg et al., 1994). Adults of *Centrorhynchus* sp. are thought to be parasites of birds (Dobson et al., 1992). New host records for cystacanths are established for *Centrorhynchus* sp. in *Anolis aeneus*, *A. gingivinus*, and *A. richardi* (Table 2).

The occurrences of helminths in Lesser Antillan anoles from this study and others (Dobson et al., 1992; Goldberg and Bursey, 1996; Goldberg et al., 1996b) are summarized in Table 3. Clearly, *Parapharyngodon cubensis* has the widest distribution and has been found so far in all anoles examined except *Anolis trinitatis*. This helminth is monoxenous (direct life cycle) with infection likely due to contact with contaminated soil (Anderson, 1992). Its highest prevalence (75%) was in *Anolis sabanus*. *Spauligodon cay-*

manensis had the greatest mean intensity of infection (56.8), which occurred in *Anolis marmoratus*. *Anolis gingivinus* was infected with the greatest number of species (9); *A. trinitatis* harbored the fewest (1 species).

It is of interest to note that the islands with the largest numbers of helminth species (Anguilla, $N = 9$; Antigua, $N = 9$; and Dominica, $N = 9$) are located in the northern Lesser Antilles and are much closer to the larger islands (Cuba, Hispaniola), which have larger numbers of lizard host species than do the islands of the Lesser Antilles (Schwartz and Henderson, 1991). This closeness may have allowed greater interchange of parasites before the current isolation. Given the distribution patterns of the 6 monoxenous nematodes and their occurrence in a number of host species, perhaps it is more appropriate to speak of capture of host by parasite than the reverse. That anoles lack a unique helminths fauna suggests that ecological conditions favoring egg survival of monoxenous helminths and the distribution of intermediate hosts for heteroxenous helminths are much more important than the presence of a particular lizard host species. No doubt as more amphibians and reptiles from the Lesser Antilles are examined, they will be found to harbor many of the species of parasites listed in this paper. Indeed, there are 1 toad, 8 frog, 4 turtle, 42 lizard, and 21 snake species from the Lesser Antilles (Schwartz and Henderson, 1985) and, except for anoles, few have been examined for helminths.

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Appendix 1: Museum Accession Numbers of Specimens Examined

Abbreviations are as follows: Museum of Natural History, KU = University of Kansas; LACM = Natural History Museum of Los Angeles County; CM = Carnegie Museum of Natural History; and FMNH = Field Museum of Natural History.

Anolis aeneus, Grenada (KU): 250109, 250111, 250124, 250125, 250136, 250141, 250144, 250146, 250151, 250157, 250164, 250165, 250170–250172, 250174, 250176, 250182, 250183, 250185.

Anolis extremus, Barbados (LACM): 61767, 61768; (FMNH): 21097, 21099, 21100; St. Lucia (KU): 270589, 270591, 270595, 270602, 270605.

Anolis gingivinus, Anguilla (CM): 114654, 114657, 114662, 114681–114683, 114718, 114719, 114727, 114728, 114731, 114732, 114734, 114736, 114742, 114757, 114758, 115461, 115462, 115464, 115484, 115491, 115493, 115521, 115568, 117895, 117918, 117942, 117991, 117994, 117997, 117998, 118000, 118003, 118005, 118006, 119189, 119196, 119202–119204, 119207, 119210, 119211, 119213, 124406, 124407, 124410, 124413, 124414; (LACM): 114947–114952, 114965–114972; St. Barthélemy (LACM): 114953–114958; 114973–114980.

Anolis griseus, St. Vincent (KU): 257961, 257969–257971, 257973–257977, 257984.

Anolis luciae, St. Lucia (LACM): 61637, 61638, 61700–61711; (KU): 258494, 258495, 258497, 258500, 258502–258505, 258507–258509, 258511, 258514, 258517, 271076, 271079–271081, 271083, 271084.

Anolis marmoratus, Guadeloupe (KU): 258040–258061, 258206, 258213, 258214.

Anolis oculatus, Dominica (LACM): 61769–61771, 114915–114922.

Anolis richardi, Grenada (KU): 249949–249952, 249954–249961, 249963, 249965–249971.

Anolis roquet, Martinique (LACM): 114911–114914.

Anolis sabanus, Saba (LACM): 114931–114942.

Anolis trinitatis, St. Vincent (LACM): 61620–61636.

Anolis wattsi, Antigua (KU): 246359, 246376, 246379, 246380, 246388, 246402, 246407–246409, 246412, 246416, 246417, 246419, 246421–246425, 246427, 246428.

Appendix 2: Helminths Deposited in the United States National Parasite Collection, USDA, Beltsville, Maryland

Anolis aeneus: *Parapharyngodon cubensis* 85475; *Physocephalus* sp. 85476; *Centrorhynchus* sp. 85477.

Anolis extremus: *Ascarops* sp. 86202, 86203; *Parapharyngodon cubensis* 86204; *Trichospirura teixeirai* 86205.

Anolis gingivinus: *Mesocoelium monas* 85478, *Oochoristica maccoyi* 85479, *Abbreviata* sp. 85480, 86206; *Ascarops* sp. 86207; *Parapharyngodon cubensis* 85481, 86209; *Physocephalus* sp. 85483, 86208; *Spauligodon caymanensis* 85482, 86210; *Trichospirura teixeirai* 86211; *Centrorhynchus* sp. 86212.

Anolis griseus: *Ascarops* sp. 86213; *Parapharyngodon cubensis* 86215; *Physaloptera* sp. 86214.

Anolis luciae: *Oochoristica maccoyi* 86344; *Parapharyngodon cubensis* 85484, 86216; *Porrocaecum* sp. 85485.

Anolis marmoratus: *Oswaldocruzia marechali* 85486; *Parapharyngodon cubensis* 85487; *Spauligodon caymanensis* 85488.

Anolis oculatus: *Mesocoelium monas* 86217; *Oswaldocruzia marechali* 86219; *Parapharyngodon cubensis* 86220; *Physaloptera* sp. 86218; *Spauligodon caymanensis* 86221; *Trichospirura teixeirai* 86222; *Centrorhynchus* sp. 86223.

Anolis richardi: *Parapharyngodon cubensis* 85489; *Physocephalus* sp. 85490; *Spauligodon caymanensis* 85491; *Centrorhynchus* sp. 85492.

Anolis roquet: *Parapharyngodon cubensis* 86225; *Physocephalus* sp. 86224.

Anolis sabanus: *Mesocoelium monas* 86226; *Abbreviata* sp. 86227; *Parapharyngodon cubensis* 86228.

Anolis trinitatis: *Physocephalus* sp. 85493.

Anolis wattsi: *Abbreviata* sp. 86229; *Parapharyngodon cubensis* 86230; *Spauligodon caymanensis* 86231; *Trichospirura teixeirai* 86232.

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Endohelminths of American Alligators (*Alligator mississippiensis*) from Southeast Texas

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ABSTRACT: Fifty American alligators (*Alligator mississippiensis*) were obtained from southeast Texas from September 1992 to September 1995. A total of 8,861 parasites were recovered from 46 infected alligators (92%). Necropsy revealed the presence of 1 species of pentastome (*Sebekia mississippiensis*), 3 species of nematodes (*Brevimulticaecum baylisi*, *B. tenuicolle*, and *Dujardinascaris waltoni*), and 8 species of trematodes (*Acanthostomum coronarium*, *A. loossi*, *A. pavidum*, *Archaeodiplostomum acetabulatum*, *Crocodilicola pseudostoma*, *Dracovermis occidentalis*, *Polycotyle ornata*, and *Pseudocrocodilicola georgiana*). Prevalence, mean intensity, and abundance of infection were higher in adult (≥1.80 m) alligators. There was no significant difference ($P > 0.05$) in mean intensity or abundance between male and female alligators. Infracommunity structure, based on species richness, intensity of infection, and diversity of endohelminths, is considered depauperate when compared to homeothermic hosts. However, alligator endohelminth communities are relatively rich and diverse compared to other reptilian hosts. Broadened feeding preferences, as related to maturity, are suggested as the main factor that determines endohelminth community structures in alligators.

KEY WORDS: alligator, endohelminths, population, abundance, intensity of infection, prevalence, pentastome, nematode, trematode, mature, immature.

The American alligator, *Alligator mississippiensis* Daudin, 1803, is a large crocodilian (1.8–5.0 m) that ranges throughout southeastern North America, from North Carolina, south through Florida, and west to central Texas. Parasitism among crocodilians is not well understood. Although there have been some investigations of parasites inhabiting the American alligator (*Alligator mississippiensis*), the majority of these studies have been taxonomic/systematic in nature (Byrd and Reiber, 1942; Brooks and Overstreet, 1977, 1978; Sprent, 1977, 1979; Deardorff and Overstreet, 1979; Overstreet et al., 1985). Only 2 endohelminth surveys of *A. mississippiensis* have been reported. Hazen et al. (1978) conducted the first survey on 12 alligators collected from 3 sites in South Carolina. Cherry and Ager (1982) performed a similar survey of 30 alligators from 7 counties in Florida. Although the Hazen et al. (1978) study contained far fewer host specimens, it is the most complete in terms of organ systems examined and parasite taxa recovered. There have been no scientific studies conducted on the prevalence of endohelminths in populations of Texas alligators and little inference about infracommunity structures in this host species. Herein, we provide information on endohelminths of a comparatively large sample of *A. mississippiensis* from southeastern Texas and use patterns of infection to describe the endohelminth infracommunity structure from the western portion of the host's geographic range.

Material and Methods

Nine collections of alligator viscera ($n = 50$) were examined for endohelminths over a 3-yr period between 1992 and 1995. Alligators were recovered from Chambers, Jefferson, and Liberty counties in southeast Texas through the state-sanctioned hunting program or through a state-issued scientific collection permit (SPR-0992-562). Sex, length, and county of capture of the alligator were recorded. Alligators measuring at least 1.80 m were considered sexually mature (Taylor and Neal, 1984). Alimentary tract, respiratory system, liver, heart, and kidneys were removed (the esophagus, trachea, and anus were tied closed), and organs were individually placed in labeled plastic bags to ensure recovery of all helminths from their respective site of infection. All bags were placed in ice-filled coolers for transport to the laboratory. Viscera were frozen and stored at −10°C until they were examined utilizing a Nikon SMZ-U dissecting microscope. Helminth spe-

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cies were identified using descriptions provided by Sprent (1977, 1979) for nematodes, Overstreet et al. (1985) for pentastomes, and Brooks and Overstreet (1977, 1978) and Byrd and Reiber (1942) for trematodes. No distinction was made between larval and mature helminths in this study. Voucher specimens of each species have been deposited with the United States National Parasite Collection, Beltsville, Maryland.

Nematodes, found only in the stomach, were rinsed with distilled water and placed in 70% EtOH. Temporary mounts of the worms were made utilizing lactophenol. Once cleared and identified and the sex determined, nematodes were placed in vials containing 70% EtOH. Some nematodes, after clearing, were mounted in Kleermount® according to methods described in Ash and Orihel (1991). Although this technique is not usually recommended for the mounting of nematodes, distortion was not apparent and results were satisfactory for some smaller nematodes. Pentastomes from the lungs, pleural sacs, and bronchioles of alligators were rinsed with distilled water and placed in a solution of 70% EtOH and 5% glycerin for storage. Trematodes were recovered from the intestinal tract, rinsed with distilled water, and placed in 70% EtOH. Worms were then fixed in AFA and stained with Semichon's acetocarmine stain. Staining was normally halted after 10–15 min by removing excess stain from the vials and rinsing the worms with 70% EtOH. Destaining, when necessary, was accomplished by utilizing 2% acid alcohol. Trematodes were then dehydrated through an alcohol gradient to 100%, cleared in methyl salicylate, and mounted in Kleermount®.

A nonparametric 2-tailed Welch's approximate *t*-test (Ott, 1988) was chosen to analyze the difference between abundance and mean intensity of infections of immature and mature alligators and between male and female alligators. This nonparametric *t*-test was chosen because variances between the 2 groups analyzed were significantly different. Species richness was used to describe infracommunity structure. Species richness was compared between male and female alligators, as well as between immature and mature alligators, using a Student's *t*-test (Ott, 1988). Species richness, abundance, and mean intensity were also compared between alligators in this study and alligators censused from South Carolina (Hazen et al., 1978) using a nonparametric Welch's approximate *t*-test. Brillouin's index (Pielou, 1975) was used to provide a measure of infracommunity diversity. The Student's *t*-test was used to compare diversity indices between male and female, as well as between immature and mature Texas alligators. Similarly, the Student's *t*-test was used to compare the diversity of censused Texas alligators, as measured by Brillouin's index, to the diversity of censused South Carolina alligators (Hazen et al., 1978). Use of ecological terms follow suggestions of Margolis et al. (1982).

Results and Discussion

Twelve species of helminths were collected from 50 American alligators, 4 of which were free of helminths. Parasites recovered included 3 species of nematodes, 1 pentastome species, and 8 species of trematodes. All are known from American alligators. Prevalence, abundance, and mean intensities of each species are given in Table 1. Individual alligators harbored between 0 and 9 species of helminths. Eight percent of the alligators examined were found free of helminths. Alligators with more than 5 species were rare (15.2%), with 84.8% of infected hosts harboring 1–5 species of helminths. Infections were as follows: 2 alligators had only 1 helminth species, 7 alligators had 2 species, 11 alligators had 3 species, 10 alligators had 4 species, 9 alligators had 5 species, 4 alligators had 6 species, 1 alligator had 7 species, 1 alligator had 8 species, and 1 alligator had 9 species. A total of 8,861 helminths were collected. The number of worms recovered from infected hosts ranged from 1 to 1,241 (average 192.63 ± 277.68).

Abundance and mean intensities of infections for male and female alligators were examined overall and by individual helminth species. Results from Welch's approximate *t*-test indicate no significant differences ($P > 0.05$) in abundance or mean intensity of infection between male alligators and female alligators.

Three different species of nematodes were found in the stomach of alligators: *Brevimulticaecum baylisi* Travassos, 1933, *Brevimulticaecum tenuicolle* Rudolphi, 1819, and *Dujardinascaris waltoni* Sprent, 1977. Nematodes were found in both immature (<1.80 m) and mature (≥1.80 m) alligators. Unique to the nematodes, the prevalence of infection was highest (64%) among immature alligators (Table 1). Mature alligators possessed a slightly lower prevalence of infection (60%) (Table 1). Mean intensities and abundance of individual nematode species were not significantly different ($P > 0.05$) when compared between mature and immature alligators.

Pentastomes (*Sebekia mississippiensis* Overstreet, Self, and Vliet, 1985) were also recovered from the lungs, pleural sacs, and bronchioles of immature and mature alligators, with the highest prevalence (72%) in mature alligators (Table 1). No significant difference ($P > 0.05$) in mean intensity of pentastome infection was observed between immature and mature alligators. Due to the higher prevalence, however, the abundance of *S. mississippiensis* in mature alligators was significantly higher ($P < 0.05$) than in immature alligators.

Mature alligators possessed a greater preva-

Table 1. Parasites recovered from immature and mature *A. mississippiensis* from Texas.*

Parasite	Immature				Mature			
	Prevalence	MI ± SD	Range	A ± SD	Prevalence	MI ± SD	Range	A ± SD
Nematoda	**64% (16/25)**	**14.2 ± 18.3**	**1–63**	**9.1 ± 16.0**	**60% (15/25)**	**59.5 ± 113.1**	**2–453**	**35.7 ± 91.3**
Brevimulticaecum baylisi (USNPC 86186)	40% (10/25)	5.6 ± 5.9	1–16	2.2 ± 4.6	16% (4/25)	1.8 ± 1.0	1–3	0.3 ± 0.7
Brevimulticaecum tenuicolle (USNPC 86187)	44% (11/25)	6.6 ± 7.1	1–22	2.9 ± 5.7	8% (2/25)	12.0 ± 14.1	2–22	1.0 ± 4.4
Dujardinascaris waltoni (USNPC 86188)	44% (11/25)	8.9 ± 11.0	1–33	3.9 ± 8.4	56% (14/25)	61.6 ± 117.1	1–453	34.5 ± 91.6
Pentastomida								
Sebekia mississippiensis (USNPC 86189)	12% (3/25)	3.0 ± 2.7	1–6	0.4 ± 1.3	72% (18/25)	2.3 ± 1.2	1–5	1.7 ± 1.5
Trematoda	**56% (14/25)**	**70.1 ± 90.0**	**3–318**	**39.2 ± 75.1**	**100% (25/25)**	**268.4 ± 325.8**	**2–1,240**	**268.4 ± 325.8**
Acanthostomum coronarium (USNPC 86178)	16% (4/25)	37.0 ± 33.7	1–78	5.9 ± 18.3	32% (8/25)	12.4 ± 15.1	1–47	4.0 ± 10.1
Acanthostomum loossi (USNPC 86179)	04% (1/25)	3.0	—	0.1 ± 0.2	24% (6/25)	201.3 ± 447.0	2–1,113	48.3 ± 222.1
Acanthostomum pavidum (USNPC 86180)	08% (2/25)	8.0 ± 5.7	4–12	0.6 ± 2.5	56% (14/25)	29.7 ± 62.7	1–242	16.6 ± 48.5
Archaeodiplostomum acetabulatum (USNPC 86181)	—	—	—	—	4% (1/25)	5.0	—	0.2 ± 1.0
Crocodilicola pseudostoma (USNPC 86182)	—	—	—	—	4% (1/25)	2.0	—	0.1 ± 0.4
Dracovermis occidentalis (USNPC 86183)	8% (2/25)	3.5 ± 3.5	1–6	0.3 ± 1.2	60% (15/25)	123.2 ± 165.3	9–622	73.9 ± 140.5
Polycotyle ornata (USNPC 86184)	36% (9/25)	8.4 ± 9.5	1–32	3.0 ± 6.9	52% (13/25)	11.5 ± 21.7	1–32	6.0 ± 16.4
Pseudocrocodilicola georgiana (USNPC 86185)	56% (14/25)	52.2 ± 86.1	1–312	29.2 ± 68.7	76% (19/25)	157.0 ± 241.4	2–786	119.3 ± 220.2
Total parasites	84% (21/25)	58.0 ± 92.7	1–371	48.7 ± 87.3	100% (25/25)	305.8 ± 329.0	17–1,241	305.8 ± 329.0

* Abbreviations: USNPC = United States National Parasite Collection, MI = mean intensity, A = abundance.

lence of trematode infections than immature alligators, 100 and 56%, respectively (Table 1). All trematodes recovered were found within the intestine of their hosts. *Pseudocrocodilicola georgiana* Byrd and Reiber, 1942, was the most prevalent trematode in this study (Table 1); however, in mature alligators, the mean intensity of *P. georgiana* (157) was less than that of *Acanthostomum loossi* Perez Viguera, 1957 (201) (Table 1). *Crocodilicola pseudostoma* Willemoes-Suhm, 1870, and *Archaeodiplostomum acetabulatum* Dubois, 1944, were found only in mature alligators, and both were extremely rare (Table 1). Four other trematodes also were recovered, including *Acanthostomum coronarium* Cobbold, 1861, *Acanthostomum pavidum* Brooks and Overstreet, 1977, *Dracovermis occidentalis* Brooks and Overstreet, 1978, and *Polycotyle ornata* Willemoes-Suhm, 1870.

The abundance and mean intensity of trematodes in immature alligators and mature alligators (Table 1) were significantly different ($P < 0.05$). Specific analyses of the abundance and mean intensities of individual trematode species revealed that *D. occidentalis* was significantly greater in mature alligators ($P < 0.05$). No other trematode species were found to be significantly different ($P > 0.05$) between immature and mature alligators.

The mean species richness was 3.6 ± 2.0 for each host analyzed. Examination of males and females revealed no significant difference ($P > 0.05$) in species richness. However, mature Texas alligators possessed a species richness of 4.60 ± 1.76, which was significantly different ($P < 0.05$) from that of immature alligators (2.68 ± 1.70).

Brillouin's index ranged from 0.04 to 1.31, with a mean value of 0.54 ± 0.37. Additionally, there was no significant difference ($P > 0.05$) found between the Brillouin's indices of immature and mature Texas alligators. Brillouin's indices were compared between males and females of Texas alligators and were not found to be significantly different ($P > 0.05$).

Helminth community structure from the southwestern portion of the alligator's range is similar to that reported by Hazen et al. (1978) in an endohelminth study on alligators from South Carolina. Texas alligators possessed more helminth species (12) than those of South Carolina (7), but the South Carolina alligators had significantly higher ($P < 0.05$) mean intensities (589.25 ± 482.52) than Texas alligators (192.63 ± 277.68). Additionally, abundance was also significantly higher ($P < 0.05$) in South Carolina alligators (589.25 ± 482.52) than in Texas alligators (177.22 ± 271.29). The species richness from alligators examined in South Carolina (Hazen et al., 1978) was 3.92 ± 0.79 and was not significantly different ($P > 0.05$) from southeast Texas (3.60 ± 2.00). The Brillouin's index for helminths of alligators from South Carolina (Hazen et al., 1978) was also calculated (0.56 ± 0.35) and was found not to be significantly different ($P > 0.05$) from the Brillouin's index calculated for Texas alligators (0.54 ± 0.37).

