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Some Trematodes of Amphibians and Reptiles from Taiwan[1]

JACOB H. FISCHTHAL AND ROBERT E. KUNTZ[2]

ABSTRACT: One monogenetic and 28 digenetic trematodes of amphibians and reptiles are reported from Taiwan. One new genus and eight new species are described: Paramphistomatidae, *Schizamphistomum taiwanense* sp. n.; Pronocephalidae, *Paradenogaster selfi* gen. n., sp. n.; Dicrocoeliidae, *Paradistomoides laruei* sp. n.; Plagiorchiidae, *Dolichosaccus schmidti* sp. n., *Plagiorchis* (*Metaplagiorchis*) *taiwanensis* sp. n.; Echinostomatidae, *Prionosomoides taiwanensis* sp. n.; Lecithodendriidae, *Acanthatrium taiwanense* sp. n.; Cyathocotylidae, *Mesostephanoides taiwanensis* sp. n. Previously known species reported are: Polystomatidae, *Polystomoides ocadiae*; Didymozoidae, *Torticaecum nipponicum*; Angiodictyidae, *Microscaphidium aberrans*; Paramphistomatidae, *Diplodiscus sinicus*; Pronocephalidae, *Cricocephalus albus*, *C. megastomus*, *C. resectus*, *Glyphicephalus lobatus*, *Desmogonius desmogonius*, *Diaschistorchis takahashii*; Macroderoididae, *Neomicroderma elongatum*; Dicrocoeliidae, *Paradistomum megareceptaculum*, *P. mutabile*, *Paradistomoides orientalis*; Plagiorchiidae, *Encyclometra colubrimurorum*; Telorchiidae, *Telorchis clemmydis*; Halipegidae, *Halipegus mehransis*; Mesocoeliidae, *Mesocoelium sociale*; Lecithodendriidae, *Cryptotropa kuretanii*; Diplostomatidae, *Pharyngostomum cordatum* metacercaria. *Octangium* sp. (Angiodictyidae), immature, is also reported. *Halipegus japonicus* Yamaguti, 1936, is declared a synonym of *H. mehransis* Srivastava, 1933.

The trematodes of this paper are part of a collection made by the junior author while a member of the United States Naval Medical Research Unit No. 2, Taipei, Taiwan, Republic of China. Parasites were washed in saline, killed in hot water, and transferred immediately to FAA fixative; after 4–8 hr they were stored in 70% alcohol plus 2% glycerin; staining was with carmine or hematoxylin. Host names recorded herein are those listed by Kuntz and Dien (1970). Host names preceded by an asterisk (*) represent new host records. Specimens of each trematode species have been deposited in the United States National Museum Helminthological Collection as noted. All measurements are in microns.

Schizamphistomum taiwanense sp. n. (Fig. 1)

HOST: *Chelonia japonica* (Taunberg) (Cheloniidae).

HABITAT: Small intestine.

LOCALITY: Taipei City, Taipei Prefecture.

DATE: 15 December 1959.

SPECIMEN DEPOSITED: No. 73004 (holotype).

Description

Paramphistomatidae. Body elongate, narrow, with sides nearly parallel, 8,665 long by 2,230 wide; extremities rounded. Oral sucker within body, 1,005 by 815, with small intramural diverticula, transversely oval aperture at body surface leading to sucker. Preoral space 115 long. Acetabulum 1,785 by 1,480, aperture longitudinal, narrow. Postacetabular space 60 long. Sucker length ratio 1:1.78, width ratio 1:1.82. Esophagus 610 long including muscular bulb, latter 430 by 315. Ceca sinuous, narrow, ascending sides of bulb short distance before looping posteriorly, terminating about midway between ovary and acetabulum. Excretory vesicle saccular, commencing short distance postovarian. Lymph system present.

Testes two, smooth, nearly round, tandem, contiguous, intercecal, preequatorial; anterior

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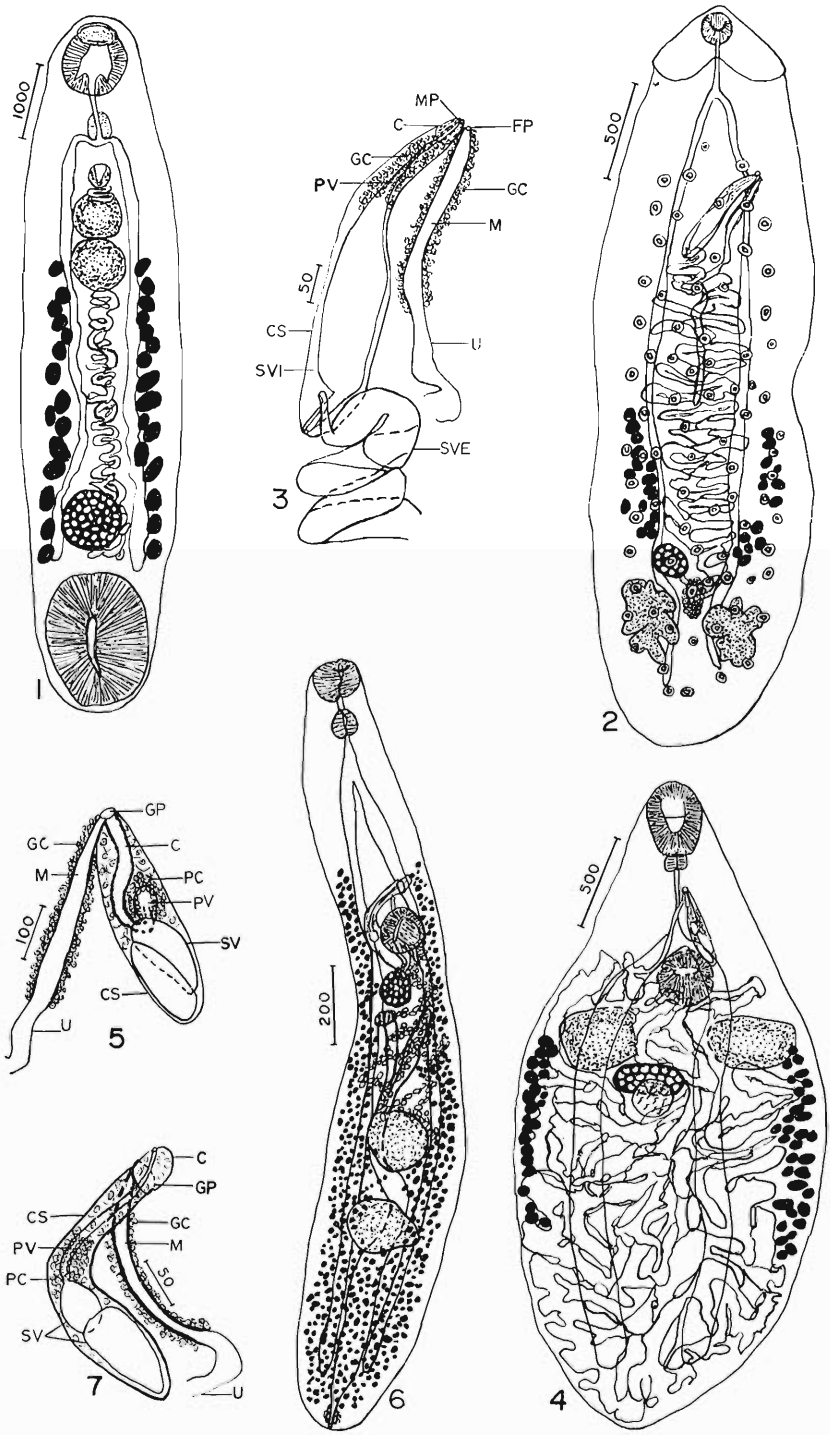

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testis 730 by 745, lying 2,680 from anterior extremity; posterior testis 750 by 705. Vas deferens much coiled between anterior testis and posterodorsal part of cirrus sac. Latter 315 by 255, postbifurcal, commencing 115 pretesticular. Genital pore median, without sucker, lying 138 pretesticular. Ovary diameter 360, smooth, dextromedian, lying 2,215 posttesticular and 1,110 preacetabular. Vitelline follicles relatively few, in one more or less single file longitudinal row in each extracecal field, extending from posterior testis level to short distance postovarian. Uterine coils intercecal from excretory vesicle to posterior testis. Eggs, if present, not discernible.

Discussion

Only one worm was found. The genus contains but a single species, *S. scleroporum* (Creplin, 1844) Looss, 1912, from cheloniids from the Mediterranean Sea and the Atlantic and Pacific oceans. The latter species differs significantly from ours in having an oval body, the testes considerably transversely elongate and slightly lobate, and the vitelline follicles scattered rather than in one more or less single file row in each field.

Paradenogaster gen. n.

Diagnosis

Pronocephalidae, Pronocephalinae. Body elongate; ventral glands more or less in longitudinal rows from about genital pores to cecal end levels, 2–7 glands in transverse row. Head collar with ventral incision, lobes connected by dorsal ridge. Oral sucker ventroterminal. Esophagus short; ceca without mesial diverticula. Testes two, symmetrical, near posterior extremity, ventrolateral to ceca. Cirrus sac elongate, comma-shaped, unipartite, containing seminal vesicle, prostatic vesicle, and cirrus. External seminal vesicle present. Male and female genitalia opening through separate pores located postbifurcal and ventral to left cecum. Ovary pretesticular, dextral. Laurer's canal present. Vitellaria extending from short distance posterior to external seminal vesicle to ovary. Uterus intercecal between Mehlis' gland and metraterm; latter shorter than cirrus sac. Eggs operculate, with single long filament on each pole. Excretory vesicle Y-shaped, stem short and saccular, arms united at esophageal level. Intestinal parasite of turtles.

TYPE SPECIES: *Paradenogaster selfi* sp. n.

Paradenogaster selfi sp. n. (Figs. 2, 3)

HOSTS: Type, *Ocadia sinensis* (Gray); *Geoclemys reevesii* (Gray) (Chelonia: Testudinidae).

HABITAT: Small intestine.

LOCALITIES: Yang Ming Shan, Taipei Prefecture; Ping-tung and Chao-chou, Ping-tung Prefecture.

DATES: 23 August, 24 September 1958; 10 February 1960.

SPECIMENS DEPOSITED: No. 73009 (holotype and paratypes, *O. sinensis*); No. 73011 (paratypes, *O. sinensis*); No. 73010 (paratypes, *G. reevesii*).

Description

Body elongate oval, 2,925–3,735 long by 915–1,390 wide; with ventral glands more or less in longitudinal rows from about genital pores to cecal end levels, 2–7 glands in transverse row, glands raised nipplelike above body surface and containing central cavity with thick lining. Head collar 350–425 by 535–665, with ventral incision, lobes connected by dorsal ridge. Oral sucker 172–191 by 167–200, lying 17–27 from anterior extremity. Esophagus narrow, 244–285 long; ceca without

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Abbreviations in figures. A, acetabulum; C, cirrus; CS, cirrus sac; E, egg; FP, female pore; GA, genital atrium; GC, gland cells; GP, genital pore; M, metraterm; MP, male pore; OV, ovary; PC, prostate cells; PV, prostatic vesicle; SV, seminal vesicle; SVE, external seminal vesicle; SVI, internal seminal vesicle; TA, anterior testis; TP, posterior testis; U, uterus; VR, vitelline reservoir.

Figures 1–7. ***Schizamphistomum taiwanense*** **sp. n. 1. Whole mount, holotype, ventral view.** ***Paradenogaster selfi*** **gen. n., sp. n. 2. Whole mount, holotype, ventral view. 3. Terminal genitalia, holotype.** ***Paradistomoides laruei*** **sp. n. 4. Whole mount, holotype, dorsal view. 5. Terminal genitalia, holotype.** ***Dolichosaccus schmidti*** **sp. n. 6. Whole mount, holotype ventral view. 7. Terminal genitalia, holotype.**

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diverticula, extending posttesticular; postcecal space 200–305 long. Excretory vesicle Y-shaped; stem short, saccular, with short lateral diverticula, extending anteroventrally from dorsal pore, latter 160–205 from posterior extremity; bifurcation ventral to stem, arms intertesticular and intercecal, crossing ceca ventrally anterior to each testis, ascending extracecally to esophageal level before uniting.

Testes two, symmetrical to subsymmetrical, multilobed, longitudinally elongate, lateral to ceca, lying 287–415 from posterior extremity; right testis 242–433 by 195–325, left testis 245–365 by 205–330. Vas efferens emerging from anterior or anteromesial surface of each testis, uniting medianly at ovarian level to form vas deferens; latter tubular, narrow, straight to slightly sinuous, extending short distance previtelline. External seminal vesicle tubular but considerably wider than vas deferens, thin-walled, straight to slightly sinuous proximally, much coiled distally. Cirrus sac elongate, comma-shaped, unipartite, moderately thick-walled and muscular, 385–542 by 85–126. Internal seminal vesicle thick-walled, muscular, usually straight, tubular to dilated, 61–100 by 27–53. Prostatic vesicle long, thin-walled, conspicuously cell-lined, 203–283 by 58–81. Cirrus elongate, muscular. Prostate cells filling most of cirrus sac. Male genital pore postbifurcal, ventral to left cecum, lying 685–835 from anterior extremity, opening separately and anterodextral to female pore.

Ovary smooth, dextral, intercecal, pretesticular, 122–210 by 140–190. Oviduct emerging from anterior, anteromesial, or mesial surface of ovary, extending posteromedian to large, compact, usually longitudinally elongate, intertesticular Mehlis' gland (121–220 by 117–174). Laurer's canal extending anteromedianly from ootype complex, opening at dorsal surface at ovarian level. Vitellaria in short, lateral, mainly extracecal fields, anteriormost extent short distance posterior to external seminal vesicle and 515–780 preovarian, posteriormost extent at ovarian level, fields continuous to one or both of them interrupted into two groups of follicles; follicles relatively large, few, numbering 15–20 per field. Uterus intercecal between Mehlis' gland and metraterm; latter 182–300 by 19–60, thick-walled, muscular, straight to slightly sinuous, surrounded by gland cells, lying sinistral to cirrus sac. Eggs yellow-brown, unioperculate, 25 measuring 27–35 (31.4) by 12–18 (14.5), with single long filament at each pole, filament up to about 200 long in older eggs (in one shed egg lying free of worm).

Discussion

The description is based on three immature, four just beginning egg production and 16 mature adult worms from *O. sinensis*, and 12 immature and four just beginning egg production from *G. reevesii*; eight mature adults from *O. sinensis* were measured. *Paradenogaster* gen. n. resembles the pronocephalid genus *Adenogaster* Looss, 1901, from turtles in possessing rows of ventral glands but differs significantly from it in having a unipartite cirrus sac, an internal seminal vesicle, and eggs with a long filament at each pole. The eggs of *Adenogaster* have only a small knob at the anopercular pole. The species is named in honor of Dr. J. Teague Self, University of Oklahoma, who has played a significant role in parasitology research and in teaching of parasitology in the Southwest.

Paradistomoides laruei sp. n. (Figs. 4, 5)

HOST: *Takydromus septentrionalis* Günther (Squamata: Lacertidae).

HABITATS: Small intestine, gall bladder, liver.

LOCALITIES: Taipei City and Hsin Yi Lu, Taipei Prefecture.

DATES: 20 June, 6 September 1957.

SPECIMENS DEPOSITED: No. 73022 (holotype and paratypes, gall bladder and liver); No. 73023 (paratypes, small intestine).

Description

Dicrocoeliidae. Body shape varying from nearly oval to elongate narrow, extremities rounded, 1,560–3,655 long by 445–1,775 wide. Forebody 402–915 long; hindbody 920–2,400 long; forebody–hindbody length ratio 1:1.9–2.9. Oral sucker ventroterminal, trapezoidal shaped (with anterior margin rounded and posterior truncated; sides usually straight and extending posteromedianly), longitudinally elongate, 190–380 by 170–355. Acetabulum round to longitudinally elongate, 145–340 by

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145–340. Sucker length ratio 1:0.76–1.08, width ratio 1:0.82–1.09. Prepharynx absent; pharynx usually round, 75–155 by 60–135; esophagus 53–305 long; cecal bifurcation preacetabular; ceca narrow to dilated, extending to near posterior extremity but not as far posteriorly as uterus. Excretory vesicle tubular, commencing at level of Mehlis' gland; pore terminal.

Testes two, smooth to slightly lobed, symmetrical, contiguous to being well separated, posterolateral to acetabulum, usually overlapping latter, round to longitudinally or transversely elongate; right testis 130–355 by 120–485, left testis 125–335 by 100–460. Cirrus sac club-shaped, 182–405 by 70–155, commencing dorsal to anterior part of acetabulum or entirely preacetabular. Seminal vesicle bipartite; posterior chamber usually coiled slightly, longitudinal extent 53–195 by 54–105; anterior chamber round to longitudinally elongate, 43–170 by 45–120. Prostatic vesicle small. Cirrus long, protrusible. Genital pore median to submedian, from just prebifurcal to pharyngeal level.

Ovary smooth to slightly lobed, usually submedian, contiguous with one or both testes to being well separated from them, usually transversely elongate, occasionally round, 125–285 by 130–405. Seminal receptacle usually dorsal to ovary, occasionally posterodorsal, 100–215 by 82–235. Laurer's canal present. Mehlis' gland posterior to posterolateral to ovary. Vitellaria in lateral, mainly extracecal fields, anteriormost extent at testicular or acetabulotesticular level, posteriormost extent 375–1,180 from posterior extremity; right field 585–1,125 long, left field 525–1,270 long. Uterus extending to posterior extremity, filling most of postovarian part of body, some worms with coils at acetabulotesticular level, usually ascending to metraterm between testes, occasionally over or lateral to testis. Metraterm thick-walled, surrounded by gland cells, commencing at about same level as cirrus sac. Eggs numerous, operculate, 30 measuring 30–44 (34.9) by 19–24 (21.8).

Discussion

The collection contains 15 adult worms from the liver and gall bladder of one host, five measured, and 107 adult and immature worms from the small intestine of another host, five adults measured. Variability is great in our specimens whether from the liver–gall bladder or small intestine and is basically similar to that noted for *P. orientalis* (Narain and Das, 1929) Travassos, 1944, by Arora and Agarwal (1960) and Arora et al. (1962). The one consistent feature in all our material is the shape of the oral sucker; no other species of *Paradistomoides* Travassos, 1944, or *Paradistomum* Kossack, 1910, exhibits this characteristic shape. Our species is named in honor of the late Dr. George R. LaRue who served as chairman of our Ph.D. dissertation committees at the University of Michigan and who contributed much to our knowledge and understanding of the platyhelminths.

Dolichosaccus schmidti sp. n. (Figs. 6, 7)

HOST: *Ocadia sinensis* (Gray) (Chelonia: Testudinidae).

HABITAT: Small intestine.

LOCALITY: Pu-li, Nan-tou Prefecture.

DATE: 20 January 1959.

SPECIMENS DEPOSITED: No. 73025 (holotype and paratypes).

Description

Plagiorchiidae. Body elongate, narrow, 1,958 long by 355 wide, spined to short distance posttesticular. Forebody 635 long; hindbody 1,218 long; forebody–hindbody length ratio 1:1.9. Oral sucker ventroterminal, 100 by 116. Acetabulum diameter 105. Sucker length ratio 1:1.05, width ratio 1:0.91. Prepharynx 30 long; pharynx 80 by 78; esophagus 95 long; cecal bifurcation 330 preacetabular; ceca narrow, extending posttesticular; postcecal space 135 long. Excretory vesicle Y-shaped; stem sigmoid, overlapping testes dorsally, passing intertesticular, bifurcation between anterior testis and ovary; arms short, commencing short distance postovarian.

Testes two, tandem, smooth, slightly overlapping ceca to entirely intercecal; anterior testis 143 by 166, lying 420 postacetabular; posterior testis 150 by 184, lying 65 from anterior testis; posttesticular space 440 long. Cirrus sac crescent-shaped, arching right or left of acetabulum, thick-walled, muscular, 285 by 55, commencing 53 postacetabular at or near

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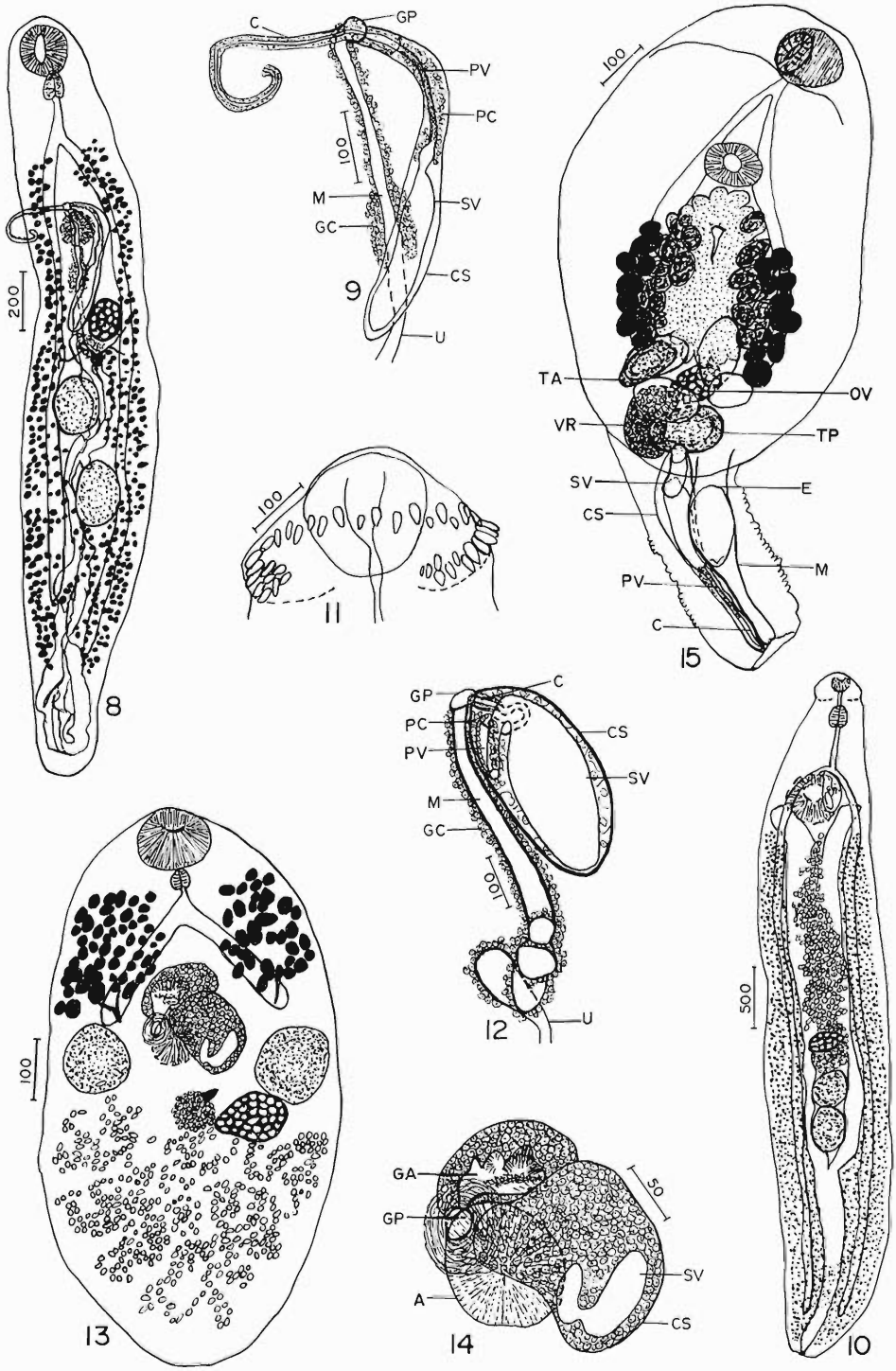

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anterior margin of ovary. Seminal vesicle bipartite, posterior chamber 110 by 48, anterior chamber 60 by 30. Prostatic vesicle tubular, 53 by 13, surrounded by prostate cells. Cirrus long, muscular, protrusible. Genital pore median, 40 preacetabular. Ovary smooth, dextromedian, overlapping cecum dorsally, 87 by 92, lying 52 postacetabular. Seminal receptacle 36 by 49, postovarian (holotype) to posterodorsal to latter (young adult). Laurer's canal extending slightly postovarian, not coiled, surrounded by gland cells, opening on dorsal surface. Vitelline follicles commencing about halfway between cecal bifurcation and acetabulum, extending posteriorly in lateral fields to posterior testis level, invading intercecal space, filling posttesticular space. Uterus coiled between anterior testis and acetabulum, some coils extending close to lateral body margins. Metraterm muscular, slightly shorter than cirrus sac, lying ventral to latter anteriorly, surrounded by gland cells. Eggs operculate, 10 measuring 29–34 (31.6) by 18–21 (19.4).

Discussion

This study is based on seven immature, one just beginning egg production and one mature adult worms from one host; latter measured. This is the second record of this genus from a reptile. Fischthal and Kuntz (1967) reported *D. lygosomae* from a lizard, *Lygosoma noctua* (Lesson) (Scincidae) from New Hebrides Islands. Yamaguti (1971) inadvertently listed the latter species among the amphibian trematodes. Our species is morphologically closest to *D. trypherus* Johnston, 1912, from Australian amphibians. The latter differs in having the oral sucker much larger than the acetabulum, the cirrus sac S-shaped, the genital pore close to the cecal bifurcation, and a much longer and coiled Laurer's canal. The new species is named in honor of Dr. Gerald D. Schmidt, University of Northern Colorado, for his outstanding work in parasitology, particularly in helminth taxonomy.

Plagiorchis (Metaplagiorchis) taiwanensis sp. n. (Figs. 8, 9)

HOST: *Takydromus septentrionalis* Günther (Squamata: Lacertidae).

HABITAT: Small intestine.

LOCALITY: Taipei City, Taipei Prefecture.

DATE: 26 June 1956.

SPECIMENS DEPOSITED: No. 73035 (holotype and paratypes).

Description

Plagiorchiidae. Body 2,645–3,348 long by 430–490 wide, elongate, narrow, narrowest postcecally, extremities rounded, spined to short distance posttesticular. Forebody 685–890 long; hindbody 1,740–2,390 long; forebody–hindbody length ratio 1:2.1–2.9. Oral sucker ventral, slightly longitudinally elongate, 178–220 by 170–215, aperture longitudinal, narrow, continuing anteriorly across ventral lip of sucker; preoral space 17–34 long. Acetabulum round or nearly so, 125–157 by 125–165. Sucker length ratio 1:0.63–0.70, width ratio 1:0.63–0.77. Prepharynx 31–48 long; pharynx 80–102 by 85–109, anteriorly with circular muscle ring, remainder weakly muscular and with degenerated areas containing vesicular spaces; esophagus 126–225 long, devoid of cell lining anteriorly, somewhat cellular posteriorly; cecal bifurcation 235–345 preacetabular; ceca long, narrow, cell-lined, ending subequally; postcecal space 307–470 long. Excretory vesicle Y-shaped, stem long, narrow, passing between testes, bifurcation between ovary and anterior testis, arms extending to sides of ovary; pore just ventroterminal.

Testes two, smooth, usually longitudinally elongate, usually slightly diagonal with anterior testis sinistral, tandem in one worm, separated from one another in seven worms, contiguous and levels overlapping in one, usually overlapping ceca ventrally; anterior testis 202–264 by 160–275, lying 435–677 postacetabular and

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Figures 8–15. ***Plagiorchis (Metaplagiorchis) taiwanensis*** **sp. n. 8. Whole mount, holotype, dorsal view. 9. Terminal genitalia, holotype.** ***Prionosomoides taiwanensis*** **sp. n. 10. Whole mount, holotype, dorsal view. 11. Head collar and spines, holotype. 12. Terminal genitalia, paratype, dorsal view.** ***Acanthatrium taiwanense*** **sp. n. 13. Whole mount, holotype, dorsal view. 14. Terminal male genitalia, holotype.** ***Mesostephanoides taiwanensis*** **sp. n. 15. Whole mount, holotype, ventral view.**

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125–260 postovarian; posterior testis 215–270 by 165–215; posttesticular space 848–1,235 long. Cirrus sac crescent-shaped, 400-540 (longitudinal extent) by 68–82, thick-walled, muscular, commencing 220–355 postacetabular and mesial to ovary, curving around right side of acetabulum to genital pore opening near anterosinistral margin of acetabulum, overlapping margins of acetabulum and right cecum dorsally. Seminal vesicle 275–390 by 41–56, saccular, bipartite, anterior chamber considerably smaller. Prostatica vesicle long, narrow, cell-lined, surrounded by prostate cells. Cirrus long, protrusible.

