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Neotropical Monogenoidea. 28. Ancyrocephalinae (Dactylogyridae) of Piranha and Their Relatives (Teleostei, Serrasalmidae) from Brazil and French Guiana: Species of *Notozothecium* Boeger and Kritsky, 1988, and *Mymarothecium* gen. n.

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ABSTRACT: Seven species (5 new) of *Notozothecium* and 4 new species of *Mymarothecium* are described and/or reported from the gills of 13 species of Serrasalmidae from the Brazilian Amazon and 1 serrasalmid from French Guiana: *N. bethae* sp. n. from *Myleus pacu* and *M. rhomboidalis*; *N. euzeti* sp. n. from *Acnodon normani*; *N. foliolum* sp. n. from *Pristobrycon* sp.; *N. minor* from *Pygocentrus nattereri, Serrasalmus elongatus, S. rhombeus, S. spilopleura,* and *Serrasalmus* sp. (2n = 58); *N. penetrarum* from *Pygocentrus nattereri*; *N. robustum* sp. n. from *Pristobrycon striolatus*; *N. teinodendrum* sp. n. from *Pristobrycon eigenmanni, Pristobrycon* sp., *Serrasalmus elongatus, S. gouldingi, S. manuelli, S. rhombeus,* and *Serrasalmus* sp. (2 of Jégu); *Mymarothecium dactylotum* sp. n. from *Pristobrycon* sp., *Serrasalmus rhombeus, Serrasalmus* sp. (2 of Jégu), and *Serrasalmus* sp. (2n = 58); *M. galeolum* sp. n. from *Pristobrycon eigenmanni, Pristobrycon* sp., *Pygocentrus nattereri, Serrasalmus gouldingi,* and *S. rhombeus*; *M. perplanum* sp. n. from *S. spilopleura*; and *M. whittingtoni* sp. n. from *Serrasalmus rhombeus, S. spilopleura,* and *Serrasalmus* sp. (2n = 58). The generic diagnosis of *Notozothecium* is emended, and *Mymarothecium* gen. n. is proposed for species with an expanded nonsclerotized vagina opening on the right side of the trunk, an anteromedial projection on the ventral bar, and a hooked termination of the articulation process of the accessory piece.

KEY WORDS: Monogenoidea, Dactylogyridae, Ancyrocephalinae, *Notozothecium, Mymarothecium* gen. n., *Mymarothecium dactylotum* sp. n., *Mymarothecium galeolum* sp. n., *Mymarothecium perplanum* sp. n., *Mymarothecium whittingtoni* sp. n., *Notozothecium bethae* sp. n., *Notozothecium euzeti* sp. n., *Notozothecium foliolum* sp. n., *Notozothecium minor, Notozothecium penetrarum, Notozothecium robustum* sp. n., *Notozothecium teinodendrum* sp. n., Serrasalmidae, *Acnodon normani, Myleus pacu, Myleus rhomboidalis, Pristobrycon eigenmanni, Pristobrycon striolatus, Pristobrycon* sp., *Pygocentrus nattereri, Serrasalmus elongatus, Serrasalmus gouldingi, Serrasalmus manuelli, Serrasalmus rhombeus, Serrasalmus spilopleura, Serrasalmus* sp., Amazon Basin, Brazil, French Guiana.

Serrasalmids are primary freshwater fishes of the Neotropical Region and are hosts to 52 described species of Dactylogyridae: 35 species of *Anacanthorus* Mizelle and Price, 1965 (Anacanthorinae), 1 of *Linguadactyloides* Thatcher and Kritsky, 1983 (Linguadactyloidinae), and 6 of *Amphithecium* Boeger and Kritsky, 1988, 3 of *Cleidodiscus* Mueller, 1934, 2 of *Notothecium* Boeger and Kritsky, 1988, 2 of *Notozothecium* Boeger and Kritsky, 1988, 1 of *Rhinoxenus* Kritsky, Boeger, and Thatcher, 1988, and 2 of *Urocleidus* Mueller, 1934 (all Ancyrocephalinae) (Mizelle and Price, 1965; Kritsky et al., 1979, 1988, 1992; Thatcher and Kritsky, 1983; Boeger and Kritsky, 1988; Van Every and Kritsky, 1992, 1995; Boeger et al., 1995). Since 1984, 20 serrasalmid species were examined for Monogenoidea to further determine the diversity of dactylogyrids (Ancyrocephalinae) infesting this host group. Host species examined from the Amazon Basin during the present study include *Acnodon normani* Gosline, *Catoprion mento* (Cuvier), *Myleus pacu* (Schomburgk), *M. rubripinnis* (Müller and Troschel), *M. schomburgkii* (Jardine), *M. torquatus* (Kner), *Pristobrycon eigenmanni* (Norman), *Pristobrycon* sp., *P. striolatus* (Steindachner), *Pygocentrus nattereri* (Kner), *Pygopristis denticulata* (Cuvier), *Serrasalmus compressus* Jégu, Leão and dos Santos, *S. elongatus* Kner, *S. gouldingi* Fink and Machado-Allison, *S. manuelli* Fernández-Yépez, *S. rhombeus* (Linnaeus), *S. spilopleura* Kner, *Serrasalmus* sp. (2n

= 58), and *Serrasalmus* sp. (2 of Jégu). *Myleus rhomboidalis* (Cuvier) was obtained from a coastal river in French Guiana.

The present paper is the first of 4 contributions dealing with the Ancyrocephalinae from the gills of these 20 hosts and includes reports and/or descriptions of 7 species of *Notozothecium* Boeger and Kritsky, 1988, and 4 species of *Mymarothecium* gen. n. In the following 3 contributions, an additional 37 species of Ancyrocephalinae are recorded from these hosts, and the previously described species of *Cleidodiscus* and *Urocleidus* from serrasalmids are reassigned to new Neotropical genera (see Kritsky et al., in press a, b, c).

Materials and Methods

Serrasalmids were collected by hook-and-line or seine, gill, or throw net. Methods of parasite collection, preparation of helminths for study, measurement, and illustration are those of Kritsky et al. (1986). Measurements, in micrometers, represent straight-line distances between extreme points (except for the length of the copulatory organ of *Notozothecium* spp.) and are expressed as a mean followed by the range and number of specimens measured in parentheses; body length includes that of the haptor. The length of the copulatory organ of *Notozothecium* spp. is an approximation of total length obtained by using a Minerva curvimeter on camera lucida drawings; 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 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 the Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil (INPA); the U.S. National Museum, 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 were also examined: 4 paratypes (HWML 23666), 4 vouchers, (HWML 23665), 2 vouchers (USNPC 79809, 79810) of *Notozothecium penetrarum* Boeger and Kritsky, 1988; and 5 vouchers (personal collection of E. Belmont-Jégu, Manaus, Brazil) of *Notozothecium* sp. (=*N. bethae* sp. n.).

Presumed undescribed hosts have been provisionally identified by M. J. as *Pristobrycon* sp., *Serrasalmus* sp. (2 of Jégu), and *Serrasalmus* sp. (2n = 58). Hosts from the Rio Uatumã that were previously reported as *Pristobrycon* sp. by Kritsky et al. (1992) and Van Every and Kritsky (1992) have been subsequently identified as *S. gouldingi* by M. Jégu (unpubl.). Representative specimens of provisionally identified host taxa are deposited in the ichthyology collection of the INPA.

Taxonomic Account

Class Monogenoidea Bychowsky, 1937

Order Dactylogyridea Bychowsky, 1937

Dactylogyridae Bychowsky, 1933

Ancyrocephalinae Bychowsky, 1937

Notozothecium Boeger and Kritsky, 1988

EMENDED DIAGNOSIS: Body 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 4; granules ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; 2 intestinal ceca confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens looping left intestinal cecum; seminal vesicle a sigmoid dilation of vas deferens. Two 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; copulatory organ an elongate coiled tube with counterclockwise ring(s) (Kritsky et al., 1985); accessory piece with proximal articulation process, distal rod, terminal flabellate plate. Vagina single, nondilated, lightly sclerotized, looping right intestinal cecum, opening on dextrodorsal surface of trunk; seminal receptacle lying on midline anterior to germarium. Haptor globose to subhexagonal; with dorsal, ventral anchor/bar complexes, 7 pairs of hooks with ancyrocephaline distribution. Ventral bar with anteromedial projection. Hooks similar; each with truncate protruding thumb, delicate point, shank comprising 2 subunits; proximal subunit usually variable in length between hook pairs; FH loop extending to union of shank subunits. Parasites of gills of Serrasalmidae.

TYPE SPECIES: *Notozothecium penetrarum* Boeger and Kritsky, 1988, from *Pygocentrus nattereri*.

OTHER SPECIES: *Notozothecium bethae* sp. n. from *Mylesinus paraschomburgkii, M. paucisquamatus, Myleus pacu* (type host), and *M. rhomboidalis*; *N. euzeti* sp. n. from *Acnodon normani*; *N. foliolum* sp. n. from *Pristobrycon* sp.; *N. minor* Boeger and Kritsky, 1988, from *Pygocentrus nattereri* (type host), *S. elongatus, S. rhombeus, S. spilopleura,* and *Serrasalmus* sp.

(2n = 58); *N. robustum* sp. n. from *Pristobrycon striolatus*; and *N. teinodendrum* sp. n. from *P. eigenmanni* (type host), *Pristobrycon* sp., *S. elongatus, S. gouldingi, S. manuelli, S. rhombeus,* and *Serrasalmus* sp. (2 of Jégu).

REMARKS: Characters distinguishing this genus include the combined presence of a single sclerotized nondilated vagina looping the right intestinal cecum and opening on the dextrodorsal body surface, a ventral bar with an anteromedial projection, and a copulatory complex comprising a counterclockwise coiled copulatory organ and an accessory piece with proximal articulation process, distal rod, and terminal flabellate plate. Boeger and Kritsky (1988) reported that *Notozothecium penetrarum* had a single prostatic reservoir. Reexamination of the paratypes and present specimens of *N. penetrarum* confirms the presence of a second, poorly staining reservoir lying dextral to the previously described pyriform reservoir. All known species of *Notozothecium* have 2 prostatic reservoirs.

Notozothecium penetrarum Boeger and Kritsky, 1988 (Figs. 4–10)

RECORDS: *Pygocentrus nattereri:* Furo do Catalão, Manaus, Amazonas (27 November 1984); Rio Guaporé, Surpresa, Rondônia (16 June 1984).

PREVIOUS RECORDS: *Pygocentrus nattereri* (type host): Furo do Catalão, Manaus, Amazonas; Ilha da Marchantaria, Rio Solimões, Manaus, Amazonas; Rio Mamoré, Surpresa, Rondônia; Rio Guaporé, Surpresa, Rondônia (type locality) (all Boeger and Kritsky, 1988).

SPECIMENS STUDIED: Four paratypes, HWML 23666; 15 vouchers, HWML 23665, USNPC 79809, 79810, 85727, 85728.

MEASUREMENTS (9 specimens collected during present study, USNPC 85727, 85728): Ventral anchor 35 (32–43; $n = 8$) long, base 32 (30–35; $n = 8$) wide; dorsal anchor 30 (28–36; $n = 8$) long, base 25 (21–30; $n = 4$) wide; hook prs. 1, 5—17 (15–18; $n = 7$), prs. 2, 6, 7—19 (18–20; $n = 13$), prs. 3, 4—20 (19–21; $n = 13$) long; copulatory organ 236 (210–245; $n = 9$) long, ring diameter 63 (56–69; $n = 7$); distal rod of accessory piece 62 (60–67; $n = 8$) long.

REMARKS: *Notozothecium penetrarum* is the largest species in the genus, with Boeger and Kritsky (1988) reporting specimens exceeding 1 mm in length. All specimens collected during the present study were mounted unstained in Gray and Wess' medium; measurements of internal organs, body dimensions, and haptoral bars were not obtained.

Pygocentrus nattereri is widespread in the white waters of the western Amazon including the major tributaries of the Madeira and Japurá basins. The host is apparently absent (or rare) in black waters of the Amazon (Goulding, 1980), except that it occurs in reduced numbers in regions where a mixing of black and white water results during annual high-water periods such as in Lago Tapaná on the Rio Uatumã and Furo do Catalão near Manaus. In the eastern Amazon, this host is restricted to the white waters of the main Amazon River and its varzea foodplain and in the lower reaches of major Amazonian tributaries. Depending on hydrochemical characteristics, *P. nattereri* may extend from 20 to 80 km upstream in eastern tributaries.

Notozothecium penetrarum appears to be restricted to this host, and its known geographic distribution coincides with that of its host in the western Amazon. Geographic records for this parasite reported by Boeger and Kritsky (1988) and those recorded herein include the Madeira Basin and the main Amazon in the environs of Manaus. The parasite has been collected from the mixed waters of the Furo do Catalão near Manaus but not from the lower reaches of the Rio Uatumã (Lago Tapaná). *Pygocentrus nattereri* has not been examined for Monogenoidea from the eastern Amazon and its tributaries east of the Rio Uatumã.

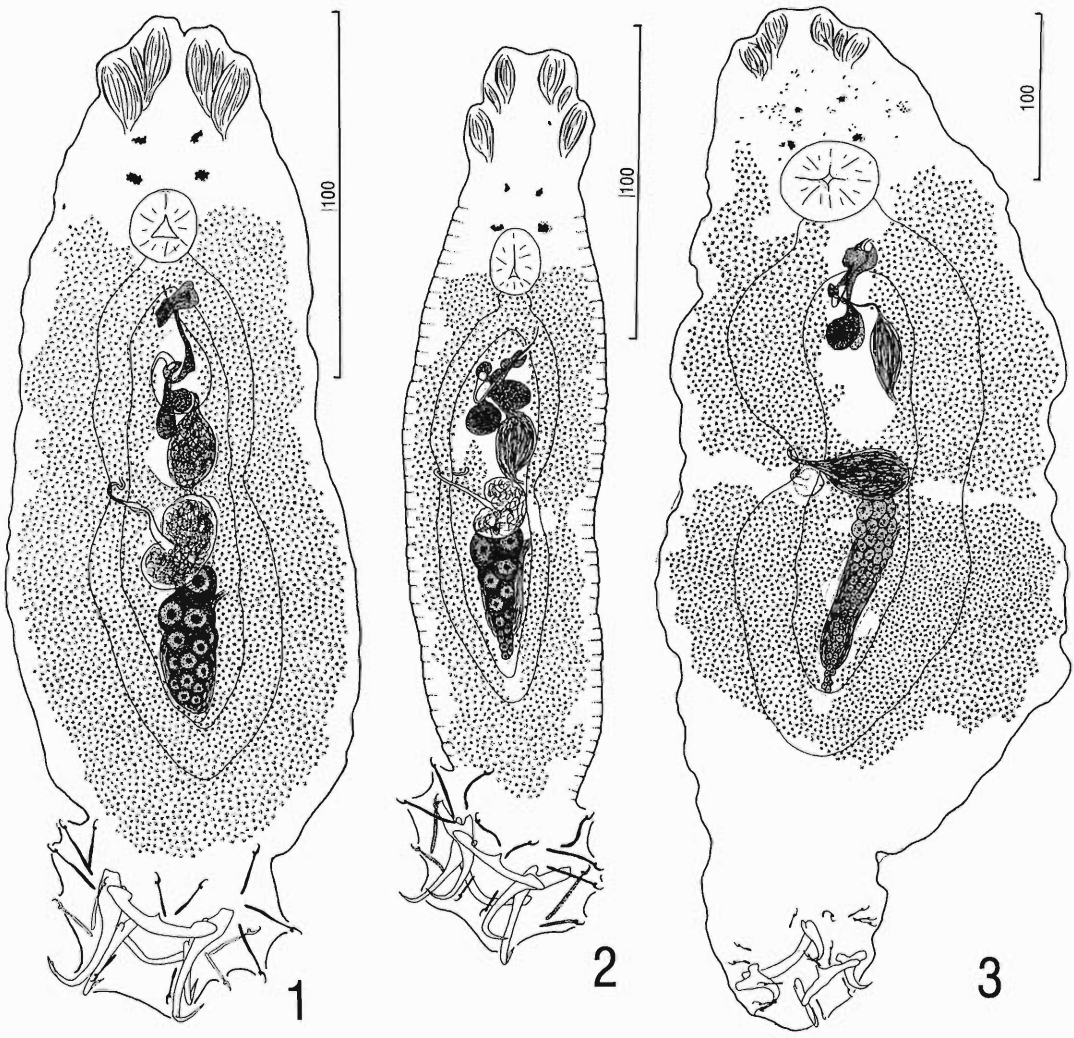
Notozothecium bethae sp. n. (Figs. 1, 11–19)

SYNONYM: *Notozothecium* sp. (of Belmont-Jégu, 1992).

TYPE HOST AND LOCALITY: *Myleus pacu:* Rio Pitinga, Cachoeira 40 Ilhas, Amazonas (12 October 1989).

OTHER RECORDS: *Myleus rhomboidalis:* Rio Approuague, Saut Mapaou, French Guiana (29 November 1989).

PREVIOUS RECORDS: *Mylesinus paraschomburgkii* Jégu, Santos, and Ferreira: Bacia do Rio Uatumã, Rio Capucapú, Cachoeira das Garças, Amazonas; Rio Pitinga, Cachoeira 40 Ilhas, Amazonas; Rio Trombetas, Cachoeira Porteira, Amazonas; Rio Jari, Cachoeira de Santo Antônio, Pará. *Mylesinus paucisquamatus* Jégu and



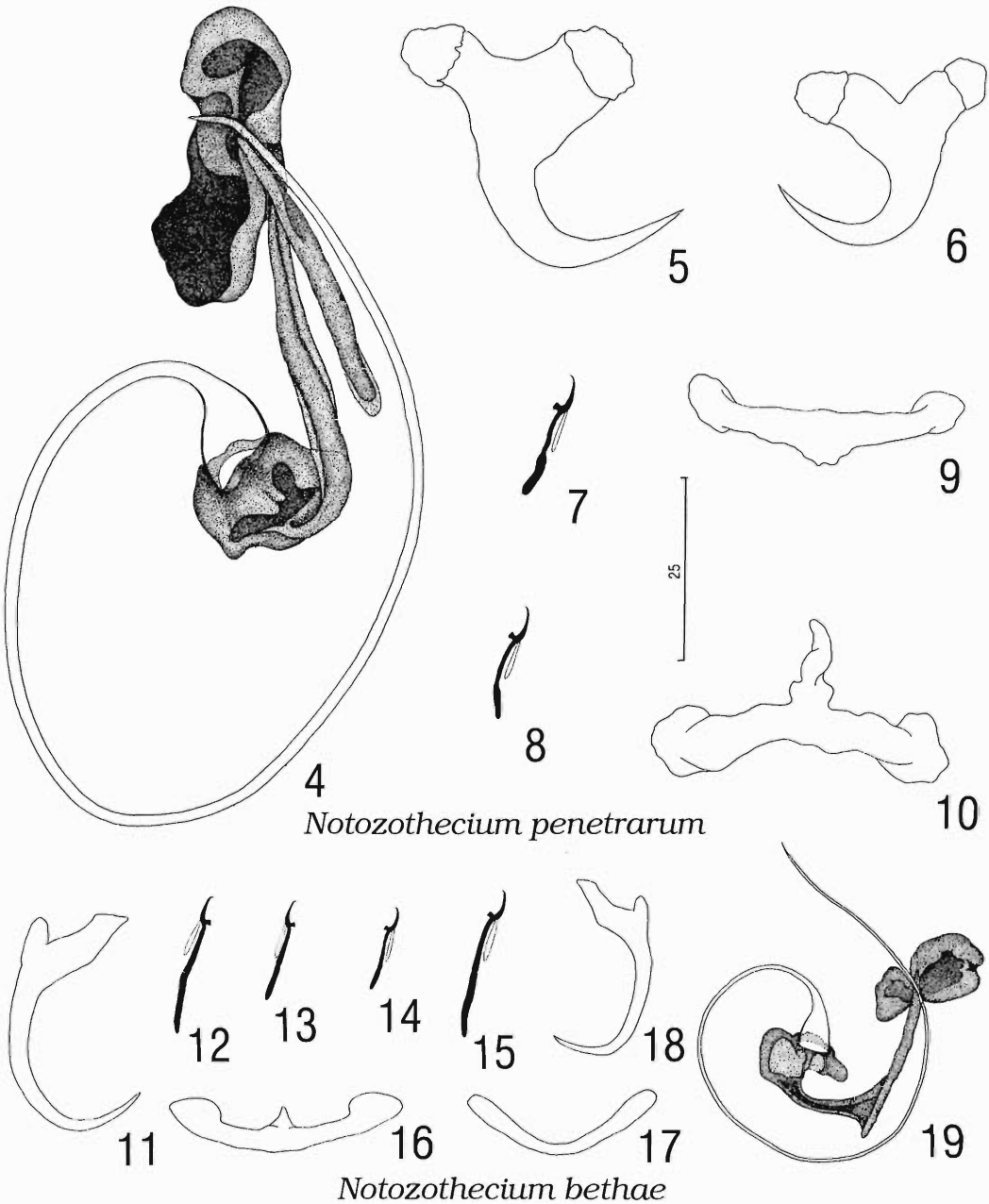
Figures 1–3. Whole-mount illustrations of *Notozothecium* species (composite, ventral views). 1. *Notozothecium bethae* sp. n. (from *Myleus pacu*). 2. *Notozothecium euzeti* sp. n. 3. *Notozothecium foliolum* sp. n. Each figure is drawn to respective 100-μm scales.

Santos: Rio Tocantins, Cachoeira à montante de Marabá, Pará (all Belmont-Jégu, 1992).

SPECIMENS STUDIED: Holotype, INPA PLH 234; 33 paratypes, INPA PLH 235, USNPC 85729, HWML 38583, from *M. pacu.* Five vouchers from *Myleus rhomboidalis,* USNPC 85730; 5 vouchers from *Mylesinus paraschomburgkii,* collection of E. Belmont-Jégu.

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

DESCRIPTION: Body fusiform, 318 (226–430; $n = 20$) long; greatest width 88 (71–106; $n = 22$) in posterior trunk. Tegument infrequently with scaled annulations. Cephalic lobes moderately developed. Posterior pair of eyes larger, slightly farther apart than anterior pair; accessory granules usually absent, infrequently few in cephalic, anterior trunk regions. Pharynx spherical, 18 (12–21; $n = 24$) in diameter. Peduncle broad; haptor subhexagonal, 55 (44–81; $n = 23$) long, 69 (61–82; $n = 22$) wide. Anchors similar; each with elongate slightly depressed superficial root, prominent deep root, evenly curved shaft, elongate point; ventral anchor 35 (30–37; $n = 6$) [34 (32–35; $n = 5$)] long, base 14 (13–16; $n = 6$) [14



Figures 4–19. Sclerotized structures of *Notozothecium* spp. 4–10. *Notozothecium penetrarum* Boeger and Kritsky, 1988. 4. Copulatory complex (ventral view). 5. Ventral anchor. 6. Dorsal anchor. 7. Hook pr. 2. 8. Hook pr. 5. 9. Dorsal bar. 10. Ventral bar. 11–19. *Notozothecium bethae* sp. n. (from *Myleus pacu*). 11. Ventral anchor. 12. Hook pr. 7. 13. Hook pr. 1. 14. Hook pr. 5. 15. Hook pr. 4. 16. Ventral bar. 17. Dorsal bar. 18. Dorsal anchor. 19. Copulatory complex (ventral view). All drawings are to the 25-μm scale.

(13–15; n = 5)] wide; dorsal anchor 26 (25–27; n = 6) [26 (25–27; n = 5)] long, base 10–11 (n = 3) [9–10 (n = 5)] wide. Ventral bar 32 (28–33; n = 20) long, yoke-shaped, with enlarged usually depressed terminations, short triangular anteromedial process. Dorsal bar 25 (21–27; n = 13) long, broadly U-shaped, delicate, with slightly enlarged ends. Hook prs. 1, 5—15 (14–16; n =

7) [15 (14–16; n = 7)], pr. 2—21 (19–23; n = 3) [20 (19–21; n = 4)], prs. 3, 4, 7—23 (20–26; n = 13) [23 (21–24; n = 12)], pr. 6—19 (18–20; n = 4) [18 (17–19; n = 4)] long. Copulatory organ 116 (93–133; n = 5) [93 (88–105; n = 4)] long, comprising about 1¼ ring; ring diameter 32 (29–35; n = 4) [25 (24–26; n = 4)]; base with sclerotized margin, small proximal flap. Articulation process of accessory piece uniting with proximal end of distal rod; distal rod 32 (30–34; n = 6) [29 (26–31; n = 5)] long, straight; flabellate plate nearly perpendicular to distal rod. Testis 44 (38–50; n = 3) long, 20–21 (n = 3) wide, ovate; vas deferens not observed; seminal vesicle large; dextral prostatic reservoir pyriform; sinistral reservoir subspherical. Germarium 42 (29–54; n = 11) long, 18 (15–22; n = 11) wide, irregular in outline; oviduct, ootype, uterus not observed; vagina expanded into an inverted cone immediately before entering large kidney-shaped seminal receptacle; vitellaria dense throughout trunk except absent in regions of reproductive organs.

REMARKS: This species was initially reported as an unnamed *Notozothecium* from *Mylesinus paraschomburgkii* and *M. paucisquamatus* by E. Belmont-Jégu (1992) in an unpublished master's thesis. She indicated that it was sister species to *N. minor* based on a phylogenetic analysis of the then 3 known species in the genus. It differs from *N. minor* by possessing a straight distal rod of the accessory piece (submedial double bend in *N. minor*), an elongate proximal articulation process of the accessory piece, a ventral bar with ends slightly directed anteriorly (straight to ends bent slightly posteriorly in *N. minor*), a triangular anteromedial process of the ventral bar, and haptoral sclerites smaller and more delicate than those of *N. minor*. It is morphologically similar to *N. euzeti*, from which it differs by having shorter superficial anchor roots. This species is named for Elizabeth Belmont-Jégu, discoverer of the species.

All known hosts of *Notozothecium bethae*, including those recorded by Belmont-Jégu (1992), are rheophilic species and are restricted to the higher fast-flowing reaches of clear- and black-water tributaries of the Amazon. The low host specificity of *N. bethae* suggests that the distribution of this parasite may correlate more with ecological factors associated with fast-flowing streams and their hydrochemical characteristics than with host preferences. However, survey of the monogenoidean parasites of myleine hosts from other habitats within the Amazon Basin will be necessary to determine the ecological dependencies of this parasite.

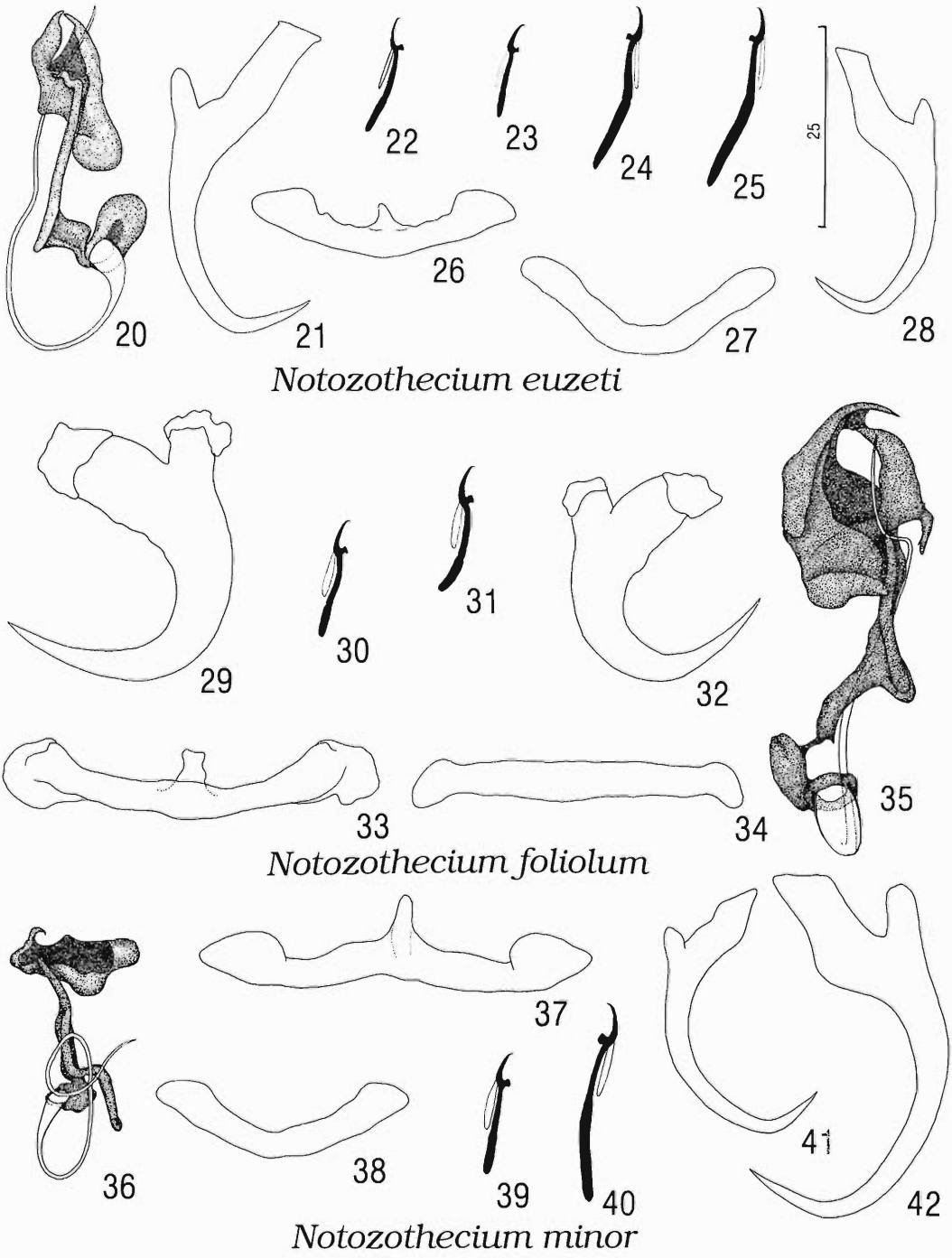
Notozothecium euzeti sp. n. (Figs. 2, 20–28)

TYPE HOST AND LOCALITY: *Achodon normani:* Kaikuta, Rio Xingu, Pará (10, 14 October 1992).

SPECIMENS STUDIED: Holotype, INPA PLH 220; 19 paratypes, INPA PLH 221, USNPC 85731, HWML 38584.

DESCRIPTION: Body fusiform, 273 (235–329; n = 10) long; greatest width 78 (67–116; n = 10) usually in anterior trunk. Tegument with scaled annulations throughout trunk, peduncle. Cephalic lobes moderately developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules numerous to few in cephalic, anterior trunk regions. Pharynx spherical to subovate, 17 (15–19; n = 9) in greatest width. Peduncle broad; haptor subhexagonal, 61 (49–72; n = 11) long, 77 (70–85; n = 10) wide. Anchors similar, each with long truncate superficial root, prominent deep root, curved shaft, elongate point; ventral anchor 37 (34–40; n = 8) long, base 17 (16–19; n = 7) wide; dorsal anchor 33 (30–35; n = 7) long, base 13 (12–14; n = 5) wide. Ventral bar 32 (29–33; n = 10) long, arcuate, with enlarged terminations, short triangular anteromedial process. Dorsal bar 31 (28–34; n = 10) long, broadly U-shaped. Hook prs. 1, 5—15 (14–16; n = 7), prs. 2, 3—22 (20–23; n = 14), prs. 4, 7—25 (24–27; n = 12), pr. 6—18 (17–19) long. Copulatory organ 72 (68–80; n = 8) long, a slender tube of about 1½ rings arising from cone-shaped base, prominent proximal basal flap; ring diameter 21 (17–25; n = 6). Articulation process of accessory piece uniting with proximal end of distal rod; distal rod 30 (26–31; n = 2) long, usually bent near tip; long axis of flabellate plate nearly parallel to distal rod. Testis 24 (22–25; n = 2) long, 16 (14–17; n = 2) wide, ovate; prostatic reservoirs subspherical. Germarium 30 (26–34; n = 5) long, 14 (13–19; n = 5) wide, conical; oviduct, ootype, uterus not observed; vagina delicate, flared into cone before entering kidney-shaped seminal receptacle; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: *Notozothecium euzeti* differs from congeneric species by possessing a ventral anchor with an exaggerated superficial root with truncate tip. It resembles *N. bethae* by lacking a free end of the distal rod of the accessory piece. This species is named for Dr. L. Euzet, Laboratoire de



Figures 20–42. Sclerotized structures of *Notozothecium* spp. 20–28. *Notozothecium euzeti* sp. n. 20. Copulatory complex (ventral view). 21. Ventral anchor. 22. Hook pr. 1. 23. Hook pr. 5. 24. Hook pr. 4. 25. Hook pr. 7. 26. Ventral bar. 27. Dorsal bar. 28. Dorsal anchor. 29–35. *Notozothecium foliolum* sp. n. 29. Ventral anchor. 30. Hook pr. 1. 31. Hook pr. 7. 32. Dorsal anchor. 33. Ventral bar. 34. Dorsal bar. 35. Copulatory complex (ventral view). 36–42. *Notozothecium minor* Boeger and Kritsky, 1988 (from *Serrasalmus spilopleura*). 36. Copulatory complex (ventral view). 37. Ventral bar. 38. Dorsal bar. 39. Hook pr. 1. 40. Hook pr. 7. 41. Dorsal anchor. 42. Ventral anchor. All figures are drawn to the 25-μm scale.

Parasitologie Comparée, U.S.T.L., Montpellier, France, in recognition of his extraordinary contribution to systematics and taxonomy of the Monogenoidea.

Acnodon normani, the host of this parasite, is a rheophilic species restricted to the upper reaches of the Tocantins and Xingu basins of the eastern Amazon (Géry, 1979; Jégu and dos Santos, 1990). Although the monogenoidean fauna of other species of *Acnodon* are unknown, *Notozothecium euzeti* may be restricted to rheophilic hosts.

Notozothecium foliolum sp. n. (Figs. 3, 29–35)

TYPE HOST AND LOCALITY: *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988).

SPECIMENS STUDIED: Holotype, INPA PLH 212; 2 paratypes, USNPC 85732, HWML 38585.

DESCRIPTION: Body foliform, strongly flattened dorsoventrally, 607 (600–615; $n = 2$) long; greatest width 267 (246–288; $n = 2$) in anterior or posterior trunk. Tegument smooth. Cephalic lobes poorly developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules numerous in cephalic, anterior trunk regions. Pharynx spherical, 58 (56–60; $n = 2$) in diameter. Peduncle broad; haptor variable, globose, 101 (88–114; $n = 2$) long, 122 (113–132; $n = 2$) wide. Anchors similar, each with heavy diverging roots with prominent caps, short curved shaft, elongate point; ventral anchor 33 (28–35; $n = 3$) long, base 25 (23–27; $n = 3$) wide; dorsal anchor 27 (26–28; $n = 3$) long, base 19 (17–21; $n = 2$) wide. Ventral bar 48 ($n = 1$) long, straight, with enlarged irregular ends, short truncate anteromedial process. Dorsal bar 42 (41–44; $n = 2$) long, straight, rod-shaped, with slightly enlarged ends. Hook pr. 1—14–15 ($n = 2$), prs. 2, 3, 4, 5, 6, 7—17 (16–18; $n = 8$) long. Copulatory organ 68 (63–78; $n = 3$) long, a slender tube arising from cone-shaped base by sharp bend; ring not apparent; base with sclerotized margin, lacking proximal flap. Articulation process of accessory piece uniting with proximal end of distal rod; distal rod 39 (38–41; $n = 2$) long, straight or somewhat sigmoid; flabellate plate appearing chelate. Testis bacilliform, 124 ($n = 1$) long, 35 ($n = 1$) wide; prostatic reservoirs subspherical to pyriform. Germarium 151 (137–166; $n = 2$) long, 52 (44–59; $n = 2$) wide, forming elongate cone; oviduct, ootype, uterus not observed; vagina with distal sclerotized funnel; seminal receptacle large, pyriform; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: This comparatively large dactylogyrid shares characters with *N. penetrarum.* Both species have foliform (dorsoventrally flattened) bodies, modified anchors and ventral bars, and hooks of almost uniform length. They differ in morphology of the copulatory complex. The specific name is from Latin (*foliolum* = a small leaf) and refers to the body shape.

Notozothecium minor Boeger and Kritsky, 1988 (Figs. 36–42)

RECORDS: *Pygocentrus nattereri:* Furo do Catalão, Manaus, Amazonas (6, 27 November 1984). *Serrasalmus elongatus:* Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (26 November 1984); Rio Negro, Manaus, Amazonas (28 December 1988). *Serrasalmus rhombeus:* Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (26 November 1984). *Serrasalmus spilopleura:* Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (14 September 1984). *Serrasalmus* sp. (2n = 58): Furo do Catalão, Manaus, Amazonas (30 January 1991).

PREVIOUS RECORDS: *Pygocentrus nattereri* (type host): Furo do Catalão, Manaus, Amazonas (type locality); Rio Mamoré, Surpresa, Rondônia; Rio Guaporé, Surpresa, Rondônia (all Boeger and Kritsky, 1988).

SPECIMENS STUDIED: Three vouchers from *Pygocentrus nattereri,* USNPC 85736; 3 vouchers from *S. elongatus,* USNPC 85738, 85739; 1 voucher from *Serrasalmus rhombeus,* USNPC 85735; 7 vouchers from *S. spilopleura,* USNPC 85733, 85734; 9 vouchers from *Serrasalmus* sp. (2n = 58), USNPC 85737.

COMPARATIVE MEASUREMENTS: See Table 1.

REMARKS: This species was adequately described by Boeger and Kritsky (1988). It has a wide host preference within the Serrasalmidae having been found on 5 host species that commonly occur in white, clear, and black waters of the Amazon. *Notozothecium minor* is distinguished from all other congeneric species by having a double bend near the midlength of the distal rod of the accessory piece. It is most similar to *N. teinodendrum,* from which it differs by the latter species possessing a comparatively shorter, straight distal rod of the accessory piece.

Table 1. Comparative measurements (in micrometers) of *Notozothecium minor* Boeger and Kritsky, 1988, from 5 serrasalmid hosts.

	Pygocentrus nattereri	*N*	*Serrasalmus elongatus*	*N*	*Serrasalmus rhombeus*	*N*	*Serrasalmus spilopleura*	*N*	*Serrasalmus* sp. (2n = 58)	*N*
Body										
Length	—	—	—	—	—	—	251	1	—	—
Width	—	—	—	—	—	—	92	1	—	—
Haptor										
Length	—	—	—	—	—	—	73	1	—	—
Width	—	—	—	—	—	—	73	1	—	—
Pharynx										
Diameter	—	—	—	—	—	—	19	1	20	1
Copulatory organ										
Length	63 (55–75)	3	61 (58–65)	3	58	1	57 (53–60)	3	59 (48–65)	7
Ring diameter	20	2	16	2	15	1	20 (18–21)	2	19 (18–21)	6
Accessory piece										
Length	31 (28–33)	3	33 (31–35)	3	31	1	31 (30–32)	4	33 (30–37)	6
Dorsal anchor										
Length	32 (31–33)	4	31 (30–32)	2	—	—	32 (31–34)	5	32 (31–33)	6
Base width	11 (10–13)	3	11 (10–12)	2	—	—	12 (11–13)	4	11 (10–12)	6
Ventral anchor										
Length	41 (39–43)	6	42 (41–43)	3	41	1	42 (39–45)	6	42 (38–44)	7
Base width	18 (17–19)	6	18 (15–21)	3	17	1	17 (16–18)	5	18 (17–19)	7
Bar length										
Ventral	46 (45–47)	2	41	1	—	—	43	1	42	1
Dorsal	30	1	29	1	—	—	26	1	31	1
Hook lengths										
Pair 1	15	1	17	1	17	1	15	1	17 (16–18)	2
Pair 2	19	1	19	2	19	1	19 (18–20)	2	19 (17–21)	4
Pair 3	23	3	22	1	23	1	23	1	23 (22–24)	3
Pair 4	25	1	25	1	27	1	25–26	3	25–26	3
Pair 5	17	1	17	1	16	1	17–18	4	17 (16–18)	2
Pair 6	20	2	19	1	—	—	21–22	3	21	2
Pair 7	25	1	24	1	—	—	25	1	25	1

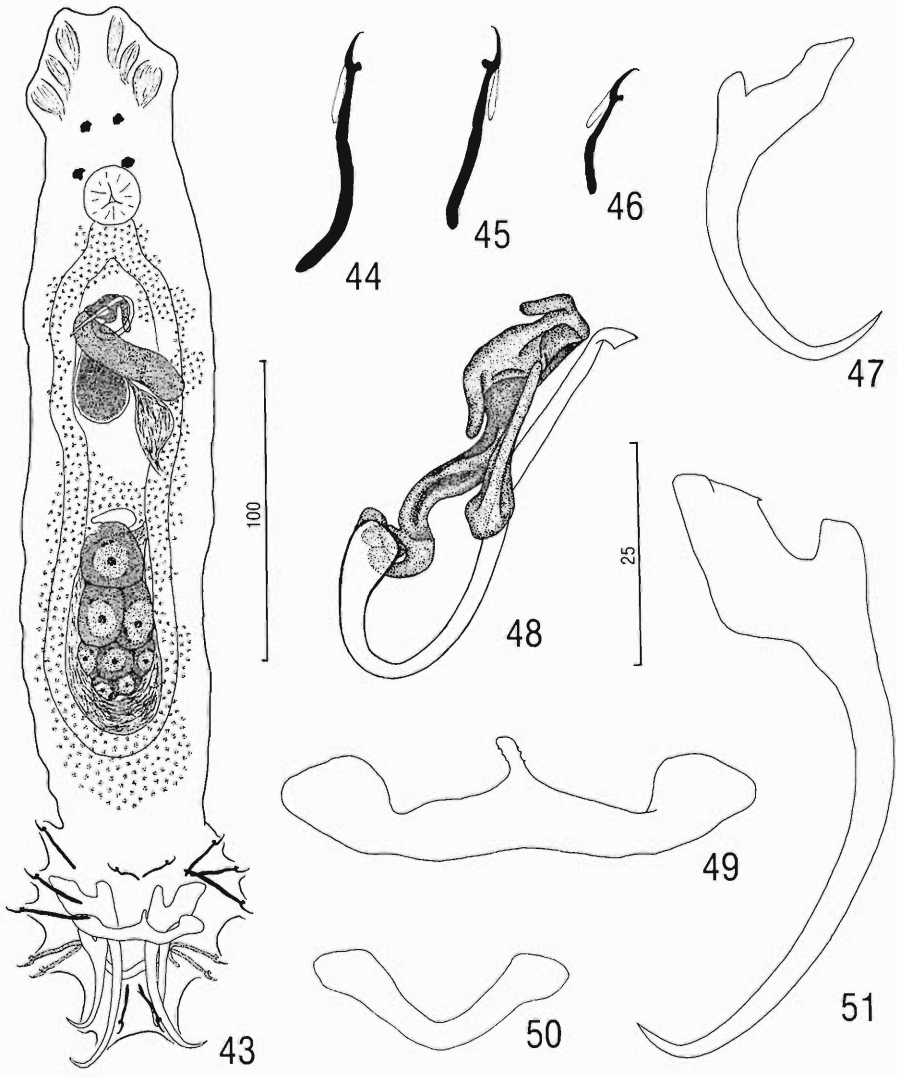
Notozothecium robustum sp. n. (Figs. 43–51)

TYPE HOST AND LOCALITY: *Pristobrycon striolatus:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989).

OTHER RECORDS: *Pristobrycon striolatus:* Rio Capucapú at its confluence with Rio Jatapú, Cachoeira das Garças, Amazonas (31 October 1989); Santa Luzia, Rio Uatumã, Amazonas (20 September 1985); Lago Samaumá, Rio Uatumã, Amazonas (25 September 1985); Rio Xingu, Kaikuta, Pará (12 October 1992).

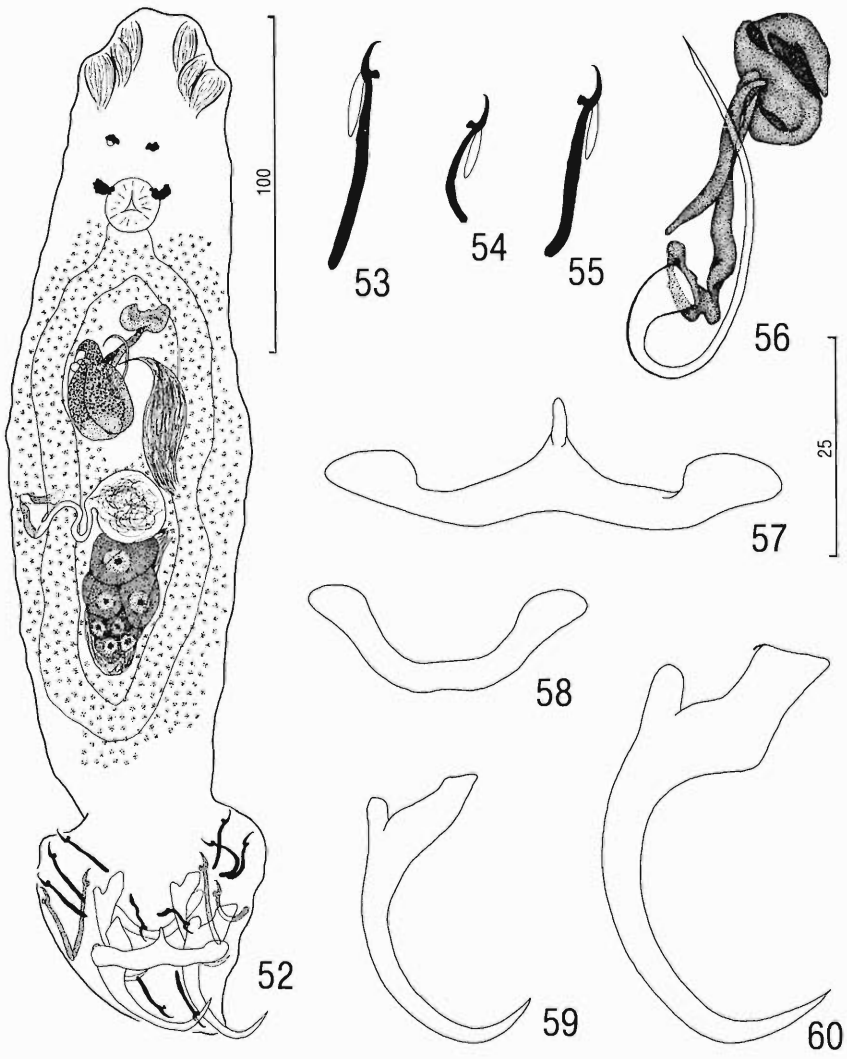
SPECIMENS STUDIED: Holotype, INPA PLH 222; 33 paratypes, INPA PLH 223, PLH 224, PLH 225, PLH 226, USNPC 85740, 85741, 85742, 85743, 85744, HWML 38586.

DESCRIPTION: Body fusiform to lateral margins parallel, 328 (227–390; $n = 12$) long; greatest width 81 (66–110; $n = 13$) in anterior or posterior trunk. Tegument smooth, infrequently with scaled annulations. Cephalic lobes moderately developed. Posterior eyes slightly larger, farther apart than anterior pair; accessory granules usually present in cephalic, anterior trunk regions. Pharynx spherical, 18 (13–21; $n = 11$) in diameter. Peduncle broad; haptor subhexagonal, 85 (71–92; $n = 13$) long, 79 (74–85; $n = 12$) wide. Ventral anchor 62 (60–65; $n = 21$) long, with heavy depressed superficial root, prominent deep root,



Figures 43–51. ***Notozothecium robustum*** **sp. n. 43. Whole mount (composite, ventral view). 44. Hook pr. 7. 45. Hook pr. 2. 46. Hook pr. 1. 47. Dorsal anchor. 48. Copulatory complex (ventral view). 49. Ventral bar. 50. Dorsal bar. 51. Ventral anchor. All figures are drawn to the 25-μm scale except Figure 43 (100-μm scale).**

distinct hump on superficial surface of base, gently curved elongate shaft, short point; base 19 (16–21; n = 16) wide. Dorsal anchor 35 (33–36; n = 18) long, with elongate slightly depressed superficial root, short deep root, curved shaft, moderately long point; base 15 (13–16; n = 11) wide. Ventral bar 45 (43–47; n = 12) long, yoke-shaped, with enlarged terminations, short rod-shaped anteromedial process with irregular margins. Dorsal bar 27–28 (n = 9) long, broadly U- or V-shaped, with slightly enlarged ends. Hook pr. 1—16 (15–17; n = 8), prs. 2, 3, 4—24 (23–26; n = 24), pr. 5—17 (16–19; n = 13), pr. 6—22 (21–24; n = 6), pr. 7—30 (29–31; n = 7) long. Copulatory organ 70 (60–80; n = 14) long, comprising robust coil of less than 1 ring, appearing J-shaped; ring diameter 18 (15–20; n = 10); base with sclerotized margin, lacking proximal flap. Articulation process of accessory piece elongate; distal rod 31 (27–36; n = 12) long, straight, free proximally, with club-shaped proximal end; main axis of flabellate plate perpendicular to converging with distal rod. Testis ovate, 56 (38–69; n = 5) long, 34 (26–38; n = 5) wide; ventral (sinistral) prostatic reservoir bacilliform, lying diagonally in anterior trunk; dorsal reservoir pyriform. Ger-



Figures 52–60. ***Notozothecium teinodendrum*** **sp. n. (from** ***Pristobrycon eigenmanni*****). 52. Whole mount (composite, ventral view). 53. Hook pr. 7. 54. Hook pr. 1. 55. Hook pr. 4. 56. Copulatory complex (ventral view). 57. Ventral bar. 58. Dorsal bar. 59. Dorsal anchor. 60. Ventral anchor. All figures are to the 25-μm scale except Figure 52 (100-μm scale).**

marium 56 (47–64; $n = 4$) long, 30 (17–39; $n = 4$) wide, subovate; oviduct, ootype, uterus, vagina not observed; seminal receptacle indistinct; vitellaria limited in trunk, absent in regions of reproductive organs.

REMARKS: We were unable to observed the vagina or vaginal pore in this species. An indistinct duct could be seen in a few specimens originating from the left side of the small seminal receptacle, and we assume a delicate pore occurs on the sinistrodorsal surface of the trunk probably between 2 tegumental annulations. Based on morphology of the haptoral sclerites and copulatory complex, this species most closely resembles *Notozothecium teinodendrum*. It differs from this and all other congeneric species by possessing a ventral anchor with an elongate shaft and short point. The specific name is from Latin (*robustus* = strong) and refers to the comparatively well-developed copulatory organ.

Notozothecium robustum has been collected from *Pristobrycon striolatus* in only black- and clear-water localities and apparently does not occur in congeneric hosts (*P. eigenmanni*) from white-water habitats in the Amazon Basin. Although the parasite appears restricted to *P. striol-*

Table 2. Comparative measurements (in micrometers) of *Notozothecium teinodendrum* sp. n., from 7 serrasalmid hosts.

	Pristobrycon eigenmanni	*N*	*Pristobrycon* sp.	*N*	*Serrasalmus elongatus*	*N*	*Serrasalmus gouldingi*	*N*	*Serrasalmus manuelli*	*N*	*Serrasalmus rhombeus*	*N*	*Serrasalmus* sp. (2 of Jégu)	*N*
Body														
Length	250 (198–308)	6	311 (298–324)	2	—	—	358 (298–390)	9	—	—	293 (243–338)	11	—	—
Width	73 (65–85)	5	66 (64–69)	2	—	—	91 (72–109)	9	—	—	76 (63–92)	11	—	—
Haptor														
Length	68 (62–73)	6	63 (59–67)	2	—	—	78 (68–87)	9	—	—	67 (61–85)	11	—	—
Width	72 (56–92)	6	69 (63–74)	2	—	—	92 (86–98)	9	—	—	82 (71–94)	11	—	—
Pharynx														
Diameter	14 (12–16)	5	18	2	—	—	21 (19–22)	8	—	—	19 (15–21)	11	—	—
Copulatory organ														
Length	70 (63–78)	8	63	2	65	1	64 (60–68)	10	63 (60–65)	2	61 (58–65)	3	64 (60–68)	4
Ring diameter	20 (14–21)	7	22 (19–24)	2	17	1	20 (16–23)	9	21 (17–25)	2	20 (16–21)	3	23 (22–25)	2
Accessory piece														
Length	31 (28–35)	8	30–31	2	30	1	29 (28–32)	10	25–26	2	28 (27–29)	3	29 (27–31)	5
Dorsal anchor														
Length	32 (30–34)	7	30–31	2	32–33	2	32 (30–33)	9	32 (31–33)	2	30–31	2	34 (30–38)	7
Base width	13 (11–14)	7	13–14	2	10	1	13 (12–14)	8	13 (11–14)	3	13	1	13 (11–14)	6
Ventral anchor														
Length	45 (42–48)	8	41–42	2	45–46	2	45 (42–47)	10	43–44	4	43 (42–44)	3	47 (43–50)	7
Base width	19 (18–21)	8	19–20	2	19–20	2	19 (18–20)	10	20–21	4	18–19	3	21 (18–22)	7
Bar length														
Ventral	44 (42–46)	6	44–45	2	48	1	45 (42–49)	7	—	—	45 (42–49)	10	—	—
Dorsal	30 (28–32)	6	27–28	2	30	1	30 (28–32)	7	—	—	31 (28–35)	10	—	—
Hook lengths														
Pair 1	15–16	2	16–17	2	16	1	16–17	2	17	2	—	—	17 (16–19)	4
Pair 2	19 (18–20)	5	19	2	19	1	19–20	7	21	1	—	—	20 (18–21)	4
Pair 3	21–22	5	21–22	2	—	—	21–22	6	22–23	2	22	2	23 (21–25)	4
Pair 4	25 (24–26)	4	25–26	2	26	1	25–26	7	27 (25–28)	3	25–26	4	28 (26–29)	5
Pair 5	16–17	2	17–18	2	16–17	2	17–18	9	18	3	17	2	17–18	5
Pair 6	20 (19–21)	6	20	2	19–20	2	20 (19–21)	5	21 (20–22)	2	—	—	20–21	4
Pair 7	26 (23–28)	4	25	2	26	1	26 (25–27)	6	29–30	2	—	—	26 (24–30)	4

Table 2. Continued.

	Pristobrycon eigenmanni	*N*	*Pristobrycon* sp.	*N*	*Serrasalmus elongatus*	*N*	*Serrasalmus gouldingi*	*N*	*Serrasalmus manuelli*	*N*	*Serrasalmus rhombeus*	*N*	*Serrasalmus* sp. (2 of Jégu)	*N*
Germarium														
Length	30 (28–34)	3	40 (34–47)	2	—	—	—	—	—	—	47 (34–52)	5	—	—
Width	15 (12–18)	3	18 (13–24)	2	—	—	—	—	—	—	18 (12–21)	5	—	—
Testis														
Length	28	1	—	—	—	—	—	—	—	—	—	—	—	—
Width	12	1	—	—	—	—	—	—	—	—	—	—	—	—

atus, it may also lack a tolerance to the hydrochemical features of white water.

Notozothecium teinodendrum sp. n. (Figs. 52–60)

TYPE HOST AND LOCALITY: *Pristobrycon eigenmanni:* Nazare, Rio Uatumã, Amazonas (17 September 1985).

OTHER RECORDS: *Pristobrycon eigenmanni:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Negro, Manaus, Amazonas (28 December 1988). *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988). *Serrasalmus elongatus:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989). *Serrasalmus gouldingi:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989). *Serrasalmus manuelli:* Kaikuta, Rio Xingu, Pará (10 October 1992). *Serrasalmus rhombeus:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Uatumã, Amazonas (15 September 1985); Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (26 November 1984). *Serrasalmus* sp. (2 of Jégu): Nazare, Rio Uatumã, Amazonas (17 September 1985); Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Santa Luzia, Rio Uatumã, Amazonas (20 September 1985).