Texas alligators tended to have a wider diversity of endohelminths than South Carolina alligators, but the South Carolina alligators had heavier infections. Sample size, different habitats, temperatures, and prey items may likely play a role in the endohelminth differences noted between alligators from South Carolina and Texas.

Highly variable helminth communities of this study and the Hazen et al. (1978) study correlate strongly with parasite communities of other reptiles (Aho, 1990). Although alligator helminth communities are comparatively depauperate when compared to helminth communities of homeothermic hosts, they are relatively rich when compared to other reptiles (Aho, 1990).

The prey taken by alligators generally appears to be determined by alligator size, as well as by its availability in the habitat. The size of the alligator has been shown to be positively correlated with the size of its prey (McNease and Joanen, 1977; Delany and Abercrombie, 1986; Wolf et al., 1987). It was also observed through this study, as well as through the study conducted in South Carolina (Hazen et al., 1978), that species richness, abundance, mean intensity of infection, and diversity increased as alligator size increased. Therefore, it is suggested that the broadening of general feeding preferences, as related to maturity, is a significant factor that determines infracommunity structure of alligator helminths.

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Maxomystrongylus yasumai gen. and sp. n. (Nematoda: Trichostrongylina: Heligmonellidae) Collected from Murid Rodents in Kalimantan, Indonesia

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ABSTRACT: *Maxomystrongylus yasumai* gen. and sp. n. (Nematoda: Trichostrongylina: Heligmonellidae: Nippostrongylinae) is described based on the specimens collected from the small intestine of *Maxomys whiteheadi* (Rodentia: Muridae) from East Kalimantan, Indonesia. This parasite was also found from *Rattus rattus diardii* and *Niviventer cremoniventer* (Muridae) in the same locality. *Maxomystrongylus* is closely allied to *Heligmonoides* but is distinguished by having a more strongly inclined axis of orientation of ridges in midbody, developed slender ridges lacking basal thickening in left lateral side of body, and a large unilateral diverticulum of the vagina vera. *Maxomystrongylus yasumai* is distinguished from *Maxomystrongylus musseri* (Hasegawa and Syafruddin, 1994) comb. n. (syn. *Heligmonoides musseri*) from *Maxomys musschenbroekii* of Sulawesi by having a smaller body, more closely set left lateral developed ridges, unequal dorsoventral height in the lateral lobes of the bursa copulatrix, a dorsal ray being divided distal to its midlength and shorter spicules in the male, and absence of a carene at the level of the ovejector and a more pointed tail in female. *Maxomys* murines seem to be the primary hosts of *Maxomystrongylus* in both Kalimantan and Sulawesi.

KEY WORDS: *Maxomystrongylus yasumai* gen. and sp. n., *Maxomystrongylus musseri* comb. n., Nematoda, Trichostrongylina, Heligmosomoidea, Heligmonellidae, Muridae, Kalimantan, Indonesia.

Heligmonoides musseri Hasegawa and Syafruddin, 1994 (Trichostrongylina: Heligmosomoidea: Heligmonellidae: Nippostrongylinae), described from the endemic murines of Sulawesi, Indonesia, was tentatively classified in the genus *Heligmonoides* Baylis, 1928, because the left lateral 4 ridges in the midbody are well developed (Hasegawa and Syafruddin, 1994). This species, however, is quite specialized in that the developed left lateral ridges are slender and winding, and the vagina vera has a unilateral prominent diverticulum, suggesting that it belongs to an undescribed genus (Hasegawa and Syafruddin, 1994). During a medicozoological survey carried out in East Kalimantan, Indonesia, in 1993, a new nematode species sharing many common characteristics with *H. musseri* was collected. This paper proposes a new genus for these 2 species.

Materials and Methods

Rodents were captured in the Bukit Soeharto Preserved Forest near Samarinda, East Kalimantan, Indonesia, using wire-cage live traps and plastic snap traps baited with baked coconuts. Their viscera were fixed in 70% ethanol and transported to the laboratory and refixed with 5% formalin solution. Then the alimentary canals were cut open and washed with running water on a mesh with a pore size of 0.075 mm in diameter, and the residues on the mesh were transferred to a petri dish and examined carefully under a stereomicroscope. Detected nematodes were rinsed in 70% ethanol, cleared in glycerol by evaporation of a glycerol–alcohol solution, and then mounted with 50% glycerol for microscopical examination. Freehand cross-sections were made for observation of the synlophe and cephalic structures (Durette-Desset, 1985). Figures were made with the aid of a drawing tube. Measurements, in micrometers unless otherwise stated, are given for the holotype male and the allotype female, followed in parentheses by the range for paratype males and females from the type host. The classification system follows Durette-Desset and Chabaud (1993). The terminology of the synlophe and bursal rays follows that of Durette-Desset (1983). Specimens are deposited in the Museum Zoologi Bogor (MZB), Bogor, Indonesia, and the United States National Parasite Collection (USNPC), Beltsville, Maryland, U.S.A.

Results

A species of nematode belonging to the subfamily Nippostrongylinae (Trichostrongylina: Heligmosomoidea: Heligmonellidae) was collected from *Maxomys whiteheadi*, *Rattus rattus diardii*, and *Niviventer cremoniventer*. It was common in *M. whiteheadi*, and the intensity of infection was also high in this murine (Table 1).

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Table 1. Prevalence and intensity of *Maxomystrongylus yasumai* sp. n. in murines collected in the Bukit Soeharto Preserved Forest, East Kalimantan, Indonesia, August 1993.

Host species	Prevalence (No. positive/ No. examined)	Mean intensity (range)
Maxomys whiteheadi	14/17	>70 (1–200)
Rattus rattus diardii	1/1	5
Niviventer cremoniventer	1/2	5
Rattus exulans	0/2	—
Leopoldamys sabanus	0/1	—

This nematode was not found in 2 *Rattus exulans* and 1 *Leopoldamys sabanus* captured in the same forest.

The following description is based on the material from *M. whiteheadi*.

Description

Maxomystrongylus gen. n.

DIAGNOSIS: Trichostrongylina: Heligmosomoidea: Heligmonellidae: Nippostrongylinae. Synlophe with pointed ridges. Axis of orientation of ridges passing from ventral right to dorsal left sides with inclination of about 70° from sagittal axis in midbody. Gradient in size of ridges in dorsal side lateromedian. Carene of type B present. Left lateral 3 or 4 ridges developed, slender but not thickened basally. Bursa copulatrix asymmetrical with larger left lobe. Dorsal ray divided distal to level of derivation of ray 8. Genital cone not protruded prominently. Vagina vera with unilateral diverticulum. Parasitic in murines.

GENOTYPE: *Maxomystrongylus yasumai* sp. n.

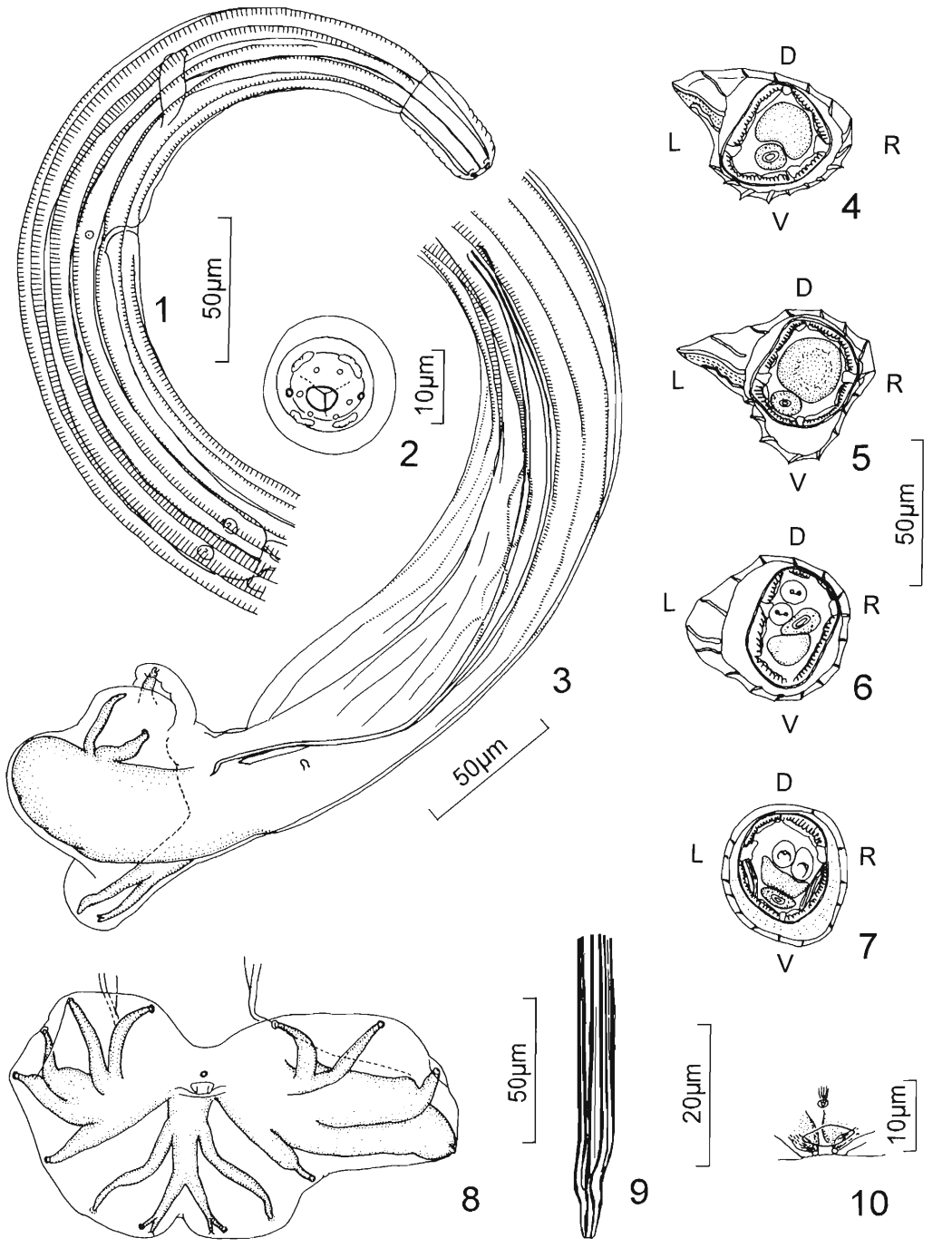
OTHER SPECIES: *Maxomystrongylus musseri* (Hasegawa and Syafruddin, 1994) comb. n. (syn. *Heligmonoides musseri* Hasegawa and Syafruddin, 1994)

ETYMOLOGY: The generic name is made by combining "*Maxomys*," the genus of the type host, and "strongylus," meaning a round worm.

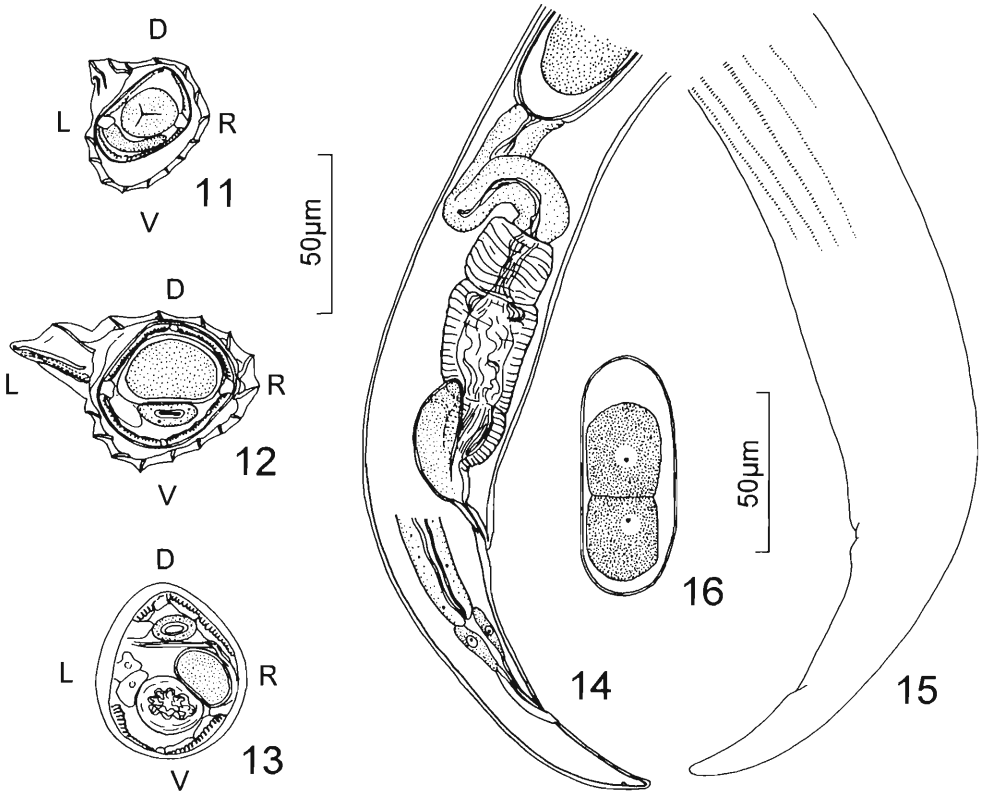
Maxomystrongylus yasumai sp. n. (Figs. 1–16)

GENERAL: With generic characteristics already outlined. Small worm forming sinistral coils about ventral surface. Cephalic vesicle present (Fig. 1). Esophagus club-shaped (Fig. 1). Nerve ring at anterior portion of middle ⅓ of esophagus, and excretory pore and deirids slightly posterior to middle of esophagus (Fig. 1). Mouth triangular, surrounded by 4 cephalic papillae, 6 minute externolabial papillae and amphidial pores (Fig. 2). Cuticle with fine transverse striations. Synlophe ridges commencing posterior to cephalic vesicle (Fig. 1) and ending anterior to level of prebursal papillae in male (Fig. 3) and at level of sphincter in female (Fig. 15). Inclination of synlophe ridges from sagittal axis 30° in esophageal level (Fig. 11), 50° in anterior intestinal level (Fig. 4), and 70° in middle and posterior body (Figs. 5, 6, 12). Ridges becoming minute, lacking clear axis of orientation at level anterior to prebursal papillae of male (Fig. 7). In midbody, 17 or 18 ridges present in both sexes; cuticle of left lateral side markedly dilated forming carene supported by 3 slender ridges of which middle one longest, closely set with ventral undulating ridge, and cuticle between these 2 ridges strongly sclerotized; right lateral ridge and adjacent dorsal ridge well developed; left ventral 3 ridges larger than other ventral ridges (Figs. 5, 12).

MALE (holotype and 10 paratypes): Length 1.89 (1.67–2.03) mm, width at midbody 53 (48–56). Cephalic vesicle 37 (32–37) long by 19 (17–21) wide. Nerve ring 124 (108–151), excretory pore 178 (156–195) and deirids 184 (158–201) from cephalic end. Esophagus 325 (291–353) long by 23 (21–26) wide near posterior end. Bursa asymmetrical: dorsoventral height larger in right lobe and lateral width much larger in left lobe, and dorsal and ventral incisions present (Figs. 3, 8). Ray 1 minute, at level of gubernaculum (Fig. 3). Bursal rays terminating near bursal edge: rays 2 and 3 almost equal in size, widely divergent from base; lateral rays with thick common base, rays 4 and 5 stout, especially in left lobe, running together but divergent distally; ray 6 thinner than rays 4 and 5 and arising from middle of ray 5 in right lobe and from proximal ⅓ of ray 5 in left lobe; dorsal ray divided into 2 widely divergent branches at level distal to midlength, and each branch divided again into 2 unequal offshoots distally; ray 8 arising from basal ⅓ of dorsal ray, almost equal with dorsal ray in length (Fig. 8). Genital cone slightly elevated, with 1 unpaired papilla on anterior lip and 1 pair of papillae on posterior lip (Fig. 10). Spicules equal, alate, distal ends adhered to each other and abruptly bent dorsally, 260 (235–270) long, equivalent to 14% (13–15)



Figures 1–10. Male of *Maxomystrongylus yasumai* gen. and sp. n. from *Maxomys whiteheadi* of East Kalimantan, Indonesia. 1. Anterior part of holotype, right lateral view. 2. Cephalic extremity, apical view. 3. Posterior part of holotype, left lateral view. 4–7. Cross-sections through anterior portion of intestine (4), midbody (5), proximal portion of spicules (6), and midlevel of spicules (7). 8. Bursa copulatrix of a paratype, ventral view. 9. Distal ends of spicules. 10. Genital cone, ventral view. Abbreviations: d-dorsal, l-left, r-right, v-ventral.



Figures 11–16. Female of *Maxomystrongylus yasumai* gen. and sp. n. from *Maxomys whiteheadi* of East Kalimantan, Indonesia. 11–13. Cross-sections through posterior portion of esophagus (11), midbody (12), and vestibule (13). 14. Posterior part of allotype, right lateral view. 15. Cuticle surface of posterior part of allotype, left lateral view. 16. Egg. Abbreviations: d-dorsal, l-left, r-right, v-ventral.

of worm length (Figs. 3, 9). Gubernaculum boat-shaped, 24 (22–28) long (Fig. 3).

FEMALE (allotype and 10 paratypes): Length 2.04 (1.72–2.22) mm, width at midbody 51 (48–58). Cephalic vesicle 35 (29–35) long by 20 (18–22) wide. Nerve ring 121 (103–134), excretory pore 174 (144–186) and deirids 180 (146–190) from cephalic end. Esophagus 319 (299–355) long by 24 (19–26) wide near posterior end. Vulva 104 (93–125) and anus 46 (36–53) from caudal end (Fig. 14). Vagina vera with elongated right side forming horn-shaped diverticulum reaching midlevel of vestibule, and 60 (49–64) long; vestibule 53 (50–69) long, divided into anterior dilated and posterior compact portions; sphincter 21 (16–24) long; infundibulum 91 (84–116) long (Fig. 14). Tail conical with moderately pointed apex (Fig. 14). Eggs ellipsoidal, thin-shelled, containing 1–2-cell-stage embryos, and 64–74 by 26–34 (Fig. 16).

TYPE HOST: *Maxomys whiteheadi* (Muridae: Murinae).

OTHER HOST: *Rattus rattus diardii*, *Niviventer cremoniventer* (Muridae: Murinae).

TYPE LOCALITY: Bukit Soeharto Preserved Forest (0°51′S, 117°2′E, 50 m elevation).

SITE OF INFECTION: Small intestine (duodenum to middle of jejunum).

DATE OF COLLECTION: 21 August 1993.

ETYMOLOGY: The species name is dedicated to Dr. Shigeki Yasuma, the Tropical Forest Research Project, Samarinda, East Kalimantan, Indonesia, to whom we are greatly indebted for his kind help in trapping the rodents.

SPECIMENS DEPOSITED: MZB Na286 (holotype and allotype); MZB Na287 (4 male and 4 female paratypes), and USNPC No. 86763 (6 male and 6 female paratypes), from *M. whiteheadi*. USNPC No. 86764 (2 males and 2 females) from *R. rattus diardii* and USNPC No.

86765 (1 male and 2 females) from *Niviventer cremoniventer*.

REMARKS: *Maxomystrongylus* resembles *Heligmonoides* in that the 3 or 4 left lateral ridges are larger than other ridges supporting a carene of type B (Durette-Desset, 1983). *Maxomystrongylus*, however, differs from *Heligmonoides* because the inclination of axis of orientation of ridges in midbody exceeds the range for other members of Nippostrongylinae (45–67°) (Durette-Desset, 1983). Moreover, the slender left lateral ridges are quite different from the developed left lateral ridges in *Heligmonoides* species that are thickened basally except in *Heligmonoides bulbosus* Ow Yang, Durette-Desset, and Ohbayashi 1983 (Durette-Desset, 1970; Wertheim and Durette-Desset, 1975; Hasegawa and Otsuru, 1982; Ow-Yang et al., 1983; Hasegawa, 1990). Although the vagina vera has not been adequately described or illustrated in some *Heligmonoides* species, its diverticulum is usually extending dorsally, not laterally (cf. Hasegawa, 1990). Thus, the unilateral diverticulum of female *Maxomystrongylus* may also be a key characteristic of the genus.

Maxomystrongylus musseri belongs to this genus because it has all of the generic characteristics described earlier (Hasegawa and Syafruddin, 1994). This species is easily distinguished from *M. yasumai* because it has a larger body (1.78–2.38 mm by 70–86 in male and 2.29–2.94 mm by 64–81 in female), the left lateral slender ridges are widely separated from each other in midbody, the dorsoventral height of the bursa copulatrix is almost equal in both sides, ray 6 in the left lobe is arising from the distal half of ray 5, the dorsal ray is divided proximal to its midlevel, rays 8 are longer than the dorsal ray, the spicules are much longer (395–404 long—i.e., equivalent to 17–24% of worm length), the carene is still present at the level of the ovejector, the female tail is more rounded distally, and the eggs are wider (64–74 by 30–46) (Hasegawa and Syafruddin, 1994).