Ovary longitudinally elongate, 133–185 by 123–157, smooth, usually dextral and in tandem with posterior testis, overlapping cecum, median and in tandem with both testes in one worm, lying 165–300 postacetabular. Ootype complex posteromedian to ovary. Seminal receptacle absent. Laurer's canal opening on dorsal surface at level of posterior margin of ovary. Uterus descending dextral or ventrodextral to anterior testis, between testes, then sinistral to posterior testis to posterior extremity, filling postcecal space; ascending sinistral to posterior testis, not passing between testes, lying ventral to anterior testis and sinistral to descending uterus at this level and more anteriorly. Metraterm 250–375 by 30–34, much more thick-walled and muscular proximally and giving somewhat bulbous appearance, surrounded by gland cells which are more numerous in bulbous region, commencing 103–190 postacetabular, ascending sinistral to cirrus sac and dorsal to acetabulum. Vitellaria follicular, extending from level of cecal bifurcation or slightly more posteriorly to cecal ends or slightly anterior or posterior to ends, fields entirely separated or confluent dorsally posterior to testes or confluent in latter region as well as dorsally anterior to acetabulum. Eggs yellow-brown, operculate, 30 measuring 29–35 (32.1) by 17–21 (19.7).

Discussion

The description is based on eight adult worms; six were measured. This species differs from all others in the subgenus in having a partially degenerated pharynx with an anterior circular muscle ring, and in the metraterm being significantly thicker walled and more muscular proximally and thus giving a bulbous appearance.

Prionosomoides taiwanensis sp. n. (Figs. 10–12)

HOST: *Geoclemys reevesii* (Gray) (Chelonia: Testudinidae).

HABITAT: Small intestine.

LOCALITY: Chao-chou, Ping-tung Prefecture.

DATE: 10 February 1960.

SPECIMENS DEPOSITED: No. 73145 (holotype and paratypes).

Description

Echinostomatidae. Body elongate, slender, 3,090–5,170 long by 445–985 wide at acetabular level, spined to acetabular level dorsally and posttesticular level laterally and ventrally, usually appearing serrated on one side of body only in postacetabular region. Forebody 335–890 long; hindbody 2,355–3,855 long; forebody–hindbody length ratio 1:4.3–7.2. Head collar reniform, 180–235 by 260–385, with double, dorsally uninterrupted crown of 39–45 bluntly pointed spines, latter same size in both rows; corner spines 4–4 in five worms, 6–6 in one, 20–59 by 6–15; lateral spines 27–46 by 6–15; dorsal spines 24–41 by 8–13. Oral sucker ventroterminal, 138–186 by 120–180. Acetabulum 337–425 by 317–440. Sucker length ratio 1:2.28–2.57, width ratio 1:2.44–2.83. Prepharynx 48–85 long; pharynx large, slightly smaller than oral sucker, 128–150 by 106–135; esophagus 160–425 long, bipartite, anterior part (29–110 long) devoid of cell lining, posterior part (107–315 long) lined with cells similar to cecal bifurcation and ceca; cecal bifurcation just preacetabular or slightly overlapping latter; ceca narrow, extending to within 138–295 of posterior extremity. Excretory vesicle Y-shaped, occasionally dilated just before opening terminally through narrow muscular duct, bifurcation just posterior to posterior testis, arms dilated, extending to acetabular level.

Testes two, smooth, intercecal, tandem, contiguous to 40 apart, longitudinally elongate, anterior testis 332–440 by 210–265, posterior testis 325–510 by 180–275; posttesticular space 530–1,740 long, distances 23–43% of hindbody length. Cirrus sac elongate oval, overlapping

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right side of acetabulum dorsum, thick-walled, muscular, 305–385 by 160–200, overlapping acetabulum 250–340 (59–89%) in four to extending 15 postacetabular. Seminal vesicle somewhat thick-walled, muscular, 205–320 (longitudinal extent) by 114–152, mostly saccular (unlobed) but tubular and looping posteriorly short distance at anterior end. Prostatic vesicle elongate tubular, winding, surrounded by prostate cells. Cirrus short, muscular. Genital pore median to submedian, at bifurcal level to just prebifurcal.

Ovary smooth, intercecal, tandem with testes, round to transversely or longitudinally elongate, 165–195 by 170–255, lying 700–1,180 postacetabular and 130–275 anterior to anterior testis, separated from latter by large Mehlis' gland complex. Vitelline follicles in lateral fields, anteriormost extent 70–340 postacetabular, distances 8–40% of distance between acetabulum and ovary, fields confluent or not posttesticularly, extending postcecal, anteriorly parts of follicles extend into intercecal space. Vitelline reservoir dorsal. Uterus coiled between anterior testis and short distance postacetabular, intercecal, occasionally overlapping ceca, postovarian coils containing sperm. Metraterm thick-walled, muscular, commencing postacetabular, latter part much coiled, remainder straight to sinuous, sinistral to sinistrodorsal to cirrus sac. Eggs large, operculate, 17 measuring 74–107 (88.5) by 48–63 (56.1), older ones containing oculate miracidia.

Discussion

Six adult worms were studied. The genus contains two species, *P. scalaris* Freitas and Dobbin, 1967 (Brazil) and *P. phrynopsis* (Mañé-Garzón and Gil, 1961) Freitas and Dobbin, 1967 (Uruguay); both are from the same host species of chelhydrid turtle. These species differ from ours in being much larger, having considerably larger collar spines and the genital pore between the cecal bifurcation and acetabulum, and occurring in South America. *P. scalaris* differs further in having larger eggs. *P. phrynopsis* differs further in having the pharynx about half as long as the oral sucker, the testes transversely elongate, and the nearly globose cirrus sac preacetabular or nearly so.

Acanthatrium taiwanense sp. n. (Figs. 13, 14)

HOST: *Japalura swinhonis* Günther (Squamata: Agamidae).

HABITAT: Small intestine.

LOCALITY: Yang Ming Shan, Taipei Prefecture.

DATE: 25 August 1958.

SPECIMEN DEPOSITED: No. 73146 (holotype).

Description

Lecithodendriidae. Body elongate oval, extremities rounded, 937 long by 515 wide. Forebody 352 long; hindbody 495 long; forebody–hindbody length ratio 1:1.4. Oral sucker ventroterminal, 106 by 126. Acetabulum diameter 90. Sucker length ratio 1:0.85, width ratio 1:0.71. Prepharynx very short; pharynx diameter 43; esophagus 10 long; ceca short, extending to acetabular level. Excretory vesicle V-shaped, pore posterodorsal.

Testes two, smooth, subsymmetrical, postcecal, at acetabular level; right testis 133 by 126, left testis 121 by 123. Cirrus sac large, between ceca, overlapping acetabulum dorsum, 203 by 196. Seminal vesicle winding, tubular, dextral to acetabulum. Prostatic vesicle and cirrus indistinct. Prostate cells numerous, filling most of cirrus sac. Genital atrium an expanded chamber proximally, spined, terminal (distal) part tubular and surrounded by circular muscles, opening submedian ventral to anterosinistral part of acetabulum. Atrial spines numerous, scattered; ventralmost spines few, lying anterosinistral (5–7 by 1), anterodextral (13 by 1.2), and posterior (3–7 by 1); dorsalmost spines more numerous, lying anteromedian, clustered, projecting posteriorly, 12–16 by 2–2.5; at middepth, between spines already noted, band of many spines extending transversely, 10–11 by 1–1.5.

Ovary smooth, 93 by 115, postacetabular, posteromedian to and contiguous with right testis. Mehlis' gland large, median, at ovarian level. Laurer's canal present. Vitelline follicles in two anterolateral clusters, prececal but slightly overlapping them dorsally, extending from pharyngeal to just preacetabular levels, right field 203 by 170, left field 250 by 157. Vitelline reservoir 37 by 26, ventral to Mehlis' gland. Uterus filling hindbody posterior to

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testes and Mehlis' gland, ascending sinistral to latter. Metraterm present. Eggs numerous, operculate, 10 measuring 24–27 (25) by 15–16 (15.5).

Discussion

The collection contains only the holotype specimen. This is the first record of the genus from a reptile as all other species are from mammals, particularly bats. In the keys to the species given by Dubois (1961) our worm came closest to *A. nycteridis* Faust, 1919, from bats from the United States in having the atrial spines scattered. *A. nycteridis* differs from ours in being almost round and at least twice as large, in the distribution and size range of the atrial spines (10–15), and in having larger eggs (33–44 by 19–23). Both *A. nycteridis* and *A. tatrense* Zdzitowiecki, 1967, from bats from Poland also have the terminal (distal) part of the genital atrium surrounded by circular muscles. *A. tatrense* differs from ours in the distribution and size of the atrial spines (said to be extremely small compared to *A. nycteridis*), and in having a very large seminal vesicle, a tubular genital atrium, the ovary at acetabular level, and smaller eggs (21–23 by 9–12).

Mesostephanoides taiwanensis sp. n. (Fig. 15)

HOST: *Enhydris chinensis* (Gray) (Serpentes: Colubridae).

HABITAT: Small intestine.

LOCALITY: Taipei Prefecture.

DATE: 19 June 1962.

SPECIMEN DEPOSITED: No. 73148 (holotype).

Description

Cyathocotylidae. Body phylliform, elongate, 1,220 long; bipartite, anterior disclike part oval, somewhat concave ventrally, spined, 870 long by 445 wide, posterior appendage unspined, 355 by 187, continuous with posterodorsal part of anterior disc, containing terminal genitalia but no gonads. Oral sucker ventroterminal, 100 by 119 (measurements unreliable as anterior part of body bent ventrad). Acetabulum 85 by 97, lying 265 from anterior extremity. Pharynx 85 by 58; esophagus 73 long; cecal bifurcation 77 preacetabular; ceca narrow, extending to anterior testis level; esophagus, cecal bifurcation, and beginning of ceca devoid of cell lining, remainder of ceca cell-lined. Tribocytic organ 340 by 250, lobed, deep, narrow incisions between lobes, aperture a longitudinal slit 58 long, lying just postacetabular. Lateral longitudinal excretory ducts extending from pharyngeal level to near posterior extremity.

Testes two, smooth, diagonal; anterior testis dorsodextral, 125 by 85, diagonally oriented; posterior testis ventromedian, 80 by 133, transversely oriented, 45 from posterior margin of disclike part of body. Cirrus sac slightly thick-walled, muscular, 400 by 53, commencing ventral to posterior testis. Seminal vesicle tubulosaccular, 223 by 41. Prostatic vesicle tubular, 108 by 16, surrounded by prostate cells. Cirrus muscular, spined, 68 by 22. Genital atrium short, at posterior extremity. Genital pore terminal.

Ovary 95 by 90, smooth, sinistromedian, at same depth as anterior testis, in tandem with posterior testis. Vitellaria in lateral fields, lying dorsal to lateral parts of tribocytic organ and ventral to ceca, few follicles protruding extracecally, right field 255 by 162, left field 305 by 138. Vitelline reservoir large, 145 by 78, dextral, overlapping testes. Uterus short, lying ventral to gonads and dorsal to posterior part of tribocytic organ, containing four eggs. Metraterm 342 long, thick-walled, muscular, sinistral to cirrus sac, opening beside cirrus into genital atrium, containing one egg. Eggs yellow-brown, four somewhat collapsed ones measuring 131–151 by 80–100.

Discussion

Only the holotype worm is in our collection. The genus contains only the type species, *M. burmanicus* (Chatterji, 1940) Dubois, 1951, from *Enhydris enhydris* (Schneider) from Burma. The latter species differs from ours in having a smaller posterior appendage, tribocytic organ (with smooth margins), acetabulum, and pharynx, a shorter seminal vesicle and metraterm, and the cecal bifurcation much farther preacetabular.

Previously Known Species

1. *Polystomoides ocadiae* Fukui and Ogata, 1936 (Monogenea: Polystomatidae) from the

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small intestine and body cavity of *Ocadia sinensis* (Gray) (Chelonia: Testudinidae) from Hsin-chu, Hsin-chu Prefecture and Pu-li, Nan-tou Prefecture; collected 8, 20 January 1959. Specimens deposited: No. 72996, 72997.

2. *Torticaecum nipponicum* Yamaguti, 1942 (Digenea: Didymozoidae) from the small intestine of **Pelamis platurus* (L.) (Serpentes: Hydridae) from Kee-lung Sheh, Taipei Prefecture; collected 21 June 1962. Specimen deposited: No. 72998. This is the second record of an immature didymozoid from a reptile. Fischthal and Kuntz (1965) reported *T. nipponicum* from the dog-faced water snake, *Cerberus rhynchops* (Schneider) (Serpentes: Colubridae) from North Borneo (Malaysia).

3. *Microscaphidium aberrans* Looss, 1902 (Angiodictyidae) from the stomach and small intestine of **Chelonia japonica* (Taunberg) (Chelonia: Cheloniidae) from Nan-shah Island (about 100 miles southwest of Taiwan in South China Sea) and Taipei City, Taipei Prefecture; collected 16 November, 15 December 1959. Specimens deposited: No. 72999, 73000. Most worms were immature but a few had 1–3 eggs.

4. *Diplodiscus sinicus* Li, 1937 (Paramphistomatidae) from the small intestine and rectum of *Rana tigrina regulosa* Wiegmann, *R. limnocharis* Wiegmann (Anura: Ranidae), and **Sphenomorphus indicus* (Gray) (Squamata: Scincidae) from Shih-men, Ping-tung Prefecture; Shan-shen Village, Chang-hua Prefecture; and Hung T'ou Ts'un and Ya Yu Village, Yan Yü or Orchid Island; collected 27 March, 28 April 1958, and 10, 16 March 1959. Specimens deposited: No. 73001 (from *R. tigrina*), No. 73002 (*R. limnocharis*), No. 73003 (*S. indicus*).

5. *Cricocephalus albus* (Kühl and van Hasselt, 1822) Looss, 1899 (Pronocephalidae) from the stomach of *Chelonia japonica* from Nan-shah Island and Taipei City; collected 16 November, 15 December 1959. Specimens deposited: No. 73005.

6. *Cricocephalus megastomus* Looss, 1902, from the small intestine of **Chelonia japonica* from Taipei City; collected 15 December 1959. Specimens deposited: No. 73006. The genital pore is extracecal as originally described rather than ventral to the cecum as noted by Chattopadhyaya (1972) for worms from *Chelonia mydas* (L.) from India.

7. *Cricocephalus resectus* Looss, 1902, from the stomach of **Chelonia japonica* from Nan-shah Island; collected 16 November 1959. Specimen deposited: No. 73007. Our single specimen combines features of *C. resectus* and *C. indicus* Chattopadhyaya, 1972. The distribution of the vitellaria and position of the genital pore are as noted for the latter species, whereas the path of the ceca and the distinct bipartite cirrus sac are as for the former. Chattopadhyaya (1972), in comparing her four specimens of *Cricocephalus megastomus* with the original description, noted that the genital pore is variable in position. Perhaps the position of the genital pore in *C. indicus* is also a variation of that originally described for *C. resectus*. Comparisons of additional populations of both these species are necessary to determine the extent of variability and the validity of *C. indicus*.

8. *Glyphicephalus lobatus* Looss, 1901 (Pronocephalidae) from the small intestine of **Chelonia japonica* from Taipei City; collected 15 December 1959. Specimens deposited: No. 73008.

9. *Desmogonius desmogonius* Stephens, 1911 (Pronocephalidae) from the stomach and small intestine of *Chelonia japonica* from Nan-shah Island and Taipei City; collected 16 November, 15 December 1959. Specimens deposited: No. 73006, 73007. The excretory vesicle, undescribed for this species, is Y-shaped, bifurcating just postovarian; the arms are lateral to the ceca, extending anteriorly to the esophageal level. It is similar to that described for *D. loossi* Chattopadhyaya, 1972.

10. *Diaschistorchis takahashii* Fukui and Ogata, 1936 (Pronocephalidae) from the small intestine of *Ocadia sinensis*, **Clemmys mutica* (Cantor), and **Geoclemys reevesii* (Gray) (Chelonia: Testudinidae) from Yang Ming Shan, Taipei Prefecture; Ping-tung and Chao-chou, Ping-tung Prefecture; Pu-li, Nan-tou Prefecture; Hsin-sheh, Tai-chung Prefecture; and Hsin-chu, Hsin-chu Prefecture; collected 5 May, 23, 28 August, 24 September 1958; 8, 20 January, 5 September 1959; 10 February, 24 October, 12 December 1960. Specimens deposited: No. 73011,

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73009, 72997, 73025 (from *O. sinensis*); No. 73012 (*C. mutica*); No. 73013 (*G. reevesii*).

11. *Neomicroderma elongatum* Park, 1940, (Macroderoididae) from the small intestine of **Natrix piscator* (Schneider) (Serpentes: Colubridae) from Pu-li, Nan-tou Prefecture; collected 7 January 1959. Specimen deposited: No. 73014.

12. *Paradistomum megareceptaculum* (Tamura, 1941) Yamaguti, 1971 (Dicrocoeliidae) from the gall bladder of **Dinodon rufozonatum* (Cantor), **Elaphe carinata* (Günther), **Natrix swinhonis* (Günther), **Ptyas mucosus* (L.), **Zaocys dhumnades* (Cantor) (Serpentes: Colubridae), and **Trimeresurus stejnegeri* Schmidt (Serpentes: Crotalidae) from Hua-lien and Tung-men, Hua-lien Prefecture; Yang Ming Shan, Taipei Prefecture; Wu-sheh and Pu-li, Nan-tou Prefecture; and Tai-tung, Tai-tung Prefecture; collected 15 August 1958; 25 February, 7, 8 May 1959; 28 March, 11 June, 26 October 1960. Specimens deposited: No. 73015–20 (one slide from each host species).

13. *Paradistomum mutabile* (Molin, 1859) Travassos, 1920, from the gall bladder of **Japalura swinhonis* Günther (Squamata: Agamidae) from Tung-men, Hua-lien Prefecture; collected 5 April 1960. Specimens deposited: No. 73021.

14. *Paradistomoides orientalis* (Narain and Das, 1929) Travassos, 1944 (Dicrocoeliidae) from the small intestine of **Japalura swinhonis* from Lan Yü or Orchid Island; collected 8 March 1959. Specimen deposited: No. 73024.

15. *Encyclometra colubrimurorum* (Rudolphi, 1819) Dollfus, 1929 (Plagiorchiidae) from the mouth, esophagus, small intestine, and gall bladder of **Natrix annularis* (Hallowell), *N. piscator* (Schneider), **N. stolata* (L.), **Enhydris chinensis* (Gray), *E. plumbea* (Boie), **Ptyas korros* (Schlegel), *P. mucosus* (L.) (Serpentes: Colubridae); **Bungarus multicinctus* Blyth, **Naja naja* Cantor (Serpentes: Elapidae) from Taipei, Ping-tung, Chang-hua, Nan-tou, Tai-chung, and Kao-hsiung Prefectures; collected from 1957–61. Specimens deposited: No. 73026–34 (one slide from each host species).

16. *Telorchis clemmydis* Yamaguti, 1933 (Telorchiidae) from the small intestine of **Clemmy mutica* (Cantor) (Chelonia: Testudinidae) from Hsin-sheh, Tai-chung Prefecture; collected 19 July 1960. Specimens deposited: No. 73036.

17. *Halipegus mehransis* Srivastava, 1933 (Halipegidae) from the body cavity of *Rana tigrina regulosa* Wiegmann (Anura: Ranidae) from Ya Yu, Lan Yü or Orchid Island; collected 17 March 1959. Specimens deposited: No. 73037. Two adult worms were obtained from one host. Pandey (1969) redescribed *H. mehransis*, noting that a very short esophagus is discernible in some worms. From libellulid dragonflies Nath and Pande (1971) obtained progenetic metacercariae fully resembling *H. mehransis* "which, on account of its smaller dimensions, appears to represent the earlier developmental stages of *H. mehransis*." Saoud and Roshdy (1970) synonymized *H. udaipurensis* Gupta and Agrawal, 1967, with *H. mehransis*, stating that the differences are not of specific importance, whereas Nath and Pande (1971) considered it valid as it was unique in possessing a well-developed esophageal pouch. Yamaguti (1936) separated his new species *H. japonicus* from *H. mehransis* solely on the basis that his species possessed an esophagus while the latter did not. Since *H. mehransis* has an esophagus, as noted by Pandey (1969) and by us in our specimens, we declare *H. japonicus* a synonym of *H. mehransis*.

18. *Mesocoelium sociale* (Lühe, 1901) Odhner, 1911 (Mesocoeliidae) from the small intestine of *Bufo melanostictus* Schneider (Anura: Bufonidae), **Rana limnocharis* Wiegmann (Anura: Ranidae), **Japalura swinhonis* Günther (Squamata: Agamidae), and **Natrix stolata* (L.) (Serpentes: Colubridae) from Yang Ming Shan and Taipei City, Taipei Prefecture; Pu-li, Nan-tou Prefecture; I-lan, I-lan Prefecture; and Hung T'ou Ts'un, Lan Yü or Orchid Island; collected 24 April, 3, 14 July, 29 August 1958; 11 February, 15, 16 March 1959; 7 April 1960. Specimens deposited: No. 73038–41 (one slide from each host species).

19. *Cryptotropa kuretanii* (Ozaki, 1926) Strand, 1928 (Lecithodendriidae) from the small intestine of **Japalura swinhonis* from Wu-sheh, Nan-tou Prefecture; and Hua-lien and Tung-men, Hua-lien Prefecture; collected

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29 April, 2 May 1959; 5 April 1960. Specimens deposited: No. 73147.

20. *Pharyngostomum cordatum* (Diesing, 1850) Ciurea, 1922 (Diplostomatidae), metacercaria, from the small intestine and lungs of *Natrix stolata* from Yang Ming Shan, Taipei Prefecture, and Shan-sheng Village and Pu-yen, Chang-hua Prefecture; collected 14 March, 26 August, 14 October 1958. Specimens deposited: No. 73149.

Octangium sp. (Angiodictyidae): Four immature worms were found in the stomach of *Chelonia japonica* from Nan-shah Island on 16 November 1959, but could not be identified to species. Specimens deposited: No. 73000.

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Neoleptus gen. n. and a Revision of the Genus *Proleptus* Dujardin, 1845[1]

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ABSTRACT: *Neoleptus* gen. n. is created for *Paraleptus australis*. *Proleptus robustus* and *P. dogiyeli* are synonymized with *P. acutus* which is redescribed. The occurrences of *P. acutus* in *Heterodontus francisci*, *Platyrhinoides triseriata*, *Mustelus henlei*, and *M. californicus* represent new host records. *Proleptus anabantis* is removed from the genus. A new combination, *Heliconema urolophi*, is proposed for *Proleptus urolophi*. Keys to the genera of the subfamily Physalopterinae reported from fish and the genus *Proleptus* are included.

Examination of approximately 150 elasmobranchs representing five families of rays and 11 families of sharks from Pacific waters off the Southern California coast by one of us (MDD) revealed numerous specimens of the genus *Proleptus*. This genus is particularly confusing as many species descriptions are based on few specimens and usually lack adequate figures and measurements. Even the genotype, *Proleptus acutus* Dujardin, 1845, is poorly known. The original description included no figures and measurements were from a single male specimen. In reviewing the genus, Baylis (1933) recognized only six of the 12 species described at that time.

Comparison of the specimens collected in this study with specimens from the USNM, Beltsville, and the Museum National D'Histoire Naturelle, Paris, and with descriptions of *P. acutus*, *P. robustus* (v. Beneden, 1871), and *P. dogiyeli* Osmanov, 1940, revealed that all were synonymous with the genotype. In view of the paucity of information concerning the genotype, the limited variation reported by Baylis (1933) for *P. robustus* and by Osmanov (1940) for *P. dogiyeli*, as well as the addition of lucid scanning electron micrographs of the cephalic region, the generic description is revised and *P. acutus* is redescribed.

In reviewing *Proleptus*, the type specimen of *P. anabantis* Pearse, 1933, was examined and determined to have been incorrectly placed in the genus. In addition, the species *P. urolophi* Johnston and Mawson, 1951, was found to vary considerably from the other species in *Proleptus* and has been provisionally removed to the genus *Heliconema*. As an aid to identifying species in *Proleptus*, a key is presented.

Review of the literature for genera related to *Proleptus* indicates that *Paraleptus australis* Johnston and Mawson, 1943, is sufficiently distinct from other members of the genus *Paraleptus* Wu, 1927, to warrant the erection of the new genus, *Neoleptus*, for this species.

Materials and Methods

All specimens were fixed in alcohol–formalin–acetic acid (AFA) and stored in 70% ethanol. Specimens prepared for scanning electron microscopy were prepared as described by Allison et al. (1972, 1973). Anterior segments approximately 10 mm long were mounted on specimen stubs, outgassed for 1 hr or more in a vacuum evaporator, coated with gold-palladium (200 A or less), and examined in a model MSM-2 Mini SEM and JEOL JSMU-2 scanning electron microscope. Measurements obtained by light microscopy were made from 11 male and 12 female specimens removed from the stomach of *Mustelus californicus* Gill, 1864, and prepared by standard glycerine techniques. All measurements are in millimeters with ranges followed by averages in parentheses.

Neoleptus gen. n.

DIAGNOSIS: Mouth bounded by two lateral pseudolabia, each bearing a conical apical projection and a row of smaller denticles along the inner anterior margin. Two large papillae present on each pseudolabia. Inflated cephalic collarette distinct; excretory pore posterior to nerve ring. Esophagus divided into anterior muscular and posterior glandular portions.

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MALE: Caudal alae very poorly developed; nine pairs of sessile papillae, four preanal, five postanal. No unpaired papillae present. Spicules very unequal and dissimilar; gubernaculum absent.

FEMALE: Tail bluntly pointed. Vulva in posterior half of body. Eggs thick-shelled, embryonated at deposition.

TYPE SPECIES: *Neoleptus australis* (Johnston and Mawson, 1943), comb. nov.

HOSTS: *Heterodontus philippi* and *Mustelus antarcticus*.

Remarks

The genus *Neoleptus* has been erected for *Paraleptus australis* due to several distinctive characteristics inconsistent with the genus *Paraleptus* or with any existing genus in Physalopteridae. The presence of minute caudal alae, sessile caudal papillae, very unequal, dissimilar spicules, as well as the absence of a buccal vestibule represent sufficient deviation from any existing genus to warrant the erection of the new genus *Neoleptus*. The following key serves to identify the genera of the subfamily Physalopterinae from fishes.

1A. Caudal penduculate papillae present 2
1B. Caudal pedunculate papillae absent 4
2A. Vulva located adjacent to tail ..... *Proleptus* Dujardin, 1845
2B. Vulva located in middle third of body ... 3
3A. Spicules equal, similar ..... *Paraleptis* Wu, 1927
3B. Spicules unequal, dissimilar ..... *Heliconema* Travassos, 1919
4A. Caudal alae united ventrally to form vesicle ..... *Dogielina* Sobolev, 1949
4B. Caudal alae absent 5
5A. Vestibule absent, esophagus divided into anterior muscular portion and posterior glandular portion ..... *Neoleptus* gen. n.
5B. Vestibule present, extremely long, esophagus undivided ..... *Pseudoproleptus* Khera, 1955

Proleptus Dujardin, 1845

SYNONYMS: *Spiroptera* Rudolphi, 1819, partim; *Spiropterina* Beneden, 1858; *Histiocephalus* Molin, 1860, partim; *Coronilla* Beneden, 1871.

DIAGNOSIS: Mouth bounded by two simple pseudolabia, each bearing two submedian fused compound papillae and lateral amphid. Large conical projection found on inner surface of each pseudo labia. Mouth bounded by numerous conical or bifurcated denticles. Apparent junction of pseudolabia indicated by raised area of unknown function; this structure grooved medially along its length. Cephalic collarette present; cervical papillae symmetrical, in front of nerve ring; excretory pore some distance posterior to it. Esophagus divided into anterior muscular region and posterior glandular region.

MALE: Posterior extremity spirally coiled with broad membranous caudal alae supported by seven to 10 pairs of pedunculate papillae. Spicules unequal and dissimilar, gubernaculum absent.

FEMALE: Vulva in posterior half of body, most often close to anus; uteri parallel, ovijector short, oviducts and ovaries intertwined in posterior part of body. Eggs small, thick-shelled, embryonated at deposition. Tail short, blunt-pointed, directed dorsally.

HABITAT: Stomach and intestine of selachians and teleosts.

TYPE SPECIES: *Proleptus acutus* Dujardin, 1845. *Proleptus acutus* Dujardin, 1845.