SPECIMENS STUDIED: Holotype, INPA PLH 214; 13 paratypes, INPA PLH 215, PLH 216, USNPC 85745, 85746, 85747, HWML 38587, from *Pristobrycon eigenmanni.* 5 vouchers from *Pristobrycon* sp., USNPC 85758; 1 voucher from *Serrasalmus elongatus,* USNPC 85754; 19 vouchers from *Serrasalmus gouldingi,* USNPC 85752; 2 vouchers from *Serrasalmus manuelli,* USNPC 85753; 16 vouchers from *Serrasalmus rhombeus,* USNPC 85755, 85756, 85757; 7 vouchers from *Serrasalmus* sp. (2 of Jégu), USNPC 85748, 85749, 85750, 85751.

COMPARATIVE MEASUREMENTS: See Table 2.

DESCRIPTION: Body fusiform; greatest width near midlength. Tegument smooth, infrequently with delicate scaled annulations in trunk, peduncle. Cephalic lobes moderately developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules uncommon in cephalic, anterior trunk regions. Pharynx spherical. Peduncle broad; haptor subhexagonal. Ventral anchor with heavy depressed superficial root, prominent deep root, superficial hump on base, curved shaft, elongate point. Dorsal anchor with

well-differentiated roots, curved shaft, moderately elongate point. Ventral bar yoke-shaped, with enlarged terminations, short anteromedial digitiform process. Dorsal bar broadly U-shaped. Copulatory organ a coil appearing J-shaped; base with sclerotized margin, proximal flap absent. Distal rod of accessory piece straight to sigmoid. Testis ovate; prostatic reservoirs pyriform, filled with granules of varying stain affinity. Germarium irregular; oviduct, ootype, uterus not observed; vagina with distal sclerotized funnel; seminal receptacle subspherical, large; vitellaria throughout trunk, absent in regions of reproductive organs.

REMARKS: *Notozothecium teinodendrum* sp. n. appears ubiquitous as a parasite of fishes belonging to *Pristobrycon* and *Serrasalmus,* having been found on 7 host species. It resembles *N. minor,* from which it differs by lacking a submedial double bend of the distal bar of the accessory piece. *Notozothecium teinodendrum* is distinguished from all congeneric species by the relatively large sclerotized distal funnel at the vaginal pore. The specific name is from Greek (*teino* = to stretch + *dendron* = a stick) and refers to the copulatory complex.

Mymarothecium 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 4; granules ovate. Mouth subterminal, midventral; pharynx muscular, glandular; esophagus short; 2 intestinal ceca confluent posterior to testis, lacking diverticula. Gonads intercecal, overlapping; testis dorsal to germarium. Vas deferens apparently looping left intestinal cecum; seminal vesicle a sigmoid dilation of vas deferens. Two prostatic reservoirs; prostates comprising 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; copulatory organ a broad arcuate tube; accessory piece consisting of short proximal articulation process, distal rod, subterminal hooked process originating from distal rod. Vagina nonsclerotized, dilated, opening on middorsal, dextrodorsal, or dextroventral surfaces near midlength of trunk; seminal receptacle absent. Haptor subhexagonal; with dorsal, ventral anchor/bar complexes; 7 pairs of similar hooks with ancyrocephaline distribution. Ventral bar with anteromedial projection. 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. Parasites of gills of serrasalmid fishes.

TYPE SPECIES: *Mymarothecium dactylotum* sp. n. from *Pristobrycon* sp., *S. rhombeus* (type host), *Serrasalmus* sp. (2n = 58), and *Serrasalmus* sp. (2 of Jégu).

OTHER SPECIES: *Mymarothecium galeolum* sp. n. from *Pristobrycon eigenmanni* (type host), *Pristobrycon* sp., *Pygocentrus nattereri, Serrasalmus gouldingi,* and *S. rhombeus*; *M. perplanum* sp. n. from *Serrasalmus spilopleura*; *M. whittingtoni* sp. n. from *Serrasalmus rhombeus* and *Serrasalmus* sp. (2n = 58) (type host).

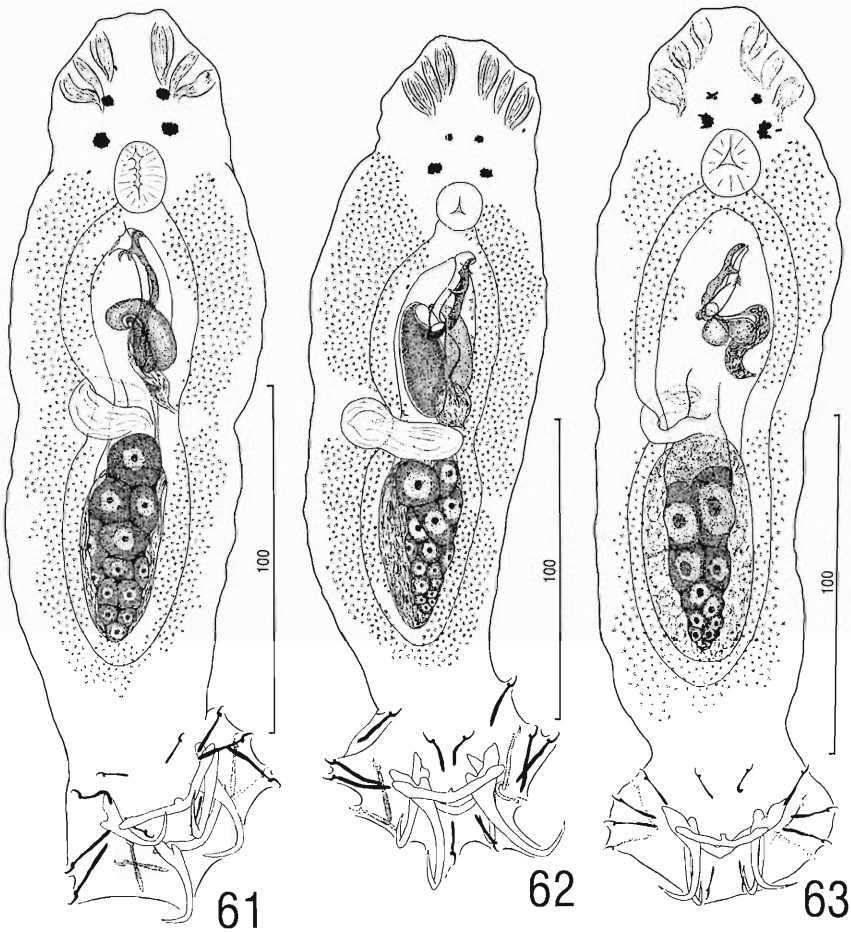
REMARKS: *Mymarothecium* resembles *Notozothecium* by including species with an anteromedial process on the ventral bar and a vagina opening on the right side of the trunk. The genera are distinguished by *Mymarothecium* spp. lacking a coiled copulatory organ and sclerotization of the vagina (present in *Notozothecium*). The generic name is from Greek (*mymar* = a mockery + *theke* = a small case) and refers to the similarity of members of this genus to others infesting serrasalmid hosts, particularly *Notozothecium* species.

Mymarothecium dactylotum sp. n. (Figs. 61, 64–70)

TYPE HOST AND LOCALITY: *Serrasalmus rhombeus:* Rio Pitinga, Igarape Agua Branca, Rio Uatumã, Amazonas (15 September 1985).

OTHER RECORDS: *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988). *Serrasalmus rhombeus:* Rio Capucapú at its confluence with Rio Jatapú, Cachoeira das Garças, Amazonas (31 October 1989); Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Uatumã, Amazonas (15 September 1985). *Serrasalmus* sp. (2 of Jégu): Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Nazaré, Rio Uatumã, Amazonas (17 September 1985). *Serrasalmus* sp. (2n = 58): Furo do Catalão, Manaus, Amazonas (2 November 1993).

SPECIMENS STUDIED: Holotype, INPA PLH 229; 12 paratypes, INPA PLH 230, PLH 231, USNPC 85759, 85760, 85761, HWML 38588 from *Serrasalmus rhombeus.* Two vouchers from



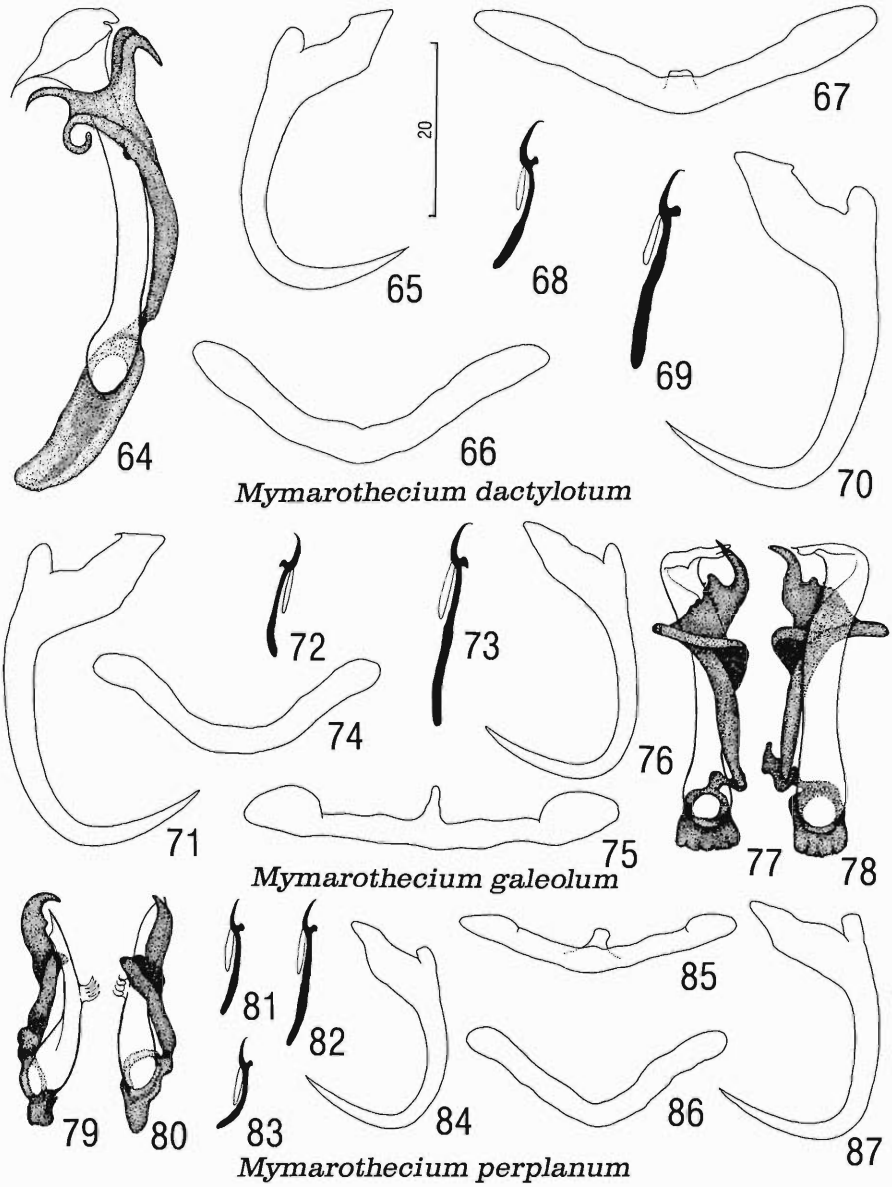
Figures 61–63. Whole-mount illustrations of *Mymarothecium* species (composite, ventral views). 61. *Mymarothecium dactylotum* sp. n. (from *Serrasalmus rhombeus*). 62. *Mymarothecium galeolum* sp. n. (from *Pristobrycon eigenmanni*). 63. *Mymarothecium perplanum* sp. n. Each figure is drawn to the respective 100-μm scale.

Pristobrycon sp., USNPC 85764; 3 vouchers from *Serrasalmus* sp. (2 of Jégu), USNPC 85762, 85763; 4 vouchers from *Serrasalmus* sp. (2n = 58), USNPC 85765.

COMPARATIVE MEASUREMENTS: See Table 3.

DESCRIPTION: Body tapered posteriorly from midregion of anterior trunk; greatest width in anterior trunk. Tegument smooth or with scaled annulations. Cephalic area broad; cephalic lobes moderately to poorly developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules few or absent in cephalic, anterior trunk regions. Pharynx ovate. Peduncle broad. Anchors similar; each with well-developed slightly depressed roots, curved shaft, elongate point. Ventral bar broadly V-shaped or straight, with short truncate anteromedial process arising from dorsal surface of bar; dorsal bar broadly V- or U-shaped. Copulatory organ a broad tube with distal flare; base with elongate spatulate proximal flap. Distal rod of accessory piece curled distally, subterminal flap with 3 or 4 hook-shaped processes. Testis subovate; prostatic reservoirs elongate; sinistral reservoir looping anterior to base of copulatory organ. Germarium fusiform; oviduct short; ootype, uterus not observed; vaginal aperture middorsal; vitellaria in bilateral fields of trunk.

REMARKS: *Mymarothecium dactylotum* differs from *M. galeolum* and *M. perplanum* by having 3 or 4 distal digits on the subterminal flap of the accessory piece and from *M. whittingtoni*



Figures 64–87. Sclerotized structures of *Mymarothecium* spp. 64–70. *Mymarothecium dactylotum* sp. n. (from *Serrasalmus rhombeus*). 64. Copulatory complex (ventral view). 65. Dorsal anchor. 66. Dorsal bar. 67. Ventral bar. 68. Hook pr. 1. 69. Hook pr. 7. 70. Ventral anchor. 71–78. *Mymarothecium galeolum* sp. n. (from *Pristobrycon eigenmanni*). 71. Ventral anchor. 72. Hook pr. 1. 73. Hook pr. 7. 74. Dorsal bar. 75. Ventral bar. 76. Dorsal anchor. 77. Copulatory complex (ventral view). 78. Copulatory complex (dorsal view). 79–87. *Mymarothecium perplanum* sp. n. 79. Copulatory complex (dorsal view). 80. Copulatory complex (ventral view). 81. Hook pr. 2. 82. Hook pr. 7. 83. Hook pr. 1. 84. Dorsal anchor. 85. Ventral bar. 86. Dorsal bar. 87. Ventral anchor. All drawings are to the 20-μm scale.

by having the vaginal aperture on the middorsal surface of the trunk (dextroventral in *M. whittingtoni*). The specific name is from Greek (*daktylos* = finger) and refers to the distal end of the accessory piece.

Mymarothecium galeolum sp. n. (Figs. 62, 71–78)

TYPE HOST AND LOCALITY: *Pristobrycon eigenmanni:* Nazaré, Rio Uatumã, Amazonas (17 September 1985).

Table 3. Comparative measurements (in micrometers) of *Mymarothecium dactylotum* sp. n., from 4 serrasalmid hosts.

	Pristobrycon sp.	*N*	*Serrasalmus rhombeus*	*N*	*Serrasalmus* sp. (2 of Jégu)	*N*	*Serrasalmus* sp. (2n = 58)	*N*
Body								
Length	—	—	306 (265–411)	6	—	—	—	—
Width	—	—	86 (70–117)	6	—	—	—	—
Haptor								
Length	—	—	59 (55–65)	6	—	—	—	—
Width	—	—	79 (62–93)	6	—	—	—	—
Pharynx								
Diameter	—	—	19 (18–21)	6	—	—	—	—
Copulatory organ								
Length	52	2	48 (43–55)	5	47 (46–49)	2	51–52	2
Accessory piece								
Length	32–33	2	29 (27–33)	5	27 (25–29)	2	29–30	2
Dorsal anchor								
Length	30–31	2	31 (29–35)	6	30 (29–31)	2	31 (29–33)	3
Base width	11–12	2	13 (11–14)	4	12 (11–13)	2	12–13	3
Ventral anchor								
Length	32–33	2	35 (33–37)	6	37 (36–38)	2	34 (33–35)	3
Base width	15 (14–16)	2	15 (13–16)	5	14–15	2	15 (14–17)	3
Bar length								
Ventral	—	—	39 (38–40)	4	—	—	—	—
Dorsal	—	—	34 (32–35)	4	—	—	—	—
Hook lengths								
Pair 1	—	—	15–16	3	16–17	3	17	1
Pair 2	16–17	2	17	2	17	1	17	1
Pair 3	20–21	2	20–21	5	22 (21–23)	3	22–23	3
Pair 4	23 (22–24)	2	24 (23–25)	6	24 (23–26)	3	24–25	3
Pair 5	15	1	15–16	4	15 (14–16)	2	17	1
Pair 6	16–17	2	16–17	5	16–17	3	17	1
Pair 7	20 (19–21)	2	22 (21–23)	5	22 (21–23)	3	23	1
Germarium								
Length	—	—	65 (52–94)	5	—	—	—	—
Width	—	—	22 (18–27)	5	—	—	—	—
Testis								
Length	—	—	62 (50–87)	4	—	—	—	—
Width	—	—	24 (18–34)	4	—	—	—	—

OTHER RECORDS: *Pristobrycon eigenmanni:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Santa Luzia, Rio Uatumã, Amazonas (20 September 1985). *Pristobrycon* sp.: Rio Negro, Manaus, Amazonas (28 December 1988). *Pygocentrus nattereri:* Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989); Furo do Catalão, Manaus, Amazonas (27 November 1984); Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (14 April 1984). *Serrasalmus gouldingi:* Rio Jatapú, Lago Maracana, Amazonas (2 November 1989). *Serrasalmus rhombeus:* Rio Capucapú at its confluence with Rio Jatapú, Cachoeira das Garças, Amazonas (31 October 1989); Rio Jatapú, Lago Maracana, Amazonas (2 November 1989); Rio Pitinga, Igarape Agua Branca, Rio Uatumã, Amazonas (15 September 1985).

SPECIMENS STUDIED: Holotype, INPA PLH 227; 19 paratypes, INPA PLH 228, USNPC 85766, 85767, 85768, HWML 38589 from *Pristobrycon eigenmanni.* One voucher from *Pristobrycon* sp., USNPC 85771; 10 vouchers from *Pygocentrus nattereri,* USNPC 85774, 85775,

Table 4. Comparative measurements (in micrometers) of *Mymarothecium galeolum* sp. n., from 5 serrasalmid hosts.

	Pristobrycon eigenmanni	*N*	*Pristobrycon* sp.	*N*	*Pygocentrus nattereri*	*N*	*Serrasalmus gouldingi*	*N*	*Serrasalmus rhombeus*	*N*
Body										
Length	295 (221–356)	8	—	—	299 (243–331)	3	363 (267–420)	16	309 (248–427)	11
Width	77 (58–91)	9	—	—	73 (69–76)	3	106 (86–129)	16	95 (74–125)	11
Haptor										
Length	64 (58–76)	8	—	—	60 (59–62)	2	70 (59–78)	16	63 (48–82)	11
Width	71 (62–81)	2	—	—	79 (78–80)	2	97 (82–112)	16	86 (74-111)	11
Pharynx										
Diameter	15 (13–17)	9	—	—	16	3	22 (19–25)	16	20 (17–24)	11
Copulatory organ										
Length	37 (34–40)	10	41	1	38 (33–41)	6	44 (42–46)	3	38 (33–43)	6
Accessory piece										
Length	28 (27–30)	8	33	1	29 (25–33)	6	35 (34–36)	3	31 (26–38)	6
Dorsal anchor										
Length	31 (29–34)	9	29	1	28 (26–31)	6	29–30	3	30 (29–31)	4
Base width	11–12	9	10	1	11 (10–12)	5	11–12	2	13 (12–14)	3
Ventral anchor										
Length	37 (36–41)	7	35	1	34 (33–36)	6	35 (34–36)	3	36 (35–38)	5
Base width	15 (14–16)	8	14	1	15 (13–16)	6	14 (13–15)	3	14 (13–15)	5
Bar length										
Ventral	37–38	5	—	—	38 (36–40)	3	38 (35–40)	14	38 (35–40)	8
Dorsal	30 (29–32)	3	—	—	32 (30–33)	3	32 (30–35)	14	30 (27–33)	6
Hook lengths										
Pair 1	14–15	2	15	1	15 (14–16)	4	16 (15–17)	2	15 (14–16)	2
Pair 2	18 (16–19)	4	17	1	15–16	5	18	1	18 (17–19)	4
Pair 3	21 (20–22)	5	21	1	19 (18–20)	5	21–22	2	21 (20–22)	5
Pair 4	24 (23–25)	6	25	1	21 (20–23)	4	24	1	24–25	4
Pair 5	16 (15–17)	3	—	—	15–16	3	15–16	2	15–16	5
Pair 6	16–17	4	16	1	16 (15–17)	5	—	—	16–17	3
Pair 7	21 (20–24)	7	21	1	19 (18–20)	4	22	1	23	2
Germarium										
Length	52 (24–77)	8	—	—	57 (43–64)	3	62 (45–73)	15	48 (41–57)	7
Width	18 (12–23)	8	—	—	18 (16–21)	3	23 (19–26)	15	23 (12–30)	7
Testis										
Length	52 (33–64)	8	—	—	58 (43–67)	3	62 (41–94)	14	47 (34–55)	6
Width	19 (11–25)	8	—	—	21 (18–25)	3	28 (21–34)	14	22 (17–27)	6

85776; 19 vouchers from *Serrasalmus gouldingi,* USNPC 85770; 17 vouchers from *Serrasalmus rhombeus,* USNPC 85769, 85772, 85773.

COMPARATIVE MEASUREMENTS: See Table 4.

DESCRIPTION: Greatest width usually in anterior trunk. Tegument with scaled annulations. Cephalic lobes moderately to poorly developed. Posterior eyes larger, farther apart than anterior pair; accessory granules uncommon in cephalic, anterior trunk regions. Pharynx spherical. Peduncle broad; haptor subhexagonal. Anchors similar; each with well-differentiated slightly depressed superficial root, short deep root, gently curved shaft, elongate point. Ventral bar straight, with short triangular anteromedial projection, enlarged terminations; dorsal bar broadly U-shaped. Copulatory organ a broad straight tube with terminal hood, several small tooth-like pus-

tules on sinistral surface near tip; base with short proximal flap. Distal rod of accessory piece usually with terminal incomplete loop; subterminal flap with hook, thumb. Testis subovate; prostatic reservoirs large, pyriform. Germarium conical; oviduct, ootype, uterus not observed; vagina with slit-like aperture dorsal to right intestinal cecum; vitellaria throughout trunk except absent in regions of reproductive organs.

REMARKS: Features distinguishing this species from its congeners include presence of a terminal broad hook of the subterminal flap of the accessory piece. The specific name is from Latin (*galeola* = a helmet-shaped vessel) and refers to the copulatory organ.

Mymarothecium perplanum sp. n. (Figs. 63, 79–87)

TYPE HOST AND LOCALITY: *Serrasalmus spilopleura:* Rio Uatumã, Lago Tapaná, Santana, Amazonas (3 November 1989).

OTHER RECORD: *Serrasalmus spilopleura:* Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (14 September 1984).

SPECIMENS STUDIED: Holotype, INPA PLH 232; 13 paratypes, INPA PLH 233, USNPC 85777, 85778, HWML 38590.

DESCRIPTION: Body 275 (259–289; $n = 5$) long; greatest width 82 (73–91; $n = 5$) in anterior trunk. Tegument smooth or infrequently with scaled annulations. Cephalic area broad; cephalic lobes moderately to poorly developed. Posterior eyes larger, slightly farther apart than anterior pair; accessory granules uncommon in cephalic, anterior trunk regions. Pharynx spherical, 17 (16–18; $n = 5$) in diameter. Peduncle broad; haptor 58 (51–65; $n = 5$) long, 73 (66–81; $n = 4$) wide. Anchors similar; each with well-developed roots, gently curved shaft, elongate point; superficial root slightly depressed; ventral anchor 27 (20–29; $n = 9$) long, base 12 (10–13; $n = 9$) wide; dorsal anchor 25 (24–26; $n = 8$) long, base 9–10 ($n = 6$) wide. Ventral bar 30 (29–31; $n = 3$) long, broadly V-shaped, with short truncate anteromedial process arising from dorsal surface of bar; dorsal bar 25 (23–26; $n = 3$) long, broadly U- or V-shaped. Hook prs. 1, 2, 5, 6—14 (12–15; $n = 23$); prs. 3, 7—17–18 ($n = 16$); pr. 4—20–21 ($n = 6$) long. Copulatory organ a broad flattened tube with dorsal comb arising near midlength; base with short proximal flap; copulatory organ 27 (26–28; $n = 8$) long. Accessory piece 19 (18–20; $n = 6$) long, with comma-shaped subterminal flap, short distal rod. Testis 47 (40–59; $n = 3$) long, 23 (19–27; $n = 2$) wide, ovate. Germarium with irregular margin, elongate, 49 (38–58; $n = 5$) long, 23 (17–27; $n = 5$) wide; oviduct short; ootype, uterus not observed; vagina opening to right of midline on dorsal body surface; vitellaria in anterior and posterior lateral fields of trunk.

REMARKS: *Mymarothecium perplanum* sp. n. differs from all other congeneric species by possessing a dorsal comb arising near the midlength of the copulatory organ. This species appears restricted to the white waters of the Amazon, the varzea, and lowest portion of the eastern Amazon tributaries, based on the distribution of the host, *Serrasalmus spilopleura.* The specific name is from Latin (*perplanus* = flat) and refers to the flattened tube of the copulatory organ.

Mymarothecium whittingtoni sp. n. (Figs. 88–95)

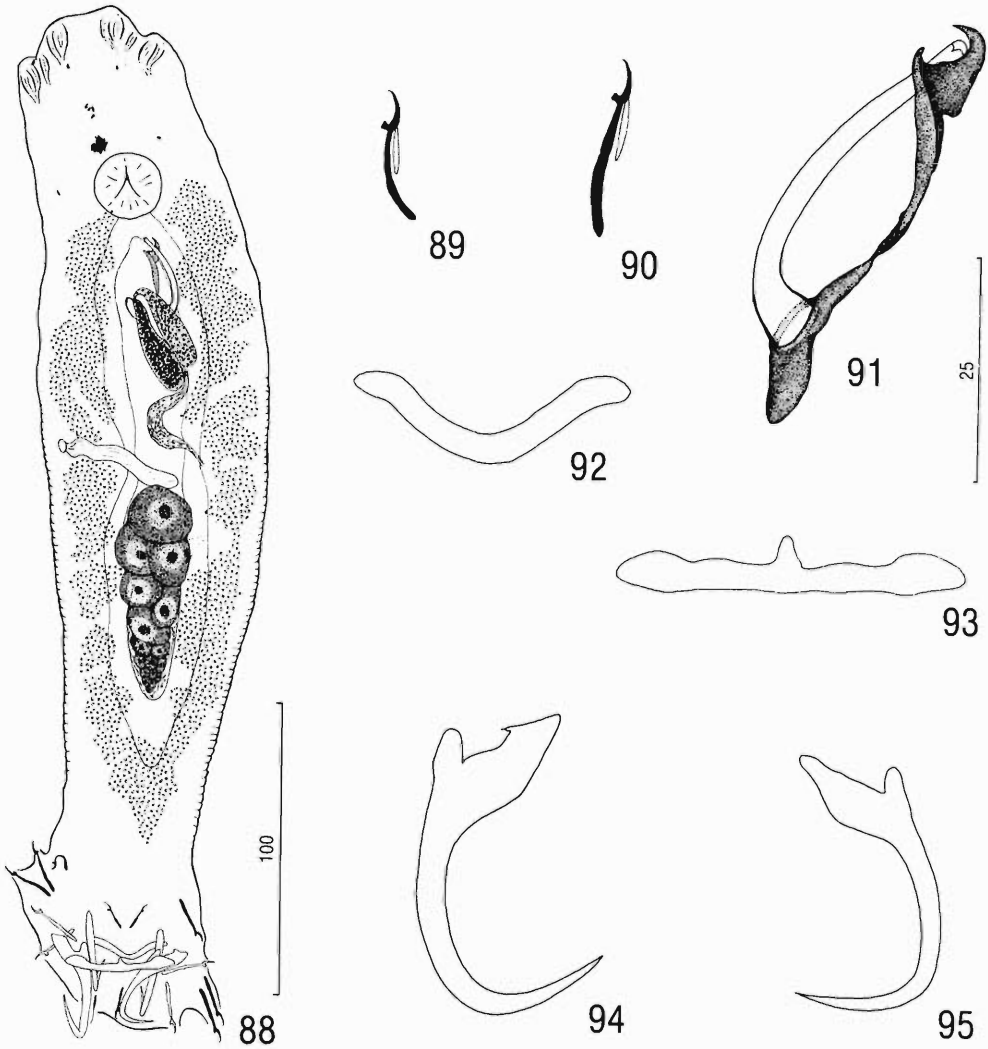
TYPE HOST AND LOCALITY: *Serrasalmus* sp. (2n = 58): Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (27 October 1993).

OTHER RECORDS: *Serrasalmus rhombeus:* Rio Solimões, Ilha da Marchantaria, Manaus, Amazonas (27, 28 October 1993); Furo do Catalão, Manaus, Amazonas (1, 2 November 1993). *Serrasalmus spilopleura:* Furo do Catalão, Manaus, Amazonas (no date). *Serrasalmus* sp. (2n = 58): Furo do Catalão, Manaus, Amazonas (5 January 1989; 1, 2 November 1993); Ilha do Careiro, Manaus, Amazonas (28 June 1986).

SPECIMENS STUDIED: Holotype, INPA PLH 217; 27 paratypes, INPA PLH 218, PLH 219, USNPC 85779, 85780, 85781, HWML 38591 from *Serrasalmus* sp. (2n = 58). 15 vouchers from *Serrasalmus rhombeus,* USNPC 85782, 85783; 3 vouchers from *Serrasalmus spilopleura,* USNPC 85784.

COMPARATIVE MEASUREMENTS: See Table 5.

DESCRIPTION: Greatest width usually in anterior trunk. Tegument of peduncle, posterior trunk with scaled annulations. Cephalic lobes moderately developed. Eyes usually 4; anterior pair smaller, closer together than posterior pair; anterior members, infrequently 1 member of posterior pair dissociated or absent; accessory granules usually in cephalic, anterior trunk regions. Pharynx spherical. Peduncle broad; haptor subhexagonal. Anchors similar, each with well-differentiated slightly depressed superficial root, short deep root, gently curved shaft, elongate point. Ventral bar straight, with short sub-



Figures 88–95. ***Mymarothecium whittingtoni*** **sp. n. (from** ***Serrasalmus*** **sp. [2n = 58]). 88. Whole mount (composite, ventral view). 89. Hook pr. 1. 90. Hook pr. 4. 91. Copulatory complex (ventral view). 92. Dorsal bar. 93. Ventral bar. 94. Ventral anchor. 95. Dorsal anchor. All figures are to the 25-μm scale except Figure 88 (100-μm scale).**

triangular anteromedial projection, enlarged terminations; dorsal bar broadly U-shaped. Copulatory organ arcuate, with anterior and posterior basal flaps. Distal rod of accessory piece somewhat sigmoid; subterminal flap hooked. Testis fusiform to subovate; prostatic reservoirs elongate, pyriform. Germarium conical; oviduct, ootype, uterus not observed; vagina dilated, with slit-like aperture on dextroventral body surface near midlength; 2 bilateral bands of vitellaria confluent posterior to gonads.

REMARKS: *Mymarothecium whittingtoni* differs from its congeners by having a dextroventral vaginal aperture. This character is apparently derived within the genus and represents an autapomorphy for *M. whittingtoni.* Undoubtedly, more species of this genus have yet to be discovered. Future discoveries may justify erection of a new genus for *M. whittingtoni* based in part on the presence of a dextroventral vaginal aperture. The specific name is in honor of Dr. Ian Whittington, Department of Parasitology, University of Queensland, Australia, in recognition of his valuable work on the Monogenoidea.

Table 5. Comparative measurements (in micrometers) of *Mymarothecium whittingtoni* sp. n., from 3 serrasalmid hosts.

	Serrasalmus rhombeus	*N*	*Serrasalmus spilopleura*	*N*	*Serrasalmus* sp. (2n = 58)	*N*
Body						
Length	—	—	—	—	360 (312–435)	7
Width	—	—	—	—	96 (80–118)	8
Haptor						
Length	—	—	—	—	74 (61–85)	7
Width	—	—	—	—	76 (66–89)	7
Pharynx						
Diameter	—	—	—	—	21 (20–23)	8
Copulatory organ						
Length	43 (40–49)	9	45 (43–46)	2	47 (44–50)	13
Accessory piece						
Length	17 (16–19)	12	16–17	3	17 (16–19)	18
Dorsal anchor						
Length	27 (26–29)	11	29 (27–31)	5	28 (26–30)	14
Base width	11 (10–12)	8	11–12	3	11 (10–12)	7
Ventral anchor						
Length	31 (29–33)	13	33 (30–35)	5	32 (30–34)	18
Base width	14 (11–16)	13	15–16	5	14 (13–16)	18
Bar length						
Ventral	—	—	—	—	37 (34–39)	6
Dorsal	—	—	—	—	31 (29–33)	5
Hook lengths						
Pair 1	15–16	5	15–16	3	15–16	10
Pair 2	18 (16–19)	7	18 (17–19)	3	18 (16–20)	11
Pair 3	22–23	6	22–23	3	22 (21–24)	11
Pair 4	24 (23–27)	8	24–25	3	24 (23–26)	10
Pair 5	15–16	8	16	2	15–16	8
Pair 6	18 (16–19)	3	17–18	2	18 (17–19)	8
Pair 7	20–21	5	20–21	5	21 (20–22)	7
Germarium						
Length	—	—	—	—	78 (47–91)	8
Width	—	—	—	—	26 (20–34)	8
Testis						
Length	—	—	—	—	70 (54–86)	6
Width	—	—	—	—	29 (22–40)	6

Discussion

Mymarothecium and *Notozothecium* are apparently sister taxa, but patterns of association of species of these genera with their hosts differ. Species of *Notozothecium* occur on members of 6 host genera (*Myleus, Acnodon, Mylesinus, Pygocentrus, Pristobrycon,* and *Serrasalmus*) representing 2 serrasalmid subfamilies (Myleinae and Serrasalminae), whereas *Mymarothecium* species are restricted to serrasalmine hosts (*Pygocentrus, Pristobrycon,* and *Serrasalmus*) that apparently originated late in the phylogeny of the subfamily (Machado-Allison, 1983; Ortí et al., in press). These distributions suggest that host–parasite associations in *Notozothecium* and *Mymarothecium* are relatively old, with the common ancestor of the genera occurring on an early serrasalmid form.

In a phylogenetic hypothesis for the Serrasalmidae, grounded on morphological data (Machado-Allison, 1983), 2 primary clades, each representing a subfamily, are present. Based on this hypothesis and on host preferences of *No-*

tozothecium spp., the ancestral host for this genus was probably that of the host family. Because species of *Mymarothecium* are known only from members of Serrasalminae with comparatively recent origins, extinction of *Mymarothecium* spp. on host clades originating early in the evolutionary history of the Serrasalmidae was apparently not uncommon.

In a competing hypothesis based on chromosome number and nucleolar organizer regions (Porto et al., 1991) and molecular data (Ortí et al., in press) in which the myleine clade (including *Myleus* and *Mylesinus,* but excluding *Colossoma, Piaractus, Mylossoma,* and *Acnodon*) is sister group to the Serrasalminae, the common ancestor of *Notozothecium* and *Mymarothecium* could have occurred on a later serrasalmid ancestor. This idea is tentative because ancyrocephalines are unknown from the gills of species of *Colossoma, Piaractus,* and *Mylossoma* spp., 3 genera excluded from the Myleinae in this phylogenetic hypothesis for the Serrasalmidae.

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Announcement

"Diagnostic Parasitology Course" being offered August 5–August 16, 1996, at the Uniformed Services University of the Health Sciences, Bethesda, MD 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 two-week 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. CME cerdits will be available for this course. Previous laboratory experience is recommended. For further information contact Dr. John H. Cross (301) 295-3139 or Ms. Ellen Goldman (301) 295-3129. FAX: (301) 295-1971.

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Metacamopiella euzeti gen. n., sp. n., and *Hargicola oligoplites* (Hargis, 1957) (Monogenea: Allodiscocotylidae) from Brazilian Fishes

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ABSTRACT: *Metacamopiella euzeti* gen. n., sp. n., is described from *Trachinotus carolinus* (Carangidae) from the littoral zone off the shore of Rio de Janeiro, Brazil. The new genus most closely resembles *Metacamopia* Lebedev, 1972, differing mainly by having vaginal apertures ventral and atriolateral, in the presence of a small row of papillae-like structures, instead of sclerotized structures inside the vaginal sacks, and in the structure of the mediobasal sclerite of clamps. *Hargicola oligoplites* (Hargis, 1957) Lebedev, 1970, is reported from *Epinephelus guaza* (Serranidae).

KEY WORDS: Monogenea, Allodiscocotylidae, Camopiinae, *Metacamopiella euzeti, Hargicola oligoplites,* fish, *Trachinotus carolinus, Epinephelus guaza,* southern Atlantic Ocean, Brazil.

A new genus and species of Camopiinae, representing the first occurrence of this subfamily in the southern Atlantic ocean, are described from Brazilian fishes. *Hargicola oligoplites* (Hargis, 1957) Lebedev, 1970, is reported for the first time from Brazil and is redescribed.

Materials and Methods

The fishes from Guanabara Bay (23°48′S, 43°10′W), Brazil, were obtained from fishermen and free markets. The worms collected from gills were fixed in 5% formalin without pressure or with slight coverslip pressure. Some specimens were mounted unstained in Gray and Wess medium (Humason, 1979) for the study of sclerotized structures; others were washed in 70% ethanol and directly stained in alcoholic chlorydric carmine (Langeron, 1949), dehydrated through an alcohol series, cleared in beechwood creosote, and mounted in Canada balsam.

Figures were made with the aid of a drawing tube. Measurements were made with the use of a calibrated filar micrometer and are given in micrometers with the mean in parentheses followed by the number of specimens measured when more than 2.

Holotype and voucher specimens were deposited in the Helminthological Collections of the "Instituto Oswaldo Cruz" (CHIOC), Rio de Janeiro, Brazil, and in the Parasitological Collection of the Institute of Biology and Pedology, Russian Academy of Sciences (PC-IBPRAS), Vladivostok, Russia.

Results

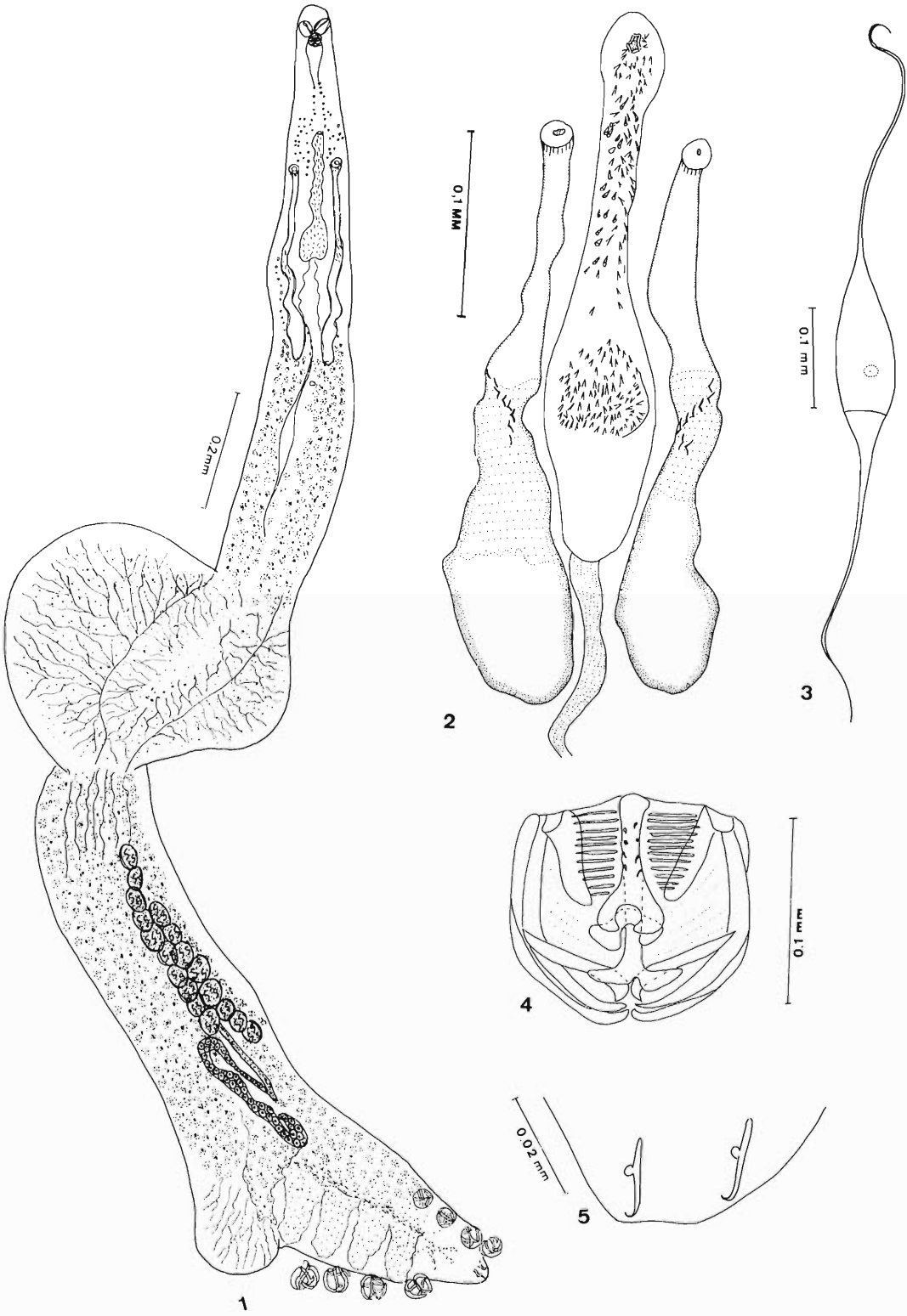
Metacamopiella gen. n.

Gastrocotylinea; Allodiscocotylidae; Camopiinae. Body elongated with expanded areas in the middle and in the posterior part. Haptor asymmetrical, with 1–2 pairs of anchors and 2 rows of 2–4 clamps on each side, with enlarged U- or V-shaped mediobasal sclerite, with wings. Testes preovarian; cirrus with multiple spines. Two muscular vaginal pores open laterally, behind genital pore. Vaginal ducts enlarged modified into vaginal seminal receptacle sacks, interior lacking sclerotized structures, 1 small row of papillae-like thickenings inside present or absent.

TYPE SPECIES: *Metacamopiela euzeti* sp. n.

Metacamopiella euzeti sp. n. (Figs. 1–5)

DESCRIPTION (based on 11 specimens): Body 3,157–5,835 (4,270) 8 long with bilateral asymmetrical expansions in middle of body and another unilateral located immediately anterior to haptor, on the same side as the larger clamps and the wider median expansion. In immature specimens, the median expansions can be less developed. Width at testes level is 271–476 (381) 11; width at median expansion is 550–1,121 (814) 11 and width at posterior expansion 300–880 (563) 10. Haptor asymmetrical with 2–4 pedunculated clamps on each row, slightly dissimilar in size. Mediobasal sclerite with distal part U- or V-shaped, wings present. Larger clamps located over muscular areas of haptor measure 65–120 (82) 11 long by 63–126 (85) 11 wide; smaller



Figures 1–5. ***Metacamopiella euzeti*** **gen. n., sp. n. 1. Holotype (ventral view). 2. Vaginal ducts with papillae-like thickenings in middle region and spined cirrus. 3. Egg. 4. Clamp showing mediobasal sclerite with distal part U-shaped and wings. 5. Detail of anchors.**

clamps located in the distal half of haptor length and measure 51–96 (67) by 46–96 (69) 9. One pair of anchors, 36–45 (39) 11, is present on terminal lappet. A second very small pair was observed in a juvenile stage.

Buccal suckers oval 37–60 (44) 11 long by 36–46 (39) 10 wide; pharynx small, rounded to oval 36–48 (43) by 36–46 (39) 10. Esophagus long without diverticula, bifurcating anterior to genital atrium; intestinal crura ramified.

Testes ovoid, 14–22 (17) 8 arranged in 2 longitudinal rows in posterior third of body, mainly preovarian and the last few paraovarian. Cirrus cylindrical, 308–476 (398) 8 long, dilated posteriorly, covered with spines of 3 different sizes and with pad-like roots. Anterior spines 12–21 long, median spines 24–42 long, posterior spines 9–10 long. Genital pore median, unarmed, 193–480 (354) 11 from anterior end.

Ovary tubular, post-testicular, looped, in the median third of hindbody. Two ventral vaginal pores, slightly posterior to genital atrium 267–597 (457) 11 from anterior end; vaginal ducts tubular, 423–810 (597) 10 long, sometimes with 1 row of papillae-like thickenings in middle region. Mehlis gland not observed. Vitellaria follicular, co-extensive with the crura and their branches, extending from level of seminal receptacle posterior into haptor. Transverse vitelline ducts short and narrow, uniting to form the median vitelline duct, which runs forward ventrally and opens at the common genital pore. Egg fusiform, 170–225 (199) long by 46–70 (60) 5 wide, with anterior filament 240–270 (251) 3 long, posterior filament 207–255 (227) 3 long.

TYPE HOST: *Trachinotus carolinus* (Linnaeus, 1766) Carangidae.

SITE: Gills.

LOCALITY: "Baía de Guanabara, Rio de Janeiro," Brazil.

MATERIAL COLLECTED AND STUDIED: One, 3, 5, and 7 specimens from 4 *T. carolinus*.

MATERIAL DEPOSITED: CHIOC: Holotype n. 33.059 and voucher specimens n. 33.060a–c, 33.062a–f. PC-IBPRAS: Paratype 301/SA-23374a.

ETYMOLOGY: The new species is named in honor of Prof. Louis Euzet, France, for his contributions to helminthology.

Hargicola oligoplites (Hargis, 1957) Lebedev, 1970 (Figs. 6, 7)

DESCRIPTION (based on 1 specimen): Body 3,076 long with posterior end abruptly curved to 1 side, 2 expansions present: 1 bilateral asymmetrical in middle of body and another unilateral expansion immediately anterior to haptor. Body width at bilateral expansion level is 733 and 366 just anterior to it. Cuticle thick, strongly plicate.

Haptor asymmetrical with 4 pairs of thick clamps, gastrocotylid type, dissimilar in size. Large clamps measure 114–120 by 96–112 (117 by 106) 4 and the small 89 by 70. One pair of anchors 37 and 39 long at terminal end of haptor.

In the specimen studied, the anterior extremity of body was extremely constricted, not allowing the observation of the buccal suckers and pharynx. Intestinal crura ramified.

Testes 35, ovoid, pre- and paraovarian, in 2 longitudinal rows in posterior third of body. Cirrus cylindrical, 390 long armed with numerous small spines. Vas deferens long and sinuous. Genital pore midventral, unarmed.

Ovary tubular, posteriormost portion lobed, located in middle region of posterior third of body. Two ventrolateral vaginal pores situated slightly posterior to genital atrium at about 210 from anterior end. Vaginal ducts, 390 long, are strongly muscular, anterior and posterior portions expanded forming muscular pouches connected by an isthmus, without sclerotized structures or papillae. Vitellaria follicular, densely massed, co-extensive with the crura. Egg fusiform 180 long by 44 wide with polar filaments.

HOST: *Epinephelus guaza* (L. 1758), Serranidae, new host record.

SITE: Gills.

LOCALITY: "Baia de Guanabara, Rio de Janeiro," Brazil.

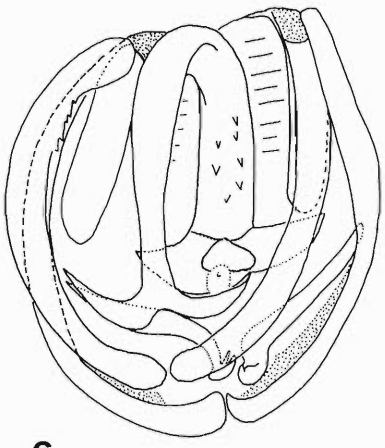
MATERIAL COLLECTED AND STUDIED: One specimen.

MATERIAL DEPOSITED: CHIOC: 33.063.

Discussion

Lebedev (1972, 1984, 1986) published revisions of Gastrocotylinea, including the genus *Metacamopia* Lebedev, 1972, and the species *Hargicola oligoplites*.

Metacamopia with the 2 species *M. indica* (Unnithan, 1963) Lebedev, 1972, and *M. chorinemi* (Yamaguti, 1953) Lebedev, 1984, is characterized by having 4 pairs of clamps (pedunculated on 1 side of the haptor and without peduncles on the other) and 1 pair of anchors, testes preovarial in the posterior half of the body, and dorsolateral vaginae paired and vaginal ducts modified into vaginal seminal receptacles with sclerotized structures (situated in semicircle rows) inside.



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Figures 6, 7. ***Hargicola oligoplites.*** **6. Clamp. 7. Total body view.**

Metacamopiella gen. n. differs from *Metacamopia* by having vaginal apertures ventral and atriolateral a small row of papillae-like structures inside the vaginal sacks, lacking sclerotized spines inside vaginae, by having *Camopia*-like–shaped distal part of mediobasal sclerite of clamp, and by host and locality. It differs from the other Camopiinae genera, *Camopia* Lebedev, 1970, *Hargicola* Lebedev, 1970, and *Vallisia* Perugia and Parona, 1890 (see Lebedev, 1970, 1986), mainly in the body shape and vaginae structure. The new genus and species represent the first occurrence of Camopiinae in the southern Atlantic Ocean.

Hargicola oligoplites, the only species of the genus, described by Hargis (1957) and redescribed by Bravo-Hollis (1989) from *Oligoplites saurus* (Bloch and Schneider), is now redescribed from the southern Atlantic Ocean from a new host, with a more extensive range of measurements in number and size of clamps, size of anchors, and number of testes.

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Atriaster heterodus (Lebedev and Paruchin, 1969) and *Polylabris tubicirrus* (Paperna and Kohn, 1964) (Monogenea) from *Diplodus argenteus* (Val., 1830) (Teleostei: Sparidae) from Brazil

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ABSTRACT: *Atriaster heterodus* Lebedev and Paruchin, 1969, and *Polylabris tubicirrus* Paperna and Kohn, 1964, are reported from a new host *Diplodus argenteus* (Val., 1830) (Sparidae) from the Rio de Janeiro coast, Brazil, with new morphological data on *A. heterodus* using scanning electron microscopy. The holotype of *P. tubicirrus* is redescribed, and *Polylabris diplodi* is considered its new synonym.

KEY WORDS: *Atriaster heterodus, Polylabris tubicirrus,* Monogenea, fish, gills, parasite, Brazil, SEM.

Atriaster heterodus Lebedev and Paruchin, 1969, from *Sparus heterodus* (Sparidae) from Walvis Bay, Namibia, southwest Africa, also was reported from *Diplodus sargus, Diplodus annularis,* and *Diplodus vulgaris* (Sparidae) from Sète, France (Euzet and Maillard, 1973), and *D. sargus* from the Tenerife Islands (Lopez-Roman and De Armas Hernandez, 1989). *Polylabris tubicirrus* Paperna and Kohn, 1964, was reported from *D. annularis, D. sargus, D. vulgaris,* and *Sparus aurata* from the Mediterranean. In this paper, we present new host and geographical records for these monogeneans, as well as new morphological data for *A. heterodus* using scanning electron microscopy (SEM), and a new synonym for *P. tubicirrus.*

Materials and Methods

The fish were collected at Copacabana beach, Rio de Janeiro, Brazil. Monogeneans were fixed in 5% buffered formalin under slight coverglass pressure and stained with Mayer's Carmalum (Humason, 1972). For SEM studies, living specimens were fixed for 1 hr in a solution containing 2.5% glutaraldehyde and 4% paraformaldehyde in seawater. Samples were postfixed in 1% osmium tetroxide in 0.1 M sodium cacodylate, 0.8% potassium ferricyanide, 5 mM CaCl, and 3% sucrose, pH 7.2, for 2 hr. Specimens were dehydrated in graded ethanol, critical point–dried using CO_2, coated with gold, and observed on a DSM 962 scanning electron microscope. Measurements are presented in micrometers with means in parentheses followed by the number measured. *Atriaster heterodus* numbers Ti 182 and Ti 183 and *Polylabris diplodi* number Tc 178 from the Helminthological Collection of the Muséum National D'Histoire Naturelle de Paris and *Polylabris tubicirrus* number 29.837 from the Helminthological Collection of Instituto Oswaldo Cruz also were studied.

Results

Atriaster heterodus Lebedev and Paruchin, 1969 (Figs. 1–10)

HOST: *Diplodus argenteus* (Val., 1830), Sparidae.

SITE: Gills.

LOCALITY: Copacabana beach, Rio de Janeiro, Brazil.

STUDIED MATERIAL: Sixty-five specimens collected from 25 fish (prevalence = 64%, mean intensity = 4). CHIOC n. 33.357a–b, 33.358, 33.359, 33.360, and 33.361.

REDESCRIPTION: Body 3,000–6,160 (4,370) 19 long, 161–724 (464) 19 wide at ovarian level. Anterior part of body slender, with 3 groups of apical glands. Two internal suckers 30–46 by 53–108 (37 by 86) 15, rounded by small flanges, divided into 2 almost equal parts by muscular walls. Pharynx 23–46 by 23–46 (34 by 36) 16. Haptor 1,155–3,942 (2,022) 19 long with 63–100 pairs of clamps. Larger clamps 34–92 by 60–92 (48 by 96) 9, smaller 23–32 by 27–46 (29 by 42) 4. Sixteen to 35 (27) 10 postovarian testes. Sinuous vas deferens opens into anterodorsal part of muscular genital atrium. Genital atrium 115–230 by 106–190 (153 by 150) 16 situated at 152–539 (336) 15 from anterior end has 2 forcep-like spines 67–115 (90) 19 long and 11–18 (14) 19 median spines 55–83 (66) 19 long arranged in 2 semicircles. Sclerotized plate 23–34 by 28–46 (28 by 36) 5 lying in the bottom of atrium in a muscular pad articulated with 6–11 (8) 17 small and strong spines 25–69 (45) 17 long, acting like jaws.