Discussion

Maxomystrongylus yasumai is apparently shared by murines belonging to several genera, as already shown. However, the high prevalence and high intensity of infection in *M. whiteheadi* suggest that this murine is the primary host of *M. yasumai* in the Kalimantan forest surveyed, although only a limited number of individuals of other murines has been examined. This condition resembles that of *M. musseri* in South Sulawesi, where this nematode is shared by *Maxomys musschenbroekii*, the type host, *Eropeplus canus*, and *Margaretamys elegans*, but the intensity of infection was highest in *M. musschenbroekii* (Hasegawa and Syafruddin, 1994).

The Makassar Strait between Kalimantan and Sulawesi has been known to represent the famous zoogeographical border called Wallace's line, which separates the Oriental and Australian regions. It is therefore suggested that the 2 allied nematodes, *M. yasumai* and *M. musseri*, are derived from a common ancestor and speciated in the geographically isolated conditions. It is of interest that these 2 nematodes seem to have murines of the genus *Maxomys* as their primary hosts in both Kalimantan and Sulawesi. If *Maxomys* was responsible for dispersal of *Maxomystrongylus*, its members in continental Southeast Asia and the Philippines may harbor nematodes of this genus.

Maxomys whiteheadi is distributed widely in continental Southeast Asia and the islands on Sundashelf (Musser and Carleton, 1993). Ow Yang et al. (1983) studied the heligmosomoid fauna of *M. whiteheadi* in the Malay Peninsula and described 4 species in the subfamily Nippostrongylinae. Among them, *H. bulbosus* seems to be closely related to the genus *Maxomystrongylus* because its synlophe has 3 slender left lateral ridges supporting a carene. However, it remains unclear whether *H. bulbosus* actually belongs to *Maxomystrongylus* or not because the unilateral diverticulum of the vagina vera has not been known and the male has been described to have a protruded genital cone (Ow Yang et al., 1983). It is expected that a careful comparison of nematodes of *M. whiteheadi* between the Malay Peninsula and Borneo/Kalimantan will provide a clue to solve the systematic relationship between *Maxomystrongylus* and *Heligmonoides*.

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Announcement

Diagnostic Parasitology Course

The Diagnostic Parasitology course will be offered 4–15 August 1997 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 video tapes will be available for study. The course will be held on 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-wk course is $1,000. U.S. Government and Military personnel may take the course at a reduced rate. Those interested should register as soon as possible, as the number of students will be limited. Previous laboratory experience is recommended.

For further information, contact Dr. John H. Cross at (301) 295-3139 or Ms. Ellen Goldman at (301) 295-3129.

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Effects of Exogenous Reproductive Hormones on *Haemonchus contortus* Populations in Lambs*

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ABSTRACT: The potential roles of 2 reproductive hormones, prolactin and prostaglandin, in the regulation of nematode growth, fecundity, and survival in lambs were examined in 2 experiments. In the first experiment, prolactin (25 IU/lamb) was administered to 3 groups of lambs at 1-wk intervals during each of the first 3 wk of patency of *Haemonchus contortus* infections, respectively. Fecundity (eggs/female/day) and total daily egg production were significantly higher in the group treated with prolactin during week 2 of patency. Male worms were significantly longer, and female worms were significantly shorter after each weekly treatment with prolactin. In experiment 2, a prostaglandin $F_2\alpha$ analogue, BOVILENE® (0.25 mg/lamb), was injected daily with or without exogenous prolactin (25 IU/lamb) throughout the first 3 wk of patency, the period of highest egg production. BOVILENE treatment resulted in decreased survival of both adult male and female worms and increased fecal egg concentrations, as estimated on a daily basis throughout this period. The interactions of BOVILENE with prolactin were negative relative to total daily egg production and worm growth at the terminus of the experiment (day 42 postinoculation). Additive or synergistic effects of prolactin and BOVILENE were not evident relative to fecundity. Decreased survival of worms from treatment with this potent prostaglandin analogue alone is intriguing for parasite control applications.

KEY WORDS: periparturient egg rise, prostaglandin, prolactin, parasite, nematode, growth fecundity.

An example of regulation of growth and reproduction of parasitic nematodes by the host is the phenomenon of periparturient egg rise. Increased fecal egg output is coincident with lambing and lactation in ewes with nematodiasis (Salisbury and Arundel, 1970; reviewed by Gibbs, 1986). The precise physiological cues that communicate the reproductive and immune status of the ewe have not been defined; however, exogenous prolactin, either alone or with progesterone, has been implicated as a regulatory semiochemical (i.e., a chemical that communicates between species) between lambs and their parasites. Longer term administration (2 wk) of prolactin at physiological levels throughout patency of infections of *Haemonchus contortus* resulted in increased fecundity and adult worm length (Fleming, 1993). Similarly, in ovariectomized ewes that received preinoculation injections (20 days) of progesterone followed by postinoculation injection (30 days) of prolactin, adult *H. contortus* were more numerous and larger than populations from saline-injected control lambs (Fleming and Conrad, 1989). Intravenous infusion of another hormone associated with lambing, prostaglandin $F_2\alpha$ ($PGF_2\alpha$), increased fecal egg concentrations in sheep infected with *H. contortus* (Honde and Bueno, 1983). Although these authors attributed this effect to the resumption of development of arrested fourth-stage larvae, periodic worm recoveries were not attempted to support this hypothesis.

The current experiments were designed to evaluate the temporal regulation by prolactin on growth and reproduction of *H. contortus* infections. Specifically, do discrete intervals in the parasitic adult life cycle occur when this endocrine is most effective? Additionally, the effects of a potent $PGF_2\alpha$ analogue, BOVILENE® (7-[3,5-dihydroxy-2-(3-hydroxy-4-phenoxy-1-butenyl) cyclopentyl]-4,5-heptadienoic acid) (Diamond Laboratories Inc., Des Moines, Iowa), both with and without prolactin, on growth, reproduction, and survival of *H. contortus* were examined.

Materials and Methods

Ewe lambs were raised through 60–80 days of age under worm-free conditions on concrete paddocks with hay and water provided ad libitum.

Experiment 1

Lambs (N = 30) were inoculated with 5,000 infective larvae of *H. contortus* on day 0. During the first

* Mention of a trademark of proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, nor does it imply its approval to the exclusion of others that might also be suitable.

3 consecutive wk of patency, beginning day 21, 28, or 35 postinoculation, groups of 10 lambs were placed in individual raised pens with suspended screens for fecal collections and daily intramuscular injections with saline (n = 5) or 25 IU (n = 5) of ovine prolactin (L-6520, Sigma Chemical Co., St. Louis, Missouri), a level that was found to increase parasite fecundity when injected over the course of the infection (Fleming and Conrad, 1989). These 3 wk of sampling correspond to the period of highest nematode fecal egg output. During each week of injections, the lambs were sampled daily for fecal egg concentrations (modified McMaster technique [Whitlock, 1948]) and total egg production, by weighing individual total fecal production. After 7 days of injections, lambs were removed from feed for 24 hr and then killed by captive-bolt gun and exsanguination. Abomasa were removed, and adult worms were rinsed with warm physiological saline and fixed immediately in 5% phosphate-buffered formalin. Adult worms were separated by sex, counted, and measured using computer-assisted digitized morphometry (Bioquant, Nashville, Tennessee). The number of female worms from this terminal collection and the average of the previous 2 days of total daily egg production per lamb were utilized to estimate fecundity (eggs/female/day). Fecal egg data were transformed to $\log_{10}+1$ and analyzed by a generalized linear model that recognized repeated sampling within an experimental unit, that is, each lamb (SAS Institute, Inc., Cary, North Carolina). Worm numbers, sizes, and fecundity were analyzed by nonparametric the Kruskal-Wallis test, and means were compared using multiple comparisons of ranked sums (Hollander and Wolfe, 1973). Differences were considered significantly different at $P < 0.05$.

Experiment 2

Three groups of lambs (n = 10/group) were inoculated with 5,000 infective *H. contortus* larvae/lamb. From days 18 to 40 postinoculation, lambs were injected intramuscularly with saline (group 1), BOVILENE (0.25 mg/lamb; group 2), or BOVILENE (0.25mg/lamb) and ovine prolactin (25 IU/lamb; Fleming, 1993; group 3). This analogue of $PGF_2\alpha$ has a biological potency 25 times that of the native compound in cattle for luteolysis. Daily fecal collections were similar to those in experiment 1. On day 40 postinoculation, lambs were removed from feed and, on day 41 postinoculation, adult worms were collected, and data were analyzed as described in experiment 1.

Results

Experiment 1

No differences occurred in nematode egg production between treatment groups throughout week 1 (days 21–28) of patency (Fig. 1). During week 2 of patency (days 28–35), prolactin treatment significantly increased total daily egg production. However, during week 3 (days 35–42), prolactin treatment significantly decreased total daily egg production. Fecundity was significantly higher at the end of week 2 of patency with prolactin administration (Fig. 2). No differences occurred in the number of males at the end of each week (data not shown); significantly fewer females occurred with treatment × time (Fig. 2). Females were significantly shorter each week after prolactin treatment; conversely, males were significantly longer with prolactin administration (Fig. 3).

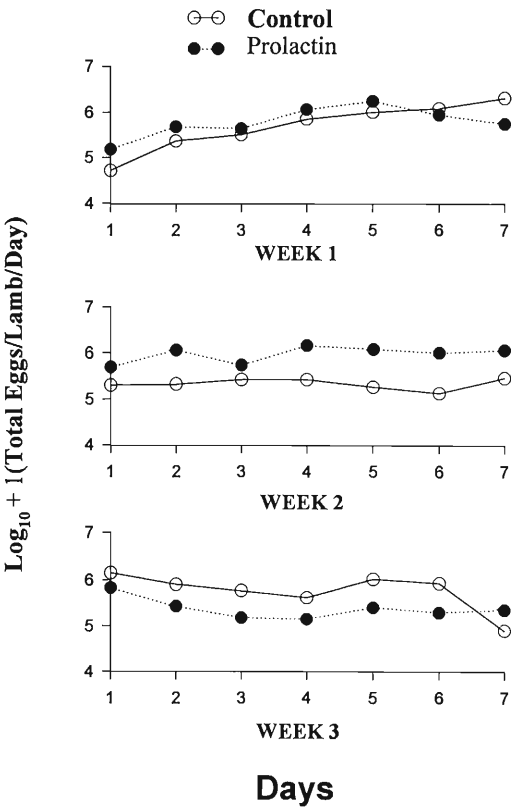

Figure 1. Logarithmic transformation of the mean total daily *H. contortus* egg production in lambs (n = 10/group) during the first 3 wk of patency with and without daily injections of ovine prolactin (25 IU/day). Lambs receiving prolactin in week 2 had significantly ($P < 0.05$) higher egg production; in week 3, egg production was significantly lower in this group (middle and lower panels, respectively).

Experiment 2

BOVILENE treatment alone significantly increased daily egg concentrations (EPG) but did not alter total daily egg production (Fig. 4, lower and upper panels, respectively). BOVILENE with prolactin resulted in shorter adult males and

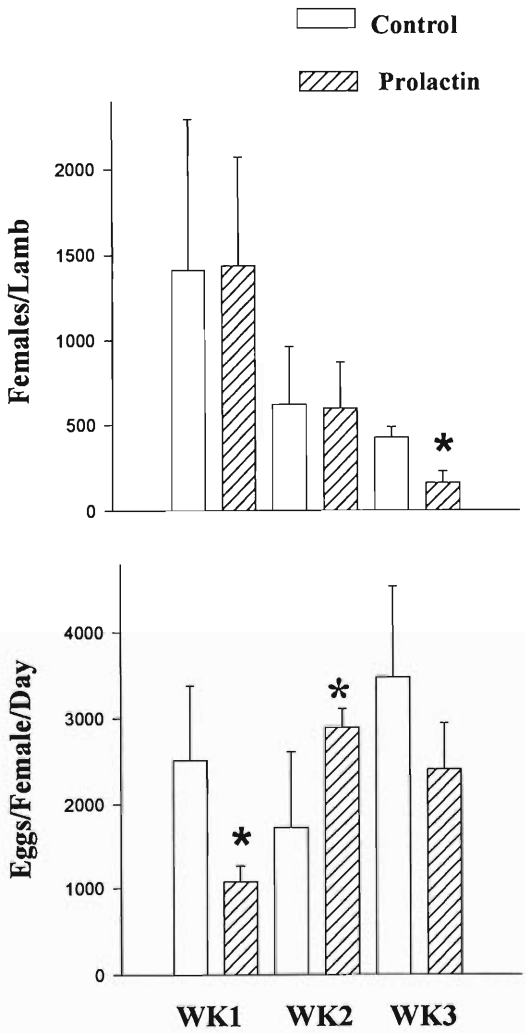

Figure 2. Mean (±SEM) number (upper panel) and fecundity (lower panel) of female *H. contortus* recovered from the abomasa of lambs (n = 10/wk) at the end of each of the first 3 wk of patency. Columns with an asterisk are significantly different (P < 0.05) than controls.

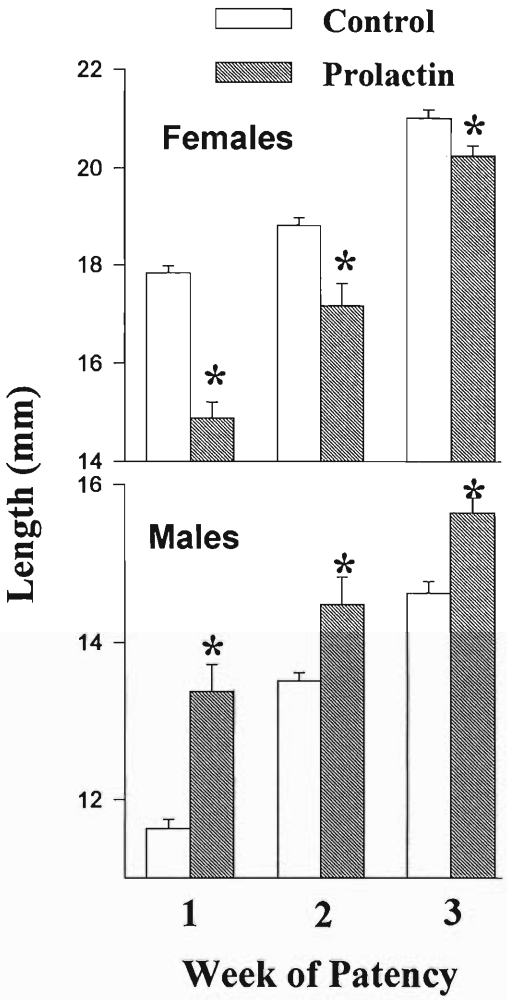

Figure 3. Length ($\bar{x}$ ± SEM; n = 25/group) of adult female (upper panel) and male (lower panel) *H. contortus* recovered from lambs (n = 10/wk) at the end of each of the first 3 wk of patency. Columns with an asterisk are significantly different (P < 0.05) than respective controls.

females (Fig. 5). No detectable differences occurred in fecundity with treatment, although BOVILENE significantly decreased survival of both male and female adult *H. contortus* (Fig. 5).

Discussion

Relatively short-term (7 day) administration of prolactin had few consistent effects on *H. contortus* populations. In contrast, fewer females and larger males occurred with more prolonged administration of prolactin (Fleming, 1993). In the current study, enhanced fecundity (eggs/female/day) with short-term treatment with prolactin was limited to the second week of patency, suggesting a shift in metabolic resources to egg production rather than growth. Similarly, enhanced fecal egg concentrations (EPG), the conventional measurement of periparturient egg rise, was identifiable only in the second week of treatment. Apparently, prolonged continuous exposure of lambs to prolactin is a requisite for consistently increased rates of egg production in

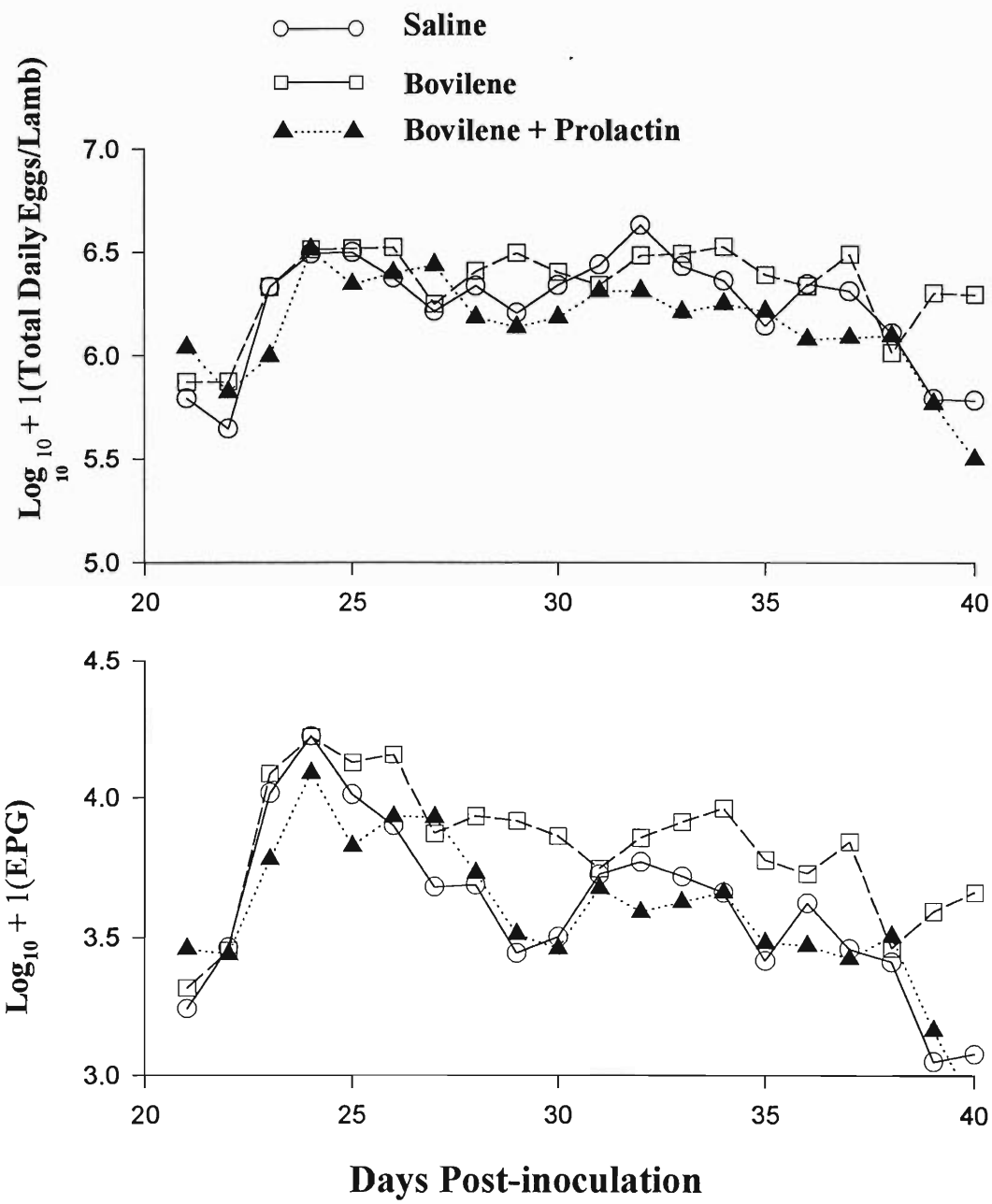

Figure 4. Logarithmic transformation of egg concentrations (lower panel) and total daily nematode egg production (upper panel) from *H. contortus* infections in lambs (n = 10/group) that were injected daily with saline, BOVILENE (0.25 mg), or BOVILENE (0.25 mg) and prolactin (25 IU) from days 20–40 postinoculation. Daily egg concentrations were significantly higher ($P < 0.05$) in the lambs receiving BOVILENE alone (lower panel).