SYNONYMS: *Spiroptera dacnodes* Creplin, 1851; *Histiocephalus dacnodes* Molin, 1860; *Spiropternia dacnodes* Diesing, 1861; *Coronilla robusta* Beneden, 1871; *Coronilla minuta* Beneden, 1871; *Spiropternia robusta* Linstow, 1903; *Proleptus robustus* (Beneden, 1871) Seurat, 1916.

(Figs. 1–3)

DESCRIPTION: Elongate, slender, white nematodes with characters of the genus. Circular cuticular striations evident, especially at anterior end. Mouth bounded by numerous conical or bifurcated denticles, with paired submedian enlarged bifid teeth. A raised area of unknown function is found on either side of the mouth at the apparent junction of the pseudolabia.

MALE: Mature specimens 23.3 to 35.5 (29.8) long, 0.370 to 0.533 (0.453) wide. Esophagus 3.26 to 4.31 (3.71) long divided into anterior muscular region 0.387 to 0.555

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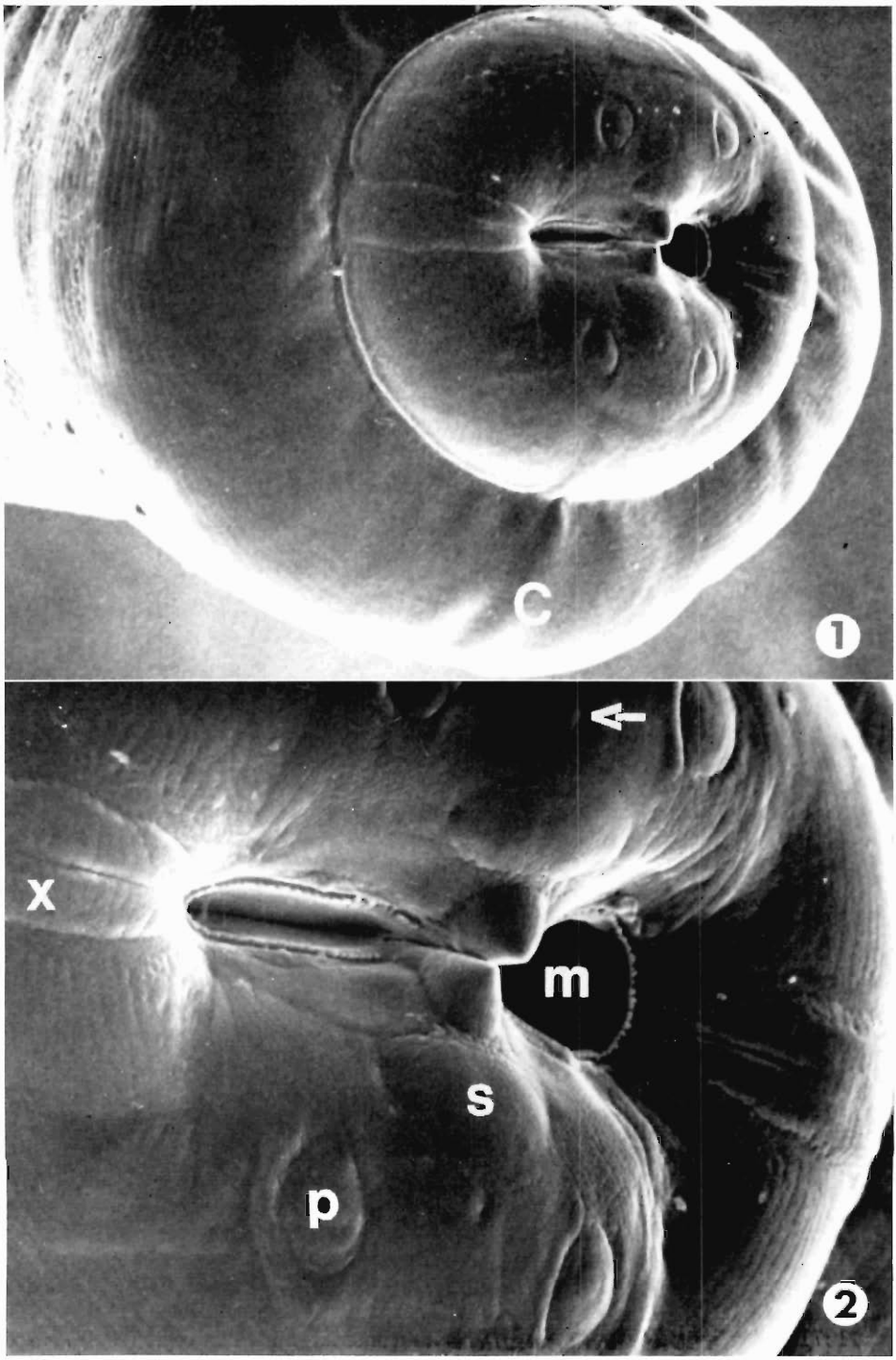

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(0.489) long and posterior glandular region 2.76 to 3.75 (3.33) long. Nerve ring 0.343 to 0.497 (0.445); excretory pore 0.715 to 0.934 (0.825) from anterior end, respectively. Cervical papillae located anterior to nerve ring 0.431 to 0.584 (0.504) from anterior end. Tail coiled, extending 0.599 to 1.460 (0.818) from anus. Caudal alae well developed and symmetrical, meeting ventrally anterior to cloaca. Caudal alae supported by eight pairs of riblike, pedunculate, symmetrically arranged papillae. Three pairs preanal, three pairs postanal, two pairs situated at level of cloacal aperture. Two additional pairs of very small cloacal papillae located just before and just after cloacal aperture. Spicules unequal, dissimilar. Right spicule 0.301 to 0.587 (0.464) long, broad at base and tapering rapidly to tip. Left spicule 1.094 to 1.773 (1.346) long, with long tubular shaft widening at posterior due to ala narrowing sharply before tip. Ventral surface of body tessellated for some distance anterior to cloaca.

FEMALE: Mature specimens 26.2 to 49.4 (34.5) long, 0.438 to 0.986 (0.569) maximum width. Esophagus 3.56 to 6.13 (4.31) long, divided into anterior muscular portion 0.475 to 0.672 (0.533) long and posterior glandular region 3.01 to 5.46 (3.71) long. Nerve ring 0.423 to 0.577 (0.467); excretory pore 0.686 to 1.221 (0.796) from anterior end, respectively. Cervical papillae located anterior to nerve ring 0.307 to 0.365 (0.336) from anterior end. Tail directed dorsally extending 0.227 to 0.431 (0.336) from anus. Vulva 0.229 to 0.511 (0.394) anterior to anus. Vagina muscular, directed posteriorly, ovijector short. Two parallel uteri present, coiled about intestine in posterior half of body. Eggs 0.021 to 0.042 (0.033) long, 0.021 to 0.027 (0.023) wide. Eggs ovoid, almost round, shell 0.003 to 0.006 (0.004) thick, with larva at deposition.

HOSTS: Literature reports include: *Raja clavata* L., 1758, *R. circularis*, *R. madererusis*, *R. miraletus*, *Mustelus laevis*, *Scyllium catulus*. The following represent new host records: Thornback ray, *Platyrhinoides triseriata* (Jordan and Gilbert), horn shark, *Heterodontus francisci* (Girard), brown smoothhound shark, *Mustelus henlei* (Gill), and gray smoothhound shark, *M. californicus* (Gill).

Remarks

Dujardin (1845) originally described *Proleptus acutus* on the basis of a single male recovered from the ray, *Raja clavata*. The description was brief and unfortunately not figured. A search for Dujardin's original specimen was futile; however, several specimens recorded as *P. acutus* by Fouras, 1946, were obtained from the Museum National D'Histoire Naturelle, Paris. Although these specimens were recovered from *Raja clavata*, closer examination of the specimens revealed them to be identical with *P. robustus* as redescribed by Baylis (1933).

Proleptus robustus was first recorded from *Raja circularis* and *R. clavata* by Beneden (1871); although figures were presented, measurements were not. Baylis (1933), on the basis of Beneden's figures, was able to recognize specimens recovered from *R. clavata* as identical to *P. robustus*, and redescribed the species. Unfortunately, Baylis had only three mature specimens, one male and two females, available for study. Despite identical hosts, Baylis considered *P. robustus* distinct from *P. acutus* primarily due to the disparity in size.

Proleptus dogiyeli was recorded by Osmanov (1940) from *Raja clavata*. He was undoubtedly unable to identify the nematode as *P. robustus* due to the scanty description given by Beneden (1871). The measurements listed by Osmanov concur with those listed by Baylis (1933) and fall within the range listed in the present study.

The original descriptions of *Proleptus acutus*, *P. robustus*, and *P. dogiyeli* failed to note the presence of denticles on the margins of the mouth. In addition, Baylis (1933) made no

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Figures 1, 2. Scanning electron micrographs of the anterior end of *Proleptus acutus*. 1. Head region and cephalic collar (c) (× 330). 2. Higher magnification of head showing detail of papillae (p), mouth (m), amphid (at arrow), and dorsal and ventral located raised structures (x). Note the raised surface (s) adjacent to the amphid. (× 840).

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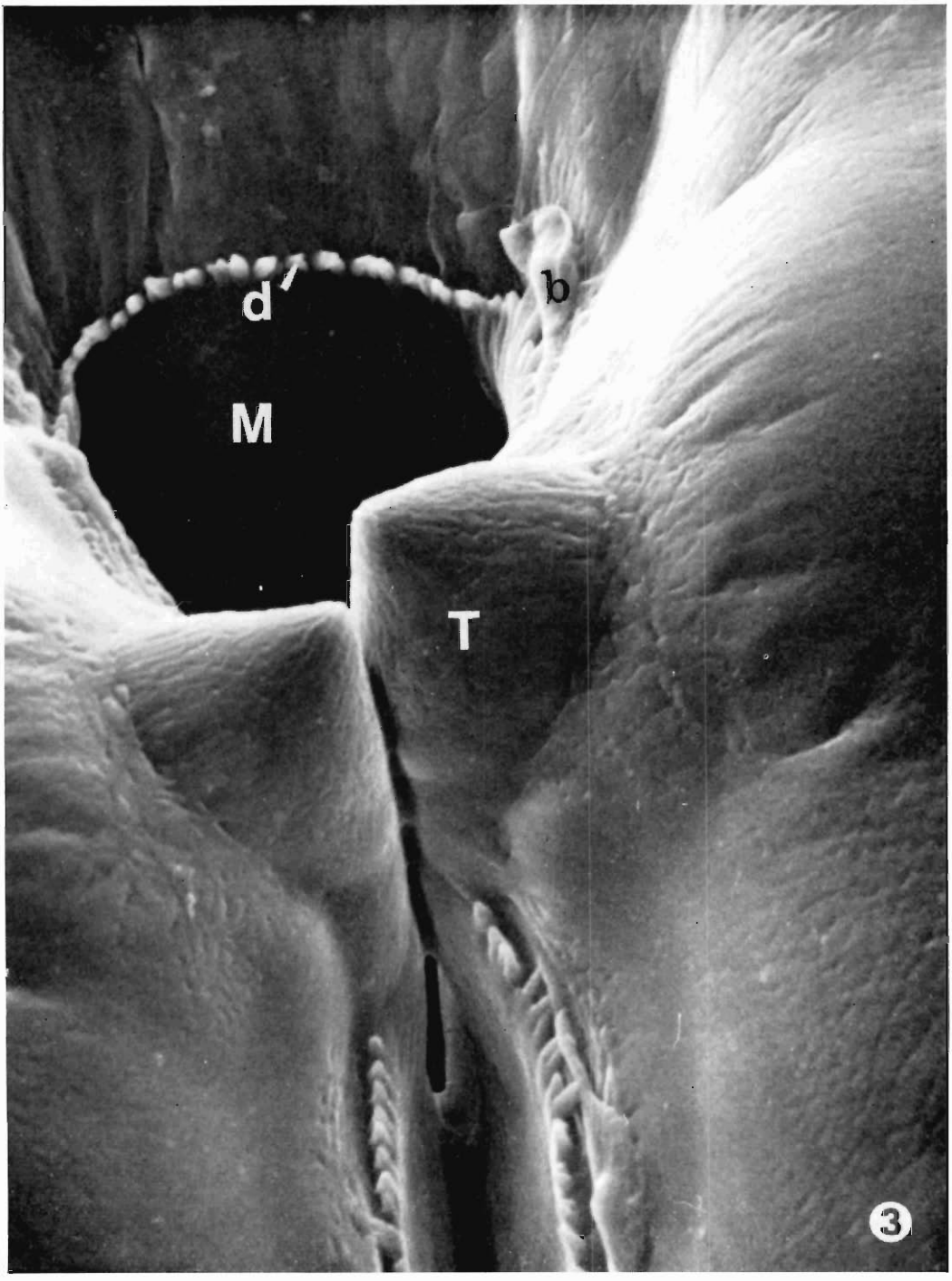

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Table 1. Comparison of absolute measurements and ratios of measurements for *Proleptus acutus* (original description, Dujardin, 1845), *P. robustus* (as redescribed by Baylis, 1933), and the present redescription of *P. acutus*.

	P. acutus Dujardin, 1845	*P. robustus* Baylis, 1933	*P. dogiyeli* Osmanov, 1940	Present description
Male length	12 mm	33 mm	37 mm	23.3–35.5 mm
Rt. spicule length	0.46 mm	1.5 mm	1.383 mm	1.09–1.56 mm
Lt. spicule length	0.12 mm	0.4 mm	0.14 mm	0.299–0.518 mm
Rt. spicule/body length	1:26.0	1:22.0	1:26.9	1:17.6–1:27.5
Lt. spicule/body length	1:100.0	1:82.5	1:88.6	1:59.7–1:91.3
Lt. spicule/rt. spicule	1:3.8	1:3.8	1:3.2	1:2.4–1:5.2

mention of them in his redescription of *P. robustus*. Campana-Rouget (1955), in a review of the cephalic morphology and spicules of *P. robustus*, reported the denticles to be identical to those characteristic of the genus *Ablreviata*. Our present data confirms that of Campana-Rouget.

Variation in measurements are well known for *Proleptus scillicola* (= *P. obtusus*). Lloyd (1920), working with a large sample, concluded that absolute measurements were without value. Similar variation in other marine nematodes has been reported by Davey (1971) in an excellent revision of the genus *Anisakis*. Davey concludes that absolute size can vary within a single species especially when recovered from different hosts and that a far more useful parameter is the ratio of two measurements.

To determine if similar ratios could be employed in *Proleptus* the right and left spicules were compared to body length and to each other. The results are depicted in Table 1 for *P. acutus*, *P. robustus*, and *P. dogiyeli*.

From the data presented in Table 1, it is evident that although the absolute measurements of *P. acutus* fall outside the range reported for *P. robustus* and *P. dogiyeli*, the ratios of right spicule to body length, left spicule to body length, and right spicule to left spicule indicate a correlation between the three species.

Inasmuch as parasite size is influenced by many factors including maturity, the separation of species based on absolute measurements, especially when few organisms are recovered and great variation is known in other members of the genus, is subject to question. In view of the preceding extensions of measurement ranges, a consideration of the various measurement ratios, and the recovery of *P. acutus*, *P. robustus*, and *P. dogiyeli* from the same host species, the authors think that *P. robustus* and *P. dogiyeli* are synonymous with the genotype, *P. acutus*.

Pearse (1933) described *Proleptus anabantis* from a single female specimen. Subsequent examination of this specimen indicated that it was immature and contained three lips rather than the two characteristic of the family Physalopteridae, thus this species must be considered a *species inquirenda*. As the specimen was immature, we were unable to assign it to genus.

Johnston and Mawson (1951) described the species *Proleptus urolophi* which, in view of the extreme anterior location of the vulva, does not allow placement within the genus *Proleptus*. Although *P. urolophi* does have an unusual arrangement of cephalic teeth which is not consistent with any existing generic description, in all other characteristics it fits the criteria established for the genus *Heliconema* which was revised by Ogden (1969). Chitwood and Wehr (1934) implicate the taxonomic importance of cephalic structures on the classification of the Spiruroidea, and if these cephalic structures can be confirmed, then perhaps a

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Figure 3. Scanning electron micrograph of anterior end of *Proleptus acutus*. High magnification showing detail of mouth opening (M) surrounded by irregularly shaped denticles (d), bifurcated submedian tooth (b), and the conical projection (T). (× 2,460).

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new genus would be indicated. At present, however, we are proposing the new combination *Heliconema urolophi.*

In view of the great confusion existing in species identification on the genus *Proleptus*, a key is presented to those species which can be recognized with accuracy.

1A. One pair preanal papillae, two pairs of adanal papillae. Vulva close to anus. Tip of right spicule bent at right angle to shaft ..... *P. obtusus* Dujardin, 1845

1B. More than one pair of preanal papillae. Vulva position variable. Tip of right spicule straight 2

2A. Two pairs of preanal papillae 3

2B. More than two pairs of preanal papillae 4

3A. Seven pairs pedunculate papillae supporting caudal alae; two pairs preanal, five postanal ..... *P. problematicus* Kries, 1940

3B. Ten pairs pedunculate papillae supporting caudal alae; two pairs preanal, three pairs adanal, five pairs postanal ..... *P. inflatus* (Linstow, 1890)

4A. Three pairs of preanal papillae 5

4B. More than three pairs of preanal papillae 6

5A. Vulva located very near anus ..... *P. acutus* Dujardin, 1845

5B. Vulva located about ⅓ of body length anterior to anus ..... *P. malayi* Sandosham, 1954

6A. Four pairs of preanal papillae 7

6B. Five pairs of preanal ..... *P. soridus* Lent et Freitas, 1948

7A. Nine pairs of pedunculate papillae 8

7B. Ten pairs of pedunculate papillae ..... *P. trygonorrhonae* Johnston and Mawson, 1943

8A. Most posterior two pairs of caudal papillae reduced in size, situated at posterior tip of tail, isolated from remaining seven pairs ..... *P. australis* Baylis, 1933

8B. Caudal papillae all similar in size, no papillae on posterior tip of tail ..... *P. africanus* (Linstow, 1899)

Several species are reported from this genus which are insufficiently known as to be recognizable and must be listed as *species inquirendae*: *Proleptus rajae* (Diesing, 1851); *P. coronatus* (Beneden, 1858); *P. gordiodes* (Beneden, 1858); *P. elegans* (Orley, 1885); *P. tortus* (Linstow, 1906).

No new information was found on these species to supplement the review of the genus by Baylis (1933), and thus in lieu of specimen examination they must remain listed as unknown species.

Acknowledgments

We wish to thank Dr. J. Ralph Lichtenfels for the loan of specimens of *Proleptus obtusus* and *P. anabantis* from the USNM collection and Dr. Anne J. Petter for her hospitality and assistance in recovering specimens of *P. acutus* from the Museum National d'Histoire Naturelle, Paris. Dr. Leo Margolis kindly provided appropriate parts of the paper by Osmonov.

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Immunological Studies on the Origin of the Cyst Wall of *Posthodiplostomum minimum* (Trematoda: Diplostomidae)[1]

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ABSTRACT: The biological origin of the cyst wall of *Posthodiplostomum minimum* was investigated by means of antibody–antigen precipitin tests and immunofluorescence microscopy. Reagents were prepared from the gamma globulin-rich fraction of sera obtained from rabbits immunized with homogenates of fish tissue, metacercarial, or cyst wall. The results of these preliminary immunological studies revealed that the cyst wall has components that reacted with both the rabbit anti-fish serum as well as the rabbit anti-metacercarial serum. These studies confirm and extend previous, less sensitive morphological and biochemical observations on the origin of the cyst wall of *P. minimum*.

Numerous studies dealing with the nature of helminth cyst walls have been conducted using histological, histochemical, and electron microscopic techniques. Several investigations have considered the metacercariae of the digenetic trematode, *Posthodiplostomum minimum* (MacCallum, 1921) Dubois, 1936. Hughes (1928) described the wall to be in two layers consisting of a cellular, host-formed outer part and an acellular parasite-produced inner layer. Hunter and Hunter (1940) added to the earlier description by Hughes in reporting the outer layer to be formed of modified host liver cells. However, Hoffman (1958) reported the outer layer to consist of a thin layer of connective tissue and postulated the inner one to be of worm origin. Bogitsh (1962), using histochemical techniques, agreed with reports on host origin of the outer wall, but withheld judgment about the inner layer due to its chemical similarities to ground substance in vertebrate tissue. Recently, Mitchell (1974), using electron microscopy on *P. minimum* metacercariae, reported a primary cyst wall of parasite origin surrounded by an outer viable fibrous coat which is produced by the host and which becomes an integral component of the cyst. This report is similar to that of Stein and Lumsden (1971) for the metacercarial cyst of the heterophyid, *Ascocotyle leighi* Burton, 1956, as it likewise forms a two-layered cyst of dual origin. Howell (1973) employed fluorescent microscopy as one of several techniques to analyze the cyst wall of *Stictodora lari* Yamaguti, 1939.

The purpose of the present study was to initiate preliminary research into the feasibility of employing immunofluorescent methods in determining the nature of the cyst wall of *P. minimum* in hopes that the findings would be supportive of other results already obtained about *P. minimum* cysts as well as contribute to related works.

Materials and Methods

Posthodiplostomum minimum metacercariae were obtained from 15 bluegill, *Lepomis macrochirus*, collected in Limestone County, Texas. The 250 to 300 larvae used for each antigen homogenate were taken from heart, liver, and

[1] Supported in part by a University Research Award.

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kidney tissue, washed in 0.75% Hanks' saline, and excysted mechanically. Fish tissue of the dorsal musculature, excysted metacercariae, and cyst walls were washed in 0.75% Hanks' saline and refrigerated separately at 5 C.

Four kinds of homogenates employed were fish, parasite, and cyst wall, and a 0.85% sterilized saline control. Fish antigen was prepared by macerating 0.25 g of tissue in a chilled tissue homogenizer with 1.5 ml saline. Parasite and cyst wall homogenates were prepared similarly using 250 to 300 parasites and walls, respectively. Homogenate solutions were centrifuged at 10,000 rpm for 30 min at 5 C in preparation for Lowry total protein determination (Lowry et al., 1951). This test proved to be of little value since protein concentrations differed with each new preparation of antigen and since presence of protein was subsequently shown by positive FA and interfacial tests.

New Zealand strain 2.5-kg laboratory rabbits were injected using Freund's complete adjuvant as a vehicle for antigen administration. Three separate series of experiments were made with injection protocol changed in each series to determine the method of maximum antibody production. In series one, 3-ml injections were given to each of four rabbits in single intramuscular injections with bleedings 86, 90, and 94 days later. Four injections to each of four rabbits were administered in series two, one initial intramuscularly and subsequent injections subcutaneously, the latter 5 and 12 days later, and a booster 14 days prior to bleeding on days 141 and 143. The final series consisted of five 3-ml intramuscular injections spaced evenly over 116 days with bleeding 5 and 7 days later. Most discrete ring and FA reactions were from sera of the final series.

Blood was taken by ear vein incisions at a 48-hr interval in 25-ml quantities for a total of 50 ml from each rabbit. One hour at room temperature and 24 hr at 5 C were allowed for clot contraction. Sera were then decanted and centrifuged at 5,000 rpm for 30 min at 5 C.

Precipitation of the gamma globulin fraction of each serum sample was by a saturated ammonium sulfate solution at pH 7.8. Three separate precipitations were made with a 1:2 antiserum–ammonium sulfate solution ratio and continuous stirring for 3 hr. Solutions were then centrifuged at 3,000 rpm for 30 min at room temperature. The final precipitate was dissolved in a volume of borate-buffered saline equivalent to one-half of the volume of the original antisera samples. Final solutions were dialyzed against borate-buffered saline (pH 7.8) at 4 C and clarified by centrifugation at 3,000 rpm for 30 min at 4 C. Quantitation of protein was by the Lowry technique using a BSA standard (Sigma). Sera were not inactivated.

Presence of antibody was determined by interfacial tests (Campbell et al., 1970) in which known solutions containing the supernatant from fish tissue, cyst wall, and parasite homogenates were layered with antisera. Precipitate bands were easily distinguished with the unaided eye.

Fluorochrome conjugation was accomplished by using 0.05 mg fluorescein isothiocyanate (FITC) per mg protein (Coons, 1958). The borate-buffered (pH 8.4) suspension of conjugated protein was dialyzed for 8 days against borate-buffered saline until visually free of color when examined under ultraviolet light of long wavelength. The conjugate after clarification was stored at 5 C with the addition of 0.01 ml of 1:10,000 merthiolate solution per ml solution.

A Leitz Ortholux fluorescent microscope equipped with Streuscheibe, BG-38, BG-12, and Blau filters and producing a light transmission optimum of 400 nm was used. Slides were prepared by a method modified from Cherry et al. (1960).

Results and Discussion

Interfacial tests clearly showed that rabbit antiserum possessed antibody to its homologous antigens (Table 1). The fact that anti-parasite serum was positive to parasite and cyst wall antigens, but negative to fish antigen, indicated that the cyst wall is at least partially of parasite origin. This was also supported by positive reaction of anti-cyst wall serum with parasite and cyst wall antigens. However, the reaction of cyst wall antiserum with fish antigen and the anti-fish serum reaction with cyst wall antigen are indistinct. If these two tests had not been ambiguous, a fish origin for cyst wall would be indicated. It is possible that this

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Table 1. Results of interfacial tests.

Antigen / Antiserum	Parasite	Cyst wall	Fish	Saline
Control	—	—	—	—
Anti-parasite	+	+	—	—
Anti-cyst Wall	+	+	+ (Slight)	—
Anti-fish	—	+ (Slight)	+	—

is due either to a low concentration of antigen or its homologous antibody since slight reactions were apparent in most tests. When considered in their entirety, these tests showed that cyst wall and parasite shared antigenic properties, with fish and cyst wall affinities being less distinct. Quantitative data were not obtained.

Other procedures including colorimetric and electrophoretic analyses failed to show presence of soluble antigen in the supernatant of the crude homogenate. This is possibly due to the dilute nature of the antigen which was detected by the more sensitive ring tests. Several slight positives obtained in ring tests are also possibly explained by the dilute antigen solutions.

Essentially the same findings observed in interfacial tests were obtained during immunofluorescent studies as shown in Table 2 where (++) indicates bright fluorescence, (+++) very bright, and (−), the dull natural autofluorescence of the specimen. The results are based on several observations for each sample. Because of the much more sensitive nature of this test, more significance can be placed on the findings here than with those obtained in the former study. FA studies indicated a non-fish origin for cyst wall because fish tissue incubated with anti-cyst conjugate yield the characteristic natural fluorescence. However, both outer and inner cyst wall tissues incubated with anti-fish conjugate gave bright fluorescence suggesting a fish origin for the wall. Fish protein adsorbed onto the surface of the inner cyst wall membrane may account for its fluorescence when incubated with anti-fish conjugate.

Table 2. Results obtained by immunofluorescent microscopy.

Antigen / Antiserum	Parasite	Fish	Cyst wall (outer)	Cyst wall (inner)
Anti-cyst wall	++	—	+++	++
Anti-parasite	++	—	—	+++
Anti-fish	—	++	++	++
Control	—	—	—	—
Saline	—	—	—	—

The results of the interfacial and FA tests indicate a dual origin for the total cyst wall, although they do not absolutely resolve its nature. Taken in conjunction with findings obtained through other techniques (Bogitsh, 1962; Mitchell, 1974), these studies support that *P. minimum* metacercarial cysts have both a fish and parasite origin. It appears that immunologic methods have a place as a tool in such studies, and will be even more valuable after refinement of the techniques for this purpose. The present study, although a preliminary one, shows the value in the use of these methods.

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Parasites of the Common Crow (*Corvus brachyrhynchos* Brehm, 1822) in Insular Newfoundland[1]

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ABSTRACT: Ninety-nine crows (*Corvus brachyrhynchos* Brehm, 1822) obtained from 12 localities in insular Newfoundland were examined for parasites using standard parasitological techniques. Whenever possible blood smears were made. Eighteen species of parasites (3 trematode, 3 cestode, 5 nematode, 1 acanthocephalan, 3 mallophagan, and 3 haematozoan) were recovered. One is a new host and distribution record while six are new host records for North America. Ninety-five percent of the crows examined were infected with helminth parasites, the number of species per infected bird ranging from 1–7 (mean 4) with the number of individuals per infected bird ranging from 1–190 (mean 63). Preferred age and sex of host and site of infection/infestation for each parasite species are noted. Three species of helminth (*Cyathostoma lari, Conspicuum macrorchis, Prosthorhynchus formosum*) were observed to cause damage to the host but none was lethal.