Ovary long bent anteriorly. Two dorsal vagi-

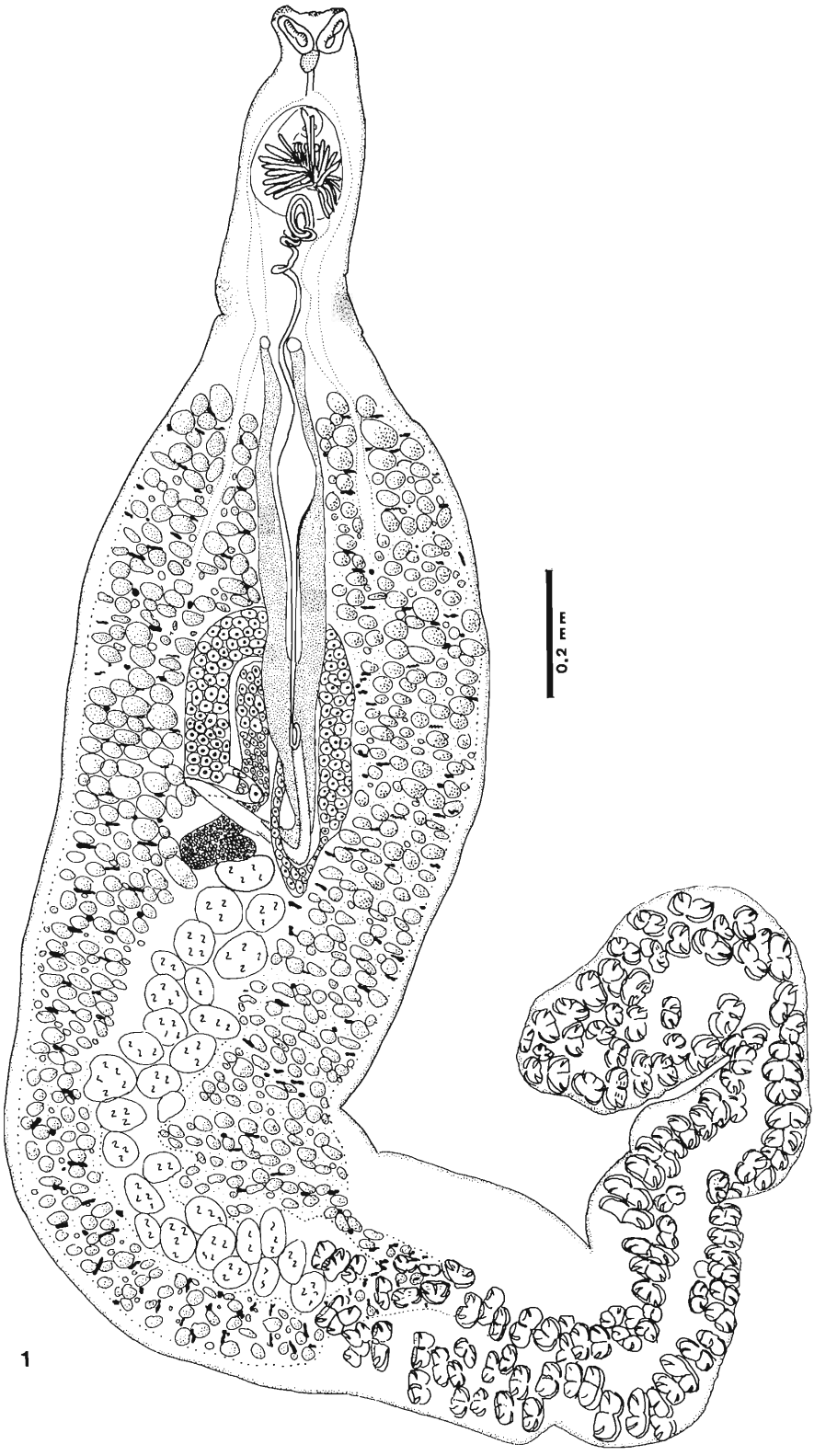
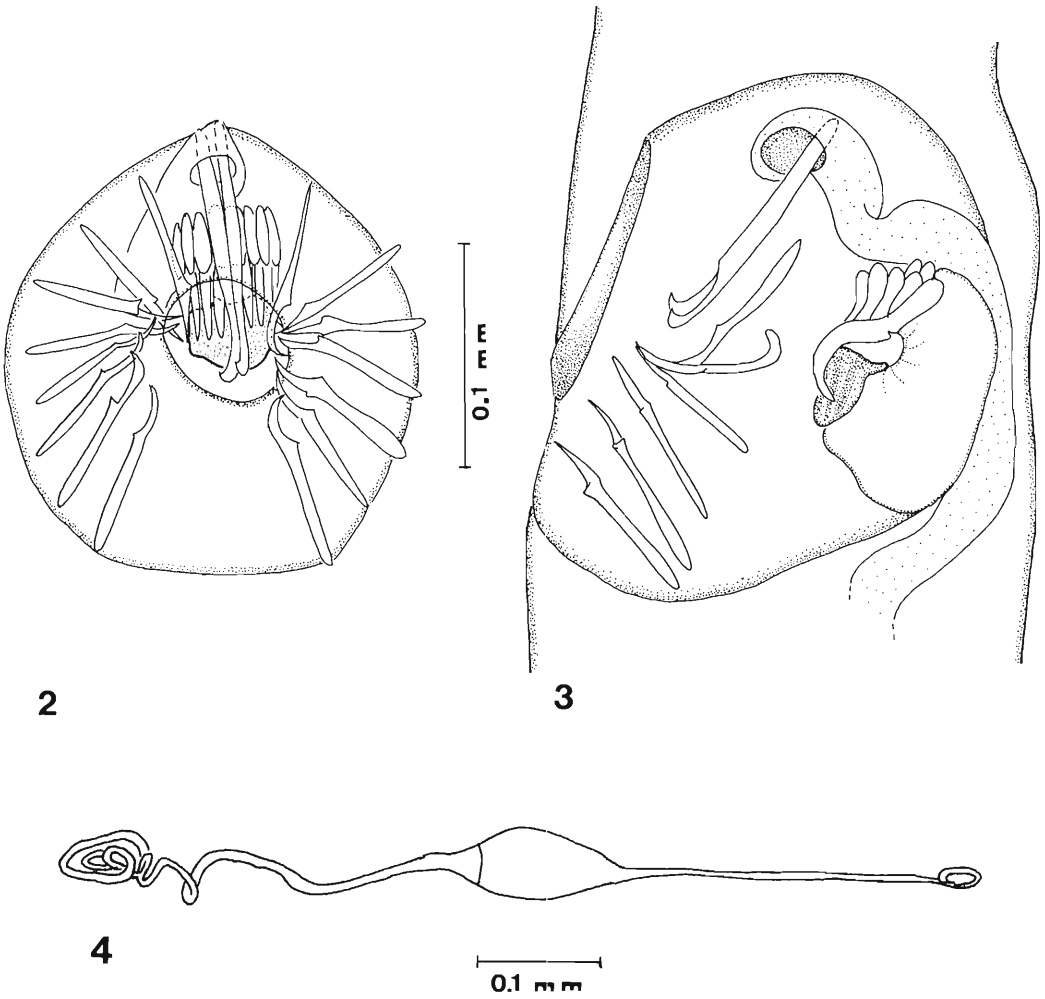


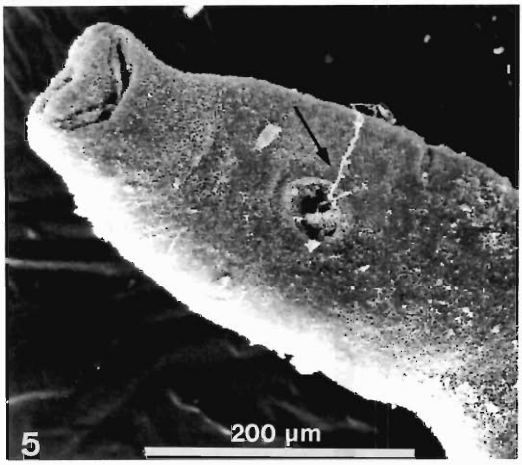
Figure 1. ***Atriaster heterodus:*** **CHIOC n. 33.358, total view.**

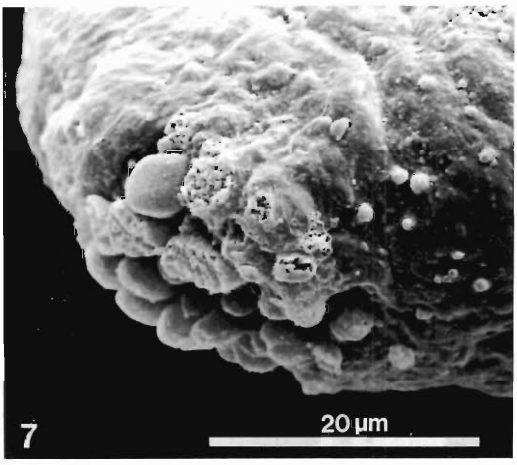


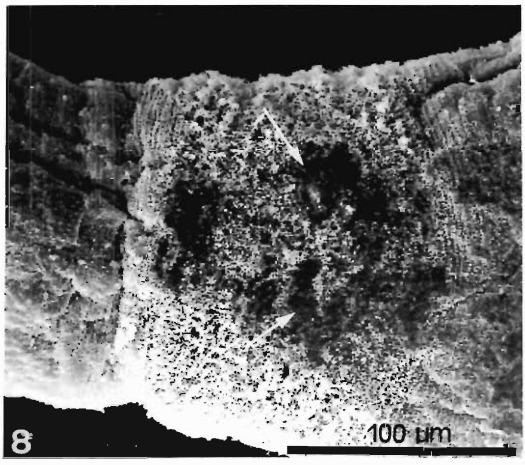
Figures 2–4. ***Atriaster heterodus:*** **2. Ventral view of genital atrium. 3. Lateral view of genital atrium. 4. Egg.**

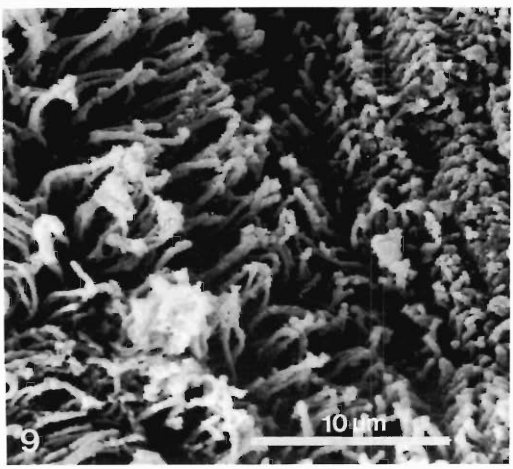
nae open at 246–707 (517) 10 from anterior end. Eggs 115–170 by 55–78 (141 by 67) 3 with anterior filament long and coiled; posterior filament 258–368 (321) 4 long. Uterus opens on posterior side of genital atrium. SEM study showed anterior glands of prohaptor disposed in 2 large lateral groups and a small one around the buccal aperture. Constricted area of body just behind genital atrium has a laterodorsal band with numerous small filaments covering the vaginae. In the middle of this band, filaments are larger, decreasing in length gradually toward the extremities, always disposed in horizontal rows. In the round genital atrium, 2 forcep-like spines were observed with some of the medial spines around them tangled with filaments like those around vaginae.

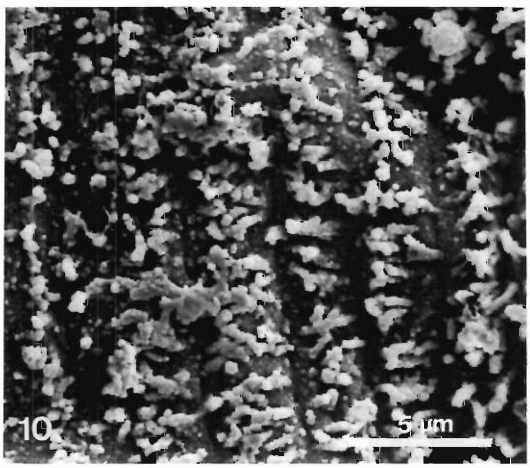
REMARKS: Lebedev and Paruchin (1969) described *Atriaster heterodus* from *Sparus heterodus* collected in southwestern Africa, and Mamaev (1984) examined the type specimens. Their descriptions of genital atrium includes 2 long spines, a range of 14–20 median ones measuring 65–90 in length disposed in 2 semicircles, and 5–9 small spines 17–30 in length. Euzet and Maillard (1973) redescribed this species collected from *Diplodus sargus, D. annularis,* and *D. vulgaris* from the Mediterranean. They discussed the differences in the number of clamps (80–105 against 70 pairs showed by Lebedev and Paru-











Figures 5–10. ***Atriaster heterodus:*** **5. Ventral view of prohaptor and genital atrium with arrow on egg filament. 6. Spines (arrows) in genital atrium. 7. Lateral glands of prohaptor. 8. Detail of vaginal apertures (arrows). 9. Longer filaments in the middle of the band. 10. Smaller filaments disposed in rows.**

chin [1969]), the smaller number of testes (14–22 instead of 30–40), and the slightly smaller size of genital atrium spines. They considered these differences as host and geographical adaptations. Mamaev (1984) confirmed the presence of 2 dorsal vaginae in type specimens. Lopez-Roman and De Armas Hernandez (1989) reported *A. heterodus* from *D. sargus* in the Tenerife Islands as a new geographical record. The specimens collected from *D. argenteus* from Rio de Janeiro show slight differences in the numbers of genital atrium spines, although they have the same distribution. Examination of Euzet and Maillard's specimens showed no significant differences. In earlier studies of *A. heterodus,* the constricted area near vaginae was described as having a thick tegument with ridges. The SEM study showed that the ridges are, in reality, filaments of different sizes disposed in symmetrical rows. Although we did not observe mating, we suppose that the spines arranged in semicircles project outside the genital atrium with the genital plate and its small spines grasp the filaments around the vaginae. Some of these filaments were found around the spines of the genital atrium. Concurrently, 2 longer forcep-like spines protrude, expanding the 2 vaginae and enabling the entry of sperm from the vas deferens. *Atriaster heterodus* is now redescribed with new morphological data on SEM with new host record and geographical distribution.

Polylabris tubicirrus Paperna and Kohn, 1964 (*P. diplodi* Lebedev and Paruchin, 1969, syn. n.) (Figs. 11–13)

Type Redescription

HOST: *Diplodus annularis* L.

SITE: Gills.

LOCALITY: Littoral zone of the Israel coast, Mediterranean.

STUDIED MATERIAL: Holotype n. 29.837 from the CHIOC.

REDESCRIPTION: Microcotylidae, Prostatomicrocotylinae. Body lanceolate 2,690 long, 550 wide at ovarian level. Haptor 1,540 long reaches the testes level tapering posteriorly with 116 clamps of typical microcotylid arranged in 2 rows linked anteriorly. Clamps dissimilar in size, be-

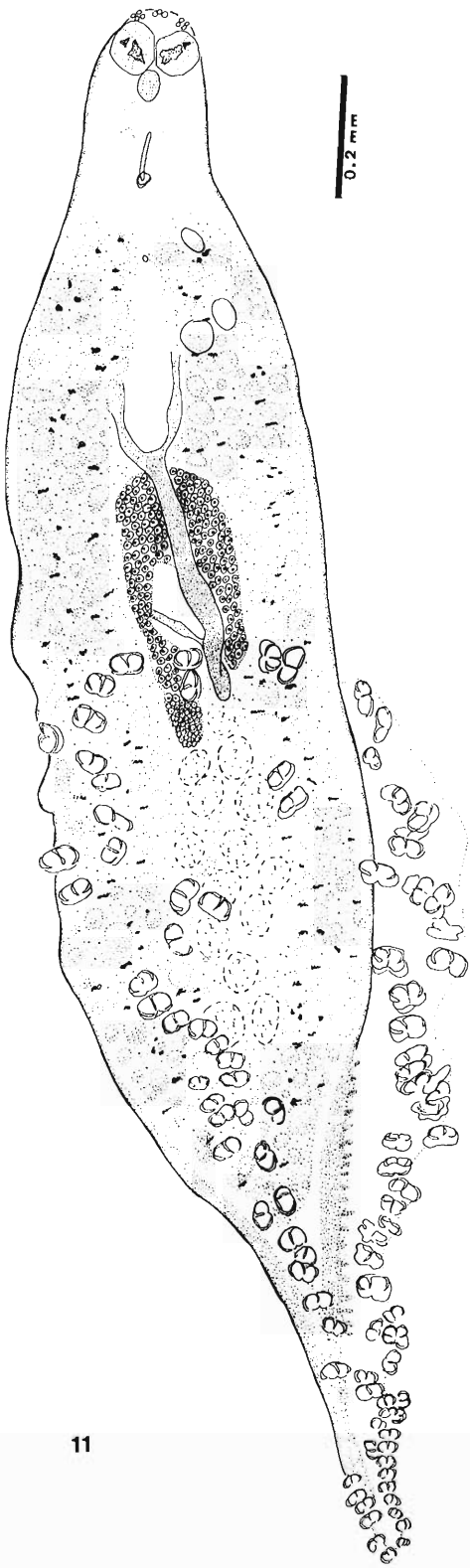


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Figure 11. ***Polylabris tubicirrus:*** **total view of holotype CHIOC n. 29.837.**

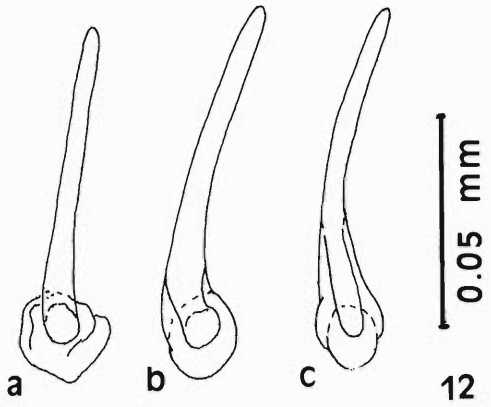

Figure 12. ***Polylabris tubicirrus:*** **Cirrus. a. CHIOC n. 29837. b. MNHN n. Tc 178. c. CHIOC n. 33.362.**

coming progressively smaller posteriorly; larger clamps 34–39 by 64, smaller 20–23 by 32. Three groups of small glands disposed in anterior end of body, followed by 2 prohaptoral suckers 64–66 long by 69 wide, unequally septate. Pharynx subspherical 40 in diameter. Intestinal crura ramified extending into the haptor. Due to the strong compression of specimen, clamps are scattered and testes were slightly visible. Tube-like cirrus 80 long situated 277 from anterior end. Ovary pretesticular. Dorsomedian vaginal aperture just posterior to level of cirrus at 361 from anterior end.

Main Measurements of New Specimens of *P. tubicirrus*

HOST: *Diplodus argenteus* (Val., 1830), Sparidae.

SITE: Gills.

LOCALITY: Copacabana beach, Rio de Janeiro, Brazil.

STUDIED MATERIAL: Three specimens collected from 25 fish (prevalence = 12%). CHIOC n. 33.362 and 33.363.

REDESCRIPTION: Total body length 3,742–4,446 (4,199) 3 and width at ovary level 416–585 (472) 3. Oral suckers 66–85 by 85–94 (75 by 91) 3, pharynx 41 by 41. Intestinal crura ramified. Haptor 1,540–2,000 (1,796) 3 long with 122–128 (125) 3 clamps. Larger clamps 39–46 by 74–78, smaller 25–30 by 37–39. There are 13–15 postovarian testes. Tube-like cirrus 76–90 (82) 3 long. Genital atrium opens at 322–339 (332) 3 from anterior end. Vagina median at 368–440 (402) 3 from anterior end. Eggs 170–184 by

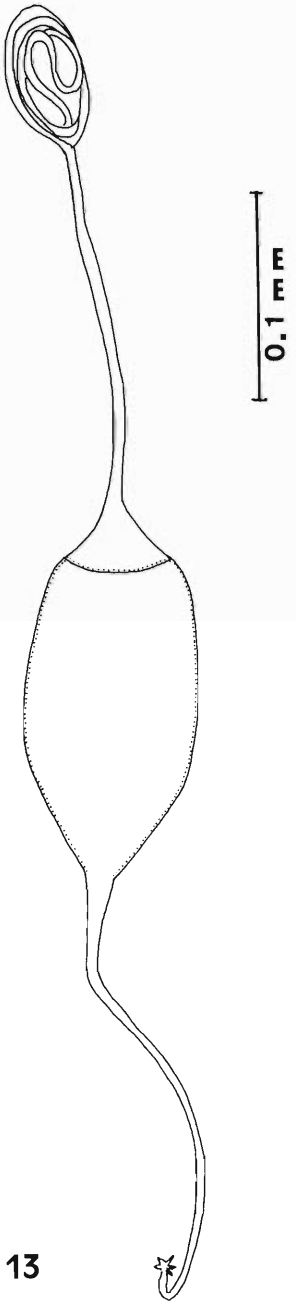

Figure 13. ***Polylabris tubicirrus:*** **CHIOC n. 33.362, egg.**

69–87 (177 by 81) 3 with anterior filament coiled and posterior one 198–241 (215) 3 long with small digitiform processes at the end.

REMARKS: *Polylabris tubicirrus* was first re-

ported from *Diplodus annularis* in the Mediterranean Sea. Noisi and Euzet (1979) also reported this species from *D. sargus* in the Mediterranean, and Silan et al. (1985) in the same area found it on *D. sargus, D. annularis,* and *D. vulgaris* and also on farmed gilt head sea breams, *Sparus aurata. Polylabris* was created by Euzet and Cawet (1967) with *P. diplodi* as the type species, collected from *D. sargus, D. annularis,* and *D. vulgaris* also from the Mediterranean. It was later reported by Lopez-Roman and Guevara Pozo (1973) on *D. sargus* and *D. vulgaris* from the Granada coast and by Lopez-Roman and De Armas Hernandez (1989) on *D. sargus* and *D. vulgaris* and on *Puntazzo puntazzo* and *Oblada melanura* from the Spanish coast. Mamaev and Paruchin (1976) presented a new diagnosis for *Polylabris* (type species *P. diplodi*), including the new combinations *P. kuhliae, P. maomao, P. acanthogobii, P. gerres, P. acanthopagri,* and *P. tubicirrus.* Ogawa and Egusa (1980) emended the diagnosis of Prostatomicrocotylinae, confirming *P. diplodi* as the type species of the genus. Mamaev (1986) listed the species of *Polylabris* with *P. diplodi* as the type species and *P. tubicirrus* as species inquirenda. Comparing the type specimens of *Polylabris tubicirrus* and *P. diplodi,* no significant differences were found, although in *P. tubicirrus* the position of the clamps is slightly distorted because of contraction. Considering that in both species the structure of cirrus and clamps are equivalent, the hosts are many, and both were described from the same geographical region, we propose that *P. diplodi* be considered a junior synonym for *P. tubicirrus.* This species is reported for the first time from the Rio de Janeiro coast, southwest Atlantic ocean, in the new host *Diplodus argenteus.*

Acknowledgments

We are grateful to Dr. A. Kohn from Instituto Oswaldo Cruz, Brazil, and Dr. J. L. Justine from the Muséum National D'Histoire Naturelle de Paris for providing specimens from the respective helminthological collections and to Dr. Klaus Rohde from University of New England for the suggestions made.

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Further Information on *Gymnorhynchus isuri* (Trypanorhyncha: Gymnorhynchidae) from the Shortfin Mako Shark

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ABSTRACT: The morphology of the mature segments of *Gymnorhynchus isuri* Robinson, 1959, is described for the first time from specimens collected from shortfin mako sharks at Montauk, Long Island, New York. This species was found to possess a muscular cirrus sac with a conspicuous external seminal vesicle but no accessory seminal vesicle. It possesses an ovary that is tetralobed in cross-section, a uterus that is porally deviated and circumcortical vitellaria that are external to the longitudinal muscle bundles of the segment. Scanning electron microscopy of the scolex reveals that all types of microtriches are conspicuously absent from all regions of the scolex with the exception of the distal bothridial surfaces, which bear densely packed, filiform microtriches. The diagnosis of the genus *Gymnorhynchus* and family Gymnorhynchidae are emended to reflect these new data.

KEY WORDS: Gymnorhynchidae, *Gymnorhychus,* mako shark, morphology.

In their recent reorganization of the poecilacanthous trypanorhynch families, Beveridge and Campbell (1989) transferred the genera *Molicola* Dollfus, 1935, and *Stragulorhynchus* Beveridge and Campbell, 1988, from the family Gymnorhynchidae to the family Molicolidae Beveridge and Campbell, 1989, leaving only the genera *Gymnorhynchus* and *Chimaerarhynchus* as valid gymnorhynchids. This resulted in a much more restricted and concrete family diagnosis; they proposed the group could thus be characterized by its possession of an accessory seminal vesicle and paired chainette elements each with a single lateral wing. Beveridge and Campbell (1989) provided a very detailed description of the scolex and segment morphology of the type and only known species of *Chimaerarhynchus, C. rougetae* Beveridge and Campbell, 1989. Although taxa now placed in *Gymnorhynchus* have been known since at least 1817, when Cuvier described *Gymnorhynchus gigas* (Cuvier, 1817) Rudolphi, 1819 (as *Scolex gigas*), the segment morphology of species belonging to this genus remains poorly known. Most reports of valid *Gymnorhynchus* species are of plerocerci (see, e.g., Cuvier, 1817; Dollfus, 1942; Brian, 1952; Seyda, 1976). The few existing reports of adult worms are generally not accompanied by descriptions or illustrations (see, e.g., Lopez-Neyra, 1947; Heinz and Dailey, 1974). Robinson (1959) provided a brief description and figure of a whole mount and cross-section of *G. isuri,* but because his material consisted entirely of a single immature specimen many details of mature segment morphology were unavailable. As a result, features such as the uterus and vitellaria have never been described for this genus (see Campbell and Beveridge, 1994). Although the presence of an accessory seminal vesicle is included in the diagnosis of both the family and genus (see Campbell and Beveridge, 1994), to our knowledge this feature has never been confirmed in *Gymnorhynchus.*

The collection of specimens of *Gymnorhynchus isuri* from the spiral intestines of shortfin mako sharks taken at shark tournaments at Montauk, Long Island, New York, provided us with the opportunity to investigate the morphology of this genus in more detail. These specimens also allowed us to investigate details of the scolex of this species using scanning electron microscopy (SEM).

Materials and Methods

Specimens of *Gymnorhynchus isuri* were removed from the spiral intestines of shortfin mako sharks, *Isurus oxyrinchus* Rafinesque, 1809, landed at the Star Island Yacht Club, Montauk Marine Basin, and Montauk Boatman's and Captain's Association shark-fishing tournaments at Montauk, Long Island, New York, in August 1992, 1993, and 1994. The strobila of all tapeworms were flattened on black plastic cards in a thin film of distilled water and then fixed in this flattened condition by pipetting warm alcohol/formalin/acetic acid (AFA) onto the plastic. Worms were fixed in AFA overnight and then transferred to 70% ethanol for storage.

The scolex and part of the strobila of 1 specimen of *G. isuri* was prepared as a whole mount to determine the location of immature, mature, and gravid segments in these very long worms. Based on information obtained from this initial mount, 9 portions of the strobila containing approximately 3 mature segments each were separated from the strobila of a second specimen. A razor blade was used to cut a very shallow frontal section from each of these strobilar fragments such that the surface musculature and vitellaria were removed,

but the bulk of the segment morphology remained intact. This greatly facilitated illustration and description of the internal segment morphology. These dorsal and ventral portions of the strobila were prepared as whole mounts. In each case, these 2 portions were mounted next to one another on the same slide. Whole mounts were stained in Gill's hematoxylin, cleared in xylene, and mounted in Canada balsam according to conventional techniques.

Three portions of the strobila of the third specimen, again identified as bearing mature segments based on the morphology of the first whole mount, were embedded in paraffin. Cross-sections were cut at 10-μm intervals with an American Optics rotary microtome. Sections were stained in eosin and Gill's hematoxylin, cleared in xylene, and mounted in Canada balsam according to conventional techniques.

Scolices of 3 specimens were removed from the strobila, hydrated in a graded ethanol series, placed in 1% osmium tetroxide overnight, dehydrated in a graded ethanol series, and dried using Peldri II (Ted Pella, Inc., Redding, California) according to Freidenfelds et al. (1994) or critical point–dried with liquid CO_2. All specimens were subsequently mounted on stubs with silver paint or carbon tape, sputter-coated with 100–300 Å of gold, and examined with a Coates and Welter Field Emission Scanning Electron Microscope.

All illustrations were done with the aid of a drawing tube. All measurements are given as the range followed in parentheses by the mean plus or minus the standard deviation, the number of specimens measured (n), and the number of observations ($\underline{n}$) when more than 1 structure was measured per specimen. All measurements are given in micrometers unless otherwise stated. Voucher specimens, including an unmounted intact scolex, and slide material of whole mounts and cross-sections were deposited at the U.S. National Parasite Collection in Beltsville, Maryland (USNPC Nos. 85936–85939). The stubs examined with SEM were retained in the senior author's personal collection. For comparative purposes, the holotype of *G. isuri* was borrowed from the National Museum of New Zealand, and larval material of *G. gigas* from *Brama rayi* was borrowed from the British Museum (BM Nos. 1976.4.14.15 and 1961.9.1.17–20).

Results

Four of 19 shortfin mako sharks examined were found to host *Gymnorhynchus isuri*. Three sharks hosted 1 individual and 1 shark hosted 2 individuals of this cestode. All 5 cestodes found were fully mature, possessing both mature and gravid segments. The infected sharks ranged in weight from 248 to 626 lb; none of the 13 sharks weighing less than 200 lb examined were infected with this trypanorhynch species.

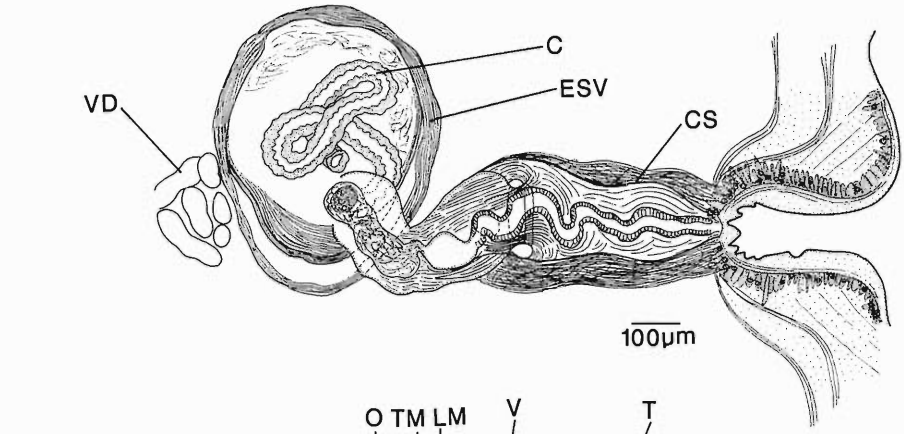
Gymnorhynchus isuri Robinson, 1959 (Figs. 1–3)

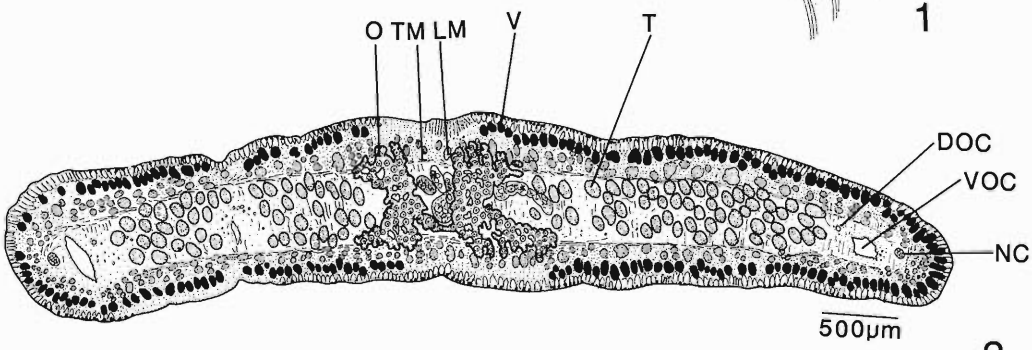
SYNONYMS: None.

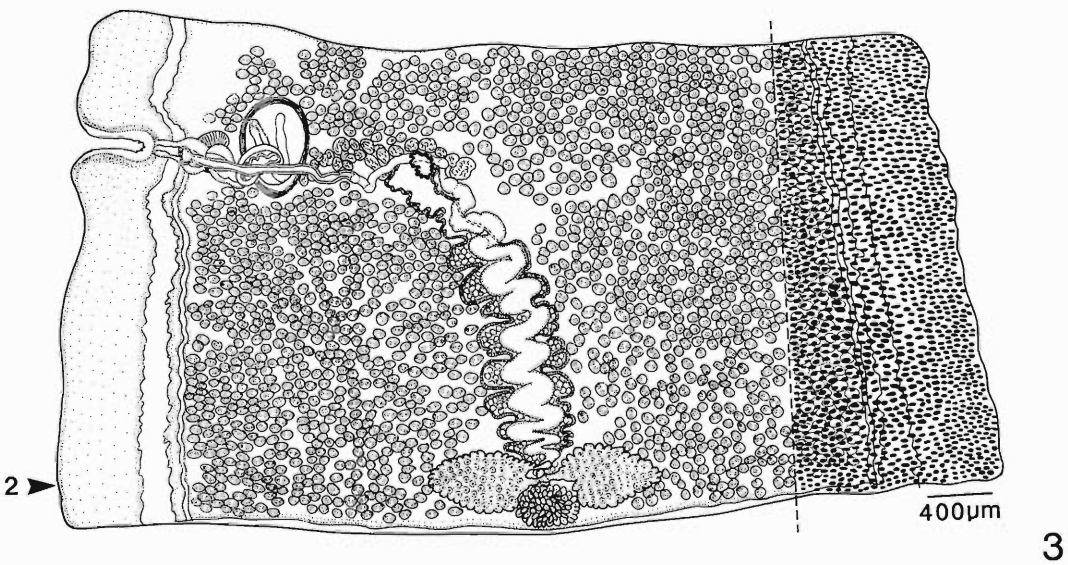
The following information, based on 4 mature specimens, should emend the description of *Gymnorhynchus isuri* provided by Robinson (1959).

Surfaces of pars bulbosa, pars vaginalis, apex of scolex, and proximal bothridial surfaces entirely devoid of microtriches. Distal bothridia surfaces with densely packed, slender, filiform microtriches.

Mature segments 3,140–3,923 (3,498 ± 431, n = 3, $\underline{n}$ = 10) long by 4,776–5,243 (5,038 ± 207, n = 3, $\underline{n}$ = 10) wide; gravid segments 2,060–3,427 (2,766 ± 802, n = 3, $\underline{n}$ = 10) long by 3,794–5,875 (5,022 ± 1,086, n = 3, $\underline{n}$ = 10) wide. Strobila acraspedote; genital pores marginal, alternate irregularly, 76.9–82.9% (80.1 ± 2.56, n = 3, $\underline{n}$ = 10) of segment length from posterior end. Genital atrium surrounded by sphincter-like condensation of muscular elements. Cirrus sac (Fig. 1) elongate, 244–376 (295.8 ± 82, n = 3, $\underline{n}$ = 10) long by 802–878 (820 ± 39.4, n = 3, $\underline{n}$ = 10) wide, walls very muscular; muscle fibers merging with genital sphincter; cirrus unarmed, retracted cirrus projecting into external seminal vesicle. External seminal vesicle (Fig. 1) oval, with thick muscular wall, 571–714 (611 ± 68.7, n = 3, $\underline{n}$ = 10) long by 387–591 (458 ± 90.6, n = 3, $\underline{n}$ = 10) wide. Accessory seminal vesicle absent. Vas deferens coiled medially, entering external seminal vesicle medially. Testes very numerous, at least 1,400 in number, oval, 40.3–80.6 (51.9 ± 21.9, n = 3, $\underline{n}$ = 18) long by 64.5–111.4 (77.2 ± 23.4, n = 3, $\underline{n}$ = 18) wide, intervascular, distributed throughout medulla in 3–4 dorsoventral layers, interrupted by ovary, uterus, and male genitalia, some follicles posterior to ovary, never confluent posterior to ovary. Vagina tubiform, sinuous, extending from ovarian isthmus to level of cirrus sac then lateral toward cirrus sac, enters genital atrium ventral to cirrus sac. Seminal receptacle absent. Ovary bilobed in dorsoventral view, tetralobed in cross-section (Fig. 2), 363–469 (416 ± 41, n = 3, $\underline{n}$ = 10) long by 1,162–1,418 (1,305 ± 82.2, n = 3, $\underline{n}$ = 10) wide. Mehlis' gland conspicuous, posterior to ovarian isthmus. Uterus tubular, median, ventral to vagina, anterior extremity porally deviated in immature and mature segments (Fig. 3), terminating just porally of median line at level of seminal vesicle; preformed uterine pore absent. Uterus becomes saccate with 8–11 lateral branches on each side, losing poral deviation in fully gravid segments. Vitelline follicles circumcortical, interrupted by ovary. Longitudinal muscles arranged in numerous bundles throughout perimeter of segment, internal to vitelline







Figures 1–3. ***Gymnorhynchus isuri*** **from** ***Isurus oxyrinchus.*** **1. Detail of male terminal genitalia. Vagina is not shown. 2. Cross-section through mature segment at level of ovary. 3. Mature segment. Dorsal surface has been removed to permit viewing of segment morphology. Vitellaria are circumcortical but are drawn only to the reader's right of the vertical dashed line. Arrow indicates location at which the section shown in Figure 2 was taken. Note: There is no preformed uterine pore; circular structure at anterior end of uterus is an artifact resulting from the removal of the dorsal surface of the segment. C = cirrus, CS = cirrus sac, DOC = dorsal osmoregulatory canal, ESV = external seminal vesicle, LM = longitudinal muscle, NC = nerve cord, O = ovary, T = testis, TM = transverse muscle, V = vitellaria, VD = vas deferens, VOC = ventral osmoregulatory canal.**

follicles. Transverse muscles weakly developed, immediately internal to longitudinal muscle bundles. Osmoregulatory canals paired; dorsal canals much smaller than and internal to ventral canals. Eggs slightly oval, 43–45 (44 ± 0.8, n = 3, $\underline{n}$ = 15) long by 37–41 (39.3 ± 2.2, n = 3, $\underline{n}$ = 15) wide.

Gymnorhynchus Rudolphi, 1819

The following information should supplement the most recent diagnosis presented by Campbell and Beveridge (1994) for this genus.

Strobila acraspedote. Segments wider than long. Testes numerous, intervascular, distributed throughout segment, some post-ovarian. Genital pores irregularly alternate. External and internal seminal vesicle present; accessory seminal vesicle absent. Vagina ventral to cirrus sac. Uterus arches toward genital pore. Preformed uterine pore absent. Vitelline follicles circumcoritcal, external to longitudinal muscle bundles.

Discussion

At this point, only 2 valid species of *Gymnorhynchus* are known: *G. gigas* and *G. isuri*. As the former is known only from larval material and the latter only from adult material, they can be distinguished solely on the basis of scolex morphology at this time. Among the criteria provided by Robinson (1959) to distinguish these 2 species, we found the number of hooks in the basal armature to be the most conspicuous; whereas *G. gigas* has approximately 18 large hooks in its basal armature, *G. isuri* has only 8 or 9. Our data suggest that adults of *G. isuri* are parasites of larger mako sharks.

Overall, the segment morphology of *Gymnorhynchus* is very similar to that of *Chimaerarhynchus*. However, several interesting differences in segment morphology exist between these 2 genera. Whereas *Chimaerarhynchus* has an ovary that is bilobed in cross-section, *Gymnorhynchus* has an ovary that is clearly tetralobed in cross-section. Whereas the vitellaria in *Chimaerarhynchus* alternate with the longitudinal muscle bundles, the vitellaria in *Gymnorhynchus* are external to the longitudinal muscle bundles. Perhaps most importantly, although *Chimaerarhynchus* possesses an accessory seminal vesicle, *Gymnorhynchus* does not, thus the diagnosis of the family Gymnorhynchidae provided by Campbell and Beveridge (1994, p. 78) should be slightly emended from "accessory seminal vesicle present" to "accessory seminal vesicle present or absent." We have emended the generic diagnosis above to reflect this finding.

SEM of the scolex of *G. isuri* reveals a surface bearing few structures. We were unable to find any evidence of palmate microtriches on any of the surfaces of the scolex of this species. In fact, no microtriches were seen on the surfaces of the pars bothridialis, pars vaginalis, apex of the scolex, or the proximal bothridial surfaces. Although the fact that slender filiform microtriches were seen on the distal bothridial surfaces argues against specimen mistreatment as the explanation for this result, this finding is so unusual for a cestode that we examined a scolex from each of 3 separate field collections to ensure that this result was not an artifact of fixation or specimen treatment. The microthrix pattern was the same in all 3 specimens. These data contradict the proposal that palmate microtriches should be considered to be a synapomorphy for the trypanorhynchs, as was suggested by Richmond and Caira (1991), because this feature is absent from *Gymnorhynchus*. To our knowledge, *Gymnorhynchus isuri* is by far the largest cestode yet to be examined with SEM, its scolex being approximately 1 cm in length. It would be interesting to examine the surfaces of the scolex of other similarly sized cestodes to see whether or not this lack of microtriches is correlated with size. The exact function or functions of microtriches remains poorly known. Perhaps one or more functions are not required by a worm of this size.

Acknowledgments

We thank Dr. Ian Beveridge for his assistance with the interpretation of the terminal genitalia of this species. We would also like to thank David Gibson and Ricardo Palma for lending specimens. We are especially grateful to Sam Gershowitz of the Star Island Yacht Club, Carl Darenberg of Montauk Marine Basin, and Joe McBride and the Montauk Boatman's and Captain's Association for allowing us to dissect shortfin mako sharks at their shark tournaments in 1992–1994.

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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) 3:48–87; (1983) 50:200–204 and (1993) 60:144–150.

Financial Report for 1995

Balance on hand, January 1, 1995		$15,766.11
Receipts:*		
Interest received in 1995	$794.03	
Total		$794.03
Disbursements:		
Support of author's page charges	($200.00)	
Grant to the Helminthological Society of Washington for 1995	($ 50.00)	
Membership in the Americal Association for Zoological Nomenclature	($ 50.00)	
Total		($300.00)
On hand, December 31, 1995		$16,260.14

*Contributions to the Fund by members of the Helminthological Society of Washington amounted to $204.00 in 1994 and $145.00 in 1995. These funds were received in 1996 and are not included in this report.

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Parasites of Some Fish Introduced into an Arizona Reservoir, with Notes on Introductions

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ABSTRACT: Of 6 species of introduced fishes examined from Lake Mohave, an impoundment of the Colorado River in northwestern Arizona, 5 yielded 8 species of metazoan parasites during March 1994. *Atractolytocestus huronensis* infected *Cyprinus carpio*; *Corallobothrium fimbriatum* and *C. giganteum* infected *Ictalurus punctatus*; *Proteocephalus ambloplitis* adults and plerocercoids infected *Micropterus salmoides* and *Lepomis macrochirus*, respectively; *Ornithodiplostomum ptychocheilus* and *Posthodiplostomum minimum* metacercariae infected the liver of *L. macrochirus*; *Hysterothylacium* sp. larvae infected the body cavity of *M. salmoides, I. punctatus, C. carpio,* and *Morone saxatilis*; and *Myzobdella lugubris* infected *I. punctatus*. All records, except that of *O. ptychocheilus,* are new for the state of Arizona. Fish were most heavily infected with *Hysterothylacium* sp., which also infected and killed 2 native Gila topminnows, *Peociliopsis o. occidentalis*. The introduction of fishes and their parasites are discussed.

KEY WORDS: fish parasites, Lake Mohave, Arizona, introductions.

Natural and artificial aquatic habitats of Arizona are shared by a depauperate indigenous fish fauna of about 28 freshwater species and an equal but increasing number of nonindigenous fishes (at least 30 taxa are naturalized; Minckley, 1973, 1982, 1991) introduced from a wide variety of sources. Only a few fish populations, native or nonnative, have been examined in any detail for parasites. Most records are incidental in reports on other aspects of fish biology (e.g., for razorback sucker, *Xyrauchen texanus* (Abbott), Minckley, 1983; Minckley et al., 1991). Exceptions for native fishes include reports by James (1968; a copepod, *Lernaea*), Amin (1969b; helminths of suckers), Mpoame (1982) and Mpoame and Rinne (1983) (protozoans, helminths), Mpoame and Landers (1981; *Ophiotaenia critica,* a new species from Colorado squawfish, *Ptychocheilus lucius* Girard), Mpoame and Rinne (1984; endemic trouts, *Onchorhynchus apache, O. gilae* helminths), and Heckmann et al. (1986; woundfin minnow, *Plagopterus argentissimus* Cope helminths). In other relevant works, Flagg (1980, 1982) has reviewed protozoan and metazoan parasites of native fishes in the Upper Colorado Basin, Utah–Colorado. Reports on parasites of introduced species are those of Amin (1969a; buffalofish, *Ictiobus* spp. helminths) and Mpoame and Rinne (1984; helminths of brown trout, *Salmo trutta*).

This study reports on the parasite fauna of cyprinids, ictalurids, and centrarchids that were introduced into a Colorado River reservoir. Most if not all of the parasitic taxa identified were probably introduced into the Colorado River basin with their natural fish hosts, largely from the Mississippi River Valley near the turn of the century (Minckley, 1973; Allen and Roden, 1978; Sigler and Sigler, 1987). Some remain restricted to their original hosts; others have shifted into native fishes of the region. One case is documented for transfer of a pathogenic nematode to a susceptible native species. That 7 of the 8 reported parasitic taxa have apparently not before been recorded from Arizona is an indication of the poor state of our knowledge of fish parasites in that state. The extent of dissemination of these and other parasites into native fishes is yet to be fully evaluated.

Materials and Methods

Ninety individuals of 6 fish species were trammelnetted in March 1994 from Lake Mohave, Arizona–Nevada, a narrow, 108-km-long reservoir formed on the Colorado River mainstream in the early 1950's by closure of Davis Dam. It is widest (6.4 km) in Cottonwood Basin, where collections were made, and deepest (30.5 m) at the upstream face of the dam (Allan and Roden, 1978).

Species examined were rainbow trout, *Onchorhynchus mykiss* Walbaum, total length 21–27 cm, mean 24 cm; common carp, *Cyprinus carpio* Linnaeus, 39–60, 45; channel catfish, *Ictalurus punctatus* (Rafinesque), 36–57, 46; bluegill, *Lepomis macrochirus* Rafinesque, 13–17, 15; largemouth bass, *Micropterus salmoides* (Lacèpéde), 24–43, 35; and striped bass, *Mo-*

rone saxatilis (Walbaum), 19–60, 31. Fishes were dissected at a lakeside field facility shortly after capture. Parasites were removed and fixed directly in cold ethanol/formalin/glacial acetic acid and then transported to the laboratory for routine processing and whole mounting. All parasite voucher specimens are deposited in the Harold W. Manter Laboratory (HWML), University of Nebraska State Museum, Lincoln.

Results and Discussion

Eight parasitic taxa, 7 helminths and 1 leech species, were collected from 5 of the 6 species of nonnative fishes examined (Table 1). All taxa recovered in channel catfish, bluegill, and largemouth bass naturally infect the same hosts within their native ranges in the Mississippi River and associated drainages east of the Continental Divide. All reported helminths have indirect life cycles, and finding them indicates the presence of their intermediate and other hosts in the Lower Colorado Basin. Rainbow trout, stocked by the U.S. Fish and Wildlife Service within 1 wk before sampling, were uninfected.

Atractolytocestus huronensis Anthony, 1958 (Lytocestidae Wardle and McLeod, 1952, Cestoda)

Three gravid worms infected the small intestine just posterior to the stomach of 2 common carp (Table 1). This caryophyllaeid cestode is known only from North American common carp. It was originally described in Michigan but appears widespread (Hoffman, 1967; Jones and Mackiewicz, 1969; present study). This is a new state record for Arizona. Another regional record is that of Edwards and Nahhas (1968) from the Sacramento–San Joaquin Delta, California. The presence of this worm in Arizona likely dates to the introductions of common carp just before 1885 (Taggart, 1885, and Rule, 1885, *in* Minckley, 1973).

The phylogenetic origin of *A. huronensis* is problematic considering its apparent absence in European stocks from which common carp was originally brought in 1872 from Germany into California (Allen and Roden, 1978). The few sterile testes of the parthenogenetic *A. huronensis* led Jones and Mackiewicz (1969) to imply an origin from the similar *Markevitschia sagittata* Kulakovskaja and Akhmerov, 1965, with many testes, from Amur carp, *Cyprinus carpio haemopterus* Timminck and Schlegel.

SPECIMENS: HWML Coll. No. 38728.

Corallobothrium fimbriatum Essex, 1927 *Corallobothrium giganteum* Essex, 1927 (Proteocephalidae La Rue, 1911, Cestoda)

Schmidt (1986) did not recognize the independent status of *C. giganteum.* Two distinct species of *Corallobothrium* Fritsch, 1886, clearly referable to *C. fimbriatum* and *C. giganteum,* nonetheless coinhabit channel catfish in Lake Mohave. The former's scolex has a collar of large lappets, proglottids considerably broader than long, and an ovary in a linear band near the posterior margin of the proglottis. The latter has a less developed fimbriate collar, proglottids far longer than broad, and a butterfly- or H-shaped ovary (Van Cleave and Mueller, 1934).

Coincident infection of channel catfish with the same 2 cestode species has been reported in the Mississippi River basin (Amin, 1991). Channel catfish, probably with their parasites, were introduced into the Colorado River basin in 1892–1893 (Worth, 1895; Sigler and Sigler, 1987) and must have been repeatedly stocked and/or translocated within the region numerous times. The recovery of these 2 species represents new state records for Arizona. Introductions and occurrences of *Corallobothrium* species in California were recorded by Haderlie (1953), Edwards and Nahhas (1968), and Hensley and Nahhas (1975) and in Texas by Underwood and Dronen (1984).

Prevalence and intensity of infection were rather high in channel catfish in Lake Mohave (Table 1). Such infections require support by stable populations of intermediate hosts (e.g., copepods and small fishes). The cestodes recovered were recently recruited juveniles and large mature adults. Development, maturation, prevalence, and intensity of infection by both cestode species appear to increase in spring and summer (Haderlie, 1953; Amin, 1991).

SPECIMENS: HWML Coll. No. 38731 (*C. fimbriatum*) and No. 38732 (*C. giganteum*).

Proteocephalus ambloplitis (Leidy) (Proteocephalidae La Rue, 1911, Cestoda)

Light infections occurred in Lake Mohave, with adults in the intestine of largemouth bass and plerocercoids in the liver of bluegill (Table 1). These are new definitive and intermediate host records for Arizona. Appearance of *P. ambloplitis* adults and/or plerocercoids in western drainages have been reported for Colorado–Utah

Table 1. Parasitic infections of Lake Mohave, Arizona, fishes, March 1994.

Parasite species	Fish species (number examined)				
	Micropterus salmoides (7)	*Lepomis macrochirus* (20)	*Ictalurus punctatus* (14)	*Cyprinus carpio* (15)	*Morone saxatilis* (14)
Cestoda					
Atractolytocestus huronensis	–	–	–	2 (13), 3 (0.2), 2*	–
Corallobothrium†	–	–	13 (93), 125 (8.9), 30	–	–
Proteocephalus ambloplitis	2 (29), 7 (1.0), 4	–	–	–	–
Proteocephalus ambloplitis‡	–	2 (10), 4 (0.2), 3	–	–	–
Trematoda					
Ornithodiplostomum ptychocheilus‡	–	20 (100), 14	–	–	–
Posthodiplostomum minimum‡	–	5 (25), 5	–	–	–
Nematoda					
Hysterothylacium sp.‡	7 (100), 402 (57.4), 110	–	9 (64), 278 (19.8), 146	2 (13), 2 (0.1), 1	2 (14), 2 (0.1), 1
Hirudinea					
Myzobdella lugubris	–	–	2 (14), 26 (1.9), 16	–	–

* Number of fish infected (% prevalence), number of parasites recovered (mean per examined fishes), maximum number of parasites per host.
† Includes *Corallobothrium fimbriatum* and *C. giganteum*.
‡ Larval forms in body cavity sites.

(e.g., in Colorado squawfish and possibly roundtail chub, *Gila robusta* Baird and Girard by Vanicek and Kramer (1969)). Sparks (1951), Ingham and Dronen (1980, 1982), and Underwood and Dronen (1984) have reported it in largemouth bass from Texas. Introductions of this tapeworm may date to stocking of largemouth bass, bluegill, and other sunfish from their native ranges east of the Rocky Mountains into Lake Mead and other reservoirs between 1935 and 1942 and perhaps earlier (Minckley, 1973). The presence of *P. ambloplitis* in largemouth bass and bluegill indicates the availability of crustacean intermediate hosts (cladocerans, copepods, or amphipods) at densities sufficient to sustain the worms. Pathology of plerocercoids in bluegill livers was comparable but less severe than that reported in heavier infections, as described by Amin (1990). Specimens from largemouth bass were young mature adults that were probably recruited in late winter–early spring, as previously reported by Amin and Cowen (1990) and Eure (1976).

SPECIMENS: HWML Coll. No. 38729 (adults) and No. 38730 (plerocercoids).

Ornithodiplostomum ptychocheilus (Faust, 1917) *Posthodiplostomum minimum* (MacCallum, 1921) (Strigeidae Railliet, 1919, Trematoda)

Metacercariae of these 2 trematode species were recovered from the body cavity and viscera, mostly liver, of bluegill. Infections of *O. ptychocheilus* were more prevalent and heavier than those of *P. minimum*. Metacercariae of *O. ptychocheilus* appear to belong to the new subspecies proposed by Amin (1982). Metacercariae of the latter species have also invaded a number of native fishes in Arizona (Mpoame, 1982; Mpoame and Rinne, 1983). Herons and other fish-eating birds are clearly sufficiently abundant along the lower Colorado River to sustain populations of these 2 strigeid trematodes.

The record of *P. minimum* metacercariae is, to our knowledge, the first for Arizona. Heckmann et al. (1986) reported them from woundfin in the Virgin River, Utah, a stream flowing from Utah into Arizona to enter Lake Mead in Nevada, just upstream from Lake Mohave. Metacercariae of *P. minimum* have also been reported from largemouth bass in Texas (Ingham and Dronen, 1980, 1982), and from a number of fish species in California (Haderlie, 1953; Edwards and Nahhas, 1968).

SPECIMENS: HWML Coll. Nos. 38733, 38734 (*P. minimum*) and HWML Coll. No. 38735 (*O. ptychocheilus*).

Hysterothylacium Ward and Magath, 1917 (Heterocheilidae Railliet and Henry, 1915, Nematoda)

Third-stage larvae of a species of *Hysterothylacium* were encysted in large numbers in the body cavity of largemouth bass and channel catfish but rarely in common carp and striped bass from Lake Mohave (Table 1). The first 2 fish species are well-known hosts of *Hysterothylacium brachyurum* Ward and Magath, 1917, and *Hysterothylacium spiculigerum* (Rudolphi, 1809) Railliet and Henry, 1912, in the Mississippi River basin. Worms were tightly coiled in a single plane (flat coil) within a tough hyaline cyst wall. Specimens photographed in Johnson (1980) from "bullhead catfish" and in Mitchum (1995) from largemouth bass and plains killifish are identical in appearance to Lake Mohave material; the Mitchum (1995) specimens were identified as *H.* (=*Contracaecum*) *spiculigerum*.

Introduction of these nematodes into Arizona was likely coincident with Mississippi basin fishes, as noted for other taxa. The anadromous striped bass, native to the Atlantic Coast and Gulf of Mexico, also could have transported this worm. Striped bass was first stocked in the lower Colorado River from the east in 1969 (Allan and Roden, 1978) and later from the Pacific Coast where it was introduced and established in the late 1900's (Minckley, 1973). This fish species ultimately spread to Lake Mohave, becoming abundant after 1983. This is the first published report of *Hysterothylacium* in Arizona. These nematodes appear to be widespread in nearby states (e.g., Texas [Sparks, 1951; Ingham and Dronen, 1980, 1982; Johnson, 1980]) and may be of potential public health and veterinary health importance because some *Hysterothylacium* species are capable of penetrating the alimentary tract of mammals (Deardorff and Overstreet, 1981).

SPECIMENS: HWML Coll. No. 38724–38727.