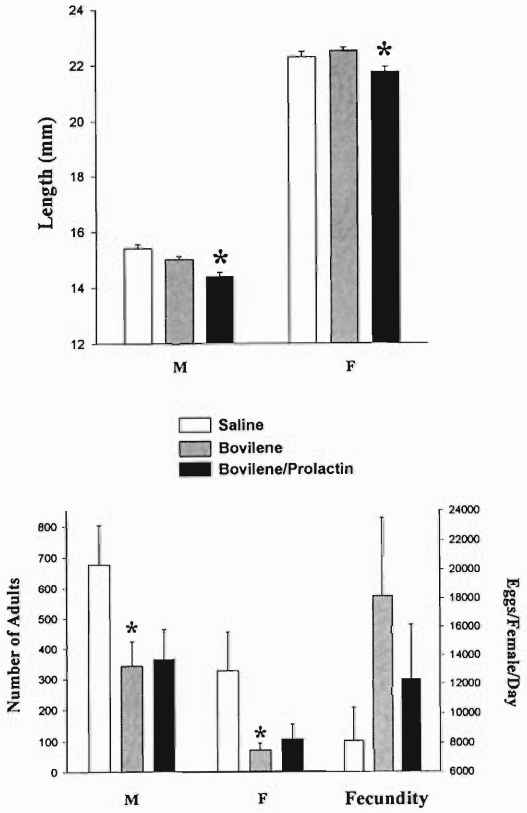

Figure 5. Lengths ($\bar{x}$ ± SEM; n = 25/group) of adults (upper panel) and adult worm numbers and fecundity (lower panel) of *H. contortus* recovered at day 41 postinoculation from lambs that were injected daily with saline, BOVILENE (0.25 mg), or BOVILENE (0.25 mg) and prolactin (25 IU) from days 20 to 40 postinoculation. Columns with an asterisk are significantly different ($P < 0.05$) than respective control groups. Abbreviations: F = females, M = male.

H. contortus infections (Fleming and Conrad, 1989; Fleming, 1993). Experimental treatment of peri- or postparturient ewes with bromocryptine (twice daily for 14 days), a potent dopamine agonist that lowers prolactin, did not alter fecal egg concentrations or the generalized immune responsiveness in sheep inoculated with *Teladorsagia* (formerly *Ostertagia*) *circumcincta* (Jeffcoate et al., 1990).

Characteristically, this gastrointestinal nematode does not have the logarithmic range in egg concentrations or fecundity that is found in *H. contortus* infections, thus perhaps limiting the opportunity to detect significant treatment differences. Similarly, the injection of exogenous steroids in nonpregnant ewes (daily for 48 days), which induced a rise in peripheral prolactin concentrations, did not induce detectable increases in egg concentrations in ewes inoculated with *T. circumcincta* (Coop et al., 1990).

Chronic daily administration of BOVILENE demonstrated increases in fecal egg concentration as demonstrated by Honde and Bueno (1983) with daily infusion of the native compound, $PGF_{2\alpha}$, although the routes of application were different (intramuscular vs. intravenous). However, the efficacy of treatment in the latter study was apparent only on day 50 postinoculation and beyond, whereas as the current study was terminated at day 41 postinoculation. Although the endogenous release of prolactin and prostaglandins are essentially simultaneous at lambing (Davis et al., 1971; Thorburn et al., 1972), no interactive effects were apparent relative to worm fecundity or growth in the current study.

BOVILENE administration was highly effective in reducing the adult worm burden by over 50%. In the bovine, $PGF_{2\alpha}$ increased contractility in the longitudinal and circular gastric muscle (Vandeplassche et al., 1982). Hence, administration of BOVILENE might enhance expulsion of the nematodes from the abomasum, thereby reducing populations of the luminal parasite. Elucidation of the mode of action of this effect, and the extent to which it occurs in other parasitic nematodes, potentially could lead to a new class of anthelminthics.

The minor alteration in most worm population parameters due to short-term prolactin and/or $PGF_{2\alpha}$ analogue treatments suggests that prolonged exposure to increased endocrine levels are requisite, at a minimum, to effect the nematode reproductive characteristics of the periparturient egg rise.

Acknowledgment

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Description of *Neolacunisoma geraldschmidti* gen. n., sp. n., (Acanthocephala: Centrorhynchidae) from South African Shorebirds

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ABSTRACT: *Neolacunisoma geraldschmidti* gen. n., sp. n. (Centrorhynchidae), is described from 7 species of shorebirds (Caradriiformes) in South Africa. Worms are spindle-shaped: proboscis globular anteriorly where it has 39–43 longitudinal rows of 9–11 rooted hooks per row and cylindrical posteriorly where it has 2–5 rootless spines per row; males with 2 preequatorial contiguous longer than wide testes and 3 tubular cement glands; females with subterminal gonopore and elongate ovoid sculptured eggs. The new genus is intermediate between the only 2 other genera of the family Centrorhynchidae, *Sphaerirostris* Golvan, 1956, and *Centrorhynchus* Lühe, 1911. It is similar to the former genus in proboscis and trunk shape and size and to the latter in testes shape. Its lacunar system is intermediate between those of the 2 other genera combining the transverse pattern characteristic of *Centrorhynchus* and the dendritic pattern of *Sphaerirostris*. The lacunar system pattern is one of the most important taxonomic characters in the classification of acanthocephalans. *Neolacunisoma* also has unique anteriorly prominent longitudinal riblike trunk muscles.

KEY WORDS: Acanthocephala, *Neolacunisoma geraldschmidti* gen. n., sp. n. (Centrorhynchidae), South African shorebirds.

Specimens of a centrorhynchid acanthocephalan collected from 7 species of shorebirds in South Africa proved to represent a new species of a new genus, raising the number of genera in this family to 3. This new taxon is described and compared with the 2 other genera, *Centrorhynchus* and *Sphaerirostris*.

Materials and Methods

Thirty-seven individuals (16 males and 21 females) of a new centrorhynchid acanthocephalan were recovered from 7 species of shorebirds (Charadriiformes) collected from Berg River, Cape Province, South Africa, between May 24 and July 31, 1981. Host species are curlew sandpiper, *Calidris ferruginea* (Pontoppidan, 1763) (1 specimen); white-fronted sand plover, *Charadrius marginatus* Vieillot, 1818 (3); chestnut-branded plover, *Charadrius pallidus* (Strickland, 1852) (1); Kittlitz's plover, *Charadrius pecuarius* (Temminck, 1823) (9); triple-banded plover, *Charadrius tricollaris* Vieillot, 1818) (14); stilt, *Himantopus himantopus* (Linnaeus, 1758) (6); and black-smith plover, *Hoplopterus armatus* (Burchell, 1822) (3).

Specimens were collected by Al Canaris and processed by the late Gerald Schmidt, who apparently intended to describe them. We do not know the processing method used. The specimens were properly extended with everted proboscides, but the mounting medium has undergone some changes in a few slides.

Measurements are in micrometers unless otherwise stated. The range is followed by mean values (in parentheses). Width measurements refer to maximum width. Specimens are deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland (Dr. J. R. Lichtenfels, Curator).

[3] Corresponding author.

Results

A new centrorhynchid genus, intermediate between the only 2 other genera of family Centrorhynchidae Van Cleave, 1916, *Centrorhynchus* Lühe, 1911, and *Sphaerirostris* Golvan, 1956, is recognized from South African shorebirds and described here.

Neolacunisoma gen. n.

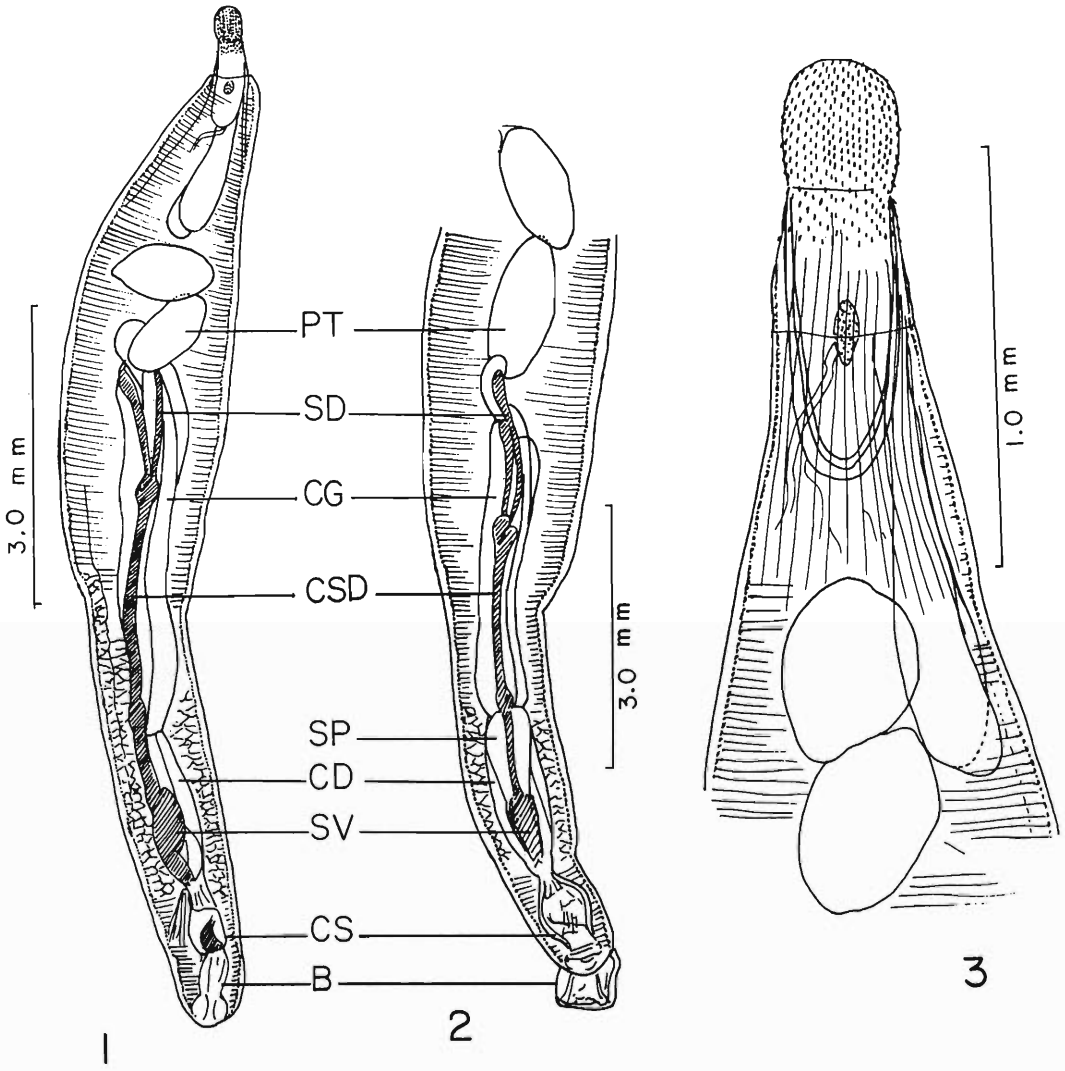
Diagnosis

Centrorhynchidae. Trunk fusiform, small–medium in length, with longitudinal ribbed muscles most prominent anteriorly, and with transverse secondary lacunar canals anteriorly, and mostly laterally dendritic lacunar anastomoses posteriorly. Proboscis globular anteriorly with rooted hooks, and cylindrical posteriorly with spines. Neck prominent. Brain at middle of proboscis receptacle. Lemnisci markedly longer than proboscis receptacle. Testes longer than wide in anterior third of trunk. Cement glands 3, tubular. Eggs elongate-ovoid with transverse sculpturing.

Neolacunisoma geraldschmidti sp. n. (Figs. 1–9)

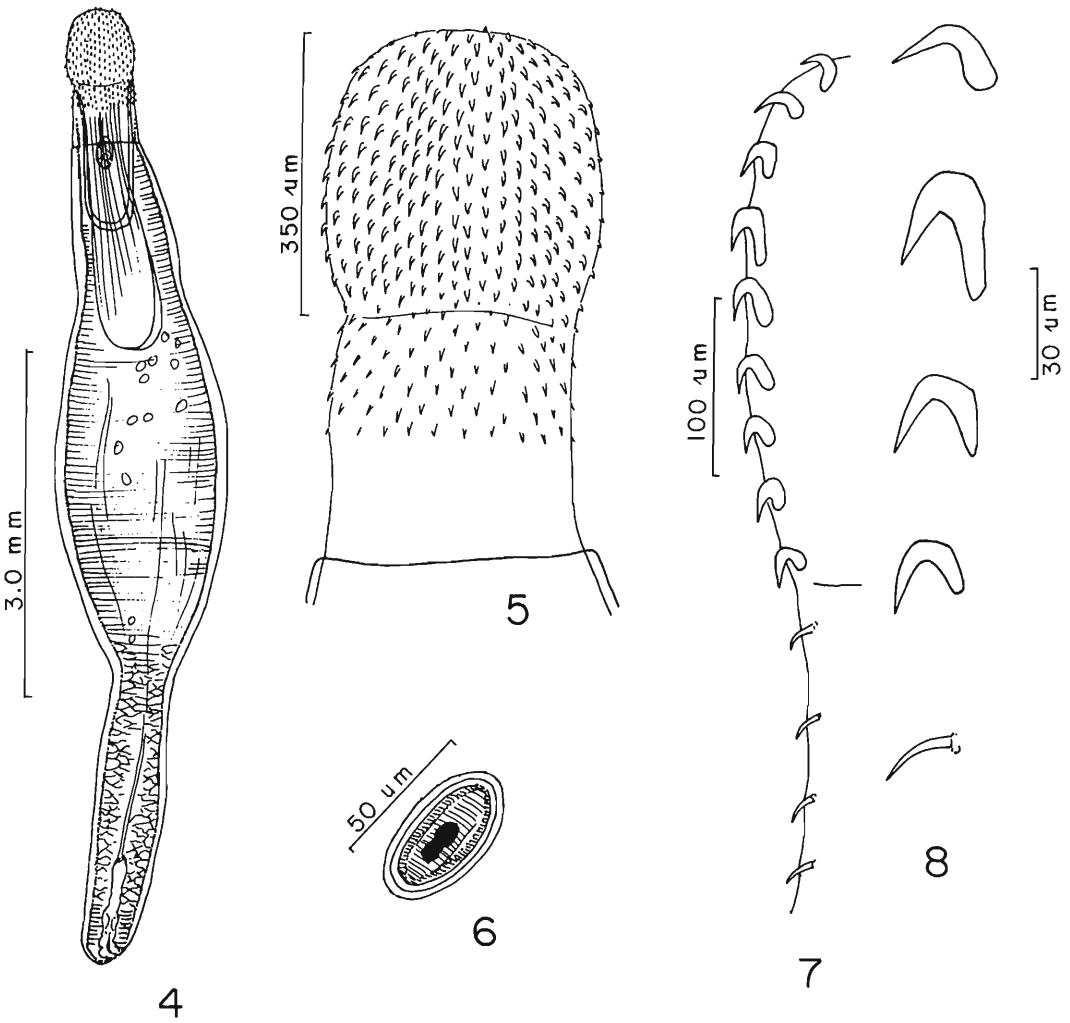
Description

GENERAL: Centrorhynchidae. Shared structures larger in females than in males. Trunk



Figures 1–3. ***Neolacunisoma geraldschmidti*** **gen. n., sp. n. 1. Holotype male, profile. 2. Ventral view of reproductive system of a paratype male. Abbreviations: B = bursa, CD = cement duct, CG = cement gland, CS = cirrus sac, CSD = common sperm duct, PT = posterior testis, SD = sperm duct, SP = Saefftigen's pouch, SV = sperm vesicle. 3. Anterior end of a paratype male showing the relationship between the size and shape of proboscis, neck, proboscis receptacle, and lemnisci as well as the anterior riblike trunk muscles. Lacunar vessels are not shown where they overlap organs or other structures.**

small–medium in size, spindle-shaped, more acutely so in younger than in older specimens with posterior part more narrow and cylindrical (Fig. 4). Longitudinal ribbed muscles along trunk contour particularly prominent anteriorly. Secondary lacunar vessels transverse in anterior ⅔ of trunk, anastomosing dendritically laterally in the posterior cylindrical ⅓ except for a short distance at the posteriormost end where the pattern becomes transverse again (Figs. 1–4, 9). Proboscis variably globular anteriorly and cylindrical posteriorly as it slightly widens into the neck (Figs. 3–5). Proboscis with 39–43 hook rows each with 9–11 rooted hooks in anterior globular part and 2–5 rootless spines in posterior part. Proboscis hooks and spines not considerably different in length; anteriormost hooks smallest, 4th and 5th hooks largest, more pos-



Figures 4–8. ***Neolacunisoma geraldschmidti*** **gen. n., sp. n. 4. Young allotype female. Lacunar vessels are not shown when they overlap organs or other structures. 5. Proboscis of allotype female. 6. Egg from a paratype female. 7. Lateral view of a complete row of proboscis hooks and spines of a paratype male. 8. Lateral view of enlarged proboscis hooks Nos. 1, 4, 7, and 9 and a spine of a paratype male.**

terior hooks gradually decrease in size to that of posterior spines. All hook roots simple and directed posteriorly; those of anterior hooks markedly longer than blades, but gradually decrease in size to become about as long as blades of posteriormost hooks (Figs. 7, 8). Neck marked, widest posteriorly, and slightly wider than both parts of the proboscis. Double-walled proboscis receptacle slightly longer than proboscis and neck together, but shorter than subequal sacciform lemnisci (Fig. 3). Brain at middle of proboscis receptacle where it is widest (Fig. 3).

MALES (based on 12 specimens): Trunk 2.808–9.516 (5.328) mm long by 0.686–1.654 (1.037) mm wide at dilation. Proboscis 444–572 (506) long; anterior part 279–343 (311) long by 178–317 (267) wide at middle dilation; posterior part 152–254 (195) long by 191–343 (272) wide at junction with neck. Proboscis with 39–42 (40.5) longitudinal rows of 9–11 (9.6) rooted hooks in anterior part and 4–5 (4.3) rootless spines in posterior part; a total of 13–16 (14.0) hooks and spines per row. Blades of rooted hooks measure from anterior 22–32 (25), 26–32 (28), 29–32 (30), 32–35 (32), 29–35 (31), 26–32 (28), 22–29 (25), 19–32 (24), 22–29 (24);

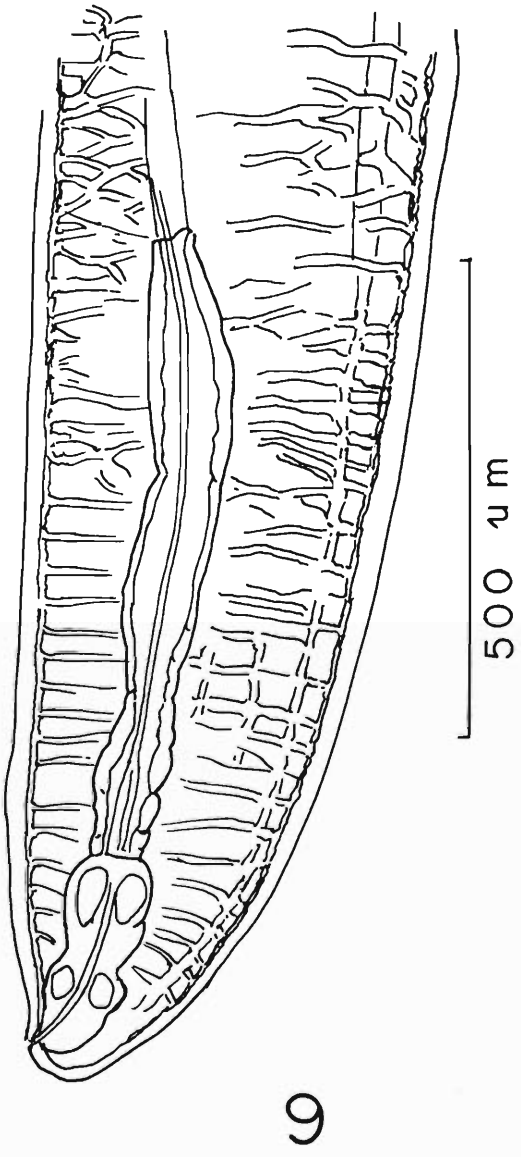


Figure 9. ***Neolacunisoma geraldschmidti*** **gen. n., sp. n. Reproductive system of a paratype female.**

spines 19–29 (24), 22–29 (24), 22–26 (24), 22–29 (26) long. Neck 102–254 (142) long by 216–368 (295) wide at base. Proboscis receptacle 571–889 (730) long and 190–317 (257) wide at middle. Lemnisci usually extend past anterior testis but may reach middle of posterior testis (Fig. 3), subequal, the longer lemniscus 1.016–1.651 (1.311) mm long by 114–419 (251) wide, the shorter 0.889–1.587 (1.251) long by 190–444 (232) wide. Testes about equal in size, relatively large, markedly longer than wide, tapering into rounded poles, and usually obliquely contiguous (Figs. 1–3). Anterior testis 343–927 (585) long by 203–559 (363) wide; posterior testis 356–952 (587) long by 216–508 (341) wide. Two independent sperm ducts join in an anteriorly dilated common sperm duct that develops into a distinct sperm vesicle overlapping Saefftigen's pouch posteriorly. Cement glands 3, tubular, of different lengths, all connect with corresponding cement ducts with a constriction at same level posteriorly but originate at different levels anteriorly; the first begins near middle of posterior testis, the second just posterior to that testis, and the third just behind the latter. Longest cement gland 0.825–4.127 (2.333) mm long by 51–279 (174) wide, shortest 0.825–3.810 (2.021) long by 38–343 (155) wide. Cement ducts tubular, similar in appearance to cement glands, 0.444–1.460 (1.101) mm long by 51–254 (127) wide. Saefftigen's pouch pear-shaped 0.483–1.397 (0.786) long by 127–508 (265) wide anteriorly, widest anteriorly at level of junction between cement glands and ducts and connects posteriorly with the posterior end of cement ducts and with that of the sperm vesicle (Figs. 1, 2). Gonopore terminal.