The common crow (*Corvus brachyrhynchos* Brehm, 1822) is widely distributed throughout North America, breeding in both Canada and the United States (AOU Check-list, 1957). While many aspects of the biology of the crow have been investigated, few detailed studies have been made of its parasites. A study was, therefore, initiated to determine the nature and burden of parasites of the common crow in Newfoundland, and to compare the results obtained with the work of previous authors. Andrews and Threlfall (1973) gathered together many of the previous records dealing with this host in their checklist of the helminth parasites of members of the genus *Corvus* (Aves).

Materials and Methods

Common crows were collected (shot, 12-gauge shotgun, shot size 2-7½) during the period May 1971–December 1973, from 12 localities in Newfoundland [11 areas on the Avalon Peninsula and one on the west coast (Bonne Bay)]. Weights and standard measurements (wing, tail, tarsus, and culmen) of the birds were recorded, as part of a wider survey, and then the specimens were examined for parasites. Autopsies were normally performed, using conventional techniques, within 4 hr of death. If any delay was anticipated the birds were deep-frozen (–10 C) for later examination.

The various regions of the digestive tract [esophagus, proventriculus, gizzard, duodenum, small intestine (subdivided into three equal sections), rectum, ceca, and cloaca] were

[1] This paper consists mainly of material submitted by the senior author in partial fulfillment of the requirements for the degree of M.Sc., Memorial University of Newfoundland.

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Table 1. Details of infection of common crows (*Corvus brachyrhynchos* Brehm, 1822) with helminths.

Parasite	No. (%) birds infected	Total No. parasites recovered	Range of No. recovered	Average No. per infected bird	Status
Conspicuum macrorchis Denton and Byrd, 1951	79 (80%)	891	1–97	11	
Brachylecithum stunkardi (Pande, 1935)	2 (2%)	160	35–125	80	**
Prosthogonimus macrorchis Macy, 1934	17 (17%)	41	1–6	2	
Dilepis undula (Schrank, 1788)	56 (57%)	766	1–111	14	**
Hymenolepis farciminosa (Goeze, 1782)	13 (13%)	57	1–22	4	**
Schistocephalus solidus (Müller, 1776)	4 (4%)	27	1–21	7	**
Capillaria contorta (Creplin, 1839)	59 (60%)	400	1–32	7	
Capillaria resecta (Dujardin, 1843)	69 (70%)	2,177	1–153	32	*
Cyathostoma lari Blanchard, 1849	37 (37%)	153	1–15	4	**
Prosthorhynchus formosum (Van Cleave, 1918)	60 (61%)	1,268	1–190	21	

* New host and distribution record.
** New host record for North America.

examined individually to determine the linear distribution of any parasites found.

Trematodes and cestodes were relaxed in 1% ethyl carbamate prior to preservation while nematodes were killed and fixed in glacial acetic acid. Ectoparasites were fixed and preserved in 70% ethyl alcohol. Trematodes were stored in 70% ethyl alcohol while cestodes and Acanthocephala were placed in Demke's solution. Nematodes were preserved in glycerine alcohol. Trematodes and cestodes were stained [Semichon's Acetic-Carmine, Gomori's Trichrome, Celestine Blue (cestodes only), Mayers HCL Carmine], dehydrated, cleared, and mounted in Canada balsam. Acanthocephala, nematodes, and ectoparasites were mounted and cleared in Rubin's fluid, while blood smears were air-dried, fixed in 100% ethanol, and stained with Giemsa.

All measurements are given in microns.

Results and Discussion

Ninety-nine common crows (37 adult males, 18 adult females, 4 adults of unknown sex, and 40 immatures) were examined during the survey. A total of 18 species of parasites were recovered (3 trematode, 3 cestode, 5 nematode, 1 acanthocephalan, 3 mallophagan, and 3 haematozoan). Ninety-four crows (95%) were infected with helminth parasites (Table 1), the number of species per infected bird ranging from 1–7 (mean 4) with the number of individual parasites per infected bird ranging from 1–190 (mean 63).

Trematoda

Three species of digenetic trematodes belonging to three genera (Table 1) were recovered from 79 (80%) of the crows examined (range 1–125; mean 14 per infected bird).

Conspicuum macrorchis, recovered from 79 (80%) of the crows examined, was described by Denton and Byrd (1951) from *C. brachyrhynchos* taken in Texas. Jones (1968) recorded this parasite from the same host in Ohio. Immature crows were the most frequently infected age class, while adult males and immatures had the highest intensity of infection. The gall bladder yielded 58% of the parasites recovered, the bile ducts 35%; the remaining 7% being located in various other body regions, probably as a result of postmortem migration. Measurements and morphological characters of specimens obtained during the present study agreed with those of Denton and Byrd (1951), with the exception of two specimens in which the cirrus sac was extremely large (961 by 175; 692 by 429, respectively). The size difference may have been due to differences in the techniques of preservation and subsequent treatment (Ulmer, 1952). On removal of *C. macrorchis* from the gall bladder wall, small mushroom-shaped projections at the site of attachment were noted. Bassett (1958), in a study of *C. icteridorum*, reported similar mushroom-shaped projections with a subsequent loss of the supporting tissue and lining of the gall bladder wall.

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Two male crows were infected with *Brachylecithum stunkardi*, the majority of the helminths (91%) being found in the gall bladder. It is interesting to note that the two host specimens were collected on the west coast of Newfoundland, approximately 270 miles from the main sampling areas. This would suggest that either the parasite is at the extremity of its range or that its intermediate hosts are present only in the western part of the island. The possibility also exists that there may be differences in the diets of different host populations. Measurements of the specimens agreed with those of Denton and Byrd (1951) with the exception of the eggs (preserved) which were 38–49 (44) by 26–33 (28), while Denton and Byrd (1951) reported egg measurements (preserved) of 30–41 by 21–27. They noted, however, that the eggs were 38–45 by 28–33 before preservation, which corresponds with the size range of preserved eggs in the present study.

Prosthogonimus macrorchis was recovered from the bursa of Fabricius of 17 (17%) of the immature crows examined. This parasite, normally found in domestic fowl, has been recovered previously from experimentally infected *C. brachyrhynchos* by Macy (1934a, b). This author notes that *P. macrorchis* shows a tendency for considerable variation and that the host may influence the size of the organism.

Cestoda

Three species of cestodes (Table 1) belonging to three genera were recovered from 60 (61%) of the crows examined (range 1–111; mean 14 per infected bird).

Dilepis undula was noted in 56 (57%) of the crows examined, the greatest intensity of infection being seen in adult male and immature birds. The preferred site of infection was the mid-section of the small intestine.

Hymenolepsis farciminosa was recovered from 13 (13%) of the birds. Immature birds were the most frequently infected age class while the midsection of the small intestine harbored the greatest number of parasites.

Two adult male and two immature crows were infected with *Schistocephalus solidus*. The midsection of the small intestine harbored the greatest number of parasites. The adult of this cestode normally occurs in the intestine of fish-eating birds (Hopkins and Smyth, 1951), and despite a wide range of definitive hosts, the adult worm is rarely found. This is probably due to the rapid (36 hr) maturation of the plerocercoid larva in the definitive host, and the short time (3–4 days) that the adult remains there (Hopkins and Smyth, 1951). The crows, in this instance, were probably accidental hosts as they do not normally consume large amounts of fish. The time of collection coincided with an annual mass die-off of threespine sticklebacks (*Gasterosteus aculeatus* L.) which are the second intermediate host of this helminth (Threlfall, 1968a). The crows, being scavengers, probably fed on dead fish as they washed ashore.

Nematoda

Three species of adult nematodes belonging to two genera and two larval forms belonging to two other genera were recovered from 73 (74%) of the crows examined (range 1–153; mean 37 per infected bird).

Two commonly found adult parasitic forms were *Capillaria contorta* located in the esophagus, and *Capillaria resecta* found in the duodenum and small intestine. Immature birds harbored the greatest numbers of these parasites.

Cyathostoma lari was noted in the nasal cavities of 37 (37%) of the crows examined, immature birds being the most heavily infected age class. Threlfall (1968b) noted this helminth in herring gulls (*Larus argentatus* Pont.) taken in Newfoundland. It is possible that infection of the crow occurs at the sanitary fill where the birds were collected and where considerable species interaction occurs. Since the life cycle of *C. lari* is direct, transfer from one host to another might be expected in this situation. *C. lari* was observed to cause damage to host tissue, as was recorded by Threlfall (1966) and Colam (1971).

Two immature crows were infected with larval ascaridids, one specimen being recovered from the midsection of the small intestine of one crow and another from the posterior section of the small intestine of a second crow. No representatives of the family Ascarididae have been recorded previously from crows in North America.

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Table 2. Details of infestation of common crows (*Corvus brachyrhynchos* Brehm, 1822) with ectoparasites.

Ectoparasite	No. (%) infested birds	Total No. parasites recovered	Range of No. recovered	Average No. per infected bird
Philopterus ocellatus (Scopoli, 1763)	70 (70%)	1,300	1–357	19
Myrsidea interrupta (Osborn, 1896)	67 (68%)	1,218	1–202	18
Brucelia rotundata (Osborn, 1896)	44 (44%)	1,692	1–262	38

One bird was infected with microfilariae. Anderson (1959), in an extensive survey of microfilariae, included records of these parasites from crows in Canada and the United States.

Acanthocephala

The mid and posterior sections of the small intestine of 60 (60%) of the crows examined harbored *Prosthorhynchus formosum*. This acanthocephalan can cause a considerable amount of damage at the site of attachment, since its hooks and proboscis usually penetrate the mucosa of the small intestine. Schmidt (1963) reported the histopathological changes associated with the attachment of this parasite in a robin.

Ectoparasites

Three species of mallophaga representing three genera were recovered from 82 (83%) of the birds examined (range 1–357; mean 51 per infested bird) (Table 2).

Philopterus ocellatus was recovered in greatest numbers from the head and neck of 70 (70%) of the crows examined, adult female and immature birds having the highest intensity of infestation. Immature *P. ocellatus* were found in greater numbers than either adult males or females.

Greatest numbers of *Myrsidea interrupta* were recovered from the ventral regions of 67 (68%) of the birds. Adult male and immature birds showed the highest intensity of infestation. Adult male *M. interrupta* were the most prevalent age class.

Brucelia rotundata infested 44 (44%) of the birds, greatest numbers being recovered from the ventral region. Immature birds had the highest intensity of infestation while immature forms of this ectoparasite were most numerous.

Haematozoa

A light infection with haematozoa was noted in 13 (13%) of the crows. The parasites recovered belong to three genera, namely *Leucocytozoon* (six birds infected); *Haemoproteus* (six birds infected); and *Plasmodium* (two birds infected).

Acknowledgments

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Unicoelium prochilodorum gen. et sp. n. (Trematoda: Haploporidae) from a Freshwater Fish (*Prochilodus reticulatus*) in Colombia[1]

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ABSTRACT: *Unicoelium prochilodorum* gen. et. sp. n. is described from the intestinal tract of a Colombian freshwater characid fish, *Prochilodus reticulatus* Steindachner. The new form is included in the subfamily Unisaccinae Martin, 1973, because of the union of the intestinal branches. The new genus differs from others in the subfamily by the more posterior position of the ovary, testis, vitelline glands, and acetabulum, and by the more anterior extension of the uterus and the receptaculum seminis uterinum.

The family Haploporidae is a small group of digenetic trematodes found principally in the intestines of the mullet and other closely related marine fishes. Some members of the family have been reported from freshwater fishes, however. Martin (1973a) presented a comprehensive review of the genera and species in this family along with their distribution. Haploporid trematodes have been reported from South America by Szidat (1954), Freitas (1947), and Thatcher and Dossman (1974).

During examinations of freshwater fishes of the upper Cauca River, near Cali, Colombia, an undescribed genus of Haploporidae was collected from a characid fish (*Prochilodus reticulatus* Steindachner). The host fish is of commercial importance and is known locally as the "bocachico" (smallmouth). The new genus of trematode described herein is widespread in the upper Cauca River and its tributaries. Infection rates of from 10–60% with infection densities of from 1–53 worms per fish have been encountered.

Materials and Methods

The trematodes were washed from the host viscera in tap water, killed on slides with gentle

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heat, fixed in alchohol–formalin–acetic acid (AFA) solution, stained with Mayer's carmalum, and cleared in methyl salicylate. Drawings were made with the aid of a camera lucida, and all measurements are in millimeters unless otherwise indicated. Average measurements are indicated in parentheses after the ranges. The new generic name refers to the union of the ceca while the new specific name is taken from the host genus.

Unicoelium gen. n.

GENERIC DIAGNOSIS: Haploporidae, Unisaccinae; body fusiform, cuticle spinous to near posterior end. Oral sucker subterminal. Acetabulum equatorial. Prepharynx short; pharynx smaller than suckers; esophagus long; ceca united to form single bilobed sac, situated equatorially. Testis large, ovoid, in posterior one-third of body. Hermaphroditic bursa containing internal seminal vesicle, prostatic cells, and distal portion of uterus. External seminal vesicle pyriform. Ovary spherical, immediately anterior to testis, in posterior one-half of body. Receptaculum seminis uterinum prominent, looping anteriorly to near pharynx. Laurer's canal not observed. Uterus looped laterally from level of testis to level of pharynx. Genital pore on midline a short distance posterior to pharynx. Vitelline glands follicular, in two groups, at level of ovary. Eggs large, operculate. Miracidial eyespots present in eggs of distal portion of uterus. Excretory vesicle Y-shaped; bifurcation at anterior end of testis. Intestinal parasites of freshwater fishes.

GENOTYPE: *Unicoelium prochilodorum* sp. n. (Fig. 1).

SPECIES DIAGNOSIS (based on 10 specimens): Body fusiform, 0.96–1.62 (1.2) long by 0.37–0.66 (0.47) wide at level of acetabulum. Cuticular spines minute, extend to near posterior end. Oral sucker 0.14–0.19 (0.17) in diameter. Pharynx 0.10–0.15 (0.13) in diameter. Prepharynx short; esophagus long, 0.22–0.36 (0.27). Ceca united medially to form a single bilobed sac; cecal sac 0.074–0.15 (0.09) wide by 0.15–0.26 (0.18) long. Acetabulum 0.15–0.24 (0.18) in diameter. Testis near posterior end of body, 0.11–0.29 (0.19) wide by 0.14–0.52 (0.32) long. Hermaphroditic bursa contains internal seminal vesicle, prostatic cells, and distal portion of uterus, measures 0.052–0.15 (0.11) wide by 0.13–0.22 (0.17) long. External seminal vesicle 0.014–0.11 (0.06) wide by 0.037–0.22 (0.15) long. Ovary spherical, 0.04–0.10 (0.073) in diameter. Receptaculum seminis uterinum prominent, elongate, looped; extends from ootype to near pharynx. Laurer's canal not observed. Vitelline glands follicular, in two

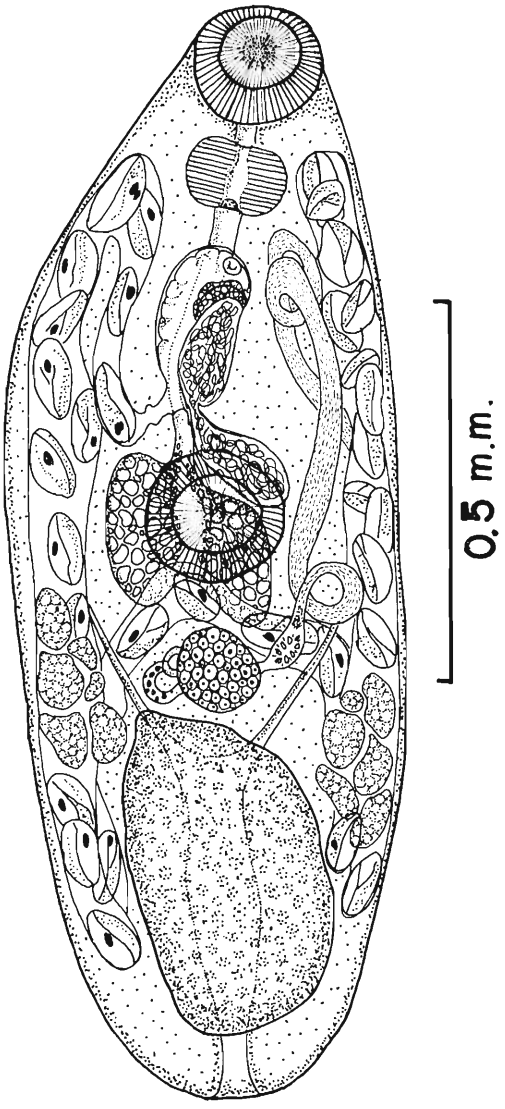

Figure 1. Ventral view of *Unicoelium prochilodorum* gen. et sp. n.

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lateral groups at level of ovary. Uterine loops mostly lateral, extend from mid-testicular level to level of pharynx. Eggs few, large, 29–37 by 73–74 mμ; miracidial eyespots visible in mature eggs. Excretory vesicle Y-shaped, pore terminal.

HOST: *Prochilodus reticulatus* Steindachner.

LOCATION: Intestinal tract.

LOCALITY: Upper Cauca River and tributaries, Department of Valle, Colombia.

HOLOTYPE: United States National Museum Helm. Coll. No. 73743.

PARATYPES: Authors' collections.

Discussion

Martin (1973b) described a new subfamily of Haploporidae which he called Unisaccinae to contain his two new genera *Unisaccus* and *Unisaccoides*. This subfamily was characterized mainly on the basis of the union of the ceca to form a single bilobed sac. His material had been collected from mullets in the Brisbane River of Australia. Present specimens from Colombia share this characteristic with Martin's genera and are, therefore, considered to belong to the same subfamily.

The new genus herein described bears some resemblance to *Unisaccus*, but differs from the latter in a number of important respects. In *Unicoelium* the testis, ovary, vitelline glands, and the acetabulum are all more posterior than in *Unisaccus*. The uterus in *Unicoelium* is much more extensive and more anterior, running up to the level of the pharynx. In *Unisaccus*, on the other hand, the uterus is confined to the posterior one-half of the body with a considerable portion posterior to the testis. The receptaculum seminis uterinum is much more extensive in the new genus than in Martin's genera. The eggs of the new species are somewhat larger than those of the other known species in the subfamily.

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Studies on *Acanthocephalus jacksoni* Bullock, 1962 (Acanthocephala: Echinorhynchidae). I. Seasonal Periodicity and New Host Records

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ABSTRACT: *Acanthocephalus jacksoni* has a seasonal periodicity at Jackson Cutoff (Wood County), Ohio, where it is present in the definitive hosts from December to July and absent in August to the middle of November. Factors such as water temperature, definitive host spawning period, amount of vegetation present, and the presence or absence of the intermediate host influencing this seasonal periodicity were investigated. *A. jacksoni* is reported from 15 species of fish, 12 of which are new host records in Ohio streams. The isopod, *Lirceus lineatus* (Say), is a new intermediate host for *A. jacksoni*.

Several authors (Komarova, 1950; Styczynska, 1958; Wysocka, 1965; Wierzbicki, 1971; Halvorsen, 1972) have considered the possible seasonal periodicity of certain species of *Acanthocephalus* in fish, but few have investigated the mechanisms regulating and maintaining the host–parasite system.

Chubb (1964) failed to demonstrate a seasonal periodicity of *Echinorhynchus clavula* (shown to be *Acanthocephalus clavula* by Grabda-Kazubska and Chubb, 1968) in fish of Llyn Tegid (Bala Lake), Merionethshire. He, nevertheless, investigated the factors affecting the host–parasite systems.

Bullock (1963) observed that *Acanthocephalus jacksoni* was present in trout throughout the year. His observations were from a hatchery and probably not indicative of a natural system.

The present study was undertaken to determine whether *Acanthocephalus jacksoni* has a seasonal periodicity in Ohio.

Materials and Methods

Jackson Cutoff, a runoff stream, is located 13.5 miles SW of Bowling Green, Wood County, Ohio. It is normally 8–10 feet wide with a depth of 2.0–3.5 feet and consists of pools in late summer. The bottom is mud and sand and has an abundance of aquatic vegetation. The isopod, *Lirceus lineatus*, is abundant. Poplar trees are found on both sides of the stream; their leaves provide a suitable substrate for *L. lineatus*.

This study was begun in April 1969 and continued through November 1973. Fish were obtained by seining, electrofishing, and trapping. Fish were transported to the laboratory in an ice chest; supplemental oxygen was furnished during transportation.

A total of 456 fish representing five species were examined (*Lepomis cyanellus, L. macrochirus, Semotilus atromaculatus, Cyprinus carpio, and Carassius auratus*).

Specimens of *Acanthocephalus jacksoni* have been deposited at the Manter Parasitology Lab of the University of Nebraska State Museum.

Results

The data obtained in this investigation are represented in Table 1 and Figure 1.

Cystacanths of *Acanthocephalus jacksoni* first appear in *Lirceus lineatus* in October (Table 1). Fish become infected by ingesting infected isopods. Adult acanthocephalans were first demonstrated in fish in November; the intensity of infection rose sharply through the spring months (Fig. 1). Three of 42 fish autopsied in November were infected, each with one male. The percentages of fish infected in January and February were derived from small samples. Jackson Cutoff freezes over in these months, making sampling difficult. Female worms containing ovarian balls were recovered from December through July, and worms containing shelled acanthors are present from January through July. There was a decrease in the percentage of infected fish in July and no fish were found infected in August through October (Fig. 1).

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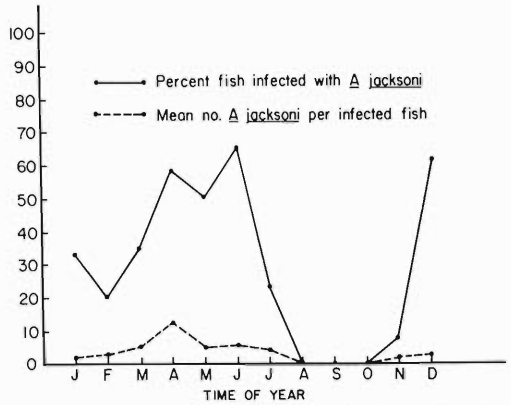

Figure 1. Seasonal periodicity of *Acanthocephalus jacksoni* in *Lepomis cyanellus, L. macrochirus, Semotilus atromaculatus, Cyprinus carpio,* and *Carassius auratus* for the period April 1969 to November 1973.

The authors found *A. jacksoni* in 15 species of fish, 12 of which are new host records. They are (by family) as follows: Percidae—*Etheostoma blennoides*; Centrarchidae—*Lepomis cyanellus, L. macrochirus, Ambloplites rupestris*; Cyprinidae—*Notropis spilopterus, N. hudsonius, N. umbratilis, N. crysocephalus, Carassius auratus, Cyprinus carpio, Campostoma anomalum*; Catostomidae—*Hypentelium nigricans.* Infected *Lepomis gibbosus* and *Catostomus commersoni* were also recorded. Bullock (1962) found immature worms in *Semotilus atromaculatus*, but mature acanthocephalans were found in *S. atromaculatus* in the present study. The naturally infected intermediate host was found to be *Lirceus lineatus*, which is a new intermediate host for *A. jacksoni.* The state of Ohio is a new locality record for *A. jacksoni.*

Discussion

Jackson Cutoff is generally reduced to isolated pools from July through October. The intermediate host of *Acanthocephalus jacksoni, Lirceus lineatus*, is absent or nonavailable in July through September (Table 1). Mature *L. lineatus* appear very abruptly in October, indicating that *L. lineatus* may survive the dry periods in interstitial spaces and crayfish burrows at Jackson Cutoff. Clifford (1966) has demonstrated this to be the case for *Lirceus fontinalis* and Creaser (1931) for ostracods, copepods, and amphipods. The substrate (leaf litter and vegetation) of *L. lineatus* is absent from July through October. The definitive hosts of *A. jacksoni* are present in these months.

It is suggested that *A. jacksoni* survives the harsh environmental conditions (July through October) at Jackson Cutoff in the egg stage, thus ensuring its continuation when *L. lineatus* becomes available. The lack of infected *L. lineatus* in the environment during May through September (Table 1) can be correlated with the lack of contact between *L. lineatus* and eggs of *A. jacksoni.* The absence of infected fish during August through the middle of November (Table 1) can be related to the absence of infected intermediate hosts in the environment.

Table 1. The occurrence of *Acanthocephalus jacksoni* in *Lepomis cyanellus, L. macrochirus, Semotilus atromaculatus, Cyprinus carpio,* and *Carassius auratus* for the period April 1969 to November 1973.

Month	No. of fish examined	No. and per cent fish infected	Mean no. *A. jacksoni* per infected fish	*Lirceus* present in environment	Cystacanths present in *Lirceus*
Jan.	12	4(33.3)	1.8	+	+
Feb.	15	3(20.0)	2.0	+	+
Mar.	52	18(34.6)	5.1	+	+
Apr.	60	35(58.3)	11.7	+	+
May	26	13(50.0)	4.5	+	0
June	34	22(64.7)	5.3	+	0
July	39	9(23.0)	3.4	0	0
Aug.	52	0(00.0)	0.0	0	0
Sept.	52	0(00.0)	0.0	0	0
Oct.	46	0(00.0)	0.0	+	+
Nov.	42	3(7.1)	1.0	+	+
Dec.	26	16(61.5)	2.8	+	+

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Chubb (1964) found *Acanthocephalus clavula* in eels of Llyn Tegid but did not find this worm in streams that flow into Llyn Tegid. He suggested that the absence of *Asellus meridianus*, intermediate host of *A. clavula*, from these streams may be the limiting factor.

Little is known about the effect of fish hormones on parasite burden. Thomas (1964) demonstrated that the percentage of infected trout with *Neoechinorhynchus rutili* during the spawning period was not significantly different from the other periods of the year.

Reighard (1910) observed that *Semotilus atromaculatus* in southern Michigan spawned from April to July. Morgan (1951) found that *Lepomis macrochirus* in Ohio spawned from May to the middle of August. The spawning periods of *S. atromaculatus*, *L. macrochirus*, and *L. cyanellus* at Jackson Cutoff were found to begin in April and continue through August. The number of infected fish and the mean number of *A. jacksoni* per infected fish is high during this period (Table 1). The level of infection in fish during this period is perhaps a reflection of a hormonal influence on infectiveness of the fish host or some environmental factor, i.e., the availability of infected isopods.

L. lineatus reproduces throughout the year at Jackson Cutoff, with the highest peak in March through June. This spring peak may explain the high percentage of infected fish and the high mean number of *A. jacksoni* per fish during the spawning period.

Chubb (1964) postulated that temperature may play a major role in determining the presence or absence of a well-defined seasonal periodicity. The water temperature at Jackson Cutoff was taken in August (24 C), September (23 C), 1 October (19 C), 17 October (11 C), November (5 C), and December (5 C). *L. lineatus* infected with cystacanths of *A. jacksoni* appear about mid-October as the water temperature approaches 11 C. Infected fish appear in November as water temperature approaches 5 C.

Two young *L. lineatus* from the broodpouch of a female isopod were experimentally infected in the laboratory with *A. jacksoni* at 21 C (room temperature). Bullock (1962) experimentally infected *Asellus* sp. with *A. jacksoni* at room temperature, thus demonstrating that *A. jacksoni* will develop in its intermediate hosts at 21 C (laboratory temperature) and at 11 and 5 C (ambient environmental temperatures). The infection of the definitive hosts may be dependent on low temperature, but more data from the field and laboratory are needed.

The seasonal periodicity of *L. lineatus* in the environment and *A. jacksoni* in fish may be related to the increasing water level, the increasing abundance of the vegetation, the availability of *L. lineatus* to ingest eggs of *A. jacksoni*, and the availability of infected *L. lineatus* to fish. Factors other than the lack of availability of *L. lineatus* in the environment may be involved in this seasonal periodicity. The life cycle of *A. jacksoni* has to be fully demonstrated in the laboratory before more concrete evidence can be obtained.

L. lineatus is present at Jackson Cutoff from October through June and is infected with cystacanths from October through April (Table 1). These data are difficult to explain, but they may be due to a sampling deficiency of infected *L. lineatus* in May and June, a missing hatching stimulus in *L. lineatus*, or eggs of *A. jacksoni* may need a latency period to become infective to *L. lineatus*.

Many authors have shown that the intensity of fish predation on members of the family Asellidae is roughly parallel to the changes in the biomass of the members. The biomass of asellids is directly related to the concentration or amount of vegetation present. Berglund (1968) observed that the number of *Asellus aquaticus* increased with increasing amounts of vegetation and states that "this marked parallelism seems highly significant and cannot possibly be the result of chance." This relationship between vegetation (leaf litter) and *L. lineatus* has also been observed at Jackson Cutoff.