Hysterothylacium has apparently spilled over to some native and endangered fishes in Arizona. Two female Gila topminnows, *Poeciliopsis o. occidentalis* (55 mm in total length each) from Cienega Creek, Pima County (31°30′N, 110°30′W;

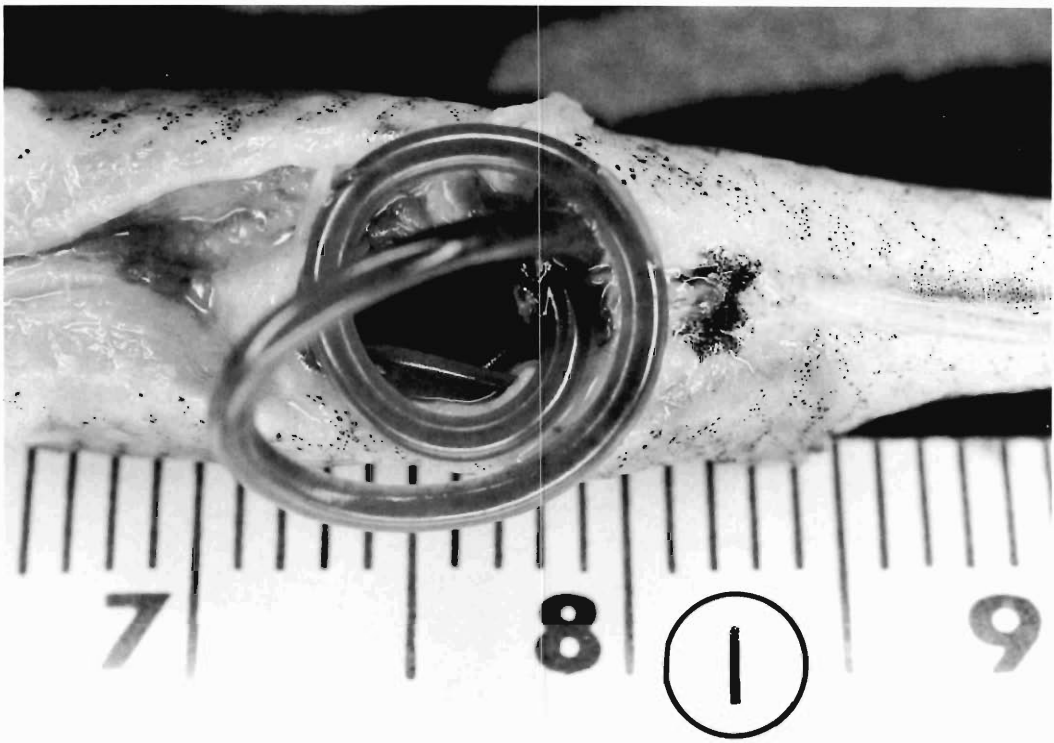

Figure 1. ***Hysterothelacium*** **sp. protruding from the body cavity through the abdominal wall of an infected** ***Poeciliopsis o. occidentalis*** **from Cienega Creek. Ruler scale in centimeters.**

Gila River basin, Santa Cruz River drainage), taken under permit to establish a captive stock, had body cavities infected with *Hysterothylacium* larvae. One had 3 nematodes in its grossly enlarged abdomen; the body wall was intact. The other carried a worm that protruded through the body wall (Fig. 1). The infection killed both topminnows. The worms were large and markedly coiled but not enclosed in any membranes. Impact of infection on small, susceptible native fishes that may be threatened or endangered cannot be overlooked in stocking and management decisions. Fisheries managers should carefully consider the potential impacts of transplanting exotic parasites.

Cienega Creek is a thermally fluctuating stream that supports only 2 other native fishes, Gila chub, *Gila intermedia* (Girard), and longfin dace, *Agosia chryogaster* (Girard) (Simms, 1991). No nonnative fishes are known in the watershed, but various centrarchids and ictalurids almost certainly live in nearby livestock-watering tanks, from which they could invade the creek. According to Simms (1991, p. 6), however, "unauthorized stockings of exotic fishes are much more likely to occur directly into Cienega Creek from sources outside the watershed . . . ." The source of infection of Cienega Creek topminnows has not been ascertained.

SPECIMENS: HWML Coll. No. 38723.

Myzobdella lugubris Leidy, 1851 (Piscicolidae, Johnston, 1865, Hirudinea)

This leech infected only channel catfish in Lake Mohave. They were in moderate numbers, usually around the mouth and on the ventral sides of paired fins. Channel catfish appear to be the preferred hosts for *M. lugubris*. At one locale in the Mississippi River basin the same leech species had infected 13 fish species, mostly centrarchids. Channel catfish were, however, the most heavily parasitized, with 185 leeches on 1 individual (Amin, 1981). Introductions of channel catfish (see earlier) were likely the principal vehicle of transmission for this parasite. This is apparently the first published record for *M. lu-*

gubris from Arizona. The same leech species is widely found on California ictalurids (Hensley and Nahhas, 1975). Material reported as *Illinobdella* sp. by Haderlie (1953, fig. 63b) from northern California catfish are likely *M. lugubris*.

SPECIMENS: HWML Coll. No. 38753.

Conclusions

Translocations of fishes and their parasites into new niches or sparsely populated waters such as those of the American West may represent serious threats to the health and survival of susceptible native fish populations. Spread of freshwater fish diseases and increased pathogenicity accompanying such introductions is of growing concern (Bauer and Hoffman, 1976; Bauer, 1991; Kennedy, 1993). Fish parasites are readily transferred with their hosts (e.g., catfishes, carps, basses, sunfishes), and some parasite taxa have substantially expanded their ranges due to increasing aquaculture and expanding sport fisheries (Hoffman, 1970).

The parasite fauna from our sample of introduced fishes does not appear as rich compared to that reported from the same hosts in the Mississippi River basin. The phenomenon of reduced parasite diversity in introduced-fish assemblages was first noted by Dogiel (1948). Parasites introduced into a new area without an ability to infect indigenous fishes can be disseminated if their introduced hosts are dispersed by human manipulation (Kennedy, 1994). Among other factors, reduced parasite diversity in introduced assemblages of fishes may also result from intentional or chance introduction of uninfected hosts into new habitats or an inability on the part of parasites species-specific to native-fish hosts to infect new, alien taxa, or both.

Notable by their absence from our Lake Mohave samples are acanthocephalans. Barriers to their establishment may include (1) their tendency for narrow specificity in intermediate hosts, (2) general absence or occurrence below threshold levels, necessary to sustain a viable worm population, of amphipod or isopod intermediate hosts (no native amphipods or isopods are know from this area), and (3) times of host introductions not coinciding with natural infective seasons during which generation cycle/recruitment occurs. The transmission window for these parasites may thus be seasonally restricted. Kennedy (1994) noted a similarly conspicuous absence of acanthocephalans among fish parasites colonizing the British Isles.

Dispersal success of an introduced parasite depends on its reproductive potential, degree of host specificity, availability of appropriate or ecologically equivalent intermediate hosts, and time of introduction. A generalist should be better able than a specialist to invade and colonize new habitats. Among the parasites recorded in Lake Mohave, *P. ambloplitis* may be such a generalist. Despite a complex life cycle, it has broad specificity in each host category used (Amin, 1990; Amin and Cowen, 1990) and has succeeded in dispersing widely. Hoffman (1970, p. 77) reported its successful spread from "East to Midwest to the state of Washington in largemouth black bass."

Clearly, species of the nematode genus *Hysterothylacium* are also successful, infecting a number of Lake Mohave fish species and often occurring in large numbers (Table 1). This suggests an efficient generalist. Under such conditions, a native fish like the Gila topminnow need not be related to the parasite's original host to experience interspecific transfer and ultimately suffer death. Introduced parasites like *Hysterothylacium* that use many taxa of intermediate hosts are likely to establish readily. Intermediate invertebrate hosts such as copepods, cladocerans, and oligochaetes (Bauer, 1991) lending themselves to support such parasite taxa are often cosmopolitan in distribution.

A host-specific parasite may be ill-adapted for successful invasion because its dispersal may be sorely limited by the restricted distribution of its host. *A. huronensis* is a potential example in Lake Mohave because it is host-specific in common carp. Obviously, the potential restriction is far outweighed by the great dispersal and reproductive capabilities of the host and because *A. huronensis* is triploid with a stable, parthenogenetic reproductive cycle capable of sustaining it under conditions of host rarity (Jones and Mackiewicz, 1969). Oligochaete (tubificid) intermediate hosts must be present in Lake Mohave for *A. huronensis* to occur and persist but, again, those invertebrates are consistent in reservoir benthos, in Arizona (Rinne, 1973) and elsewhere. Other relatively host-specific cestodes include *C. fimbriatum* and *C. giganteum,* restricted to the narrow choice of ictalurid catfishes. Again, the great dispersal abilities of those hosts, albeit often through artificial human translocation, have

vastly enhanced the tapeworm's success at invading new habitats.

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Acanthocephala from Arabian Gulf Fishes off Kuwait, with Descriptions of *Neoechinorhynchus dimorphospinus* sp. n. (Neoechinorhynchidae), *Tegorhynchus holospinosus* sp. n. (Illiosentidae), *Micracanthorhynchina kuwaitensis* sp. n. (Rhadinorhynchidae), and *Slendrorhynchus breviclaviproboscis* gen. n., sp. n. (Diplosentidae); and Key to Species of the Genus *Micracanthorhynchina*

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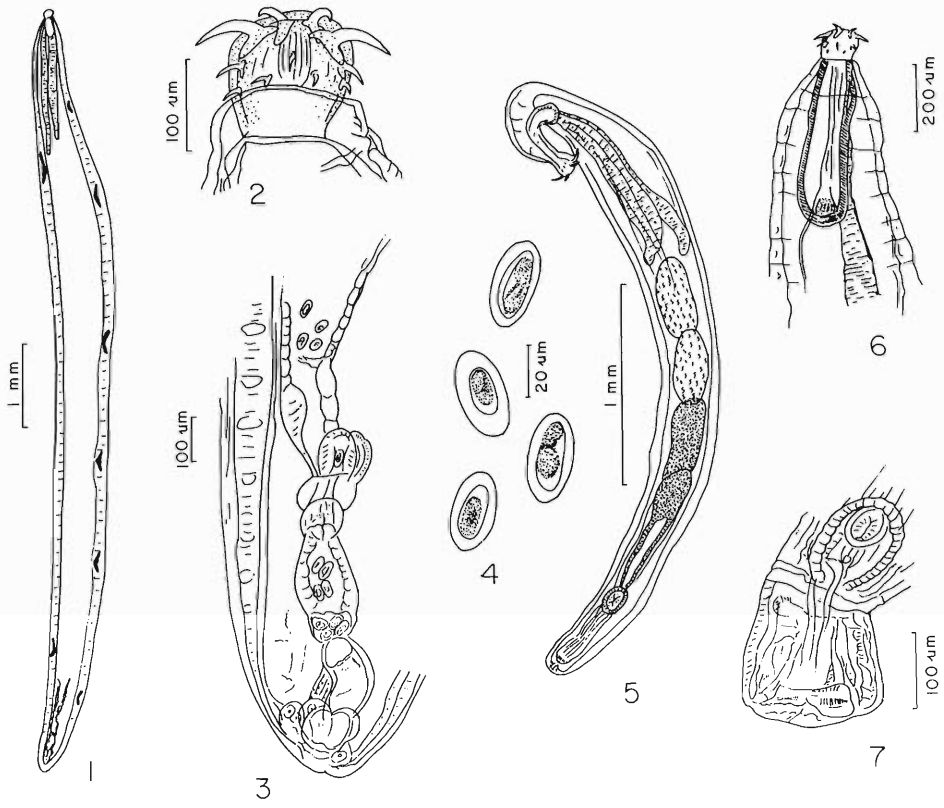
ABSTRACT: Five species of acanthocephalans were collected from 14 species of Arabian Gulf fishes off the coast of Kuwait between 1993 and 1995. They are the following. (1) *Neoechinorhynchus dimorphospinus* sp. n. (Neoechinorhynchidae) from *Allanetta forskali* (Ruppell, 1828), *Dorosoma nasus* (Bloch, 1795), and *Liza macrolepis* (Smith, 1849). It is distinguished from the only other species of *Neoechinorhynchus* Stiles and Hassall, 1905, from fish with unequal proboscis hooks in the anterior circle, *Neoechinorhynchus doryphorus* Van Cleave and Bangham, 1949, by having smaller terminal proboscis hooks and eggs. (2) *Tegorhynchus holospinus* sp. n. (Illiosentidae) from *Leiognathus fasciatus* (Lacépède, 1798), *Leiognathus bindus* (Cuvier and Valenciennes, 1835), and *Pseudorhombus arsius* (Hamilton-Buchanan, 1827). It is the only species of the genus with cuticular spines covering almost the whole trunk. (3) *Micracanthorhynchina kuwaitensis* sp. n. (Rhadinorhynchidae) from *Hemiramphus marginatus* Forskal, 1775. It has the largest number of proboscis hooks per row (13–15) compared to all other species of the genus. A key separating the latter species from the other 6 valid species of the genus is included. (4) *Slendrorhynchus breviclaviproboscis* gen. n., sp. n. (Diplosentidae, Allorhadinorhynchinae), from *Lagocephalus lunaris* (Bloch and Schneider, 1801) and *Leiognathus bindus* (Cuvier and Valenciennes, 1835). It has trunk spines that cover almost the entire body and 4 cement glands. The other 2 monotypic genera of the subfamily, *Allorhadinorhunchus* Yamaguti, 1959, with 2 cement glands and *Golavanorhynchus* Noronha, Fabio, and Pinto, 1978, with 6 cement glands, have spines in the anterior part of the trunk only. The diagnosis of the subfamily Allorhadinorhynchinae is emended. (5) Juveniles of *Serrasentis sagittifer* (Rhadinorhynchidae) were recovered from the body cavity of 6 fish species; all are new host records.

KEY WORDS: marine Acanthocephala, Kuwait, new taxa, Arabian Gulf fishes.

Helminth parasites, especially acanthocephalans, of Arabian Gulf fishes are poorly known and their zoogeographical affinities to Red Sea fish parasites need to be studied. The present collection of acanthocephalans offers a unique opportunity to contribute significantly to our knowledge on these parasitic invertebrates including the description of 4 new species and 1 new genus. Most of the reported fish species have not been previously examined for parasites despite the fact that they have been taken from a commercially accessible source. This suggests that other (perhaps many) undescribed helminth species from Arabian Gulf fishes await discovery. Of the few helminthological reports from the same region, only Amin et al. (1984) reported on 3 acanthocephalan species from a considerably smaller collection.

Materials and Methods

Of 70 species obtained from a local fish market in Kuwait City between October 1992 and May 1995, 218 fishes were examined for parasites. Of these fishes, 13 species were infected with a total of 5 species of acanthocephalans between 1993 and 1995. Those 13 fish species (including family and number examined and dates parasites collected in parentheses) are as follows: *Allanetta forskali* (Ruppell, 1828), Atherinidae (6, June 1993); *Hemiramphus marginatus* Forskal, 1775, Hemiramphidae (7, June, July, October 1993); *Liza macrolepis* (Smith, 1849) Mugilidae (1, May 1995); *Mulloidichthys auriflamma* Forskal, 1775, Mullidae (11, June, July 1993); *Leiognathus bindus* (Cuvier and Valenciennes, 1835) Leiognathidae (11, March 1995); *Leiognathus fasciatus* (Lacépède, 1798), Leiognathidae (4, June 1993); *Lagocephalus lunaris* (Bloch and Schneider, 1801) Tetraodontidae (9, March 1995); *Dorosoma nasus* (Bloch, 1795), Clupeidae (11, October, December 1993, January 1994); *Acanthopagrus berda* (Forskal, 1775), Sparidae (8, December 1993);



Figures 1–7. ***Neoechinorhynchus dimorphospinus*** **sp. n. 1. Allotype female. 2. Proboscis of a paratype female. 3. Reproductive system of a paratype female; note nucleated cells surrounding vagina. 4. Ripe eggs from the body cavity of female in Figure 3. 5. Holotype male. 6. Presoma of a paratype female showing the relationship between the proboscis and proboscis receptacle. 7. Bursa and cirrus of a paratype male.**

Platycephalus indicus (Linnaeus, 1758) Platycephalidae (6, December 1993); *Upeneus sulphureus* Cuvier et Valenciennes, 1824, Mullidae (8, December 1993); *Pseudorhombus arsius* (Hamilton-Buchanan, 1827), Bothidae (18, February 1994, May 1995); and *Synaptura orientalis* (Bloch and Schneider, 1801), Soleidae (6, February 1994). Worms were fixed in 70% ethanol under slight coverglass pressure, stained in Mayer's acid carmine, dehydrated in ascending concentrations of ethanol, cleared in graded terpineol–100% ethanol, and mounted in Canada balsam.

Measurements are in micrometers unless otherwise stated. The range is followed by mean values (in parentheses). Width measurements refer to maximum width. Body (=trunk) length does not include neck, proboscis, or male bursa. The male reproductive system occupies the area between the anterior margin of the anterior testis and the posterior end of the trunk. Eggs refer to fully developed shelled acanthors measured in situ through the body wall of females. Specimens are deposited in the U.S. National Parasite Collection (USNPC), Beltsville, Maryland (Dr. J. R. Lichtenfels, Curator).

Results

Neoechinorhynchus dimorphospinus sp. n. (Figs. 1–7)

Amin et al. (1984) reported 4 female specimens of an undescribed species of *Neoechinorhynchus* Stiles and Hassall, 1905, from *L. macrolepis* and *P. arsius*. This material was considered inadequate for description purposes. The present collection included males and more females sufficient to produce a complete description. One of the females from the Amin et al. (1984) report (USNPC No. 77427) is now designated as the allotype female of the new species. Female measurements include those from that earlier report.

Fifteen gravid females and 6 mature adult males (5 with sperm) were collected from 3 of 6 examined *A. forskali* (8 female, 1 male worms),

from 3 of 11 *D. nasus* (4 females, 5 males), and from 1 *L. macrolepis* (3 females).

Description

GENERAL: Neoechinorhynchidae, Neoechinorhynchinae; with characters of the genus. Shared structures larger in females than in males. Trunk cylindrical and widest in anterior half, particularly in younger adults but with more parallel sides in older and larger specimens; with 6 dorsal giant subcuticular nuclei and 2 ventral ones. Proboscis wider than long with the 2 lateral hooks in anterior ring longer and more vertically directed than the other 4 hooks in the same ring; all hooks rooted; roots with prominent anterior and posterior manubria; hooks in 2nd and 3rd rings progressively smaller. Proboscis receptacle considerably longer than proboscis with brain at its posterior end. Lemnisci near equal, considerably longer than proboscis receptacle.

MALES (based on 5 specimens): Trunk 2.970–6.660 (4.430) mm long by 330–660 (462) wide. Proboscis 65–117 (82) long by 91–130 (104) wide. Two lateral hooks in anterior ring 59–96 (79) long, others in same ring 51–86 (66) long; hooks in middle ring 30–49 (38) long, in posterior ring 23–36 (30) long. Proboscis receptacle 325–585 (442) long by 78–169 (121) wide. Lemnisci 1.300–1.950 (1.595) mm long by 91–130 (108) wide. Reproductive system in posterior ⅔ of trunk: anterior testis 338–1,300 (682) long by 169–377 (273) wide, contiguous to and relatively larger than posterior testis 377–1,040 (630) long by 169–390 (243) wide; cement gland 143–182 (160) long by 104–143 (126) wide; cement reservoir prominent, overlaps cement gland posteriorly; 2 main cement ducts; Saefftigens pouch 312–585 (429) long by 143–390 (221) wide; bursa 195 long by 169 wide (one specimen).

FEMALES (based on 10 specimens): Trunk 3.135–15.411 (9.867) mm long by 330–880 (641) wide. Proboscis 86–117 (95) long by 96–156 (122) wide; 2 lateral hooks in anterior ring 59–105 (81) long, larger than others in same ring 51–92 (68) long; hooks in middle ring 26–53 (43) long, in posterior ring 26–40 (32) long. Proboscis receptacle 351–650 (483) long by 91–195 (138) wide. Lemnisci 2.240–2.730 (2.596) mm long by 143–195 (160) wide. Reproductive system robust, compact, and highly muscular with nucleated cells surrounding the vagina and at base of uterine bell. Ripe eggs oblong without prolongation of fertilization membrane, 29–36 (32) long by 9–13 (10) wide.

Taxonomic Summary

TYPE HOST: *Dorosoma nasus* (Bloch, 1795) (Clupeidae).

OTHER HOSTS: *Allanetta forskali* (Ruppell, 1828) (Atherinidae), *Liza macrolepis* (Smith, 1849) (Mugilidae), and *Pseudorhombus arsius* (Hamilton-Buchanan, 1827) (Bothidae).

SITE OF INFECTION: Intestine.

TYPE LOCALITY: Arabian Gulf off the coast of Kuwait.

SPECIMENS DEPOSITED: USNPC No. 85944 (holotype male); No. 77427 (originally of Amin et al., 1984) (allotype female); No. 85945 (paratypes).

OTHER SPECIMENS EXAMINED: USNPC No. 77428 of Amin et al. (1984) and *Neoechinorhynchus doryphorus* Van Cleave and Bangham, 1949, type material (USNPC Nos. 37136, 37634, 65067, 37136.00, 37634.00, 65067.00).

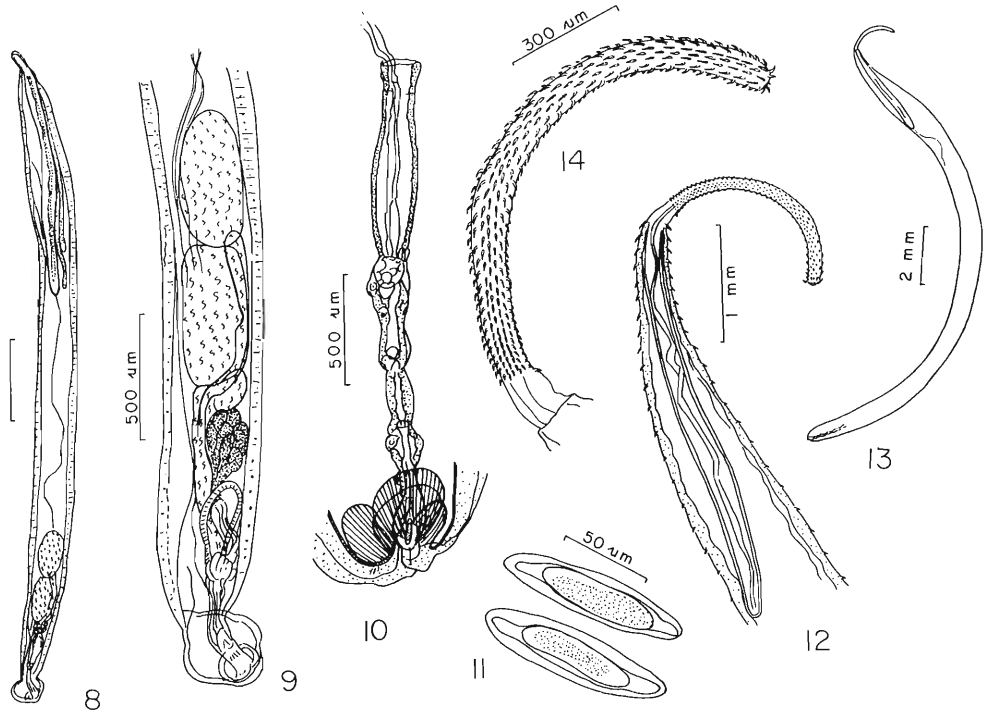
ETYMOLOGY: The new species is named for its dimorphic terminal proboscis hooks.

Remarks

Neoechinorhynchus doryphorus from a brackish water fish, *Jordanella floridae* Good and Bean, of the Englewood area in Florida is the only other fish acanthocephalan with lateral terminal proboscis hooks distinctly larger than dorsal and ventral hooks in the same ring. The 2 highly modified lateral terminal hooks of *N. doryphorus* are markedly larger (105–132) than those of *N. dimorphospinus* sp. n. Its (*N. doryphorus*) eggs are also considerably larger (48–55 by 14–16) and with a small rounded polar prolongation of the fertilization membrane. Van Cleave and Bangham (1949) included only 4 figures of 2 proboscides and 2 anterior hooks and provided a brief account of a few females' trunks, hooks, and egg measurements; 1 male allotype was included in the type material listed. Examination of the poorly processed and mounted (apparently in Permount) holotype female and other paratypes revealed no internal structures, rendering further comparison with our material impossible.

Tegorhynchus holospinosus sp. n. (Figs. 8–14)

The present material is recognized in the genus *Tegorhynchus* Van Cleave, 1921, as defined by



Figures 8–14. ***Tegorhynchus holospinus*** **sp. n. 8. Holotype male; proboscis is retracted. 9. Details of the reproductive system of the holotype male. 10. Reproductive system of allotype female showing internal fan-shaped muscles at posterior end. 11. Ripe eggs in the body cavity of a paratype female. 12. Presoma of a paratype female showing the slender and long proboscis and proboscis receptacle. 13. Allotype female; lemnisci, trunk spines, and reproductive cells not shown. 14. A greater magnification of proboscis of female in Figure 12.**

Bullock and Mateo (1970) to include its junior synonym *Illiosentis* Van Cleave and Lincicome, 1939. Reservations expressed by Leotta et al. (1982) regarding the internal fan-shaped muscles attached to the transverse cleft at the posterior end of female *Illiosentis* only have already been addressed by Bullock and Mateo (1970). Van Cleave and Lincicome (1939) previously indicated that the proboscis surface of both *Illiosentis* and *Tegorhynchus* have similarly "conspicuous investing cuticula," and Van Cleave (1945) removed the genital spines from consideration as a generic character. This synonymy, recognized by Amin (1985), is considered valid and is retained herein.

Eighty-one specimens (38 females and 43 males) were collected from the intestines of 2 of 4 examined *L. fasciatus,* 2 of 18 *P. arsius,* and 2 of 11 *L. bindus.*

Description

GENERAL: Illiosentidae; with characters of the genus. Shared structures larger in females than in males. Trunk cylindrical, long, and slender and covered totally with cuticular spines (except the genital orifice in females and posteriormost end of males behind level of Saefftigen's pouch. Trunk spines in complete nonrandom rings very close together anteriorly and become progressively smaller in more widely spaced rings posteriorly. Proboscis bent ventrally, long and cylindrical, widest near its posterior end, where it joins the equally wide and slightly conical neck. Proboscis hooks in 14 longitudinal rows, larger ventrally than dorsally; largest hooks in anterior half of proboscis and become progressively smaller and more closely spaced *posteriorly* with posteriormost circle including only ventral enlarged modified hooks. Sensory papillae between 1st and 2nd complete posterior circles of proboscis hooks. Proboscis receptacle about twice as long as proboscis with brain at its anterior end. Leminisci near equal, slightly shorter than proboscis receptacle.

MALES (based on 15 mature adults with sperm): Trunk 3.135–8.580 (6.135) mm long by 231–

561 (412) wide. Proboscis 1.155–1.485 (1.320) mm long by 99–132 (108) wide. Proboscis hooks 29–32 (31) per longitudinal row; largest dorsal hooks 32–43 (38) long by 5–6 (5) wide at base; largest ventral hooks 46–49 (48) long by 13–16 (14) wide at base; ventral hooks in posteriormost complete circle 16–23 (20) long; enlarged basal ventral hooks 23–33 (27) long. Proboscis receptacle 1.815–2.970 (2.396) mm long by 99–198 (142) wide. Lemnisci 1.419–2.145 (1.838) mm long by 49–99 (64) wide. Reproductive system at posterior end of trunk. Testes oblong, in tandem, contiguous; anterior testis 325–676 (546) long by 143–286 (214) wide; relatively smaller posterior testis 273–702 (455) long by 156–286 (214) wide; pear-shaped cement glands, 78–143 (124) long by 39–130 (76) wide. Saefftigen's pouch 221–481 (304) long by 91–208 (159) wide; well-developed sperm duct and vesicle; bursa 195–416 (326) long by 195–390 (299) wide. Gonopore terminal.

FEMALES (based on 18 gravid specimens): Trunk 7.425–19.140 (13.084) mm long by 429–900 (643) wide. Proboscis 1.320–1.815 (1.563) mm long by 99–165 (128) wide. Proboscis hooks 36–40 (38) per longitudinal row. Largest dorsal hooks 33–47 (39) long by 5–6 (5) wide at base; largest ventral hooks 50–60 (53) by 16–20 (18) at base; ventral hooks in posteriormost complete circle 16–27 (22) long; enlarged basal ventral hooks 27–33 (29) long. Proboscis receptacle 2.475–3.630 (2.825) mm long by 132–231 (187) wide. Lemnisci 2.145–2.871 (2.535) mm long by 50–132 (80) wide. Reproductive system as in Figure 10. Eggs elliptical with polar prolongation of fertilization membrane, 93–105 (98) long by 20–25 (22) wide. Posterior end of trunk with internal fan-shaped muscles attached to transverse cleft associated with dorsoterminal gonopore.

Taxonomic Summary

TYPE HOST: *Pseudorhombus arsius* (Hamilton-Buchanan, 1827) (Bothidae).

OTHER HOSTS: *Leiognathus fasciatus* (Lacépède, 1798) and *Leiognathus bindus* (Cuvier and Valenciennes, 1835) (Leiognathidae).

SITE OF INFECTION: Intestine.

TYPE LOCALITY: Arabian Gulf off the coast of Kuwait.

SPECIMENS DEPOSITED: USNPC No. 85947 (holotype male); No. 85948 (allotype female); No. 85949 (paratypes).

ETYMOLOGY: The species is named for its extensive trunk spination covering almost the whole body of males and females.

Remarks

Pseudorhombus arsius becomes the type host because the best available male (holotype) was from that fish species; *L. fasciatus* was considerably more heavily and frequently infected.

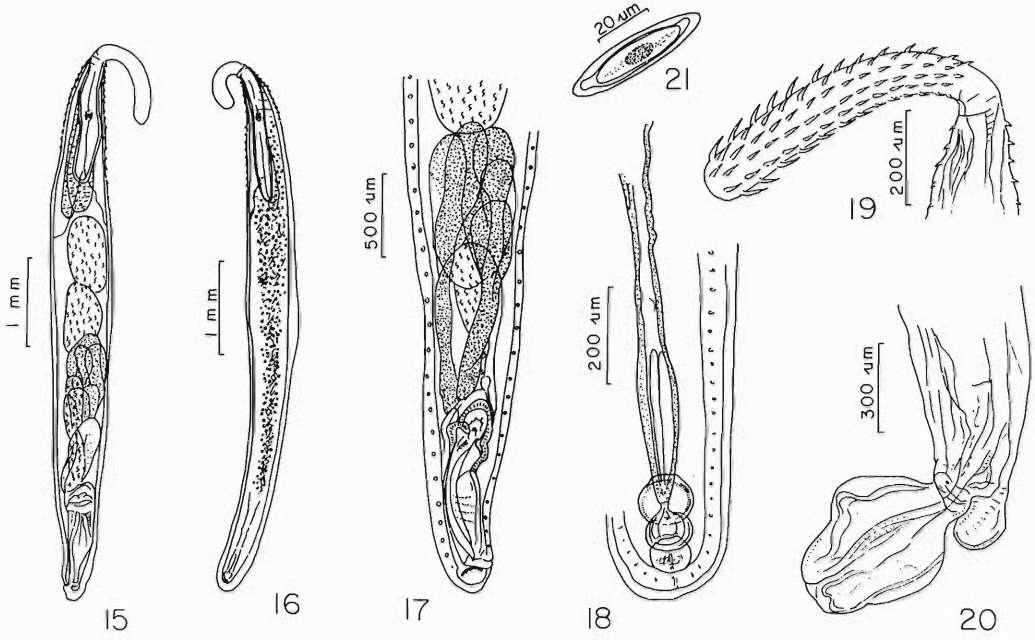
Tegorhynchus holospinosus sp. n. is distinguished from those of the genus *Dollfusentis* Golvan, 1969, by the absence of large separated crescent hooks at the base of the proboscis and the presence of internal fan-shaped muscles at the posterior end of females. It is the only species of the genus *Tegorhynchus* with cuticular spines covering almost the whole trunk of males and females. The other species of the genus have more limited trunk spination. These are *Tegorhynchus africanus* (Golvan, 1955) Amin, 1985; *Tegorhynchus brevis* Van Cleave, 1921; *Tegorhynchus cetratus* (Van Cleave, 1945) Bullock and Mateo, 1970; *Tegorhynchus edmondsi* (Golvan, 1960) Amin, 1985; *Tegorhynchus furcatus* (Van Cleave and Lincicome, 1939) Bullock and Mateo, 1970; and *Tegorhynchus multacanthus* (Mamaev, 1970) comb. n. (=*Illiosentis multacanthus* Mamaev, 1970). *Tegorhynchus pectinarius* Van Cleave, 1940, is believed to belong to another genus (see Bullock and Mateo, 1970). Of the preceding species, *T. multacanthus* has the largest distribution of cuticular spines covering the anterior half of males and females, with an additional group of spines near the posterior end of females (Mamaev, 1970). It is the closest species to *T. holospinosus* sp. n. anatomically but differs further from it by having more proboscis hooks per row (43–48 that may reach 61 ventrally or 65 dorsally) and smaller eggs (70–73 by 14–15).

Micracanthorhynchina kuwaitensis sp. n. (Figs. 15–21)

Twenty-four specimens (12 males, 12 females) were collected from 4 of 7 examined *H. marginatus*.

Description

GENERAL: Rhadinorhynchidae, Gorgorhynchinae; with characters of the genus. Shared structures larger in females than in males. Trunk cylindrical, of medium length, cigar-shaped, slightly wider at middle and gradually tapering toward blunt extremities; with pronounced subcuticular nuclei thoughout its length at regular intervals; and with anterior trunk spines forming



Figures 15–21. ***Micracanthorhynchina kuwaitensis*** **sp. n. 15. Holotype male. 16. Allotype female. 17. Reproductive system of a paratype male; sperm duct overlaps the portion of Saefftigen's pouch between cement ducts. 18. Reproductive system of the allotype female in Figure 16. 19. Proboscis of a paratype male. 20. Subterminal gonopore and bursa of a paratype male. 21. A ripe egg from the body cavity of a paratype female.**

complete rings anteriorly then extending posteriorly only on the ventral side up to the level of the posterior end of the proboscis receptacle. Proboscis bent ventrally, mildly club-shaped and of medium length. Proboscis hooks slender in 12 longitudinal rows of 13–15 (14) hooks each that are not dorsoventrally differentiated; hooks largest near middle of proboscis and progressively decrease in size posteriorly to become small spines; roots simple with anterior manubria. Prominent conical neck. Proboscis receptacle extends into neck to base of proboscis, slightly longer than proboscis, and with brain near its middle. Lemnisci plump and somewhat longer than proboscis receptacle.

MALES (based on 10 mature adults with sperm): Trunk 3.465–5.280 (4.364) mm long by 462–792 (600) wide, with cuticular spines in 14–18 (16) rings including 8–12 (11) anterior complete ones. Proboscis 650–858 (749) long by 130–208 (167) wide. Largest proboscis hooks 66–76 (70) long. Proboscis receptacle 780–1,235 (993) long by 130–208 (176) wide. Lemnisci almost reaching anterior testis, 910–1,430 (1,250) long by 117–260 (173) wide. Reproductive system in posterior ⅔–¾ of body; testes oblong-ovoid, in tandem contiguous; anterior testis 455–715 (598) long by 221–390 (289) wide; posterior testis about equal in size, 364–988 (614) long by 221–429 (320) wide. Cement glands large 260–650 (474) long by 130–364 (203) wide, in 2 clusters each with a long duct; gonopore subterminal; bursa (in 1 specimen) 532 long by 420 wide.

FEMALES (based on 9 gravid specimens): Trunk 3.960–7.194 (5.709) mm long by 462–924 (590) wide with spines in 18–22 (19) rings including 10–15 (12) anterior complete ones. Proboscis 650–858 (762) long by 169–208 (185) wide. Largest proboscis hooks 69–79 (73) long. Proboscis receptacle 663–1,430 (1,074) long by 143–195 (169) wide. Lemnisci 1.235–1.755 (1.495) mm long by 117–260 (188) wide. Reproductive system highly muscular with terminal gonopore. Eggs elliptical with polar prolongation of fertilization membrane 49–53 (50) long by 13–17 (16) wide.

Taxonomic Summary

TYPE HOST: *Hemiramphus marginatus* Forskal, 1775 (Hemiramphidae).

SITE OF INFECTION: Intestine.

TYPE LOCALITY: Arabian Gulf off the coast of Kuwait.

SPECIMENS DEPOSITED: USNPC No. 85950 (holotype male); No. 85951 (allotype female); No. 85952 (paratypes).

ETYMOLOGY: The new species is named for its type locality.

Remarks

The new species is distinguished from all other members of the genus *Micracanthorhynchina* Strand, 1936 (=*Micracanthocephalus* Harada, 1938) by proboscis armature (with largest number of proboscis hooks per row: 13–15), among other features. The following key distinguishes the new species from the other 6 valid species of the genus. These are *Micracanthorhynchina cynoglossi* Wang, 1980; *Micracanthorhynchina dakusuiensis* (Harada, 1938) Ward, 1951; *Micracanthorhynchina hemiculturus* Demshin, 1965; *Micracanthorhynchina hemirhamphi* (Baylis, 1944) Ward, 1951 (=*Bolbosentis sajori* Belous, 1952; *Micracanthorhynchina sajori* (Belous, 1952) Golvan, 1969); *Micracanthorhynchina laterolabracis* Wang, 1980; and *Micracanthorhynchina motomuri* (Harada, 1938) Ward, 1951. Two other species are considered invalid and are not included in the key. These are (1) *Micracanthorhynchina segmentata* (Yamaguti, 1959) Araki and Machida, 1987 (=*Allorhadinorhynchus segmentatus* Yamaguti, 1959), and (2) *Micracanthorhynchina indica* Farooqi, 1980, which was only reported once in the Third National Congress of Parasitology meeting at Haryana Agricultural University, Hissar, India (24–26 April 1980); the abstract (Farooqi, 1980) included only the name of the species. Attempts to obtain more information from the author were unsuccessful. This species will have to be regarded as invalid until a formal and complete description is published, including a designation of type material deposited at a recognized institute or museum.

Key to Species of *Micracanthorhynchina*

1. Proboscis with 14 longitudinal rows of hooks 2
   Proboscis with 12 longitudinal rows of hooks 3
2. Lemnisci about as long as proboscis receptacle; testes small in posterior half of trunk ..... *M. cynoglossi*
   Lemnisci longer than proboscis receptacle; testes large in middle of trunk ..... *M. lateolabracis*
3. Proboscis hooks 13–15 per row ..... *M. kuwaitensis* sp. n.
   Proboscis hooks fewer than 13 per row 4
4. Largest proboscis hooks reaching 120 long anteriorly ..... *M. hemirhamphi*
   Largest proboscis hooks considerably shorter 5
5. Proboscis hooks 12 per row ..... *M. hemiculturus*
   Proboscis hooks 8 or 9 per row 6
6. Small worms: males 1.6–3.5 by 0.5 mm, females 4.5 by 0.6 mm; with 10–11 dorsal and 18–22 ventral rings of trunk spines; eggs 40 by 16 ..... *M. motomurai*
   Larger worms: males 4.0 by 0.8 mm, females 7.6 by 1.3 mm; with 9 dorsal and 18 ventral rings of trunk spines; eggs 63 by 16 ..... *M. dakusuiensis*

Thirty-nine specimens (17 females and 22 males) of a new diplosentid genus were collected from the intestines of 2 of 11 *L. bindus* (17 females, 20 males) and 2 of 9 *L. lunaris* (2 males). The 2 *L. bindus* specimens were also concurrently infected with 6 male and 2 female *T. holospinus* sp. n. (earlier).

Slendrorhynchus gen. n.

Diagnosis

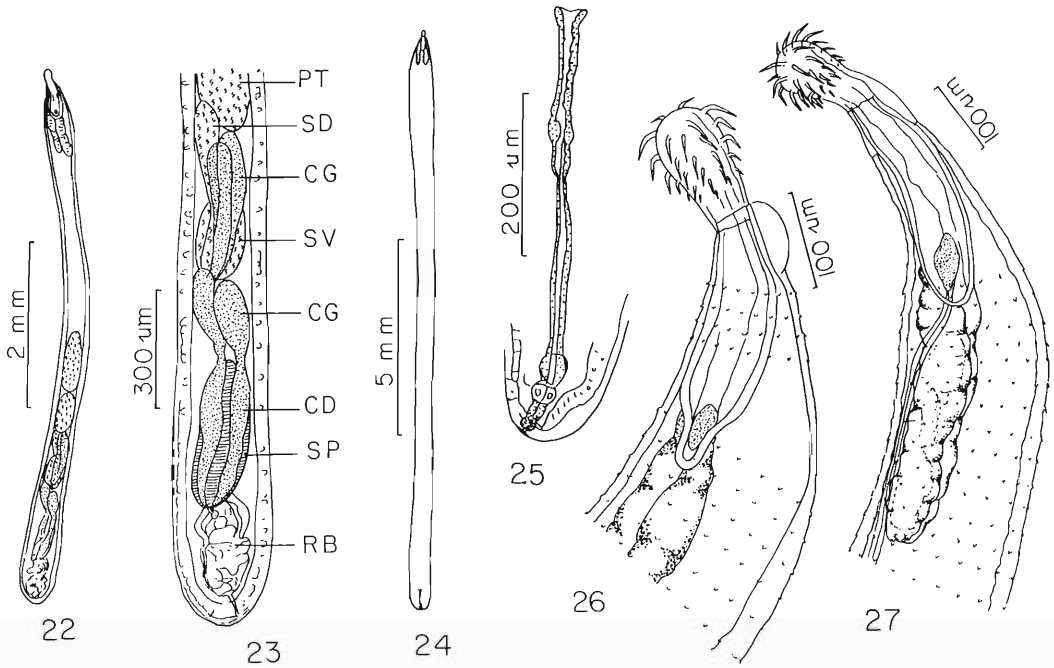
Diplosentidae, Allorhadinorhynchinae. Trunk long and slender, armed with many spines; developed spines in males in a few anterior circles separated from posterior extensive field of many circles of spines, usually with a spine free zone at the level of proboscis receptacle. In females, spines in anterior circles are vestigial or absent and may not be separated from posterior developed ones. Proboscis short and claviform; hooks few with simple roots. Proboscis receptacle about twice as long as proboscis with brain at its base. Lemnisci markedly longer than proboscis receptacle. Male reproductive system in posterior half of trunk; testes oblong, contiguous; cement glands 4; seminal vesicle, cement ducts, and Saefftigen's pouch prominent. Eggs fusiform with polar prolongation of fertilization membrane or with rounded ends. Gonopore nearly terminal.

TYPE SPECIES: *Slendrorhynchus breviclaviproboscis* sp. n.

Slendrorhynchus breviclaviproboscis sp. n. (Figs. 22–32)

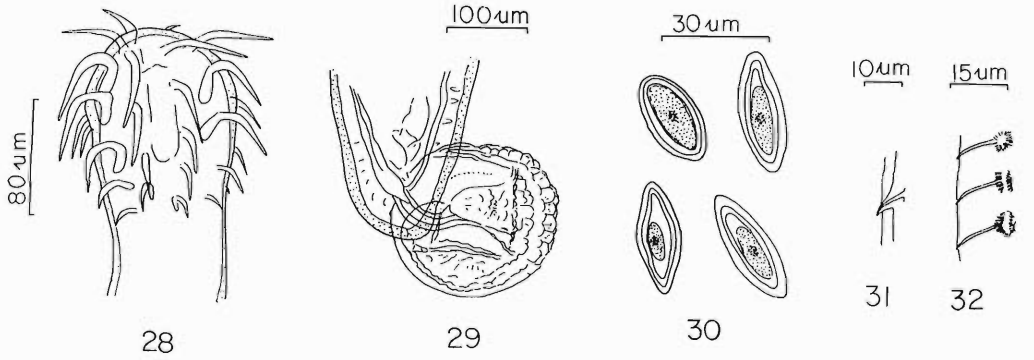
Description

GENERAL: With characters of the genus. Shared structures larger in females than in males. Trunk almost uniformly cylindrical, very long



Figures 22–27. ***Slendrorhynchus breviclaviproboscis*** **gen. n., sp. n. 22. Holotype male; proboscis retracted. 23. Reproductive system of holotype male. CD = Cement duct, CG = cement gland, PT = posterior testis, RB = retracted bursa, SD = sperm duct, SP = Saefttigen's pouch, SV = seminal vesicle. 24. A paratype female showing slender body form. 25. Reproductive system of a paratype female. 26. Anterior part of a paratype male showing anterior and portion of posterior circles of developed trunk spines. 27. Anterior part of a paratype female showing a few anterior circles of posterior trunk spines and barely visible cuticular projections more anteriorly. Trunk spines not shown in Figures 22–24. Body wall nuclei not shown in all figures.**

and slender particularly in females; slightly wider at posterior end but some large gravid females may be widest near anterior end. Body wall with many small round-ovoid nuclei dispersed throughout its length. Subcuticular area at anterior end of trunk, however, is clear and delimited from the rest of nucleated body wall to produce a collar-like structure that may become en-



Figures 28–32. ***Slendrorhynchus breviclaviproboscis*** **gen. n., sp. n. 28. Proboscis of a paratype female. 29. Bursa of a paratype male. 30. Eggs. 31. A trunk spine from the posterior field of a male. 32. Trunk spines with proximal branched ends from the posterior field of a female.**

larged dorsally into a hump. Developed trunk spines in circles extend from anterior end of trunk to level of posterior end of Saefftigen's pouch in males and shortly anterior to uterine bell in females. Pattern of anteriormost circles of developed spines variable. Those in first 4 circles in males are minute and separated from posterior circles of spines usually with a spine-free area at level of posterior half of proboscis receptacle. In females, fields of trunk spines may not be separated and spines of up to 8 or 9 anteriormost circles (level of whole length of proboscis receptacle) may be rudimentary, replaced by slightly pointed cuticular bumps, or completely absent. Anterior and posterior fields of trunk spines in males may rarely be bridged (more visible ventrally) with vestigial elements or cuticular bumps. Developed spines largest anteriorly but become progressively smaller as the circles become more widely spaced posteriorly. Posterior spines may have starlike-dendritic projections at their proximal end in some but not all females. Anterior end of trunk often bent ventrally. Proboscis short and claviform with 11 longitudinal rows of 5 slender hooks each; hooks not dorsoventrally differentiated, longest anteriorly and become progressively smaller posteriorly. Roots simple, unbranched, and directed more or less posteriorly. Neck prominent; slightly shorter than proboscis and narrowing posteriorly. Proboscis receptacle 2–3 times as long as proboscis with large brain at its base. Lemnisci near equal, about twice as long as proboscis receptacle. Posterior end of trunk bluntly rounded with gonopore ventroterminal.

MALES (based on 15 mature adults with sperm): Trunk 5.151–7.424 (6.355) mm long by 212–394 (314) wide with 2 fields of spines. Largest trunk spines 9–15 long. Proboscis 100–130 (111) long by 61–85 (75) wide. Longest anteriormost proboscis hooks 61–81 (73) long. Proboscis receptacle 231–277 (258) long by 77–92 (85) wide. Lemnisci 369–646 (506) long by 38–77 (56) wide. Reproductive system in posterior half of trunk. Testes oblong, in tandem, usually contiguous; anterior testis 385–1000 (554) long by 100–154 (129) wide; slightly shorter posterior testis 330–654 (480) long by 100–177 (132) wide. Four well-developed claviform-fusiform cement glands, each 169–231 (200) long by 54–92 (71) wide, arranged in 2 pairs, with long cement ducts emptying at base of prominent Saefftigen's pouch 231–385 (304) long by 77–138 (98) wide. Sperm duct and seminal vesicle well developed. Bursa 123–230 (194) long by 154–230 (196) wide, with scalloped posterior margin.

FEMALES (based on 8 gravid females): Trunk 12.424–20.303 (15.035) mm long by 303–484 (404) wide. Largest spines 15–18 long. Proboscis 100–123 (111) long by 85–92 (87) wide. Longest anteriormost proboscis hooks 70–91 (79) long. Proboscis receptacle 246–369 (300) long by 77–100 (86) wide. Lemnisci 615–669 (646) long by 77–85 (80) wide. Reproductive system as in Figure 25. Eggs fusiform with polar prolongation of fertilization membrane but sometimes with rounded ends, 24–33 (30) long by 15–18 (16) wide.

Taxonomic Summary

TYPE HOST: *Lagocephalus lunaris* (Block and Schneider, 1801) (Tetraodontidae).

OTHER HOST: *Leiognathus bindus* (Cuvier and Valenciennes, 1835) (Leiognathidae).

SITE OF INFECTION: Intestine.

TYPE LOCALITY: Arabian Gulf off the coast of Kuwait.

SPECIMENS DEPOSITED: USNPC No. 85953 (holotype male), No. 85954 (allotype female), No. 85955 (paratypes).

ETYMOLOGY: The new genus is named for its long and slender trunk and the specific name for the size and shape of the proboscis.

Remarks

Slendrorhynchus gen. n. is unique among the palaeacanthocephalans for the combination of its long and slender trunk, pattern and distribution of trunk spines, and short proboscis with few hooks. It is herein assigned to the family Diplosentidae Tubangui and Masilungan, 1937, and subfamily Allorhadinorhynchinae Golvan, 1969. Members of Allorhadinorhynchinae are armed with trunk spines, whereas those of the other subfamily, Diplosentinae Golvan, 1969, are unarmed. *Slendrorhynchus* gen. n. appears to have been originally (evolutionary) armed with 1 continuous field of trunk spines extending from the anterior end of the trunk to near its posterior end in both sexes, as suggested by the occasional presence of reduced-vestigial spine elements or corresponding cuticular bumps in "spine-free" areas interrupting the continuity of this field in some individual females (anteriorly) or males (between anterior and posterior circles of developed spines). This one field proposition brings the diagnosis of the new genus to agreement with that of the subfamily Allorhadinorhynchinae: "Diplosenti-

dae dont le tronc est orne, dan sa partie anterieure, d'un seul champ d'epines cuticulaires" (Golvan, 1969, p. 149). However, the subfamily diagnosis needs to be emended to include genera with cuticular spines not restricted to the anterior part of the trunk as follows: Diplosentidae with trunk anteriorly to entirely spined; some spines may be secondarily reduced or absent.

Slendrorhynchus gen. n. is distinguished from the 2 other monotypic genera of Allorhadinorhynchinae as follows. *Allorhadinorhynchus* has only anterior trunk spines, brain at middle of proboscis receptacle, lemnisci shorter than receptacle, and 2 cement glands. *Golvanorhynchus* has only anterior and irregularly distributed trunk spines, long proboscis, lemnisci about as long as proboscis receptacle, and 6 cement glands.

Serrasentis sagittifer (Linton, 1889) Van Cleave, 1923

The intestinal mesenteries of 6 species of fish were infected with a total of 18 encysted juveniles of *S. sagittifer*. These are *A. berda* (1 of 8 examined fish was infected with 1 worm [⅛, 1]), *M. auriflamma* (2/11, 2), *P. indicus* (1/6, 1), *P. arsius* (1/14, 8), *S. orientalis* (1/6, 1), and *U. sulphureus* (⅛, 5). All fish species appear to represent new host records. The general anatomy and measurements were comparable to those reported by Amin et al. (1984) from 5 additional fish species in the same waters.

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Helminth Communities in the Northern Spring Peeper, *Pseudacris c. crucifer* Wied, and the Wood Frog, *Rana sylvatica* Le Conte, from Southeastern Wisconsin

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ABSTRACT: Fifteen spring peepers and 20 wood frogs were collected in April 1993 from 2 temporary ponds in southeastern Wisconsin. Five species of adult and larval nematodes, 4 species of adult and larval trematodes, and 1 larval cestode infected wood frogs. Spring peepers harbored 1 adult and 1 larval nematode species as well as 1 adult and 5 larval trematode species. Sixteen of 20 (80%) wood frogs were infected with helminths. Mean species richness and mean helminth abundance were 2.15 and 4.90, respectively. Eight of 15 (53%) spring peepers were infected. Only 1 individual was infected by more than 1 helminth species and only 1 parasite species infected more than 1 spring peeper. Low prevalence and intensities of helminths as well as low diversity within infracommunities suggest depauperate, isolationist helminth communities in these 2 populations of anurans. This work represents new records for 5 helminth species in Wisconsin wood frogs and 3 helminth species in Wisconsin spring peepers.

KEY WORDS: *Rana sylvatica, Pseudacris crucifer, Oswaldocruzia pipiens, Cosmocercoides dukae, Rhabdias ranae, Glypthelmins pennsylvaniensis, Hematoloechus varioplexus, Fibricola texensis, Alaria mustelae,* diplostomula, mesocercaria, Wisconsin.

Rana sylvatica Le Conte is found from New Brunswick to eastern Manitoba and south to Georgia and eastern Texas (Vogt, 1981). The range of *Pseudacris crucifer* Wied extends from Alaska to Labrador and from northeastern Georgia to northeastern North Dakota in the south (Vogt, 1981). Both inhabit woodland areas throughout Wisconsin (Vogt, 1981), yet relatively little work has been done on the helminth communities of these anurans (Harwood, 1930; Walton, 1931; Brandt, 1936; Rankin, 1945; Bouchard, 1951; Odlaug, 1954; Najarian, 1955; Ashton and Rabalais, 1978; Adamson, 1980; Williams and Taft, 1980; Coggins and Sajdak, 1982; Muzzall and Peebles, 1991; McAllister et al., 1995). Of the aforementioned studies, only 2 were concerned with Wisconsin amphibians. Williams and Taft (1980) included 5 wood frogs in their study. Coggins and Sajdak (1982) sampled, among several other amphibian species, 2 spring peepers and 1 wood frog. The present study reports 5 new species of helminth parasites from Wisconsin wood frogs and 3 new species from Wisconsin spring peepers.

Materials and Methods

Twenty wood frogs and 15 spring peepers were collected by dip-net from 2 temporary ponds adjacent to the University of Wisconsin–Milwaukee field station in Ozaukee County, Wisconsin, during April 1993. Frogs were transported to the laboratory, where they were euthanized in MS-222. Snout–vent length (SVL) and wet weight (g) were recorded. The external surfaces as well as the mouth and eustachian tubes, the internal organs, including the brain, and the musculature of the limbs were examined for the presence of helminth parasites. Trematodes were relaxed and fixed in hot formalin alcohol acetic acid, whereas nematodes were killed and preserved in 70% ethanol. Voucher specimens have been sent to the H. Manter Helminth Collection, University of Nebraska, Lincoln (HWML 38396–38405). Prevalence and mean intensity were calculated for helminth species, and Brillouin's index of diversity (Pielou, 1977) was calculated for wood frog infracommunities. Brillouin's index is recommended by Pielou (1977) for fully censused communities and includes both richness and evenness of species.

Results

Sixteen of 20 (80%) wood frogs were infected with helminths. Mean helminth abundance in *R. sylvatica* was 4.90 (SD = 6.94). Mean species richness was 2.15 species per host individual (SD = 1.66, range = 0–6). No significant correlation was found between SVL and abundance ($r = -0.32$) or wet weight and abundance ($r = -0.32$). No correlation was found between these 2 host parameters and species richness ($r = -0.12$, $r = -0.14$).

Five nematode species, 4 trematode species, and 1 cestode species were found within the component community of *R. sylvatica. Oswaldocruzia pipiens* Walton, 1929, was found most frequently in wood frogs with 40% prevalence and mean intensity of 2.75 (SD = 4.2, range = 1–13).

Table 1. Prevalence and mean intensity of helminths of *Rana sylvatica* and *Pseudacris crucifer*.

	Rana sylvatica		*Pseudacris crucifer*		
	Prevalence %	Mean intensity (range)	Prevalence	Intensity	Location
Nematoda					
Oswaldocruzia pipiens	40	2.75 (1–13)	a†		Stomach, small intestine, and large intestine
Cosmocercoides dukae	15	1.67 (1–3)	a		Adults in rectum, larvae in lungs and small intestine
Rhabdias ranae	20	3.0 (1–7)	6.67	1	Lungs
Immature nematodes	10	*	a		Rectum and large intestine
Encysted nematodes	5	*	6.67	*	Small intestine mesentery
Trematoda					
Glypthelmins pennsylvaniensis	a		6.67	2	Small intestine
Haematoloechus varioplexus	25	2.4 (1–4)	a		Lungs
Fibricola texensis (Diplostomula)	35	3.57 (1–8)‡	6.67	4	Musculature and body cavity
Alaria mustelae (Mesocercariae)	5	5	13.33	3	Body cavity and rectal area
Unidentified metacercariae	30	1.67 (1–3)	6.67	21	Liver and leg muscles
Unidentified mesocercariae	a		6.67	5	Leg muscles
Unidentified immature trematode	a		6.67	1	Lung
Cestoda					
Unidentified cestode cysts	5	*	a		Organ mesentery

* Too numerous to count accurately.
† Absent in this host.
‡ Number actually recovered and most probably an underestimate.