FEMALES (based on 12 specimens, 8 gravid): Trunk 4.867–16.224 (11.041) mm long by 0.967–3.432 (1.585) mm wide at dilation. Proboscis 508–635 (586) long; anterior part 317–381 (350) long by 241–330 (295) wide at middle dilation; posterior part 178–279 (237) long by 254–394 wide at junction with neck. Proboscis with 40–43 (41.4) longitudinal rows of 9–10 (9.7) rooted hooks in anterior part and 2–5 (3.2) rootless spines in posterior part; a total of 12–15 (13.1) hooks and spines per row. Blades of rooted hooks measure from anterior 22–32 (26), 26–32 (29), 29–38 (32), 32–38 (35), 32–38 (34), 29–38 (33), 26–32 (28), 26–29 (27), 22–29 (26), 22–29 (26); spines 22–26 (24), 22–29 (26), 22–29 (26), 24–32 (28) long. Neck 165–317 (217) long by 279–483 (367) wide at base. Proboscis receptacle 0.787–1.041 (0.888) mm long by 229–330 (283) wide at middle. Longer lemniscus 1.333–1.778 (1.524) mm long by 216–381 (279) wide, the shorter 1.270–1.524 (1.397) mm long by 190–381 (267) wide. Reproductive system (Figs. 4, 9) 0.780–1.997 (1.242) mm long; 8.9–18.7% (14.0%) of trunk length. Highest percent values invariably in smallest nongravid females, and lowest values in larger worms that

Table 1. Diagnostic features of the 3 genera of the family Centrorhynchidae.

	Sphaerirostris Golvan, 1956	*Centrorhynchus* Lühe, 1911	*Neolacunisoma* Amin and Canaris (this paper)
Trunk	Short, spindle-shaped	Long, cylindrical, with mild anterior dilation	Short-medium, spindle-shaped
Longitudinal trunk muscles	?	?	Prominent anteriorly
Lacunar system	Secondary vessels anastomose in a dendritic pattern	Secondary vessels with transverse anastomoses	Anastomoses transverse anteriorly and mostly dendritic posteriorly
Proboscis	Short, anterior part globular (widest at middle), posterior part somewhat cylindrical	Long, anterior part dilated posteriorly (at insertion of proboscis receptacle), posterior part almost cylindrical	Short, anterior part globular (widest at middle), posterior part somewhat cylindrical
Testes	Spheroid, often large	Markedly longer than wide	Markedly longer than wide, large
Cement glands	Tubular, long, 3–4	Tubular, very long, 3–4	Tubular, long, 3

apparently continued to grow after the reproductive system has reached its maximum size. Gonopore subterminal (Fig. 9). Eggs sculptured with transverse lines, elongate-ovoid without prolongation of any membranes (Fig. 6) 48–61 (52) long by 19–26 (23) wide.

Taxonomic summary

TYPE HOST: Kittlitz's plover, *Charadrius pecuarius* (Temminck, 1823) (Caradriiformes).

OTHER HOSTS: Curlew sandpiper, *Calidris ferruginea* (Pontoppidan, 1763); white-fronted sand plover, *Charadrius marginatus* Vieillot, 1818; chestnut-banded plover, *Charadrius pallidus* Strickland, 1852; triple-banded plover, *Charadrius tricollaris* Vieillot, 1818; stilt, *Himantopus himantopus* (Linnaeus, 1758); blacksmith plover, *Hoplopterus armatus* (Burchell, 1822) (Caradriiformes).

SITE OF INFECTION: Intestine.

TYPE LOCALITY: Berg River, Cape Province, South Africa.

SPECIMENS DEPOSITED: USNPC No. 86954 (holotype male); No. 86955 (allotype female); Nos. 86956–86961 (paratypes).

ETYMOLOGY: The generic name is descriptive of the new pattern of its lacunar system intermediate between those of *Centrorhynchus* and *Sphaerirostris*. The new species is named for the late Dr. Gerald D. Schmidt, who originally processed and intended to describe this material, for his substantial contributions to acanthocephalan taxonomy.

Remarks

Golvan (1956) divided the genus *Centrorhynchus* Lühe, 1911, into 2 subgenera *Longirostris* and *Sphaerirostris* without type species designations. The first subgenus was preoccupied and was replaced by the subgenus *Centrorhynchus* in which all non-*Sphaerirostris* centrorhynchids are placed.

Golvan's diagnosis of *Sphaerirostris* involved the following characters: "corps de taille assez reduite, en form de fuseau large." "Proboscis court . . . portion anterieure globuleuse." "Testicules presque spherique et souvent voluminеux." "3 . . . 4 glandes cementaires." "Vaisseaux de systeme lacunaire anastomoses en formant un reseau a'mailles grossierement polyedendrique" (Golvan, 1956). His figure 1 (p. 737) shows anastomosing "cells" that are markedly longer vertically than laterally. Members of his other subgenus, *Longirostris* (=genus *Centrorhynchus*) have "grande taille, de forme allongee . . . portion anterieure . . . dilatee, le reste du corps . . . pres regulierement cylindrique." "Proboscis assez long, avec une dilation mediane, que correspond au point d'insertion du receptacle du proboscis." "Testicules toujours plus longs que larges. Glandes cementaires . . . 3 . . . 4 . . . tubulaires, tres longues." "Vaisseaux secondaires du systeme lacunaire formant des anastomoses transverse . . . ."

Distinguishing features separating *Neolacunisoma* from *Centrorhynchus* and *Sphaerirostris* are summarized in Table 1. Basically, the new

genus is an intermediate taxon that has a *Sphaerirostris*-like trunk and proboscis shape but *Centrorhynchus*-like testes and a transverse lacunar pattern in its anterior ⅔ of trunk and at its posteriormost end. The dendritic lacunar pattern characteristic of *Sphaerirostris* is present in the posterior trunk between the 2 transverse regions. The lacunar system pattern is one of the most important taxonomic criteria in the classification of acanthocephalan genera and higher taxa and represents a major justification for the erection of the new genus. Anteriorly prominent longitudinal ribbed muscles appear to be unique to *Neolacunisoma*. We are not sure whether any of the more than 25 described species of *Sphaerirostris* may share some of the preceding characters of *Neolacunisoma* that may have been overlooked or not reported. A separate study of type material of the species of *Sphaerirostris* would resolve this question and may result in reassignment(s) to the new genus.

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Research Note

Fessisentis necturorum (Acanthocephala: Fessisentidae) from the Red-Spotted Newt, *Notophthalmus v. viridescens*, in West Virginia

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ABSTRACT: *Fessisentis necturorum* was found in 8 of 55 female and 25 of 69 male red-spotted newts, *Notophthalmus v. viridescens*, collected in Wayne County, West Virginia, throughout 1995. While mean intensities of 4.38 and 2.84 were recorded for female and male hosts, respectively, those means came from *F. necturorum* populations that had the same distribution in each host sex as calculated by the Kolmogorov-Smirnov 2-sample test. Sex ratios of *F. necturorum* were female-biased but did not depart significantly from a 1:1 ratio. Ninety-five of the 107 *F. necturorum* individuals collected were found in the upper third of the small intestine.

KEY WORDS: *Fessisentis*, *Notophthalmus*, red-spotted newt, West Virginia.

Adults of the red-spotted newt, *Notophthalmus v. viridescens* (Rafinesque), are found in a variety of shallow, permanent or semipermanent bodies of water from the Maritime Provinces to the Great Lakes and south to the Apalachicola drainage of Florida (Conant, 1958). This salamander is commonly found throughout the year and has been recorded from all but 4 of West Virginia's 55 counties (Green and Pauley, 1987). Helminth parasites of newts have been reported by several investigators, most notably Rankin (1937, 1945) from North Carolina and Massachusetts, Fischthal (1955) from New York, and Aho (1990) from Florida and South Carolina. Still, there has been little published about parasitic infections by sex of newt or on the location of parasites in these salamanders. The principal goal of this note is to report on seasonal prevalences and mean intensities of the acanthocephalan, *Fessisentis necturorum* Nickol, 1967, by sex of host. Location of *F. necturorum* in the intestinal tract and sex ratios of this acanthocephalan parasite are also given.

A total of 124 *Notophthalmus v. viridescens* was collected by hand or in funnel traps from a permanently flooded marsh at Shoals, West Virginia (38° 19′ 45″ N, 82° 28′ 18″ W) over 5 periods in 1995: late winter (Feb/Mar), late spring (May/Jun), midsummer (Aug), early fall (Oct), and late fall (Dec). Newt sample sizes by sex and period of collection are given in Table 1. Each newt was sexed and weighed to the nearest 0.1 g within 24 h of capture and then killed by pithing. After opening the body cavity, the intestinal tract was removed and segregated into the small intestine and large intestine. The small intestine was further subdivided into 3 equal regions as upper (nearest the stomach), middle, and lower small intestine. Acanthocephalans found were counted and their position in the intestine recorded. All acanthocephalans were killed and fixed in 10% buffered formalin acetate with representative specimens stained in acid carmine, dehydrated in an ethanol series, cleared in xylene, and mounted in Kleermount®. Voucher specimens of *Fessisentis necturorum* have been deposited in the United States National Parasite Collection (USNPC), Beltsville, Maryland, under USNPC Nos. 86238 (female) and 86239 (male). Terminology use is in accordance with that of Margolis et al. (1982).

Overall, 8 of 55 (14.5%) females and 25 of 69 (36.2%) males were infected by *F. necturorum*, with prevalences being highest in late winter and late fall and 0 in midsummer (Table 1). Prevalence by season was reminiscent of Rankin (1937), who noted that "[A]canthocephalans are found almost exclusively during winter months." Still, Nickol (1972) cited instances where seasonal distribution of *Fessisentis* infections varies with species of *Fessisentis* and host involved. Prevalence of *F. necturorum* infection in female newts was not significantly different from that in males ($\chi^2 = 1.16$, df

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Table 1. Seasonal prevalences and mean intensities of *Fessisentis necturorum* infections in female and male red-spotted newts from Shoals, West Virginia.

Season	Prevalence*		Mean intensity (±1 SD)†	
	♀♀	♂♂	♀♀	♂♂
Late winter	4/8 (50.0)	15/37 (40.5)	6.5	2.6
Late spring	1/8 (12.5)	1/8 (12.5)	3.0	2.0
Midsummer	0/21 (0)	0/0 (—)	—	—
Early fall	0/11 (0)	2/11 (18.2)	—	2.5
Late fall	3/7 (42.9)	7/13 (53.8)	2.0	3.6
Combined	8/55 (14.5)	25/69 (36.2)	4.38 (3.93)§	2.84 (2.48)§
	8/34 (23.5)‡	25/69 (36.2)‡		

* Number infected/number examined (percent).

† Standard deviations not given by season because of small sample sizes of infected newts.

‡ χ^2 (Yates's) = 1.16, df = 1, $P > 0.05$.

§ $n_1n_2D = 45 < n_1n_2D_{05} = 104$; accept H_0 that population distributions of *F. necturorum* are the same in female and male hosts.

= 1, $P > 0.05$). Newts collected in midsummer were excluded from this prevalence comparison because of the absence of *F. necturorum* infection and because of the obvious similarity in prevalences between host sexes for the other 4 collection periods (Table 1). Seasonal mean intensities appear relatively consistent throughout the year, irrespective of the considerable fluctuation in seasonal prevalences, with overall mean intensity in female hosts higher than in males (Table 1). Because variances for mean intensities were high and appeared positively related to the magnitude of the mean, we used a nonparametric test (Kolmogorov-Smirnov 2-sample test) to determine whether populations of *F. necturorum* in female hosts had the same distribution as in male hosts (Sokal and Rohlf, 1995). Because the calculated Kolmogorov-Smirnov sample statistic n_1n_2D of 45 was less than the tabled critical value of 104 for n_1n_2D at the $P < 0.05$ level, we accepted the null hypothesis that *F. necturorum* populations had the same distribution in both sexes of newts (Table 1).

Sex ratios of this acanthocephalan parasite varied by season and were female-biased for the entire study period. The ratio of 63 *F. necturorum* females to 43 males was not, however, significantly different from a 1:1 ratio (Table 2). Similarly, Nickol and Heard (1973) reported a sex ratio of nearly 1:1 for *F. necturorum* in *Ambystoma opacum*. Only 3 of the 63 *F. necturorum* females were found with well-developed eggs, and all 3 of those individuals were collected on 16 June.

Ninety-five of the 107 (88.8%) *F. necturorum* collected in this study were found in the upper small intestine. Aggregation of acanthocephalans in this region of the intestine was highly significant (Table 3) but not without precedent, as Huffman (1970) noted that all *F. shoemakeri*

Table 2. Sex of *Fessisentis necturorum* individuals collected from red-spotted newts, by season. Chi-square value significant ($P < 0.005$) only for parasite sex ratio observed in the late winter collection.

Season	No. of *F. necturorum*			Sex ratio (♀♀:♂♂)	χ^2
	♀♀	♂♂	Juvenile		
Late winter	44	20	1	2.20 : 1.00	9.00
Late spring	4	1	0	4.00 : 1.00	NC*
Midsummer	0	0	0	—	—
Early fall	2	3	0	0.67 : 1.00	NC
Late fall	13	19	0	1.00 : 1.46	1.13
Combined	63	43	1	1.47 : 1.00	3.77

* Not calculated because of small sample numbers.

Table 3. Numbers of *Fessisentis necturorum* in hosts by season and position in gastrointestinal tract.*

Season	u	m	l	g	Totals
Late winter	58	4	3	0	65
Late spring	5	0	0	0	5
Midsummer	0	0	0	0	0
Early fall	5	0	0	0	5
Late fall	27	2	1	2	32
Combined†	95	6	4	2	107

* Abbreviations: u = upper small intestine, m = middle small intestine, l = lower small intestine, g = large intestine.

† $\chi^2 = 232.48$, df = 3, $P < 0.001$.

(=*F. necturorum*) individuals were found in the duodenum of *A. opacum*.

In summary, this work adds to the information on prevalence of *F. necturorum* in newts and is reminiscent of the study by Rankin (1937) demonstrating seasonal fluctuations in acanthocephalan populations. Our study also corroborates earlier findings on sex ratios of *F. necturorum* (Nickol and Heard, 1973), and the position of this parasite species in the host's intestine (Huffman, 1970). Information on mean intensities by host sex is new. West Virginia represents the northernmost extent of the range for *F. necturorum*, because this acanthocephalan species was not found in studies involving large sample sizes of newts from Massachusetts (Rankin, 1945) and New York (Fischthal, 1955). Additional work on *F. necturorum* populations from newts in other geographic regions should be encouraged.

We thank Brent Nickol for diagnosing our acanthocephalan material as *Fessisentis necturorum*. Collection of newts for this study was done under permit No. 85-1995, granted by the West Virginia Division of Natural Resources.

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Research Note

Field Test of Activity of the Low Dose Rate (2.64 mg/kg) of Pyrantel Tartrate on *Anoplocephala perfoliata* in Thoroughbreds on a Farm in Central Kentucky

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ABSTRACT: A field test was done to evaluate activity on *Anoplocephala perfoliata* for the low dose rate (2.64 mg/kg) of pyrantel tartrate fed once daily for 30 consecutive days to Thoroughbred mares (n = 83) and yearlings (n = 58) on a farm in central Kentucky. Tapeworm eggs were found pretreatment in feces of 35% of the mares and 33% of the yearlings. Posttreat-

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Table 1. Data on examination for tapeworm eggs in fecal samples of Farm A Thoroughbred mares treated with the low-level dose rate (2.64 mg/kg) of pyrantel tartrate.

Time relative to treatment (days)*	No. examined	No. infected (%)
0	83	29 (35)
35	77	0 (0)
72–86	45	1 (2)
153–167	69	0 (0)

* Treatment once daily for 30 consecutive days.

ment fecal samples for the mares were negative for tapeworm eggs at 35 days and 153–167 days postinitial treatment day (PIT) but positive (2%) at 72–86 days PIT. For the yearlings, posttreatment fecal samples were positive for tapeworm eggs at 2 days (71%), 7 days (33%), 14 days (13%), 21 days (7%), 35 days (2%), and 75 days (2%) but negative at 28 days PIT. Also, for the yearlings, about two-thirds of the feces was collected during the first 2 days PIT for examination for *A. perfoliata* specimens; 401 with scolices were found in 74% of these animals. Prevalence of *A. perfoliata* in the yearlings was 96%, as determined by findings eggs in feces pretreatment and 48 hr PIT in addition to specimens passed in feces.

KEY WORDS: *Anoplocephala perfoliata,* cestode, horses, Thoroughbreds, pyrantel tartrate, low dose rate, field test.

The cecal tapeworm (*Anoplocephala perfoliata*) may be detrimental to equids (Lyons et al., 1986). Limited data indicate that pyrantel tartrate (2.64 mg/kg) fed once daily for 30 consecutive days has good activity against *A. perfoliata* (Greiner and Lane, 1994). This regimen of therapy was evaluated in the present study in a field test in Thoroughbred mares and yearlings on a farm (Farm A) in central Kentucky. Efficacy was determined by presence or absence of tapeworm eggs in fecal samples of these horses before and after treatment. Also, feces of the yearlings were examined for tapeworm specimens posttreatment to supplement egg data and as an indication of prevalence.

Pyrantel tartrate (Strongid® C, Pfizer, New York), at the low dose rate (2.64 mg/kg), was fed once daily for 30 consecutive days to mares (n = 83) and yearlings (n = 58; 26 colts and 32 fillies) on Farm A. Treatment of the mares was begun in early to mid-December 1995 and of the yearlings in early March 1996.

Specific data on examination of feces of mares (Table 1) and yearlings (Table 2) for *A. perfoliata* eggs pre- and posttreatment are recorded. About one-third of the horses had feces positive for tapeworm eggs before treatment. After treatment, eggs were found in feces for only 1 of 3 sample periods for the mares but were present in 6 of 7 samplings for the yearlings. The highest prevalence in yearlings for tapeworm eggs was 71% at 2 days postinitial treatment day (PIT); this was probably because of disintegration of *A. perfoliata* specimens and release of eggs in the feces.

For the yearlings, about two-thirds of the feces passed for the first 24 and 48-hr periods PIT was collected and washed through a 10-mesh sieve; *A. perfoliata* specimens (n = 401 with scolices) were recovered from feces of 74% of these animals. Some of these specimens were atypical; observations on them are reported else-

Table 2. Data on examination for tapeworm eggs in fecal samples of Farm A Thoroughbred yearlings treated with the low-level dose rate (2.64 mg/kg) of pyrantel tartrate.

Time relative to treatment (days)*	Colts		Fillies		All horses	
	Examined	Infected (%)	Examined	Infected (%)	Examined	Infected (%)
0	26	8 (31)	32	11 (34)	58	19 (33)
2	26	18 (69)	32	23 (72)	58	41 (71)
7	26	7 (27)	32	12 (38)	58	19 (33)
14	25	2 (8)	31	5 (16)	56	7 (13)
21	26	2 (8)†	31	2 (6)	57	4 (7)
28	26	0 (0)	27	0 (0)	53	0 (0)
35	26	0 (0)	30	1 (3)	56	1 (2)
75	26	1 (4)	31	0 (0)	57	1 (2)

* Treatment once daily for 30 consecutive days.

† Also 1 suspect egg.

where (Lyons et al., 1997). Combined data (presence of eggs in feces pretreatment and 48 hr PIT in addition to specimens passed in feces) indicate prevalence of 96% for *A. perfoliata* in the yearlings. This prevalence was much higher for *A. perfoliata* than found for specimens recovered from horses (50–60%) at necropsy in central Kentucky the last several years (Benton and Lyons, 1994). It is unknown whether Farm A is unique or sampling so many individuals in a closed system accounts for the high infection rate detected for *A. perfoliata*.

Interpretation of efficacy of the low dose level of pyrantel tartrate given once daily for 30 consecutive days on *A. perfoliata* is difficult based only on examination of feces for tapeworm eggs because false-negatives are common. However, the finding of specimens in feces of 74% of the yearlings over 2 days PIT and decline in presence of eggs in feces of both yearlings and mares, during and after treatment, indicate at least some drug activity. Also, these data seem to substantiate partially the good activity found by Greiner and Lane (1994). Further research, such as controlled and critical tests, should be done to establish more definitive efficacy of the low dose rate of pyrantel tartrate on *A. perfoliata*.

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Research Note

Further Evaluation of Pyrantel Pamoate at the Therapeutic Dose Rate (6.6 mg base/kg) against *Anoplocephala perfoliata* in Horses

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ABSTRACT: Pyrantel pamoate paste was administered intraorally once at the therapeutic dose rate (6.6 mg base/kg) to 17 horses naturally infected with *Anoplocephala perfoliata*. Evaluation of drug activity by a modified critical test method indicated removals varying from 0 to 100% (aggregate average of 70%). Clearance was 0–27% (n = 2 horses), 36–44% (n = 3), 64–67% (n = 2), 75–88% (n = 4), 91–98% (n = 3), and 100% (n = 3).