Berglund also stated that *Asellus aquaticus* forms such a quantitatively important component of the benthic prey fauna that trout have probably been conditioned to search for it. It is hypothesized that if this is the case and fish are sight feeders, unpigmented isopods would be easier prey than pigmented ones. Seidenberg (1973) also postulates that this is the case concerning *Acanthocephalus dirus* in *Asellus intermedius* in Illinois. Laboratory feeding experiments to test this hypothesis have not been carried out as yet.

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The present authors have examined 894 *L. lineatus*. A total of 221 (24.7%) were infected. A definite depigmentation was observed in infected *L. lineatus*. A similar phenomenon was demonstrated by Seidenberg in *Asellus intermedius* infected with *Acanthocephalus dirus*. He found 26.1% of 2,766 male isopods and 27.0% of 2,574 female isopods infected. A seasonal periodicity in the incidence of infection of *A. intermedius* was seen, but the seasonal periodicity of this worm in the definitive host was not investigated.

It is believed that *A. jacksoni* has a short adult stage. Experimentally infected *Lepomis cyanellus* and *L. macrochirus* held infections for only eight days in the laboratory. A *L. macrochirus* autopsied 1 day after infection yielded a male and female worm. A cement plug was present on the posterior end of the female, and upon dissection sperm was seen, thus indicating rapid maturing of the cystacanth. Naturally infected fish from Jackson Cutoff held at outside ambient temperature maintained infections for as long as 16 days.

Field and laboratory observations suggest that female *A. jacksoni* may not pass eggs, but pass out of the intestine intact. The females deteriorate in the environment and eggs are then released. Male and female worms have been seen hanging out of the anus of fish. Eggs of *A. jacksoni* were not found in fecal samples when naturally infected fish from April and May were examined.

Acknowledgments

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Studies on *Acanthocephalus jacksoni* Bullock, 1962 (Acanthocephala: Echinorhynchidae). II. An Analysis of the Host–Parasite Relationship of Larval *Acanthocephalus jacksoni* in *Lirceus lineatus* (Say)

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ABSTRACT: Statistical analyses were performed on aspects of the host–parasite relationship of *Acanthocephalus jacksoni* in *Lirceus lineatus*. The host characteristics investigated were pigmentation, sex, size, and gut contents. The sex, position, and orientation of *A. jacksoni* cystacanths in *L. lineatus* was also investigated. It was demonstrated that cystacanths occupied the left side of the hemocoel more often than the right, median, and opercular (gill) area. Most of the cystacanths found were facing posteriad in *L. lineatus*.

Male and female cystacanths of *A. jacksoni* were very precocious in their development in *L. lineatus*. Sexual dimorphism was apparent in cystacanths.

The host–parasite relationships of larvae acanthocephalans and their intermediate hosts have been investigated by many authors. Holmes and Bethel (1972) and Bethel and Holmes (1973) have documented some aspects of the behavior of infected intermediate hosts. It has been demonstrated that the sex ratio of acanthocephalans in their intermediate hosts was very close to the theoretical value of 1:1 by Parenti et al. (1965), Amante et al. (1967), Crompton and Whitfield (1968), and Seidenberg (1973). Internal associations of cystacanths with intermediate hosts, such as position and orientation, have been investigated in only a few cases, most notably Nickol and Heard (1973) and Seidenberg (1973).

The present study was undertaken to elucidate some aspects of the host–parasite relationships of *Acanthocepalus jacksoni* in *Lirceus lineatus*. Pigmentation, sex, size, and gut contents of the host were examined. The sex, position, and orientation of *A. jacksoni* cystacanths in *L. lineatus* was also examined.

Materials and Methods

The isopod population studied was that at Jackson Cutoff described by Muzzall and Rabalais (1975). Isopods were collected with a dip net in March, April, and October through February. Isopods and substrate (leaf litter and vegetation) were brought to the laboratory and placed in clear plastic pans. Aeration was supplied to the pans. When the aeration was removed from the containers the isopods rose to the surface where they could be easily collected.

Parasitized (nonpigmented) and nonparasitized (pigmented) isopods were easily differentiated as described by Muzzall and Rabalais (1975). The parasitized isopods were sexed. The length was determined as that distance from the anterior margin of the cephalothorax to the posterior margin of the abdomen. The length of isopods ranged from 4.0 to 16.5 mm with a mean length of 9.7 mm as determined by a substage micrometer. The gut of the isopod was considered to be empty, half-full, or full of food.

The sex of the cystacanths found was determined at autopsy. Cystacanths were invariably found in the hemocoel. They occupied one of four areas: left, right, median (above or below the intestine), and/or the opercular (gill) area of *L. lineatus*. Cystacanths were oriented with the presoma either facing anteriorly or posteriorly.

Statistical procedures used were from Sokal and Rohlf (1969). The 5% level of significance or less was used in all statistical tests performed.

Results

A total of 1,013 *Lirceus lineatus* were examined. One hundred sixty-nine (16.7%) were infected with cystacanths of *Acanthocephalus jacksoni*. Of the 169, 139 (82.2%)

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Table 1. Number of cystacanths found in various positions of *L. lineatus* at autopsy.

	L. lineatus examined	
Entire sample (209)	♀♀ (89)	♂♂ (120)
R(76)–M(46)*	R(30)–M(24)	R(46)–M(22)*
R(76)–O.A.(14)*	R(30)–O.A.(2)*	R(46)–O.A.(12)*
L(101)–R(76)	L(48)–R(30)*	L(53)–R(46)
L(101)–M(46)*	L(48)–M(24)*	L(53)–M(22)*
L(101)–O.A.(14)*	L(48)–O.A.(2)*	L(53)–O.A.(12)*
M(46)–O.A.(14)*	M(24)–O.A.(2)*	M(22)–O.A.(12)
Total No. cystacanths 237	104	133

*Significantly different from expected 50:50 distribution at $P < 0.05$, by chi-square test.
Positions: R = right side of hemocoel; L = right side of hemocoel; M = median; O.A. = opercular region.

had single cystacanth infections and 30 (17.8%) had multiple cystacanth infections.

It was observed that infected *L. lineatus* were nonpigmented; noninfected *L. lineatus* were pigmented. The following results were based on 209 nonpigmented *L. lineatus*, of these 204 (97.6%) were infected. The sex distribution of *L. lineatus* was 128 males and 89 females. The five noninfected, nonpigmented isopods were males. A total of 237 cystacanths of *A. jacksoni* were recovered, 104 from female and 137 from male *L. lineatus*. Sex distribution of cystacanths recovered was very close to the theoretical value of 1:1, 121 (51.1%) male and 116 (48.9%) female. Male *L. lineatus* harbored 62 female and 72 male cystacanths. Female *L. lineatus* harbored 55 female and 49 male cystacanths. Male *L. lineatus* had significantly more male cystacanths ($\chi^2 = 4.37$, $P < 0.05$) than did female *L. lineatus*.

Fourteen male and 12 female *L. lineatus* harbored multiple infections.

The number of cystacanths found in each position in the hemocoel was as follows: 101 (48.3%) occupied the left side; 76 (36.3%) occupied the right side; 46 (22.0%) occupied a median position; and 14 (6.7%) occupied the opercular area. The results of chi-square tests showing the number of cystacanths found in each position by sex of isopod are shown in Table 1.

Male isopods had significantly ($\chi^2 = 7.14$, $P < 0.05$) more cystacanths in the opercular region than did females.

One hundred seventy-five (73.8%) cystacanths were directed posteriorly and 26 (26.1%) were directed anteriorly. There was a statistical difference between the number of cystacanths directed posteriorly and anteriorly ($\chi^2 = 53.87$, $P < 0.05$) as shown in Table 2.

Occasionally, cystacanths were reflected on themselves so that both ends were directed either anteriorly or posteriorly. The sex and number of folded cystacanths was investigated. One male and nine female cystacanths were folded. There was a statistical difference between the sexes of cystacanths folded in *L. lineatus* ($\chi^2 = 5.44$, $P < 0.05$).

The intestines of 82 (39.2%) *L. lineatus* were empty; 108 (51.7%) were full; and 19 (9.1%) were half-full. Isopods had more full intestines ($\chi^2 = 62.37$, $P < 0.05$) than half-full intestines. Isopods had more empty intestines ($\chi^2 = 39.29$, $P < 0.05$) than half-full intestines. The P value obtained when the number

Table 2. Orientation of cystacanths in *L. lineatus* at autopsy.

	L. lineatus examined	
Entire sample (209)	♀♀ (89)	♂♂ (120)
P(175)–A(62)*	P(72)–A(32)*	P(103)–A(30)*
P(166)–PDU(9)*	P(72)–PDU(4)*	P(103)–PDU(5)*
P(175)–ADU(1)*	P(72)–ADU(0)*	P(103)–ADU(1)*
A(61)–PDU(9)*	A(32)–PDU(4)*	A(30)–PDU(5)*
A(61)–ADU(1)*	A(32)–ADU(0)*	A(30)–ADU(1)*
PDU(9)–ADU(1)*	PDU(4)–ADU(0)*	PDU(5)–ADU(1)
Total No. cystacanths 237	104	133

*Significantly different from expected 50:50 distribution at $P < 0.05$, by chi-square test.
Orientation: P = posteriad; PDU = posteriorly folded up; A = anteriad; ADU = anteriorly folded up.

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of full intestines was compared to the number of empty intestines was very close to being significant ($0.05 > 3.55 > 0.10$).

No statistical differences were found using a test of independence in a three-way table for the following: cystacanth position and orientation, and sex of *L. lineatus*; cystacanth position and orientation, and gut content of *L. lineatus*; cystacanth position and orientation, and cystacanth sex. The above tests suggest that all characteristics analyzed together were independent of each other in occurrence. The *P* value obtained when cystacanth orientation and position were analyzed together was very close to being significant ($0.05 > 2.79 > 0.10$).

There was no statistical difference when the intensity of infection of cystacanths was analyzed with the size of *L. lineatus* (regression coefficients).

Discussion

The cystacanths of *Acanthocephalus jacksoni* are free and unencysted while occupying different positions in *Lirceus lineatus*. The proboscides were inverted in all cystacanths found. Statistical tests (Table 1, 2) analyzing many host–parasite relationships of *A. jacksoni* and *L. lineatus* suggest that cystacanths are found more often in the left side of hemocoel, facing posteriad. One hundred one (48.3%) cystacanths occupied the left side; 76 (36.3%) occupied the right side; 46 (22.0%) occupied a median position; and 14 (6.7%) occupied the opercular area. One hundred seventy-five (73.8%) cystacanths were directed posteriorly and 26 (26.1%) were directed anteriorly. A similar phenomenon was observed by Nickol and Heard (1973) for *Fessisentis necturorum*, which was facing posteriad in *Asellus scrupulosus*.

Sexual dimorphism was apparent in cystacanths of *A. jacksoni*. The females were always longer than males, and the female's cuticle tended to be wrinkled at the posterior end. The males were small and tended to be flexed in a crescent shape. It is believed that this size difference may account for the nine females that were folded, as opposed to only one male.

A. jacksoni is very precocious in its development in *L. lineatus*. Testes, seminal vesicles, and cement glands of male cystacanths stain darkly, indicating possible presence of semen. The ovaries of female cystacanths were fragmented, forming masses of large ovarian balls. This is the fourth species in which early fragmentation is known to occur. Similar fragmentation has been observed for *Prosthorhynchus formosus*, *Neoechinorhynchus rutili*, and *Fessisentis necturorum* (Schmidt and Olsen, 1964; Merritt and Pratt, 1964; Nickol and Heard, 1973).

L. lineatus reproduces throughout the year at Jackson Cutoff, with the peak in March through June. Infected female *L. lineatus* were collected in March and April. Such infected females were never observed carrying eggs in the field or laboratory in those months or at any other time of the year. A similar phenomenon was observed for *Polymorphus minutus* in *Gammarus* by Hynes and Nicholas (1965). Hynes (1955) had demonstrated that *P. minutus* interferes with the development of the ovaries of female shrimp. It appears that this may also be the case for *A. jacksoni* in female *L. lineatus*.

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Lyperosomum byrdi sp. n. (Digenea: Dicrocoeliidae) from the Rufous-sided Towhee, *Pipilo erythrophthalmus* (L.), with a Revised Synopsis of the Genus

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ABSTRACT: *Lyperosomum byrdi* sp. n. is described from rufous-sided towhees, *Pipilo erythrophthalmus* (L.), from Lake Placid, Florida, and Augusta, Georgia, and compared with related species. The genus *Lyperosomum* Looss, 1899, in which 41 species are currently listed, is revised with three subgenera recognized: *Lyperosomum* (Looss, 1899) for typical forms, *Lyperosomoides* Yamaguti, 1971, char. emend. for species with wider, spindle-shaped bodies and more caudally located acetabula, and *Sinuosoides* subg. n. for species related to *L. sinuosum* Travassos, 1917. Species are assigned to their appropriate subgenus and several synonymies are suggested.

In June 1973, eight specimens, seven of which were sexually mature, of a new dicrocoeliid trematode were found in the liver of one of four rufous-sided towhees, *Pipilo erythrophthalmus*, collected at the Archbold Biological Station near Lake Placid, Florida. Previously four badly deteriorated specimens of the same species had been removed from the gall bladder of a towhee collected at Augusta, Georgia. For this undescribed worm the name *Lyperosomum byrdi* sp. n. is proposed in honor of the late Dr. Elon E. Byrd.

Specimens were killed in hot saline under slight coverglass pressure, fixed in AFA, stained with Harris' hematoxylin, and mounted for study. The figure was drawn with the aid of a camera lucida and measurements are given in microns.

Lyperosomum byrdi sp. n. (Fig. 1)

Description (based on 7 mature worms, 2 broken): Body elongate, with almost parallel sides and rounded extremities, flattened dorsoventrally, 2,098 to 3,745 long by 300 to 441 wide, usually widest at acetabulum. Ratio of length of forebody to hindbody 1:7.0 to 7.6. Tegument thick and smooth except for small conical sensory papillae on margins beside suckers. Oral sucker subterminal ventral, muscular, round, 188 to 230 in diameter.

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Acetabulum 308 to 400 in diameter, strongly muscular with deep lumen, in anterior ⅕ of body. Ratio of diameter of oral sucker to acetabulum 1:1.6 to 1.9. Prepharynx absent; pharynx muscular, transversely oval, 63 to 78 long by 76 to 96 wide, partially to totally dorsal to oral sucker. Esophagus obscured by cirrus pouch; cecal bifurcation ⅓ to ½ distance from oral sucker to acetabulum; ceca of medium width, usually straight, passing dorsal to margins of acetabulum, lateral to gonads, dorsal to vitellaria to terminate at same or different levels ⅓ to ⅔ distance from caudal vitellaria to end of body. Excretory pore terminal.

Testes two, smooth, round, 60 to 125 in diameter, situated close together in oblique position. Anterior testis located either to right (5X) or left side (2X) of body, contiguous to or slightly separated from acetabulum. Cirrus sac elongated oval, 132 to 152 long by 60 to 69 wide, lying mostly anterior to acetabulum, containing coiled seminal vesicle, small pars prostatica, and protrusile cirrus. Genital pore median, ventral to caudal margin of pharynx.

Ovary round to transversely oval, smooth, 50 to 128 long by 60 to 144 wide, situated on same side of body as posterior testis but widely separated from it by eight to 10 loops of uterus. Seminal receptacle located just posterior to ovary, 55 to 75 in diameter. Vitellaria composed of numerous small follicles arranged in two lateral rows, beginning anteriorly at a level ⅓ to ½ distance from posterior testis to ovary and extending caudally 800 to 1,110. Uterus greatly convoluted, filling most of body caudal to testes, ascending to right or left of both ovary and posterior testes, between testes, dorsal to acetabulum and cirrus sac. Mature eggs numerous, dark brown in color, operculated, thick-walled, 30 to 35 by 18 to 21.

HOST: *Pipilo erythrophthalmus* (L.), rufous-sided towhee.

SITES: Liver and gall bladder.

LOCALITIES: Lake Placid, Highlands Co., Florida (type), and Augusta, Georgia.

SPECIMENS DEPOSITED: USNM Helm. Coll. No. 73662 (holotype); No. 73663 (paratype).

Discussion

This form appears closest to *L. direptum* Nicoll, 1914, *L. pawlowskyi* (Strom, 1928), *L.*

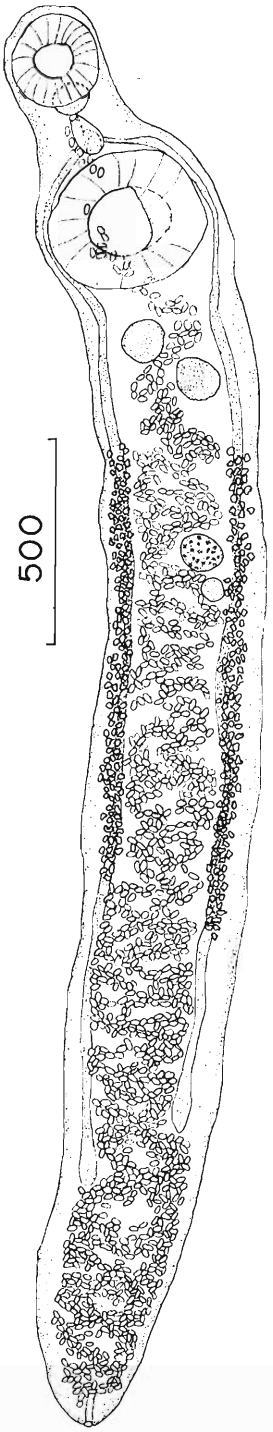

Figure 1. ***Lyperosomum byrdi*****, holotype, ventral view.**

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sarothrurae Baer, 1959, and *L. soricis* Bychovskaja-Pavlovskaja and Kulakova, 1970, all of which have the ovary widely separated from the closely situated oblique testes. It differs from *L. direptum*, described from three fragments of worms from a black curassow from South America, in being a much smaller and relatively broader worm and in having a greater sucker ratio, a definite esophagus, more obliquely situated testes, and the vitellaria beginning at a more caudal level. From *L. pawlowskyi* and *L. sarothrurae*, both described from rails and possibly synonyms, *L. byrdi* differs in being much smaller with a relatively wider body and in having a larger sucker ratio, the ovary less widely separated from the posterior testis, and the vitelline fields beginning more caudally. It differs from *L. soricis*, described from the liver of *Sorex araneus*, in being smaller, and in having shorter ceca, smaller vitelline follicles arranged in shorter fields, and a smooth, round ovary equal in size to the testes.

Revised Synopsis of the Genus *Lyperosomum* Looss, 1899

Yamaguti (1971), in the most recent revision of the Dicrocoeliidae Odhner, 1910, listed 32 species in the genus *Lyperosomum* Looss, 1899 (syn. *Oswaldoia* Travassos, 1920, *Dicrocoelioides* Dollfus, 1954, *Paralutztrema* Faust, 1967). Since his compilation seven additional species have been described in the genus and two species, *L. petiolatum* (Railliet, 1900) and *L. lari* Travassos, 1917, formerly accepted in the genus *Lyperosomum* but excluded from it by Yamaguti, are reassigned to the genus. *Brachylecithum vitellobum* Fischthal and Kuntz, 1974, is transferred to this genus as *Lyperosomum vitellobum* (Fischthal and Kuntz, 1974) comb. n., since the cup-shaped acetabulum with deep lumen, relative position of the gonads, extent and character of the vitellaria, and size of the ova indicate a closer affinity to this genus. *L. squamatum* v. Linstow, 1906, included by Yamaguti, is omitted by us since it is not a dicrocoeliid, leaving 41 species in the genus.

In comparing our new form with various species of the genus and attempting to determine to which ones it was most closely related, we were confronted with a confusing assemblage of species of diverse morphology and uncertain relationships. Many species are remarkably similar and apparently synonyms while others are inadequately described or described from insufficient poorly preserved material making critical comparison impossible. Ultimately it became obvious that the genus as now constituted contains species of three distinct morphological types. To accommodate these three types we propose recognizing three subgenera, *Lyperosomum* (Looss, 1899), *Lyperosomoides* Yamaguti, 1971, char. emend. to include the whole group with wider fusiform bodies, and *Sinuosoides* subg. n. for the *sinuosum*-like species. These subgenera are diagnosed below and discussed briefly. Species are assigned to their appropriate subgenus and those that in our opinion are synonyms are so designated.

Subgenus *Lyperosomum* (Looss, 1899)

SUBGENERIC DIAGNOSIS: *Lyperosomum*, with characters of the genus. Body almost cylindrical, very long and narrow; acetabulum large and strong, located in anterior ¼ or ⅕ of body; testes oblique or nearly in the same longitudinal axis; vitellaria consisting of numerous small follicles in a long strip on either side of body, beginning in testicular zones or caudally up to ½ distance to ovary; genital pore ventral to or at posterior margin of pharynx; ova small and thick-walled; parasitic in the gall bladder, larger bile ducts and intestine (?) of birds and mammals.

TYPE SPECIES: *Lyperosomum* (*Lyperosomum*) *longicauda* (Rud., 1809).

The 13 species we are assigning to the subgenus *Lyperosomum* fall into two distinct groups with respect to the relative position of the gonads. One group, typified by *L. longicauda*, has the gonads situated approximately equidistant one from the other. Species in addition to *longicauda* belonging to this group are *L. francolini* Osmarin, 1970, *L. malaysiae* Fischthal and Kuntz, 1974, *L. oswaldoi* (Travassos, 1919), *L. petrovi* Kassimov, 1952, *L. schikhobalovi* Kassimov, 1952, *L. skrjabini* (Solowiow, 1911), and *L. urocissae* Yamaguti, 1939. The other group has the slightly oblique testes situated close

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together near the acetabulum and the ovary widely separated from them. Species of the subgenus exhibiting this characteristic are *L. byrdi* sp. n., *L. direptum* Nicoll, 1914, *L. pawlowskyi* (Strom, 1928), *L. sarothrurae* Baer, 1959, and *L. soricis* Bychovskaja-Pavlovskaja and Kulakova, 1970.

In our opinion the following synonymies exist among species of this subgenus: *L. skrjabini* is a synonym of *L. longicauda*; *L. urocissae* a synonym of *L. oswaldoi*; *L. francolini* a synonym of *L. petrovi*; and *L. sarothrurae* a probable synonym of *L. pawlowskyi*. The type specimen of *Paralutztrema hylocichlae* Faust, 1967, was examined by us and found to be a typical specimen of *L. oswaldoi* and thus is a synonym of that species. Previously Yamaguti (1971), who examined and figured this type, had declared *Paralutztrema* a direct synonym of *Lyperosomum*, an opinion in which we concur.

The biological relationship of this subgenus to other dicrocoeliids remains undetermined since nothing is known of the life cycle of any species of this group.

Subgenus *Lyperosomoides* Yamaguti, 1971, char. emend.

SUBGENERIC DIAGNOSIS: *Lyperosomum*, with characters of the genus. Body elongated fusiform, widest in region of gonads, flattened dorsoventrally; acetabulum large and strong, situated more posteriorly in anterior ⅓ of body; testes diagonal; ovary relatively close behind posterior testis; vitellaria consisting of medium-sized follicles arranged in strips on either side of body, beginning in testicular zones; genital pore ventral to or at posterior margin of pharynx; ova medium to large in size; parasitic in gall bladder and larger bile ducts of birds and mammals.

TYPE SPECIES: *Lyperosomum* (*Lyperosomoides*) *corvi* (Yamaguti, 1939).

Other species recognized as belonging to this emended subgenus are *L. alagesi* (Skrjabin and Udinzev, 1930), *L. alaudae* (Strom and Sondak, 1935), *L. armenicum* Shcherbakova, 1942, *L. clathratum* (Deslongchamps, 1824), *L. collurionis* (Skrjabin and Issaitschikoff, 1927), *L. coracii* Sultanov, 1962, *L. dujardini* (Strom and Sondak, 1935), *L. eurynorhynchi* (Belopolskaja, 1954), *L. formosaense* Yamaguti, 1971, *L. indosinense* (Odening, 1964), *L. palawanense* Fischthal and Kuntz, 1973, *L. panduriformis* (Railliet, 1900), *L. petiolatum* (Railliet, 1900), *L. rossicum* (Skrjabin and Issaitschikoff, 1927), and *L. turdia* (Ku, 1938).

The species assigned to the subgenus *Lyperosomoides* were recognized as differing morphologically from those of the subgenus *Lyperosomum* by Dollfus (1954), who created a new genus, *Dicrocoelioides*, for them. Unfortunately, Dollfus designated *L. skrjabini* the type species of his newly created genus. Since *skrjabini* is typical of the subgenus *Lyperosomum* and is probably a synonym of the type *longicauda*, *Dicrocoelioides* Dollfus, 1954, must be suppressed as a synonym of *Lyperosomum* as pointed out by Yamaguti (1971). Several recent authors (Dollfus, 1957; Odening, 1964; Binder, 1971) have proposed recognizing the genus *Oswaldoi* for this group of species but this genus was synonymized with *Lyperosomum* by the original author himself (Travassos, 1944) when he realized that the type, *O. oswaldoi*, was typical of that genus. So the available subgenus, *Lyperosomoides*, which the author limited on the basis of artificial characters to include only three of the above species is expanded to accommodate the entire group of related species.

There is little doubt that there are a number of synonyms among members of this subgenus but until certain key species, especially species from Corvidae and Turdidae, are restudied from fresh adequate material it would be speculative to try to point them out. Binder (1971), after an extensive study of the helminths of *Turdus merula*, concluded that *L. turdia* (Ku, 1938) is a synonym of *L. petiolatum* (Railliet, 1900).

Certain species, i.e., *petiolatum*, of this subgenus appear to be closely related morphologically to species of the genus *Zonorchis* Travassos, 1944, while others appear related to avian species of the genus *Conspicuum* (Bhalerao, 1936). The only life cycle known for a species of the subgenus is that of *L. petiolatum* described by Timon-David (1960). It has a eurytremoid type cycle which is almost identical to that described by Patten (1952) for *Conspicuum icteridorum* Denton and Byrd, 1951.

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Subgenus *Sinuosoides* subg. n.

SUBGENERIC DIAGNOSIS: *Lyperosomum*, with characters of the genus. Body long and narrow, with almost parallel sides; acetabulum equal to or larger than the oral sucker, weakly muscular, situated within anterior ¼ or ⅕ of body; testes and ovary nearly in the same longitudinal axis; vitellaria consisting of medium-sized follicles in strips on either side of body, beginning midway between posterior testis and ovary or more caudally; genital pore ventral to intestinal bifurcation; ceca terminating at some distance from or near posterior end of body; ova medium to large, thin-shelled; parasitic in the pancreas, biliary tract, or intestine (?) of birds and mammals.

TYPE SPECIES: *Lyperosomum* (*Sinuosoides*) *sinuosum* Travassos, 1917.

Other species assigned to this new subgenus are *L. africanum* Baer, 1957, *L. anatis* Belogurov and Leonov, 1963, *L. charadrii* Belopolskaja, 1963, *L. duculae* Fischthal and Kuntz, 1973, *L. intermedium* Denton and Kinsella, 1972, *L. lari* Travassos, 1917, *L. scitulum* Nicoll, 1914, and *L. vitellobum* (Fischthal and Kuntz, 1974).

Three species, *L. sinuosum*, *L. intermedium*, and *L. lari*, of the subgenus are parasitic in the pancreas of their hosts and others whose habitat was questionable may be pancreas parasites. Some of the species are strikingly similar to certain avian species of the genus *Corrigia* Strom, 1940, which contains some pancreas parasites. Also, some species appear very close to the genus *Opisthobrachylecithum* Yamaguti, 1971, of which the type and only species, *O. belopolskiae* (Zueva and Belogurov, 1965), was described from a black-bellied plover. Nothing certain is known of the life history of any species of the subgenus *Sinuosoides* or the two related genera, although Schmidt (1967), from questionable evidence, has suggested a eurytremoid type cycle for the pancreatic fluke, *C. vitta* (Duj., 1845).

Three species listed in the genus *Lyperosomum* by Yamaguti (1971) are not assigned to subgenera since descriptions of these species were not available to us; they are *L. kavini* Fotedar and Raini, 1965, *L. metatestis* Belogurov and Tseva, 1967, and *L. vulpis* Paggi and Biocca, 1959.