Diplostomula of *Fibricola texensis* Chandler, 1942, were found with the highest mean intensity (3.57, SD = 3.05, range = 1–8). These latter values are probably underestimates, as these small, white larvae are difficult to find in the muscles. Values of prevalence and mean intensity for all parasites are summarized in Table 1.

Brillouin's index of diversity (Pielou, 1977) was calculated for all wood frog infracommunities using natural logarithms and included all helminth species that could be accurately counted. Mean Brillouin's diversity (H) was 0.379 (SD = 0.346, range = 0–1.15).

Eight of 15 spring peepers (53%) were infected with 1 or more helminth species. Mean abundance and mean species richness were 2.67 (SD = 5.72) and 0.6 (SD = 0.63), respectively. Only 2 adult worms were found in this component community: the nematode *Rhabdias ranae* Walton, 1929, and the digenetic trematode *Glypthelmins pennsylvaniensis* Cheng, 1961. These were found in only 1 host individual, both with an intensity of 1 worm per frog. All other helminths harbored by spring peepers were larval forms. Only the mesocercariae of *Alaria mustelae* Bosma, 1931, were found in more than 1 host individual. Only 1 spring peeper harbored more than 1 species of helminth, both larval forms. Consequently, it was unnecessary to calculate Brillouin's index for these infracommunities. Dip-net sampling during the breeding season proved to be biased toward males, as only 1 female of each species was taken. Consequently, no analysis was carried out on the basis of host sex.

Discussion

In this system, *R. sylvatica* harbored a variety of adult and larval helminths whereas *P. crucifer* seemed to serve most often as an intermediate host for helminth parasites. Additionally, the number of parasite species in the compound community, species richness at the infracommunity level, prevalence of parasites, and, with 1 exception, intensities were low in *P. crucifer* as compared to *R. sylvatica*. There exist several potential explanations for these results. First, spring peepers are considered to be tree frogs (Vogt, 1981) and are more arboreal in habit than wood frogs. This would limit their contact with soil and possibly skin-penetrating nematodes such as *R. ranae* and *O. pipiens* during most of the year. Thus, the breeding migration and emergence period would be especially important as windows

of transmission in spring peepers. Aho (1990) found the helminth communities of arboreal anurans to consist of fewer species than the communities of terrestrial anurans. Baker (1978, 1979b) found both *R. ranae* and *O. pipiens* to be most prevalent in Ontario wood frogs during late summer and fall and suggested that most transmission occurred during this time when young frogs were emerging from ponds. Additionally, there exist differences in body and gape size between these 2 anurans. Although no analysis of size-based differences in infection parameters was carried out between species, these factors may be important in terms of the probability of penetration by skin penetrators and the range of intermediate hosts ingested. These factors should be inspected more carefully in future studies. Finally, some of the helminths in this study infect both anuran species as well as other amphibia in the system. Host specificity and the assemblage of parasites at the compound community level are most likely important factors in structuring helminth infracommunities.

Although the component community of *R. sylvatica* contains species that infect similar regions of the frog body, it was rare in this study to observe more than 1 species of helminth in the same location within a given host. This would make interaction between species unlikely. In the present survey, only 3 wood frogs provided exceptions. Two of these cases involved the diplostomula of *F. texensis* and an unidentified metacercaria in the leg muscles. The third case was an unusually heavily infected wood frog that harbored 13 *O. pipiens* in its anterior small intestine along with 3 adult nematodes that could not be positively identified. These may have been damaged specimens of *O. pipiens,* but this can not be stated with certainty. One frog harbored both *Haematoloechus varioplexus* Stafford, 1902, and *R. ranae,* both of which infect the lung. In this frog, however, only 1 individual of each helminth species was recovered, and they were occupying different lungs. Within this system, it seems that the lungs of *R. sylvatica* are areas of potential interaction between these 2 helminth species. The mean intensities of each were found to be greater than 1, both were found in relatively high prevalence, and adults of both species are large relative to the frog lungs they inhabit. Baker (1979a) observed many more subadult *R. ranae* in the body cavity than adults in the lung, and Anderson (1992) suggested that this species may utilize some mechanism for avoiding intraspecific competition. Although no definitive conclusion can be reached from the present study, it is reasonable to suggest that some active avoidance of interaction between these 2 species is a possibility in those, apparently rare, situations in which both species infect a single host. Furthermore, this possibility is worthy of closer examination in future work.

Although the component communities of both anurans contain a variety of helminth taxa, prevalence, intensity, and species diversity are quite low at the infracommunity level. These values are indicative of depauperate, isolationist helminth communities. The assemblage of parasites in the component community of wood frogs in this study is similar to the findings of Muzzall and Peebles (1991), as are the relative orders of prevalence and intensity values. Muzzall and Peebles (1991) recovered *Spiroxys* sp., which was not found in our study. They reported *Haematoloechus parviplexus* Irwin, 1929, which Kennedy (1981) considers a synonym for *H. varioplexus* Stafford, 1902. Also recovered in this study were 4 larval forms not found in Michigan by Muzzall and Peebles (1991); *Fibricola texensis,* whose definitive host is the raccoon (Chandler, 1942), and *Alaria mustelae,* which utilizes mustelids, felids, and canids as definitive hosts (Pearson, 1956; Johnson, 1970). Additionally, an unidentified encysted nematode and an unidentified cestode cyst were recovered. To our knowledge, this is a new locality record for *F. texensis.*

Muzzall and Peebles (1991) found *O. pipiens* and *Cosmocercoides* sp. in spring peepers in relatively low prevalence, but these helminths were not recovered from *P. crucifer* in the present study. Due to their presence in wood frogs, these worms are known to be a part of the compound community, and failure to recover them from *P. crucifer* may be a function of low sample size.

The hypothesis that spring peepers and wood frogs in the Great Lakes region harbor depauperate, isolationist helminth communities is supported by this study. To our knowledge, this is the first report of *O. pipiens, C. dukae, H. varioplexus, F. texensis,* and *A. mustelae* in Wisconsin wood frogs and the first report of *R. ranae, F. texensis,* and *A. mustelae* in Wisconsin spring peepers.

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Oochoristica piankai sp. n. (Cestoda: Linstowiidae) and Other Helminths of *Moloch horridus* (Sauria: Agamidae) from Australia

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ABSTRACT: *Oochoristica piankai* sp. n., a new linstowiid cestode, discovered in the small intestine of the thorny devil, *Moloch horridus,* is described and illustrated. Sixteen specimens of *Oochoristica piankai* sp. n. were found in 8 of 104 (8%) *Moloch horridus* from Australia. *Oochoristica piankai* sp. n. differs from 3 other Australian species of *Oochoristica* from lizards in the number of testes and the shape of the ovary. The presence of the nematode *Parapharyngodon kartana* and an encysted larva of *Abbreviata* sp. are also reported. *Moloch horridus* represents a new host record for *P. kartana.*

KEY WORDS: *Oochoristica piankai* sp. n., cestode, *Parapharyngodon kartana, Abbreviata* sp., nematode, *Moloch horridus,* lizard, Agamidae, Australia.

Only 3 of 74 species of *Oochoristica* Lühe, 1898, a cosmopolitan genus of cestodes, have been reported previously from reptiles of Australia. *Taenia trachysauri* MacCallum, 1921, was described from specimens discovered in the intestine of the Australian lizard *Trachydosaurus rugosus* Gray, in the New York Zoological Garden. Baer (1927) moved *Taenia trachysauri* to the genus *Oochoristica.* Johnston (1932) reported *O. trachysauri* in *Trachdoysaurus rugosus.* Spasskii (1951), however, believed substantial differences existed between the specimens described by MacCallum (1921) and Johnston (1932) and established *Oochoristica australiensis* Spasskii, 1951, for Johnston's specimens. *Oochoristica vacuolata* Hickman, 1954, was described from the lizard *Egernia whitii* (Lacépède). Three additional species of *Oochoristica,* namely, *O. antechini* Beveridge, 1977, *O. eremophila* Beveridge, 1977, and *O. nyctophili* Hickman, 1954, have been described from Australian mammals; but the possession of craspedote proglottids by *O. antechini* and the passage of reproductive ducts dorsal to osmoregulatory canals in *O. eremophila* and *O. nyctophili* suggests to us that these 3 species should be reassigned to the genus *Mathevotaenia* Akumyan, 1946. The purpose of this paper is to describe a new species of *Oochoristica* that was found in the small intestines of the thorny devil, *Moloch horridus* Gray, from Australia and to list other helminth parasites found in this host.

Materials and Methods

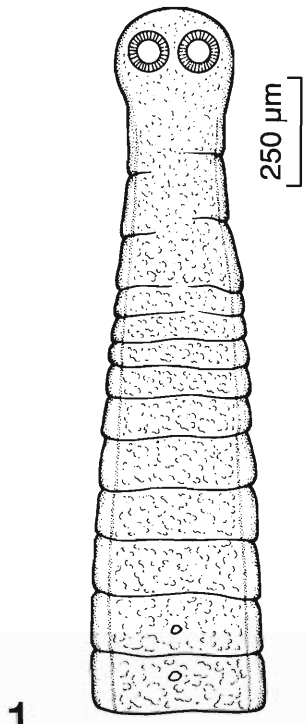
One hundred four *Moloch horridus* from the collections of the Natural History Museum of Los Angeles County (LACM 54134–54223, 55269–55282) were examined: 102 from Western Australia and 2 from the Northern Territory (snout–vent length = 86.1 mm ± 14.5 SD). These specimens had been collected between October 1966 and January 1968 for use in an ecological study (Pianka and Pianka, 1970); collection data will be found in that report. Because the ecological study included stomach analysis, only small and large intestines remained with most of the carcasses, but 3 intact stomachs and 5 pyloric stomach regions were present. Each organ was searched for helminths using a dissecting microscope, and the helminths found were identified utilizing a glycerol wet mount. Five cestodes were stained with Harris' hematoxylin, dehydrated in an alcohol series, cleared in xylene, whole-mounted in Canada balsam, and examined by compound microscopy. Drawings were made with the aid of a microprojector.

Results

Five nematodes, 4 *Parapharyngodon kartana* (Johnston and Mawson, 1941) Adamson, 1981, and 1 larva of *Abbreviata* sp., were found in 5 lizards; 16 cestodes identifiable only to the genus *Oochoristica* were found in 8 lizards. One lizard (LACM 54223) had a dual infection, namely, 1 cestode and 1 male *Parapharyngodon kartana.* All infected lizards were from central Western Australia within the area bounded by 26°14′S–28°31′S and 121°00′E–123°15′E. Voucher specimens in vials of alcohol were deposited in the U.S. National Parasite Collection (USNPC) (Beltsville, Maryland): *Oochoristica piankai,* 84590; *Parapharyngodon kartana,* 84591; and *Abbreviata* sp. (larva), 84592. Except where noted, all measurements are in micrometers.

Oochoristica piankai sp. n. (Figs. 1–4)

With characters of the genus: specifically, scolex with 4 suckers and without rostellum or ar-



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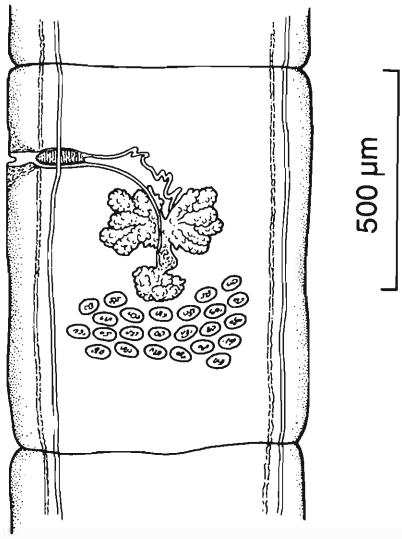

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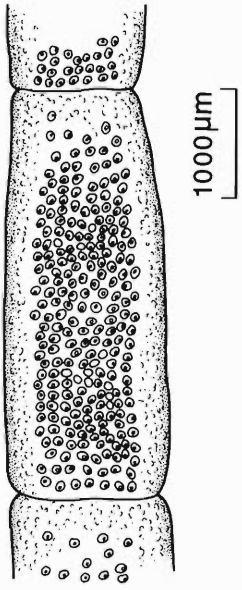

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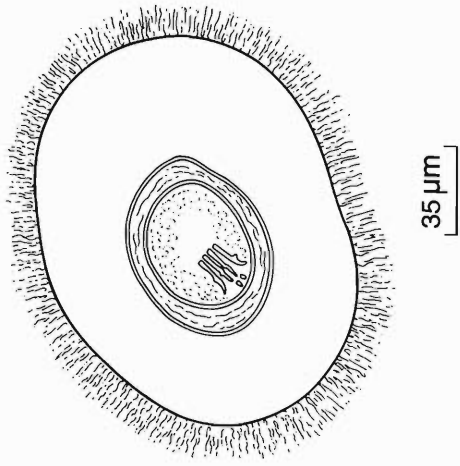

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Figures 1–4. ***Oochoristica piankai*** **sp. n. 1. Anterior portion of cestode, scolex to proglottids with sexual primordia. 2. Mature proglottid. 3. Gravid proglottid. 4. Uterine capsule with onchosphere.**

mature; proglottids acraspedote; genital pores irregularly alternate; genital ducts lie between osmoregulatory canals; uterus ephemeral; testes posterior to vitellarium.

Description based on 5 specimens; mean measurement and range. Total length 60 (40–70) mm; maximum width of strobila, 1.15 mm; proglottid number in mature worms 72 (60–80); 16–22 immature proglottids wider than long (0.615–0.714 mm by 0.179–0.255 mm), 18–30 mature proglottids (0.620–0.750 mm by 0.765–0.893 mm); 16–28 gravid proglottids longer than wide (0.750–1.147 mm wide by 2.04–6.00 mm long). Scolex 221 (170–256) wide by 189 (170–200) long, with 4 circular suckers, 92 (80–103) in diameter. Osmoregulatory system of 4 longitudinal canals visible throughout length of strobila. Genital pores irregularly alternating, situated in first third of proglottid. Cirrus sac length 127 (114–142) long by 34 (22–45) wide. The genital ducts pass between the osmoregulatory canals. Ovary bilobed and situated in center of proglottid; 247 (142–285) wide by 93 (68–114) long; each lobe subdivided into 6–8 well-defined secondary lobes. Oval vitelline gland situated on midline directly behind ovary, 121 (85–143) wide by 66 (45–85) long. Ootype and Mehlis' gland complex between ovary and vitelline gland. Testes posterior to ovary and vitelline gland in 1 cluster, numbering 31 (24–38) in each proglottid; testes measure 11–17 by 17–22. In gravid proglottids, uterine capsules, 127 (114–142), each containing a single egg, fill entire proglottid; eggs 52 (45–57); oncosphere 38 (34–40); oncosphere hook lengths (19) 17–20.

Taxonomic Summary

TYPE HOST: *Moloch horridus* Gray, 1841, "Thorny Devil" or "Moloch" (Sauria: Agamidae), deposited in the LACM, No. 54199, adult female, 90 mm snout–vent length.

TYPE LOCALITY: Western Australia (8 km NE Dunges Table Hill), 28°05′S, 123°55′E, 250 m elevation.

SITE OF INFECTION: Small intestine, adjacent to pyloric valve.

PREVALENCE: Eight of 104 (8%) lizards were infected.

MEAN INTENSITY: Sixteen cestodes, range 1–5, mean 2.

TYPE SPECIMENS: Holotype: USNPC No. 84588, 1 slide; Paratype: No. 84589, 1 slide.

ETYMOLOGY: The specific epithet honors Eric R. Pianka, Denton A. Cooley Centennial Professor of Zoology, University of Texas at Austin, for his pioneering studies on the ecology of Australian lizards.

Remarks

Comparisons of selected measurements of *Oochoristica piankai* sp. n. with 74 species of cestodes generally accepted as *Oochoristica* that infect reptiles are presented in Table 1; data were taken from original papers. *Oochoristica piankai* sp. n. belongs to that group of species having circular suckers, 20–40 testes occurring in a single cluster, and an ovoid vitellarium, namely, *O. gallica* Dollfus, 1954, *O. junkea* Johri, 1950, *O. parvula* (Stunkard, 1938), *O. vacuolata,* and *O. vanzolinii* Rego and Oliveira-Rodrigues, 1965. In *O. junkea, O. vacuolata,* and *O. vanzolinii,* each lobe of the ovary is not lobulate; each lobe of the ovary of *O. piankai* sp. n. is subdivided into 6–8 distinct lobules. The strobila of *O. piankai* sp. n. is twice the length of *O. gallica* and *O. parvula.* Of the Australian species, *O. piankai* sp. n. has half as many testes as *O. australiensis,* 24–38 compared to 65–80, and lacks the vacuoles seen in *O. vacuolata. Oochoristica trachysauri* has testes in 2 clusters as compared to the single cluster in *O. piankai* sp. n.

Discussion

In addition to *Oochoristica piankai* sp. n., other helminths found in *Moloch horridus* are reported for the first time. Two male and 2 female *Parapharyngodon kartana* were found in the large intestines of 4 lizards. *Parapharyngodon kartana* was originally described as *Thelandros kartana* from the skink *Hemiergis peronii* from Kangaroo Island, Australia (Johnston and Mawson, 1941). It was also found in the gecko *Christinus marmoratus* as well as *H. peronii* by Angel and Mawson (1968) and in the agamid *Ctenophorus fionni* and the skink *Lerista* sp. as well as *H. peronii* by Mawson (1971). *Thelandros kartana* was reassigned to the genus *Parapharyngodon* by Adamson (1981) and has since been reported from the skinks *Emoia nigra* and *E. samoenses* from Samoa by Goldberg and Bursey (1991). *Moloch horridus* is a new host record for *P. kartana.*

A stomach cyst containing 1 larva of *Abbreviata* sp. was also found. Jones (1995) examined the stomach contents of 85 *Moloch horridus* and found 9 (10.6%) to contain larval physalopterids (mean intensity 1.4). Jones (1995) believes that

Table 1. Geographic distribution and selected characters of species of *Oochoristica* from reptiles.

Realm *Oochoristica* sp.	Strobila			Scolex	Sucker		Testes		Ovary	Vitellaria
	No. prog-lottids	Maximum length (mm)	Neck (mm)	Mean width (μm)	Size (μm)	Shape	Number	Arrange-ment	Lobules/ lobe	Shape
Australian realm										
O. australiensis Spasskii, 1951	—*	220	0.4	335	120	Circular	65–80	1 Cluster	3–7	Ovoid
O. novaezealandae Schmidt and Allison, 1985	20	20	None	250	90	Circular	12–15	1 Cluster	None	Spheroid
O. piankai sp. n.	82	70	0.6	213	92	Circular	24–38	1 Cluster	5–7	Ovoid
O. trachysauri (MacCallum, 1921)	—	50	—	330	150	Circular	60	2 Clusters	None	Ovoid
O. vacuolata Hickman, 1954	53	53	0.8	300	130	Circular	19–45	1 Cluster	None	Ovoid
Ethiopian realm										
O. chavenoni Capron, Brygoo, and Broussert, 1962	150	50	2.0	370	120 × 154	Oval	22–31	1 Cluster	3–6	Ovoid
O. courduieri Capron, Brygoo, and Broussert, 1962	130	110	1.5	780	180–208	Oval	35–46	1 Cluster	7–9	Ovoid
O. crassiceps Baylis, 1920	100	30	2.5	1,050	250 × 300	Oval	20–30	1 Cluster	None	Ovoid
O. danielae Capron, Brygoo, and Broussert, 1962	100	60	0.8	840	104 × 130	Oval	30–42	1 Cluster	2–3	Triangular
O. najdei Magzoub, Kasim, and Shawa, 1980	—	75	Present	320	95	Circular	16–24	2 Clusters	1–3	Triangular
O. nupta Kugi and Mohammad, 1988	—	50	None	250	53 ± 82	Oval	28–30	2 Clusters	None	Ovoid
O. theileri Fuhrmann, 1924	28	8	None	350	130	Circular	26–35	2 Clusters	None	Round
O. truncata (Krabbe, 1879)	>48	115	None	550	180	Circular	27–48	1 Cluster	6–9	Triangular
O. ubelakeri Bursey, McAllister, Freed, and Freed, 1994	65	25	None	388	150 × 200	Oval	22–30	2 Clusters	3–5	Ovoid
Nearctic realm										
O. americana Harwood, 1932	—	40	3	500	160	Circular	35–40	1 Cluster	6–8	Triangular
O. anniellae Stunkard and Lynch, 1944	45	15	None	385	112 × 163	Oval	60–70	1 Cluster	None	Triangular
O. anolis Harwood, 1932	—	70	2	350	160 × 300	Oval	20–35	1 Cluster	5–6	Triangular
O. bezyi Bursey and Goldberg, 1992	30	8	0.57	250	119 × 150	Oval	22–32	2 Clusters	6–8	Triangular
O. bivitellobata Loewen, 1940	21	150	0.43	413	147	Circular	48–106	1 Cluster	None	Bilobed
O. crotaphyti McAllister, Trauth, and Ubelaker, 1985	52	27	None	373	105 × 126	Oval	23–37	1 Cluster	3	Ovoid
O. elaphis Harwood, 1932	—	75	5.5	350	145	Circular	30–53	1 Cluster	None	Kidney shape
O. eumecis Harwood, 1932	—	103	2	500	220 × 260	Oval	40–55	1 Cluster	3–5	Triangular
O. gracewileyae Loewen, 1940	>200	>850	2.4	426	145 × 152	Oval	70–140	1 Cluster	Numerous	Triangular
O. islandensis Bursey and Goldberg, 1992	69	24	None	318	120 × 170	Oval	38–46	2 Clusters	8–10	Triangular
O. natricis Harwood, 1932	—	130	1–2	550	190 × 260	Oval	50–70	1 Cluster	None	Triangular
O. osheroffi Meggitt, 1934	>200	205	0.95	385	136	Circular	59–76	1 Cluster	4–8	Ovoid
O. scelopori Voge and Fox, 1950	171	120	3	365	115	Circular	22–43	1 Cluster	Numerous	Triangular
O. whitentoni Stellman, 1939	>211	275	3.3	400	165	Circular	100–150	1 Cluster	10–12	Ovoid
Neotropical realm										
O. ameivae (Beddard, 1914)	—	120	Short	550	175	Circular	39–50	1 Cluster	5–8	Irregular
O. bresslaui Fuhrmann, 1927	—	40	2	140	54	Circular	60	1 Cluster	5–6	Irregular

Table 1. Continued.

Realm *Oochoristica* sp.	Strobila			Scolex	Sucker		Testes		Ovary	Vitellaria
	No. prog-lottids	Maximum length (mm)	Neck (mm)	Mean width (μm)	Size (μm)	Shape	Number	Arrange-ment	Lobules/ lobe	Shape
O. insulaemargaritae Lopez-Neyra and Diaz-Ungria, 1957	78	115	None	1,025	260 × 358	Oval	67–83	1 Cluster	Numerous	Irregular
O. parvula (Stunkard, 1938)	65	25	4	245	78	Circular	20–30	1 Cluster	3–5	Ovoid
O. travassosi Rego and Ibanez, 1965	—	12	0.75	600	158 × 165	Oval	26–32	1 Cluster	6–10	Irregular
O. vanzolinii Rego and Oliveira-Rodrigues, 1965	180	90	1.9	172	95	Circular	20–28	1 Cluster	None	Ovoid
Oriental realm										
O. aulicus Johri, 1961	—	172	2.00	325	115	Circular	25–30	1 Cluster	Several	Triangular
O. bailea Singal, 1961	—	128	None	182	78	Circular	42–46	2 Clusters	Several	Irregular
O. calotes Nama and Khichi, 1974	176	100	None	210	92	Circular	45–55	1 Cluster	10–20	Ovoid
O. celebesensis Yamaguti, 1954	140	40	0.52	700	225	Circular	22–31	1 Cluster	5–7	Irregular
O. chinensis Jensen, Schmidt, and Kuntz, 1983	128	71	1	225	84 × 108	Oval	12–25	1 Cluster	5–7	Irregular
O. cryptobothrium (Linstow, 1906)	—	130	0.23	600	140 × 250	Oval	80–90	1 Cluster	None	Spheroid
O. excelsa Tubangui and Masiluñgan, 1936	—	26	Short	250	82	Circular	23–29	1 Cluster	None	2 Lobes
O. fibrata Meggitt, 1927	—	90	None	338	126 × 170	Oval	35–36	2 Clusters	7–10	2 Lobes
O. hainanaensis Hsü, 1935	202	134	1.94	352	150	Circular	40–50	1 Cluster	5–8	Ovoid
O. hemidactyli Johri, 1955	—	49	Short	200	80	Circular	19–30	2 Clusters	5–8	Irregular
O. indica Misra, 1945	>91	200	6.0	350	180	Circular	30–36	1 Cluster	13–18	Irregular
O. javaensis Kennedy, Killick, and Beverley-Burton, 1982	100	44	1.35	177	48	Circular	25–31	1 Cluster	5–7	Spheroid
O. jodhpurensis Nama, 1977	91	50	1, 18	205	105	Circular	24–26	2 Clusters	Several	Irregular
O. junkea Johri, 1950	—	53	None	225	125	Circular	23	1 Cluster	None	Ovoid
O. langrangei Joyeux and Houdemer, 1927	—	60	2.24	400	180	Circular	50–60	1 Cluster	Numerous	Ovoid
O. lygosomae Burt, 1933	45	15	Short	280	140	Circular	17–18	1 Cluster	5–7	Ovoid
O. lygosomatis Skinker, 1935	45	11	2	230	110	Circular	14–18	1 Cluster	Several	Crescent
O. mandapamensis Johri, 1958	—	14	5.0	160	90	Circular	30–34	2 Clusters	None	Irregular
O. microscolex Della Santa, 1956	—	>35	None	236	95	Circular	50–60	1 Cluster	None	Triangular
O. ophia Capoor, Srivastava, and Chauhan, 1974	—	140	4.20	540	160	Circular	38–70	2 Clusters	4–14	Triangular
O. pauriensis Malhotra and Gapoor, 1984	—	174	0.23	197	50 × 105	Oval	31–55	1 Cluster	3–5	Crescent
O. tandani Singh, 1957	40	90	Short	270	115	Circular	37–45	1 Cluster	4–5	Spheroid
O. thapari Johri, 1934	—	21	None	305	—	—	48–62	1 Cluster	None	Ovoid
O. varani Nama and Khichi, 1972	—	30	Short	370	152 × 287	Oval	40–55	1 Cluster	Several	Globular
Palaearctic realm										
O. brachysoma Dupouy and Kechemir, 1973	63	40	1.0	1,000	185	Circular	20	2 Clusters	None	Ovoid
O. chabaudi Dollfus, 1954	65	53	—	430	145 × 155	Oval	36–38	1 Cluster	4–6	Ovoid
O. darensis Dollfus, 1957	—	72	Present	485	145	Circular	52–70	2 Clusters	5–7	Irregular
O. elongata Dupouy and Kechemir, 1973	—	>50	Present	315	80	Circular	20–25	1 Cluster	None	Spheroid
O. gallica Dollfus, 1954	—	30	Present	278	117	Circular	39–40	1 Cluster	5–7	Ovoid

Table 1. Continued.

Realm *Oochoristica* sp.	Strobila			Scolex	Sucker		Testes		Ovary	Vitellaria
	No. proglottids	Maximum length (mm)	Neck (mm)	Mean width (μm)	Size (μm)	Shape	Number	Arrangement	Lobules/lobe	Shape
O. japonensis Kugi, 1993	–	36.6	Absent	213	100	Circular	18–19	2 Clusters	Many	Elongate
O. khalili Hamid, 1932	–	–	0.9	460	210	Circular	44–61	1 Cluster	None	Ovoid
O. longicirrata Dupouy and Kechemir, 1973	98	120	0.3	580	125 × 135	Oval	35–40	1 Cluster	None	Ovoid
O. okinawaensis Kugi, 1993	–	6.2	0.35	270	100	Circular	12–13	2 Clusters	2	Ovoid
O. parvogenitalis Dupouy and Kechemir, 1973	35	24	–	410	83	Circular	8–15	1 Cluster	Several	Triangular
O. pleionorches (Dollfus, 1954)	–	17	Present	368	125 × 135	Oval	75–83	1 Cluster	5–8	Irregular
O. pseudocotylea Dollfus, 1957	–	39	Present	443	194	Circular	27–38	1 Cluster	None	Spheroid
O. rostellata Zschokke, 1905	–	130	2.3	900	190 × 375	Oval	86–100	1 Cluster	Numerous	Bilobed
O. salensis Dollfus, 1954	–	100	–	420	210	Circular	40–60	1 Cluster	5–7	Irregular
O. sobolevi (Spasskii, 1948)	52	15	–	225	93	Circular	18–23	1 Cluster	Numerous	Ovoid
O. tuberculata (Rudolphi, 1819)	–	200	Present	313	110 × 140	Oval	30–50	1 Cluster	4–6	Ovoid
O. zonuri Baylis, 1919	215	120	Present	1,025	389 × 497	Oval	60–90	1 Cluster	None	Irregular

* Not given in original paper.

termites, perhaps beetles and cockroaches as well, act as intermediate hosts for larvae of species of *Abbreviata.* These hosts are consumed by many species of small lizards that act as paratenic hosts and no further development of the nematode occurs until these paratenic hosts are consumed by one of the larger lizards (i.e., species of *Varanus* or *Pogona*). Pianka (1994) reported *Moloch horridus* and other species of small lizards to be regular items of the diet of species of *Varanus.* Of the 58 species of *Abbreviata* known to infect reptiles (see Baker, 1987), 15 species (26%) are known from Australian lizards including *Varanus* spp. Because these definitive hosts do not feed directly on termites, paratenic hosts are an essential link in *Abbreviata* life cycles (Jones, 1995).

Pianka and Pianka (1970) examined the stomachs of 103 *Moloch horridus* and found only ants (at least 3 species) and a few tiny objects such as stones, sticks, flowers, and insect eggs, which they believed the ants to be carrying at the time of ingestion. These observations raise a question as to the mode of infection of *M. horridus* by the helminths reported in this paper. Although the life history of *Parapharyngodon kartana* has not been studied, it would be predicted to have a direct life cycle similar to that of other oxyurids (Anderson, 1992), with infection occurring by ingestion of eggs from a fecally contaminated substratum. Such substrata could be ingested at the time ants are taken. Physalopterids require an insect intermediate host in which development to third-stage larvae occurs (Anderson, 1992). Ants carrying dismembered but infected insect parts could be the source of infections. The biology of *Oochoristica piankai* has not been examined, but Hickman (1963) studied the life history of *O. vacuolata* in some detail. The adult cestode is estimated to live for 4 yr and shed at least 123 proglottids; the tenebrionid beetle, *Cestrinus punctatissimus* Pascoe, serves as a natural intermediate host and, experimentally, the cockroach *Platyzosteria melanaria* Erichson, the dermestid beetle *Anthrenocerus australis* Hope, and the carabid bettles *Gnathaphanus adelaidae* Castelnau, *Hypharpax moestus* Dejean, *Mecyclothorax ambiguus* Erichson, *Promecoderus gibbosus* Gray, and *Homothes guttifer* Germar are capable of serving as intermediate hosts. The paucity of these helminths in *M. horridus* suggests an "accidental" route of infection. Further study will be required to determine whether or not other desert reptiles share these helminths.

Key to Species of Australian *Oochoristica*

1. Testes in 1 cluster 2
   Testes in 2 clusters ..... *O. trachysauri* MacCallum, 1921
2. Fewer than 50 testes 3
   More than 60 testes ..... *O. australiensis* Spasskii, 1951
3. Ovarian lobes not subdivided ..... *O. vacuolata* Hickman, 1954
   Ovarian lobes subdivided into 6–8 lobules ..... *O. piankai* sp. n.

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Abomasal Parasites in Tule Elk (*Cervus elaphus nannodes*) from Grizzly Island, California

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ABSTRACT: Trichostrongylid nematodes were collected from the abomasa of 12 (67%) of 18 tule elk (*Cervus elaphus nannodes*) collected from the Grizzly Island Wildlife Area, California, in August to September 1994; overall mean (±1 SD) intensity was 44.9 ± 40.0 of abomasal nematodes per host. Three species of nematodes were found: *Ostertagia leptospicularis* and its minor morphotype *Ostertagia kolchida, Mazamastrongylus pursglovei,* and *Trichostrongylus axei.* New geographic and host records are established, respectively, for *O. leptospicularis/O. kolchida,* and *M. pursglovei* in California and for *Cervus elaphus* in North America.

KEY WORDS: tule elk, *Cervus elaphus nannodes,* abomasal nematodes, *Ostertagia leptospicularis, Ostertagia kolchida, Mazamastrongylus pursglovei, Trichostrongylus axei.*

Among North American cervids, there are numerous studies on geographic distributions of abomasal parasites in several hosts, including white-tailed deer (*Odocoileus virginianus* (Zimmermann)), mule deer (*Odocoileus hemionus* (Raffinesque)) (Walker and Beckland, 1970; Prestwood and Pursglove, 1981), and caribou (*Rangifer tarandus* (Linnaeus)) (Low, 1976; Fruetel and Lankester, 1989). However, little information is available on the occurrence of abomasal parasites in elk (*Cervus elaphus* Linnaeus), including tule elk (*C. elaphus nannodes* Merriam).

Few helminth species have been documented in previous studies of *C. elaphus* in North America, and ostertagiine nematodes rarely have been reported (Lichtenfels and Hoberg, 1993). Boddicker and Hugghins (1969) found no abomasal parasites in 20 elk from South Dakota (U.S.A.). Stock and Barrett (1983) found a 5% prevalence of *Trichostrongylus axei* (Cobbold, 1879) among 186 elk from Alberta, Canada. Among tule elk, McCullough (1969) evaluated fecal samples from 50 animals and found single unidentified eggs of a strongylid and ascarid. In contrast, the fauna of *C. elaphus* has been documented extensively in the Palearctic, where it is dominated by ostertagiine nematodes of the genera *Ostertagia* Ransom, 1907, and *Spiculopteragia* Orloff, 1933, and other trichostrongyloid nematodes (Dróżdż, 1966; Petrovic et al., 1967; Kutzer and Hinaidy, 1969; Hörning, 1975; Govorka et al., 1988).

Our objective was to document the occurrence, prevalence, and intensity of abomasal nematodes in the tule elk of the Grizzly Island Wildlife Area, California.

Materials and Methods

Elk for this study were collected during a controlled hunt at the Grizzly Island Wildlife Area (38°09′N, 121°58′W), a 3,450-ha tract of land near the delta of the San Joaquin River, approximately 11 km south of Fairfield, California. Animals initially were examined at a hunter check station, where each abomasum was removed after ligation and frozen at −10°C prior to evaluation.

Each abomasum was evaluated for the recovery of parasites. Following thawing at 20°C, contents were sequentially sieved first through a 9 mesh (1.9 mm) to remove large debris and then through a 100 mesh (150 μm); some smaller parasites, especially larvae, may not have been retained in the 150-μm sieve. Contents retained in the 150-μm sieve were diluted and examined in 10-ml aliquots until 25% of the total volume of the abomasal washings was evaluated. Nematodes were preserved in 70% ethanol and later cleared in glycerine or in phenol alcohol (80 parts melted phenol crystals and 20 parts absolute methanol). Intensity of infection was estimated by multiplying the numbers of actual nematodes recovered ×4 as determined by the 25% aliquots. The female specimens of *Ostertagia* spp. were identified based on the structure of the synlophe (system of longitudinal cuticular ridges) (Lichtenfels and Hoberg, 1993). The 1 specimen of *Trichostrongylus* sp. was assigned to *Trichostrongylus axei* based on comparison to known specimens. Concepts for polymorphism are consistent with Dróżdż (1974, 1995) and Lichtenfels and Hoberg (1993).

Because of an unavoidable time lapse between the killing of the elk and the abomasa being collected at the hunter check station, some parasites could have migrated into other organs. Also, use of the 150-μm mesh size may have resulted in the loss of smaller parasites, especially larvae. Thus, the prevalences and

Table 1. Prevalence and intensity of adult abomasal nematodes among 18 tule elk, Grizzly Island Wildlife Area, California, 1994.

Species	No. infected (%)	Intensity		
		Mean	SD	Range
Ostertagia leptospicularis/Ostertagia kolchida	11 (61)	47.9	40.0	12–148
Mazamastrongylus pursglovei	1 (6)	4	—*	4
Trichostrongylus axei	2 (11)	4	0	4
Total	12 (67)	44.9	40.0	4–148

* Not calculated.

intensities reported should be considered to be minimum values.

Results

Eighteen elk were evaluated during the hunt. Among these, 4 of 6 adult females, 2 of 5 adult males, 0 of 1 male calves, and all 6 yearling males were infected with abomasal nematodes; overall the prevalence was 67% and the mean ± 1 SD intensity of infection was 44.9 ± 40.0 nematodes per infected host, with an estimated range of 4–148 (Table 1).

Three species were identified: *Ostertagia leptospicularis* Assadov, 1953/*O. kolchida* Popova, 1937, *Mazamastrongylus pursglovei* (Davidson and Prestwood, 1979), and *Trichostrongylus axei.* Among the 12 infected elk, 8 were hosts for *O. leptospicularis,* 5 also contained the minor morphotype *O. kolchida,* 1 had *M. pursglovei,* and 2 had *T. axei.* Representative specimens of these nematodes were deposited in the U.S. National Parasite Collection (USNPC), Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland (U.S.A.), as USNPC Nos. 86016.01, 86016.02, 86017, and 86018.

Discussion

The occurrence of *Ostertagia leptospicularis/Ostertagia kolchida* and *Mazamastrongylus pursglovei* at Grizzly Island represents new geographic records for these parasites in California. *Ostertagia leptospicularis/O. kolchida* are considered typical parasites of cervids in the Palearctic and Nearctic but have not previously been reported from *Cervus elaphus* in North America (Dróżdż, 1967; Hoberg et al., 1993). Currently, these species of *Ostertagia* are considered to represent the major and minor forms of a single polymorphic species (Dróżdż, 1995). Additionally, *M. pursglovei* has not been reported in *C. elaphus,* nor was it known to occur west of Texas or in hosts other than white-tailed deer (Lichtenfels et al., 1993).

Although occurrence of *O. leptospicularis/O. kolchida* in elk is not unexpected (Rickard and Zimmerman, 1986; Mulrooney et al., 1991; Hoberg et al., 1993), the presence of *M. pursglovei* is enigmatic. The present distribution of the species we report may have been influenced by the specific history of the tule elk now inhabiting Grizzly Island.

The historical range of *C. elaphus nannodes,* endemic to California's Central Valley and delta region (McCullough, 1969), once included Grizzly Island (D. Becker, pers. comm.); tule elk were extirpated from much of this range by 1860 (McCullough, 1969).

There is some information available on the origins of the current tule elk herd at Grizzly Island. The origin of this herd resulted from introductions from 2 locations in California. In 1977, 7 adults came from the Tupman Elk Reserve in Kern County and 1 yearling female came from the Owens Valley in Inyo County, California (Botti and Koch, 1992). Later, an additional adult male was transported from the Fresno Zoo (Fresno, California) to the tule elk herd at the San Luis National Wildlife Refuge; this animal was moved to the tule elk herd at Point Reyes National Seashore (California) in 1978 and finally to Grizzly Island in 1979 (J. Fischer, pers. comm.)

Tule elk at Grizzly Island currently are isolated from other cervid populations, but the elk from Fresno had the potential for co-existence with white-tailed deer, black-tailed deer, and other cervids in a zoo environment prior to introduction on the island. Although *O. leptospicularis* and *O. kolchida* probably occur naturally in other cervid hosts in California (Hoberg et al., 1993), the occurrence of *M. pursglovei* may have resulted from cross-transmission in the zoo, with

subsequent introduction into the herd at Grizzly Island. Collections of appropriate cervids in California will be required to further evaluate this hypothesis.

Trichostrogylus axei was an uncommon parasite in tule elk but has been reported previously from *Cervus elaphus* in North America (Stock and Barrett, 1983). Additionally, several species of *Trichostrongylus* have been reported from cervids, particularly deer in California (Walker and Becklund, 1970). Domesticated bovids are considered typical hosts for *T. axei,* and this species has a broad host range among ruminants, as summarized by Skrjabin et al. (1954). Although transmission between domesticated stock and wild cervids is often minimal (Pursglove et al., 1976), the nematode could have been acquired from bovids during the complicated history of the elk herd on Grizzly Island.

Abomasal nematodes found in the tule elk did not appear to be pathogenic, but the intensities of infection were very low. Among these species, *O. leptospicularis* has been associated with severe disease and mortality of red deer (*Cervus elaphus*) in Britain (Dunn, 1983).

The relatively low intensity and prevalence of the ostertagiines, particularly *M. pursglovei,* if not an artifact of the methods used in collections, is evidence that these parasites may only recently have been established in the herd at Grizzly Island. This is compatible with the history of known introductions of ostertagiine nematodes associated with the transport of infected cervid hosts in other regions (Hoberg et al., 1993). Such introductions appear to have been relatively common, as indicated by *O. leptospicularis*/*O. kolchida* and species of *Spiculopteragia* in New Zealand and South America (Andrews, 1973; Suarez et al., 1991); *Spiculopteragia* spp. in North America (Rickard et al., 1993); and *O. mossi* Dikmans, 1931, in Eastern Europe (Kotrlá and Kotrly, 1977). The apparent ease with which these ostertagiines become established in new environments and geographic regions is notable. These findings provide additional support for emphasizing the importance of careful parasite surveillance of all animals that may be used in translocations to prevent the unintended spread of potential pathogenic agents to new host species and geographic regions.

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Epidemiologic and Zoogeographic Studies on *Trichinella nativa* in Arctic Fox, *Alopex lagopus,* in Greenland

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ABSTRACT: Studies were carried out on the prevalence of *Trichinella nativa* in 266 arctic foxes, *Alopex lagopus,* in Greenland. Infection intensity was determined by digestion of muscle samples from each fox. Sixteen foxes (6%) were found to be infected. Highest prevalence was found in foxes from Northern (9%) and Eastern (35%) Greenland, where polar bear is traditionally hunted and sledge dogs are common. In these areas, the average age of infected animals was found to be significantly higher (4.1 yr) than that of all animals examined (2.6 yr). No positive animals were found in the southern parts of West Greenland. Prevalence increased with age of the foxes. The number of muscle larvae varied considerably among the foxes (0.1–148.2 larvae/g), the highest values being found in juveniles. No significant differences in larval burdens or prevalence between male and female or between blue and white foxes could be demonstrated. No differences in the body weight between infected and noninfected foxes was demonstrated.

KEY WORDS: *Trichinella nativa,* arctic fox, *Alopex lagopus,* Greenland, prevalence, color, sex, age, larval burden, transmission.

Trichinellosis in humans and animals may have long existed in Greenland, but the nematode was not reported until 1947, when 295 human cases were registered in Central West Greenland (Thorborg et al., 1948). Other outbreaks were recorded in 1949, 1953, and 1959 (Roth, 1950; Holgersen, 1961). Sporadic cases have, since then, been registered, the majority in the Thule district, North West Greenland (Bohm, 1984; Bohm and van Knapen, 1989).

The prevalence of *Trichinella* in wildlife in Greenland was first investigated by Thorborg et al. (1948), and later the parasite was demonstrated in polar bear (*Ursus maritimus* Phipps, 1774), walrus (*Odobenus rosmarus* Linnaeus, 1758), arctic fox (*Alopex lagopus* Linnaeus, 1758), bearded seal (*Erignathus barbatus* Erxleben, 1777), ringed seal (*Phoca hispida* Schreber, 1775), and sledge dog (*Canis familiaris* Linnaeus, 1758) (Roth, 1949, 1950; Madsen, 1961; Thing and Henriksen, 1976; Born et al., 1982; Born and Henriksen, 1990; Henriksen et al., 1993). La Rosa et al. (1990) demonstrated that muscle larvae found both in sledge dog from Northern Greenland and in polar bear from Southern Greenland were of the species *Trichinella nativa* Britov and Boev, 1972. The present study provided more detailed information on the epidemiology of *T. nativa* in some Greenlandic fox populations, particularly on the influence of sex, age, color, level of infection, and geographical area of origin.

Materials and Methods

Muscle samples were obtained from 266 arctic foxes, *A. lagopus,* caught in Greenland in 1992 and 1993. Of the total, 245 foxes were caught in traps for subsistence purposes by the Inuit hunters and 21 through governmental initiatives in attempts to manage local fox populations. Trapping is possibly one of the most objective ways of collecting foxes. However, inexperience of younger foxes may possibly predispose them to capture. Shooting tends to favor size or color, depending on the preference of the hunter, but the foxes shot for the present study were killed without preference for size or color simply to control a population locally. Therefore, even though the number of foxes is limited, composition of the populations might be well represented. The foxes sampled originated from 8 different geographical regions (Figure 1). The foxes were transported to Denmark and kept frozen at −20°C for a period of 2–3 mo prior to sampling of muscle tissue. Muscle tissues (ca. 10 g) were obtained from the flexor and extensor muscles of the lower front leg, which were demonstrated as predilection sites of *Trichinella* muscle larvae in caged and wild arctic fox (Kapel et al., 1994, 1995). The muscle samples were examined using a combined HCl-pepsin-digestion and filtration technique (Henriksen, 1978), with a detection level of approximately 0.1 larvae per gram of muscle tissue. From each infected animal, a sample of 5–15 g muscle tissue from 18 selected muscles or muscle groups was examined. The muscle or muscle groups originated from eye (straight and oblique muscles), hind leg (*m. gas-*

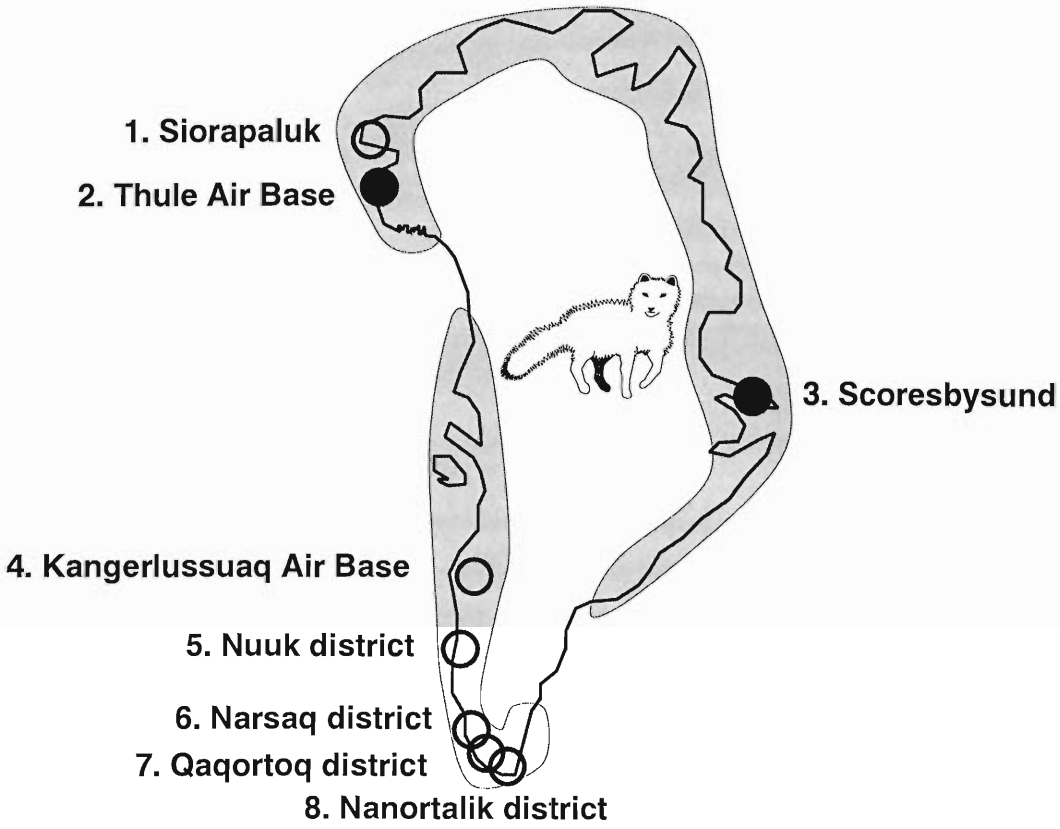

Figure 1. Distribution of arctic fox (*Alopex lagopus*) in Greenland (shaded areas). Sampling areas are illustrated by circles. Filled circles represent areas in which *Trichinella nativa* was demonstrated. The areas not shaded represent the inland ice and coastlines totally constituted by glaciers.

trocnemius), leg (*m. biceps brachii/m. triceps brachii*), sublumbar (*m. psoas minor*), hind leg (*m. rectus femoris*), front leg (lower part. flexors/extensors), neck (*m. splenius*), back (*m. longissimus dorsi*), thorax (intercostal muscles), diaphragm (lumbar and costal parts), tail (ventral muscles), lower and upper jaw (*m. masseter, m. temporalis*), throat (*m. sternohyoideus*), abdomen (*m. obliqui abdominis*), tongue (tip and base of tongue), and ear (extrinsic auricular muscles). In larger muscles or muscle groups, tissue samples were taken from the part of the muscle closest to the tendon. In smaller muscles or muscle groups, the entire muscle was included. The individual samples freed from tendons and fasciae were minced by means of a pair of scissors and subsequently examined by digestion as already described. For each fox, the mean number of muscle larvae per gram of all muscle tissue examined was calculated.

The age of the foxes was determined from the number of annual layers in the cementum of 1 lower canine tooth. For that purpose, the teeth were decalcified in 10% formic acid, and sagittal histological sections (12 μm) were stained in a Toluidine blue solution as described by Kapel (1995).

The body weight of infected and noninfected foxes was also compared. This was done for each geographical area to eliminate any potential differences in food availability or quality.

Differences in weight of infected and noninfected animals were analyzed statistically for all age classes using Kruskal-Wallis 1-factor analysis of variance (ANOVA) (Campbell, 1974). Correlations between host age and prevalences were tested according to Siegel (1956). All other comparisons were tested statistically employing χ^2-tests and contingency tables (Zar, 1984). Yates correction was used where the group size was less than 5 animals.

Results

Of 266 arctic foxes examined, 16 were found to be infected with *T. nativa* (Table 1). The overall prevalence was 6%, with a geographical variation from 0 to 35%. All the infected foxes originated from 2 areas (areas 2 and 3). No infected animals were demonstrated in the southernmost parts of Greenland. The average age of infected

Table 1. Prevalence of *Trichinella nativa* in arctic foxes (*Alopex lagopus*) from different regions of Greenland according to age and color of the foxes.

Area	No. examined						No. infected					
	Blue		White		Total		Blue		White		Total	
	No.	Age*	No.	Age*	No.	Age*	No. (%)	Age	No. (%)	Age	No. (%)	Age
1 Siorapaluk	15	1.2	4	1.3	19	1.2	0	–	0	–	0	–
2 Thule Air Base	79	2.3	18	3.9	97	2.6	5 (6)	3.4	4 (22)	4.6	9 (9)	3.9
3 Scoresbysund	8	3.2	12	2.4	20	2.7	3 (38)	6.7	4 (33)	2.7	7 (35)	4.4
Areas where polar bear is traditionally hunted	102	2.2	34	3.0	136	2.4	8 (8)	4.6	8 (24)	3.6	16 (12)	4.1
4 Kangerlussuaq Aur Base	25	4.4	31	3.5	56	3.9	0	–	0	–	0	–
5 Nuuk district	19	2.7	14	1.1	33	2.0	0	–	0	–	0	–
6 Narsaq district	5	2.2	8	4.0	13	3.3	0	–	0	–	0	–
7 Qaqortoq district	13	4.7	9	3.2	22	4.1	0	–	0	–	0	–
8 Nanotalik district	4	3.3	2	1.8	6	2.8	0	–	0	–	0	–
Areas where polar bear is rare or absent	66	3.8	64	2.9	130	3.3	0	–	0	–	0	–
All areas	168	2.9	98	2.9	266	2.9	8 (5)	4.6	8 (8)	3.6	16 (6)	4.1

* Average age in years.

Table 2. Prevalence and larval burdens of *Trichinella nativa* muscle larvae in arctic foxes (*Alopex lagopus*) from Greenland according to age and sex of the foxes. Only animals from areas in which *Trichinella nativa* was demonstrated are included.

Age group (yr)	♂		♀		All			
	Examined*	Positive (%)	Examined*	Positive (%)	Examined*	Positive (%)	l/g†	Range
−1	28	0 (0)	26	2 (8)	54	2 (4)	6.7	0.7–12
1–2	8	1 (13)	9	1 (11)	17	2 (12)	85.3	22–148
2–3	13	0 (0)	8	1 (13)	21	1 (5)	21.3	—
3–5	20	4 (20)	12	3 (25)	32	7 (22)	32.5	0.1–105
5–7	6	2 (33)	3	1 (33)	9	3 (33)	42.0	27–71
7–11	1	0 (0)	2	1 (50)	3	1 (33)	48.8	—
All	76	7 (9)	60	9 (15)	136	16 (12)	38.0	0.1–148

* Number of foxes examined.
† Average number of larvae per gram muscle tissue.

foxes was found to be significantly higher (4.1 yr) than that of noninfected animals (2.8 yr) (χ^2-test, $P > 0.05$). Testing North and East Greenland separately, no differences in prevalence could be demonstrated between white and blue foxes (χ^2-test, $P < 0.05$). The prevalence of infection was found to increase with age of the foxes (Spearman rank correlation test, $P < 0.05$) (Table 2). Between muscle larvae burden and age a similar correlation could not be demonstrated statistically, even though the highest larval burdens were demonstrated among foxes 1–2 yr old. The larval burdens varied considerably between the foxes, ranging from 0.1 to 148.2 larvae/g with an overall mean of 38.0 larvae/g. No significant host sex differences in larval burdens or prevalence rates could be demonstrated. Likewise, differences in body weights between infected and non-infected foxes were not significant in any age group (Kruskal-Wallis 1-factor ANOVA, $P < 0.05$).

The intensity of infection in different muscle groups is described by Kapel et al. (1995).

Discussion and Conclusion

In Greenland, like in other parts of the Arctic, the arctic foxes are opportunistic and generalistic feeders and the diversity and availability of the prey fauna seem to determine what is actually ingested (Birks and Penford, 1990; Kapel, 1995). Thus, 2 factors seem to be very important in determining *Trichinella* infections in foxes in Greenland: the composition of the surrounding fauna and the hunting practices of the traditional Inuit culture.

In the northern and eastern parts of Greenland, polar bear is common and constitutes an important element of the Inuit's food (Kapel and Petersen, 1979; Born, 1983). The polar bear is the most frequently infected game animal in Greenland. Prevalence rates of 27.7% (Roth, 1950), 24.2% (Madsen, 1961), and 22.8% (Henriksen et al., 1993) have been reported, but the prevalence varies somewhat geographically. In Scoresbysund, East Greenland, prevalences of 41% (Madsen, 1961) and 32% (Born and Henriksen, 1990) have been found, in contrast to the southernmost parts of Greenland, where *Trichinella* infections in polar bears are very rare (Madsen, 1961). Presumably, polar bears acquire their infections through scavenging on carcasses of other polar bears and cannibalism (Taylor et al., 1985; Born and Henriksen, 1990). Because polar bear hunting in the northern areas is more intense, the number of carcasses available is higher, and consequently, the transmission of *Trichinella* between bears and other potential hosts may also be greater. This hypothesis is supported by the fact that the prevalence of *Trichinella* in the normal prey of the polar bear, the seals, is very low (0.0–0.8%) (Madsen, 1961). Thus, the polar bear itself may be the most important natural reservoir of *Trichinella* for arctic fox in Greenland.