KEY WORDS: *Anoplocephala perfoliata*, horses, efficacy, pyrantel pamoate paste, therapeutic dose rate, modified critical test.

Anoplocephala perfoliata is commonly found in equids and may cause health problems (Lyons et al., 1986; Benton and Lyons, 1994). Pyrantel pamoate, commercially available as a nematocide, has been reported as active on *A. perfoliata* at the therapeutic dose rate (6.6 mg base/kg) (aggregate average removal = 88%) and 13.2 mg base/kg dose rate (aggregate average removal = 93%); however, activity was quite variable for

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both dose rates (Lyons et al., 1986, 1989). Limited early research on pyrantel pamoate showed that the 2× dose rate was much more effective than the 1× dose rate on *A. perfoliata* (Slocombe, 1979).

The purpose of the present research was to obtain additional data on activity of the therapeutic dose rate (6.6 mg base/kg) of pyrantel pamoate paste (Strongid® Paste, Pfizer, New York) on natural infections of *A. perfoliata* in horses. The drug was administered once intraorally between 5 November 1992 and 3 July 1996 to 28 horses, but only 17 were infected with specimens of *A. perfoliata*. The 17 infected, treated horses included 13 Thoroughbreds, 2 Thoroughbred crossbreeds, 1 Arabian, and 1 Quarter Horse. Their ages were weanling (n = 2), 1 yr (n = 7), 2 yr (n = 5), 5 yr (n = 1), 10 yr (n = 1), and 18 yr (n = 1); sexes were 8 females, 6 males (intact), and 3 geldings.

A modified critical test was used to evaluate efficacy of the drug and details have been published (Todd and Brown, 1952; Lyons et al., 1986, 1989). A brief description of the modified critical is as follows: At necropsy, usually at 24 hr posttreatment, *A. perfoliata* found in the small intestine and cecum, in addition to those attached to the mucosa of the ventral colon, are considered remaining or not removed by a drug. However, specimens recovered from contents of the ventral colon, dorsal colon, small colon, and rectum are regarded as removed by a drug. The basis for the modified critical test is that *A. perfoliata* normally inhabit the cecum but occasionally are found in the small intestine and ventral colon. By 24 hr posttreatment, tapeworms affected by a drug, such as pyrantel pamoate, generally will have passed posteriorally from their normal location in the intestine, but probably few have been eliminated in the feces.

For 13 of the 17 infected horses, a 24-hr critical test was done, for which feces passed posttreatment were not examined for tapeworm specimens (Lyons et al, 1986). With the other 4 infected horses, feces were collected and examined for *A. perfoliata* specimens for 48 hr posttreatment.

Results are given in Table 1. Aggregate average removal was 70% with variation of individual efficacies between 0 and 100%. Grouping of the data for the horses indicates removals were ≥91% for 6, 75–88% for 4, and 67% for the other 7. For the 4 horses for which feces were examined for 48 hr posttreatment, individual efficacies were 0, 67, 100, and 100%. The aggregate average efficacy (70%) of pyrantel pamoate at the dose rate of 6.6 mg base/kg in the present study was 18% less than that (88%) previously found for the paste formulation, but it was similar to that (75%) recorded for the suspension formulation (Lyons et al., 1989). Findings in this research, while efficacies were greatly variable, substantiate the potential beneficial activity of the therapeutic dose rate (6.6 mg base/kg) of pyrantel pamoate on *A. perfoliata* in equids.

Prevalence of *A. perfoliata* was 61% in the 28 test horses; 24 were Thoroughbreds, for which prevalence was 54%, and if the 2 Thoroughbred crossbreeds are also included as Thoroughbreds it was 58% for this breed. These prevalence values are similar to those found the last several years for horses, most data are for Thorough-

Table 1. Data for *Anolocephala perfoliata* recovered from 17 horses treated with pyrantel pamoate paste intraorally at the therapeutic dose rate (6.6 mg base/kg) in modified critical tests.*

	Anoplocephala perfoliata			
Horse No.	No. removed†	No. remaining‡	Total No.	Percent removal
1	9	3	12	75
2	10	1	11	91
3	37	65	102	36
4	16	3	19	84
5	17	46	63	27
6	289	19	308	94
7	232	301	533	44
8	9	5	14	64
9	3	4	7	43
10	171	23	194	88
11	9	0	9	100
12	16	5	21	76
13	316	155	471	67
14	1	0	1	100
15	60	1	61	98
16	2	0	2	100
17	0	1	1	0

* Thirteen horses were killed at 24 hr posttreatment; for the other 4 horses (Nos. 13, 14, 16, and 17), feces were examined for tapeworms for 48 hr posttreatment, at which time these horses were killed.

† Removed = specimens recovered from contents of the ventral colon, dorsal colon, small colon, and rectum at necropsy; also includes specimens passed in feces of the 4 horses killed at 48 hr posttreatment.

‡ Remaining = specimens recovered from the small intestine and cecum, in addition to those attached to the mucosa of the ventral colon at necropsy.

breds, in central Kentucky from which *A. perfoliata* specimens were recovered at necropsy (Benton and Lyons, 1994).

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Research Note

Atypical External Characteristics of *Anoplocephala perfoliata* in Equids in Central Kentucky

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ABSTRACT: As part of a study evaluating efficacy of pyrantel tartrate fed at the low dose rate (2.64 mg/kg) once daily for 30 consecutive days against *Anoplocephala perfoliata* in Thoroughbreds on Farm A in central Kentucky, about two-thirds of the feces passed by yearlings (n = 58) for 2 days postinitial treatment day was examined for specimens of this parasite. Efficacy data are given elsewhere (Lyons, et al., 1997), and observations on external characteristics of *A. perfoliata* specimens recovered from feces are presented here. Of a total of 401 *A. perfoliata* specimens with scolices found in feces of 43 of the yearlings, external features were typical (normal strobila and scolex with 4 suckers/4 lappets) for 97.5% (n = 391 specimens). However, 2.5% (n = 10) were atypical: (a) 1 had a normal strobila but a scolex with 6 suckers/4 lappets, (b) 7 had a triradiate strobila and a scolex with either 5 suckers/6 lappets (n = 1) or 6 suckers/6 lappets (n = 6), and (c) 2 had a tetraradiate strobila and a scolex with either 7 suckers/7 lappets or 8 suckers/8 lappets. Reexamination of 22,557 specimens of *A. perfoliata* from equids in previous investigations at the University of Kentucky, for comparison of external characteristics in specimens from Farm A horses, revealed 99.95% (n = 22,545) were typical and 0.05% (n = 12) were atypical (all had a triradiate strobila and a scolex with 6 suckers/6 lappets).

KEY WORDS: *Anoplocephala perfoliata,* cestode, equids, atypical, external characteristics, polyradiate, scolex abnormalities.

A field test was done on Thoroughbred mares (n = 83) and yearlings (n = 58) on Farm A in central Kentucky to evaluate activity against *Anoplocephala perfoliata* for pyrantel tartrate (Strongid® C, Pfizer, New York) fed at the low dose rate (2.64 mg/kg) once daily for 30 consecutive days (Lyons et al., 1997). About two-thirds of the feces passed by the yearlings for 2 days postinitial treatment day was examined for specimens of *A. perfoliata*: (a) for evaluation of activity of the drug and (b) to more clearly establish prevalence of this parasite in horses on Farm A (Lyons et al., 1997).

The purposes of the present paper are to relate findings on external features of *A. perfoliata* recovered from Farm A yearlings and the com-

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parison of exterior characteristics of *A. perfoliata* from feces of Farm A yearlings with those of specimens from equids in previous investigations at the University of Kentucky.

A total of 401 *A. perfoliata* specimens with scolices were recovered from feces of 43 of the 58 treated yearlings and fixed in a cold alcohol–formalin–glycerin solution (AFG). For these specimens, 391 (97.5%) were typical (normal strobila and scolex with 4 suckers/4 lappets) (USNPC No. 86870) (Figs. 1, 2) and 10 (2.5%) were atypical (Figs. 3–10). Representative typical and atypical specimens were deposited in the United States National Parasite Collection (USNPC), Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland.

The 10 atypical *A. perfoliata* specimens included 1 with a normal strobila but a scolex with 6 suckers/4 lappets (USNPC No. 86871). Seven of the atypical specimens had a triradiate strobila (Fig. 9); 1 of these had a scolex with 5 suckers/6 lappets (Fig. 3) (USNPC No. 86872), and 6 others had scolices with 6 suckers/6 lappets (Fig. 4) (USNPC No. 86873). The other 2 atypical *A. perfoliata* had a tetraradiate strobila (Fig. 10); the scolex on 1 had 7 suckers/7 lappets (Fig. 5) (USNPC No. 86874), and the other had 8 suckers/8 lappets (Figs. 6–8) (USNPC No. 86875).

Atypical specimens of *A. perfoliata* were found in feces of 8 (14%) of the 58 yearlings, 4 colts and 4 fillies. For these yearlings, prevalence of atypical specimens varied from 2 to 17% ($\bar{x}$ = 4%) of the total number (6–110) of specimens recovered from each animal. The number of atypical specimens per individual was 1 each for 6 yearlings and 2 each for the other 2 yearlings. For the yearlings with 2 atypical *A. perfoliata* each, both specimens from 1 (No. 54) and 1 from the other (No. 26) had a triradiate strobila and scolex with 6 suckers/6 lappets. In addition, yearling No. 26 had 1 specimen with a normal strobila, but the scolex had 6 suckers and 4 lappets.

The term polyradiate is used by Foster (1916) to describe strobila with 3 or more wings extending from a common axis. According to Clapham (1939), this condition is associated with an increase in numbers of suckers on the scolex. There are at least 4 reports of polyradiate specimens of *A. perfoliata* being found in equids (Neumann, 1890; Meggitt, 1916; Drudge and Leland, 1954; Lyons et al., 1989). All of these specimens had a scolex with 6 suckers/6 lappets and a strobila that was triradiate; the authors are not aware of any other atypical external characteristics previously reported for *A. perfoliata.* Structural abnormalities of the scolex and strobila have been reported for several other species of cestodes (Foster, 1916; Clapham, 1939; Kuntz, 1948; Spasskii, 1951); these include various atypical forms of strobila, such as tri-, tetra-, or quadri- and pentaradiate.

Finding several atypical specimens of *A. perfoliata* in a relatively small number examined from yearlings on Farm A seemed unusual. Therefore, the authors decided to reexamine *A. perfoliata* specimens collected and preserved in AFG from previous investigations in equids (n = 547) at the University of Kentucky; these specimens were recovered at necropsy in prevalence studies and in feces and/or at necropsy in drug efficacy tests. Most of the equids were horses; the majority were Thoroughbreds. The scolex and strobila were examined closely on each specimen. Lappets were not counted on all specimens; suckers were not evident on scolices of some specimens because of apparent retraction of the scolex. Of 22,557 specimens examined, 99.95% were typical. Twelve specimens (0.05%) were atypical; they all had a triradiate strobila and scolex with 6 suckers and 6 lappets. Two of these atypical specimens were reported previously (Lyons et al., 1989). Atypical specimens, 1 each, were recovered from 12 (2%) of the 547 equids examined. Prevalences in the animals with triradiate specimens ranged from <1 to 13% of the total number (9–1,023) of specimens recovered from each infected individual. The equids positive for atypical *A. perfoliata* included 10 Thoroughbreds, 1 Tennessee Walking Horse, and 1 Arabian; their ages varied from <1 to 24 yr old, and all were from different farms.

Tapeworms from yearlings on Farm A had a much higher (50×) prevalence of atypical individuals (2.5%) than those from equids (0.05%) from different farms. There seems to be no known reason for this. Clapham (1939) stated the belief that polyradiate cestodes result from ". . . incomplete division in the ovum in its early stages . . . ."

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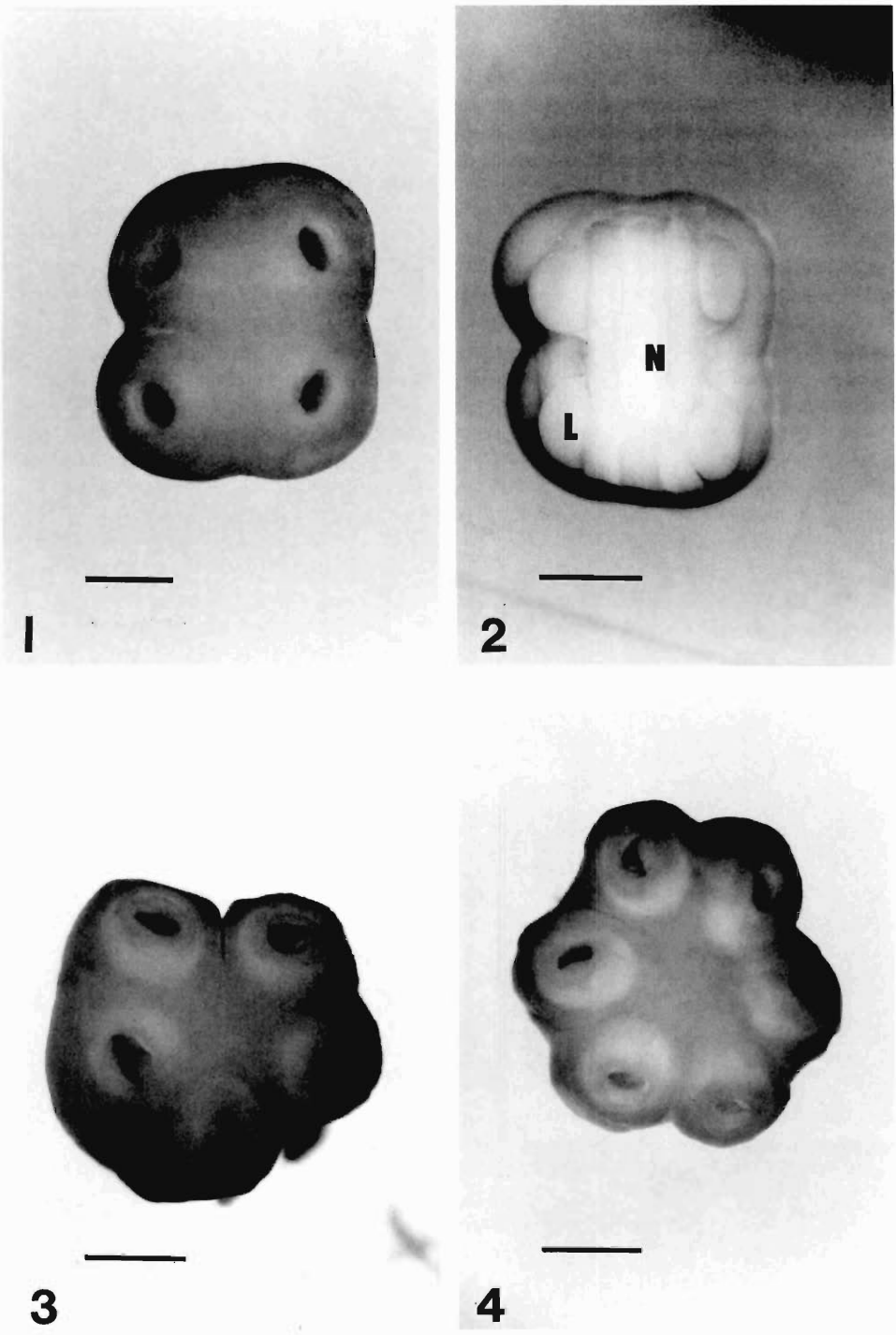
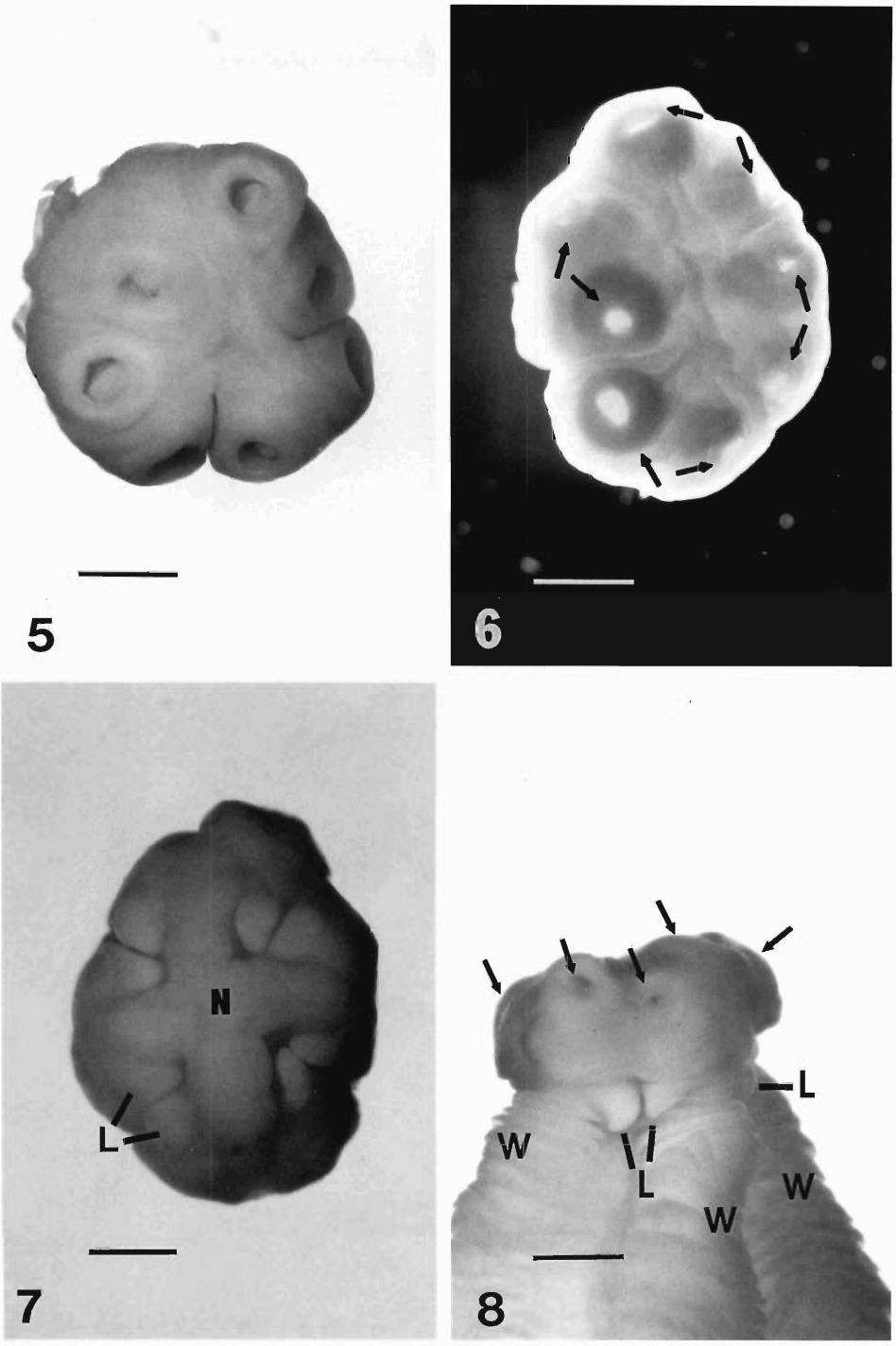


Figures 1–4. *Anoplocephala perfoliata.* **Scale bars = 1.0 mm. 1, 2. Typical scolex. 1. Apical view of the 4 suckers. 2. Underside showing the 4 lappets (L) and cross-section of neck (N) region. 3, 4. Atypical scolices, apical view. 3. Specimen with 5 suckers. 4. Specimen with 6 suckers.**



Figures 5–8. Atypical *Anoplocephala perfoliata*. Scale bars = 1.0 mm. 5, 6. Scolices, apical view. 5. Specimen with 7 suckers. 6. Specimen with 8 suckers (arrows). 7. Underside of specimen in Figure 6 showing 8 lappets (L) and cross-section of neck (N) region with tetraradiate symmetry. 8. Surficial view of specimen in Figures 6 and 7 (before scolex removed) showing 5 (arrows) of the 8 suckers, 3 of the 8 lappets (L), and 3 of the 4 wings (W).

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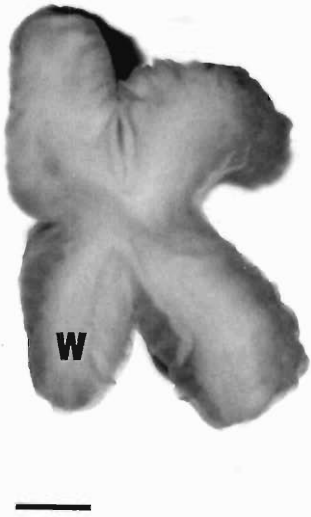

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Figures 9, 10. Atypical *Anoplocephala perfoliata* cross-section (cut with scalpel) of midportion of strobila. Scale bars = 1.0 mm. 9. Triradiate specimen showing the 3 wings (W). 10. Tetraradiate specimen showing the 4 wings (W).