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Intestinal Helminths of Some Southeastern Wisconsin Fishes[1]

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ABSTRACT: Three hosts [the white sucker, *Catostomus commersoni* (Lacépède); creek chub, *Semotilus atromaculatus* (Mitchill), and green sunfish, *Lepomis cyanellus* Raf.] from southeastern Wisconsin's Pike River were each infected with two or more of the following nine helminths: *Neoechinorhynchus* sp. (Acanthocephala: Neoechinorhynchidae); *Pomphorhynchus bulbocolli* (Linkins, 1919) Van Cleave, 1919 (Acanthocephala: Pomphorhynchidae); *Biacetabulum biloculoides* Mackiewicz and McCrae, 1965, and *Glaridacris catostomi* Cooper, 1920 (Cestoda: Caryophyllaeidae); *Bothriocephalus cuspidatus* Cooper, 1917 (Cestoda: Bothriocephalidae), new host record in *L. cyanellus*; *Triganodistomum attenuatum* Mueller and Van Cleave, 1932 (Trematoda: Lissorchiidae), metacercariae of *Ornithodiplostomum ptychocheilus* (Faust, 1917), a new state record, and *Posthodiplostomum minimum* (MacCallum, 1921) (Trematoda: Diplostomatidae); *Dorylaimus* sp. (?) (Nematoda: Dorylaimidae).

Current efforts are devoted to the study of various fish parasites from the previously uninvestigated streams and lakes of southeastern Wisconsin. Findings on the following parasites have been recently reported: The copepod *Lernaea cyprinacea* Linn. from 10 Root River fish species by Amin et al. (1973), five intestinal helminths from Root and Pike Rivers' white sucker, *Catostomus commersoni* (Lacépède) by Amin (1974), and the description, variability, and host associations of a new *Acanthocephalus* sp. (*A. parksidei*) (Acanthocephala: Echinorhynchidae) from 11 Pike River fish species by Amin (1975a, b, c). A new proteocephalid cestode of the genus *Proteocephalus* from *Semotilus atromaculatus* is currently being described. The following is an account of the remainder of the helminths which were recovered from various sites from 3 Pike River fish species between 1972 and 1974.

Materials and Methods

After seining, fish were transported to the laboratory on wet ice and examined for parasites within 1–2 days. The sucker gut was divided into the following segments: A (stomach), B (first limb of intestine), C-1 (second limb), C-2, C-3 (coils), and C-4 (last limb including rectum). The sunfish gut was divided into: A (stomach), B (first limb of intestine), and C-1, C-2 (second and last limbs). Trematodes and cestodes were stained in Semichon's carmine, cleared in xylene, and whole-mounted in Canada balsam. Acanthocephalans were stained in Mayer's acid carmine, cleared in Beechwood creosote, and whole-mounted in Canada balsam. Nematodes were cleared in glycerol.

Results and Discussion

Two hundred and 31 white suckers, *Catostomus commersoni* (Lacépède), 398 creek chubs, *Semotilus atromaculatus* (Mitchill), and 48 green sunfish, *Lepomis cyanellus* Raf., were examined for parasites (Table 1). The effect of host size and collection site on intensity of acanthocephalan infections as well as other variables affecting parasitic load and localization of helminths in specified segments of host gut were previously reported by Amin (1975c).

Neoechinorhynchus sp. (Acanthocephala: Neoechinorhynchidae)

Forty-six specimens (21 males, 25 females) were recovered from the intestine of *L. cyanellus* during May 1973 (28 worms) and July 1973 (18 worms). They infected six hosts commonly concurrently with *Acanthocephalus parksidei* in May. In July, seven of 18 hosts were infected (maximum of 8/host), one of which was concurrently infected with one cestode, *Bothriocephalus cuspidatus*. None was recovered from fishes examined during November 1973 or July 1974. Virtually all *Neoechinorhynchus* females were fully distended with embryos. Individuals were mostly localized posteriorly, in intestinal regions C-1

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Table 1. Three Pike River fishes examined for parasites between 1972 and 1974.

Fish species	Date exam.	No. exam.	Length (cm) mean (range)	Coll. site
Catostomus commersoni	Sept., Oct. '72	135[1]	11 (5–37)	2,6,7,5,3
	May '73	25	41.5 (31–48)	α6
	Nov. '73	45	17 (13–32)	α6
	July '74	26	19 (16–30)	α6
		231		
Semotilus atromaculatus	Sept., Oct. '72	300	8.5 (5–25)	5,6,α6,2
	May '73	55	14.5 (12–20)	α5
	Nov. '73	34	14.5 (11–20)	α5
	July '74	9	16.6 (14–20)	α6
		398		
Lepomis cyanellus	May '73	6	7 (5.5–10.5)	α5
	July '73	18	9 (7–12.5)	α5
	Nov. '73	21	9.5 (7–13.5)	α5
	July '74	3	8.3 (8–9)	α6
		48		

[1] Reported in part by Amin (1974).

and C-2. These sites considerably overlapped with those of *A. parksidei* in the same host during the spring of 1973.

Pomphorhynchus bulbocolli (Linkins, 1919) Van Cleave, 1919 (Acanthocephala: Pomphorhynchidae)

Only one female in the ovarian ball stage was found deeply embedded in the intestine of a 41-cm-long breeding male *C. commersoni* during May. This sucker was also infected with 61 *A. parksidei*.

Biacetabulum biloculoides Mackiewicz and McCrae, 1965 (Cestoda: Caryophyllaeidae)

This cestode was first reported in Wisconsin from Pike River suckers by Amin (1974) during September–October 1972. Notes on its distribution, structural observations, and host associations were included. Its relationship and that of *Glaridacris catostomi* with *A. parksidei* in concurrent infections is discussed in Amin (1975c). Additional information is presented below.

The September–October specimens were small and included a number of young adults (8%). Similarly, a collection of the closely related cestode *B. macrocephalum* McCrae, 1962, infecting suckers in the nearby Root River during September–October was made up of mostly (95%) small young adults (Amin, 1974). Annual variations are believed to be responsible for the relatively smaller specimens ($N = 54$, 25% of which were young adults) of November 1973 compared to those of September–October 1972. The summer and early autumn of 1972 were markedly warmer than those of 1973 and might, accordingly, have stimulated the acceleration of *B. biloculoides* growth in the intestine of its piokilothermic host. In November 1973 hosts were more frequently (22%) and heavily (mean: 1.20, max.: 25/host) infected than in September–October 1972 (20%, 0.40, 4). They became more heavily infected posteriorly (82% of worms were in intestinal region B with the remainder between regions A and C-2, compared to 100% in region A during September–October). They included as many as 25 worms per pit and pits as large at $4 \times 6 \times 4$ mm (compared to single worms per $1 \times 1 \times 1$ mm pits during September–October). In May 1973 a small proportion of 136 cestodes recovered from suckers was *B. biloculoides*; the remainder was *G. catostomi*. Both cestodes infected 44% of 25 breeding suckers (mean: 5.44, max.: 41/host) which were concurrently infected with *A. parksidei*. The distribution of these two cestodes in host intestine was almost identical to that of *B. biloculoides* alone in the same host during November 1973. During July 1974 23 *B. biloculoides* (mostly mature adults) infected three suckers (11%) with three pits in two fish containing a maximum of five worms per pit; no *G. catostomi* were recovered, however.

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Glaridacris catostomi Cooper, 1920 (Cestoda: Caryophyllaeidae)

Over 100 of the 136 cestodes recovered from *C. commersoni* during the spring of 1973 were *G. catostomi*. The smaller *B. biloculoides* made up the remainder. Both cestodes were recovered between intestinal regions A and C-2 but mostly (80%) in region B. All *G. catostomi* specimens were mature adults that were up to 34 mm long and 1.48 in maximum body and scolex widths (whole mounts). Some reached at least twice that length when observed live in the host intestine. It is suspected that the partial replacement of *B. biloculoides* by *G. catostomi* in the intestine of the larger breeding suckers during the spring might be a function of host size, season, or both. Calentine and Fredrickson (1965) and Lawrence (1970) showed that *G. catostomi* reached its peak in *C. commersoni* during winter and early spring in Iowa and Maine, respectively.

Bothriocephalus cuspidatus Cooper, 1917 (Cestoda: Bothriocephalidae)

A total of 26 cestodes were recovered from *Lepomis cyanellus* during July 1973 (7 specimens, 22% infection rate, mean: 0.39) and late autumn, 1973 (19, 29, 0.90). All but two were *B. cuspidatus*. This represents a new host record. It was found exclusively in intestinal region B during the autumn but somewhat more posteriorly in the summer. More than half the autumn specimens were young (immature) adults. The summer specimens were comparatively larger in size and were all mature adults.

Triganodistomum attenuatum Mueller and Van Cleave, 1932 (Trematoda: Lissorchiidae)

This trematode was first found in Pike River suckers by Amin (1974) during September–October 1972 and more commonly in suckers from the nearby Root River during the same period. Notes on its distribution, structural observations, and host associations were included. Maturation of this trematode corresponded with its progressive migration posteriorly in the intestinal tract of growing suckers. Uglem and Beck (1972) observed that the position of *T. attenuatum* in the intestine of *C. macrocheilus* (Girard) was associated with aminopeptidase activity. Amin (1974) and Lawrence (1970) also found that the density of infection with this trematode was inversely related to host size (age). The latter finding might explain its virtual absence in the larger suckers examined during May 1973 despite its expected spring population peak as noted by Fried et al. (1964) in Pennsylvania suckers. In May, only one mature adult trematode was recovered from intestinal region C-3 of a 23-cm-long breeding male sucker. During July 1974, 30 *T. attenuatum* (mostly mature adults) infected two hosts; note fish size differences (Table 1).

Ornithodiplostomum ptychocheilus (Faust, 1917) Dubois, 1936 *Posthodiplostomum minimum* (MacCullum, 1921) Dubois, 1936 (Trematoda: Diplostomatidae)

Mixed infections of metacercariae of these two trematodes (larval genus *Neascus*) were encountered in the intestinal mesenteries of *Semotilus atromaculatus*. Recovery of *O. ptychocheilus* metacercariae in this study represents a new state record. Hosts were most heavily and frequently infected during late autumn 1973 but were scarcely infected in the spring of the same year.

Dorylaimus sp. (?) (Nematoda: Dorylaimidae)

This free-living nematode was first reported in Wisconsin as an accidental "parasite" of Pike River suckers, where it was only found by Amin (1974) during September–October 1972. Over 1,000 specimens were recovered from up to 15-cm-long suckers. Its absence in the larger hosts probably accounts for the negative findings in the larger suckers captured during November and May.

Findings from 38 15–31-cm-long suckers examined so far from the nearby Root River during September–October 1974 are somewhat similar to those from other Root River suckers examined during the same period in 1972 (Amin, 1974). In 1974, fish were markedly more heavily and frequently infected with considerably older and more mature *Biacetabulum macrocephalum* adults, than the smaller suckers examined during 1972. *T. attenuatum* infections were, however, significantly lighter

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in 1974 than in 1972. Host size differences probably account for many of these differences. In addition, one *B. biloculoides*, which exclusively parasitized Pike River suckers (Amin, 1974), was found in a stomach pit of a Root River sucker. Root River chubs were only scarcely infected with what appears to be a new *Proteocephalus* sp. which more commonly infected Pike River chubs, among other helminths.

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Monordotaenia honessi sp. n. (Cyclophyllidea: Taeniidae), from a Dog in Wyoming: A Second Taeniid from North America with a Single Circle of Hooks[1]

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ABSTRACT: *Monordotaenia honessi* sp. n. is described from a dog in Wyoming; this is the second known North American taeniid with a single circle of hooks; *M. honessi* is differentiated from *M. taxidiensis* from the badger.

Cestodes of the family Taeniidae are characterized, in part, by possessing a double circlet of characteristic hooks of variable number and size on the rostellum. Exceptions to this rule are *Taeniorhynchus saginatus* (Goeze, 1782) Weinland, 1858, with no hooks; *Monordotaenia taxidiensis* (Skinker, 1935) Little, 1967, with a single circle of hooks; and two inadequately described species with hooks

[1] Published with the approval of the Director, Agricultural Experiment Station, College of Agriculture, University of Wyoming, as JA 659.

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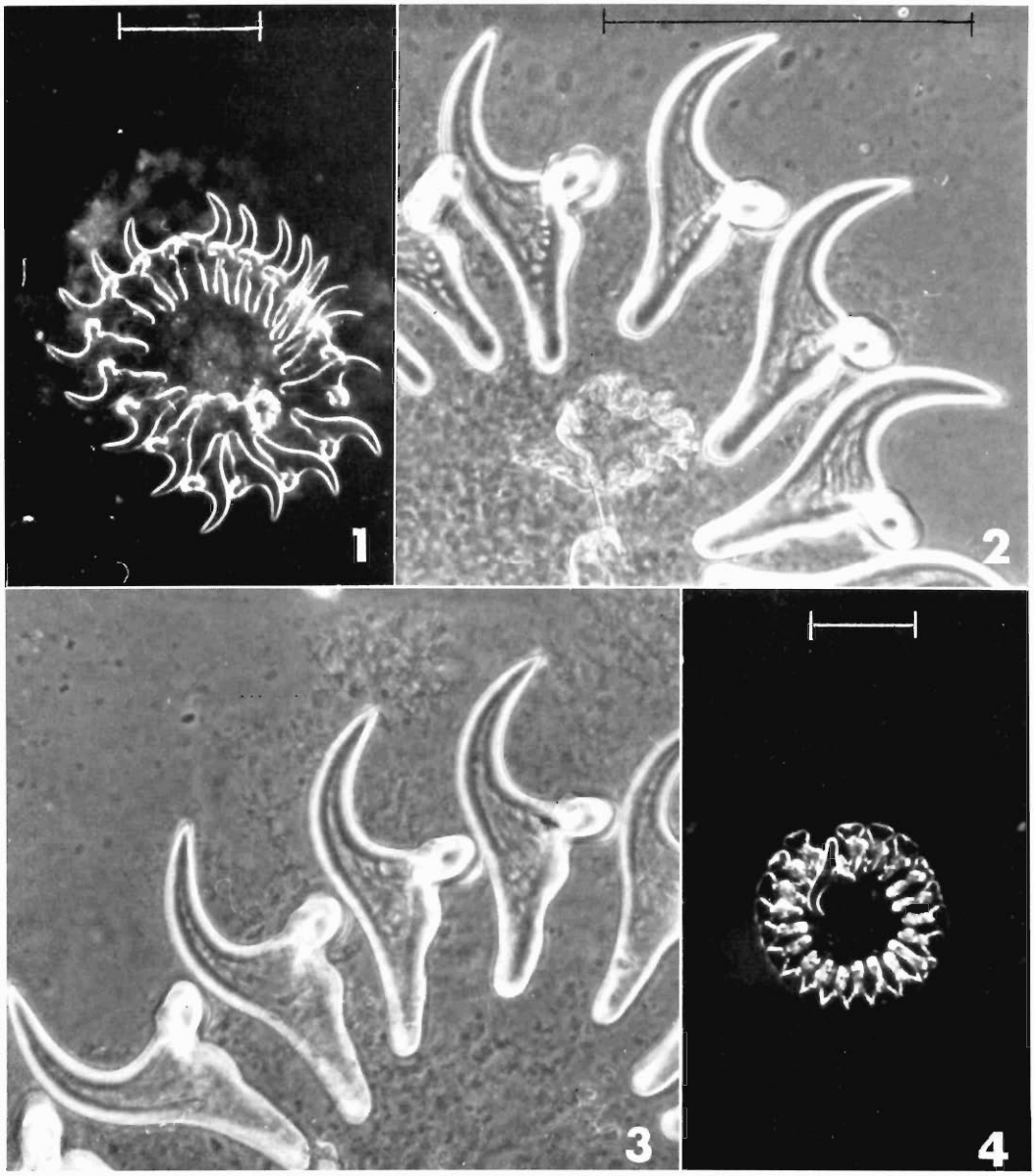

Figure 1. Photograph of *en face* mount of the single row of rostellar hooks of *Monordotaenia honessi* sp. n. Holotype, 19 hooks. Scale = 200 μ.

Figures 2, 3. Photographs of hooks taken from Figure 1. Scale = 150 μ.

Figure 4. Photograph of *en face* mount of single row of hooks of paratype of *M. honessi* sp. n. showing 21 hooks. Hooks rotated so that guards are on circumference, one hook lateral. Scale = 200 μ.

in a single circle: *Taenia monostephanos* Linstow, 1905, and *Taenia* sp. Hiregauder and Rao, 1955.

Honess (1937) reported on cestodes from badgers in Wyoming which possessed a single circle of hooks, describing them as *Fossor angertrudae*. Skinker (1935) had previously described *Taenia taxidiensis* from the badger

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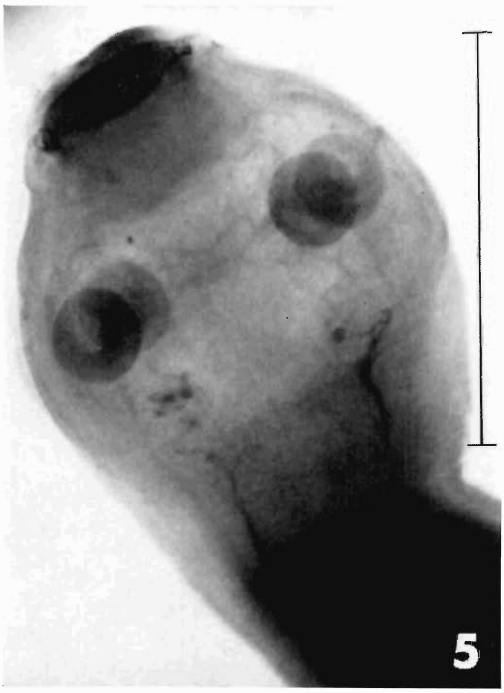
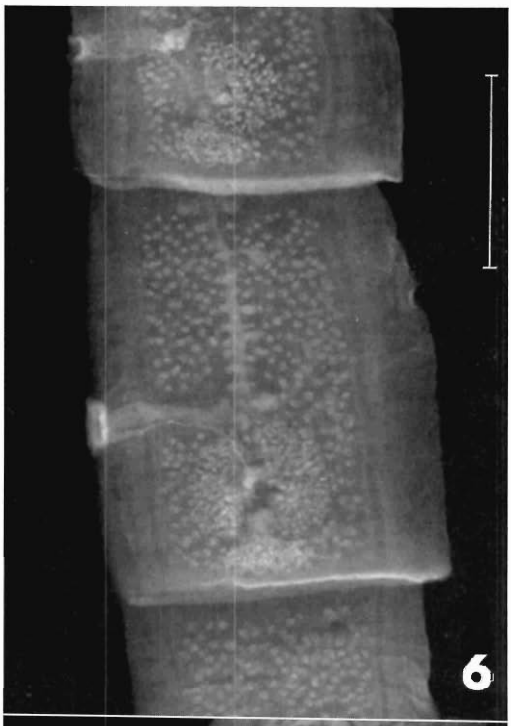


Figure 5. Scolex of *Monordotaenia honessi* sp. n., paratype. Most hooks missing from rostellum but single circle of hook scars visible. Scale = 1 mm.

in Montana but considered the single row of hooks to be the result of the loss of an entire circlet of hooks. Rausch (1947) redescribed *T. taxidiensis* and pointed out the single circle of hooks was normal for this species. Little (1967) compared Rausch's and Honess' material and concluded that *Fossor angertrudae* was conspecific with *Taenia taxidiensis* and that *Fossor* (Honess, 1937) was a homonym of *Fossor* Lichtenstein, 1884 (mammal); he erected the genus *Monordotaenia* to accommodate the species from the badger. Keppner (1967) concurred in identifying *F. angertrudae* with *T. taxidiensis* but



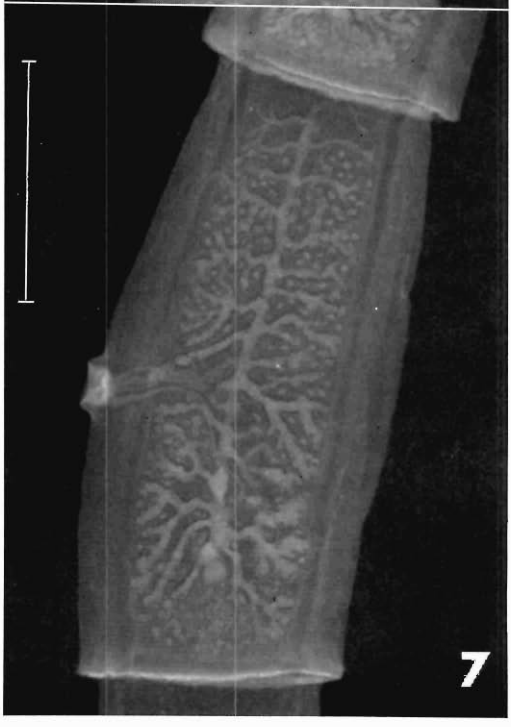


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Figure 6. Mature proglottid of *M. honessi* sp. n. Scale = 2 mm.

Figure 7. Gravid proglottid of *M. honessi* sp. n. Twelve to 14 side branches off uterine stem. Scale = 3 mm.

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Table 1. Comparison of *Monordotaenia taxidiensis* and *Monordotaenia honessi* sp. n.

Author structure	*Monordotaenia taxidiensis*						*Monordotaenia honessi* sp. n.
	Skinker, 1935	Honess, 1937	Rausch, 1947	Little, 1967	Pederson and Leiby, 1969	Verster, 1969	Present work
Strobila (L mm)	100	390–460	480	382	9.7–685 113–205*		500–648
Strobila (W mm)	2	2.9–3 1.83–2.02 (L mature) 2.39–2.43 (W)	3	2.6			1.62–3.6 (L mature) 2.10–2.46 (W)
Gravid segment (mm)		7.8–8.1 (L) 2.28–2.8 (W)	8–8.5	7.3			3.78–9 (L) 2.28–3.48 (W)
Scolex	450	577–838 × 666–818	497–596	780		900	1,497–1,523
Rostellum	170	262–308				251	689–755
Suckers	140	192–239	156	200		215	307–337 (L) 297–337 (W)
Number hooks		22–25	20–27	20	23–25 20–23*	22	19–21
Hooks size (L)	90–93	83–99	79–99	89	90–99	100–104	138.2–152.7 (144.2)[m]
Width							80.7–93.8 (85.4)
Handle (L)	56		54				87.3–98.9 (92.9)
Blade (L)							44.4–57.5 (51.8)
Guard (L)	44–47		46	43			23.3–31.3 (27.1)
Cirrus pouch (L)		281	240–330	270		229–279	495–514.8 (506.8)
(W)		137	100	110		91–101	188.1–227.7 (203.9)
Number testes	150–250	numerous	200–300	200–300		150	196–260 (212)
Size	31	69	70–90	60–80		41–46 × 37–41	49.5–89.2 (72.6)
Number uterine side branches	11–19	11–23	10			12–15	10–17 (14)
Eggs			31 × 31				32.2–36.8 (34.8) × 26.5–27.6 (27.3)
Host			Badger, *Taxidea taxus* Schreber				Dog, *Canis familiaris*
Locality	Montana	Wyoming	Wisconsin	Wyoming	North Dakota	North America	Wyoming
Additional records	Colorado (Leiby, 1961)	(Keppner, 1967)			(Leiby et al., 1971)		Iowa (Wittrock and Ulmer, 1974)

Measurements in microns except where indicated.
* = experimental.
[m] = mean.

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retained the genus *Fossor*. Verster (1969), studying the genus *Taenia*, transferred *M. taxidiensis* into this genus on the grounds that the difference in a single character (in this instance, number of hook rows) was not sufficient to erect a new genus. Pederson and Leiby (1969) agreed with Little (1967) as to the identity of the species from the badger and worked the life cycle; *Citellus* spp. served as intermediate hosts for *Monordotaenia taxidiensis*. Recently, one of us (R.G.) recovered five specimens of a cestode from the intestine of a dog submitted to the Wyoming State Veterinary Laboratory, Laramie. All specimens were gravid, two possessed a complete, but single row, of 19–21 rostellar hooks. The remaining specimens had only a few hooks intact, but hook scars indicated that a single circle of hooks was the normal condition. Specimens at first were thought to be *Monordotaenia taxidiensis*; further detailed examination proved them to be a new species of the genus *Monordotaenia* which is described below.

Materials and Methods

The tapeworms collected were washed in saline and fixed in 10% formalin. *En face* hook preparations were made in Hoyer's fluid and photographed; measurements were made from projected photographs according to the procedures outlined in Wardle and McLeod (1952) and according to the method of Skinker (1935). Scolices and proglottids were stained using Ehrlich's acid hematoxylin and projected directly onto print paper by means of a photo enlarger.

Description of *Monordotaenia honessi* sp. n.

Measurements in microns except where otherwise noted; ranges are followed by means in parentheses. Large, craspedote, taeniid tapeworm measuring 500–648 mm long by 1.02 (neck)–3.48 (gravid) mm wide. Scolex well developed measuring 1,497–1,523 in width; with a pronounced rostellum measuring 689–755 in width. Rostellum bears a single circle of 19–21 (two specimens) hooks. Measurements of 20 hooks from two scolices: hook length 138.2–152.7 (144.2); hook width 80.7–93.8 (85.4); handle length 87.3–98.9 (92.9); blade length 44.4–57.5 (51.8); guard length 23.3–31.3 (27.1) (by the method of Skinker, 1935). Suckers large measuring 307–337 by 297–337. Neck reduced in length followed by a region of immature proglottids. Mature proglottids from wider than long to longer than wide measuring 1.62–3.6 mm by 2.10–2.46 mm; and bearing a single set of reproductive organs. Genital pores marginal and alternating irregularly. Cirrus pouch large measuring 495–514.8 (506.8) by 188.1–227.7 (203.9), seminal vesicle coiled and extending to midline of proglottid. Testes numerous, from 196–260 (212) per segment, large, measuring from 49.5–89.2 (72.6) in diameter, and extending posterior to ovarian field. Ovary posterior, bilobed, with poral lobe usually smaller than aporal lobe. Vitellarium posterior to ovary. Immature uterus a median tube extending to anterior margin of proglottid. Gravid proglottids elongate measuring 3.78–9.0 mm by 2.28–3.48 mm. Gravid uterus with 10–17 (14) side branches which in terminal proglottids show secondary branching; filled with eggs, 17 of which measured 32.2–36.8 (34.8) by 26.5–27.6 (27.3).

HOST: Dog, Labrador, male (*Canis familiaris*).

LOCATION: Small intestine.

TYPE LOCALITY: Laramie, Albany County, Wyoming, USA.

TYPE SPECIMENS: Holotype and paratype deposited in United States National Museum (USNM Nos. 73676 and 73677): Holotype strobila stained and mounted *in toto*, rostellar hooks *en face*; paratype scolex and strobila stained and mounted *in toto*.

Monordotaenia honessi sp. n. is named in honor of Professor Emeritus Ralph F. Honess, University of Wyoming; Professor Honess was the first to recognize that a single row of hooks in *M. taxidiensis* was the normal condition for the genus.

Discussion

A comparison of the measurements of *Monordotaenia honessi* sp. n. and *M. taxidiensis* from various authors is given in Table 1.

Monordotaenia honessi sp. n. is similar to *M. taxidiensis* in possessing but a single circle of hooks on the rostellum: *M. honessi*, how-

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Figure 8. Hook of *Monordotaenia taxidiensis* from a paratype in the helminthological collection, University of Wyoming, showing differences in form of blade and guard length when compared with hooks of *M. honessi* sp. n. Scale = 100 μ.

ever, has only 19–21 hooks (two specimens) versus 20–27 hooks in *M. taxidiensis* (Figs. 1, 4). Hook sizes also differ in these two species with *M. honessi* possessing a hook approximately 50% greater in length than the hook of *M. taxidiensis*, and the guard in the latter species is almost twice the length of that of *M. honessi* (Table 1). These differences in handle, guard, and blade sizes produce a hook in *M. honessi* distinct in size, shape, and proportion allowing for differentiation of this species from other taeniids with a single circle of hooks. Specimens of *M. honessi* were compared with paratypes of *M. taxidiensis* in the University of Wyoming Parasite Collection, and these differences are clearly noted (Figs. 2, 3, 8). The scolex, rostellum, and suckers of *M. honessi* are also larger by factors of 1½–2 than the corresponding structures in *M. taxidiensis*. The cirrus pouch of *M. honessi* is approximately twice the size of that organ in *M. taxidiensis*.

The other species of Taeniidae with a single circle of hooks are *Taenia monostephanos* v. Linstow, 1905, with 29 hooks (190–220 in length) from a lynx in Russia; and a single specimen of *Taenia* sp. recovered from a dog in India by Hiregauder and Rao (1955) with 13 hooks (118 in length) with no further description available (Abuladze, 1964). Clapham (1942) considers the former to be an immature form owing to the much reduced hook handle giving the hook the appearance " . . . of a rose thorn." Verster (1969) synonymized this species with *Taenia laticollis* Rudolphi, 1819. The hook handle of *M. honessi* is pronounced and long (92.9 μ), comprising almost ⅔ of the total hook length. Based on these considerations, *M. honessi* is considered specifically distinct from *M. taxidiensis*. It is of interest that *M. taxidiensis* has been reported only from the northern tier of states from Wisconsin to Montana and Wyoming and only from badgers, *Taxidea taxus*; the dog may not be the natural host for *M. honessi* and it should probably be looked for in other carnivores in these areas.