Although walrus is another important element in the diet of the Inuits, its role in transmission of *Trichinella* to arctic fox may be limited because only low prevalence rates (1.0–1.6%) have been reported (Madsen, 1961; Born et al., 1982).

The prevalence of *Trichinella* in sledge dog in Greenland has been found to be high (71%), the highest prevalence being found in North (91%)

and Central West Greenland (61%), whereas no *Trichinella* infections were observed in the southern areas (Madsen, 1961). The dogs are fed all remains from the hunt including polar bear and walrus carcasses, but scavenging on carcasses of other dogs can be ascribed an important role in the epidemiology also, at least in the northern areas. As it is normal practice to sink dead dogs in the tidal zone crevasses or leave them on the sea ice, infected animals become available to the surrounding fauna. Due to the intensive use of dogs and the minimal health care they normally recieve, the mortality among the approximately 30,000 dogs in Greenland (Holck, 1992) is considerable and may also contribute in transmission of *Trichinella* to arctic fox.

The arctic fox was formerly an important fur animal of the Inuits in all parts of Greenland; the fur was used for traditional clothing and for export (Kapel and Petersen, 1979). However, due to changing fashion and lower market prices on fur, the fox is hunted infrequently in most places, nowadays.

Trichinella infections in arctic fox in Greenland were first reported by Roth (1950), who found an overall prevalence of 1.1% in foxes from all parts of Greenland. Madsen (1961) reported an overall prevalence of 1.4% but stated that this does not give a true picture because of considerable geographical variation. He reported high prevalences (up to 27.2%) on the east coast and northern parts of the west coast and low prevalences (0–1.2%) in southern parts of West Greenland. Similar geographical distribution patterns were demonstrated in the present study. Even though the overall prevalence was found to be 6%, this may be ascribed to the relatively large number of animals from areas with high prevalences. As described earlier, the northern areas, in which high prevalence of *Trichinella* were found in arctic fox, are the same as those in which polar bear and walrus are hunted regularly and where sledge dog is common. A remarkable situation exists in the northernmost settlement in Greenland, Siorapaluk (Fig. 1). Even though this settlement is situated in an area in which polar bear is very common and where dog-drawn sledges are still the major means of transportation, no *Trichinella* infections could be demonstrated. Analyses revealed that stomach contents of foxes from this settlement consist primarily of feathers and eggs from small birds (Kapel, 1995). It seems that foxes from this particular area feed strategically on birds and eggs from one of the world's largest colonies of little auk (*Alle alle* Linnaeus, 1758). Similar extensive use of birds by arctic foxes have been found by Fay and Stephenson (1989).

Prevalence of *Trichinella* in arctic foxes has been described circumpolarly. The parasite has been reported in arctic foxes in Canada (Parnell, 1934; Curtis et al., 1988; Smith and Snowdon, 1988), Alaska (Rausch et al., 1956, 1990), Svalbard (Larsen and Kjos-Hansen, 1983; Prestrud et al., 1993), and the former U.S.S.R. (Berezantzev, 1956). From these studies, prevalence rates of between 1.4 and 13% have been reported. Some of these authors described variations in prevalence as related to local geographical areas. Thus, Prestrud et al. (1993) concluded that differences in prevalence between the northern parts of Svalbard (14%) and the southern parts (5%) probably were due to different diet of the foxes. The polar bear is most abundant in the north, whereas large reindeer herds are found to the south. The assumed epidemiological link between polar bear and fox seems to resemble the Greenlandic situation. This theory was supported by Larsen and Kjos-Hansen (1983), who demonstrated that prevalence in arctic foxes decreased from 67% in 1955 to 3% in 1979 after polar bear hunt was forbidden on Svalbard in 1973.

Trichinella larvae encyst in the muscle tissue. This may explain why adult arctic foxes are more frequently infected with *Trichinella* than juvenile foxes. Accordingly, Prestrud et al. (1993) found the prevalence to be significantly higher (36%) among adult foxes (>6 yr) than among juveniles (<1 yr) (4%). Rausch et al. (1990) found 4% of juveniles and 9% of adults to be infected. The same positive correlation between age of the arctic fox and prevalence of *Trichinella* was demonstrated in the present material (foxes <1 yr: 4%; foxes >5 yr: 33%). The finding that larval burdens were not significantly higher among older animals seems to indicate that arctic foxes acquire protective immunity to reinfection.

As in the present study, no difference in prevalence between the sexes could be demonstrated in arctic foxes from Svalbard (Prestrud et al., 1993). This may be explained by similarity of behavior of male and female arctic foxes; that is, arctic foxes have been showed to aggregate in

large family groups with 3–4 cohorts (pups, parents, yearlings, "helpers") (Macpherson, 1969) with no specific behavioral differences with regard to hunting (Birks and Penford, 1990). Therefore, both sexes seem to be exposed to infective food items in the same way.

Variations in prevalence of *Trichinella* according to color of the foxes have been discussed by Madsen (1961). He concluded that the occurrence of *Trichinella* in the arctic fox in Greenland coincides with the distribution of the "big white lemming fox," which should prey mainly on the collared lemming (*Dicrostonyx groenlandicus* Traill, 1823). This conclusion, which could not be supported by results of the present study, is questionable. First, the taxonomic distinction of the "white lemming fox," solely described from hunting statistics (Braestrup, 1941; Elton, 1949) and morphological measurements on skulls (Vibe, 1950), is unproven. Second, no lemmings have ever been found in northern West Greenland, where *Trichinella* is of relatively high prevalence (Madsen, 1961; and the present study). Third, Madsen (1961) was not able to demonstrate any differences in prevalence according to the color because fox color was not recorded.

In the present study, the larval burdens were very different between the foxes. It seems difficult to state whether a certain larval burden in a wild animal reflects a clinically high, moderate, or low infection of *Trichinella*. Clinical observations from *Trichinella*-infected wild-living animals are rare and difficult to obtain. One possible result of infection might, in severe infections, be reflected in changes of body weight. In the present material, no significant differences of body weight between infected and noninfected arctic foxes was detected. Similarly, no differences in the weight of infected and noninfected animals was observed in arctic foxes from Svalbard (Prestrud et al., 1993). The number of larvae found in the muscles (0.1–148 larvae/g, $\bar{x} = 38.0$) is probably too low to cause clinically severe infections. In a study on arctic foxes reared in cages, with larval burdens of up to 291 *T. spiralis* larvae per gram, no clinical signs were observed (Kapel et al., 1994). From these indirect observations, it is likely that *T. nativa* infections play only a minor role in the overall fitness of arctic foxes.

The present study has demonstrated a substantial geographical variation of the prevalence of *T. nativa* infections in the arctic fox in Greenland. Furthermore, it was demonstrated that prevalence is positively correlated to the age of the fox and that the sex of the fox seems not to influence their susceptibility to infection.

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Helminth Infections in the Townsend's Ground Squirrel during Drought

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ABSTRACT: From February to June 1992, 117 Townsend's ground squirrels (*Spermophilus townsendii*) were collected for necropsy on 11 open and 10 shrubby sites at the Snake River Birds of Prey Area, Ada County, Idaho. Cumulative precipitation was well below the 50-yr mean during the study period. Four species of helminths were recovered during the study: *Hymenolepis citelli* (10%, 12 of 117), *Pterygodermatites coloradensis,* sensu Hall 1916, (5%, 6 of 117), *Syphacia citelli* (3%, 4 of 117), and *Spirura infundibuliformis* (2%, 3 of 117). *Hymenolepis citelli* was present on 8 of 11 (73%) of the more stressful open sites vs. 2 of 10 (20%) of the shrub sites. Prevalence of infection with *H. citelli* was not significantly different between the 2 site types. There were no significant differences in prevalence of infection between males and females or adults and juveniles for any helminth species. *Hymenolepis citelli* was present in all months sampled except June, but there was no significant increase or decrease in prevalence as the drought progressed. The other helminths were observed in 2 or fewer months. Only a single squirrel was infected with >1 helminth species. Each helminth species occurred in a unique region of the squirrel gut. Measurements are given for the first intact females of *P. coloradensis,* increasing the size ranges for females of this species.

KEY WORDS: helminths, Townsend's ground squirrel, *Spermophilus,* drought.

The Townsend's ground squirrel (*Spermophilus townsendii* Bachman, 1839) is a small, short-eared ground squirrel that is locally abundant in parts of the Great Basin (Rickart, 1987). It is an obligate hibernator and is only active from February to May or June in most years. The helminth parasites of the Townsend's ground squirrel have been examined by Jenkins and Grundmann (1973) and Leiby (1962) and the coccidia by Wilber et al. (1994).

In conjunction with a larger mark–recapture study, we collected animals for necropsy during the entire period of squirrel activity (February to June) in 1992 at the Snake River Birds of Prey Area (SRBPA) near Boise, Idaho. Throughout the study, cumulative precipitation in the region was significantly below the 50-yr (1940–1990) mean (Fig. 1A); 1992 was the third driest year on record since 1900 (National Weather Service, Boise). In addition, mean maximum daily temperatures per month were above the 50-yr mean (Fig. 1B) (National Weather Service, Boise).

During the 4–5-mo active season, Townsend's ground squirrels (*Spermophilus townsendii*) accumulate body fat to allow survival during the 7–8 mo of dormancy they experience each year. In 1991 (a normal year), mean body masses of adults (averaged within weeks) increased about 50 g (20–28%) between 1 April 1991 and onset of dormancy. Juvenile body masses increased about 100 g (75–115%). In 1992, over the same time period, mean body masses of adult males and females declined (45 and 21%) while juveniles gained only 10–20% vs. 75–115% in 1991 (Van Horne, unpubl. data). Squirrel body masses were also grouped by age, sex, and site type (adult, juvenile, male, female, shrubby, open) and compared between 1991 and 1992, using an analysis of variance of body mass with day of year as a covariate. This analysis compared daily, not monthly, means and showed that body masses were significantly less in May 1992 than in May 1991 for adults and juveniles on open sites and for juveniles on shrubby sites (Table 1) (Van Horne, unpubl. data). Therefore, open sites seemed more stressful than shrubby sites. In addition to declines in body mass, recruitment was negatively affected. Eighteen percent (72 of 398) of juvenile males and 38% (169 of 444) of juvenile females PIT-tagged (Schooley et al., 1993) in the mark–recapture study in 1991 were recaptured in 1992. In 1992, 1,423 juveniles were PIT-tagged but only 9 (0.6%) were recaptured in 1993. Furthermore, total number of animals cap-

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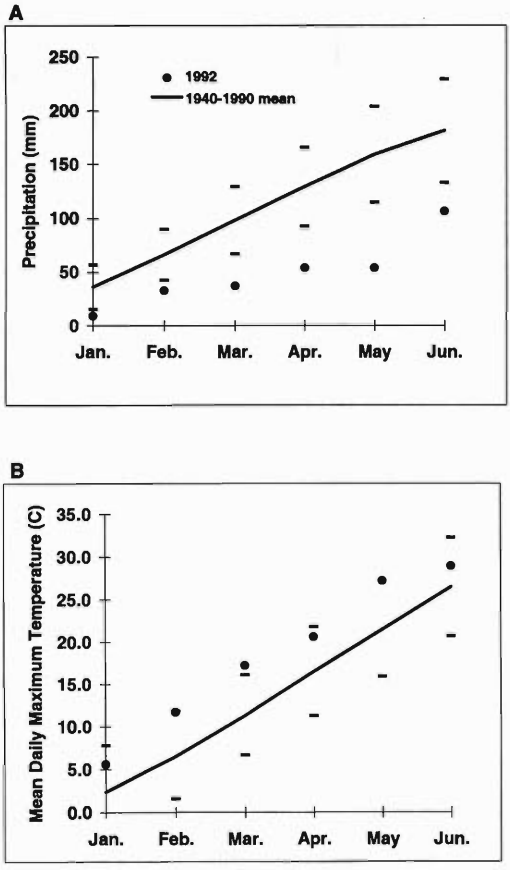

Figure 1. A. Cumulative precipitation encompassing the period of squirrel activity (February to June) in 1992 (dots) and for the 50-yr mean (1940–1990) (solid line) at the Boise Weather Station in Boise, Idaho, about 20 mi from the study site. The standard deviation for the 50-yr mean is indicated by the dashes. Note that the 1992 values are always below the lower limit of the standard deviation. B. Mean maximum daily temperatures (C) from January through June 1992 and for the 50-yr mean (1940–1990) at the Boise Weather Station in Boise, Idaho. Note that the maximum daily temperatures for 1992 are at or above the upper limit of the standard deviation 50% of the time and that all values in 1992 are above average.

tured in 1992 was 2,558 whereas only 872 animals were captured in 1993, despite an 18% increase in trapping effort in 1993 (68,068 trap sets) (Van Horne, unpubl. data). These data demonstrate that there was a drought in 1992 at the SRBPA during the period of squirrel activity and that this drought had a serious negative impact on squirrels. A drought, with similar effects on the Townsend's ground squirrels, was documented at the SRBPA in 1977 (Smith and Johnson, 1985).

Table 1. The helminth work was a subset of a larger mark-recapture study. Data from the larger study was used to determine the effects of drought on squirrel body mass. An ANOVA was performed, with day of year as a covariate, to compare body weights at last capture for adult male, adult female, juvenile male, and juvenile female Townsend's ground squirrels (*Spermophilus townsendii*) on 2 site types (open and shrubby) in May 1991 vs. May 1992 (Van Horne, unpubl. data). This analysis compares daily, not monthly, means, so means are not included. Sample size, *F* value, and *P* value are presented.

Site	Age	Sex	*n*	*F* value	*P* value
Shrub	Adult	Male	51	0.10	0.7483
	Adult	Female	44	0.00	0.9846
	Juvenile	Male	150	49.96	0.0001
	Juvenile	Female	195	52.51	0.0001
Open	Adult	Male	58	47.83	0.0001
	Adult	Female	147	57.59	0.0001
	Juvenile	Male	232	19.07	0.0001
	Juvenile	Female	241	30.39	0.0001

Many authors, including Esch et al. (1975) and Scott (1988), have suggested that decline in nutritional status of the host may result in increased prevalence of disease and parasitism in a host population and/or increased intensity of parasites in individual hosts. However, a relationship between nutritional status and parasitism is not well documented in wild rodents and only poorly documented in wild populations in general. We examined helminth parasites in Townsend's ground squirrels during the drought in 1992.

We compared helminth infections in squirrels living on open vs. shrubby sites and examined some of the biotic and abiotic factors affecting the structure of the helminth community in Townsend's ground squirrels. We present measurements for the first intact females of *Pterygodermatites coloradensis* sensu Hall, 1916.

Materials and Methods

Field collections

Between February and June 1992, 1 adult squirrel per month, as available, was collected for necropsy at the SRBPA near Boise, Idaho, from each of 10 open sites ($n = 37$) dominated by the grass *Poa segunda* and each of 10 shrubby sites ($n = 20$) dominated by big sage (*Artemisia tridentata*), winterfat (*Ceratoides lanata*), or a combination of the 2 shrubs. In May 1991, open sites averaged 0.3 ± 0.4% shrub cover while shrubby sites averaged 26.1 ± 9% shrub cover (Van Horne, unpubl. data). Sites ranged in size from 1 to

Table 2. The number of Townsend's ground squirrels (*Spermophilus townsendii*) infected with helminths each month, followed by prevalence and mean intensity of infection for all helminths recovered from the necropsy of 117 squirrels at the Snake River Birds of Prey Area near Boise, Idaho, in 1992.

		Hymenolepis citelli		*Syphacia citelli*		*Pterygodermatites coloradensis*		*Spirura infundibuliformis*	
Month	*N*	Infected (%)	Mean intensity	Infected (%)	Mean intensity	Infected (%)	Mean intensity	Infected (%)	Mean intensity
February	20	4 (20)	16.5	1 (5)	6	0	0	0	0
March	23	2 (9)	3	0	0	0	0	0	0
April	32	1 (3)	2	0	0	0	0	0	0
May	37	5 (14)	4.2	3 (8)	86.3	6 (16)	9.2	2 (5)	1
June	5	0	0	0	0	0	0	1 (20)	1
Total	117	12 (10)	7.9	4 (3)	66.3	6 (5)	9.2	3 (2)	1

9.5 ha. Twelve adult squirrels were obtained in February from an additional open site (nearly devoid of shrubs) for which exact cover information was not obtained. One juvenile per site per month was collected from the same sites following juvenile emergence (early April) until immergence in June (n = 20, open; n = 28, shrub).

Captured animals were transported to the field laboratory where they were euthanized with Halothane within 8 hr of capture. Blood for direct blood smears was drawn immediately after death via cardiac puncture. Blood smears were air-dried and carcasses were bagged and frozen within 5 min of death. Microslides and carcasses were transported to The University of New Mexico in June 1992 for analyses.

Laboratory procedures

Blood smears were fixed in absolute methanol, and stained with Giemsa-Wright. All slides were examined by a single observer for at least 10 min under oil immersion at × 1,250 using a Leica microscope.

For necropsy, animals were thawed and the entire gastrointestinal tract was removed. The stomach and cecal contents were examined separately using the same methods. Contents were washed through a 40-gauge (0.425-mm) sieve, transferred to a petri dish, and examined under a dissecting scope at ×20 or ×30. Presence of arthropod parts in the stomach was recorded, but no identifications were made. The stomach and cecal tissues were also examined. The small and large intestines were slit longitudinally, and tissue and contents were examined under a dissecting microscope.

The location of all helminths within the gastrointestinal tract was recorded, and then worms were fixed in 10% buffered formalin for 24 hr. Nematodes were transferred to 70% EtOH with 3% glycerol and examined using lactophenol wet mounts under both dissecting and compound microscopes. Detailed measurements of morphologically intact *P. coloradensis* were made using a Zeiss compound microscope at various magnifications following Lichtenfels (1970). All measurements are in micrometers unless otherwise stated. Cestodes were stained with either Grencher's borax carmine, Ehrlich's hematoxylin, or Delafield's hematoxylin and permanently mounted in Canada balsam for examination.

The prevalence of infection for each helminth over the entire season in shrubby vs. open sites, males vs. females, and juveniles vs. adults was compared using Fisher's exact test ($P > 0.05$) (Mehta and Patel, 1992), but sample sizes for all helminths was low. We also determined prevalence and mean intensity of infection for each worm by month (Table 2). We used linear regression to determine whether or not there were any time-related trends in prevalence and intensity for *Hymenolepis citelli* (McLeod, 1933), the only parasite found in >2 mo. We excluded infections in adults from shrubby sites (n = 1; captured 17 March 1992; infected with 1 tapeworm) from the regression analysis because adults on the shrubby sites were less severely affected by the drought than juveniles on shrubby sites and all animals on open sites (Table 1).

Voucher specimens of the helminth species recovered were deposited with the U.S. National Parasite Collection (USNPC), Beltsville, Maryland.

Results

No blood parasites were observed in the squirrels we examined, but 4 helminth species, all of which are new host records, were found (Table 2). Despite freezing of carcasses prior to necropsy, helminths were intact and easily identified and measured. Furthermore, location within the gastrointestinal tract for each species was consistent with locations described for these species in other hosts.

Hymenolepis citelli (McLeod, 1933) USNPC No. 83939

Prevalence and intensities are given in Table 2. Range of intensity was 1–41. There were no significant differences between prevalences of tapeworm infections for male vs. female or adult vs. juvenile Townsend's ground squirrels. *Hy-*

menolepis citelli did occur on significantly more of the open sites than shrubby sites (8 of 11 [73%] open sites vs. 2 of 10 [20%] shrub sites, $P = 0.03$), but prevalence of infection in the squirrel populations was not significantly different between the 2 site types (10 of 69 [14%] of squirrels on open sites vs. 2 of 46 [4%] on shrub sites, $P = 0.12$). There were no significant temporal trends for prevalence or intensity of infection. We excluded the single adult from a shrub site that was infected with *H. citelli* from this analysis.

Pterygodermatites coloradensis sensu Hall, 1916, USNPC No. 83941

Prevalence and intensities are given in Table 2. Range of intensity was 6–22. There were no significant differences between prevalences of infection for shrub vs. open sites, males vs. females, or adults vs. juveniles. Temporal trends were not analyzed because *P. coloradensis* was observed only in May (Table 2).

Syphacia citelli Tiner and Rausch, 1950, USNPC No. 83940

Prevalences and intensities are given in Table 2. Range of intensity was 6–119. There were no significant differences between prevalences of infection for adults vs. juveniles, males vs. females, or shrub vs. open sites. Temporal trends were not analyzed because worms were only detected in 2 mo.

Spirura infundibuliformis (McLeod, 1933) USNPC No. 83942

Prevalence and intensities are given in Table 2. No statistical comparisons were performed because only 3 individuals were infected and intensity was always 1. Only immature female worms were present.

Discussion

Three species of helminths have been reported from the Townsend's ground squirrel: *Citellina triradiata* Hall, 1916; *Physaloptera massino* Schultz, 1928 (Jenkins and Grundmann, 1973); and *Syphacia eutamii* Tiner, 1948 (Leiby, 1962). We did not recover any of these species; all 4 helminths we collected were new host records. We did not observe any parasites in the blood smears.

The original description of *Pterygodermatites coloradensis* by Hall (1916) was based on 2 males and a partial female taken from the chipmunk *Tamias quadrivittatus* (Say, 1823) in Colorado. The parasite was then redescribed by Tiner (1948) using 9 females and 2 males recovered from 3 species of *Peromyscus*. Lichtenfels (1970) reviewed this genus and suggested that the specimens collected by Tiner (1948) were distinct from those described by Hall (1916), and he renamed Tiner's specimens *Pterygodermatites peromysci* (Tiner, 1948) while the worms described by Hall retained the name *P. coloradensis*. Unfortunately, although many authors have reported this nematode from rodents, few have deposited their specimens in an accredited national repository. Thus, Lichtenfels (1970) was forced to base his redescription on only 3 specimens: 1 male and 2 partial females, 1 mature and 1 immature.

Pterygodermatites coloradensis has previously been described from only 1 species of ground squirrel, *Spermophilus variegatus* (Erxleben, 1777) (Jenkins and Grundmann, 1973). However, it has been reported from several other sciurids, *Tamias amoenis* Allen, 1890 (Rankin, 1945); *Tamias palmeri* (Merriam, 1889) (Archie et al. 1988); the antelope ground squirrel (no scientific name given) (Grundmann, 1957); and *Ammospermophilus leucurus leucurus* (Merriam, 1889) (Jenkins and Grundmann, 1973). It has also been reported from deer mice (*Peromyscus* spp.) (Rankin, 1945; Frandsen and Grundmann, 1959). This is the second observation from a spermophilid, and we present averages and size ranges for 11 males and 14 complete females. Our measurements of males are in close agreement with those of Lichtenfels (1970), with minor extensions of the size range (Table 3). The size range for many of the characters of the females has been extended. General morphological characteristics of the females were consistent with the description by Lichtenfels (1970). Because of the poor condition of the specimens available to Lichtenfels (1970), he was not able to determine the position of the vulva relative to the esophagus. We found that the vulva was posterior to the esophagus in the smallest females (9 mm) and anterior to the posterior end of the esophagus in females longer than 9 mm. In all cases, the vulva was between the 31st and 32nd pair of combs.

During our study in 1992, there was drought at the SRBPA (see the introduction). Based on comparisons of body masses between years (Table 1), open sites seemed the most stressful. If decreased nutritional status leads to an increase in parasitism (Esch et al., 1975; Scott, 1988),

Table 3. Measurements of *Pterygodermatites coloradensis* collected from Townsend's ground squirrels at the Snake River Birds of Prey Area near Boise, Idaho, in 1992 compared to those from Lichtenfels (1970).

	Males (N = 11)			Females (N = 14)		
	This study average (range)		Lichtenfels average	This study average (range)		Lichtenfels average
Total length (mm)	3.5	(3.0–4.0)	3.3	13	(9.0–17.0)	9 (est)*
Maximum diameter	277	(235–298)	277	448	(372–683)	360
Diameter base of buccal cavity	81	(70–89)	81.3	142	(120–174)	120
Buccal cavity depth/width	29/41	(24–35/35–50)	27/49	55/74	(50–65/65–89)	54/78
Esophagus length	1,044	(893–1,118)	875	2,152	(1,739–2,484)	1,500
Nerve ring from anterior	185	(180–223)	100	248	(200–310)	250
Largest comb height/width	45/99	(35–55/80–114)	45/85	48/105	(40–60/89–114)	42/105
Diameter of vulva		—		320	(285–397)	270
Vulva from anterior		—		2,074	(1,490–2,359)	—
Vulva from posterior		—		1,030	(675–1,491)	—
Egg length/width		—		42/30	(38–46/24–36)	38–40/22–24
Longest spine		—		92	(84–104)	81

* Estimated.

prevalence and intensity of parasitism should increase from February to June 1992 in juveniles on all sites and in adults on the open sites at the SRBPA, and infections should be more prevalent on open sites than on shrubby sites. We found no significant increase or decrease in the prevalence of infection for *H. citelli,* and there was no significant change in intensity during the drought (Table 2). Although the number of sites we compared was small and the proportions we obtained were only accurate to within 25% (Zar, 1984), significantly more open sites than shrubby sites harbored infected squirrels (8 of 11 [73%] open sites vs. 2 of 10 [20%] shrubby sites, P = 0.03). However, the prevalence of infection on open vs. shrubby sites was not significantly different (10 of 69 squirrels [14%] vs. 2 of 48 [4%], P = 0.12). The difference in distribution of *H. citelli* on open vs. shrub sites did not reflect differences in arthropod consumption rates by squirrels between the 2 site types; squirrels captured on open sites were significantly less likely to have arthropod parts in their gastrointestinal tracts than those captured on shrubby sites (16 of 69 [23%] vs. 20 of 48 [42%], P = 0.04). The species of arthropods that were consumed may be important, but arthropod parts were not identified.

The lack of temporal trends in prevalence and intensity of infection for *H. citelli* during the drought, and the lack of difference in prevalence of infection between the open (more stressful) and the shrubby sites suggests that either (H1) chance of infection with *H. citelli* was small enough that the temporal effects of the drought were not observable with the samples sizes we collected or (H2) no temporal trends in the prevalence or intensity of *H. citelli* occurred. The current study does not allow us to distinguish between these 2 hypotheses.

Wilber et al. (1994) found a significant decrease in the prevalence of eimerian infections in 1992 in this same population of Townsend's ground squirrels, but an increase in the prevalence of gastric ulcers from February to April (Wilber, pers. obs.). Based on the varied temporal trends observed for *H. citelli,* eimerians, and gastric ulcers in the Townsend's ground squirrels at the SRBPA in 1992, we suggest that differences in parasite life-history parameters, immune responses of the host to the parasites, and abiotic effects on the parasites may interact to produce highly variable temporal responses to the same environmental perturbation.

Prevalence of infection with the tapeworm *H. citelli* at the SRBPA was similar to values reported in other spermophilids as was range of intensity (1–41) and average intensity (Table 2) (see Broda and Schmidt, 1978; Shults and Stanton, 1987).

Prevalence of *P. coloradensis* (Table 2) was not significantly different than the prevalence of 3% (1 of 54) in *S. variegatus* (Jenkins and Grundmann, 1973). Intensity and mean intensity could not be compared to other reports because no other data on intensity of *P. coloradensis* in spermophilid or ammospermophilids has been published.

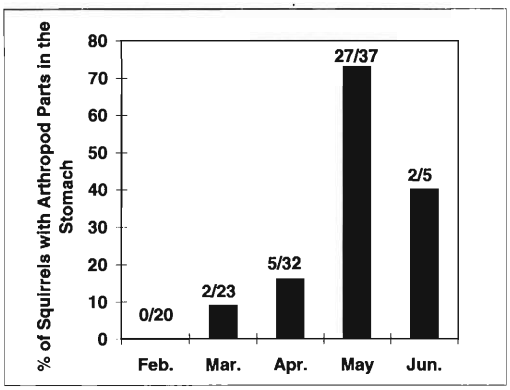

Figure 2. The percentage (%) of Townsend's ground squirrels (*Spermophilus townsendii*) ($N = 117$) collected at the SRBPA from February to June 1992 with arthropod parts in the gastrointestinal tract.

The low levels of infection with *P. coloradensis* early in the season may reflect a lack of suitable intermediate hosts in the environment, incomplete development of the intermediate stage in the arthropods, or low levels of consumption of arthropods by the squirrels from February to April (Fig. 2).

The prevalence of *S. citelli* in Townsend's ground squirrels ranged from 0 to 8% (Table 2), which is low compared to most other reports (see Jenkins and Grundmann, 1973; McGee, 1980; Shults and Stanton, 1987). The range of intensity (6–119) and average intensity (Table 2) were similar to previous reports.

Spirura infundibuliformis has been described from 3 species of ground squirrel and was redescribed by Anderson et al. (1993). Prevalence of infection for *Spermophilus richardsonii* (Sabine, 1822) ranged from 7% in May to 100% in June, probably because the "local grasshoppers" (no scientific name given) that can serve as the intermediate host for this nematode became more abundant later in June (Anderson et al., 1993). Townsend's ground squirrels were also infected in May and June (Table 2) but prevalence and intensity (1 worm/squirrel) were low compared to those in other reports (McGee, 1980; Anderson et al., 1993).

There is general interest in understanding factors that structure helminth communities. In Townsend's ground squirrels at the SRBPA during the drought in 1992, only 1 of 117 squirrels was infected with >1 species of helminth. Given the low prevalence of the helminths in 1992, squirrels may have encountered infective stages so infrequently that the opportunity to acquire multiple infections was rare, thus the community structure was probably determined primarily by chance.

Interestingly, the 4 helminths occupied different regions of the gut: *S. infundibuliformis* was found only in the stomach, *P. coloradensis* only in the small intestine just below the pyloric sphincter, *H. citelli* only in the middle of the small intestine, and *S. citelli* only in the cecum. Possible overlap may occur between *P. coloradensis* and *H. citelli,* but the 2 worms were never observed to coexist. The use of different regions of the gut by the helminths may result in decreased competition when multispecies infections occur.

The helminth community in this sample of Townsend's ground squirrels consisted of 3 worms with indirect life cycles requiring arthropods and only 1 with a direct life cycle. In addition, *Dipodomys merriami* Mearns, 1890 (Merriam's kangaroo rat), at the Sevilleta National Wildlife Refuge near Socorro, New Mexico, had 10 helminths, 8 which require arthropods as the intermediate host and 2 with direct life cycles (Patrick, 1995). The predominance of helminths with indirect life cycles in these 2 arid environments contradicts Dobson's (1989) hypothesis that macroparasites with direct life cycles should be more common than those with indirect life cycles in arid regions. We suggest that parasites utilizing arthropods as intermediate hosts may be especially well adapted to xeric environments because arthropods tend to be abundant in deserts (McMahon, 1985) (facilitating infection of the arthropod by the parasite) and the intermediate host may provide a buffer against desiccation. Parasites in arid areas that have direct life cycles might be most effectively transmitted through direct contact between hosts, as may be the case for the cecal worms in both the kangaroo rats and the ground squirrels, or have eggs/propagules that are resistant to desiccation, as do eimerians. Seven species of *Eimeria* inhabit both Townsend's ground squirrels (Wilber et al., 1994) and Merriam's kangaroo rats (Patrick, 1995).

In summary, the Townsend's ground squirrel in Idaho during a drought was infected with 4 species of helminths, all of which were new host records. Three of these helminths have indirect life cycles and 1 has a direct life cycle, contra-

dicting Dobson's (1989) hypothesis. *Hymenolepis citelli* was more widely distributed among the more stressful open sites, but there were no differences in prevalence of infection between open and shrubby sites, and no temporal trends in the prevalence or intensity of this helminth were observed. Only 1 squirrel harbored a multispecies infection, and each helminth occupied a unique region of the gut.

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Parasitic Helminths and Arthropods from Brazilian Free-Tailed Bats (*Tadarida brasiliensis cynocephala*) in Florida

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ABSTRACT: Forty-five Brazilian free-tailed bats (*Tadarida brasiliensis cynocephala*) from 5 locations in Florida were examined for parasites. Eleven species of helminths were identified and included 7 trematodes, 3 nematodes, and 1 cestode, all of which are new records for bats from Florida. The identification of the cestode *Vampirolepis decipiens* is the first record in the United States, and the identification of the trematode *Ochoterenatrema breckenridgei* is a new record for *Tadarida brasiliensis* in the United States. The nematode *Molinostrongylus delicatus* was the most prevalent helminth collected (64%). Eight species of mites were identified, with *Chiroptonyssus robustipes* being the most prevalent (100%). The mites *Ewingana* (*Ewingana*) *longa, Dentocarpus macrotrichus,* and *Notoedres* (*Bakeracarus*) sp. are reported for the first time infesting bats from Florida.

KEY WORDS: Brazilian free-tailed bat, *Tadarida brasiliensis cynocephala,* Chiroptera, trematodes, cestodes, nematodes, mites, Florida.

Brazilian free-tailed bats, *Tadarida brasiliensis cynocephala* (Le Conte, 1831), are found commonly throughout Florida, except the Florida Keys, and are 1 of the 2 species of Molossidae that occur in the state (Brown, 1987). Although the ectoparasites of Brazilian free-tailed bats from Florida have been documented, their endoparasites have not been reported (Forrester, 1992). In the United States, the helminth records for *T. brasiliensis* (Geoffroy Saint-Hilaire, 1824) are summarized by Webster (1973), and significant surveys since then include Martin (1976) and Lotz and Font (1991). Surveys have been conducted also in Jamaica (Webster, 1971), Cuba (Baruš and Valle, 1967; Groschaft and Valle, 1969; Rutkowska, 1980; Zdzitowiecki and Rutkowska, 1980), and Mexico (Caballero, 1940, 1942, 1943). *Tadarida brasiliensis cynocephala* was included in only 2 of these studies (Martin, 1976; Lotz and Font, 1991). The present report concerns the parasites of 45 *T. brasiliensis cynocephala* from Florida.

Methods

Forty-three Brazilian free-tailed bats from north-central Florida (Alachua County [Gainesville], $n = 33$; Marion County [Ocala], $n = 7$; Polk County [Lakeland], $n = 3$) were collected from 1992 to 1995; 1 bat from central Florida (Lake Placid, Highlands County) was collected in March 1973; and 1 bat from southern Florida (Davie, Broward County) was collected in March 1989. Two bats were examined fresh; the rest were frozen before necropsy.

Twenty-eight bats from Alachua County were examined for ectoparasites, and arthropods collected were placed in 70% ethanol. Representatives of each putative taxon were mounted on glass microscope slides in Hoyer's medium and examined with an interference contrast microscope.

All 45 bats were examined for endoparasites. Organs were separated from each other and placed into individual petri dishes; the small intestine was divided into 3 equal parts. Under a dissecting microscope, the hollow organs were incised and solid organs macerated. Cestodes and trematodes were preserved in Roudabush's alcohol/formalin/acetic acid and nematodes in 70% ethanol with glycerin. Cestodes were stained with either Harris' hematoxylin or Semichon's acetocarmine, and trematodes were stained with Semichon's acetocarmine. Nematodes were mounted in lactophenol. Helminth voucher specimens have been deposited in the Harold W. Manter Collection, University of Nebraska State Museum (Lincoln, Nebraska), and the U.S. National Parasite Collection (Beltsville, Maryland). Arthropod voucher specimens have been deposited in the U.S.D.A. National Veterinary Services Laboratories, Parasitology Reference Collection (Ames, Iowa).

Results and Discussion

Eleven species of helminths were collected from the 45 bats. These included 7 species of trematodes, 3 nematodes, and 1 cestode (Table 1). None has been recorded previously from this host in Florida. Seven bats were free of helminths. Multiple helminth infections were as follows: 9 bats had 1 species of helminth, 11 had 2 species, 11 had 3 species, 4 had 4 species, and 3 had 5 species. A total of 804 helminth specimens was collected.

Of the helminths collected in this study, *Mol-*

Table 1. Helminths from 45 Brazilian free-tailed bats (*Tadarida brasiliensis cynocephala*) from Florida.

Helminth	Alachua County (n = 33)		Marion County (n = 7)		Polk County (n = 3)		All Bats* (n = 45)	
	% prevalence	Intensity $\bar{x}$ (range)	% prevalence	Intensity $\bar{x}$ (range)	% prevalence	Intensity $\bar{x}$ (range)	% prevalence	Intensity $\bar{x}$ (range)
Trematoda								
Acanthatrium sp. (2, 3)† (USNPC 83849–50, HWML 37519–20)‡	9	4 (3–5)	—		—		7	4 (3–5)
Limatulum oklahomense Macy, 1931 (1) (USNPC 83853–54, HWML 37524–26)	36	2 (1–10)	29	4 (2–6)	67	5 (1–8)	36	3 (1–10)
Paralecithodendrium chilostomum (Mehlis, 1831) (2) (USNPC 83852, HWML 37528)	6	4 (1–7)	—		33	3 (—)	7	4 (1–7)
Ochoterenatrema breckenridgei (Macy, 1936), (2, 3) (HWML 37521)	—		14	6 (—)	33	2 (—)	7	4 (2–6)
Ochoterenatrema labda Caballero, 1943 (2, 3) (USNPC 85415, HWML 37523)	3	1 (—)	29	86 (2–171)	33	8 (—)	11	76 (1–197)
Urotrema scabridum Braun, 1900 (3, 4) (USNPC 83851, HWML 37527)	27	1 (1–4)	14	1 (—)	—		22	2 (1–4)
Dicrocoelium rileyi Macy, 1931 (5) (HWML 37522)	3	3 (3)	—		—		4	7 (3–10)
Cestoda								
Vampirolepis decipiens (Diesing, 1850) (2, 3) (USNPC 83855–56, HWML 37529–31)	30	3 (1–8)	—		—		22	3 (1–8)
Nematoda								
Molinostrongylus delicatus (Schwartz, 1927) (1, 2) (USNPC 83857–59, HWML 37516–18)	64	6 (1–34)	29	2 (1–3)	—		53	6 (1–34)
Capillaria sp. immature (1)	15	2 (1–5)	—		—		11	2 (1–5)
Physoloptera sp. immature (1, 2)	33	13 (1–43)	14	1 (—)	—		27	13 (1–43)

* Totals include 1 bat from Broward County, which had 1 *M. delicatus* and 197 *O. labda*, and 1 bat from Highlands County, which had 5 *O. breckenridgei* and 10 *D. rileyi*.
† Numbers in parentheses indicate locations in host: (1) stomach, (2) upper ⅓ small intestine, (3) middle ⅓ small intestine, (4) lower ⅓ small intestine, and (5) liver/gall bladder.
‡ Sample accession numbers: HWML = Harold W. Manter Laboratory parasite collection, USNPC = U.S. National Parasite Collection.

inostrongylus delicatus had the highest prevalence (64%). This nematode is common to *T. brasiliensis* throughout its North American range, occurring in prevalences ranging from 11 to 44%.

Three bats had high numbers of physalopterid larvae encysted in their stomach walls (i.e., 37, 37, and 45 larvae). Martin (1976) reported immature *Physaloptera* sp. in *T. brasiliensis* from Texas and Louisiana, but he gave no intensities or locations within the host.

Twelve specimens of *Acanthatrium* sp. were collected from 3 bats from Alachua County. The genital atrial spines in each were arranged as a main group of spines pointing posteriorly and a smaller grouping of opposing spines pointing anteriorly. This arrangement of spines in the genital atrium closely resembled that described by Macy (1940) in what he called *Acanthatrium eptesici* Alicata from an *Eptesicus fuscus* (Palisot de Beauvois) collected in St. Paul, Minnesota. However, the *Acanthatrium* from Florida differed from Alicata's (1932) original description of *A. eptesici*. The length and width of the Florida fluke were much smaller (503 by 319 μm), the sizes of both the oral and ventral suckers were smaller (ratio = 1.27–1), the prostate mass was half as big (87 by 76 μm), the length of the atrial spines is 19–21 μm for the anterior set of spines and 17–18 μm for the opposing set of spines, and the testes much smaller (85 by 82 μm). The blunt papilla to the right of the genital atrium that was observed consistently in *A. eptesici* by Lotz and Font (1983) was absent in all of our specimens. Attempts to obtain the specimen of *A. eptesici* described by Macy (1940) for comparison were unsuccessful. The Florida specimens of *Acanthatrium* did not conform to any of the published species descriptions of *Acanthatrium*; therefore, we feel that it may be a new species. However, because our specimens were frozen, in some cases up to 4 mo, we do not feel confident about describing a new species until fresh specimens can be examined.

Ochoterenatrema labda Caballero was collected from 4 bats. Two bats, 1 each from Broward and Marion counties had high intensities with 194 and 171 specimens, respectively. Specimens of *O. breckenridgei* were collected from bats in Highlands, Marion, and Polk counties. This is the first record of *O. breckenridgei* from *T. brasiliensis* in the United States.

Limatulum oklahomense was described originally by Macy (1931) from *T. brasiliensis cynocephala* collected from Oklahoma and Kansas with a prevalence of 3.6%. The prevalence of *L. oklahomense* in the Florida sample was much higher at 36%. Lotz and Font (1991) reported that no *L. oklahomense* were found in the 59 *T. brasiliensis cynocephala* they sampled in Louisiana.

Two cestodes are known to infect *T. brasiliensis*: *Vampirolepis gertschi* (Macy, 1947) and *V. decipiens* (Diesing). Thirty percent of the bats from Alachua County were infected with *V. decipiens* and yielded a total of 30 specimens. Diesing (1850) first described this cestode from *Tadarida laticaudata* (É. Geoffroy) in Paraguay. Previously, only *V. gertschi* was reported from *T. brasiliensis* in the United States (Cain, 1966; Martin, 1976). Cain (1966) was uncertain about the identification of the cestode he found and tentatively identified it as *V. gertschi,* even though it differed from Macy's (1947) description. This is the first published report of *V. decipiens* in the United States; it is also a new host record in *T. brasiliensis cynocephala*. However, Rogers (1965), in an unpublished master's thesis, reported *V. decipiens* in *T. brasiliensis mexicana* (Saussure, 1860) from Oklahoma, and it was the only species of cestode collected in the 898 *Tadarida* he sampled.

One insect and 8 mite species were collected from the 28 bats from Alachua County examined for ectoparasites (Table 2). Every bat was infested with at least 1 mite. Multiple arthropod infestations were as follows: 20 bats bore only 1 arthropod species, 6 had 2 species, and 2 had 3 species. A total of 1,429 arthropod specimens was collected and identified, but intensities could not be calculated because quantitative techniques were not used to obtain every parasitic arthropod from each host as they were for the parasitic helminths.

Among the collected arthropod assemblage, only 6 of the mite species are truly bat parasites; the other 3 arthropods probably were accidentally or incidentally present on the sampled bats. Two bats yielded a total of 3 individual unidentified psocids (Insecta: Psocoptera). These insects are normally free-living herbivores, fungivores, or detritivores (Mockford, 1993), with only rare occurrences noted on mammal fur (Pearman, 1960).

Two of the collected mites are either known or putative prostigmatid predators on other mites and, like the psocids, both were probably present

Table 2. Ectoparasites from 28 Brazilian free-tailed bats (*Tadarida brasiliensis cynocephala*) from Alachua County, Florida.

Arthropod	No. bats infested	% prevalence	No. mites collected*
Chiroptonyssus robustipes (Ewing, 1925) (94-16229)†	28	100	67 M, 121 F, 1,227 N
Dentocarpus macrotrichus Dusbábek and Cruz, 1966 (94-16226)	1	3.5	1 M, 1 N, 1 L
Ewingana (*Doreyana*) *inaequalis* (Ewing, 1938) (94-16222)	1	3.5	1 F
Ewingana (*Ewingana*) *longa* (Ewing, 1938) (94-16226)	1	3.5	1 M, 2 F
Ewingana (*Doreyana*) sp. (94-16209)	1	3.5	1 F
Notoedres (*Bakeracarus*) sp. (94-16212)	1	3.5	1 F
Raphignathus sp. (94-16213)	1	3.5	1 F
Prostigmata: Cheyletidae (Cheyletiini) (94-16218)	1	3.5	1 M
Psocid (Insecta: Psocoptera) (94-16214)	2	7.0	3

* F = female, M = male, L = larva, N = nymph.
† U.S.D.A. National Veterinary Services Laboratories accession numbers.

by contamination from the bats' environment. One male cheyletid mite was in poor condition and unidentifiable, although it was not *Cheletonella vespertilionis* Womersley the member of the predator family Cheyletidae most frequently associated with bats (Volgin, 1969), because it possessed eyes where *C. vespertilionis* does not. A female *Raphignathus* mite collected on another bat did not match any of the approximately 2 dozen species described in the family Raphignathidae (Robaux, 1976). Numerous parasitic mites inhabited both bats from which the 2 predaceous mites were taken.

Chiroptonyssus robustipes (Mesostigmata: Macronyssidae) was the only mite with a prevalence of 100%. Its typical and nearly exclusive host is *T. brasiliensis,* on which it is known to breed (Radovsky, 1967). A few collections from several other bat species probably represent strays and were acquired when sharing roosts with *T. brasiliensis* (Radovsky, 1967; Durden et al., 1992). Both adults and nymphs were present on every host we examined, with 71% being the active protonymphal stage.

One female specimen of an undescribed species of *Notoedres* (Astigmata: Sarcoptidae) was collected from 1 bat. Our specimen belongs in the subgenus *Bakeracarus,* which contains the 9 described species that occur on vespertilionid and molossid bats in the United States, the neotropics, Europe, and Korea (Klompen, 1992). One species, *N.* (*Bakeracarus*) *lasionycteris* (Boyd and Bernstein), has been collected previously from *T. brasiliensis* in Cuba (Dusbábek, 1970), but our mite is different from that species.

The remaining 4 mite species collected were astigmate fur mites. *Dentocarpus macrotrichus* (Chirodiscidae) was represented by 3 specimens from a single bat. The type host of *D. macrotrichus* is *T. brasiliensis muscula* (Grundlach) from Cuba (Fain, 1973); it is known also from *T. brasiliensis mexicana* in Texas (McDaniel and Coffman, 1970), but this is the first record for this mite from Florida.

Three species of *Ewingana* fur mites (Myobiidae) occurred on our bats, each on a separate host individual. Two female and 1 male *E.* (*Ewingana*) *longa* coinhabited a bat with *C. robustipes* and *D. macrotrichus.* This mite was first collected and described from Berkeley, California, on *T. brasiliensis mexicana* in 1934 (Ewing, 1938). It also is known from Texas and Alabama but has not been collected before in Florida. Our second species (1 female), *Ewingana* (*Doreyama*) *inaequalis,* was first collected and described from Leon County, Florida, on *T. brasiliensis cynocephala* in 1934 (Ewing, 1938). The third *Ewingana* mite (a single female) also belongs in the subgenus *Doreyama,* but it differs from *E. inaequalis* in several respects, most notably the tarsal claws, morphology of the first pair of legs, and the structure and arrangement of the dorsal setae. Three other species of *E.* (*Doreyama*) were described from neotropical molossid bats, although only *E. inaequalis* is known from *T. brasiliensis*; our specimen differs from all 4 species, and it seems to represent an undescribed species.

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Helminths of Mink, *Mustela vison*, and Muskrats, *Ondatra zibethicus*, in Southern Illinois

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ABSTRACT: Five species of helminths were detected in 50 mink, *Mustela vison*, and 3 in 50 muskrats, *Ondatra zibethicus*, taken between fall 1993 and fall 1995 from Randolph, Monroe, Washington, and Jackson counties in southern Illinois. Although both mammals share similar habitats and some common food items, their endoparasites were dissimilar. Species and prevalences of infection for mink included *Capillaria putorii* (34%), *Dirofilaria immitis* (2%), *Filaroides martis* (62%), *Molineus* sp. (2%), and *Paragonimus kellicotti* (14%), whereas those for muskrats included *Echinostoma trivolvis* (42%), *Quinqueserialis quinqueserialis* (18%), and *Taenia taeniaeformis* cysticerci (22%). All helminths from *M. vison* and *T. taeniaeformis* cysticerci from *O. zibethicus* in Illinois constitute new geographic locality records. *Dirofilaria immitis* in *M. vison* represents a new host record.

KEY WORDS: mink, muskrat, helminths, *Capillaria putorii, Dirofilaria immitis, Filaroides martis, Molineus* sp., *Paragonimus kellicotti, Echinostoma trivolvis, Quinqueserialis quinqueserialis, Taenia taeniaeformis.*

Both the mink, *Mustela vison* Schreber, 1777, and the muskrat, *Ondatra zibethicus* Linnaeus, 1766, are widely distributed throughout most of North America. Mink occur in all parts of the contiguous United States with the exception of Arizona and inhabit most of Alaska and all of Canada south of the treeline except for the Anticosti Island and the Queen Charlotte Islands (Banfield, 1974). The geographic distribution of muskrats extends from northern Mexico to northern Alaska and northern Canada. They are, however, absent in Florida and parts of extreme northern Alaska and Canada (Doyier, 1953; Lowery, 1974).

Mink are well adapted for hunting both aquatic and terrestrial prey (Linscombe et al., 1982), whereas muskrats are chiefly herbivores (Bailey, 1937; Doyier, 1953). However, both feed on clams, crayfish, fish, frogs, and young birds, all of which may serve as intermediate hosts in parasite transmission. Because mink and muskrats are carnivores and rodents, respectively, one would not expect them to have helminths in common, except when a muskrat serves as an intermediate host for adult helminths in mink.

The purpose of the present study was 2-fold: (a) to ascertain the prevalence and intensity of helminths that infect both mink and muskrats in southern Illinois and (b) to determine whether these mammals share common helminths.

Materials and Methods

Fifty *Mustela vison* and 50 *Ondatra zibethicus* were collected in Randolph, Monroe, Washington and Jackson counties, of southern Illinois between September 1993 and January 1995. Animals were obtained by means of live trapping and from commercial hunters during the trapping season. Examinations of carcasses were performed either on the day of the capture or the next day.

The esophagus, stomach, small intestine, large intestine, liver, and lungs were separated and placed into containers of physiological saline. These organs, in addition to the body cavity, were then examined with a dissecting microscope. Digeneans and cestodes were fixed in alcohol–formalin–acetic acid solution, stained in Harris hematoxylin, dehydrated, cleared in beechwood creosote, and mounted in Canada balsam. Nematodes were fixed in warm glacial acetic acid or hot 70% ethanol, stored in a solution of 5 parts glycerine and 95 parts 70% ethanol, cleared in glycerine, and studied as temporary mounts.

The ecological terms *prevalence* and *intensity* used in this report are those of Margolis et al. (1982). Voucher specimens have been deposited in the U.S. National Parasite Collection, USDA, Beltsville, Maryland 20705, under the accession numbers listed in Tables 1 and 2.

Results and Discussion

Digeneans of a single species and nematodes of 5 species were recorded from 50 mink, and digeneans of 2 species and a cestode were obtained from 50 muskrats. The species of helminth, anatomical location within the host, prevalence, mean intensity, range of intensity, and accession numbers for deposited specimens are listed in Table 1 for *M. vison* and Table 2 for *O. zibethicus*. Comparison of the data in these 2 tables reveals that mink were infected with a greater variety of helminths than muskrats.

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Table 1. Helminths recovered from 50 mink, *Mustela vison*, in southern Illinois.

Species	Anatomical location	Prevalence (%)	Mean intensity	Range of intensity	USNPC no.
Nematoda					
Capillaria putorii	Small intestine, stomach	34	5	2–11	85416
Dirofilaria immitis	Heart	2	1	1	85417
Filaroides martis	Lungs	62	70	30–120	85418
Molineus sp.	Small intestine	2	1	2	*
Trematoda					
Paragonimus kellicotti	Lungs	14	2	1–4	85419

* *Molineus* species were lost during transport.

Thirty-four (68%) of 50 mink including 10 (62.5%) of 16 females and 24 (70.5%) of 34 males were infected. Twenty-two (44%) of 50 mink were infected with a single species of helminth, whereas 12 (24%) of 50 were infected with 2 species. The data concerning the species found in mink in the present study (Table 1) reveal that nematodes and digeneans are more prevalent than cestodes and acanthocephalans.

Thirty (60%) of 50 muskrats including 11 (55%) of 20 females and 19 (63.3%) of 30 males were infected. Twenty-four (48%) of 50 muskrats were infected with a single species of helminth, whereas 6 (12%) of 50 were infected with 2 species. The data concerning the species found in muskrats in the present study (Table 2) reveal that cestodes and digeneans are more prevalent than nematodes and acanthocephalans.

Although helminths common to both mink and muskrats have been reported previously, common parasites were not found in the present study. This may be due to a couple of factors. As already stated, helminths common to both species would be expected if muskrats served as intermediate hosts for adult helminths in mink. In the present study, the helminths detected in muskrats did not include those which allow the muskrat to serve as an intermediate host for mink helminths; therefore, they are not expected to be common to both species. Second, the sample size was not very large and, because most animals were obtained in the months of December and January, the time frame of the present study did not allow for comparison of helminths during other months of the year.

Whereas most infections in either mink or muskrats were single infections, multiple infections were limited to no more than 2 species of helminths. A brief discussion of each species found is presented.

Parasites of Mink, *Mustela vison*

Nematoda

Capillaria putorii (Rudolphi, 1819) Travassos, 1915

Capillaria Zeder, 1800, is a large genus including species that parasitize nearly all organs and tissues of all classes of vertebrates. Yamaguti (1961) listed 88 species in mammals alone. Several attempts have been made to divide the genus into smaller taxa. However, Butterworth and Beverley-Burton (1980) in a study of the taxonomy of *Capillaria* spp. presented a historical

Table 2. Helminths recovered from 50 muskrats, *Ondatra zibethicus*, in southern Illinois.

Species	Anatomical location	Prevalence (%)	Mean intensity	Range of intensity	USNPC no.
Cestoda					
Taenia taeniaeformis (cysticerci)	Liver	22%	3	2–7	85420
Trematoda					
Echinostoma trivolvis	Small intestine	42%	15	2–67	85423
Quinqueserialis quinqueserialis	Small intestine, large intestine	18%	2	1–5	85421 85422

review of the genus and rejected the concept of recognizing other genera based on single characters. Their examination of specimens of *C. putorii, C. erinacei* (Rudolphi, 1819) Travassos, 1915, and *C. mustelorum* Cameron and Parnell, 1933, from type hosts lead to the conclusion that the latter 2 species are synonyms of *C. putorii.* They further demonstrated that *C. putorii* is readily distinguished by the presence of 2 lateral caudal alae, large terminal caudal ala, and 2 digitiform papillae in the male, in addition to the network of ridges on the eggshell. Moravec (1982), who proposed a new systematic arrangement of nematodes of the family Capillariidae, supported the view that the morphological features of various capillariid species, their different location, and the heterogeneity of their definitive hosts give evidence for the existence of several genera in the family.

In the present study, *C. putorii* was found in the stomach or small intestine or both in the same individual of 17 (34%) of 50 mink (Table 1) representing 5 (31.2%) of 16 females and 12 (35%) of 34 males. Of the 4 species of nematodes found in mink, *C. putorii* was the second most common roundworm. The finding of *C. putorii* in mink from Illinois represents a new geographic locality record.