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Research Note

Seasonal Occurrence of *Cosmocercoides dukae* and Prey Analysis in the Blue-Spotted Salamander, *Ambystoma laterale*, in Southeastern Wisconsin

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ABSTRACT: From April to October 1993, 83 blue-spotted salamanders, *Ambystoma laterale*, were collected from Waukesha County, Wisconsin, and examined for helminth parasites. Twelve percent of salamanders were infected with the nematode *Cosmocercoides dukae* Holl, 1928. Monthly parasite prevalence and mean intensity remained low from April through July, ranging from 6% prevalence in July to 13% in May. The highest prevalence was in September, when 50% (5/10) of the salamanders were infected. Forty-four percent of the salamanders contained identifiable stomach contents. Amphibians may acquire temporary infections of *C. dukae* by ingesting gastropods. Prevalence of infection increased proportionally with the number of slugs recovered from stomach contents, suggesting that this gastropod may be a primary reservoir of *C. dukae* observed in *A. laterale*.

KEY WORDS: Nematoda, *Cosmocercoides dukae*, amphibia, *Ambystoma laterale*, Gastropoda, stomach content, seasonal study, Wisconsin.

Although there is extensive literature on parasites of amphibians of the United States, most reports have concentrated on anurans (Aho, 1990). Excluding new species descriptions, little work has been done on helminth ecology of salamanders (Rankin, 1937, 1945; Fischthal, 1955; Coggins and Sajdak, 1982; Goater et al., 1987; Aho, 1990; Muzzall, 1990; Muzzall, 1991; Muzzall and Schinderle, 1992). The only published reports of helminths from the blue-spotted salamander, *Ambystoma laterale* Hallowell, 1856, are those by Coggins and Sajdak (1982), who examined 26 specimens from Wisconsin, and Muzzall and Schinderle (1992), on the helminths of the salamanders *A. t. tigrinum* Green, 1825, and *A. laterale* from southern Michigan.

Ambystoma laterale were collected during April–October 1993 from Waukesha County, Wisconsin. Salamanders were hand-captured by overturning rocks and logs during the day or by collecting while they foraged at night. Each monthly sample included between 10 and 17 specimens except for October, when only 1 individual was collected. Animals were put on ice or pithed and preserved in 10% neutral-buffered formalin (NBF) within 12 hr after capture. Snout–vent length (SVL) was recorded for each individual, and sex was determined and recorded for adults. The digestive tract, body wall musculature, and internal organs were examined for helminths using standard necropsy techniques (Pritchard and Kruse, 1982). Nematodes were preserved in 10% NBF, dehydrated to 70% ethanol, cleared in glycerol, and identified as temporary mounts using descriptions provided by Anderson (1960). All undigested stomach content was preserved in 10% NBF and identified to class or order following Barnes et al. (1993). Prevalence is the percentage of infected hosts in the sample; mean intensity is the mean number of parasites divided by the number of infected hosts. Voucher specimens have been deposited in the H. Manter Helminth Collection, University of Nebraska, Lincoln (accession No. HWML 39184).

Ten (12%) of 83 *Ambystoma laterale* were infected with 1 or more individuals of *Cosmocercoides dukae* Holl, 1928. A total of 13 nematode individuals were found: 4 adult males, 3 adult females, 1 L_4 larva, and 5 L_3 larvae. All nematodes were found in the small and large intestine. Monthly parasite prevalence and mean intensity remained low from April through July, ranging from 6% prevalence in July to 13% in May (Table 1). The highest prevalence was in September, when 50% (5/10) of the salamanders were infected. Mean intensity remained low dur-

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Table 1. Monthly and overall prevalence and mean intensity of *C. dukae* in *A. laterale*.

Month	No. examined	Prevalence*	Mean intensity (range)	Mean SVL (mm) ± 1 SD (range) of *A. laterale*
April	10	1 (10.0)	1 (1)	44.38 ± 10.30 (30.55–60.00)
May	15	2 (13.3)	2 (1–3)	42.29 ± 8.98 (30.15–57.00)
June	14	1 (7.1)	1 (1)	36.80 ± 7.81 (27.10–52.90)
July	16	1 (6.3)	1 (1)	31.53 ± 6.96 (26.55–56.45)
August	17	0 (0)	— (0)	31.01 ± 2.23 (28.35–36.20)
September	10	5 (50.0)	1.2 (1–2)	37.83 ± 5.41 (31.15–50.50)
October	1	0 (0)	— (0)	34.14
Overall	83	10 (12.0)	1.3 (1–3)	36.59 ± 8.56 (26.55–60.00)

* Number infected (percent infected).

ing this collection period averaging 1.3 worms per infected host. No parasites were found in August or October; however, the October collection represented only 1 host. Due to low prevalence and mean intensity values, no statistical analysis was performed.

Mean SVL of the salamanders also differed during the 7-mo collection (Table 1). The greatest mean SVL was recorded in April (44.38) and decreased each month, reaching its minimum value in August (31.01), before increasing in September (37.83). Statistically significant differences in mean SVL were observed for April and July, April and August, May and July, and May and August ($P < 0.001$, single-factor, independent measure ANOVA; $P = 0.05$ for all pairwise comparisons, Scheffe's test).

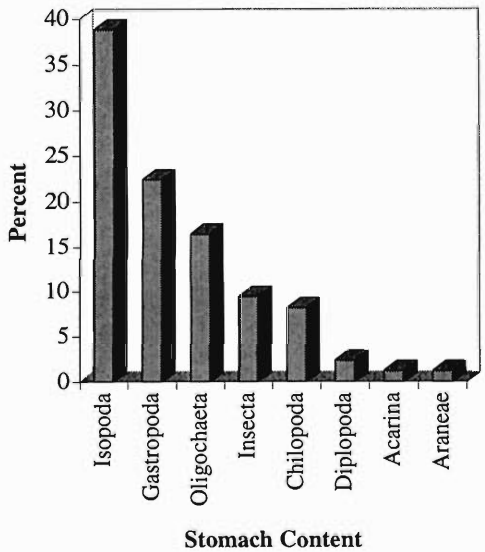

Figure 1. Undigested stomach content of *A. laterale* from 1993.

In the present study, 44% of salamanders contained identifiable stomach contents. Ambystomid salamanders have a broad prey base and do not concentrate on any specific prey items (Vogt, 1981). Stomach content analysis of *A. laterale* revealed a broad range of invertebrates (Fig. 1). Terrestrial isopods, gastropods, and oligochaetes made up the largest portion of the diet, respectively, followed by insects, chilopods, diplopods, and other arthropods. These results are similar to those of other investigators (Minton, 1972; Gilhen, 1974). Gastropods appear to be an important food item in the diet of the blue-spotted salamander. Gilhen (1974) recorded slugs as being the most common food item recovered from salamanders in Nova Scotia, whereas they were the secondmost common item found in the present study.

Salamanders are ectothermic insectivore generalists (Goater et al., 1987). Their parasite fauna and parasite prevalence may reflect the number of invertebrate prey available to the salamanders. As found in this study and other previous work, it is suggested that salamanders have both a low parasite prevalence and mean intensity (Rankin, 1937, 1945; Fischthal, 1955; Coggins and Sajdak, 1982; Goater et al., 1987). These patterns of prevalence and intensity of infection seem to indicate that salamander helminths are not host-specific but are opportunistic generalists. Their distribution can be correlated to habitat type used by the salamanders and prey availability to the hosts, which in turn depends on ecological factors influencing variation in life history traits in local populations (Aho, 1990). The pattern of different helminth communities found in the study by Muzzall and Schinderle (1992) and the present study of *A. laterale* support this hypothesis. Possible explanations for

these observed differences can range from the absence of the parasite in the study area, the lack of an appropriate intermediate host, or both.

The nematode *C. dukae* has been reported from numerous gastropods, amphibians, and reptiles in North America (Harwood, 1930; Ogren, 1953; Anderson, 1960; Lewis, 1973; Baker, 1978; Vanderburgh and Anderson, 1986a, b). Recently, it has been shown by Vanderburgh and Anderson (1986a) that *C. dukae* is a parasite of terrestrial molluscs with inadvertent occurrence in animals feeding upon terrestrial molluscs. *Cosmocercoides variabilis* is considered to be a parasite of amphibians. This nematode has a direct life cycle by skin penetration, molting in the lungs or body cavity and maturing in the intestine (Baker, 1978; Vanderburgh and Anderson, 1986a). It was suggested that this parasite may be restricted to certain amphibian groups such as representatives of the Hylidae, Microhylidae, and Bufonidae (Vanderburgh and Anderson, 1986a). More recently, *C. variabilis* has been shown to infect *Plethodon cinereus*, the red-backed salamander, in Virginia (Bursey and Schibli, 1995), extending its occurrence into the Caudata. The major difference in the 2 species is the number of rosette papillae: *C. dukae* with 12 pairs of rosette papilla and *C. variabilis* with 14–20 pairs (Travassos, 1931). Each male specimen in the present study possessed 12 pairs of rosette papillae, and no larva were found in the host lungs or body cavity. The parasite prevalence of this nematode was also low, and mean intensity was very low. Thus, it is felt that the specimens are accidental infections of *C. dukae*.

The present report of *C. dukae* in *A. laterale* may be due to ingesting infected gastropods (Anderson, 1960). Larval *C. dukae* were found in salamanders in months when gastropods were commonly found in the stomach contents for all months except August (see Fig. 2). However, all salamanders collected during the month of August (Table 1) were newly metamorphosed larva that did not have enough time to feed heavily and acquire the infection. Newly metamorphosed salamanders in the study by Muzzall and Schinderle (1992) also contained little food in the gastrointestinal tract; they indicated that they were collected before the onset of heavy feeding. Although statistical analyses was not performed due to small sample sizes, these results show a proportional increase in prevalence of *C. dukae* in *A. laterale* and number of gastropods recovered from stomach content.

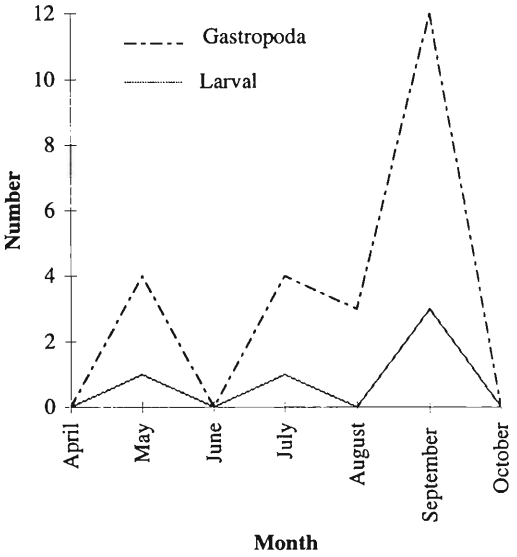

Figure 2. Combined larval *C. dukae* and Gastropoda recovered from monthly salamander samples in 1993.

The lack of seasonal data on salamander parasites may indicate the difficulty in collecting these animals throughout the year. Coggins and Sajdak (1982) collected their animals during the spring rains or after melting of the snows. Collecting this early in the year may not have allowed hosts enough time to acquire their regular helminth fauna after a long winter hibernation. The study by Muzzall and Schinderle (1992) was also a survey of helminths from 257 larvae, 24 newly metamorphosed individuals, and 21 adult *A. laterale* from 2 different locations in Michigan. The present study is the first seasonal study of helminths of Wisconsin salamanders. The results of this study are consistent with previous reports of salamander parasites (Rankin, 1937; Dyer and Brandon, 1973; Price and St. John, 1980; Coggins and Sajdak, 1982; Goater et al., 1987; Muzzall and Schinderle, 1992). These findings support the results of earlier workers, indicating that salamander helminths are not strongly host-specific; rather, they are generalists whose distribution is correlated with ecological factors influencing local populations and their diet.

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Research Note

Hematozoa of Spring- and Fall-Migrating Northern Saw-Whet Owls (*Aegolius acadicus*) in Wisconsin

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ABSTRACT: Seventy-two Wisconsin northern saw-whet owls (*Aegolius acadicus*) were sampled for hematozoans during spring and fall migrations in 1993–1994. Three species of parasites were found: *Leucocytozoon ziemanni* in 39 of 72, *Haemoproteus* sp. in 3 of 72, and an unidentified microfilaria in 8 of 72. Thirty birds harbored *L. ziemanni* only, 2 had microfilariae only, 6 had both *L. ziemanni* and microfilariae, and 3 had *L. ziemanni* and *Haemoproteus* sp. Relative age indicated that the birds ranged from <1 yr old to >3 yr old. All age groups were infected. Our sample size was too small to determine a trend; however, the fact that we found infected birds older than 3 yr suggests that infections may persist for more than 1 yr or that older owls are capable of being reinfected.

KEY WORDS: northern saw-whet owls (*Aegolius acadicus*), *Leucocytozoon ziemanni*, *Haemoproteus* sp., microfilariae, Wisconsin, fall and spring migrants.

No information is available on the hematozoa of migrating northern saw-whet owls (*Aegolius acadicus* Gmelin) through Wisconsin, and very little is known about this species in general. Bennett et al. (1989) recorded members of the genus *Leucocytozoon* and *Trypanosoma* in this owl in Canada, but we are aware of no other studies. Herein we present data obtained from 72 birds of relative age, captured during their spring and fall migrations in 1993–1994.

Saw-whet owls were trapped in mist nets at the Linwood Springs Research Station in central Wisconsin (44°28′N, 89°40′W) (during their nocturnal migration [18 October to 7 November 1993, 3–24 March, and 28 September to 23 October 1994]). Ages of all owls were determined by plumage characteristics (Evans and Rosenfield, 1987). Blood samples were taken, fixed in methanol, and stained in Giemsa as reported by Taft et al. (1996). Following Godfrey et al. (1987), blood cells from positive smears were counted in order to enumerate hematozoa. Statistical tests follow Zar (1984) and were conducted with SYSTAT (Wilkinson 1992). Significance was accepted at the 0.05 level.

Voucher specimens for *Leucocytozoon ziemanni*, *Haemoproteus* sp., and microfilariae from northern saw-whet owls were deposited in the University of Nebraska State Museum, Harold W. Manter Laboratory Collection (HWML Nos. 38736–38739), Lincoln, Nebraska 68588.

We found 3 species of hematozoans among 72 saw-whet owls aged from <1 yr to >3 yr: *Leucocytozoon ziemanni* were found in 39 of 72 birds, *Haemoproteus* sp. in 3 of 72, and microfilariae in 8 of 72. Thirty owls harbored *L. ziemanni* only, 2 microfilariae only, 6 both *L. ziemanni* and microfilariae, and 3 had both *L. ziemanni* and *Haemoproteus* sp. Measurements of 10 microfilariae averaged 151 × 5 μm. Infected birds older than 3 yr indicates that infections persist >1 yr or that older birds are reinfected.

We found no evidence of a seasonal prevalence or yearly difference of *L. ziemanni* in saw-whet owls. There was no significance between the number of *L. ziemanni* per 2,000 erythocytes in saw-whets captured during the autumns of 1993 and 1994 (Mann-Whitney *U*-test statistic = 132, $P = 0.11$, df = 1). We further did not find a significant difference between the number of *L. ziemanni* per 2,000 erythrocytes in owls trapped during the spring and fall of 1994 (Mann-Whitney *U*-test statistic = 117.5, $P = 0.20$, df = 1), nor did we find a significant difference between numbers of *L. ziemanni* per 2,000 erythrocytes in these owls caught during the fall of 1993 and spring of 1994 (Mann-Whitney *U*-test statistic = 67.5 $P = 0.25$, df = 1). Samples were too small for analyses of other potential interyear or interseasonal differences in

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Table 1. Mean number and range of *Leucozytozoon ziemanni* per 2,000 erythrocytes in migrating northern saw-whet owls in Wisconsin. Number in parentheses equals sample size.

Season and year	Age of owls			
	1 Yr	2 Yr	3 Yr	>3 Yr
Fall 1993	5.2 (5)	13.5 (6)	5 (2)	20 (1)
	0–17	0–34	3–7	—
Fall 1994	2.0 (4)	2.1 (9)		
	0–3	0–5		
Spring 1994		3.9 (7)	7.8 (4)	0 (1)
		0–11	5–12	—

parasites (*Haemoproteus* sp. and microfilarial prevalence in Table 1). Parasitemia was low, with the highest number parasites being 34/2,000 in 1 bird. Our data suggests that both spring and fall migrants exhibit chronic low level infections. Taft et al. (1994) surveyed hematozoans from Wisconsin Cooper's hawks (*Accipiter cooperii* Bonaparte) and observed prevalence rates for *L. toddi* and *Haemoproteus* sp. as high as 100 and 88%, respectively, but no other hematozoa were noted. Taft et al. (1996) examined blood from a total of 116 autumnal migrant hawks and 2 long-eared owls (*Asio otus* L.) from Duluth, Minnesota. Prevalence rates of *L. toddi* and *Haemoproteus* sp. ranged from 100 to 0% in 8 species of hawks, and 1 of 2 owls harbored *L. ziemanni*, reported as *L. toddi*. In 4 of 11 strigiform and falconiform species from Florida, Forrester et al. (1994) found *Haemoproteus* to be most common, followed by *Plasmodium*, *Leucocytozoon*, and 1 example of *Trypanosoma confusum* in *Strix varia* Barton and an unidentified microfilaria from *Tyto alba* Scopoli. They suggested that, compared to strigiforms, leucocytozoons are more common in falconiforms because of the diurnal behavior and higher perch used by hawks and falcons. Our data regarding *L. ziemanni*, *Haemoproteus*, and microfilariae seem to be the reverse of those of Forrester et al. (1994). We suppose that leucocytozoons (relative to *Haemoproteus* sp.) would be the most common parasites of strigiforms because owls tend to forage at night and roost during the day when blackfly vectors of leucocytozoons (Crosskey, 1990), are generally active. Ceratopogonids (*Culicoides*), the most likely vectors of *Haemoproteus* sp., are, however, active nocturnally (Kettle, 1977). Greiner et al. (1975) recorded few microfilariae from owls. Gutierrez (1989) surveyed 3 subspecies of spotted owls from 6 areas in California and found a range from 9 to 82% of microfilarial prevalence among sites. He suggested that the wide range could have been a function of survey technique, failure to account for parasite periodicity, or real differences in distribution and abundance. Compared to the work of Gutierrez (1989), our microfilariae prevalence was low; however, ours is high compared to other surveys on raptors. Prevalence could be related to the time of day the birds were sampled. Anderson (1992) reported that periodicity in 3 species of avian microfilariae occurred between 1600 and 2300 hrs in diurnally foraging birds. In our study, we sampled Saw-whets between 1930 and 2400 hours when microfilariae in the peripheral blood should be lowest due to the owl's activity. If periodicity is a factor, one would expect to find a higher prevalance of microfilariae in the peripheral blood of resting saw-whets during the day compared to the blood sampled at night.

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Research Notes

Some Parasites from Sumatran Elephants in Indonesia

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ABSTRACT: Three Sumatran elephants (*Elephas maximus sumatranus*) in Way Kambas National Park, Indonesia, that died of clostridiosis were infected with 1 species of nematode (*Murshida falcifera* (Cobbold, 1882)), 2 trematodes (*Hawkesius hawkesi* (Cobbold, 1875), *Pfenderius papillatus* (Cobbold, 1882)), and 1 larval botfly (*Cobboldia elephantis* (Steel, 1878)) species in the gastrointestinal tract. This is the first report of *Hawkesius hawkesi*, *P. papillatus*, and *C. elephantis* infection in Sumatran elephants in Indonesia.

KEY WORDS: Sumatran elephant (*Elephas maximus sumatranus*), Indonesia, nematode, trematode, botfly.

The Sumatran elephant (*Elephas maximus sumatranus*) is the smallest of the 4 subspecies of Asian elephants and is distributed only in the island of Sumatra. The genus *Elephas* is considered to have appeared in the Pliocene; however, it is not clear when the Sumatran elephant was isolated from other Asian elephants. At present, the Sumatran elephant is an endangered species, and their number is estimated to be between 2,800 and 4,800 (Santiapillai and Jackson, 1990).

The Way Kambas National Park is located in Lampung Province, on the southeast tip of Sumatra (4°37′S–5°16′S, 105°55′E). This national park has abundant wildlife species, including the Sumatran elephant, tiger (*Panthera tigris sumatrae*), and rhinoceros (*Dicerorhinus sumatrensis*). The elephant training center in the national park keeps more than 120 elephants, which were caught in various parts of Sumatra.

In a previous study, strongylid eggs were found in fecal samples from 40 (34%) of 118 elephants in this elephant training center (Hayani, 1994); however, other reports of parasites recovered from Sumatran elephants have not been published to date.