Acknowledgments

We would like to express our appreciation to Larry Vasey who prepared the photographs of scolices and proglottids and to Jamie K. Morton who aided in translation.

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Quinisulcius tarjani sp. n. (Nematoda: Tylenchorhynchinae) with Key to *Quinisulcius* Species and Notes on Other Plant-parasitic Nematodes from Mexico[1]

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ABSTRACT: *Quinisulcius tarjani* sp. n. from around roots of saguaro cactus in the Sonoran Desert of Mexico is described and illustrated. It differs from the most closely related species, *Q. goodeyi* (Marinari, 1962) Siddiqi, 1971, in having an areolated lateral field, shorter stylet, offset lip region with eight labial annules, and conoid tail with bluntly pointed terminus. A key to the eight species of *Quinisulcius* and notes on *Pratylenchus mulchandi* Nandakumar and Khera, 1970, and other plant-parasitic nematodes from Mexico are included.

A large population of an undescribed species of *Quinisulcius* was found in the Sonoran Desert in Mexico. It was recovered from sand at the base of a young saguaro cactus, *Cereus giganteus* Engelm. Descriptions of the male allotype and female holotype were made from fresh specimens. All other measurements were on preserved specimens, heat-killed, fixed in 4% formalin, and preserved by the glycerol–ethanol method of Seinhorst (1959).

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Quinisulcius tarjani sp. n. Fig. 1, A–D)

HOLOTYPE ♀: L = 0.71 mm; a = 31; b = 4.8; c = 15; V = 55; stylet = 19 μm; T/ABW = 3.0; tail annules = 49.

ALLOTYPE ♂: L = 0.68 mm; a = 31; b = 5.2; c = 11; stylet = 18 μm; T = 51; T/ABW = 3.9; spicules = 20 μm; gubernaculum = 10.5 μm.*

* Gubernaculum measured without the curved proximal portion which averages 3 μm in length.

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Figure 1, A–D. ***Quinisulcius tarjani* sp. n. A. Female head region. B. Male tail. C. Female posterior portion showing areolated lateral field. D. Gubernaculum showing variations. E–H. *Pratylenchus mulchandi* Nandakumar and Khera, 1970. E. Female anterior portion. F. Female reproductive tract showing posterior uterine branch. G. Female tail. H. Female esophageal gland region.**

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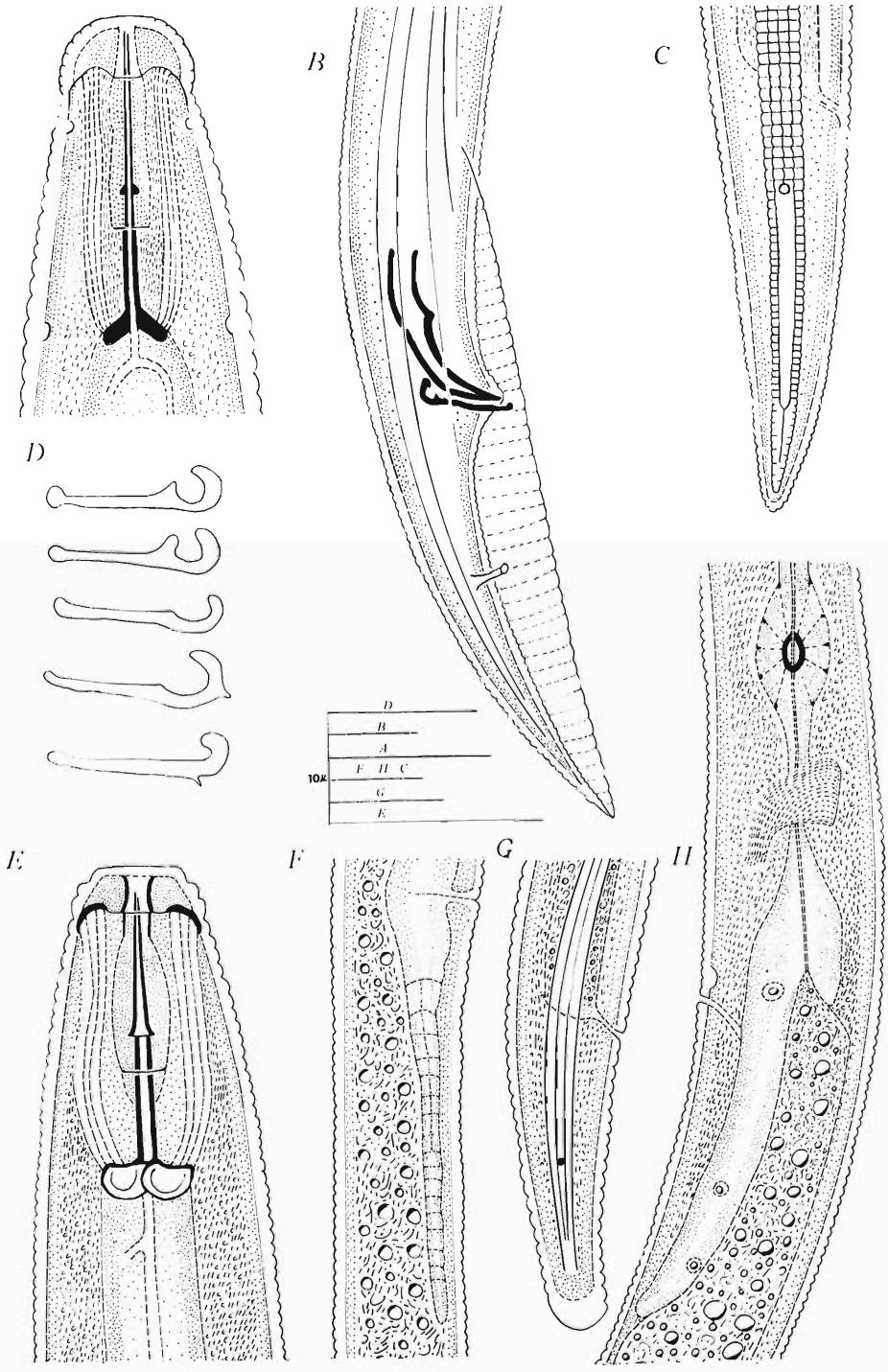

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PARATYPE ♀♀ (13): L = 0.71 (0.63–0.78) mm; a = 32 (30–32); b = 5.3 (4.8–6.3); c = 12 (11–15); V = $^{25(22-28)}54(54-55)^{25(22-28)}$; stylet = 19 (18–19) μm; T/ABW = 3.2 (2.7–3.7); tail annules = 49 (44–60).

PARATYPE ♂♂ (13): L = 0.65 (0.58–0.70) mm; a = 30 (28–33); b = 4.6 (3.6–5.2); c = 11 (10–12); T = 52 (48–53); stylet = 18 (17–19) μm; T/ABW = 3.6 (3.4–3.8); spicules = 21 (20–24) μm; gubernaculum = 11 (10–11) μm.*

FEMALE: Body vermiform, slightly ventrally arcuate in death position. Cuticle finely annulated; transverse striations average 1.4 μm apart at middle of body. Areolated field occupying about one-third of body width, with five crenate incisures (Fig. 1C). In many specimens, lines forming transverse striae are of uneven thickness producing an effect of punctuation. Lip region rounded, well set off from body, bearing eight exceedingly fine annules. Cephalic sclerotization inconspicuous. Stylet about 18–19 μm long with well-developed knobs, the anterior margins slanting backwards. Anterior cephalids located at about third annule following lip region. Posterior cephalids inconspicuous, located at about the 16th body annule. Orifice of dorsal esophageal gland about 1.6 μm behind stylet base (Fig. 1A). Median esophageal bulb ovoid; nerve ring encircling isthmus near the middle. Hemizonid about four annules long, located one annule above excretory pore. Pore opening at level of base of isthmus. Basal bulb of esophagus pyriform; cardia large, conoid–hemispherical. Ovaries paired, outstretched, with oocytes arranged in single file. Spermatheca round, filled with spermatozoa in some specimens, and clearly visible when empty. Tail conoid, bearing 44–60 annules with a bluntly pointed, annulated terminus. Anus distinct. Phasmids anterior to middle of tail. Tail length usually over three times anal body width (Fig. 1C).

MALE: Similar to female in body shape. Phasmids anterior to middle of tail. Bursa crenate, enveloping tail. Spicules tylenchoid, about 21 μm long. Gubernaculum about 11 μm long, distal end slightly enlarged; proximal end crescent- or hook-shaped (Fig. 1B). Variations in gubernaculum shape observed (Fig. 1D).

Diagnosis

Quinisulcius tarjani sp. n. can be distinguished from *Q. goodeyi* (Marinari, 1962) Siddiqi, 1971, by the areolated field (nonareolated in *Q. goodeyi*), stylet length, 17–19 μm (20–24 μm in *Q. goodeyi*), distinctly offset lip region with eight labial annules (continuous lip region with six or seven labial annules in *Q. goodeyi*), conical tail with bluntly pointed terminus (subhemispherical tip in *Q. goodeyi*). From *Q. acti* (Hopper, 1959) Siddiqi, 1971, it can be distinguished by the areolated lateral field and conical tail with annulated tip (nonareolated lateral field and conoid tail with characteristic enlarged nonannulated tip in *Q. acti*), spermatheca and many males in *Q. tarjani* and no spermatheca or known males in *Q. acti*, and 17–19 μm stylet length (16.5–17.3 μm in *Q. acti*).

TYPE HABITAT: Sand in Sonoran Desert around roots of saguaro cactus, *Cereus giganteus* Engelm.

TYPE LOCALITY: Off Highway 16 approximately 45 km SW of Hermosillo in desert between Kino Bay and Hermosillo, Sonora, Mexico.

TYPE SPECIMENS: Holotype female, from desert near Hermosillo, Sonora, Mexico, collected by N. Knobloch, 20 July 1973. Slide *T-228t* deposited with the USDA Nematode Collection at Beltsville, Maryland. Allotype male, same data as holotype, slide *T-229t*. Paratypes, same data as holotype, four slides containing males and females *T-1555p*, *T-1556p*, *T-1557p*, *T-1558p*, all deposited with the USDA Nematode Collection at Beltsville, Maryland.

The new species is named in honor of Dr. A. C. Tarjan.

Key to Females of *Quinisulcius* Siddiqi, 1971

1. Tail with 44–60 annules, terminus annulated 2
   Tail with 15–42 annules, terminus smooth 3
2. Stylet 20–24 μm long, lip region continuous, lateral field nonareolated ..... *goodeyi* (Marinari, 1962) Siddiqi, 1971
   Stylet 18–19 μm long, lip region offset, lateral field areolated ..... *tarjani* sp. n.

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3. Tail with 26–42 annules, lip region with 8 annules 4
   Tail with 15–23 annules, lip region with 4–6 annules 5
4. Tail with 42 annules, tail terminus hemispherical, anterior surface of stylet knobs inclined laterally ..... *acti* (Hopper, 1959) Siddiqi, 1971 (syn. *nilgiriensis* Seshadri et al., 1967)
   Tail with 26 annules, tail terminus bluntly pointed, anterior surface of stylet knobs inclined posteriorly ..... *capitatus* (Allen, 1955) Siddiqi, 1971
5. Spermatheca and males present 6
   Spermatheca and males absent 7
6. Body 0.80 mm long, stylet 18 μm long ..... *acutoides* (Thorne and Malek, 1968)
   Body 0.47–0.57 mm long, stylet 13 μm long ..... *obregonus* (Knobloch and Laughlin, 1973)
7. Anterior surface of stylet knobs inclined anteriorly, 17 tail annules, T/ABW = 2.1 ..... *acutus* (Allen, 1955) Siddiqi, 1971
   Anterior surface of stylet knobs inclined posteriorly, more than 17 tail annules, T/ABW = 2.7–3.0 8
8. Body 0.60–0.70 mm long, lip region with 6 annules, tail with 23 annules ..... *cacti* (Chawla et al., 1968) Siddiqi, 1971
   Body 0.49–0.63 mm long, lip region with 4–5 annules, tail with 15–22 annules ..... *curvus* (Williams, 1960) Siddiqi, 1971

Some other plant-parasitic nematodes from Mexico

Pratylenchus mulchandi Nandakumar and Khera, 1970 (Fig. 1, E–H). In August 1971 *Pratylenchus mulchandi* was recovered from soil around roots of *Sorghum vulgare* Pers. and corn, *Zea mays* L., at the Technological Institute Experimental Station at Apodeca, Nuevo Leon. This Mexican population (M.P.) differs from the original Indian population (I.P.) in certain respects given below, but these variations are not considered sufficient to establish a separate species.

Measurements

Mexican Population (20)	*Indian Population (55)* (From original author)
L = 0.55 (0.49–0.66) mm	L = 0.51 (0.44–0.58) mm
a = 33 (31–36)	a = 24 (22–28)
b = 6.2 (5.4–7.0)	b = 5.8 (5.0–6.4)
c = 16 (14–19)	c = 22 (17–27)
V = 2974 ($^{21-39}$73–76)	V = 44.6$_{76.8}$ ($^{23-50}$75–78)
stylet = 16 μm (16–17)	stylet = 16–20 μm

The I.P. was described as having a distinctly set-off lip region while M.P. has a lip region slightly set-off in some specimens but questionable in others. In M.P. the vulva averages 74% as compared to 76.8% in I.P. Though males were not found, the M.P. possesses a clearly visible spermatheca which contains refractive bands or plates in the anterior region. They are perpendicular to the longitudinal axis of the organ, as described for other species without males (Seinhorst, 1968). No spermatheca was described for the I.P. The length of the posterior uterine branch of M.P. is 32–47 μm and 2.2–2.7 times vulval body width while in I.P. it is 30–40 μm and more than 1.5 vulval body widths. Tails of M.P. are longer (c = 16; c = 22 in I.P.), some being at least 3 times anal body width, and possess 19–32 annules whereas in I.P. they are about 2.5 times anal body diameter with 16–22 annules.

Large populations of the following plant-parasitic nematodes were recovered from soil collected in July 1973 between Kino Bay and Hermosillo, Sonora, Mexico.

Nematode	Habitat
Pratylenchus thornei Sher and Allen, 1953	cotton, *Gossypium* sp., heavy clay, Granja San Angel
P. thornei	wheat, *Triticum* sp., heavy clay, Granja San Angel
P. thornei	"Grazera," cross between sorghum (*Sorghum vulgare*) and Sudan grass (*Sorghum sudanense*), Granja San Angel
Tylenchorhynchus clarus Allen, 1955	pear, *Pyrus communis* L., Hermosillo
T. claytoni Steiner, 1937	pear, *Pyrus communis* L., Hermosillo
Quinisulcius acti	pear, *Pyrus communis* L., Hermosillo
Q. acutus	pear, *Pyrus communis* L., Hermosillo

Acknowledgments

The author is deeply indebted to Dr. A. C. Tarjan for examining slides of the new species and the Mexican *Pratylenchus*, his helpful suggestions, and review of the manuscript. She wishes to thank Dr. G. W. Bird for his helpful suggestions and review of the manuscript; Dr. A. M. Golden for loan of *P. mulchandi* paratype

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slide, his examination of the Mexican nematode and comments; and Dr. I. W. Knobloch for his patience in accompanying her on collecting trips and review of the manuscript.

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Research Note

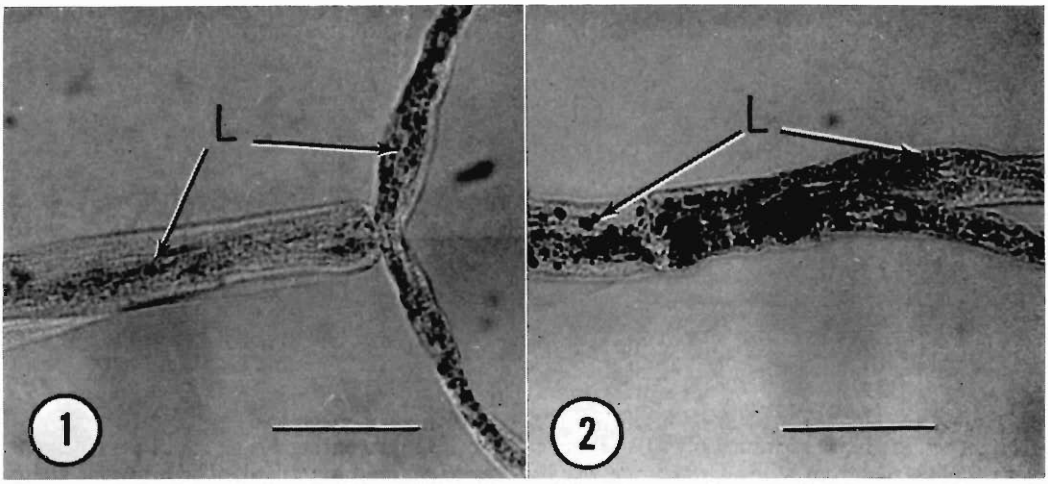
Histochemical Observations on Neutral Fat in Newly Emerged and Day-Old Cercariae of the Avian Schistosome, *Ornithobilharzia canaliculata* (Rudolphi, 1819)

Histochemical observations on neutral fat accumulation during the free-living existence of schistosome cercariae are not available. We have examined histochemically neutral fat from newly emerged and day-old cercariae of the marine avian schistosome, *Ornithobilharzia canaliculata* (Rudolphi, 1819), and our results are reported herein.

Batillaria minima (Gmelin) snails naturally infected with *O. canaliculata* larvae were obtained from a supplier in Largo, Florida, USA. Snails immersed in artificial seawater (30‰) in daylight at 23 C emitted cercariae within 15 min. Cercariae emitted 1–2 hr after snail isolation were considered newly emerged, whereas those removed from bowls containing snails and maintained separately in seawater (about 100 to 200 cercariae/100 ml seawater) for 24 ± 1 hr at 23 C were considered day-old. Although all cercariae were live and active at the time of fixation, day-old cercariae showed reduced swimming activity compared with those newly emerged.

Newly emerged and day-old cercariae were fixed in cold neutral-buffered formalin and stained according to Lillie's (1944, Stain Technol. 19: 55–58) Oil Red O (ORO) procedure for neutral fat. Controls extracted in chloroform–methanol (2:1) for 5 min were ORO negative. In addition to ORO staining in whole cercariae, microphotometric measurements on cercarial tail stems were made using the procedure of Harris and Cheng (1973, Trans. Am. Microscop. Soc. 92: 496–502). All cercariae were prepared as whole mounts in glycerine jelly and the cover slips were rimmed with paraffin to preserve the slides.

Oil Red O droplets were usually faintly visualized in the tails of newly emerged cercariae and clearly visualized in the tails of day-old cercariae (Figs. 1, 2). In newly emerged cercariae ORO droplets appeared to localize in the excretory duct of the tail stem and in the parenchyma immediately surrounding the duct. In day-old cercariae droplets were seen in the excretory duct of the tail stem



Figures 1, 2. Neutral fat in *Ornithobilharzia canaliculata* cercariae. 1. Newly emerged cercaria stained with ORO. 2. Day-old cercaria stained with ORO. Abbreviations: L, lipid droplets. Scale bars equal approximately 50 μm.

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Table 1. Data on neutral fat in cercarial tail stems based on microphotometric measurements.*

Group	No. of cercariae	Range and (Avg) % transmission in cercarial tail stems†
Newly emerged	7	76–88 (80)
Day-old	8	44–67 (56)

* Transmission of visible light at 520 nm of Oil Red O-stained material in cercarial tail stems using the microphotometric procedure of Harris and Cheng (1973).
† Student's *t* test reveals a significant difference at the 5% level between % light transmission in newly emerged vs. day-old cercariae.

and were usually uniformly distributed throughout the parenchyma. Droplets were uniformly distributed in the parenchyma of the furcae in both groups. Droplet size in the tails of both groups ranged from 0.5 to 10 μm. In newly emerged cercariae, ORO droplets in the body were only observed in organisms that had an unusually excessive amount of neutral fat in the tail. Thus, of the seven newly emerged cercariae studied quantitatively (Table 1) only one had visible droplets in the body. Seven of the eight day-old cercariae studied in Table 1 showed fine droplets in the body. In both groups body droplets did not exceed 0.5 μm and their distribution suggested localization in the excretory system. Data on microphotometric measurements revealed a significant increase in neutral fat in the tail of day-old cercariae (Table 1).

Cheng (1967, *in* Adv. Marine Biol. 5, Academic Press, New York) reviewed the literature on lipid distribution and possible function in cercariae. From his review, it is apparent that there is considerable interspecific variation in the localization of lipid in cercariae, and the nature of cercarial lipid is not well known. Speculatively, lipid may function as an hydrostatic agent to facilitate swimming, as an energy reserve, or may simply be an end product of carbohydrate metabolism.

According to von Brand (1966, Biochemistry of Parasites, Academic Press, New York) fat observed in the protonephridial system of trematodes is probably a by-product of carbohydrate metabolism. Recently, Harris and Cheng (1973, loc. cit.) suggested that lipid droplets observed in the cecal lumen of *Leucochloridiomorpha constantiae* (Mueller) metacercariae may be metabolic by-products excreted through the gut. Aging cercariae of *O. canaliculata* show a significant increase in lipid throughout the tail parenchyma. Since the tail is an ephemeral structure, lipid is undoubtedly discarded as described by von Brand (1966, loc. cit.) for cestodes which also discard accumulated fat with the expulsion of terminal proglottids.

Microphotometric analysis on neutral lipid was made at the Institute for Pathobiology, Lehigh University, Bethlehem, Pennsylvania, through the courtesy of Dr. Thomas C. Cheng and Mr. Kevin R. Harris. We are grateful for their assistance. We thank Mr. Harry Huizinga, Sr., and Mr. Lloyd Runkle of Largo, Florida, for assistance in collecting snails. This work was supported, in part, by funds from the Committee on Advanced Study and Research, Lafayette College.

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Research Note

A Survey of Fish Parasites from the Greenbrier River

Ninety-nine fish representing 13 species were collected from the Greenbrier River below Alderson, West Virginia, from May through September 1972 and 1973 and examined for helminth parasites. Eighteen species representing 17 genera of parasites were recovered and identified. These species include nine trematodes, five cestodes, three nematodes, and one acanthocephalan. Host(s) and location for each species are presented in Table 1.

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Table 1. Parasite–host checklist.

Parasite	Host and location*	No. examined	No. infected
Trematoda			
Cleidodiscus sp.	*Pylodictus olivaris* (g)	14	13
Crepidostomum cornutum	*Ambloplites rupestris* (i)	30	19
	Chaenobryttus coronarius (i)	1	1
	Lepomis sp. (i)	3	1
	Micropterus dolomieui (i)	13	12
	Ictalurus punctatus (i)	1	1
	P. olivaris (i)†	14	9
Rhipidocotyle sp.	*A. rupestris* (i)	30	3
	M. dolomieui (i)	13	3
	P. olivaris (i)	14	2
Lissorchis hypentelii	*Hypentelium nigricans* (i)	10	3
Plagioporus hypenteli	*H. nigricans* (i)	10	4
Plagioporus sp.	*H. nigricans* (b)	10	1
Diplostomulum scheuringi	*A. rupestris* (e)	30	5
Posthodiplostomum minimum centrarchi	*A. rupestris* (l,k,h,s)	30	9
	Lepomis auritus (l,k,h,s)	9	9
	M. dolomieui (l,k,h,s)	13	4
Neascus sp.	*A. rupestris* (f,q)	30	20
	Lepomis sp. (f,q)	3	2
	L. gibbosus (f,q)	1	1
	M. dolomieui (f,q)	13	8
	Hybopsis micropogon (f,q)	1	1
	Stizostedion vitreum (f,q)	1	1
Cestoda			
Atractolytocestus huronensis	*Cyprinus carpio* (i)	12	7
Isoglaridacris sp.	*H. nigricans* (i)	10	1
Corallobothrium fimbriatum	*P. olivaris* (i)	14	9
Proteocephalus sp.	*M. dolomieui* (i)	13	5
Larval proteocephalids	*A. rupestris* (i)	30	4
	M. dolomieui (i)	13	5
	P. olivaris (i)	14	5
Bothriocephalus cuspidatus	*S. vitreum* (i)	1	1
Nematoda			
Contracaecum brachyurum	*M. dolomieui* (i)	13	1
Cucullanus sp.	*P. olivaris* (i)	14	5
Spinitectus carolini	*A. rupestris* (i)	30	27
	L. auritus (i)	9	9
	L. gibbosus (i)	1	1
	Lepomis sp. (i)	3	3
	M. dolomieui (i)	13	10
Acanthocephala			
Neoechinorhynchus cylindratus	*M. dolomieui* (i)	13	1

* (b) gall bladder, (e) eye, (f) fins, (g) gills, (h) heart, (i) intestine, (k) kidney, (q) skin, (s) spleen.
† New host record.

Important aspects of the study include a new host record for *Crepidostomum cornutum* (*Pylodictus olivaris*), the first report of *Atractolytocestus huronensis* from West Virginia, and the finding of a new species of *Isoglaridacris* from *Hypentelium nigricans*. This species differs from other members of the genus by its possession of median vitellaria (J. S. Mackiewicz, pers. comm.). A description of this species will appear elsewhere.

Most parasitic infections were light with no apparent pathological effect on the host. Though this is the first survey of its type in southern West Virginia, the helminths encountered were typical for this general geographic region (Ohio, West Virginia, Kentucky, Tennessee; Hoffman, G. L., 1967, Parasites of North American Freshwater Fishes, 1st Ed., University of California Press).

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Research Note

Anthelmintic Activity of Levamisole Given in Drinking Water to Turkeys

Previously, Kates, Colglazier, and Enzie (1969, Trans. Am. Microsc. Soc. 88: 142–148) reported that levamisole (*l*-tetramisole) when given by capsule at 30 mg/kg of body weight was markedly effective against adult and immature *Ascaridia dissimilis*, adult *Heterakis gallinarum*, and adult *Capillaria obsignata* in turkeys. However, when the drug was given at 0.05 or 0.1% in feed for 1 day (8 to 19 mg/kg mean drug intake per bird), comparable efficiency was obtained only against adult *A. dissimilis*. In further attempts to devise a practical, effective treatment regimen for flock use, data were obtained in controlled anthelmintic tests with naturally infected turkeys that were given the drug in drinking water ad lib. In some experiments, low concentrations of acetic acid were added to the medicated water in an attempt to increase its palatability.

Protocols and pertinent data obtained in seven experiments involving about 300 Beltsville Small White turkeys are given in Table 1. A known volume of medicated drinking water was available to all treated birds for either 1 or 2 days, and the average drug intake per bird was calculated from the group consumption of medicated water. In all experiments the birds were necropsied for residual worm counts 6 or 7 days posttreatment. When given at concentrations of 0.06 or 0.03% of the drinking water, with or without dilute acetic acid, levamisole was highly effective against adult *Ascaridia* (99 and 99%, respectively), immature *Ascaridia* (98 and 94%, respectively), and adult

Table 1. Results of anthelmintic tests in turkeys with Levamisole in the drinking water.

Test and birds per group*	Drug dose in water—%	Acetic acid in water—%	Total drug intake (Avg mg/kg)	Total helminths at necropsy (% efficacy)			
				Ascaridia		*Heterakis*	*Capillaria*
				Adults	Immature	Adults	Adults
			Medicated 1 day				
Test 1							
16	0.06	0	14.6	12(97)	14(97)	0(100)	14(87)
16	0.03	0	8.4	0(100)	52(89)	1(75)	26(75)
16	0(controls)	0	0	464	455	4	104
Test 2							
16	0.06	0	20.9	0(100)	19(98)	0(100)	1,179(19)
15	0.03	0	13.3	1(99)	29(97)	0(100)	731(50)
16	0(controls)	0	0	327	850	15	1,456
Test 3							
16	0.06	0.06	35.6	0(100)	8(98)	0(–)	1,069(73)
16	0.03	0.03	15.5	0(100)	41(91)	0(–)	1,358(65)
16	0(controls)	0.06	0	10	435	0	3,891
Test 4							
16	0.06	0.15	27.3	0(100)	1(99)	0(100)	1,066(84)
16	0.03	0.075	17.6	0(100)	53(96)	3(99)	1,358(80)
16	0(controls)	0.15	0	296	1,246	286	6,463
			Medicated 2 days				
Test 5							
16	0.06	0.06	42.8	0(100)	1(99)	0(–)	1,195(67)
16	0.03	0.03	22.4	1(99)	70(90)	0(–)	1,001(72)
16	0(controls)	0.06	0	113	719	0	3,547
Test 6							
15	0.06	0.15	46.6	0(100)	11(99)	0(100)	839(68)
15	0(controls)	0.15	0	670	1,574	61	2,633
Test 7							
16	0.03	0.075	38.6	0(100)	15(98)	0(100)	267(77)
16	0(controls)	0.075	0	248	845	59	1,160

* Approximately equal numbers of both sexes.