Dirofilaria immitis (Leidy, 1856) Railliet and Henry, 1911

A single female found in the right side of the heart of a male mink was identical to the description of *Dirofilaria immitis* as given by Orihel (1961). This represents the first report of this nematode in *Mustela vison.*

D. immitis has been reported in a variety of mammals from various localities in North America. Although dogs are the major definitive hosts, *D. immitis* has also been reported in raccoons by Snyder et al. (1989), coyotes by Kick et al. (1984), wolverines by Williams and Dade (1976), red foxes by Kazacos (1977), muskrats by Goble and Cook (1942), and black bears by Davidson and Nettles (1988). Because only a single specimen was detected in a sample size of 50 mink, further studies involving a larger population of mink need to be conducted in order to ascertain the status of *D. immitis* in this mammal.

Filaroides martis (Werner, 1782) Dougherty, 1943

This metastrongyle was the most common nematode. It occurred in 31 (62%) of 50 mink including 11 (68.7%) of 16 females and 20 (58.8%) of 34 males. The prevalence of *F. martis* reported here is somewhat higher than that given in comprehensive surveys. Miller and Harkema (1964) found 58 (48%) of 120 mink in North Carolina infected with this helminth, whereas Dorney and Lauerman (1969) reported 18 (43%) of 42 mink from Wisconsin infected. Anderson (1962) detected this helminth in 316 of 657 males and 121 of 319 female mink from Ontario, resulting in an overall prevalence of 45%.

Examination of specimens was difficult because the worms occur in nodules in the bronchi and brochioles and are enclosed in tough, fibrous connective tissue. Worms were compacted into closely interwined knots and frequently only fragments of the nematodes could be obtained for study. Females are ovoviviparous. Eggs hatched and larvae were active upon thawing of worms in tissue that had been frozen at −20°C for 2 days. Anderson (1962) demonstrated a sigmoidal relationship between temperature and activity of first-stage larvae of *Perostrongylus pridhami* encapsulated in the liver of mice. This helminth is also a viviparous metastrongyle in mink. The finding of *F. martis* in *M. vison* in Illinois constitutes a new geographic locality record.

Molineus sp.

Two females of the genus *Molineus* were found in the small intestine of a single male *M. vison.* In the absence of male worms, this nematode could not be identified to the species level. *Molineus patens* (Dujardin, 1845) Petrow, 1928, is the only species of this genus recorded from mink. Miller and Harkema (1964) reported 34 (28%) of 120 mink infected with *M. patens* in North Carolina, whereas Dorney and Lauerman (1968) found 1 (2%) infection from 47 *M. vison* in Wisconsin. The finding of specimens of *Molineus* in mink from Illinois constitutes a new geographic locality record.

Trematoda

Paragonimus kellicotti Ward, 1908

This digenean was detected in the lungs of 7 (14%) of 50 mink including 3 (18%) of 16 females and 4 (11.7%) of 34 males. *Paragonimus kellicotti* has been reported from several vertebrate hosts in North America including skunks, red foxes, coyotes, least weasels, raccoons, and muskrats (Ramsden and Presidente, 1975). Dogs, cats, and humans may also become infected. On

the basis of the frequency of natural infections, mink are believed to be the natural hosts (Olsen, 1974).

The taxonomy of the genus in North America remains unsettled. Some workers recognize *P. kellicotti,* whereas others consider this species a synonym of *P. westermani* (Kerbert, 1878) Braun, 1899. *P. rudis* (Diesing, 1850) Stiles and Hassall, 1900, detected by Miller and Harkema (1964) from North Carolina mink, is considered by most authors to be a synonym of *P. kellicotti.*

Ward and Hirsch (1915) differentiated *P. westermani* from *P. kellicotti* on the basis of the arrangement of tegumental spines. Ameel (1934) published an account of the life history, taxonomy, and distribution of *Paragonimus* in North America. He did not agree that the 2 species could be differentiated on the basis of arrangement of spines. Miyazaki (1949) noted that the ovary in *P. westermani* is less branched than in *P. kellicotti.* More recently, Ishii (1966) stressed the nature of the tegumental spines, egg morphology, and the morphology of the testes and ovaries. Ishii concluded that adults of *P. westermani* and *P. kellicotti* may be differentiated on the basis of the morphology of the ovary. Branching of the ovary in *P. kellicotti* is more distinct and extensive than that of *P. westermani,* which is less branched.

Specimens in the present study are tentatively assigned to *P. kellicotti* based on the morphology of the ovary until more valid criteria for differentiation are established. The finding of this species in mink in Illinois represents a new geographic locality record.

Parasites of Muskrats, *Ondatra zibethicus*

Cestoda

Taenia taeniaeformis (Batsch, 1786) Wolffhuegel, 1911

Cysticerci of *T. taeniaformis* were found encysted in nodules on the surface of the liver of 11 (22%) of 50 muskrats including 2 (10%) of 20 females and 9 (30%) of 30 males.

T. taeniaeformis is commonly parasitic in the small intestine of domestic cats and other felines (Gallati, 1956), which are the main source of eggs for infection of muskrats and voles. The only report of this parasite in muskrats from Illinois is by Gilford (1954), who reported cysticerci in 2.2% of 250 muskrats from north-central Illinois. This report constitutes a new geographic locality record for this tapeworm in muskrats of southern Illinois.

Trematoda

Echinostoma trivolvis Cort, 1914

Echinostoma trivolvis was the most abundant digenean in muskrats in the present study. It was found in the small intestine of 21 (42%) of 50 muskrats, including 8 (40%) of 20 females and 8 (26.6%) of 30 males. Ulceration and bleeding of the intestinal mucosa were evident when 30 or more specimens were present.

It is one of the most common and abundant of all trematodes of warm-blooded semiaquatic vertebrates showing little host specificity (Schmidt and Roberts, 1989). The high prevalence of this parasite in many surveys may reflect the presence of numerous hosts, which may serve as part of the reservoir for this digenean (Beaver, 1937).

Adult *Echinostoma trivolvis* exhibit considerable morphological variation in response to the physiology of a particular definitive host. This has resulted in the description of numerous new species. As a result of Beaver's (1937) extensive experimental studies, about 15 species were declared synonyms of *E. revolutum.* More recently, Huffman and Fried (1990) conducted an extensive study concerning the biology, infectivity, immunology, pathology, and epidemiology of *Echinostoma* species and demonstrated that *E. trivolvis* and not *E. revolutum* is the correct name for the North American form.

Quinqueserialis quinqueserialis (Barker and Laughlin, 1911) Harwood, 1939

This monostome was found in the intestines of 9 (18%) of 50 muskrats including 4 (20%) of 20 females and 5 (16.6%) of 30 males. It is a ubiquitous parasite over the muskrat's range in North America. In addition, it also occurs in meadow voles and jumping mice in the United States and Canada (Olsen, 1974). Although *Q. quinqueserialis* has been reported in almost all surveys of muskrat parasites, the intensity of infection is usually low and it does not appear to present a serious threat to the health of the host.

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Research Note

Survey of the Parasites of Zebra Mussels (Bivalvia: Dreissenidae) in Northwestern Russia, with Comments on Records of Parasitism in Europe and North America

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ABSTRACT: We report the results of a survey of the parasites of zebra mussels, *Dreissena polymorpha,* at 13 sites in the Moscow–St. Petersburg region during 8–22 July 1993. Mussels with trematodes were observed at 7 (54%) of the sampling sites, with the following prevalence of infection: adult *Aspidogaster,* <1%, at each of 3 sites; *Phyllodistomum* sporocysts, <1%, at each of 4 sites; and *Bucephalus polymorphus* sporocysts, 9% at 1 site. Severe infections were only noted for *B. polymorphus,* which destroyed the gonads of its hosts. Ciliates in the order Hymenostomatida were observed living inside the digestive gland at 8 (62%) of the sites, with their prevalence of infection ranging up to 100%. Easily distinguishable from commensal ciliates in the orders Scuticociliatida and Rhynchodida, which are found on gills, these ciliates were separable into either a small or large form. The small ciliate was oblong to round, with a mean length × width of 58 × 45 μm. In contrast, the large ciliate was nearly cylindrical and had a mean length × width of 278 × 77 μm. Whereas dozens of the small ciliate could be found in some mussels, the large ciliates rarely exceeded 10 per host. Whereas both forms were observed moving about in the body fluid between digestive gland lobes, the small ciliates were also recorded inside these lobes. The nature of the symbiotic association of these ciliates remains to be determined.

KEY WORDS: *Dreissena,* zebra mussels, *Aspidogaster, Phyllodistomum, Bucephalus,* trematodes, ciliates.

A review of the European literature on the natural enemies of zebra mussels (*Dreissena* spp.) suggests that predators, in particular, bottom-feeding fish and diving ducks, can play a buffering role in their population dynamics. These predators, however, have only been documented to cause major reductions in mussel densities in isolated situations (e.g., Stempniewicz, 1974). In contrast to the relative abundance of information on predators, few studies have attempted to document the existence of dreissenid parasites. As a consequence, the role of parasites in regulating European populations has remained unclear. In reviewing European studies, Stanczykowska (1977, p. 503) stated that "rapid reductions of [dreissenid] population densities were always observed in dense stocks and it is possible that they resulted from . . . local invasion of parasites (possibly protozoan) or diseases or else from a complex of factors related to overpopulation." Similarly, in commenting on their studies in the River Seerhein in Germany, Cleven and Frenzel (1993) indicated that the importance of parasitism in the population dynamics of *Dreissena polymorpha* (Pallas, 1771) was largely unknown. The research described herein was undertaken to address the need for more comprehensive information on organisms parasitic in European dreissenid populations and specifically reports a 2-wk survey of parasites in northwestern Russia.

Zebra mussels (*D. polymorpha*) were sampled at 13 locations in the Moscow–St. Petersburg region during 8–22 July 1993. A variety of habitats were chosen, including canals, rivers, lakes, and reservoirs (sites A–M, Table 1). Quagga mussels, *D. bugensis* Andrusov 1897, the other exotic dreissenid species that has invaded North America, were not observed in the samples and are known to have a more southeastern European range (Rosenberg and Ludyanskiy, 1994).

Mussels were collected using a variety of techniques, including wading, snorkeling, scraping dock supports, and benthic grab sampling. An average of 216 mussels (range in length: 3–38 mm) were randomly selected from each sample, and tissues were examined for gross signs of pathology with a stereomicroscope (×70). If parasitism was suspected in these latter specimens (e.g., abnormal size, shape, and/or color of an organ), their tissues were further inspected using a phase-contrast compound microscope (×450/×1,000).

Ten additional mussels from each location were

Table 1. Locations in northwestern Russia where *Dreissena polymorpha* samples were collected for examination of parasites.

Site	Date of collection in July 1993	Number examined*	Location
A	8	367	Moscow River; 3.4-m depth; Troitse–Lykovo; in Moscow
B	9	510	Canal sluice N8; 2.8-m depth; in Moscow
C	10	260	Ivankovskoye Reservoir; 2.0-m depth; eastern end near Bolshaya Volga Railway Station; Dubnya; 120 km north of Moscow
D	11	160	Moscow River; 4.2-m depth; Rublevo; 1 km west of Moscow
E	12	210	Uchinskoye Reservoir; 2.8-m depth; Puskino; 14 km north of Moscow
F	13	210	Klazminskoye Reservoir; 4.7-m depth; Vodniki Railway Station; 9 km north of Moscow
G	14	210	Chimkinskoye Reservoir; 2.8-m depth; northern end at Butakovski Bay; near Moscow city limits
H	15	160	Chimkinskoye Reservoir; 3.2-m depth; southern end at Rechnoy Vokzal pier; near Moscow city limits
I	12	260	Udomlya Lake; rocks near shore outside of power station; Vyshniy Volochek; 300 km northwest of Moscow
J	16	106	Volkhof River; dock-scraped at mouth of river; Novaya Ladoga; 150 km northeast of St. Petersburg
K	20	42	Valdaiskoiye Lake, Valay; 400 km northwest of Moscow
L	21	162	Volkhof River; dock-scraped; Novgorod; 600 km northwest of Moscow
M	22	152	Velikaya River, Pskov; 250 km southwest of St. Petersburg

* Includes 10 mussels whose tissues were examined at ×450/×1,000; others examined for gross signs of pathology at ×70.

randomly selected (mean length [range] = 17 [3–32] mm), and their organs, irrespective of external appearance, were dissected and tissues microscopically examined. To avoid contamination of tissues with microorganisms from the mantle cavity (e.g., commensal ciliates from either the orders Scuticociliatida or Rhynchodida, which dwell on the surface of the gills or visceral mass), organs were typically dissected only after gills were removed, and the visceral mass was rinsed with filtered freshwater from the collection site.

Trematodes were observed at 7 (54%) of the sampling sites. Infections with adult *Aspidogaster* were found at 3 locations (sites A [1/367], C [1/260], and D [1/160]). Each infected mussel harbored a single adult worm that was light pink in color. At site A, the *Aspidogaster* was found immobile and externally attached by its sucker disk to the ventromedial surface of the visceral mass immediately anterior to the foot. The *Aspidogaster* recorded from site C was observed in the same location on the visceral mass. In contrast, the *Aspidogaster* recorded from site D was observed moving inside the gonads of its host, with its sucker disk appressed to the gonad's semitransparent body wall. Using the key of Bauer (1987), the latter specimen was identified as *A. limacoides* Diesing, 1834 (voucher USNPC No. 84911 [U.S. National Parasite Collection, USDA-ARS, Beltsville, Maryland]). The presence of these aspidogastrids caused no obvious adverse effects on the dreissenids; infected male and female mussels were sexually mature.

Infections with *Phyllodistomum* were found at 4 locations (sites A [1/367], E [1/210], H [1/160], and M [1/152]). Both male and female dreissenids were infected, and sporocysts appeared as flat, yellow, amorphous bodies embedded in the gill tissues (voucher USNPC No. 84913). One mussel at site E had a total of 100 such sporocysts distributed throughout its gill lamellae. Except for the presence of the sporocysts, the gills and visceral mass in infected specimens appeared to be of normal size and color, and production of sperm and eggs were noted in some mussels.

Bucephalus polymorphus Baer, 1827, the only bucephalid species known from dreissenids, was observed at a single location, site L. The prevalence rate of 9% (14/162), however, was the highest noted for any of the trematodes at any of the 13 sites. The sex of infected mussels could not be determined because their gonadal tissues were destroyed by the massive proliferation of the sporocysts (voucher USNPC No. 84914). Cercarial development was commonly observed within the sporocysts. Sporocysts occasionally were observed projecting from the gonads into the mantle epithelium lining the shells. As also observed by Baturo (1977), sporocysts often extended from the gonads into the digestive gland. While the gonads were severely affected by the infection, we could discern no adverse affect on the digestive gland; its lobes appeared as numerous and full bodied, as in uninfected specimens.

All 3 genera of trematodes encountered in this

survey have been reported previously as zebra mussel parasites. *Phyllodistomum* spp. infection has been recorded from across Europe, including The Netherlands (Davids and Kraak, 1993), Germany (Breitig, 1965), Poland (Sinitsin, 1901), Belarus (Lyakhnovich et al., 1983), and Russia (Kupriianova-Shakhmatova, 1965; Kuperman et al., 1994). *Bucephalus polymorphus* also appears widely distributed in European dreissenids, with records from France (Wallet and Lambert, 1986), Poland (Baturo, 1977), Russia (Kuperman et al., 1994), Uzbekistan (Aristanov, 1992), and Kazakhstan (Smirnova and Ibrasheva, 1967). In contrast, parasitism of European zebra mussels by *Aspidogaster* has been rarely recorded. Nagibina and Timofeeva (1971) and Kuperman et al. (1994) have observed, respectively, a $<1\%$ and $\leq 3.8\%$ prevalence with *A. limacoides*. *Aspidogaster conchicola* von Baer, 1826, the only other aspidogastrid recorded from dreissenids, has been documented only once from European zebra mussels (Kulczycka, 1939).

In bivalve hosts, *Aspidogaster* spp. are typically found in the pericardial and renal cavities, where they feed on blood cells and hemolymph (Bakker and Davids, 1973). We observed this trematode attached to the ventral surface of the visceral mass and inside the gonads—sites, that, although uncommon, are not unknown for aspidogastrids (Rohde, 1972). In contrast to the digenetic trematodes, most aspidogastrids require a single host to complete their entire life cycle (Rohde, 1972). Moreover, aspidogastrids typically have a broad host range. In addition to *Dreissena, A. limacoides* has been recorded from the mollusc genera *Cardium, Adacna,* and *Sphaerium* (Nagibina and Timofeeva, 1971). Primarily known as a parasite of unionids, *A. conchicola* also has a very wide host range among freshwater molluscans, including several genera of bivalves and snails (Hendrix et al., 1985). *Aspidogaster conchicola* has the current distinction of being the only European dreissenid parasite also native to North America, and this species has already been observed in North American *D. polymorpha* (Toews et al., 1993). Additional records of its parasitism of dreissenids on this continent are highly likely.

Some *Phyllodistomum* spp. parasitic in *Dreissena* can apparently be identified according to the number of metacercariae per sporocyst (Davids and Kraak, 1993). Such well-developed metacercariae were not observed in our infected specimens; therefore, species identification was not possible. Although *P. folium* Braun, 1899, has been frequently reported from dreissenids (Sinitsin, 1901; Kulczycka, 1939; Davids and Kraak, 1993), 2 other species, *P. macrocotyle* (Lühe, 1909) and *P. dogieli* Pigulewsky, 1953, have also occassionally been cited as parasites of *D. polymorpha* (Dawes, 1956; Wisniewski, 1957). In his taxonomic review, Yamaguti (1971) recognized *P. folium* and *P. dogieli* but considered *P. macrocotyle* invalid. Recently, Kuperman et al. (1994) reported *P. angulatum* Linstow, 1907, in *D. polymorpha* from the Volga basin. When possible, laboratory rearing of *Phyllodistomum* metacercariae obtained from *Dreissena* through to the adult stage in fish is an excellent means of determining species identity. Davids and Kraak (1993) and Wisniewski (1957) have employed this method to demonstrate the presence of *P. folium* and *P. dogieli* in *Dreissena* populations.

Phyllodistomum and *Bucephalus* are native to North American freshwaters (Margolis and Arthur, 1979) but do not include any of the species reported from European dreissenids. Stafford (1904) reported an adult *P. folium* in North America, but differences that he noted with the species description of *P. folium,* in particular, the unequal size of the suckers, make his identification questionable. Whether or not species of North American *Phyllodistomum* and *Bucephalus* that parasitize freshwater bivalves (e.g., *P. staffordi* Pearse, 1924; *P. superbum* Stafford, 1904; *B. elegans* Woodhead, 1930 (Margolis and Arthur, 1979; Van Cleave and Mueller, 1934)) will be capable of expanding their host ranges to include dreissenids is of interest. *Phyllodistomum folium* appears quite host-specific to *Dreissena.* In contrast, *B. polymorphus* has been reported in freshwater unionids *Anodonta* and *Unio* (Golikova, 1960; Smirnova and Ibrasheva, 1967). The accuracy of the latter host range data may be questionable, however, considering the similarity in appearance between the sporocysts of *B. polymorphus* and *Rhipidocotyle illense* (Ziegler, 1883), a bucephalid parasite of *Anodonta* and *Unio.* The cercariae of these latter 2 species, however, are morphologically distinguishable, and Baturo (1977), using this criterion, recorded *B. polymorphus* only in *Dreissena* and *R. illense* only in unionids.

Phyllodistomum infection has been documented to be physiologically stressful to *D. polymorpha* (Kraak and Davids, 1991; Davids and Kraak, 1993), but we could not visibly discern adverse effects in infected specimens. In our sur-

vey, the effect of trematode infection appeared to be severe only with *B. polymorphus,* whose growth destroyed gonadal tissue—a condition typical of infection with this species (Davids and Kraak, 1993).

Dissections revealed ciliates present inside the digestive gland in mussels at 8 (62%) of the sites. Prevalence of infection ranged up to 100% (sites B [2/10], C [8/10], D [2/10], E [1/10], F [3/10], G [5/10], H [4/10], and I [10/10]). When the epidermis covering the digestive gland of an infected specimen was teased open, ciliates could be seen slowly moving about in the fluid between the digestive lobes; no other organs were observed with ciliate infection. While all ciliates were in the order Hymenostomatida (D. Lynn, University of Guelph, Ontario, pers. comm.), they were readily separable into small and large forms (voucher USNPC No. 84912). The small ciliate was oblong to round, with mean (range) length × width of 58 (49–91) × 45 (34–62) μm. In contrast, the large ciliate was nearly cylindrical (anterior end slightly wider and somewhat tapered) and had a mean (range) length × width of 278 (226–343) × 77 (59–98) μm. Even though of considerable size, the large ciliate appeared well adapted for maneuvering in tight spaces between digestive gland lobes; in a fresh mount of digestive gland tissue, one squeezed through a series of tight, 20–30-μm crevices.

Besides their morphology, the intensity of infection and the microhabitats of the small and large ciliates also differed. While dozens of small ciliates could be found in some mussels, the large ciliates rarely exceeded 10 per host. Whereas both forms were observed moving about in the body fluid between digestive gland lobes, the small ciliates were also recorded inside the digestive lobes, typically at the distal end of a digestive duct.

These ciliates were observed in mussels of varying physical condition. Whereas some infected mussels had visceral masses that were robust and sexually mature, others were emaciated and possessed underdeveloped digestive glands and gonads. Recently, Toews et al. (1993) reported ophryoglenid ciliates inside the shells of living and dead *D. polymorpha* from Lake Erie. They did not, however, indicate that these protozoans were present within the digestive gland or any other organ. The only previous reference to ciliates within dreissenid organs was a personal communication from S. Kazubski appearing in Stanczykowska (1977), which reported "dangerous" infections by small and large ciliates whose lengths were, respectively, 30–50 μm and ca. 1 mm. The small ciliates, although rare (<1% infection), were capable of causing mortality "due to their mass occurrence in tissues and intercellular space." The larger form, considered an ophryoglenid ciliate, was reported to occur "in tissues, usually in [the] digestive gland." In our study, somewhat similar small and large ciliates were recorded in the digestive gland. In contrast to Kazubski's observations, however, we commonly observed high prevalences of infection (up to 100%, site I) but without clear evidence of pathogenicity. In our samples, it was clear, however, that the simple presence of these ciliates within the digestive gland did not induce an immediate, severe, debilitating condition.

The emphasis of this investigation was a survey of parasites within body tissues. For this reason, data was not collected on ciliates that were present on the surface of the visceral mass and gills at some sites.

Lethal, microbial diseases of molluscs may not produce dramatic macroscopic signs and symptoms of disease (Elston, 1990) (e.g., changes in organ size, shape, or color). This survey relied almost exclusively on gross signs of pathology as clues for parasite presence. Although several parasites were recorded during our 2 wk of field sampling, such an approach is a narrow one, in that it likely misses detecting other diseases, particularly in their early stages (see Laukner, 1983) (e.g., spore-forming protozoa, viruses). In our survey, mussels with emaciated visceral masses were encountered, but we were unable to detect parasites by dissection. Histological analysis of tissue that has been differentially stained for particular parasitic taxa is an essential approach in a comprehensive survey of dreissenid parasites and one that we will include in our future efforts.

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Research Note

Measurement of Metallic Ions in *Biomphalaria glabrata* (Gastropoda) Infected with *Echinostoma caproni* (Trematoda) and in Uninfected Snails

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ABSTRACT: Inductively coupled plasma atomic emission spectrometry (ICP-AES) was used to study metallic ions in whole bodies of uninfected *Biomphalaria glabrata* snails and those experimentally infected with larval *Echinostoma caproni* trematodes. Infected snails were analyzed at 6 wk postinfection when the digestive gland–gonad complex contained 100–200 daughter rediae per snail. Cohort snails that were left uninfected were analyzed at the same time as controls. Nine metals were detected in *B. glabrata* by ICP analysis as follows: boron, copper, iron, manganese, zinc, calcium, magnesium, sodium, and potassium. There were no significant differences (Student's *t*-test, $P > 0.05$) in the concentrations of these metals in whole infected versus whole uninfected snails.

KEY WORDS: Metallic ions, spectrometry, *Biomphalaria glabrata, Echinostoma caproni,* Trematoda, Gastropoda.

There is little information on the metallic ion content of *Biomphalaria glabrata* snails and no information on the effects of larval trematode infection on the metallic ion content of this snail. Gabrashanska et al. (1991) examined the effects of larval *Echinostoma revolutum* on the mineral composition of the freshwater snail *Lymnaea stagnalis.* They used whole snail bodies in their analysis and found significant differences in certain metallic ions between infected and uninfected snails. Another study, by Layman et al. (1996), examined the digestive gland–gonad complex (DGG) of *Helisoma trivolvis* snails naturally infected with larval *E. trivolvis* trematodes to determine the effects of parasitism on the metallic ion content of the snail. They found significant differences in certain metallic ions between infected and uninfected snails. Our laboratory has now examined the effects of larval parasitism by *E. caproni* on the metallic ion content of experimentally infected *B. glabrata* snails using inductively coupled plasma atomic emission spectrometry (ICP-AES).

B. glabrata snails were maintained at 22–24°C in aerated aquaria containing artificial spring water and exposed to *E. caproni* miracidia as described in Beers et al. (1995). Infected snails along with uninfected controls were maintained in aquaria as described in Beers et al. (1995) and used 6 wk postinfection. Snails were isolated individually to determine larval infection with *E. caproni* and then subsequently crushed to confirm the infection. Samples of infected snail bodies were pooled to achieve a wet weight of about 1 g (approximately 10 snails). Likewise, samples of uninfected snail bodies (about 10 snails) were pooled to obtain a similar wet weight. Five pools of infected snails and 6 pools of uninfected snails were prepared for each analysis. Prior to use in an analysis, each pool was rinsed several times with ultrapure (Milli-Q, Millipore, Bedford, Massachusetts) water and digested in boiling nitric acid. Each digested sample was diluted to 25.0 ml with 2% (v/v) nitric acid.

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Table 1. Mean ± standard deviation in mg/g of dry tissue of snails infected with *Echinostoma caproni* and uninfected snails as determined by ICP-AES (uninfected, $n = 6$; infected, $n = 5$).*

Element	Infected	Uninfected	Value of t
B	0.04 ± 0.04	0.04 ± 0.04	0.003
Ca	55 ± 11	59 ± 9	0.393
Cu	0.03 ± 0.02	0.03 ± 0.01	0.084
Fe	0.17 ± 0.05	0.18 ± 0.06	0.225
Mg	3.1 ± 0.4	3.2 ± 0.5	0.135
Mn	0.04 ± 0.01	0.04 ± 0.01	0.575
K	4.6 ± 0.5	4.1 ± 0.5	1.01
Na	1.2 ± 0.1	1.2 ± 0.3	0.509
Zn	0.09 ± 0.02	0.12 ± 0.06	1.26

* 95% confidence level: $t = 2.98$.

Sample solutions were analyzed for 26 elements by ICP-AES using a Thermo Jarrell Ash simultaneous-reading spectrometer with autosampler. The instrument was calibrated following EPA Method 6010A, which uses a 2-point calibration, a blank, and multielement standards. Interelement correction factors were employed to minimize any interference between elements in the samples. Reagent blank samples were also analyzed. Each sample, standard, and blank was analyzed using 3 30-sec integrations. The results for each sample were averaged and the reagent blank subtracted to calculate the final analysis values presented. A number of quality control checks were made during the analyses to verify the calibration curve, blank, and interelement correction factors.

Table 1 presents the data obtained from the ICP-AES analysis of 5 pools of infected and 6 pools of uninfected snails, each pool containing approximately 10 snails with a combined wet weight of 1 g. The elements that were not detected at concentration levels above the detection limits of the instrument were Al, Sb, As, Ba, Be, Cd, Cr, Co, Pb, Mo, Ni, P, Se, Ag, Sr, Tl, and V. Nine elements (B, Ca, Cu, Fe, Mg, Mn, K, Na, and Zn) were detected at concentrations above their detection limits. For each of these 9 elements, the means were compared for significant differences between infected and uninfected snails with Student's t-test. No statistically significant differences were found between whole snails (minus shells) infected with *E. caproni* and those not infected (Table 1).

Layman et al. (1996), using flame and graphite furnace atomic absorption spectrometry (AAS) and ICP-AES, showed changes in certain metallic ions as a result of larval *E. trivolvis* infection in the DGG of *H. trivolvis.* They found significantly higher amounts of Na and significantly lower amounts of Mg and Mn in the DGG of infected snails. Gabrashanska et al. (1991), using neutron activation analysis of metallic ion in studies of *Lymnaea stagnalis* snails infected with the larval trematode *Echinostoma revolutum,* found significantly higher concentrations of Ca, Na, Rb, and Sb and significantly lower concentrations of Ce, Cr, Cs, Cu, Fe, and Zn in the digestive glands of infected snails. Differences in metallic ions as a result of larval parasitism in the aforementioned studies reflect alterations in ionic balance and an influx of certain ions and an outflux of other ions from the larval trematodes to the snail host.

In the present study, we failed to detect any qualitative or quantitative differences with respect to metallic ions between *B. glabrata* infected with *E. caproni* and uninfected controls. Results of our study probably reflect in part the fact that whole snail bodies were used in the analyses rather than DGGs. Parasitism of *B. glabrata* by *E. caproni* is mainly confined to the DGG, which comprises about 25% of the mass of the snail. The pathochemical effects of the infection may have been diluted out in these analyses by examining the whole snail body rather than just the DGG.

There are few reports of the quantitative analysis of metallic ions in *B. glabrata.* Nduka and Harrison (1980) determined the concentrations of Ca, Mg, Na, and K in varous planorbid snails, including *B. glabrata,* by AAS. The use of ICP-AES allows the simultaneous quantification of 26 elements rather than the limited sequential determination of individual ions by AAS. In addition, ICP-AES provides detection limits that are generally lower than flame AAS. Therefore, we are able to report for the first time the trace-metal profile of *B. glabrata.* The 17 preceding elements were found to be present at concentrations below the detection limit of the instrument, which ranged from 0.02 to 5 mg/g of dry tissue. The concentrations of Ca, Mg, Na, and K (Table 1) in the bodies of snails were similar to those found earlier by AAS (Nduka and Harrison, 1980), which provides important confirmation of these values by an independent analytical method. The concentrations of B, Cu, Fe, Mn, and Zn in Table 1 are the first data reported for these elements in *B. glabrata* snails, and values

for Ca, Mg, Na, and K in *B. glabrata* infected with a larval trematode have not been reported before.

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Research Note

Gastrointestinal Helminths from Juvenile Red Drum, *Sciaenops ocellatus,* and Atlantic Croaker, *Micropogonias undulatus* (Sciaenidae), in East Matagorda Bay, Texas

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ABSTRACT: Juvenile *Sciaenops ocellatus* ($N = 20$) and *Micropogonias undulatus* ($N = 8$) from East Matagorda Bay, Texas, were examined for gastrointestinal helminths. A total of 7 parasite species or groups were recovered, 5 of which were common to both *S. ocellatus* and *M. undulatus.* No parasites were found to be unique to *M. undulatus,* although significant differences in the mean intensity of *Lecithaster confusus* (Hemiuridae) and unidentified cestode larvae were found. Differences in diet, which correlate with differences in mean length, between *S. ocellatus* and *M. undulatus* are believed to be the basis for observed differences in the mean intensity of gastrointestinal helminths.

KEY WORDS: *Lecithaster confusus, Bucephaloides* spp., Sciaenidae, red drum, *Sciaenops ocellatus,* Atlantic croaker, *Micropogonias undulatus, Diplomonorchis leiostomi.*

Although the red drum, *Sciaenops ocellatus* (Linnaeus), and Atlantic croaker, *Micropogonias undulatus* (Linnaeus), are important sportfish along the Gulf of Mexico coast, few studies have been conducted on their gastrointestinal helminths, and much of the information available results from survey reports. Particularly lacking is quantified data concerning parasitic infections in juvenile red drum and Atlantic croaker.

Many reports of parasites from red drum and Atlantic croaker are a result of the inclusion of these species in general surveys of fishes from a particular area. Loftin (1960) published an annotated checklist of trematodes and cestodes from northwest Florida and included a report of "*Bucephalopsis* sp." from *Sciaenops ocellata* in Alligator Harbor, Florida. Riggin and Sparks (1962) later identified this parasite as a new species, *Bucephaloides megacirrus,* and provided a full description including its occurrence in red drum from Grand Isle, Louisiana. Nahhas and Short (1965) published a list of the digenetic trematodes of fishes from Apalachee Bay, Florida, and

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Table 1. Gastrointestinal helminths recovered from red drum, *Sciaenops ocellatus*, and Atlantic croaker, *Micropogonias undulatus*, from East Matagorda Bay, Texas.

Parasite	*Sciaenops ocellatus* ($N = 20$)		*Micropogonias undulatus* ($N = 8$)	
	Prevalence	Intensity [mean ± SD (range)]	Prevalence	Intensity [mean ± SD (range)]
Digenea				
Lecithaster confusus (USNPC Nos. 85231, 85235)*	80%	12.1† ± 19.9 (1–82)	100%	26.8† ± 11.5 (4–42)
Bucephaloides caecorum (USNPC Nos. 85233, 85237)*	65%	4.2 ± 3.8 (1–16)	50%	3.5 ± 2.1 (2–7)
Bucephaloides megacirrus (USNPC No. 85234)	30%	2.7 ± 1.8 (1–5)	–	–
Diplomonorchis leiostomi (USNPC Nos. 85232, 85236)*	5%	2.0 ± 0 (2)	37.5%	3.3 ± 1.7 (1–5)
Cestoda				
Unidentified cestode larvae (USNPC Nos. 85239, 85241)*	75%	1,403 ± 1,808 (2–5,769)	100%	72.4‡ ± 172.6 (1–528)
Tetraphyllidea larvae (USNPC Nos. 85238, 85240)*	45%	6.3 ± 6.3 (2–23)	50%	3.8 ± 1.1 (2–4)

* The first USNPC number represents helminths recovered from *S. ocellatus*, while the second USNPC number represents helminths recovered from *M. undulatus*.

† Significant at $P < 0.05$, df = 22, $t = -1.75$.

‡ Significant at $P < 0.05$, df = 21, $t = 1.85$.

reported 3 species (*B. megacirrus* Riggin and Sparks, 1962, *Opecoeloides fimbriatus* (Linton, 1934) Soganderes-Bernal and Hutton, 1959, and *Lecithochirium mecosaccum* Manter, 1947) from red drum and 3 species (*O. fimbriatus, L. parvum* Manter, 1947, and *Sterrhurus musculus* Looss, 1907) from Atlantic croaker. Corkum (1968) reported on the family Bucephalidae in fishes from the northern Gulf of Mexico and included Mississippi Sound, Mississippi, as a new locality record for *B. megacirrus* in red drum. Overstreet (1983) reported at least 3 cestodes, 9 digenetic trematodes, and 6 nematodes from red drum. Virtually all of the parasites, however, were recovered from adult fish. Thoney (1991) reported 4 cestodes, 3 digenetic trematodes, and 1 nematode from 127 juvenile Atlantic croaker from Pamlico Sound and 1 cestode, 7 digenetic trematodes, and 1 nematode from 103 juvenile Atlantic croaker from Chesapeake Bay, along the Atlantic coast.

Due to the relative paucity of information concerning the parasites of red drum and Atlantic croaker from the Texas Gulf coast, as well as the importance of these fish species to the sportfishing industry, a brief survey was conducted on the gastrointestinal helminths of juvenile red drum and Atlantic croaker in East Matagorda Bay, Texas.

Twenty juvenile red drum (mean standard length [SL] = 6.4 cm ± 1.4 SD, range 4.3–9.2 cm) and 8 juvenile Atlantic croaker (mean SL = 4.6 cm ± 0.4 SD, range 4.1–5.4 cm) were collected by bag seine from East Matagorda Bay during February and March 1994. All fish were placed in individual plastic bags and transported on ice to Texas A&M University. The digestive tract extending from the esophagus to the rectum was removed and examined for helminths. Recovered parasites were fixed in alcohol/formalin/acetic acid, stained in Semichon's carmine, and mounted in Kleermount®. The terms prevalence and mean intensity are used as defined by Margolis et al. (1982). Differences in the mean intensity of endohelminths were compared using a 2-tailed *t*-test.

The parasites recovered are listed in Table 1. Two species of *Bucephaloides* were found in red drum, *B. caecorum* Hopkins, 1956, and *B. megacirrus*. Only *B. caecorum* was also found in Atlantic croaker. No nematodes were found within the lumen of the gastrointestinal tract. The cestodes were represented by 2 distinct groups, both larval forms. Larval tetraphylids were found in 45% (9 of 20) and 50% (4 of 8) of *S. ocellatus* and *M. undulatus*, respectively. However, due to their immature state, conclusive identification to genus could not be made.

The most notable cestode present in the survey was represented by numerous unidentifiable scolices, often reaching several thousand in number within a single infected host. Cestode larvae that appear identical to those recovered in this survey have been reported from many fish and invertebrate hosts, especially shrimp (Kruse, 1959; Feigenbaum, 1975), although none have been linked with an adult.

The mean intensity of *Lecithaster confusus* Odhner, 1905, was significantly greater ($P < 0.05$) in *M. undulatus* than in *S. ocellatus* (26.8 versus 12.1). When these differences are considered in light of the mean SL of the host, the accompanying differences in diet, and the life cycle of *Lecithaster confusus,* such differences in mean intensity might be expected. *Lecithaster confusus* utilizes the copepod *Acartia tonsa* Dana, 1849, and presumably other related copepods, as the second intermediate host (Hunninen and Cable, 1943). Copepods also constitute a large portion of the diet of sciaenids less than 5.0 cm long (Matlock, 1990). Because the mean SL of Atlantic croaker was 4.6 cm, the preponderance of copepods in their diet would lead to a greater intensity of those parasites that utilize copepods as intermediate hosts, including *Lecithaster confusus.*

The mean intensity of the unidentified cestode larvae is significantly greater ($P < 0.05$) in *S. ocellatus* than in *M. undulatus* (1,403 versus 72.4). Again, these differences appear to be related to diet. As the size of *S. ocellatus* and *M. undulatus* increases beyond 5.0 cm, their diet shifts to include larger prey items. These items include a greater number of fish and shrimp (Matlock, 1990), both of which have been found to commonly harbor unidentified cestode larvae.

The correlation between diet and the mean intensity of parasites is further evidenced by the occurrence of the genus *Bucephaloides.* When considered as a genus, the mean intensity of *Bucephaloides* is greater in red drum than in Atlantic croaker. Species of *Bucephaloides* tend to use fish as the second intermediate host and, thus, would be expected to have a greater intensity in the larger red drum.

In summary, the general parasite fauna of Texas Gulf coast red drum and Atlantic croaker appear very similar. Of the 7 gastrointestinal helminths recovered from juvenile red drum, 5 were also recovered from juvenile Atlantic croaker. However, significant differences in mean intensity of *Lecithaster confusus* and the unidentified cestode larvae were found. Differences in diet with increasing host length are believed to be the basis for the differences in the mean intensity of *L. confusus* and the unidentified cestode larvae.

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Research Note

An Anomaly (Gynandromorphism) in *Abbreviata* sp. (Nematoda: Physalopteridae)

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ABSTRACT: A single gynandromorphous *Abbreviata* sp. was recovered from the stomach of a black tree monitor, *Varanus beccarii,* from the Aru Islands, Indonesia.
KEY WORDS: gynandromorph, *Varanus,* anomaly, hermaphrodite, *Abbreviata.*

Anomalies in nematodes are seldom seen. Among anomalies reported for nematodes, those occurring in the reproductive system are by far the most common (Belogurov and Belogurova, 1979). In a review of 14 reports (1924–1989) on anomalies in nematodes, 10 dealt with abnormalities of the reproductive system (spicules, gubernacula, bursal rays, uteri, ovaries, and eggs) (Becklund, 1960; Andrews, 1970; Goldstein, 1977; Amin, 1989), whereas the other 4 dealt with abnormalities of the musculature or the digestive system (Lyons and Goldsmid, 1973); however, none described a gynandromorph. Most reported anomalies involve ascarids or strongylates, which possibly reflects frequency with which these nematodes are examined relative to other kinds of nematodes.

A black tree monitor (*Varanus beccarii*) had been wild-caught in the Aru Islands, Indonesia, and illegally shipped to the United States. When confiscated by authorities, the monitor was in very poor physical condition, and it died shortly thereafter. At necropsy, a single nematode specimen was found in the stomach and submitted to the Department of Veterinary Pathology, Iowa State University, for identification. After clearing in Hoyer's solution (Baker et al., 1956), the nematode was discovered to be a gynandromorphous *Abbreviata* sp. (Fig. 1). It was assumed that this bisexual condition represented an anomaly, because gynandromorphism is not a characteristic of nematodes and no gynandromorphs were mentioned in specimens of *Abbreviata* spp. commonly found in monitors (Jones, 1988).

The gynandromorph had a single uterus with a long vagina opening near the cloaca (precise site of this opening could not be seen). The uterus and vagina contained small (44 by 25 μm) embryonated eggs typical for the genus. Male components included a typical physalopterine bursa and dissimilar, unequal spicules (right = 350 μm, left = 2,200 μm). The parasite has been deposited in the U.S. National Parasite Collection (Accession No. 85054).

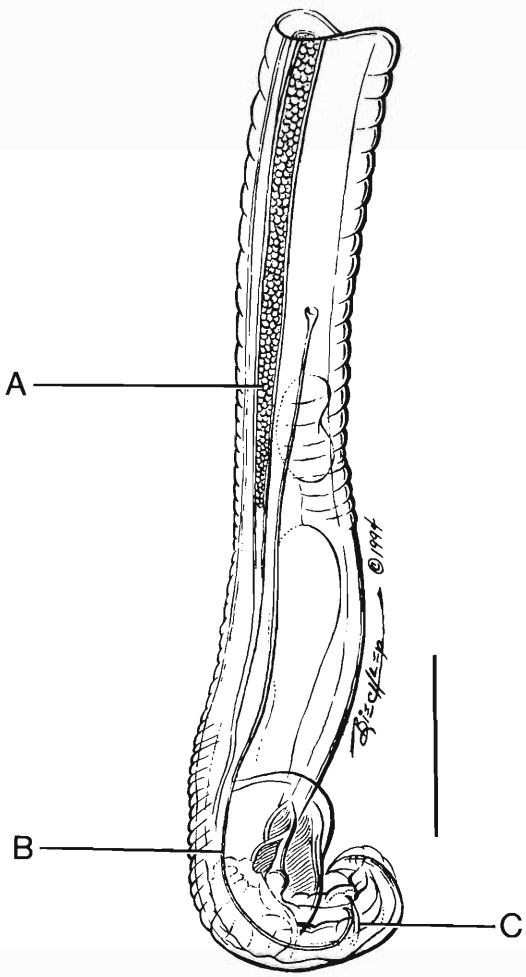

Figure 1. Outline drawing of posterior portion of gynandromorphous *Abbreviata* sp. from black tree monitor. Highlighted features are uterus (A), left spicule (B), and right spicule (C). Scale bar = 500 μm.

Furthermore, the finding of *Abbreviata* sp. in *Varanus beccarii* appears to be a new host record (Baker, 1987).

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Research Note

Helminth Parasites of the Osprey, *Pandion haliaetus*, in North America

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ABSTRACT: A total of 28 species of helminths (17 trematodes, 3 cestodes, 7 nematodes, and 1 acanthocephalan) was recovered from 17 ospreys (*Pandion haliaetus*) from the United States. Intensities of infection were low and no lesions were attributed to the parasites. Seven species appear to be specialists in ospreys, 2 species generalists in raptors, and the remainder generalists in other orders of fish-eating birds. *Pandiontrema rjikovi, Diasiella diasi,* and *Contracaecum pandioni* are reported for the first time from North America.

KEY WORDS: helminths, osprey, parasites, *Pandion haliaetus, Pandiontrema rjikovi, Diasiella diasi, Contracaecum pandioni.*

The osprey, *Pandion haliaetus* (Linnaeus), is a cosmopolitan, monotypic member of the family Falconidae comprising its own subfamily, Pandioninae. Ospreys breed primarily in the Northern Hemisphere (North America and Eurasia) and winter in the Southern Hemisphere (South America, Africa, and India), with the exception of 2 nonmigratory subspecies in the Caribbean and Indonesia (Poole, 1989). Although this predominantly fish-eating raptor was considered threatened in North America in the 1960's because of pesticide contamination of the food chain, it has made a strong recovery and is now common in many parts of its former range (Ewins, 1994).

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Table 1. Prevalences and intensities of helminths of 5 ospreys in Florida.

	HWML No.	Location in host*	Prevalence		Intensity	
			No. inf.	%	Mean	Range
Trematoda						
Scaphanocephalus expansus (Creplin, 1842)	36935	SI	2	40	361	17–704
Mesorchis denticulatus (Rudolphi, 1802)	36936	SI	3	60	81	2–232
Ribeiroia ondatrae (Price, 1931)	36938	P	2	40	33	11–54
Renicola ralli Byrd and Heard, 1970	36934	K	3	60	96	14–167
Neogogatea pandionis (Chandler and Rausch, 1948)	—	SI	2	40	89	9–169
Microparyphium facetum Dietz, 1909	36937	C	1	20	2	2
Cestoda						
Paradilepis rugovaginosus Freeman, 1954	—	SI	1	20	3	3
Nematoda						
Capillaria falconis (Goeze, 1782)	—	SI	1	20	1	1
Sexanoscara skrjabini Sobolev and Sudarikow, 1939	—	E	1	20	3	3
Tetrameres sp.	—	P	2	40	7	3–10
Contracaecum pandioni Sobolev and Sudarikow, 1939	—	P	1	20	1	1
Contracaecum multipapillatum (Drasche, 1882)	36939	P	2	40	9	7–10
Cardiofilaria pavlovskyi Shtrom, 1937	36940	BC	1	20	1	1
Acanthocephala						
Andracantha mergi Lundstrom, 1941	36941	SI	1	20	4	4

* Location in host: BC = body cavity, C = cloaca, E = esophagus, K = kidney, P = proventriculus, SI = small intestine.

Perhaps because of its protected status, the osprey has not been surveyed for helminth parasites in either North or South America. Isolated records from North America include a few trematodes (*Scaphanocephalus expansus* by Hoffman (1953), *Neogogatea pandionis* and *Nematostrigea serpens* by Chandler and Rausch (1948), and *Renicola lari* by Kennedy and Frelier (1984)); 2 cestodes (*Paradilepis rugovaginosus* by Freeman (1954) and *Paradilepis simoni* by Rausch (1949)); and 1 nematode (*Sexansocara skrjabini* by Schmidt and Huber (1985)). In this report, we combine records of osprey helminths collected at the Department of Pathobiology, University of Florida (UF), Gainesville, and the National Wildlife Health Center (NWHC), Madison, Wisconsin.

Five injured or dead ospreys submitted to the Department of Pathobiology (UF) between October 1974 and September 1978 were examined at necropsy according to the methods of Kinsella and Forrester (1972). Ospreys submitted to the NWHC were examined for cause of death and helminths were collected when found, but parasite examinations were incomplete and not quantitative. Helminths were collected from 12 birds between November 1991 and April 1994. Voucher specimens of helminths were deposited in the Harold W. Manter Collection of the University of Nebraska, Lincoln.

A total of 28 species of helminths (17 trematodes, 3 cestodes, 7 nematodes, and 1 acanthocephalan) was recovered from the 17 ospreys. Prevalences and intensities of helminths from the 5 completely necropsied birds are listed in Table 1. Although the sample size was small, intensities were low and no significant lesions were associated with any of the infections. In Table 2, we list helminths and collection localities for the other 12 birds. Again, helminth infections were not implicated as the cause of significant lesions or death in these hosts. *Pandiontrema ryjikovi, Diasiella diasi,* and *Contracaecum pandioni* are reported from North America for the first time.

Seven species can be considered specialists in ospreys (helminths only reported from 1 host species). Three of these (*N. pandionis, P. rugovaginosus,* and *P. simoni*) have been reported only from North America. The other 4 (*P. ryjikovi, S. expansus, C. pandioni,* and *S. skrjabini*) have been reported now from both North America and Eurasia (Sobolev and Sudarikow, 1939; Dubois, 1960; Oshmarin and Parukhin, 1960). This number of specialists is large in comparison to other avian hosts and may reflect the osprey's

Table 2. Helminths from ospreys examined at the National Wildlife Health Center, Madison, Wisconsin.

Helminth species	HWML No.	Location in host*	Collection localities
Trematoda			
Scaphanocephalus expansus (Creplin, 1842)	—	SI	Florida
Mesorchis denticulatus (Rudolphi, 1802)	—	SI	Florida
Ribeiroia ondatrae (Price, 1931)	—	P	Virginia, Massachusetts
Neogogatea pandionis Chandler and Rausch, 1948	38381	SI	Virginia
Diasiella diasi (Travassos, 1922)	38581	SI	Virginia
Pandiontrema ryjikovi (Oshmarin and Parukhin, 1960)	38105	SI	Washington
Nematostrigea serpens (Nitzsch, 1819)	38104	SI	Virginia
Mesophorodiplostomum pricei (Krull, 1934)	38386	SI	Florida, Massachusetts, Montana, Virginia
Neodiplostomum sp.	—	SI	Maryland
Phagicola longa Ransom, 1920	38387	SI	Florida, South Carolina
Phagicola sp.	—	SI	Florida
Ascocotyle sp.	—	SI	South Carolina
Echinochasmus dietzevi Issaitschkoff, 1927	38382	SI	Florida
Cryptocotyle lingua (Creplin, 1825)	38380	SI	Massachusetts
Pygiodopsis pindoramensis Travassos, 1929	38385	SI	Florida
Cestoda			
Paradilepis rugovaginosus Freeman, 1954	38106	SI	Maryland
Paradilepis simoni Rausch, 1949	38384	SI	Montana
Cyclustera ibisae (Schmidt and Bush, 1972)	38383	SI	Florida
Nematoda			
Capillaria falconis (Goeze, 1782)	—	SI	Florida
Sexanoscara skrjabini Sobolev and Sudarikow, 1939	38394	E	Maryland
Tetrameres sp.	—	P	Virginia
Contracaecum multipapillatum (Drasche, 1882)	—	P	Florida, South Carolina
Contracaecum spiculigerum (Rudolphi, 1809)	—	P	Massachusetts, Montana, Virginia
Contracaecum larvae	—	P	Florida, Washington
Acanthocephala			
Andracantha mergi (Lundstrom, 1941)	—	SI	Massachusetts

* Location in host: E = esophagus, P = proventriculus, SI = small intestine.

reproductive and ecological isolation from other raptors since the Pleistocene (Poole, 1989).

All of the remaining helminths that could be identified to species can be considered generalists, found in more than 1 host species. In an earlier study on 6 species of hawks and falcons in Florida (Kinsella et al., 1995), the majority of helminths were judged to be generalists in raptors, not found in other orders of birds. In contrast, only 2 generalists in the osprey, *Capillaria falconis* and *N. serpens,* are restricted to raptors. The rest appear to exhibit ecological rather than host specificity and are found in members of other orders of fish-eating birds, including Anseriformes and Pelicaniformes (e.g., *Ribeiroia ondatrae, Phagicola longa, Cryptocotyle lingua, Contracaecum multipapillatum, Contracaecum spiculigerum*) (McDonald, 1969).

Perhaps the most unusual record found here was 3 specimens of *D. diasi* in the small intestine of an osprey from Virginia. This trematode was described from the pancreas of anhingas, *Anhinga anhinga,* in Brazil by Travassos (1922) and has recently been found in cysts on the pancreas of a great blue heron in Florida (Kinsella and M. G. Spalding, unpubl. data) and in the intestine of a bald eagle, *Haliaectus leucocephalus,* from Virginia (Cole, unpubl. data). The pancreas appears to be the normal site of infection for this trematode, and its presence in the intestine of the osprey and eagle may be due to postmortem migration.

Although life-cycle data are not available for any of the 7 osprey specialists, it is highly probable that most are acquired through the ingestion of fish intermediate hosts, both freshwater and

marine. The osprey's diet consists almost exclusively (>99%) of fish (Poole, 1989; Ewins, 1994), and more data on helminth distribution will provide clues to the identity of intermediate hosts.

A few of the trematode generalists found (*Phagicola longa, Cryptocotyle lingua,* and *Ascocotyle* sp.) have life cycles primarily associated with estuarine and marine ecosystems and were found only in birds from coastal states such as Florida and South Carolina. These species could potentially act as biological tags reflecting the migratory behavior of the host; however, the host collection data provided in the present study was not precise enough to warrant any such conclusions.

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Research Note

Babesia thylacis (Apicomplexa: Babesiidae) in a Northern Quoll, *Dasyurus hallucatus* (Marsupialia: Dasyuridae), from Western Australia

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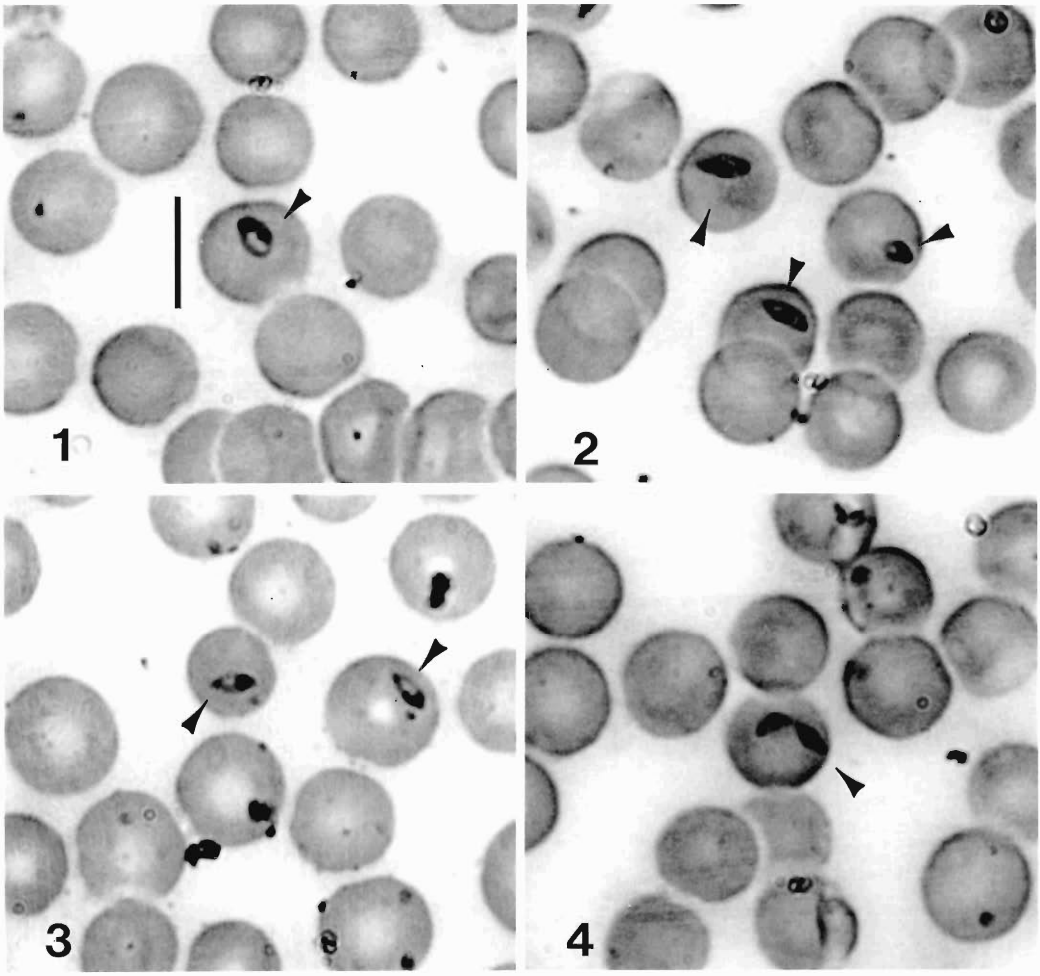
ABSTRACT: *Babesia thylacis* Mackerras, 1959, is provisionally identified and described from a stained blood smear obtained from a female northern quoll, *Dasyurus hallucatus* (Gould, 1842), captured on the Mitchell Plateau, Kimberley, Western Australia. This represents the third known natural host of this parasite and the first published account of its presence in Western Australia. *Babesia thylacis* has so far been found only in small carnivorous or insectivorous marsupials from Australia. Parasite morphology is characteristically pleomorphic, ranging from small amoeboid organisms to fully grown, pyriform protozoans, either single or paired, 2–4 by 1–1.5 μm. In most cases, mature parasites contain a prominent vacuole with a rounded nucleus either centrally or terminally located. Nuclear material that was elongated and stretched out along the periphery of some organisms was not uncommon. Infected red blood cells commonly contained only 1 parasite and occasionally paired merozoites.