In February 1995, 17 elephants were transported to West Lampung Prefecture; 3 male elephants, ranging from 10 to 13 yr old, died suddenly of a clostridial infection. All animals were necropsied in the field and the gastrointestinal tract was removed from the abdominal cavity. Each part (stomach, small intestine, and large intestine) was opened and visible worms collected. No attempt was made to recover all parasite specimens.

One botfly species was collected from the stomach and fixed in 70% ethanol, the 1 species of nematode from the large intestine was fixed in glycerol–alcohol, and 2 trematode species from the large intestine were fixed in 10% formalin. Several trematode specimens were flattened between glass slides and placed in 70% ethanol for Schneider's acetocarmine staining.

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One species of botfly larvae (*Cobboldia elephantis* (Steel, 1878)), 1 nematode species (*Murshida falcifera* (Cobbold, 1882)), and 2 trematodes (*Hawkesius hawkesi* (Cobbold, 1875) and *Pfenderius papillatus* (Cobbold, 1882)) were obtained from all 3 animals. Voucher specimens were deposited in the Laboratory of Parasitology, Department of Disease Control, Graduate School Veterinary Medicine, Hokkaido University, Sapporo, Japan (Helm. Coll. Nos. 2968–2971).

Murshida falcifera was previously reported from other subspecies of Asian elephants in India (Baylis, 1936), Sri Lanka (Fernando and Fernando, 1961c), Malaysia (Fernando and Fernando, 1961b), Burma (Bhalerao, 1932), and Indonesia (Yamaguti, 1961). Although *H. hawkesi*, *P. papillatus*, and *C. elephantis* were reported from Asian elephants in India (Baylis, 1936), Sri Lanka (Fernando and Fernando, 1961c), Burma (Bhalerao, 1932), Cambodia (Fernando and Fernando, 1961a), and Malaysia (Fernando and Fernando, 1961b), this is the first report from the Sumatran elephants in Indonesia.

We thank Professor M. Kamiya and Assistant Professor Y. Oku, Laboratory of Parasitology, Hokkaido University, for many helpful suggestions in identifying the parasites. We also thank Head of the Animal Disease Investigation Centre Region III and the staff there.

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In Memoriam

Kenneth Casper Kates
(1910–1997)

Dr. Kenneth C. Kates, 86, passed away on 26 January 1997 at his home in Vero Beach, Florida. He died of kidney failure following several strokes. A former resident of College Park and Dunkirk, Maryland, Dr. Kates moved to Florida in 1983 after the death of his first wife of 40 years, Marguerite. There he remarried and resided for 13 years, enjoying an active retirement that included golf, bowling, dancing, and playing bridge. He is survived by his second wife, Florida, of Vero Beach; 2 children from his first marriage, Kenneth C. Kates, Jr., of Dunkirk, Maryland, and Virginia D. Willis of Wichita, Kansas; 3 stepchildren from his second marriage, Charles R. Kates, of Nashville, Tennessee, Marilyn K. Sotter, and Arlene S. Brosnan, both of Vero Beach; 10 grandchildren; and 4 great-grandchildren. He was dedicated to his family and his work. He had a long and full career in research that contributed significantly to the field of parasitology.

Dr. Kates was born in Millville, New Jersey, 29 April 1910, where he attended public schools. He received an A.B. degree in 1932 from Columbia University, St. Stephen's-Bard College, majoring in zoology and minoring in chemistry; and an M.A. in 1934 and a Ph.D. in 1937 from Duke University with a major in cytology and a minor in physiology. His awards include the 1978 Anniversary Award of the Helminthological Society of Washington and election to Life Membership in 1981; the Biology Prize, St. Stephen's-Bard College, Columbia University, 1932; University Fellow, Zoology, Duke University, 1934–1935; member of Sigma Xi, 1934; and Fellow, American Association for the Advancement of Science, 1949.

His career spanned 37 years of federal service, 28 years as a zoologist and parasitologist with research organizations in the U.S. Department of Agriculture, 3 years with the Army in World War II as a medical parasitologist and hospital laboratory officer, and 6 years with the Food and Drug Administration as a veterinary parasitologist. He gained national and international recognition in veterinary parasitology.

Dr. Kates had about 80 scientific publications and numerous presentations at scientific meetings to his credit. He also wrote many confidential opinions on new and supplemental antiparasitic drug applications and, upon request, prepared numerous reviews of technical books. He was an active member of the Helminthological Society of Washington. In 1942, he served as Secretary of this Society, as Vice-President in 1943 and as President in 1947. He served on the editorial board of the Society's Proceedings, and was a trustee of the Ransom Memorial Trust Fund from 1956–1982. From 1949–1953, he was a Council Member of the American Association for the Advancement of Science; from 1961–1971, a member of the Editorial Board, *Journal of Parasitology,* and from 1972–1975, Editorial Consultant, *Journal of Parasitology.*

Dr. Kates' major endeavors were investigations of sheep and swine parasites and anthelmintic control of animal parasites. A few of his many accomplishments include studies of the life cycle and biology of the swine thorny-headed worm, *Macracanthorhynchus hirudinaceus*; the discovery of several new orbatid mite vectors of the broad tapeworm of ruminants, *Moniezia expansa,* and, to my knowledge, the only work on experimental infections in sheep with this parasite; and the characterization and description of the interrelationships between climatic conditions and the epizootiology of helminth parasites in sheep, which are generally applicable to other ruminant parasites and very important in management practices. He demonstrated the life history and pathinogenicity of the intestinal nematode parasite of sheep, *Nematodirus spathiger,* and documented for the first time the importance of immature stages of this parasite in causing damage to the intestinal lining—an important contribution toward determining those species of nematodes truly harmful to ruminants. He demonstrated that the Mongolian gerbil/*Trichostrongylus* spp. host–parasite system could be used effectively as a primary screen for candidate anthelmintic chemicals. He contributed to the identification and experimental characterization of two naturally occurring isolates of *Haemonchus*

contortus of sheep and other ruminants, which are resistant to some benzimidazole anthelmintics; he also was involved in the first experimental development in the laboratory of an anthelmintic-resistant strain of *H. contortus* from a drug-sensitive strain, and the demonstration that this cambendazole-resistant strain was cross-resistant to other chemically related anthelmintics. He also contributed substantially to the evaluation of numerous old and new anthelmintics in domestic animals, including studies with turkeys and equids.

Dr. Kates was always a teacher: from 1935–1938, he was head of the Biology Department, Dickinson Junior College, Williamsport, Pennsylvania. From 1946–1974, he was Lecturer and Professorial Lecturer in Zoology (Parasitology), George Washington University, Washington, D.C., where he taught introductory parasitology to undergraduate students, and in 1951, 1960, and 1963, he was Lecturer in Zoology, University of Maryland, College Park, where he taught histology.

My personal association with Dr. Kates covered more than 49 years, and I would like to add an expression of my high regard for the man and for his scientific acumen, his unselfish willingness to assist others, his forthrightness, and his unrelenting pursuit of excellence. To me, he was a man without peer. It is my distinct honor to memorialize this gentlest of men, Dr. Kenneth C. Kates, leader, colleague, scientist, critic, teacher, advisor, and friend.

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In Memoriam

ROBERT TRAUB
(1916–1996)

Dr. Robert Traub died at the age of 80 on 21 December 1996 after a long battle with prostate cancer. He became a member of the Helminthological Society of Washington in 1946 and was a member for 50 years. He published 2 papers in the Proceedings of the Helminthological Society of Washington, and he hosted meetings of the Society when he was at Walter Reed. In 1996, he was elected Honorary Member of the Society.

Bob received his B.S. degree in biology in 1938 from what is now the City College of New York. In 1939, he earned the M.S. degree from Cornell University, majoring in medical entomology. That year, he entered the University of Illinois to study entomology. He served as parasitologist on the 1941 Harry Hoogstrall Expedition to Mount Tancitaro in Mexico. His new bride, Renee, served as the cook for the group. It was perhaps the only expedition to have a Phi Beta Kappa cook! Hoogstrall and Traub remained lifelong friends.

When World War II broke out, Bob joined the U.S. Army and served as a medical entomologist with the Typhus Commission in Burma and India. After the war, he served in Army medical research units in Malaya, Borneo, and Korea. He was a member of the team nominated for a Nobel prize in 1948 for work that elucidated the ecology of scrub typhus in Malaya and its treatment with chloramphenicol.

Bob received the Ph.D. degree in 1949 from the University of Illinois; his dissertation dealt with the fleas he had collected in Mexico before the war. He championed the use of the aedeagus of the flea as a useful taxonomic character. He continued his studies of fleas until his final hospital stay. Bob described 113 new species or subspecies of fleas and 124 species of chiggers. He was a noted authority on zoogeography, and his writings supported the theory of continental drift long before it was widely accepted. Bob retired from the military in 1962 with the rank of Colonel. He then was a professor in the Department of Microbiology at the University of Maryland Medical School, where he continued his work on fleas and rickettsial diseases until his retirement in 1983. Among his research associate appointments were the Bishop Museum, Field Museum, Carnegie Museum of Natural History, and the U.S. National Museum.

Robert Traub had a wit and a sense of humor that were legendary, and he never lost them despite years of health problems with diabetes and cancer. He loved puns, plays on words, and jokes. For example, on one occasion at the Bethesda Naval Hospital, he was sent to see a Dr. Watson. When asked what his problem was, Bob replied, "Alimentary, my dear Watson."

Bob Traub is survived by his wife of 57 years, Renee, of Bethesda, Maryland, his son, Roger, of Ossining, New York, 4 grandchildren, and a great-grandchild. He will be missed by his family, his friends, and scientists in many disciplines.

Ralph P. Eckerlin
Northern Virginia Community College

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Anniversary Award

The Helminthological Society of Washington

FRANKLIN A. NEVA, M.D.

Franklin A. Neva, M.D., left, receiving the 1996 Anniversary Award from Harley Sheffield at the 1996 Anniversary Dinner Meeting.

The Anniversary Award, as the name implies, is presented annually by the Society to a scientist who has achieved distinction in any of a variety of ways. Our Constitution delineates several achievements that may be used to select a candidate. Briefly, they are outstanding contributions to parasitology or related sciences, presenting an exceptional paper at a Society meeting or publishing one in the Journal, notable service to the Society, or other achievements or contributions warranting special recognition by the Society.

It is not clear to me but I think that the first Anniversary Award was presented to Edna Buhrer, long-time secretary-treasurer of the Society, in 1960. With the exception of 1963 and 1968, an award has been made each year. In several cases, there have been corecipients.

Today, it gives me great pleasure to announce that the Awards Committee, consisting of John Cross, Gene Hayunga, and myself, has selected Dr. Franklin A. Neva, better known to us as Frank, as the 1996 awardee. Frank meets the criteria for the award in several ways. He has published an exceptional paper in the Journal (I probably shouldn't be the judge, as I was a coauthor). In regard to service to the Society, Frank has sponsored a yearly meeting of the Society at the National Institutes of Health since his arrival there in 1969. These meetings have always been well attended because Frank was able to bring together speakers who were on the cutting edge of parasitological science. Perhaps the most important contribution that Frank has made concerns his ability to recruit, organize, and train young scientists.

As a little background, Frank was born and raised in Minnesota—possibly that is why the coldest meetings of the Society were held in January at the NIH. He received his B.S. and M.D. degrees from the University of Minnesota. Following medical school, he broadened his training and experience by serving with the navy at NAMRU-3 in Egypt, taking a fellowship at Harvard School of Public Health and then at Children's Medical Center, Boston. He spent time in Central America as

a China Medical Board Fellow and then in various South American countries on a WHO Travel Fellowship. Frank's employment centered on the Boston area, mostly Harvard-related, except for a two-year period as an instructor at the University of Pittsburgh School of Medicine. In 1969, he came to the NIH to serve as the Chief of the Laboratory of Parasitic Disease, National Institute of Allergy and Infectious Diseases, a position he held until 1994.

Frank's CV cites numerous publications spread over many areas of infectious diseases. I guess I would characterize his early career as one of a medical researcher in the field of microbiology. Many papers relate to clinical and epidemiological studies on virus infections. To my knowledge, his first publication in the area of parasitology appeared in 1961, when a study of factors relating to the growth of *Trypanosoma cruzi* in vitro was published in the *American Journal of Tropical Medicine and Hygiene*. While maintaining his interest in trypanosomes, Frank branched into malaria, schistosomiasis, leishmaniasis, filariasis, and strongyloidiasis. It is obvious from his publications that Frank has a tremendous amount of interest and knowledge in both the clinical and biological aspects of the broad spectrum of parasitic diseases.

As mentioned earlier, one of Frank's many strong points is the ability to recruit and train young scientists. During his tenure as Chief of LPD, the laboratory grew in size, quality, and importance due to Frank's ability to convince upper management of the importance of tropical diseases. In recognition of his work, the American Society of Tropical Medicine and Hygiene recently presented him with the Ben Kean Medal. It is based on Ben Kean's career: identification with clinical issues, academic credibility, and a cadre of trainees. In presentation of the medal, Dr. Don Krogstad pointed out that under Frank's leadership, the LPD/NIAID developed into the country's preeminent center for both basic and clinical research training.

This brief review probably doesn't do justice to Frank's many accomplishments. I have chosen some of those that I consider to be major ones. Nevertheless, today, I am most honored to be able to present Frank Neva with the 1996 Anniversary Award of the Helminthological Society of Washington.

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MINUTES

Six Hundred Fifty-First Through Six Hundred Fifty-Fifth Meetings

651st Meeting: USDA, Animal Parasitology Institute, Beltsville, MD, 16 October 1996. President Susan Fricke Meyer presided over the business meeting and Dr. J. Ralph Lichtenfels presided over the scientific session. The following three papers were presented: "Ascariasis: fact and fiction," by Dr. Darwin Murrell; "An update on *Cyclospora,*" by Dr. J. P. Dubey, and "A report on the 9th International Conference on Trichinellosis," by Dr. Ray Gamble. The slate of officers for 1997 was presented: Ellen Andersen, President; Eric P. Hoberg, Vice President; Harley G. Sheffield, Corresponding Secretary-Treasurer; W. Patrick Carney, Recording Secretary.

652nd Meeting: Sabang Indonesian Restaurant, Wheaton, MD, 20 November, 1996. The Anniversary Dinner Meeting and program were presided over by Vice President Ellen Andersen. The slate of officers for 1997 was elected and installed: Ellen Andersen, President; Eric P. Hoberg, Vice President; Harley G. Sheffield, Corresponding Secretary-Treasurer; W. Patrick Carney, Recording Secretary. The 1996 Anniversary Award was presented to Dr. Franklin Neva, Parasitology Laboratory, National Institutes of Allergy and Infectious Diseases, National Institutes of Health, who served as the Keynote Speaker following the Anniversary Dinner.

653rd Meeting: Armed Forces Institute of Pathology, Walter Reed Army Medical Center, Washington, D.C., 15 January, 1997. President Ellen Andersen presided over the business meeting and Ronald Neafie presided over the scientific session. The following papers were presented: "Out of Africa-" by Dr. Wayne Meyers; "The role of the Pathologist in Parasitology," by Dr. Aileen Marty; and "Case Presentations," by Dr. Ronald Neafie.

654th Meeting: Uniformed Services University of the Health Sciences, Bethesda, MD, 19 March 1997. President Ellen Andersen presided over the business meeting. Dr. John Cross presided over the scientific session which consisted of three presentations: "Sexual development in *Plasmodium falciparum* cultures," by Dr. Jackie Williams; and "Malaria control in the Americas, with a discussion of the applicability of remote sensing and geographic information systems to malaria investigations," by Dr. Richard Andre.

655th Meeting: A joint meeting of the Helminthological Society and the New Jersey Society of Parasitologists was held at the New Bolton Center, University of Pennsylvania, Kennett Square, PA, 3 May 1997. President Ellen Andersen presided over the business meeting. Dr. Gerhard A. Schad organized the scientific session and introduced Dr. Larry S. Roberts, Vice President, American Society of Parasitologists (ASP). Dr. Roberts brought greetings, discussed membership concerns of the ASP and invited all participants to attend the ASP meeting in Nashville this June. Dr. Robert Rew, Pfizer Animal Health, Exton, PA introduced the speakers in the mini-symposium "Parasite-Induced Changes in Host Cells: New Insights from Cell Biology," which consisted of three presentations: Dr. David McK. Bird, University of North Carolina, spoke on "Dedifferentiation in host cells attacked by plant parasitic nematodes," Dr. Dickson D. Despommier, Columbia University, presented "Trichinella-nurse cell complex: how the worm turns," and Dr. Irwin Sherman, University of California, Riverside, spoke on "Plasmodium-induced changes in the host erythrocyte." A reception followed the symposium.

The following new members were elected at their respective meetings: 651st: Leopoldina Aquirre-Macedo, Matthew G. Bolek, Jose Luis Luque, Helio Martons de Arauyo Costa, Nicolas A. Mauro, Birger Neuhaus, and Andrew A. Radomski; 653rd: Sidney Ewing, Pablo Gutierrez, Donald F. McAlpine, and Patricio Torres.

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KEY WORD AND SUBJECT INDEX FOR VOLUME 64

ANNIVERSARY AWARD RECIPIENTS

*Edna M. Buhrer	1960	*Kenneth C. Kates	1978
*Mildred A. Doss	1961	*Everett E. Wehr	1979
*Allen McIntosh	1962	*O. Wilford Olsen	1980
*Jesse R. Christie	1964	*Frank D. Enzie	1981
*Gilbert F. Otto	1965	Lloyd E. Rozeboom	1982
*George R. LaRue	1966	*Leon Jacobs	1983
*William W. Cort	1966	Harley G. Sheffield	1984
*Gerard Dikmans	1967	A. Morgan Golden	1985
*Benjamin Schwartz	1969	Louis S. Diamond	1986
*Willard H. Wright	1969	Everett L. Schiller	1987
*Aurel O. Foster	1970	Milford N. Lunde	1988
*Carlton M. Herman	1971	J. Ralph Lichtenfels	1989
*May Belle Chitwood	1972	A. James Haley	1990
*Elvio H. Sadun	1973	*Francis G. Tromba	1991
E. J. Lawson Soulsby	1974	Thomas K. Sawyer	1992
David R. Lincicome	1975	Ralph P. Eckerlin	1993
Margaret A. Stirewalt	1975	Willis A. Reid, Jr.	1994
*Leo A. Jachowski, Jr.	1976	Gerhard A. Schad	1995
*Horace W. Stunkard	1977	Franklin A. Neva, M.D.	1996

HONORARY MEMBERS

*George R. LaRue	1959	E. J. Lawson Soulsby	1990
*Vladimir S. Ershov	1962	Roy C. Anderson	1991
*Norman R. Stoll	1976	Louis Euzet	1992
*Horace W. Stunkard	1977	John C. Holmes	1993
*Justus F. Mueller	1978	Purnomo	1994
John F. A. Sprent	1979	Naftale Katz	1995
Bernard Bezubik	1980	*Robert Traub	1996
Hugh M. Gordon	1981		

CHARTER MEMBERS 1910

*W. E. Chambers	*Philip E. Garrison	*Maurice C. Hall	*Charles A. Pfender
*Nathan A. Cobb	*Joseph Goldberger	*Albert Hassall	*Brayton H. Ransom
*Howard Crawley	*Henry W. Graybill	*George F. Leonard	*Charles W. Stiles
*Winthrop D. Foster			

LIFE MEMBERS

*Maurice C. Hall	1931	*Mildred A. Doss	1977
*Albert Hassall	1931	*Everett E. Wehr	1977
*Charles W. Stiles	1931	Marion M. Farr	1979
*Paul Bartsch	1937	John T. Lucker, Jr.	1979
*Henry E. Ewing	1945	George W. Luttermoser	1979
*William W. Cort	1952	*John S. Andrews	1980
*Gerard Dikmans	1953	*Leo A. Jachowski, Jr.	1981
*Jesse R. Christie	1956	*Kenneth C. Kates	1981
*Gotthold Steiner	1956	*Francis G. Tromba	1983
*Emmett W. Price	1956	A. James Haley	1984
*Eloise B. Cram	1956	*Leon Jacobs	1985
*Gerald Thorne	1961	*Paul C. Beaver	1986
*Allen McIntosh	1963	*Raymond M. Cable	1986
*Edna M. Buhrer	1963	Harry Herlich	1987
*Benjamin G. Chitwood	1968	Glenn L. Hoffman	1988
*Aurel O. Foster	1972	Robert E. Kuntz	1988
*Gilbert F. Otto	1972	Raymond V. Rebois	1988
*Theodor von Brand	1975	Frank W. Douvres	1989
*May Belle Chitwood	1975	Thomas K. Sawyer	1989
*Carlton M. Herman	1975	*J. Allen Scott	1990
Lloyd E. Rozeboom	1975	Judith H. Shaw	1990
*Albert L. Taylor	1975	Milford N. Lunde	1991
David R. Lincicome	1976	Everett L. Schiller	1991
Margaret A. Stirewalt	1976	Harley G. Sheffield	1991
*Willard H. Wright	1976	Louis S. Diamond	1994
*Benjamin Schwartz	1976	Mary Hanson Pritchard	1994

*Deceased.

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