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Heterakis (100 and 99%, respectively). These concentrations were also moderately effective against adult *Capillaria* (70 and 72%, respectively). Differences in efficacy at the two dose levels were not statistically significant. At both the 0.06 and 0.03% treatment levels, drug intake increased when an equal concentration of acetic acid was provided in the medicated drinking water for 1 day. Drug intake decreased, whether or not acetic acid was added, when the medicated water was provided for 2 days. When the ratio of acetic acid to levamisole was changed from 1:1 to 2.5:1, drug intake generally increased but there was no consistent improvement in efficacy.

These results on the anthelmintic activity of levamisole in turkeys are similar to those reported by others with either *l*-tetramisole or *dl*-tetramisole against the same or closely related helminths in chickens and pigeons (Altaif, 1972, Am. J. Vet. Res. 33: 1547–1549; Bruynooghe et al., 1968, Vet. Rec. 82: 701–706; Clarkson and Beg, 1970, Vet. Rec. 86: 652–654; Pankavich et al., 1973, Am. J. Vet. Res. 34: 501–505; Stoican et al., 1973, Lucrar. Inst. Cerc. Vet. Bioprep. Pasteur 9: 179–186; Thienpont et al., 1966, Nature 209: 1084–1086).

The estimated intake of levamisole appeared to be somewhat greater when the drug was given in drinking water rather than in feed, but definitive comparisons cannot be made because equivalent drug levels were not available to the birds with these two methods of administration. The influence of acetic acid on the palatability of medicated drinking water was variable, and the limited data did not permit definitive interpretation.

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Research Note

Incidence of *Marshallagia marshalli* Orloff, 1933, in Wyoming Sheep, *Ovis aries*, and Pronghorn Antelope, *Antilocapra americana*[1]

Marshallagia marshalli Orloff, 1933, a trichostrongylid nematode found in the abomasa of sheep and goats as well as wild ruminants of the western United States, is common in Wyoming. Ransom (1911, U. S. Bureau Anim. Indust. Bull. 127: 132 p.) reported *M. marshalli* from domestic sheep in Montana and it has been reported from adjacent states as well. Dikmans (1932, J. Parasitol. 19: 83) reported *M. marshalli* from a deer in Yellowstone National Park, Wyoming. Lucker and Dikmans (1945, Proc. Helminthol. Soc. Wash. 12: 2–4) reported *M. marshalli*, as identified by Dr. L. Seghetti, from Montana, as the first record of the parasite in antelope.

During the months of January–March 1964–68, the writer conducted annual surveys of internal parasites of domestic sheep under three types of management, namely: Farm flocks on small irrigated acreages, range ewes under fence (4–6 strand, barbed, which does not exclude antelope), and range ewes that were herded at least during spring, summer, and fall months.

Fecal analyses (by flotation, saturated sugar solution with centrifugation @ 2,000 rpm) were made on the 10–30 ewes on each of six ranches each year in the case of the fenced and herded

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Table 1. Incidence of *Marshallagia marshalli* in Wyoming sheep under three types of management and in pronghorns, 1964–68, according to fecal analyses.

		Egg counts (e.p.g.)				
		Trichostrongylid		*Marshallagia marshalli*		
Animal group	No. sampled	Range	Mean	Range	No. positive	Per cent
Farm flock	120	56–14,000	4,204	4*	1	(0.80)
Fenced (range)	280	0– 692	145	2–68	84	(30.0)
Herded (range)	320	8– 2,464	374	2–16	99	(31.0)
Pronghorn antelopes	50	0– 216	24	0–72	18	(36.0)

* Ewe may have grazed with range sheep for 1 or 2 months.

sheep and on six farms for 2 years in the case of the farm flocks. Worm eggs were identified only to genus except eggs of *M. marshalli* which were identified to species. Ranges and arithmetical mean numbers of trichostrongylid eggs per gram of sheep feces were established for ewes in each of the management types. Ten ewes from each management practice group were sacrificed each year in order to augment data gathered by fecal analyses. Adult worms were taken from the abomasum and small intestine, counted, sexed, and identified to species.

Fecal analyses were conducted on specimens from 50 pronghorn antelope during 3 years of the study (1964–66).

Examination of the gastrointestinal contents of 10 pronghorn antelope was made. Only *M. marshalli* eggs were counted in the pronghorn fecal samples and only *Nematodirella longispiculata* and *M. marshalli* adults were counted from pronghorn gastrointestinal contents.

Young ewes (1–3 yr) were selected for the parasite survey since such ewes carry trichostrongylid nematodes (*Nematodirus spathiger, N. filicollis,* and *M. marshalli*) which are usually absent in older ewes. No specific age or sex distribution was attempted in the pronghorn group because of the small sample but about half the pronghorns were does.

There was a direct correlation between worm egg numbers in feces and adult worm burdens. Ranges and mean numbers of trichostrongylid eggs are tabulated by type of sheep management (Table 1). Farm flock ewes had, by far, the most trichostrongylid parasites, with mean egg counts in excess of 4,000 eggs per gram (e.p.g.) but there were almost no *M. marshalli* present (exception in one ewe). Those results were verified by the necropsy from 40 farm flock ewes where no *M. marshalli* adults or juveniles were found (Table 2). In general it can be said that farm flock sheep had no access to range or pasture grazed by pronghorns. The ewe that was positive by fecal analysis for *M. marshalli* may have grazed outside a woven-wire enclosure.

Fenced ewes carried low worm burdens as represented by a mean of 145 e.p.g. in 280 individuals sampled but (30%) were positive for *M. marshalli.* None of the ewes under this type of management had high numbers of eggs in feces. From 460–3,000 trichostrongylid worms were found at necropsy. Of the total trichostrongylid burden, *M. marshalli* adults numbered from 17–340 in 11 of 30 ewes.

Thirty-one per cent of herded range ewes were positive for *M. marshalli.* In each instance, herded sheep in this study grazed with, or in the same area utilized by, prong-

Table 2. Incidence of *Marshallagia marshalli* in Wyoming sheep under three types of management and in pronghorn antelope, 1964–68, according to necropsy results.

		No. of trichostrongylids in G.I. tract		No. of *Marshallagia marshalli* in abomasum		
Animal group	No. examined	Range	Mean	Range	No. pos.	% pos.
Farm flock	40	187–46,000	14,500	0	0	0
Fenced (range)	30	460– 3,000	960	17–340	11	36
Herded (range)	30	9–10,000	1,020	29–482	12	40
Pronghorn	10	0– 5,500	N.D.	10–130	5	50

N.D.—Not determined.

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horns. Some range ewes had egg counts of up to 16 e.p.g. of *M. marshalli*. Worm burdens at necropsy ranged from 9–10,000, but 27 of 40 ewes (68%) carried less than 4,000 trichostrongylid nematodes. *M. marshalli* adults numbered from 29–482 in 12 positive ewes.

Eighteen of 50 pronghorns (36%) were positive by fecal analyses for *M. marshalli*. One-half of the pronghorns were positive for *M. marshalli* (10–130 adult worms) by abosmal examination.

It is apparent that pronghorns can share *M. marshalli* with domestic sheep if both ruminant species graze the same range. Even though farm flock ewes carry relatively heavy burdens of nematodes, few or none are *M. marshalli*. The incidence of *M. marshalli* in Wyoming sheep seems to depend, in most cases, on the type of management and on the amount of contact between sheep and wild ruminants, especially pronghorns.

Sundstrom, Hepworth, and Diem (1973, Wyo. Game & Fish Comm. Bull. No. 12: p. 33) state that the maximum zone of pronghorn abundance appears to be closely correlated with the distribution of big sagebrush, *Artemsia tridentata*, and silver sagebrush, *A. cana*. If this concept be correct, perhaps the trichostrongylid nematode, *M. marshalli*, is limited in its occurrence in the United States by the distribution of sagebrush and pronghorn antelope.

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Research Note

Encystment of *Philophthalmus hegeneri* (Trematoda) Cercariae on *Artemia salina* (Crustacea)

The cercaria of *Philophthalmus hegeneri* Penner and Fried, 1963, encysts rapidly when it contacts solid objects such as the sides and bottom of finger bowls. Penner and Fried (1963, J. Parasit. 49: 974–977) found no evidence that this cercaria encysts on arthropods. In November 1973, one of us (B.F.) collected *Batillaria minima* (Gmelin) snails naturally infected with *P. hegeneri* from an intertidal beach near Clearwater, Florida. Fiddler crabs, *Uca* sp., and hermit crabs, *Pagurus* sp., from this beach contained *P. hegeneri* cysts. Some fiddler crabs were experimentally exposed to *P. hegeneri* cercariae and encystment occurred rapidly on the exoskeleton.

To examine more closely the relationship of *P. hegeneri* cercariae and a crustacean intermediate host, we initiated encystment studies using the brine shrimp, *Artemia salina*, and our observations are reported herein.

A. salina larvae were reared from eggs in a 5-gal aerated aquarium containing artificial seawater (30‰). Nauplii ranging in size from 0.6 to 0.8 mm were exposed to cercariae which were obtained within 6 hr following immersion of naturally infected *B. minima* snails in finger bowls containing 100 ml seawater. Snails were removed from bowls prior to the introduction of nauplii.

Observations made 1 to 24 hr postexposure revealed that *P. hegeneri* cercariae encysted apparently at random on all body surfaces of the *Artemia*. Although nauplii usually contained one cyst, some had two or three. The ventral aspect of the cyst conformed to the surface on which encystment occurred and was convex on *Artemia* and flat on glass (Figs. 1, 2, 4). *Artemia* with cysts usually swam in circles at or near the bottom of the bowl. The length of the cyst was approximately half that of the nauplius. Cysts acted like weights and

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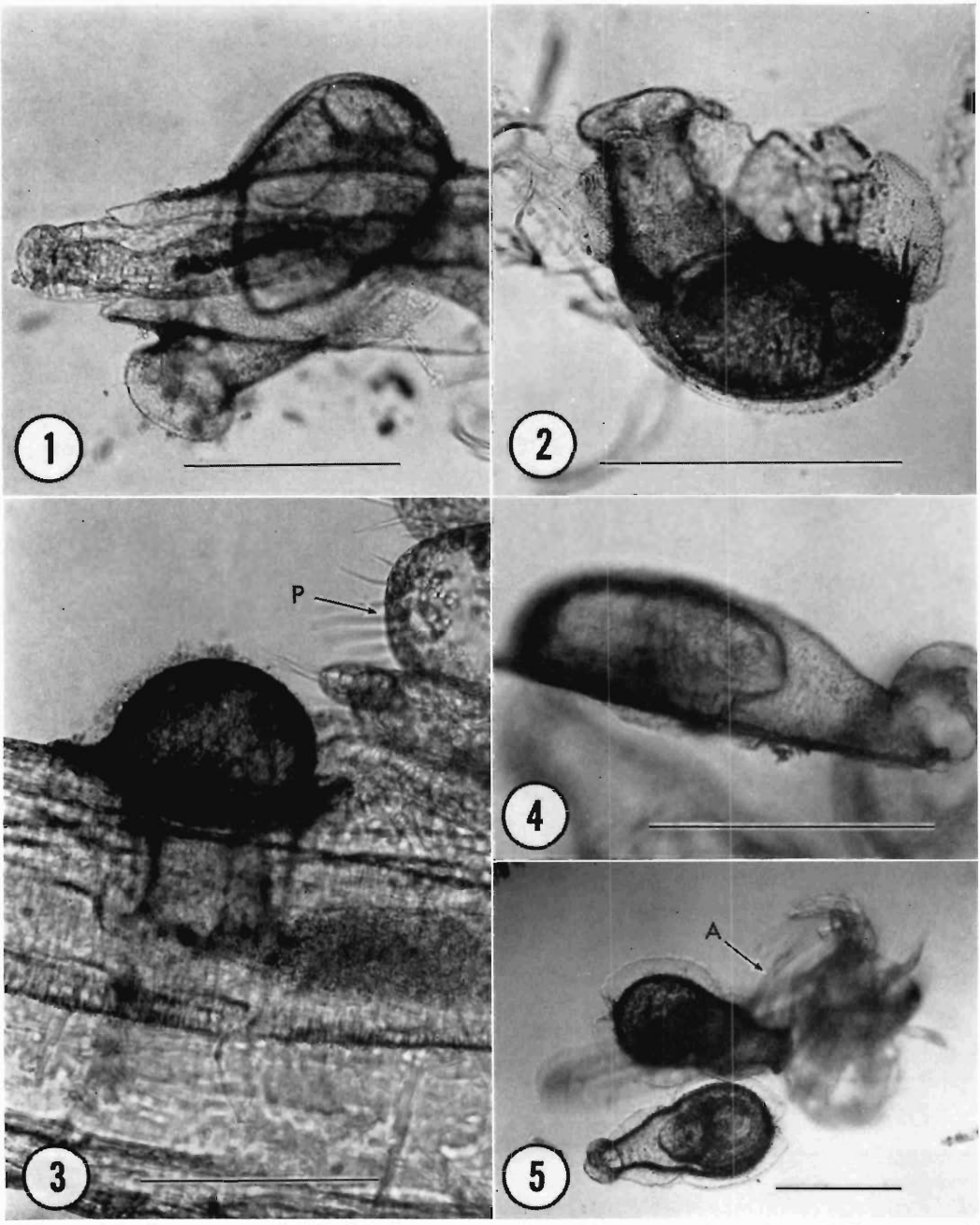

Figures 1–5. Encystment of *Philophthalmus hegeneri* cercariae on *Artemia salina*. 1. Cyst on trunk of live nauplius. 2. Cyst on dead nauplius. 3. Cyst on abdomen of live adult *Artemia*. 4. Lateral view of cyst scraped from finger bowl. 5. Nauplius stuck to cyst on bottom of bowl. Abbreviations: A, antenna; P, phyllopodium. Scale bars equal approximately 0.3 mm.

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influenced the orientation of the *Artemia*. Thus, a cyst on the head caused a nauplius to orient vertically or obliquely with the head-end towards the bottom of the bowl. *Artemia* with cysts were usually inactive, moribund, or dead within 24 hr postexposure.

Incidental to observations on encystment we noted some nauplii that were stuck to cysts on the bottom of bowls. Such entrapment was usually fatal to the nauplius and occurred when the distal tip of the antenna contacted a cyst (Fig. 5).

To determine cercarial preference for *Artemia*, 100 nauplii were introduced into each of four bowls containing 25, 50, 50, or 75 cercariae in 100 ml seawater/bowl. When this experiment was terminated 16 to 24 hr post-exposure, a total of 30 *Artemia* contained 32 cysts and 26 cysts were on bowls. Our results on *P. hegeneri* encystment are not surprising since Fisher and West (1958, J. Parasit. 44: 648) stated that the cercaria of *P. megalurus* shows a preference for chitin and West (1961, Am. Midl. Nat. 66:363–383) reported that this species normally encysts on arthropods, especially crayfishes. *P. hegeneri* cysts were not found on the gastropod host (Penner and Fried, 1963, loc. cit.). In the present study we never observed cysts on *B. minima* shells, but found some on the margin of the operculum.

When the experiments with nauplii were completed, adult *Artemia* became available and were used to observe encystment. Ten adults (approximate length of an adult was 1 cm) were exposed to 25 cercariae in 100 ml seawater. The experiment was terminated 20 hr postexposure at which time four *Artemia* contained a total of six cysts located on the thorax, abdomen, and on a phyllopodium (Fig. 3). Four cysts were observed on the bottom of the finger bowl. At the end of this experiment the 10 *Artemia* were alive and active and behavioral differences between brine shrimp with or without cysts were not apparent.

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Research Note

Lepocreadiid Metacercariae (Digenea) in Marine Hydromedusae, *Polyorchis penicillatus* (Eschscholtz, 1829) (Coelenterata), from the California Coast

Unencysted metacercariae of *Lepocreadium* sp. are reported for the first time from the manubrium and mesoglea of the planktonic hydromedusa, *Polyorchis penicillatus* (Eschscholtz, 1829). Twenty-two infected specimens of *P. penicillatus* collected along the California coast at Raccoon Island (February 1906), San Francisco Bay (October 1912; January and July 1913; December 1951), and Bodega Bay (December 1971) were sent to the Harold W. Manter Laboratory, Division of Parasitology, University of Nebraska State Museum, by Ronald J. Larson, Division of Echinoderms, Smithsonian Institution, Washington, D. C. Representative specimens of the metacercariae are deposited in the National Parasite Collection (USNM Helminthological Collection No. 72995), in the California Academy of Sciences (Department of Invertebrate Zoology No. I. Z. 0013), and in the University of Nebraska State Museum Manter Laboratory (No. 20031).

Since 1830 there have been numerous reports of larval digenes in marine coelenterates, especially in the planktonic forms. Dollfus (1963, Bull. Inst. Pêches Marit. Maroc 9–10: 33–57) reviewed the literature and prepared an annotated list of such hosts and their parasites. Thapar (1964, Indian Jour. Helminthol. 16: 75–81) described a new cercaria

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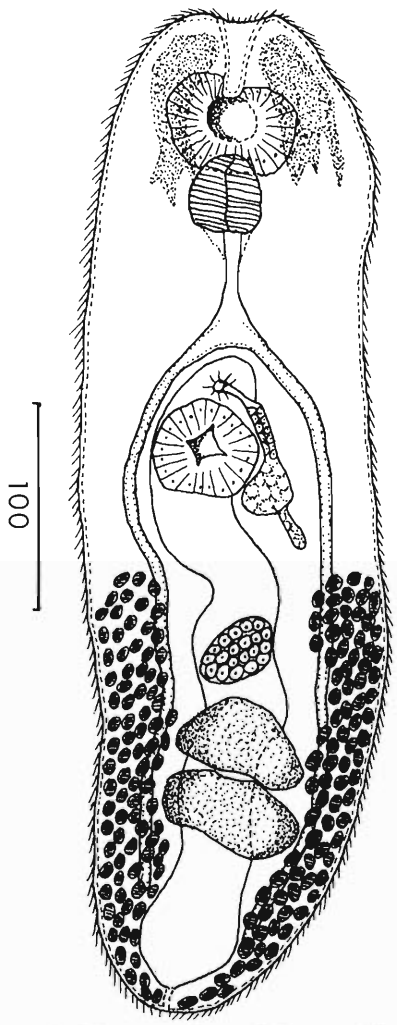

Figure 1. Metacercaria of *Lepocreadium* sp. from *Polyorchis penicillatus* (Eschscholtz, 1829).

and metacercaria from a larva of an *Aurelia* sp. from Indian waters. Boyle [1966, Trans. Roy. Soc. N. Z. (Zool.) 8: 51–62] mentioned a larval trematode in a ctenophore. Stunkard (1967, Biol. Bull. 133: 488; 1968, Biol. Bull. 135: 439) reported natural infections of unencysted larval trematodes from the medusae of *Bougainvillia carolinensis* (McCrady), *Gonionemus vertens* A. Agassiz, and *Chrysaora quinquecirrha* Desor at Woods Hole. Stunkard (1969, Biol. Bull. 136: 96–113) experimentally infected *Mnemiopsis leidyi* A. Agassiz, a ctenophore, with the cercariae of *Neopechona pyriforme* (Linton, 1900) Stunkard, 1969. During another life-history study, Stunkard (1972, Biol. Bull. 142: 326–334) experimentally infected the scyphomedusa *Chrysaora quinquecirrha* with *Cercaria setiferoides* Miller and Northup, 1926. All unencysted larval trematodes found in coelenterates are assigned to the superfamilies Lepocreadioidea, Hemiuroidea, and Accacoelioidea.

The metacercariae recovered from *Polyorchis* were fixed along with the host in formalin, and most are strongly contracted and ovoid. One specimen (Fig. 1) appears to be relaxed except for the oral sucker, and two are only slightly contracted. Body measurements (in microns) are based on these three least contracted specimens; other measurements are from a series of 15 specimens. Averages are in parentheses.

BRIEF DESCRIPTION: Body 340–476 (400) long, 104–140 (124) wide; relatively thick tegument covered with small spines. Oral sucker subterminal or withdrawn into body, spherical, 46–56 (52) in diameter; acetabulum near midbody, 42–54 (45) in diameter; sucker ratio 1:1.15. Pigment granules conspicuous in region of oral sucker and pharynx. Pharynx 30–36 (34) in diameter; esophagus observed in more relaxed specimens, 30–48 (34) long; ceca extending to near posterior end of body. Excretory pore terminal; excretory vesicle I-shaped, wide and sinuous, reaching to cecal bifurcation in more relaxed specimens. Genital anlagen include two tandem testes and ovary anterosinistral to testes; genital pore median, immediately preacetabular; cirrus sac curving sinistrally, extending to posterior margin of acetabulum, external seminal vesicle present; vitelline anlagen lateral to ceca in hindbody.

Metacercariae of the closely related lepocreadiid genera *Lepocreadium*, *Opechona*, and *Neopechona* have been reported from hydromedusae. Serial sagittal sections of two of the present specimens show that the cecal epithelium does not extend into the esophagus, indicating the genus *Lepocreadium*. These metacercariae, having tandem testes and the vitelline anlagen confined to the hindbody, show resemblance to the adult form of *Lepocreadium bimarinum* Manter, 1940, which has been reported from the Mexican Pacific and Tortugas, Florida.

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Three fragments of the hydromedusae collected from San Francisco Bay in January 1913 contained metacercariae and four larval nematodes. Dr. B. J. Myers, Southwest Foundation for Research and Education, San Antonio, Texas, suggested that the nematodes be referred to as *Contracaecum* "type." About the same time, Lichtenfels (1974, Proc. Helm. Soc. Wash. 41: 115) reported *Contracaecum* sp. from specimens of *P. penicillatus*. The hosts had been sent to him from Smithsonian Institution and were part of the same collections reported herein.

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Research Note

Neodiplostomum (*Neodiplostomum*) *georgesduboisi* sp. n. (Trematoda: Diplostomatidae) from the Serpent Eagle from Palawan Island, Philippines

Fischthal and Kuntz (1972, J. Helm. 46: 363–380) reported *Neodiplostomum* (*Neodiplostomum*) *reflexum* Chandler and Rausch, 1947, from the small intestine of the serpent eagle, *Spilornis cheela palawanensis* Sclater (Falconiformes: Accipitridae), from Palawan Island, Philippines. Dr. Georges Dubois, Institut de Zoologie, Université de Neuchâtel, Switzerland (pers. comm.) examined the two worms deposited in the USNM Helm. Coll. (No. 72199) and informed us that we were dealing with a distinct new species. We have reexamined all our specimens and agree with Dr. Dubois. Therefore, we are designating the new species (Figs. 1, 2) as *Neodiplostomum* (*Neodiplostomum*) *georgesduboisi* [syn. *N.* (*N.*) *reflexum* of Fischthal and Kuntz, 1972] in honor of Dr. Dubois for calling to our attention the new species status of our specimens and for his many contributions to a better understanding of the digenetic trematodes.

All measurements and data given by Fischthal and Kuntz (1972) are fully applicable to the new species. Additional observations are: Esophagus short; ceca narrow, extending to near posterior extremity of body. Excretory pore dorsal, just posterior to large, dorsal genital pore, aperture longitudinal. Seminal vesicle convoluted; male papilla opening into genital atrium. Ovary usually contiguous with anterior testis, latter usually separated from posterior testis, latter usually bilobed. Ootype complex posterodorsal to anterior testis; vitelline reservoir intertesticular; vitellaria anteriormost extent from just pre- to just postacetabular, extending to posterior extremity; follicles in anterior segment of body usually absent middorsally and midventrally, overlapping lateral edges of tribocytic organ dorsally, radiating to lateral margins of body in bands, filling body from posteriormost part of anterior segment to short distance postovarian, lying ventral to gonads and not reaching lateral margins of body, usually lying ventral and lateral postgonadally; uterus ascending to anterior third of space between ovary and anterior segment, descending dorsal to male papilla.

SPECIMEN DEPOSITED: USNM Helm. Coll. No. 72199 (holotype); No. 72972 (paratypes).

The new species most closely resembles *N.* (*N.*) *reflexum* from strigiform birds from the U. S. and Canada, and *N.* (*N.*) *lanceolatum* Dubois and Angel, 1972, from a strigiform bird from South Australia. *N. reflexum* differs in having a wider body and larger oral sucker, acetabulum, pharynx, and eggs, in the

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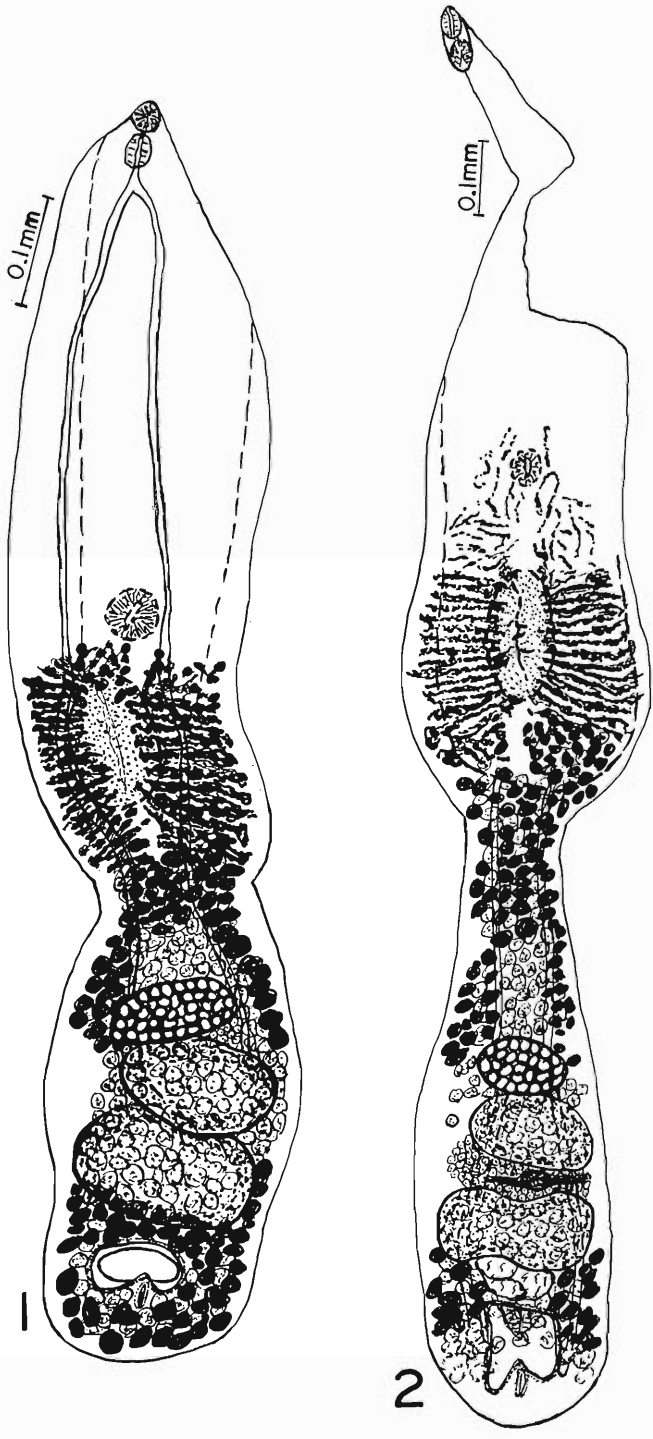

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acetabulum being more anteriorly placed, in the distribution of the vitelline follicles which occupy the posterior half of the anterior segment rather than the posterior third, in the follicles being scattered around the tribocytic organ rather than radiating to the lateral body margins, and in its hosts being strigiform birds from North America. *N. lanceolatum* differs in having the acetabulum more anteriorly placed, a smaller ovary, the vitelline follicles arranged in longitudinal bands in the anterior segment, larger eggs, and a strigiform host, and in the distribution of the vitelline follicles which occupy the posterior half to three-fourths of the anterior segment.

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Figures 1, 2. ***Neodiplostomum (Neodiplostomum) georgesduboisi*** **sp. n. 1. Whole mount of slightly contracted worm, holotype, dorsal view; with one egg lying transversely in genital atrium. 2. Whole mount of relaxed worm, paratype, dorsal view; eggs lacking.**

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