KEY WORDS: Apicomplexa, Sporozoea, Piroplasmida, Babesiidae, *Babesia thylacis, Dasyurus hallucatus,* northern quoll, Marsupialia, Dasyuridae, Western Australia.

As part of an ongoing study on the prevalence and distribution of blood parasites in Indonesian mammals, numerous unstained blood smears were kindly lent to us by the Western Australian Museum, Perth, for staining and examination. We report on 1 specimen that had been collected many years earlier (17 July 1982) by W. A. Maxam from a captured female quoll identified as *Dasyurus hallucatus* (Coll. No. 11–35, Western Aust. Mus.) from the Mitchell Plateau (14°37′S, 125°52′E), Kimberley, Western Australia. In 1993, the thin peripheral blood film was fixed in methanol and stained for 15 min with Giemsa diluted 1:15 in pH 7.2 sodium phosphate buffer prepared from deionized water, revealing the *Babesia* described herein. Photomicrographs (Figs. 1–4) were processed and measurements made using a micrometer while examining parasites under a high oil immersion objective (× 1,000). The permount blood film (No. M21944) is deposited in the Department of Biogeography and Ecology, Western Australia Museum, Perth, Western Australia, 6000.

Parasites were found only in erythrocytes at a density of 5–10 per microscopic field of blood. Morphology was characteristically pleomorphic, ranging from small amoeboid to larger filiform organisms to fully grown, pyriform parasites, either single or paired, 2–4 by 1–1.5 μm. This parasite is considered a "large" *Babesia* based on the size of the intraerythrocytic parasites. Despite the age of the unstained blood film (~11 yr), the resultant staining was remarkedly good. The background coloration of stained erythrocytes were pink. Cytoplasm was a dull blue, concentrated to diffuse, and often vacuolated. Chromatin was often a bright reddish-purple. The nucleus was rounded and either centrally or terminally located. Nuclear material that was elongated and stretched out along the periphery of some organisms was not uncommon. In most cases, mature trophozoites contain a prominent central vacuole. Infected red blood cells commonly contained only 1 parasite (Figs. 1–3) and occasionally, after merogony, formed binary pyriform merozoites (Fig. 4). Maltese cross tetrads and hemozoin pigment were not detected. Mackerras's (1959) description of *Babesia thylacis* is very close to our observations in the northern quoll. However, unlike the original description, we did not observe altered (enlarged, pale color) erythrocytes as a result of parasitism, nor were erythrocytes found to contain 4 or more daughter cells.

Only 6 species of *Babesia* have been reported in Australia and, with the exception of *B. thylacis* and *Babesia tachyglossi,* all are nonnative parasites (Backhouse and Bollinger, 1959; Mahoney et al., 1977). From available descriptions, known hosts and locality, the parasite we observed appears to be indistinguishable from *B. thylacis* first described in *Isoodon macrourus* (=*Thylacis obesulus*) (Mackerras, 1959). Reports of *B. thylacis* have been confined to 2 species of Australian bandicoots (Marsupialia: Peramelidae), *Isoodon macrourus* (short-nosed bandicoot), and *Pera-*



Figures 1–4. Photographs of *Babesia thylacis* (darts) in erythrocytes of *Dasyurus hallucatus*. 1–3. Single annular or pyriform trophozoites presenting varying distribution of chromatin. 4. Binary forms (merozoites). Scale bar = 6 μm.

melas nasuta (long-nosed bandicoot) collected near Brisbane, Queensland (L. Cannon, pers. comm.). Additionally, Mackerras (1959) mentioned parasites generally resembling *B. thylacis* from a short-nosed echidna, *Tachyglossus aculeatus* (Monotremata), collected in New South Wales, but these were far more pleomorphic in stained preparations. This parasite was subsequently described by Backhouse and Bollinger (1959) as *B. tachyglossi*. If correct, *B. thylacis* in the northern quoll would extend the known range of this multihost species from the eastern coast of Queensland to northern Western Australia. Although common practice in the past, we agree with Levine (1971) that giving new names to piroplasms merely because they are found in new hosts is not warranted unless there are clear differences from those that have already been described.

The northern quoll or northern native "cat," *Dasyurus hallucatus* (Gould, 1842), is the smallest of 6 species in the genus *Dasyurus* E. Geoffroy St.-Hilaire, 1796 (Nowak, 1991). The northern quoll is restricted to Australia, and the genus, in general, to Australasia. A predacious marsupial and nocturnal in habit, it is fairly common in woodland and rocky areas. Although *Dasyurus hallucatus* has been used commonly for laboratory studies in physiology and ontogeny, relatively little is known about its natural ecology or

parasitic fauna (Schmitt et al., 1989). This appears to be the first report of a babesiosis identified in *D. hallucatus*.

Levine (1988) identified 111 species in the genus *Babesia* Starcovici, 1893, most representatives occurring in mammalian orders, particularly rodents, and a few birds and reptiles. *Babesia* represents a large and diverse assemblage of organisms, yet only three species are known to naturally infect marsupials—*Babesia brasiliensis* Regendanz and Kikuth, 1928; *Babesia ernestoi* DA Serra Freire, 1979; and *B. thylacis*, Markerras, 1959. Two have been described in American marsupials, *Didelphis marsupialis* (*B. brasiliensis, B. ernestoi*), *Didelphis albiventris, Philander opossum,* and *Metachirus nudicaudatus* (*B. brasiliensis*), all in South America (Ayala et al., 1973; Serra Freire, 1979; Herrera and Urdaneta-Morales, 1991). It appears that *B. thylacis* is the only described representative found in Old World marsupials. Interestingly, despite extensive reviews, *B. thylacis* was overlooked as a named species by Levine (1971, 1973) and Ristic and Lewis (1977). Moreover, this species is not included in the most current Index-Catalogue of Medical and Veterinary Zoology (Protozoa), an apparent oversight (R. Lichtenfels, pers. comm.). Telford et al. (1993) included this species in a list of 78 nonruminant mammalian *Babesia* but incorrectly attributed the, now presumed extinct, Tasmanian wolf (*Thylacinus cynocephalus*) as the type host. Eventually, Levine (1988) correctly identified *B. thylacis* from the literature. The single type blood slide of *B. thylacis* (syntypes G 2436) is held at the Queensland Museum, Brisbane.

As far as is known, *Babesia* are exclusively transmitted by Ixodid or Argasid ticks (Young and Morzaria, 1986). In Australia, all 3 marsupials identified with *B. thylacis* can occur together and thus may be preyed upon by the same vector species. The vector of this parasite is not known.

We thank Drs. D. Kithchner and R. How of the Western Australia Museum for kindly providing the blood slide, Dr. R. Lichtenfels of the USDA Biosystematics and National Parasite Collection Unit and Dr. L. Cannon of the Queensland Museum for their valuable assistance and background information, and Dr. E. Andersen of the Armed Forces Institute of Pathology for the photomicrographs. This study was supported by the U.S. Naval Medical Research and Development Command, Navy Department, for Work Unit 3M161102BS13.AD410. The opinions and assertions contained herein are those of the authors and are not to be construed as reflecting the views of the U.S. Naval Service. Send reprint requests to Publications Office, U.S. Naval Medical Research Unit No. 2, Box 3, APO AP 96520-8132, U.S.A.

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Research Note

Athesmioides aiolos Cribb and Spratt, 1992 (Digenea: Dicrocoeliidae), from *Potorous tridactylus* (Marsupialia: Potoroidae) in Tasmania, Australia

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ABSTRACT: *Athesmioides aiolos* Cribb and Spratt, 1992, is recorded from *Potorous tridactylus* (Marsupialia: Potoroidae) from Tasmania, Australia. The specimens are much larger than those reported previously from rodents, but the differences are interpreted as being host-induced. This is the first record of a dicrocoeliid from a macropodoid marsupial.

KEY WORDS: Digenea, Dicrocoeliidae, *Athesmioides,* Australia, marsupial, *Potorous tridactylus.*

The Dicrocoeliidae is one of the principal families of digenetic trematodes infecting terrestrial mammals. Cribb and Spratt (1992) summarized information on 6 described species of dicrocoeliids from Australian native mammals. These species, together with several undescribable forms, were reported from marsupials (dasyurids, peramelids, and petaurids) and from rodents (murids). In an addendum, attention was drawn to poor, undescribable fragments of a dicrocoeliid from the long-nosed potoroo (*Potorous tridactylus*) from Tasmania. Further specimens of this species have now become available and are described herein.

Potoroos are cat-sized, forest-dwelling marsupials that belong to the Macropodoidea, the superfamily that contains the kangaroos and wallabies, which are the most conspicuous part of the Australian mammal fauna. Although the Macropodoidea includes about 50 species in Australia, only 4 trematodes have been reported from the group: *Fasciola hepatica,* 2 species of paramphistomes, and a possible psilostomid (Spratt et al., 1990).

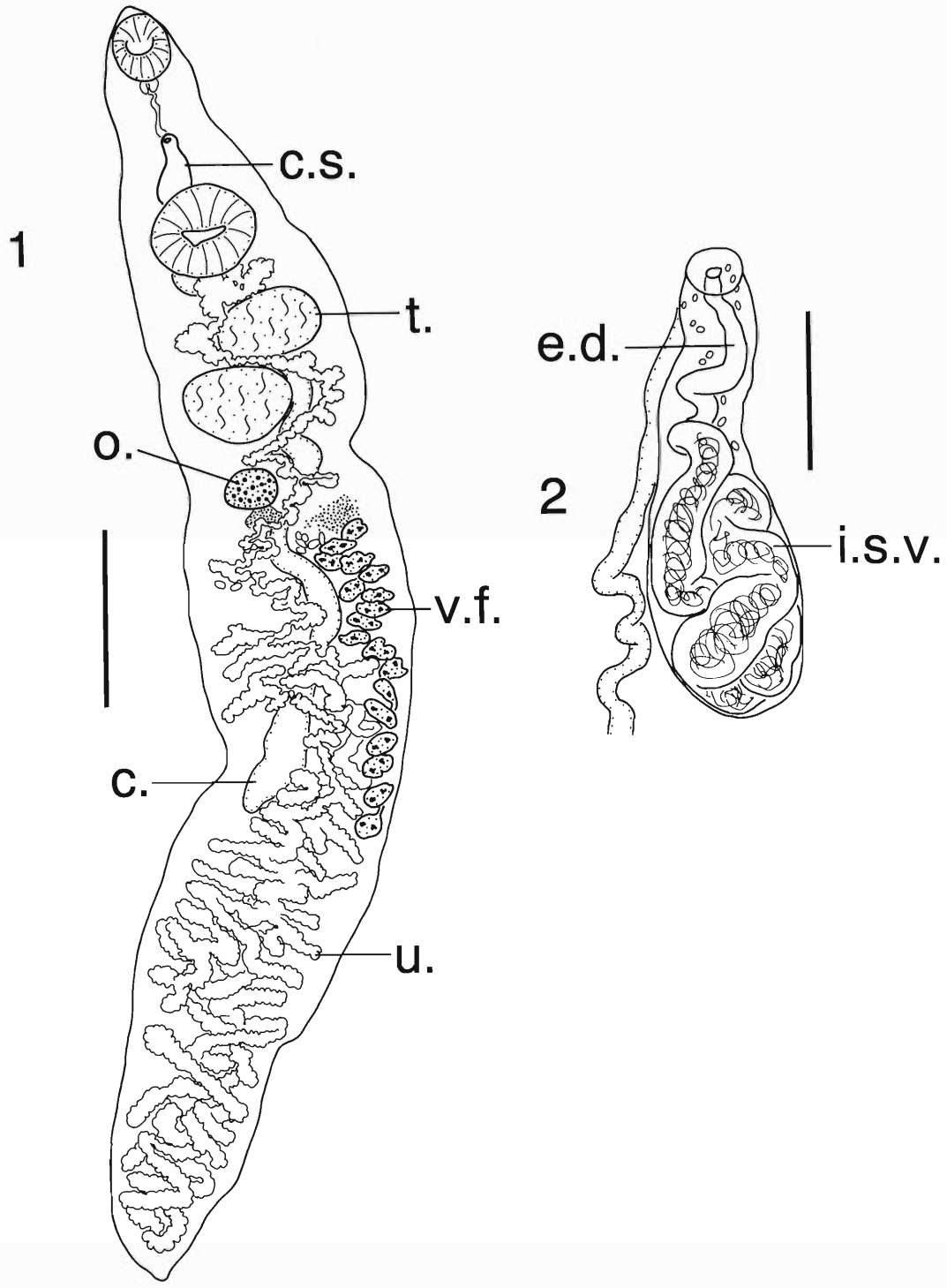
Specimens were collected by Dr. D. Obendorf. Whole mounts were stained with Mayer's hematoxylin, dehydrated in ethanol, cleared in methyl salicylate, and mounted in Canada balsam. All measurements are given in micrometers as ranges with means in parentheses. Figures were drawn with the aid of a camera lucida.

Athesmioides aiolos Cribb and Spratt, 1992 (Figs 1, 2)

MATERIAL EXAMINED: Abundant in bile ducts *Potorous tridactylus* (Kerr, 1792) (Marsupialia: Potoroidae), 6 km south of Beaconsfield, 41°11′S, 146°46′E, Tasmania, 24 June 1992.

DEPOSITION OF SPECIMENS: Queensland Museum, Brisbane, QM G 212965-74.

DESCRIPTION (measurements are of 15 specimens.): Body elongate, lanceolate, 2,928–6,224 (4,581) long and 304–656 (491) wide, body length/width ratio 4.68–20.47 (10.18). Forebody 366–931 (653), occupies 11–18% (14) body length. Distinct preoral lobe present. Oral sucker 132–270 (210) by 141–218 (185). Ventral sucker weakly muscular, 212–334 (258) by 221–398 (304). Ratio oral to ventral sucker widths 1:1.3–1.9 (1.6). Pharynx 32–58 (43) by 45–71 (58). Esophagus muscular, extends dorsal to cirrus sac. Cecum undivided, thin-walled, inconspicuous, extends to near posterior end of vitellarium. Testes diagonal to tandem depending on contraction of body, separated by uterus; anterior testis may overlap ventral sucker slightly in contracted specimens or may be separated from it, 186–411 (322) by 205–366 (296); posterior testis 225–475 (348) by 238–379 (309). Cirrus sac almost entirely dorsal, partly dorsal or entirely anterior to ventral sucker depending on state of contraction of body, 193–334 (247) by 61–96 (78), contains winding internal seminal vesicle, opens at common genital pore just in front of ventral sucker. Ovary 116–193 (161) by 109–244 (173). Seminal receptacle dorsal, posterior to ovary. Laurer's canal opens dorsally at level of ovary. Vitellarium in form of 14–18 (16) follicles forming band on left or right side (usually left) of body, lateral to uterus, from close to posterior margin of ovary, to point 603–1,929 (1,485) from posterior end of body; field occupies 19–32% (24) body length.



Figures 1, 2. ***Athesmioides aiolos*** **from** ***Potorous tridactylus*** **from Tasmania. 1. Adult, ventral. Scale = 0.5 mm. c. = cecum, c.s. = cirrus sac, o. = ovary, t. = testis, u. = uterus, v.f. = vitelline follicle. 2. Cirrus sac, ventral. Scale = 0.1 mm. e.d. = ejaculatory duct, i.s.v. = internal seminal vesicle.**

Uterus passes posteriorly from ovary in laterally directed coils to point near posterior end of body, then passes anteriorly laterodorsally to ovary, between testes, and finally passes to common genital pore. Eggs operculate, tanned, 32–43 (38) by 14–21 (17) (n = 15). Excretory vesicle I-s-haped, extends to near anterior end of vitelline field.

REMARKS: Our specimens are all considerably larger than those reported by Cribb and Spratt (1992) from the rodents *Rattus fuscipes, R. lutreolus, R. norvegicus,* and *Pseudomys higginsi.* The specimens from rodents were 1–3 mm long, whereas those from *Potorous tridactylus* are 3–6 mm. In the specimens of similar length (approximately 3 mm), the specimens from the potoroo differed in body width and ventral and oral sucker widths, typically twice as wide as those from rodents. Apart from these size differences, these specimens are otherwise indistinguishable from *A. aiolos.* We believe the morphological distinctions simply represent host-induced intraspecific variability. The potoroo is a far larger animal than the rodents reported as hosts for this species and typically weighs approximately 1 kg, whereas none of the rodents weigh more than 200 g (Strahan, 1983). We hypothesize that this difference is reflected by an increase in the size of the bile ducts allowing the dicrocoeliids in the potoroo to grow larger.

The identification proposed here requires that this parasite is shared by both eutherians and marsupials. Although such low specificity is superficially surprising, 2 observations make it plausible. The first is that another liver fluke, *Fasciola hepatica,* is also shared between a wide range of eutherians and marsupials (Spratt et al., 1990). The second is that, because dicrocoeliids obviously have not co-evolved with marsupials, the parasite has been acquired by host-switching from rodents at some stage. Rodent and marsupial populations in Tasmania are sympatric, thus making this possible.

We thank Dr. D. Obendorf for sending us the specimens examined here.

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Research Note

Human Pinworms Collected from a Chimpanzee, *Pan troglodytes,* in a Zoo of Okinawa, Japan

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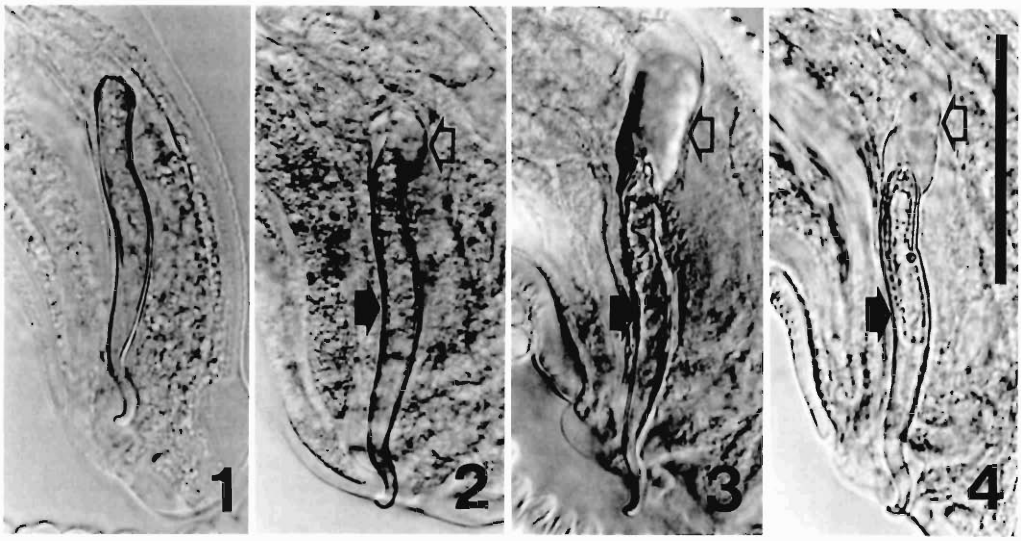
ABSTRACT: *Enterobius vermicularis* (Linnaeus, 1758) and *Enterobius gregorii* Hugot, 1983 (Nematoda: Oxyuridae), were collected from a chimpanzee, *Pan troglodytes,* reared in a zoo of Okinawa, Japan. This is the first record of *E. gregorii* from chimpanzee. The male of *E. vermicularis* was significantly larger than that of *E. gregorii.* The 2 species were readily distinguished by the shape and length of the basal portion of the spicule while the morphology of the distal tubular portion was identical. The spicule in the males immediately after the final molt had only a distal tubular portion, indicating that the basal portion develops during the subsequent maturation process. Presence of intermediary forms of the basal portion between the typical *E. vermicularis* and *E. gregorii* types suggests that the basal portion of the former grows from that of the latter.

KEY WORDS: *Enterobius vermicularis, Enterobius gregorii,* morphology, chimpanzee, zoo.

Two species of human pinworms have been recognized, namely, *Enterobius vermicularis* (Linnaeus, 1758) and *Enterobius gregorii* Hugot, 1983. The males of the 2 species are easily distinguished from each other by the length and shape of the spicule, while no morphological feature has been found to discriminate their females (Hugot, 1983; Hugot and Tourte-Schaefer, 1985). *Enterobius gregorii* seems to have worldwide distribution because its occurrence, often concurrent with *E. vermicularis,* has been recorded from various geographical regions (Chittenden and Ashford, 1987; Barnish and Ashford, 1989; Pampiglione et al., 1989; Hasegawa et al., 1991; Mangali et al., 1993). Besides humans, some nonhuman primates under captive condition have been known to harbor *E. vermicularis* (cf. Rewell, 1948; Sandosham, 1950; Kosuge and Miyamoto, 1984). However, it has not been elucidated whether or not *E. gregorii* is also parasitic in such primates. Recently, we had an opportunity to examine pinworms expelled from a chimpanzee, *Pan troglodytes* (Blumenbach, 1775), in a zoo of Okinawa, Japan, and found *E. gregorii* along with *E. vermicularis.* A close examination also raised a question as to the distinctness of *E. gregorii* as discussed herein.

The pinworm infection was proved by a fecal examination of the female chimpanzee with anorexia in the middle of April 1995. This chimpanzee had been reared for more than 14 yr and developed a coprophilic habit. An anthelmintic, pyrantel pamoate, was given orally with food on 24 April and 22 May 1995, and the fecal masses found on the floor of the chimpanzee pen were collected on the next morning. The feces were fixed in 5% formalin solution at room temperature. The fixed feces were gently washed on a stainless-steel sieve with a pore size of 0.075 mm. The residues left on the sieve were then transferred to a petri dish and examined under a stereomicroscope for pinworms. Collected worms were rinsed in 70% ethanol, cleared in a glycerol–alcohol solution, and mounted on glass slide with 50% glycerol aqueous solution. To examine the pericloacal morphology, the posterior body was severed and cut horizontally and mounted with the ventral side up. Observation was made with a Nikon Optiphoto microscope equipped with a Nomarski interference apparatus. Statistical comparison of measurements was made by Welch's test. Representative specimens were deposited in the U.S. National Parasite Collection, Beltsville, Maryland, Nos. 85455–85457.

Numerous immature adult pinworms, immediately after the final molt, as well as many fourth-stage larvae were recovered from the feces collected on 25 April 1995, and many mature males and immature females were collected from the feces of 23 May 1995. They were apparently human pinworms because the distal end of the spicule formed a recurved hook (Figs. 1–4), being clearly distinguished from the chimpanzee pinworm, *Enterobius anthropopitheci* (Gedoelst, 1916), of which the spicule has a round distal end (Hugot, 1993). All of the males collected on 25 April 1995 had a simple tubular spicule that



Figures 1–4. Spicules of pinworms collected from a chimpanzee, *Pan troglodytes*. 1. Male immediately after final molt. 2. Male of *E. gregorii*. 3. Male of *E. vermicularis* with developed basal portion. 4. Male of *E. vermicularis* with small basal portion. Closed arrows indicate the distal tubular portion and open arrows indicate the basal portion. Scale bar = 50 μm.

was morphologically identical to that of *E. vermicularis* and *E. gregorii* (Fig. 1). Measurements are stated in Table 1.

The males collected on 23 May 1995 were readily divided into *E. gregorii* and *E. vermicularis* based on the criteria of the spicule morphology proposed by Hugot and Tourte-Schaefer (1985). The spicule was composed of a distal tubular portion and a basal portion (Figs. 2, 3). The basal portion of *E. gregorii* was a round refractive mass (Fig. 2), and that in *E. vermicularis* was elongated and sac-like, filled with various amounts of refractive material that extended from the basal end of the distal tubular portion (Fig. 3). Meanwhile, the morphology of the distal tubular portion was identical between *E. gregorii* and *E. vermicularis* (Figs. 2, 3). In some *E. vermicularis,* the basal portion was still small and differed from that in *E. gregorii* only by a slight dorsal protrusion and a sac-like structure (Fig. 4). Although Hugot and Tourte-Schaefer (1985) claimed that the fine pericloacal morphology in males was different between the 2 species, such difference was not observed in the present examples.

With the exception of the length of the distal tubular portion of the spicule, all of the mean measurements of the immature males collected on 25 April 1995 were significantly smaller than those of *E. gregorii* collected on 23 May 1995 ($P < 0.0001$). Again, all of the mean measurements, except the spicule distal portion length, of the *E. gregorii* males were significantly smaller than those of *E. vermicularis* collected on the same day ($P < 0.01$). The mean length of the distal tubular portion of the spicule showed no significant difference between the immature males of 25 April 1995 and *E. gregorii* of 23 May 1995 and between *E. gregorii* and *E. vermicularis* of 23 May 1995. However, the distal portion of the spicule in the immature males was smaller than that of *E. vermicularis* ($P < 0.01$).

The difference in the worm size of males of the species was already noticed by Hasegawa et al. (1991), who recorded the body length of *E. vermicularis* and *E. gregorii* from an Okinawan woman to be 2.33–2.85 mm (mean 2.61) and 1.25–2.45 mm (mean 1.94), respectively. Hugot and Tourte-Schaefer (1985) also reported that the maximum body length of *E. vermicularis* was much larger than that of *E. gregorii* (3.845 vs. 2.8 mm). Although the minimum body length of *E. vermicularis* in their report was shorter than that of *E. gregorii* (0.92 vs. 1.37 mm), it is surmised that some males of *E. vermicularis* examined by them were much shrunken. This presumption may be supported by the fact that the male of *E. vermicularis* illustrated had a shorter

Table 1. Measurements of male pinworms expelled from a chimpanzee, *Pan troglodytes*. Mean ± SD (range) in micrometers.

Date of Collection: No. measured:	*Enterobius* sp. 25 April 1995 25	*E. gregorii* 23 May 1995 25	*E. vermicularis* 23 May 1995 25
Body length	1,556 ± 90 (1,380–1,730)	1,949 ± 193 (1,550–2,490)	2.321 ± 210 (1,970–2,740)
Body width	103.6 ± 10.4 (83–126)	155.1 ± 21.1 (112–119)	183.1 ± 22.7 (141–230)
Esophagus			
Total length	408.9 ± 19.6 (358–435)	506.2 ± 22.6 (460–550)	536.3 ± 24.6 (480–590)
Bulb length	92.4 ± 34 (86–99)	106.6 ± 4.4 (96–115)	110.6 ± 4.5 (99–122)
Bulb width	61.0 ± 2.7 (53–66)	75.0 ± 5.2 (60–86)	80.2 ± 6.2 (64–97)
Nerve ring*	109.5 ± 5.7 (101–125)	131.5 ± 9.1 (112–153)	138.6 ± 8.8 (115–154)
Excretory pore*	426.2 ± 28.9 (385–483)	587.3 ± 40.6 (510–653)	656.8 ± 57.2 (550–736)
Spicule length			
Total	70.6 ± 2.4 (64–74)	78.0 ± 2.7 (69–83)	96.6 ± 4.4 (82–106)
Distal portion	70.6 ± 2.4 (64–74)	71.3 ± 2.6 (66–76)	72.4 ± 1.9 (69–75)

* Distance from anterior extremity.

but thicker body than *E. gregorii* (see table 1 of Hugot and Tourte-Schaefer, 1985).

Because the immature males immediately after the final molt lack the basal portion of spicule, it is apparent that this structure is formed during the subsequent maturation process. It would be thus expected to find various stages of development in the basal portion of *E. vermicularis*. However, only observed stages were the intermediate forms between the typical *E. vermicularis*–type and the typical *E. gregorii*–type basal portions (Fig. 4). It is therefore surmised that the *E. vermicularis*–type basal portion grows secondarily after the *E. gregorii*–type basal portion is completed. If this is the case, *E. gregorii* might be regarded as a developmental stage of *E. vermicularis*. The smaller body size of *E. gregorii* seems to support this possibility.

The association of *Enterobius* and primates has been considered as a good example of coevolution (Brooks and Glen, 1982). The establishment of *E. gregorii* has led evolutionary biologists to make an alternate hypothesis of the coevolutionary history of *Enterobius* and primates (Brooks and McLennan, 1993). However, further investigations are required to prove the distinctness of *E. gregorii* because the present results suggest its synonymy with *E. vermicularis*. Unfortunately, the pinworms expelled from humans are usually damaged by anthelmintics, preventing detailed morphological observation and accurate measurement. A careful study using ideally fixed specimens and/or employing some biotechnological methods will clarify the species composition of human pinworms and contribute to the understanding of the coevolutionary process of pinworms and primates.

We thank Mr. K. Kawakami for his kindness in informing one of us (H.H.) about the nematode infection of the chimpanzee.

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Research Note

Some Aspects of Experimental Infections of *Trichostrongylus axei* in Domestic Rabbits (*Oryctolagus cuniculus*)

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ABSTRACT: *Trichostrongylus axei* have been maintained in domestic rabbits (*Oryctolagus cuniculus*), by serial passage, at the University of Kentucky since 1953 for an equine strain (A) and 1954 for a bovine strain (O). On 17 August, 1995, this research was terminated. Presentation here is mostly on cumulative data on number of serial passages, infectivity, and longevity of *T. axei* since 1984/1985. Comparison is made with earlier research, much of which has been published (Lyons et al., 1987).

KEY WORDS: *Trichostrongylus axei,* nematode, experimental infections, longevity, domestic rabbits.

The domestic rabbit is an excellent host for *Trichostrongylus axei,* not only for study of this parasite but also for providing a source of larvae for research in other hosts (Drudge et al., 1955; Leland and Drudge, 1957; Leland et al., 1959a, b, 1960a, b, 1961; Leland, 1963; Lyons et al., 1987). Advantages of the rabbit as a donor are its small size, potential life span of several years, and prolonged patency of >5 yr for *T. axei* (Lyons et al., 1987).

Two strains (A from equids and O from bovids) of *T. axei* were isolated and established in 1953 (Strain A) and in 1954 (Strain O) in domestic rabbits. Both strains were maintained in rabbits, by serial passage, until 17 August, 1995, when this research was terminated. Strain O was temporarily lost in rabbits on 24 September, 1959 but restarted in this experimental host on 5 November, 1959 from calves previously infected with this strain. More complete records on the infections involved in these serial passages of *T. axei* in rabbits have been kept since 31 July, 1962. From that date through 25 October, 1985

Table 1. Data on experimental infections of *Trichostrongylus axei* in 6 domestic rabbits positive for specimens at termination of the research.

Rabbit no.	Administration of larvae		Eggs in feces		Adults in stomach at necropsy*			Longevity of parasites (yrs)
			Last date					
	Date	No.	Positive	Examined	♂	♀	Total	
20-A†	3/7/89	2,580	6/13/94	6/13/94	0	1	1	6.5
23-O‡	3/7/89	2,600	4/30/93	6/13/94	0	9	9	6.5
3272-O	1/18/93	1,350	6/13/94	6/13/94	11	27	38	2.0
3273-O	1/22/93	1,500	8/18/93	6/13/94	0	3	3	2.0
3278-O	1/18/93	1,350	8/18/93	6/13/94	17	21	38	2.0
3279-O	1/22/93	1,500	None	6/13/94	0	4	4	2.0

* 17 August 1995.
† A = equid strain—5 other rabbits (1 given L_3 at 6.5 yr and 4 at 2 yr previously) were negative for *T. axei* specimens.
‡ O = bovid strain—3 other rabbits (1 given L_3 at 8 yr and 2 at 2 yr previously) were negative for *T. axei* specimens.

for Strain A and 21 December, 1984 for Strain O, specific data pertaining to the infections have been published (Lyons et al., 1987)

The present paper is an update on data accumulated through 17 August, 1995. Besides data on presence of eggs in feces (the basis for determining patency), counts were made of specimens of *T. axei* recovered from stomachs of 14 rabbits (6, Strain A; and 8, Strain O) euthanatized and examined at necropsy at termination of the research project. In the 1987 publication (Lyons et al., 1987), counts of *T. axei* in rabbit donors were not made. Details and references on methodology and other background information on infections of *T. axei* in rabbits were previously published (Drudge et al., 1963; Lyons et al., 1987). Fecal samples for determination of presence of *T. axei* eggs by EPG (eggs per gram of feces) counts (Lyons et al., 1976) or qualitative method were collected periodically (usually every 2 wk) until 13 June, 1994, the last date of collection. In 1987, the donor rabbits were transferred to new quarters. At about the same time, the feed ration was changed and also a new supplier of donor rabbits was necessitated. Chance of natural reinfection of the rabbits with *T. axei* infective third-stage larvae (L_3) developing from eggs passed in feces was virtually impossible (Lyons et al., 1987).

Comparison of data on *T. axei* donor rabbits from 1962 through 1984/1985 (Lyons et al., 1987) and the end of those periods to 1995 (present paper) revealed several differences.

For Strain A in the period 1962–1985, there were 11 passages in 31 donor rabbits. Highest EPG count was 3,600, with patency being 154–2,055 days. The mean EPG count for all rabbits was 420 during this period, whereas, for the period 1985–1995, there were 4 passages in 31 rabbits. The highest EPG count was 290, with patencies varying from 70 to 1,945 days. For this period, there was a mean EPG count of 89. The total passages for the 33-yr study period were 15 in 62 rabbits. A decline in EPG counts began in 1986 and, since then, only 3 of 19 rabbits had values > 100. Difficulty in establishing infections was evident since 1987. In September of that year, none of 8 *T. axei*–naive rabbits developed infections after administration of L_3, as evidenced by negative EPG counts for 2 mo postinoculation. At this time, *T. axei* L_3 were readministered to 4 of these rabbits; all 4 developed infections. In January 1993, none of 4 donors became infected after being given larvae. Before the 1987 problem with infectivity, all donors developed infections following initial administration of L_3. Examination of stomachs of 6 of the Strain A donors at necropsy at termination of the experiment revealed 1 (No. 20) positive for *T. axei* (1 ♀); this donor was given L_3 6.5 yr previously (Table 1).

For Strain O, in the 1962–1984 period, there were 14 passages in 32 rabbits. The highest EPG count was 1,350, and patency ranged from 71 to 1,810 days. During the 1984–1995 period, there were 5 passages in 33 rabbits. The highest EPG count was 490, and patency varied from 140 to 1,725 days. Total passages for the 33-yr period were 19 in 65 donor rabbits. A decline in EPG counts began in 1985 and, since then, only 4 of 29 rabbits had values of > 100. There were only 3 rabbits that did not have a positive EPG count after being given L_3, 1 in 1987 and 2 in 1993. At necropsy for Strain O rabbits, 5 (1 given L_3 at 6.5 yr and 4 at 2 yr previously) of 8 harbored 3–38 specimens of *T. axei* each (Table 1).

Both *T. axei* strains showed decreased infectivity, especially Strain A, the last several years. Exactly why is uncertain, but several reasons can be surmised. Possibilities are (1) a new source of rabbits with different genetic bloodlines, (2) change in type of food for the rabbits, (3) different location and environmental conditions for housing rabbits, and (4) senility or loss of vigor of the *T. axei*. It is of interest that *T. axei* infections survived for 6.5 yr in donor rabbits; they may have lasted longer if the donors were not euthanatized. Also, 1 rabbit survived for 8 yr although *T. axei* in it apparently did not. The survival of these strains of *T. axei* for over 40 yr with relatively few passages shows the advantageous use of domestic rabbits as experimental donors for this parasite. However, certain unknown factors may determine the infectivity of the donor rabbits with this parasite.

Statistical analysis was done to determine significance (at 5% level) comparing earlier with later data for Strain A (1962–1985 vs. 1985–1995) and for Strain O (1962–1984 vs. 1984–1995) on (1) highest EPG counts, (2) infectivity (No. of rabbits given infective L_3 vs. No. of rabbits infected), and (3) patency. Analysis was by a standard *t*-test for data on EPG counts/patency and by Fisher's exact test for data on infectivity. The values for the earlier period were significantly greater than the later period for all 3 factors for Strain A and 2 factors (no significance for infectivity) for Strain O. This supported the observation of a decline in establishment of *T. axei*, especially Strain A, in rabbits in about the last 10 yr.

The investigation reported in this paper (No. 95-14-183) was made in connection with a project of the Kentucky Agricultural Experiment Station and is published with the approval of the director.

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In Memoriam

LEON JACOBS
(1915–1995)

Dr. Leon Jacobs, a medical parasitologist best known for his research on toxoplasmosis-related blindness and as a public health administrator, died at his home in Washington, D.C. on 3 October 1995. He was born in 1915 in Brooklyn, New York, graduated from Brooklyn College, and received both his M.S. and Ph.D. degrees from George Washington University.

During World War II, he served as an army malaria control officer in Brazil with responsibilities in the South Atlantic theater. Dr. Jacobs was associated with the National Institutes of Health (NIH) and the U.S. Public Health Service (USPHS) for 41 years. He began his USPHS career as a nematologist in the Zoology Division of the National Microbiological Institute, the predecessor of the National Institute of Allergy and Infectious Diseases (NIAID/NIH). He subsequently was Chief of the NIAID Laboratory of Parasitic Disease, Scientific Director of the NIH's Division of Biological Sciences, NIH Associate Director for Collaborative Research, and Assistant Secretary for Science in the Department of Health, Education, and Welfare. At the time of his USPHS retirement in 1979, Dr. Jacobs was Director of the Fogarty International Center, which coordinates NIH-wide international activities. While at NIH, Dr. Jacobs pursued collaborative research activities throughout the world, including Egypt, Japan, and Panama.

After leaving NIH, Dr. Jacobs was Scientific Director, National Society for Medical Research (1980–1984), and Chairman of the Board and President of the Gorgas Memorial Institute (GMI) for Tropical and Preventive Medicine, a U.S. corporation, which was responsible for the Gorgas Memorial Laboratory (GML) for Tropical and Preventive Medicine in Panama City, Panama (1983–1991). After the 1992 changes in the GMI corporate bylaws and transfer of GMI operations to the University of Alabama–Birmingham, Dr. Jacobs continued to serve as an ex officio GMI director. Following the reversion of GML to the Government of Panama, Dr. Jacobs was instrumental in establishing an endowment to fund the GMI Fellowship Program, which provides short-term travel grants to young investigators from the U.S.A., Central America, and Panama and the Caribbean to conduct collaborative research projects. Dr. Jacobs was also instrumental in establishing the annual Gorgas Lectureship at NIH and was the inaugural Gorgas Lecturer in 1992.

During his distinguished career, Dr. Jacobs was elected to membership in the Helminthological Society of Washington on 19 October 1937. He served on numerous committees and as an officer within the Society, including Member of the Executive Committee, 1948–1949; Vice President, 1951; and President, 1952. He received the Anniversary Award in 1983 and was elected to Life Membership in 1985. He was President of the American Society of Parasitologists in 1978 and recipient of the Henry Baldwin Ward Medal in 1963. He received the Distinguished Service Medal from the USPHS and Superior Service Award from the U.S. Department of Health, Education, and Welfare.

In retirement, he was a visiting professor at several medical schools, including the University of Arizona, Case Western Reserve University, and the University of South Florida. He is survived by Eva, his wife of 49 years; three children, Jonathan, Alice, and Abby; and a brother, George.

Reprinted with modifications from the Tropical Medicine and Hygiene News, a publication of the American Society of Tropical Medicine and Hygiene.

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In Memoriam

Aurel Overton Foster
(1906–1996)

"Whatever there may be of reward for life well spent, work well done and service to humanity—that reward is his."

Maurice C. Hall, 1925

These words of M. C. Hall were written for B. H. Ransom and reprinted in a Centenary Note on Ransom by A. O. Foster in 1980. They certainly apply to Aurel Overton Foster.

Aurel O. Foster, 89, of College Park, Maryland, passed away on 25 February 1996 at The Johns Hopkins Bayview Hospital following a brief illness.

Dr. Foster was born in Marathon, New York, 25 September 1906. He received an A.B. in 1929 and an M.A. in 1930 from Wesleyan College. His original plans for a career in religion changed in his junior year when he was offered a teaching assistantship in Zoology under Prof. George W. Hunter III at Wesleyan. He moved to the Johns Hopkins School of Hygiene and Public Health in 1930, where he majored in Helminthology under W. W. Cort and met his long-time friend, Dr. Gilbert F. Otto, who was then an instructor at Johns Hopkins. He received his Sc.D. from Johns Hopkins in 1933 and served as an Instructor at Johns Hopkins for 1 year (1933–1934).

Dr. Foster married his lovely wife, Margie, in 1931. They shared 65 years together. Dr. and Mrs. Foster are the parents of Jeanne and Richard and have 4 grandchildren. Dr. Foster was a devoted father and an active participant in civic affairs. He was active for 10 years on the Board of the College Park, Maryland, Volunteer Fire Department and had a long association with the Boys Club of that city.

Dr. Foster's research at Johns Hopkins used the dog and cat hookworm as a model of hookworm disease. One of his earliest papers, The Effect of Diet on Hookworm Infestation in Dogs, appeared in *Science* in 1931. In 1934, he moved to the Gorgas Memorial Laboratory in Panama, where, for 5 years, he studied helminths of horses and other animals of Panama, including primates. The scientific team that went to Panama in 1934 included Dr. Foster's long-time friend, Dr. Lloyd E. Rozeboom. During the 5-year period in Panama, Dr. Foster apparently established a world record for the number of horses and mules necropsied for worms. To this day, his papers on helminths of horses provide the most complete study of natural infections of equines. The specimens he collected are in the U.S. National Parasite Collection and will continue to provide information to parasitologists of future generations.

Dr. Foster left Panama in 1939, after being recruited by Dr. and Mrs. Benjamin Schwartz during a 2-week visit with the Fosters, to join the Bureau of Animal Industry, a precursor of the Agricultural Research Service (ARS) in Beltsville, Maryland. From 1940 to 1960, Dr. Foster's research centered on parasite control. He became Leader of Chemotherapy Investigations, and in 1960, he was appointed Director, Beltsville Parasitological Laboratory. From 1960 until he retired in 1971, Dr. Foster was probably the most influential parasitologist in the country. Leader of 44 scientists and 75 support staff at Beltsville, he was also responsible for national leadership of ARS parasitology programs in Auburn, Alabama; Tifton, Georgia; Albuquerque, New Mexico; Las Cruces, New Mexico; and Pullman, Washington. He was the last parasitologist to have leadership responsibility for the entire ARS parasitology program.

Dr. Foster always found time for social as well as scientific activities. He was a member of the laboratory bowling team, and he and Mrs. Foster hosted Helminthological Society of Washington family picnics at Beltsville for many years.

During this period, he became President of the American Society of Parasitologists (ASP) in 1959

and President of the Second International Congress of Parasitology in Washington in 1970. In his ASP Presidential address, Parasitological Speculations and Patterns, he termed parasitology a ". . . many splendored thing," in which, ". . . there is no place for favored disciplines . . . but ample space for togetherness . . . ." He was encouraged that parasitology was attracting many scientists who were not parasitologists by training because our science ". . . was born of interdisciplinary hybridization, and this is a sign of a growing and dynamic science." Dr. Foster cautioned, however, that our science would be supported only as long as it was perceived to serve human welfare. His thoughts are still relevant after almost 40 years.

Dr. Foster's long association with HelmSoc began in his days in graduate school at Johns Hopkins. While at Beltsville, he was a strong supporter, serving in every capacity except Editor and receiving every award HelmSoc can bestow on a member, including the Anniversary Award in 1970.

He was a prolific writer (more than 125 papers), an excellent speaker, and a recognized leader of American parasitology for several decades. At scientific meetings, Dr. Foster sat up front and usually had a penetrating question. His questions were not designed to demonstrate his knowledge but were superbly phrased and designed to provoke thought and the pursuit of knowledge.

Dr. Foster gave 39 years of service to the Brayton H. Ransom Memorial Trust Fund. He served as a Trustee (1953–1992), Secretary-Treasurer (1956–1973), and Chairman (1973–1979). He was a member of the American Association for the Advancement of Science, Sigma Xi, the American Society of Tropical Medicine and Hygiene, the Entomological Society of America, the Wildlife Disease Association, the American Microscopical Society, and the Society of Systematic Zoology. Other professional activities included membership on the FAO/OIE Expert Panel on Tick-Borne Diseases, United Nations (1958–1970).

Dr. Foster was a true gentleman of the old school, unfailingly polite, kind, and considerate of others, whether he was reviewing a manuscript or inquiring about family members at a social gathering. His closest associates considered him a good friend and respected colleague. His strikingly handsome physical appearance and refined demeanor were assets that he recognized and cultivated. He often told younger associates of the importance of presenting a positive image.

What final lesson can we learn from the life of this great man? We believe the defining features of his successes and his profound influence on those around him were a positive helpful approach to others and an enthusiastic desire to learn that are exemplified in this quote from his 1959 ASP Presidential address.

> "When I began the formal study of biological science, I found growing glory and few frustrations in the simple credo that 'anything that has to do with life is not foreign to biology.' This concept imparts all there is of worth and gives the biologist something to live for! If parasitism is a way of life, can we afford to disallow that anything having to do with that phenomenon or that way of life is germane to parasitology?"

The world is a better place because Aurel Overton Foster walked here, and those who associated with him are better people because they knew him.

J. Ralph Lichtenfels
USDA, ARS, LPSI, BNPCU
Beltsville, Maryland 20705-2350

Merle L. Colglazier
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Presentation of the 1995 Anniversary Award to Gerhard A. Schad

Gerhard A. Schad receiving the 1995 Anniversary Award from Nancy D. Pacheco at the New Bolton Center meeting, May 4, 1996.

As Chairman of the Awards Committee, I am pleased to present the 1995 Anniversary Award of the Helminthological Society of Washington to Dr. Gerhard A. Schad. Although the presentation normally would have been made at our Anniversary Dinner in November, the Society felt it was more appropriate to honor Gerry here at New Bolton Center where he has organized the Society's May meeting since 1979. The hospitality of Gerry and his lovely wife, Donna, has always made us feel welcome here.

The Anniversary Award is the highest honor given by our Society. The Awards Committee, consisting of Harley Sheffield and myself, chose to recommend Dr. Schad for this award because he qualifies under not one but all of the categories stated in our Constitution: "The recipient of the Anniversary Award shall be or have been a Society member who is honored for one or more achievements of the following nature:

(a) Outstanding contributions to parasitology or related sciences that bring honor and credit to the Society . . ." Gerry has brought credit to the Helminthological Society through his work with hookworms and other parasitic nematodes in many areas of the world.

"(b) an exceptional paper read at a meeting of the Society or published in its Journal . . ." Gerry was the guest speaker at our 80th Anniversary Dinner Meeting in 1990 and he has published 9 articles in our *Proceedings* and *Journal.*

"(c) outstanding service to the Society . . ." In addition to sponsoring the last 18 May meetings, Gerry served as a member at large on the Executive Committee from 1979 to 1980 and as Custodian of Back Issues from 1982 to 1989. He regularly attended our meetings while at Hopkins and has continued to support the Society and to attend meetings whenever possible as well as encouraging his students.

"and (d) other achievement or contribution of distinction that warrants highest and special recognition by the Society." Gerry has influenced the future of parasitology as a professor at the University of Pennsylvania and mentor of 11 graduate students and postdoctoral fellows. One of his doctoral students, John Hawdon, won our Student Presentation Competition in 1991. Gerry has received international recognition, including Wellcome Trust Fellowships in 1983, 1984, and

1985 and the Lloyd Rozeboom Lectureship at Johns Hopkins in 1992. He has been active in a number of scientific societies and served the American Society of Parasitologists as its President in 1990.

Gerry was born and raised in Brooklyn, New York, and developed an early interest in wildlife from an uncle who was a hunter and who took Gerry fishing as a child. Early on, he decided he would help save the American wildlife heritage and thus entered Cornell University to study wildlife with an emphasis in ornithology. He was disillusioned by their unscientific approach to birdwatching and recording bird sounds. By serendipity, he found a copy of Chandler's textbook on sale in the college bookstore for $1.00. He says that he started reading it on a Lehigh Valley Railroad trip from Ithaca to New York, instead of his usual pastime of playing cards and drinking beer, and that it's probably the only time he read a textbook for pure pleasure. He immediately knew that parasitology was where his future lay. He applied to the McGill Institute of Parasitology for graduate studies for several reasons: a series of circumstances prevented him from attending other schools he was considering, he wanted to go to school out of the country, and, most important, he heard that McGill had a field study program with fishing.

While in graduate school, Gerry had several interesting summer jobs, including a biological expedition to the eastern Canadian Arctic. At McGill, he also met and married Donna, who was a graduate student in nutrition. After graduation, he and Donna wanted to settle in New England but wound up at a U.S. Department of Agriculture lab branch of Beltsville in State College, New Mexico, working on a number of projects including sheep pinworms and transmission of gastrointestinal nematodes on irrigated pastures. He claims that he was a wild-eyed liberal who could not keep his mouth shut (like a good government employee should) when asked if he agreed that shooting eagles from planes was a good idea. He also didn't think it was acceptable to allow college students to die in traffic accidents driving to Juarez for beer because the area around State College was dry. He decided it was time to move on.

Gerry returned to the Institute of Parasitology at McGill but, after a few years, left a tenure-track position there to go to India with Hopkins and later moved here to Penn where he is Professor of Pathobiology, Parasitology, Biology, and Infectious Diseases. He is also an artist, as can be seen on the cover and in a review article in the May issue of *Parasitology Today,* hot off the presses.

Gerry counts among the most influential people in his life Fred Bang, who brought him to Johns Hopkins, and Lawson Soulsby, who brought him here to Penn and who was very good to him.

I remember meeting Gerry almost 30 years ago when I started attending Helminthological Society meetings, and so it is a special honor for me to be the one to present the 1995 Anniversary Award of the Helminthological Society of Washington to a most worthy recipient, Dr. Gerhard Schad.

Nancy D. Pacheco
Chair, Awards Committee

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MINUTES

Six Hundred Forty-Sixth Through Six Hundred Fiftieth Meeting

646th Meeting: National Institutes of Health, Bethesda, Maryland, 11 October 1995. Joan Jackson presided over the business meeting and Dr. Lewis H. Miller presided over the scientific session which consisted of three presentations: Dr. Olivier Garraud discussed "Antibody production specific to recombinant filarial proteins: differential regulation of antigen-specific IgG4 and IgE by Ov27 and OvD5B"; Dr. Xinzhuan Su spoke on "Malaria parasites: antigenic variation, cytoadherence and *var* genes"; and Dr. Joseph D. Smith described how "Switches in expression of *Plasmodium var* genes correlate with changes in antigenic and cytoadherence phenotypes of infected erythrocytes". The slate of officers for 1996 was presented: Susan Fricke-Meyer, President; Ellen Anderson, Vice-President; and Pat Carney, Recording Secretary. The Executive Committee notified those present that Dr. Naftale Katz of Brazil was selected for an Honorary Membership and Dr. Gerhardt Schad, University of Pennsylvania, as the 1995 Anniversay Award recipient.

647th Meeting: Uniformed Services University of the Health Sciences, Bethesda, MD, 8 November, 1995. The Anniversary Dinner Meeting and program was presided over by President Joan Jackson. The Keynote Speaker for the evening was Dr. Mary Lou Pritchard who gave an excellent talk entitled "Parasitology in Nebraska—Movers and Milestones since 1983". The slate of officers for 1996 was elected and installed: Susan Fricke-Meyer, President; Dr. Ellen Anderson, Vice-President; and Pat Carney, Recording Secretary. Dr. Harley Sheffield and Dr. Sherman Hendrix continue in office.

648th Meeting: Beltsville Agricultural Research Center, Beltsville, MD, 14 February, 1996. Dr. Susan Fricke-Meyer presided over the business meeting and David Chitwood chaired the scientific session which consisted of three presentations: Dr. William Wergen spoke on "Application of low temperature field emission scanning electron microscopy to studies in nematology"; Dr. Afar A. Handoo discussed "Observations on *Meloidogyne sasseri,* a newly discovered root-knot nematode parasitizing beachgrasses"; and Dr. Burton Y. Endo described "The ultrastructure of the infective stage of *Onchocerca volvulus*". At the conclusion of the scientific session, Dr. Gerhard Schad announced that the theme of the scientific meeting in May will be "Parasites in the treatment and control of disease".

649th Meeting: Johns Hopkins Montgomery County Center, 20 March 1996. The business meeting was presided over by Dr. Ellen Anderson and Dr. Alan L. Scott chaired the scientific program, dedicated to Emeritus Professor, Dr. Everett Schiller, at the School of Hygiene and Public Health of the Johns Hopkins University, for his contributions to the biology of onchocerciasis. Dr. Aiah A. Gbakima discussed the use of recombinant antigens for the diagnosis of onchocerciasis in children and its implications for the African Program for Onchocerciasis Control; Dr. Nithya Raghavan spoke on EST analysis, antigen discovery, the biology of filarial nematode infections and she provided an update on the filarial genome project; Dr. Thaddeus K. Graczyk presented an interesting review of waterborne cryptosporidiosis, its zoonotic potential and major outbreaks in the United States. The Executive Committee recommended to the membership present that annual dues be raised from $20 to $25 for domestic members and from $22 to $28 for foreign members. A motion to raise dues was made and approved by the membership.

650th Meeting: New Bolton Center, University of Pennsylvania, Kennett Square, PA, with the New Jersey Society of Parasitologists, 4 May, 1996. Dr. Susan Fricke-Meyer presided over the business meeting. A moment of silence was observed in memory of Dr. Aurel O. Foster, who passed away on February 25, 1996. Dr. Fricke-Meyer introduced Dr. John Oaks, representing the ASP, who advised the members present of the various ASP activities and resources. Following Dr. Oaks, Nancy Pacheco made the formal 1995 Anniversary Award presentation to Dr. Gerhard A. Schad. Dr. Schad then chaired the scientific program which consisted of four presentations in the symposium, "Parasites in the Control and Treatment of Disease." Dr. Paul Ewald, Amherst College, spoke on "Evolutionary interventions: bridges between epidemiology and parasite control." Dr. Peter Hotez, Yale University, discussed "Pharmacologically active agents from helminths" and Dr. Mary Cupp, Auburn University, continued with a presentation on "Pharmacologically active agents from arthropods", and Dr. Peter Reeve, FDA, concluded with "Prospects for success." Support for the meeting was provided by Merck Research Laboratories, Pfizer Animal Health, and the Laboratory of Parasitology, University of Pennsylvania.

The following new members were elected at the respective meetings: *646th:* Thomas Letonja, Peter Mullin, Paul F. Pineda-Lopez, Jason D. Smith, and Eric J. Wetzel; *648th:* Richard Demari, Jr., Daniel P. Malloy, Oscar V. Pung, and Mark C. Rigby; *650th:* Kevin Baird.

Respectfully submitted,

W. Patrick Carney
Recording Secretary

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KEY WORD AND SUBJECT INDEX FOR VOLUME 63

The Helminthological Society of Washington

Application for Membership

Any person interested in parasitology or related fields is eligible for membership. Subscription to the Society's Journal is included in the dues. Members are privileged to publish therein at reduced rates. The annual dues of $20.00 domestic or $22.00 foreign are payable on notification of election. Send this completed form to:

Dr. Harley G. Sheffield
11831 Enid Drive
Potomac, MD 20854

Print name: _____ Date of birth: _____

Mailing address: _____

_____

_____

Degree and year received: _____

Present position: _____

Field of interest: _____

_____

Signature of applicant: _____ Date: _____

Signature of sponsor: _____
(a member)

ANNIVERSARY AWARD RECIPIENTS

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

HONORARY MEMBERS

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

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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